GLOBAL EDITION

International Trauma Life Support
for Emergency Care Providers

NINTH EDITION

Roy L. Alson, PhD, MD, FACEP, FAEMS
Kyee H. Han, MBBS, FRCS, FRCEM
John E. Campbell, MD, FACEP

Ninth Edition
Global Edition

INTERNATIONAL Trauma Life Support

for Emergency Care Providers

ROY L. ALSON, PhD, MD, FACEP, FAEMS
KYEE H. HAN, MBBS, FRCS, FRCEM
JOHN E. CAMPBELL, MD, FACEP



Pearson

Harlow, England • London • New York • Boston • San Francisco • Toronto • Sydney • Dubai • Singapore • Hong Kong
Tokyo • Seoul • Taipei • New Delhi • Cape Town • São Paulo • Mexico City • Madrid • Amsterdam • Munich • Paris • Milan

Vice President, Content Production and Digital Studio: Caroline Power
Content Manager: Kevin Wilson
Managing Producer, Health Science: Melissa Bashe
Development Editor: Jill Rembetski
Acquisitions Editor, Global Edition: Ananya Srivastava
Content Producer: Faye Gemmellaro
Content Producer, Global Edition: Vamanan Namboodiri
Editorial Project Manager: Meghan DeMaio
Full-Service Project Management and Composition: SPi Global, Muralidharan Krishnamurthy
Vice President, Field Marketing: David Gesell
Product Marketing Coordinator: Rachele Strober
Executive Marketing Manager: Brian Hoehl
Manufacturing Buyer: Maura Zaldivar-Garcia
Manufacturing Controller, Global Edition: Caterina Pellegrino
Interior and Cover Designer: Studio Montage
Cover Photos: lem/Shutterstock
Inventory Manager: Vatche Demirdjian
Manager, Rights & Permissions: Gina Cheselka
Printing and Binding: Vivar, Malaysia

Credits and acknowledgments for content borrowed from other sources and reproduced, with permission, in this textbook appear on the appropriate within text.

Please contact https://support.pearson.com/getsupport/s/contactsupport with any queries on this content.

Pearson Education Limited
KAO Two
KAO Park
Hockham Way
Harlow
Essex
CM17 9SR
United Kingdom

and Associated Companies throughout the world

Visit us on the World Wide Web at: www.pearsonglobaleditions.com

© Pearson Education Limited, 2021

Authorized adaptation from the United States edition, entitled *International Trauma Life Support for Emergency Care Providers*, 9th Edition, ISBN 978-0-13-537931-8 by Roy L. Alson, Kyee H. Han, and John E. Campbell, published by Pearson Education © 2020.

Acknowledgments of third-party content appear on the appropriate page within the text, which constitutes an extension of this copyright page. Cover image ©

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without either the prior written permission of the publisher or a license permitting restricted copying in the United Kingdom issued by the Copyright Licensing Agency Ltd, Saffron House, 6–10 Kirby Street, London EC1N 8TS.

PEARSON, ALWAYS LEARNING, and MYLAB are exclusive trademarks owned by Pearson Education, Inc. or its affiliates in the U.S. and/or other countries.

All trademarks used herein are the property of their respective owners. The use of any trademark in this text does not vest in the author or publisher any trademark ownership rights in such trademarks, nor does the use of such trademarks imply any affiliation with or endorsement of this book by such owners. For information regarding permissions, request forms, and the appropriate contacts within the Pearson Education Global Rights and Permissions department, please visit www.pearsoned.com/permissions/.

This eBook is a standalone product and may or may not include all assets that were part of the print version. It also does not provide access to other Pearson digital products like MyLab and Mastering. The publisher reserves the right to remove any material in this eBook at any time.

ISBN 10: 1-292-35767-3

ISBN 13: 978-1-292-35767-6

uPDF ISBN 13: 978-1-292-35768-3

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

1 21

Typeset in Palatino LT Pro 10/12 by SPi Global

Notice on Care Procedures

It is the intent of the authors and publisher that this textbook be used as part of an education program taught by qualified instructors and supervised by a licensed physician, in compliance with rules and regulations of the jurisdiction where the course is being offered. The procedures described in this textbook are based upon consultation with emergency care providers including EMTs, paramedics, nurses, and physicians, who are actively involved in prehospital care. As a field, prehospital medicine is constantly evolving. The authors and publisher have taken care to make certain that these procedures reflect currently accepted clinical practice; however, the procedures cannot be considered absolute recommendations, nor do they supersede applicable local laws or rules and the medical supervision of the prehospital provider.

The material in this textbook contains the most current information available at the time of publication. However, international, national, federal, state, provincial, and local guidelines concerning clinical practices, including, without limitation, those governing infection control and universal precautions, change rapidly. The reader should note, therefore, that new regulations may require changes in some procedures.

The references to products in this text do not represent an official endorsement by ITLS. Efforts have been made to include multiple types of devices, for illustrative purposes, when possible. It is impossible to include in this text an example of every type of device. As in other areas of medicine, there is ongoing development of equipment for use in the care of the prehospital trauma patient, which the authors and editors believe is good. It remains the responsibility of the ITLS provider in conjunction with local medical direction to determine which specific devices are applicable in their specific practice setting.

It is the responsibility of the reader to familiarize himself or herself with the policies and procedures set by federal, state, provincial, and local agencies as well as the institution or agency where the reader is employed. The authors and the publisher of this textbook and the supplements written to accompany it disclaim any liability, loss, or risk resulting directly or indirectly from the suggested procedures and theory, from any undetected errors, or from the reader's misunderstanding of the text. It is the reader's responsibility to stay informed of any new changes or recommendations made by any national, federal, state, provincial, and local agency as well as by his or her employing institution or agency.

Notice on Gender Usage

The English language has historically given preference to the male gender. Among many words, the pronouns, he and his are commonly used to describe both genders. Society evolves faster than language, and the male pronouns still predominate our speech. The authors have made great effort to treat the two genders equally, recognizing that a significant percentage of EMS providers are female. However, in some instances, male pronouns may be used to describe both males and females solely for the purpose of brevity. This is not intended to offend any readers of the female gender.

Notice on Prehospital Personnel Designation

Around the world, the credentialing and training of personnel who provide prehospital care vary greatly. In some jurisdictions, physicians and nurses respond as part of the EMS crew, whereas in other areas, those responding may only be trained to a basic life support (BLS) level. As the principles of care of the multiple trauma patient are the same regardless of the level of training of the persons providing care, the authors and publisher have attempted to describe those care providers in generic terms throughout the book. Common terms in English such as *medic* or *emergency medical responder* are, in some jurisdictions, actual certification levels of personnel. The term *emergency care provider* is used in this text to describe all levels of personnel who provide care in the prehospital setting. When other common terms are used to refer to persons providing care, it is intended to represent all persons who provide prehospital care and not to exclude or offend any care provider.

Dedication

Dr. John Campbell
1943–2018
Founder, President and Patriarch, Philanthropist and Altruist,
Teacher and Mentor, Friend

Known worldwide for his ground-breaking work in developing prehospital trauma education, Dr. Campbell founded the Basic Trauma Life Support (BTLS) program in 1982. It was the first course and curriculum dedicated to prehospital trauma assessment and trauma care worldwide. Dr. Campbell conducted the first BTLS course at Southeast Alabama EMS System on August 23, 1982. The goal of the first BTLS course was to provide the student the knowledge and experience to recognize, assess, and care for critical trauma patients and ensure timely transport to the emergency department. Students were taught to identify conditions requiring "load and go." From its beginning, patient assessment has been the core of the BTLS/ITLS curriculum.

ITLS had humble beginnings in Alabama as a local course developed by Dr. Campbell for paramedics to learn the principles of Advanced Trauma Life Support (ATLS) to improve the care provided to trauma patients. ITLS is now a worldwide organization offering 15 types of trauma courses and teaching more than 30,000 students annually in more than 40 countries across the globe. Dr. Campbell's work has touched more than 800,000 trauma care providers worldwide since the program began and the millions of patients they care for.

From its very beginning, Dr. Campbell's program was based on current research while maintaining a conservative and noncontroversial approach. He wanted the course to be simple, practical, and short enough to be taught in 2 days. Dr. Campbell also recognized the importance of allowing the course to be adapted for regional differences among local EMS systems.

"I'm speechless to think of this and I can't believe that this little course has come this far," Dr. Campbell once said about the growth of ITLS worldwide. "It's just an idea whose time had come, and I just happened to be, by accident, the one who was there when it started. It's still as important now as it was then."

Dr. Campbell leaves behind a legacy of unfailing dedication and excellence in trauma care. He will be missed by the thousands of students, instructors, colleagues, and friends whose lives he touched, personally and professionally, through the reach of ITLS training and education.

International Trauma Life Support will continue to advance Dr. Campbell's mission of improving trauma care worldwide by continuing to develop innovative curricula, programs, and services that are evidence based, flexible, and assessment focused for trauma care providers and the patients they serve. The ITLS Board of Directors and Editorial Board will continue under the leadership of Board Chair Jonathan L. Epstein, MEMS, NRP, of Massachusetts, and Editor-in-Chief Roy L. Alson, PhD, MD, FACEP, FAEMS, of North Carolina.



International Trauma Life Support (ITLS) announced the passing of our Founder and President, John Emory Campbell, MD, FACEP of Alabama, in August 2018. Dr. Campbell passed away in his home after a long illness. He was 75 years old.

Table of Contents

SECTION 1 Essential Information

CHAPTER 1 Introduction to Traumatic Disease 21

Chapter Overview 22
Situational Awareness 22
Case Presentation 23
Scene Size-up 24
Standard Precautions 24
Scene Safety 24
Total Number of Patients 26
Essential Equipment and Additional Resources 26
Mechanism of Injury 27
Blunt Trauma 27
Penetrating Trauma 33
Priorities of Trauma Care 36
Trauma Triage Decisions 37
Prevention and Public Education 37

CHAPTER 2 Trauma Assessment and Management 43

Chapter Overview 44
Case Presentation 44
ITLS Primary Survey 46
Scene Size-up 46
Initial Assessment 49
Rapid Trauma Survey or Focused Exam 51
ITLS Reassessment Exam 55
ITLS Secondary Survey 56
Adjuncts for Trauma Patient Assessment 59
Transfer of Care 59

CHAPTER 3 Assessment Skills 63

ITLS Primary Survey—Critical Information 64
Scene Size-up 64
Initial Assessment 64
Rapid Trauma Survey 69
ITLS Reassessment Exam—Critical Information 72
Subjective Changes 72
Mental Status 72
Reassess ABCs 72
ITLS Secondary Survey—Critical Information 74
SAMPLE History 74
Vital Signs and Repeat Initial Assessment 74
Neurological Exam 74
Detailed Exam 76
Ground Rules for Teaching and Evaluation 77

CHAPTER 4 Hemorrhage Control and Shock 78

Chapter Overview 79
Case Presentation 79
Pathophysiology of Shock 80
Evaluation of Tachycardia 81
The Shock Syndromes 82
Management 83
Special Situations in Hypovolemic Shock 85
Obstructive Shock 86
Cardiogenic Shock 88
Current Thinking in the Treatment of Shock 90

CHAPTER 5 Shock and Hemorrhage Control Skills 97

Cannulation of the External Jugular Vein 98
Intraosseous Infusion 98
Indications 99
Contraindications 99
Recommended Sites 99
Potential Complications 99
FAST Responder™ Intraosseous Device 104
Length-Based Resuscitation Tapes 106
Control of Life-Threatening Hemorrhage 107
Application of Tourniquets 110
Use of Hemostatic Agents 112

CHAPTER 6 Airway Management 116

Chapter Overview 117
Case Presentation 117
Anatomy and Physiology 118
Nasopharynx 118
Oropharynx 118
Hypopharynx 119

Larynx 119
Trachea and Bronchi 121
The Lungs 121
The Patent Airway 121
Observation 123
Suction 123
Airway Adjuncts 124
Supplemental Oxygen 128
Ventilation 128
Normal Ventilation 128
Positive-Pressure (Artificial) Ventilation 129
Compliance 130
Ventilation Techniques 131
Airway Equipment 133

CHAPTER 7 Airway Skills 136
Chapter Overview 137
Basic Airway Management 137
The Pulse Oximeter 141
Supraglottic Airways 143
Advanced Airway Management 151
Preparation for Intubation 151
Face-to-Face Intubation 156
Confirmation of Tube Placement 158
Drug-Assisted Intubation 165
Fiberoptic and Video Intubation 169

SECTION 2 Foundational Knowledge

CHAPTER 8 Thoracic Trauma 172
Chapter Overview 173
Case Presentation 173
The Thorax 173
Anatomy 173
Pathophysiology 175
Emergency Care of Chest Injuries 175
Airway Obstruction 177
Flail Chest 177
Open Pneumothorax 179
Massive Hemothorax 181
Tension Pneumothorax 182
Cardiac Tamponade 184
Myocardial Contusion 186
Traumatic Aortic Rupture 187
Tracheal or Bronchial Tree Injury 188
Diaphragmatic Tears 188
Pulmonary Contusion 189
Blast Injuries 189
Other Chest Injuries 190
Impaled Objects 190
Traumatic Asphyxia 190
Simple Pneumothorax 190
Sternal Fractures 190
Simple Rib Fracture 190

CHAPTER 9 Thoracic Trauma Skills 193
Chapter Overview 194
Chest Decompression 194
Indications to Perform Chest Decompression 194
Performing a Chest Decompression by the Anterior Approach 195
Performing a Chest Decompression by the Lateral Approach 197
Management of Open Pneumothorax 199

CHAPTER 10 Spinal Trauma and Spinal Motion Restriction 202
Chapter Overview 203
Case Presentation 203
Evolution of Spinal Motion Restriction 204
Relationship to Patient Safety 204
Patient-Specific and Appropriate Spinal Motion Restriction 204
Summary of Patient-Centered Spinal Motion Restriction 206
The Normal Spinal Column and Cord 206
Spinal Column 206
Spinal Cord 207
Spinal Injury 208
Mechanisms of Blunt Spinal Column Injury 210
Pathophysiology of Spinal Cord Injury 210
Neurogenic Shock 210
Assessment of the Trauma Patient 211
Assessing for Possible Spinal Injury 211
Focused Evaluation of the Spinal Cord 212
Management of the Trauma Patient 212
Minimizing Spinal Movement 212
Spinal Motion Restriction in the Trauma Patient 215
The Log Roll 215

Spinal Motion Restriction Devices 217
Complications of Spinal Motion Restriction 219
Airway Intervention 219
Special Spinal Motion Restriction Situations 219

CHAPTER 11 Spine Management Skills 229
Essential Components of Spinal Motion Restriction 230
Principles of SMR 230
Applying SMR 233
Patients Requiring SMR 233
SMR with a Short Extrication Device 236
Emergency Rescue and Rapid Extrication 236
SMR with the Long Backboard 238

CHAPTER 12 Head Trauma and Traumatic Brain Injury 249
Chapter Overview 250
Case Presentation 250
Anatomy of the Head 251
Pathophysiology of Head Trauma 252
Primary and Secondary Brain Injuries 252
Intracranial Pressure 253
Cerebral Herniation Syndrome 254
Head Injuries 255
Facial Injuries 255
Scalp Wounds 255
Skull Injuries 256
Brain Injuries 256
Evaluation of the Patient with Traumatic Brain Injury 260
ITLS Primary Survey 260
ITLS Secondary Survey 265
ITLS Reassessment Exam 265
Management of the Patient with TBI 265

CHAPTER 13 Abdominal Trauma 269
Chapter Overview 270
Case Presentation 270
Anatomy of the Abdomen 271
Types of Abdominal Injuries 271
Assessment and Stabilization 272
Scene Size-up 272
Patient Assessment 273
Stabilization 274
New Trends in Managing Abdominal Trauma 275

CHAPTER 14 Extremity Trauma 280
Chapter Overview 281
Case Presentation 282
Injuries to Extremities 282
Fractures 282
Dislocations 284
Open Wounds 284
Amputations 285
Neurovascular Injuries 286
Sprains and Strains 286
Impaled Objects 287
Compartment Syndrome 287
Crush Injury and Crush Syndrome 287
Assessment and Management 288
Scene Size-up and History 288
Assessment 288
Management of Extremity Injuries 288
Management of Specific Injuries 295

CHAPTER 15 Extremity Trauma Skills 305
Traction Splints 306
Pelvic Stabilization Techniques 312

CHAPTER 16 Trauma Arrest 314
Chapter Overview 315
Case Presentation 315
The Unsalvageable Patient 315
Airway and Breathing Problems 316
Circulatory Problems 318
Approach to Trauma Patients in Cardiac Arrest 319
General Plan of Action 320
Considerations in Traumatic Cardiac Arrest Management 323

SECTION 3 Special Populations

CHAPTER 17 Burns 327
Chapter Overview 328
Case Presentation 328
Anatomy and Pathophysiology 328
The Skin 328
Classifying Burns by Depth 330
Determining the Severity of Burns 330
Patient Assessment and Management 332
ITLS Primary Survey 333
ITLS Secondary Survey 335
Patient Management 335
Special Problems in Burn Management 336

CHAPTER 18 Pediatric Trauma 351
Chapter Overview 352
Case Presentation 352
Communication with the Child and Family 353
Parental Consent 354
Assessment and Care 355
Pediatric Equipment 355
Common Mechanisms of Injury 355
General Assessment 358
Rapid Trauma Survey or Focused Exam 365
Critical Trauma Situation 365
ITLS Secondary Survey 366
Potentially Life-Threatening Injuries 367
Hemorrhagic Shock 367
Fluid Resuscitation 368
Head Trauma 368
Chest Injury 369
Abdominal Injury 370
Spine Injury 370
Child Restraint Seats 371
CHAPTER 19 Geriatric Trauma 376
Chapter Overview 377
Case Presentation 378
Pathophysiology of Aging 378
The Aging Body 378
Medications 381
Aging and Injury 381
Assessment and Management 381
ITLS Primary Survey 382
Reassessment Exams 385
CHAPTER 20 Trauma in Pregnancy 388
Chapter Overview 389
Case Presentation 389
Pregnancy 390
Fetal Development 390
Physiologic Changes During Pregnancy 391
Responses to Hypovolemia 393
Assessment and Management 393
Special Considerations 393
Types of Trauma 395
Trauma Prevention in Pregnancy 397
CHAPTER 21 The Impaired Patient 399
Chapter Overview 400
Case Presentation 400
Substance Abuse 400
Assessment and Management 402
The Uncooperative Patient 404
Excited Delirium 404

GLOSSARY 409

INDEX 417

APPENDICES

APPENDIX A Standard Precautions A-1
APPENDIX B Analgesia and Pain Control for the Trauma Patient B-1
APPENDIX C Multicasualty Incidents and Triage C-1

About the Editors



Roy L. Alson, *PhD, MD, FACEP, FAEMS*

Dr. Roy L. Alson is a Professor Emeritus of Emergency Medicine at Wake Forest University School of Medicine and the former Director of the Office of Prehospital and Disaster Medicine, also at Wake Forest. He is also an Associate Professor at the Childress Institute for Pediatric Trauma at Wake Forest University and an Adjunct Associate Professor in the Department of Military Medicine at Rocky Vista University College of Osteopathic Medicine, in Parker, Colorado. Dr. Alson received his bachelor's degree from the University of Virginia in 1974 and both his PhD and MD from the Bowman Gray School of Medicine of Wake Forest University (1982, 1985). He completed his residency in emergency medicine at Allegheny General Hospital in Pittsburgh, Pennsylvania, and is board certified in both emergency medicine and emergency medical services by the American Board of Emergency Medicine.

Dr. Alson's EMS career began in the early 1970s as an EMT in New York City. As a graduate student, he became a member of the Winston-Salem Rescue Squad and began working for the Forsyth County EMS as an EMT. Upon completion of his residency, Dr. Alson returned to Wake Forest University and the Forsyth County EMS system, serving as Assistant Medical Director for 14 years and Medical Director from 2003 to 2019. He remains actively involved in the education of EMS personnel.

Dr. Alson's involvement with ITLS dates to the 1980s. He served as the North Carolina Chapter Medical Director for 15 years. Since the early 1990s, Dr. Alson has been a member of the editorial board for ITLS as well as a contributing author. He was the co-Editor-in-Chief for the eighth edition of this textbook.

Along with EMS, disaster medicine is an area of interest. Dr. Alson served as the Medical Director for the North Carolina State Medical Response System (NC SMAT) program. He has served as the Chairman of the Disaster Preparedness and Response Committee for the American College of Emergency Physicians from 2011 until 2016, a member of the EMS Committee for ACEP, and as a member of the EMS Committee for the American Academy of Emergency Physicians. Dr. Alson was the Chairman for the NAEMSP Disaster Preparedness Committee in 2014–2016.

Dr. Alson served with the National Disaster Medical System (NDMS) for 28 years, most recently as a member of the International Medical Surgical Response Team East (IMSURT-E). He previously served as the Commander and Deputy Commander for the North Carolina Disaster Medical Assistance Team (NC-DMAT-1) and Deputy Commander of the NMRT-E

Dr. Alson has responded to numerous nationally declared disasters. He continues to teach about the delivery of care in austere and surge-type conditions and has lectured nationally and internationally on prehospital trauma care and disaster medicine.

He and his wife, Rebecca, reside in Winston-Salem, North Carolina.



Kyee H. Han, *MBBS, FRCS, FRCEM*

Dr. Kyee H. Han is a Consultant in Trauma and Emergency Medicine at the James Cook University Hospital, in Middlesbrough, which is a Regional Major Trauma Centre in the North East of England. He is also Honorary Medical Director to the North East Ambulance Service NHS Foundation Trust. Dr. Han completed his undergraduate medical training at the Institute of Medicine in Rangoon, Burma, in 1976. Following his internship and Senior House Officer surgical rotational training in Birmingham, UK, he worked as a Surgical Registrar and was awarded the FRCS in 1981. After gaining cardiothoracic surgical experience in Leicester, Dr. Han decided to pursue a career in an up-and-coming specialty then known as Accident and Emergency Medicine (A&E) in the UK. He entered the Northern Deanery residency/specialist training program at the Royal Victoria Infirmary (RVI) in Newcastle upon Tyne and Middlesbrough General

Hospital (MGH). On receiving his Certificate of Completion in Specialist Training (CCST), Dr. Han was appointed as Consultant at MGH in 1990. Over his working life as an emergency physician, he has taken on many management, training, and advisory roles including the positions of Clinical Director in A&E, Honorary Senior Lecturer at Newcastle University, Chairman of the Specialist Training Committee for the Northern Deanery, and College Examiner and Regional Chair for the Royal College of Emergency Medicine Board. Dr. Han also served on the Board for the North Tyneside Clinical Commissioning Group as Secondary Care Specialist Doctor.

Management of the acutely injured has been Dr. Han's interest and passion. Realizing very early in his career how prehospital care can influence patient outcome, he has always dedicated considerable time in prehospital training of the EMS (ambulance, fire, police) and voluntary agencies like the St. John Ambulance. For his years of service as County Surgeon and County Medical Officer, he was awarded the status of Officer (Brother) in the Order of St. John in 2004. Regionally, Dr. Han is a trustee on the board of Great North Air Ambulance Service (GNAAS), which is a publicly funded organization serving the North of England with the Helicopter Emergency Medical Service (HEMS). It deploys a physician and paramedic team to provide enhanced medical care on scene.

Dr. Han's involvement with ITLS dates to 1995. He served as the Chapter Medical Director for Tees East and North Yorkshire and the Cleveland Fire and Rescue Service Training Centre and currently as the Chapter Medical Director for North East England. Since 2011, he has been an Editorial Board member as well as a contributing author. He leads the research work group and the research forum, which is an integral part of the annual international trauma conference.

Throughout his career, Dr. Han has always actively welcomed, promoted, and collaborated with any prehospital emergency service capable of enhancing the outcome of patients. Internationally, he led a UK team of ITLS instructors to train the trainers in Lilongwe, Malawi, twice. This training has since been cascaded to trauma care providers in all parts of Malawi, where incidence of trauma and mortality are high. More recently, the ITLS Board of Directors envisioned piloting a Regional ITLS Forum in Europe and Dr. Han co-chairs the group, successfully bringing the European ITLS family closer. With this edition, he joins Professor Alson as Associate Editor.

He and his wife, Sally, reside in Norton, Stockton on Tees, United Kingdom.



John E. Campbell, *MD, FACEP*

Dr. Campbell received his BS degree in pharmacy from Auburn University in 1966 and his medical degree from the University of Alabama at Birmingham in 1970. He was in the practice of emergency medicine for 40 years, practicing in Alabama, Georgia, New Mexico, and Texas. Dr. Campbell became interested in prehospital care in 1972 when he was asked to teach a basic EMT course to members of the Clay County Rescue Squad where he was still an honorary member at the time of his death. Dr. Campbell also served as medical director of many EMT and paramedic training programs. He was also the Medical Director for EMS and Trauma for the State of Alabama.

From the original basic trauma life support course, an international organization of teachers of trauma care developed called "International Trauma Life Support, Inc.," or ITLS. Dr. Campbell was its president since the inception of the organization.

Dr. Campbell was the author of the first edition of the *Basic Trauma Life Support* textbook and continued to be the editor through to the eighth edition, now entitled *International Trauma Life Support for Emergency Care Providers*. He also coauthored *Homeland Security and Emergency Medical Response* and *Tactical Emergency Medical Essentials*.

Dr. Campbell was a member of the first faculty of Emergency Medicine at the School of Medicine at the University of Alabama at Birmingham. In 1991 he was the first recipient of the American College of Emergency Medicine's EMS Award for outstanding achievement of national significance in the area of EMS. In 2001 Dr. Campbell received the Ronald D. Stewart Lifetime Achievement Award from the National Association of EMS Physicians. He died in August 2018.

Contributors

Roy L. Alson, PhD, MD, FACEP, FAEMS
Professor Emeritus of Emergency Medicine, Wake Forest University School of Medicine, Winston-Salem, NC; Medical Director, Forsyth County EMS (retired)

James J. Augustine, MD
Director of Clinical Operations, EMP Ltd., Canton, OH; Clinical Associate Professor, Department of Emergency Medicine, Wright State University, Dayton, OH

Graciela Bauzá, MD FACS
Assistant Professor of Surgery and Surgical Critical Care and Trauma and Acute Care Surgery Service Director of Education, Department of Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA

Russell Bieniek, MD, FACEP
Director of Emergency Preparedness, University of Pittsburgh Medical Center Hamot, Erie, PA

Ingrid Bloom, MD, FACEP, FAEMS
Assistant Professor of Emergency Medicine, Emory University School of Medicine, Atlanta, GA; Associate Medical Director, Grady EMS

William Bozeman, MD, FACEP, FAAEM
Professor, Department of Emergency Medicine, and Associate Research Director, Wake Forest University School of Medicine, Winston-Salem, NC; Lead Physician, Tactical Operations, Forsyth County EMS

Walter J. Bradley, MD, MBA, FACEP
Medical Director, Illinois State Police; SWAT Team Physician, Moline Police Department; Physician Advisor, Trinity Medical Center, Moline, IL

Sabina A. Braithwaite, MD, MPH, FACEP, FAEMS, NRP
EMS Fellowship Director and Associate Professor of Emergency Medicine, Washington University School of Medicine, St. Louis, MO; State EMS Medical Director for Missouri

Jeremy J. Brywczynski, MD, FAAEM
Associate Professor, Emergency Medicine, Vanderbilt University Medical Center, Nashville, TN; Assistant Medical Director, Vanderbilt LifeFlight; Medical Director, Vanderbilt FlightComm; Assistant Medical Director, Nashville (TN) Fire Department

John E. Campbell, MD, FACEP (deceased)
Former Medical Director, EMS and Trauma, State of Alabama

Leon Charpentier, EMT-P
Harker Heights (TX) Fire Chief, Retired

Darby Copeland Ed.D, RN, NRP, NCEE
Executive Director, West Virginia Chapter, American College of Emergency Physicians, Wheeling, WV

James H. Creel, Jr., MD, FACEP (Deceased)
Clinical Associate Professor and Program Director, Department of Emergency Medicine, University of Tennessee College of Medicine, Chattanooga, TN; Chief of Emergency Medicine, Erlanger Health System

Ann M. Dietrich, MD, FAAP, FACEP
Professor of Pediatrics, Ohio State University, Columbus, OH; Director of Risk Management, Section of Emergency Medicine, Columbus Children's Hospital; Pediatric Medical Advisor, Medflight of Ohio

Maia Dorsett, MD, PhD
Senior Instructor, Department of Emergency Medicine, University of Rochester School of Medicine, Rochester, NY

Ray Fowler, MD, FACEP, DBAEMS
Professor and Chief, Division of Emergency Medical Services, The University of Texas, Southwestern Medical Center; Attending Emergency Medicine Faculty, Parkland Memorial Hospital, Dallas, TX

Pam Gersch, RN, CLNC
Program Director, AirMed Team, Rocky Mountain Helicopters, Redding, CA

Martin Greenberg, MD, FAAOS, FACS
Chief of Hand Surgery, Advocate Illinois Masonic Medical Center; Chief of Orthopedic Surgery, Our Lady of the Resurrection Medical Center, Chicago, IL; Reserve Police Officer, Village of Tinley Park, IL; Tactical Physician, South Suburban Emergency Response Team; ITOA Co-Chair, TEMS Committee

Kyee H. Han, MBBS, FRCS, FRCEM
Consultant in Accident and Emergency Medicine; Medical Director, North East Ambulance Service NHS Trust; Honorary Clinical Senior Lecturer, The James Cook University Hospital, Middlesbrough, UK

Donna Hastings, MA, EMT-P, CPCC
Co-Chair, ITLS Editorial Board; CEO, Heart and Stroke Foundation of Alberta & NWT, Calgary, Canada

Leah J. Heimbach, JD, RN, EMT-P
Principal, Healthcare Management Solutions, LLC, White Hall, WV

Lisa Hrutkay, DO, FACEP
EMS Director, USAcute Care Solutions Midwest, Wheeling, WV

Ahamed H. Idris, MD, FACEP
Professor of Emergency Medicine and Internal Medicine Department of Emergency Medicine University of Texas Southwestern Medical Center, Dallas, TX

Melanie J. Lippmann, MD, FACEP
Associate Professor of Emergency Medicine, Alpert Medical School of Brown University, Providence, RI

David Maatman, NRP/IC

Kirk Magee, MD, MSc, FRCPC
Associate Professor and Head of Department, Dalhousie University Department of Emergency Medicine, Halifax, Nova Scotia, Canada

Patrick J. Maloney, MD
Staff Physician, Denver Health Medical Center and Denver Emergency, Center for Children; Clinical Instructor, University of Colorado School of Medicine, Denver, CO

David Manthey, MD, FACEP, FAAEM
Professor of Emergency Medicine and Vice Chair of Education, Wake Forest University School of Medicine, Winston-Salem, NC

Leslie K. Mihalov, MD
Chief, Emergency Medicine, and Medical Director, Emergency Services, Nationwide Children's Hospital; Associate Professor of Pediatrics at The Ohio State University College of Medicine, Columbus, OH

Richard N. Nelson, MD, FACEP
Professor and Vice Chair, Department of Emergency Medicine, The Ohio State University College of Medicine, Columbus, OH

Jonathan Newman, MD, MMM, FACEP
Assistant Medical Director, United Hospital Center, Bridgeport, WV

Bob Page, MEd, NRP, CCP, NCEE
Edutainment Consulting and Seminars, LLC, Springfield, MO

William Bruce Patterson, Platoon Chief/EMT-P
Strathcona County Emergency Services, Alberta, Canada

Andrew B. Peitzman, MD
Distinguished Professor of Surgery, Mark M. Ravitch Chair in Surgery, Chief in the Division of General Surgery, and Vice-President for Trauma and Surgical Services, University of Pittsburgh Medical Center, Pittsburgh, PA

William F. Pfeifer, MD, FACS
Professor of Surgery, Department of Specialty Medicine, Rocky Vista University College of Osteopathic Medicine; Mile High Surgical Specialists, Littleton, CO; Colonel MC USAR (ret)

Art Proust, MD, FACEP
Medical Director, Southern Fox Valley EMS System; Emergency Physician, Northwestern Medicine Delnor Hospital, Geneva, IL

Mario Luis Ramirez, MD, MPP
Tactical and Prehospital EMS Fellow and Clinical Instructor in Emergency Medicine, Department of Emergency Medicine, Vanderbilt University Medical Center, Nashville, TN

Alexandra Rowe, NRP
CE Solutions, Burnett, TX

Jonathan M. Rubin, MD, FAAEM
Associate Professor of Emergency Medicine, Medical College of Wisconsin, Milwaukee, Wisconsin

S. Robert Seitz, MEd, RN, NRP
Assistant Professor, School of Health and Rehabilitation Sciences, Emergency Medicine Program, University of Pittsburgh, Pittsburgh, PA; Assistant Program Director, Office of Education and International Emergency Medicine, University of Pittsburgh Center for Emergency Medicine; Continuing Education Editor, *Journal of Emergency Medical Services*; Editorial Board, International Trauma Life Support

Nicholas Sowers, MD, FRCPC
Associate Professor of Emergency Medicine, Dalhousie University School of Medicine, Halifax, Nova Scotia, Canada

J. T. Stevens, NRP (ret.)
Sun City, SC

Shin Tsuruoka, MD
Vice Director and Chief of Neurosurgical Department, JA Toride Medical Center, Toride, Japan; ITLS Japan Chapter Medical Director

Howard A. Werman, MD, FACEP
Professor of Clinical Emergency Medicine, The Ohio State University, Columbus, OH; Medical Director, MedFlight of Ohio

Katherine West, BSN, MSEd, CIC
Infection Control Consultant, Manassas, VA; Editorial Board, *Journal of Emergency Medical Services*

Melissa White, MD, MPH
Associate Professor and Assistant Residency Director, Department of Emergency Medicine, Emory University School of Medicine, Atlanta, GA; Medical Director, John's Creek Fire Department; Medical Director, Emory Emergency Medical Services; Associate Medical Director, AirLife Georgia

Janet M. Williams, MD
Professor of Emergency Medicine, University of Rochester Medical Center, Rochester, New York

E. John Wipfler, III, MD, FACEP
Attending Emergency Physician, OSF Saint Francis Medical Center Residency Program; Medical Director, STATT TacMed Unit, Tactical Medicine; Sheriff's Physician, Peoria County Sheriff's Office; Clinical Associate Professor of Surgery, University of Illinois College of Medicine, Peoria, IL

Arthur H. Yancey II, MD, MPH, FACEP
Medical Director, Grady EMS Emergency Communications Center; Medical Director, College Park Fire Department; Associate Professor, Department of Emergency Medicine, Emory University School of Medicine, Atlanta, GA

Organization of This Book

The ninth edition of *International Trauma Life Support for Emergency Care Providers* has been reorganized to reflect a more functional approach to the assessment and management of the trauma patient in the prehospital environment. The book is divided into four sections.

Section I, "Essential Information," includes Chapters 1–7. These topics are core to the care of the trauma patient and include mechanism of injury, assessment of the trauma patient, hemorrhage control, and shock and airway management. Following each didactic chapter on a clinical topic is a chapter that reviews the essential skills needed to manage the clinical situation.

Section II, "Foundational Knowledge," includes Chapters 8–16. Topics include assessment and management of injuries to specific body areas: chest trauma, abdominal trauma, spinal injuries and spinal motion restriction, extremity trauma, and traumatic cardiac arrest. Chapters covering specific skills follow the didactic material.

The chapters in Section III, "Special Populations," include burn patients, older adults, pediatric and pregnant patients, and patients under the influence of intoxicating substances.

The final section, available online or in text, covers other important areas: standard precautions, pain control, multicasualty triage, trauma scoring, air medical, drowning, heat and cold injuries, advanced skills, and overview of tactical medical care.

What's New in This Edition

The ninth edition of *International Trauma Life Support for Emergency Care Providers* has been updated to provide the emergency care provider with information on the latest and most effective approaches in the care of the trauma patient. The science of trauma is constantly evolving, and the authors, in collaboration with the research working group at ITLS, have updated the text with the latest information that is pertinent to the initial care of the trauma patient.

This is the first edition without the presence of Dr. John Campbell, FACEP, the founder of ITLS and the first Editor in Chief. Dr. Campbell passed away in 2018 after a long and valiant battle with cancer. This text strives to continue his focus on providing the emergency care provider with the knowledge and skills to render to trauma patients the best possible care.

Also new to this edition is the editorial assistance of Dr. Kyee Han, Consultant in Accident and Emergency Medicine, who has joined Dr. Alson as the Associate Editor of the text. Dr. Han has extensive experience in EMS care and education and has been a contributor to the ITLS text and course for over 20 years.

The text again conforms to the American Heart Association/International Liaison Committee of Resuscitation (AHA/ILCOR) guidelines, as well as those put forth by the Committee on Trauma of the American College of Surgeons, as well as position statements from the National Association of EMS Physicians, the Committee for Tactical Emergency Casualty Care, the American College of Emergency Physicians, and other international advisory groups.

Some of the chapter-by-chapter key components and changes are:

- The *Introduction* explains the concept of the "Golden Period" and why it remains important to what we do as emergency care providers.
- *Chapter 1* continues to emphasize scene safety and the concept that trauma care as a team effort involving many disciplines as central components. The chapter now includes a discussion of the changes in response put forth by the Hartford Consensus.
- *Chapter 2* includes minor changes in the assessment sequence based on feedback from ITLS instructors and providers. It also reinforces the importance of identifying and controlling hemorrhage at the start of the assessment. As the leader performs the assessment, he or she will delegate responses to abnormalities found in the initial assessment. This is to reinforce the rule that the leader must not interrupt the assessment to deal with problems but must delegate the needed actions to team members. This emphasizes the team concept and keeps on-scene time at a minimum. The order of presentation of the three assessments (ITLS–Primary Survey, ITLS Reassessment Exam, and ITLS Secondary Survey) has been changed. The ITLS Reassessment Exam is performed before the ITLS Secondary Survey, a more common situation, and may replace it. The chapter also mentions the use of fingerstick serum lactate levels and prehospital abdominal ultrasound exams as ways to better identify patients who may be in early shock.
- The assessment skills in *Chapter 3* reflect the changes in Chapter 2.

- *Chapter 4* includes an updated discussion of hemorrhagic shock to once again reflect the latest experience of the military during recent conflicts. A discussion of the role of tranexamic acid (TXA) in the management of hemorrhage has been added as well as the need to limit crystalloid infusion to prevent hemodilution of clotting factors. Emphasis on fluid resuscitation in the field is to restore perfusion, not normalize vital signs.
- *Chapter 5* covers the skills associated with hemorrhage control including wound packing, use of hemostatic agents, and early application of tourniquets. It also reviews intraosseous access.
- *Chapter 6* again stresses capnography as the standard for confirming and monitoring the position of the endotracheal tube as well as the best way to assess for hyperventilation or hypoventilation. The volume of air delivered with each ventilation now emphasizes the response of the patient (rise and fall of the chest), rather than a fixed volume amount.
- *Chapter 7* discusses the importance of properly positioning the patient to improve successful airway management and reinforces the key role of supraglottic airways (SGAs) in basic airway management. The chapter also includes a discussion of video intubation as a tool for difficult airways and reviews drug-assisted intubation.
- *Chapter 8* reviews the indications for needle decompression of tension pneumothorax and pericardiocentesis when such procedures are in the emergency care provider's scope of practice. It also discusses the use of ultrasound to identify such injuries and also to identify a pneumothorax.
- *Chapter 9* covers needle decompression of the chest for a tension pneumothorax, reflecting challenges faced by tactical EMS providers, as well as the use of chest seals. Three-sided taping of field-expedient chest seals is replaced with four-sided taping and use of needle decompression.
- *Chapters 11 and 12* now reflect current science and evolution of when to apply spinal motion restriction based on published guidelines. Emphasis is on the use of the backboard as a transfer device and the transport of a patient on a backboard is now discouraged. These chapters also include how to remove the patient from the backboard once placed on a transport stretcher.
- *Chapter 13* now includes pelvic fractures, reflecting the association of these injuries with concurrent abdominal injuries. The chapter also discusses application of pelvic binders and reviews the use of fingerstick serum lactate levels and the use of prehospital abdominal ultrasound exams.
- *Chapter 14* reviews the management of bleeding from extremity injuries, including a discussion of hemostatic agents.
- *Chapter 15* reviews procedures for use of a tourniquet and use of hemostatic agents and includes a discussion of pelvic binders for pelvic fractures.
- *Chapter 16* now includes an algorithm for management of traumatic cardiac arrest. Again, the chapter also reviews indications for termination of resuscitation for the trauma patient in the prehospital setting.
- *Chapter 19* now includes a discussion of the ways in which advancing age increases mortality and identifies it as an independent risk factor for needing trauma center care.
- Appendices: Online at Student Resources Page (www.pearsonglobaleditions.com) and/or in-text
  - —Added a section on pain control in the prehospital setting
  - —Updated section on drowning and hypothermia (online)
  - —Bloodborne pathogens has been moved to online
  - —Tactical EMS has been revised to reflect current thinking within the Hartford Consensus (online)
  - —Additional skills includes surgical cricothyrotomy (online)
  - —Videos (online) demonstrating
    - Cricothyrotomy: needle and surgical
    - Wound packing
    - Tourniquet application
    - Chest seal application
    - IO insertion—electric and manual
    - Needle decompression of tension pneumothorax
    - Supraglottic airway insertion
    - Log roll
    - Scoop stretcher

Note on Skills and Terminology

Prehospital personnel around the world vary in their permitted scope of practice, based on local regulations. This textbook may at times describe procedures that are outside the permitted scope of practice. Completion of an ITLS course should not be construed as permission for an emergency care provider to exceed their permitted scope of practice. Ultimately, the final arbiter of what the emergency care provider is permitted to do is determined by the physician medical director (advisor) for the EMS system.

The text has attempted to be gender neutral in describing personnel. In places where it is not, it should not be construed as diminishing the ability of any one person to perform the skills needed to provide emergency care.

Throughout the world, there are many terms used to describe those who provide emergency care to the victims of injury and illness. In this text, we use emergency care provider to describe such individuals. When used, the terms "first responder" and "emergency medical technician (EMT)" refer to personnel trained at a basic life support level, while "paramedic" refers to personnel trained at an advanced life support level.

As has been said before, EMS constantly undergoes changes. Things that were only ideas a couple of years ago are now in common use. This change in technology and resources will only continue to grow. As this book goes to press, we note the markedly increasing use of point-of-care ultrasound to help identify life threatening injuries and help with determination of destination for trauma patients. EMS agencies and helicopter emergency medical services are beginning to carry blood for transfusion when dealing with a patient in shock due to blood loss. Retrograde endovascular balloon occlusion of the aorta (REBOA), which acts like cross clamping of the aorta during a thoracotomy, is showing promise as an intervention for patients with massive internal hemorrhage. At this point however, civilian field use is limited to those systems where there is an EMS physician on scene who is trained in use of the device. At this time, ITLS has not included discussion of REBOA in the text due to the limited availability of this device to EMS personnel.

Acknowledgments

The creation of a text and course is a major undertaking and could not be done without the effort of many. For many of those involved, this is a true labor of love. We want to give special thanks to the following friends of ITLS who provided invaluable assistance with ideas, reviews, and corrections of the text. This was such a big job, and there were so many people who contributed that we are sure we have left someone out. Please accept our apologies in advance.

We wish to thank the following EMS professionals who reviewed material especially for this ninth edition of *International Trauma Life Support for Emergency Care Providers*. Their assistance is appreciated.

Jacky Chan, DN, MSc, BN, RN
Advanced Practice Nurse, Hospital Authority, Hong Kong

Juan Chessa, EMT-P Professor
International Medical Academy, Lima, Peru

Barbara Sauter, RN, BSN
City of Frankfort Fire and EMS, Frankfort, KY

Walt Stoy, PhD, EMT-P
Professor, Emergency Medicine Program, School of Health and Rehabilitation Sciences and Director Emeritus, Center for Emergency Medicine, Office of Education, University of Pittsburgh, Pittsburgh, PA

Keith Wesley, MD FACEP FAEMS
HealthEast Medical Transportation, Saint Paul, MN

We wish to thank Jill Rembetski, our development editor, for her patience and for "herding the cats."

Another special thanks goes to the following photographers who donated their work to help illustrate the text:

Roy Alson, PhD, MD, FACEP, FAEMS
Jennifer Achay, Centre for Emergency Health Sciences
Sabina Braithwaite, MD, FACEP
James Broselow, MD
Brant Burden, EMT-P
Anthony Cellitti, NRP
Alexandra Charpentier, EM-P
Leon Charpentier, EMT-P
Stanley Cooper, EMT-P
Delphi Medical
Pamela Drexel, Brain Trauma Foundation
Ferno Washington, Inc.
Peter Gianas, MD
Peter Goth, MD
KING Airway Systems
Kyee H. Han, MD, FRCS, FRCEM
Michal Heron
Eduardo Romero Hicks, MD
Jeff Hinshaw, MS, PA-C, NRP
Kelly Kirk, EMT-P
Lewis B. Mallory, MBA, REMT-P
Masimo Corporation
Bonnie Meneely, EMT-P
Nonin Medical, Inc.
North American Rescue
Bob Page, MEd, NRP, CCP, NCEE
William Pfeifer, MD, FACS
Robert S. Porter
Don Resch
SAM Medical

Introduction to the ITLS Course

Trauma, the medical term for *injury*, has become the most expensive health problem in the United States and most other countries. In the United States, trauma is the fourth leading cause of death for all ages and the leading cause of death for children and adults under the age of 45. Trauma causes 73% of all deaths in the 15- to 24-year-old age group. For every fatality, there are 10 more patients admitted to hospitals and hundreds more treated in emergency departments. The price of trauma, in both physical and fiscal resources, mandates that all emergency medical services (EMS) personnel learn more about this disease to treat its effects and decrease its incidence.

Because the survival of trauma patients is often determined by how quickly they get definitive care in the operating room, it is crucial that you know how to assess and manage the critical trauma patient in the most efficient way. The purpose of the ITLS course is to teach you the most rapid and practical method to assess and manage critical trauma patients. The course is a combination of written chapters to give you the "why" and the "how" and practical exercises to practice your knowledge and skills on simulated patients so that at the end of the course you feel confident in your ability to provide rapid lifesaving trauma care.

Philosophy of Assessment and Management of the Trauma Patient

Severe trauma, along with acute coronary syndrome and stroke, is a time-dependent disease. The direct relationship between the timing of definitive (surgical) treatment and the survival of trauma patients was first described by Dr. R. Adams Cowley of the famous Shock-Trauma Center in Baltimore, Maryland. He discovered that when patients with serious multiple injuries were able to gain access to the operating room within an hour of the time of injury, the highest survival rate was achieved. He referred to this as the "Golden Hour." Over the years we have found that some patients (such as penetrating trauma to trunk) do not have a golden hour but rather a shorter period of minutes, whereas many patients with blunt trauma may have a golden period longer than an hour. It has been suggested that we now call the prehospital period the "Golden Period" because it may be longer or shorter than an hour.

The Golden Period begins at the moment the patient is injured, not at the time you arrive at the scene. Much of this period has already passed when you begin your assessment, so you must be well organized in what you do. In the prehospital setting it is better to think of the Golden Period for on-scene care as being 10 minutes. In those 10 minutes, you must identify live patients, make treatment decisions, and begin to move patients to the appropriate medical facility. This means that every action must have a lifesaving purpose. Any action that increases scene time but is not potentially lifesaving must be omitted. Not only must you reduce evaluation and resuscitation to the most efficient and critical steps, but you also must develop the habit of assessing and treating every trauma patient in a planned logical and sequential manner so you do not forget critical actions.

When performing patient assessment, it is best to proceed in a "head-to-toe" manner so that nothing is missed. If you jump around during your assessment, you will inevitably forget to evaluate something crucial. Working as a team with your partner is also important because many actions must be done at the same time.

It has been said that medicine is a profession that was created for obsessive–compulsive people. Nowhere is this truer than in the care of the trauma patient. Often the patient's life depends on how well you manage the details. It is very important to remember that many of the details necessary to save the patient occur before you even arrive at the scene of the injury.

You or a member of your team must:

- Know how to maintain your ambulance or rescue vehicle so that it is serviced and ready to respond when needed.
- Know the quickest way to the scene of an injury. Use of global positioning satellite (GPS) navigation has been shown to decrease not only the time to respond but also the time of transport.
- Know how to size up a scene to recognize dangers and identify mechanisms of injury.
- Know which scenes are safe and, if not safe, what to do about them.
- Know when you can handle a situation and when to call for help.
- Work effectively as a team so the care provided is appropriate and effective.

- Know when to approach the patient and when to leave with the patient.
- Know your equipment, and maintain it in working order.
- Know the most appropriate hospital and the fastest way to get there. (Organized trauma systems and transfer/bypass guidelines can shorten the time it takes to get a trauma patient to definitive care.)

As if all that were not enough, you also have to:

- Know where to put your hands, which questions to ask, what interventions to perform, when to perform them, and how to perform critical procedures quickly and correctly.

If you think the details are not important, then leave the profession now. Our job is saving lives, a most ancient and honorable profession. If we have a bad day, someone will pay for our mistakes with suffering or even death. Since the early beginnings of emergency medical services, patients and even rescuers have lost their lives because attention was not paid to the details listed here. Many of us can recall patients that we might have saved if we had been a little smarter, a little faster, or a little better organized. Make no mistake, there is no "high" like saving a life, but we carry the scars of our failures all our lives.

Your mindset and attitude are very important. You must be concerned but not emotional, alert but not excited, quick but not hasty. Above all, you must continuously strive for what is best for your patient. When your training has not prepared you for a situation, always fall back on the question, *What is best for my patient?* When you no longer care, burnout has set in and your effectiveness is severely limited. When this happens, seek help. (Yes, all of us need help when the stress overcomes us.) Or seek an alternative profession.

Since 1982, the International Trauma Life Support (ITLS, formerly BTLS) organization has been identifying the best methods to get the most out of those few minutes that prehospital EMS providers have to save the patient's life. Not all patients can be saved, but our goal is never to lose a life that could have been saved. The knowledge in this book can help you make a difference. Learn it well.

About ITLS

International Trauma Life Support is a global not-for-profit organization dedicated to preventing death and disability from trauma through education and emergency trauma care.

The Smart Choice for Trauma Training

Train with the best. Train with ITLS. Together, we are improving trauma care worldwide. International Trauma Life Support—a not-for-profit organization dedicated to excellence in trauma education and response—coordinates ITLS education and training worldwide. Founded in 1985 as Basic Trauma Life Support, ITLS adopted a new name in 2005 to better reflect its global role and impact. Today, ITLS has more than 80 chapters and training centers around the world. Through ITLS, hundreds of thousands of trauma care professionals have learned proven techniques endorsed by the American College of Emergency Physicians.

ITLS is the smart choice for your trauma training because it is:

- *Practical.* ITLS trains you in a realistic, hands-on approach proven to work in the field—from scene to surgery.
- *Dynamic.* ITLS content is current, relevant, and responsive to the latest thinking in trauma management.
- *Flexible.* ITLS courses are taught through a strong network of chapters and training centers that customize content to reflect local needs and priorities.
- *Team centered.* ITLS emphasizes a cohesive team approach that works in the real world and recognizes the importance of your role.
- *Grounded in emergency medicine.* Practicing emergency physicians—medicine's frontline responders—lead ITLS efforts to deliver stimulating content based on solid emergency medicine.
- *Challenging.* ITLS course content raises the bar on performance in the field by integrating classroom knowledge with practical application of skills.

Focused Content That Delivers

ITLS empowers you with the knowledge and skill to provide optimal care in the prehospital setting. It offers a variety of training options for all levels and backgrounds of emergency personnel around the world. ITLS courses combine classroom learning, hands-on skills stations, and assessment stations that put your learning to work in simulated trauma situations. Not only are courses taught as a continuing education option, but they are also used as essential curricula in many paramedic, EMT, and first responder training programs.

International Trauma Life Support Courses

ITLS Basic

ITLS Basic is designed for the Emergency Medical Technician (EMT-Basic) and the emergency care responder. This hands-on training course offers basic EMS providers complete training in the skills necessary for rapid assessment, resuscitation, stabilization, and transportation of the trauma patient. The course provides education in the initial evaluation and stabilization of the trauma patient.

ITLS Advanced

ITLS Advanced is a comprehensive course covering the skills necessary for rapid assessment, resuscitation, stabilization, and transportation of the trauma patient for advanced EMTs, paramedics, and trauma nurses. The course teaches the correct sequence of evaluation and the techniques of critical intervention, resuscitation, and packaging of a patient.

ITLS Combined

Many ITLS courses choose to train both Advanced- and Basic-level providers. In the ITLS Combined courses, the Basic-level providers partake of all didactic sessions and observe the advanced skill stations.

ITLS Military

The ITLS Military Provider course combines the fundamentals of ITLS trauma assessment and treatment with recent military innovations utilized in the world's current war zones. The course adapts proven techniques taught in the civilian ITLS course to the military environment, where limited resources are the rule, not the exception.

eTrauma

ITLS eTrauma covers the 8 hours of ITLS Provider classroom instruction providing online training on the core principles of rapid assessment, resuscitation, stabilization, and transportation of trauma patients. ITLS eTrauma is offered at both the Basic and Advanced levels. At the completion of eTrauma, the learner receives 8 hours of CEUs from CECBEMS and is qualified to take the ITLS Completer course that will lead to ITLS certification.

Completer Course

The ITLS Completer course is for the learner who has successfully completed eTrauma and wishes to become ITLS certified. The Completer course covers 8 hours of skills learning and assessment as well as the ITLS written post course exam.

Provider Recertification

This course provides continuing education in ITLS for the experienced provider who has already completed the Basic or Advanced course. Sample course agendas are available in the eighth edition ITLS Coordinator and Instructor Guide or from the International Office.

ITLS Instructor Bridge Course

The ITLS Instructor Bridge Course is designed for the instructor who has successfully completed an Advanced Trauma Life Support (ATLS) or Pre-hospital Trauma Life Support (PHTLS) instructor course and wishes to transition to the ITLS program. The course typically runs 8 hours, and a sample course agenda is available in the eighth edition ITLS Coordinator and Instructor Guide or from the International Office. Following completion of an ITLS Bridge course, a candidate must be monitored teaching an ITLS provider course to complete the steps to become an ITLS instructor.

ITLS Provider Bridge Course

The ITLS Provider Bridge Course is designed for the provider who has successfully completed a PHTLS, ATT, or TNCC course and wishes to transition to the ITLS program. The course typically runs 8 hours. A sample course agenda is available in the eighth edition ITLS Coordinator and Instructor Guide or from the International Office.

ITLS Access

This ITLS Access course provides EMS crews and first responders with training to utilize the tools commonly carried on an ambulance or first responder unit to reach entrapped patients and begin stabilization and extrication.

ITLS Pediatric

ITLS Pediatric concentrates on the care of injured children. The course is designed to train EMS and nursing personnel in the proper assessment, stabilization, and packaging of a pediatric trauma patient. The course also covers communication techniques with pediatric patients and parents.

ITLS Instructor Courses

ITLS Instructor courses are offered for both ITLS Advanced and ITLS Basic courses. Other methods of achieving instructor status are used for ITLS Pediatric and ITLS Access courses. To become an instructor, students must have successfully completed the provider-level course with specific requirements on both the written and practical exams and be monitored teaching the lecture, skills, and testing portions of the Provider course.

Enrolling in an ITLS Course

ITLS provides its courses through chapters and training centers. The ITLS Course Management System makes it easy to find a course in your area. Log on to *cms.itrauma.org* to search for courses and contact the course administrator to register.

If you need information about your local chapter or training center, check our list at *itrauma.org* or call ITLS headquarters at 888-495-ITLS or +1-630-495-6442 (for international callers). We will put you in touch with your local organization—or help you start a program in your area.

International Trauma Life Support
3000 Woodcreek Drive, Suite 200
Downers Grove, IL 60515
Phone: 888-495-ITLS
+1-630-495-6442 (International)
Fax: 630-495-6404
Web: www.itrauma.org
E-mail: info@itrauma.org

ITLS Leadership

Board of Directors

Russell Bieniek, MD, FACEP (USA)
Richard Bradley, MD, FACEP, EMT-P (USA)
Neil Christen, MD, FACEP (USA)
Elizabeth Cloughessy, AM, RN, Mast Health Mgt, FAEN (USA), MRCNA (AUS)
Tony Connelly, EMT-P, BHSc, PGCEd (Canada)
Miles Darby, EMT-P (USA)
Jonathan L. Epstein, MEMS, NRP (USA)
Aaron Jeanette, EMT-P, PI, FF (USA)
Peter Macintyre, ACP (Canada)
Eric Roy, MBA-HCM, BMaSc, CD OSJ (Canada)
Chen Zhi, MD (China)

ITLS Leadership

Editorial Board

Leaders

Chair: Darby L. Copeland, Ed.D, RN, NRP, NCEE (USA)
Past Chair: Donna Hastings, MA, EMT-P, CPCC (Canada)
Editor in Chief: Roy Alson, PhD, MD, FACEP, FAEMS (USA)
Associate Editor: Kyee Han, MBBS, FRCS, FRCEM (UK)

Members

Timothy Ballard, MD, MPH, SFS, Lt Col, USAF, MC, DIMO (USA)
Sabina Braithwaite, MD, MPH, FACEP, NRP (USA)
Maia Dorsett, MD, PhD (USA)
Jonathan Epstein, MEMS, NRP* (USA) – Board Liaison
Tim Hillier, MA, ACP (Canada)
Aurora Lybeck, MD (USA)
David Maatman, NRP/IC (USA)
Bob Page, M.Ed, NRP, CCP, NCEE (USA)
Antonio Requena Lopez, MD (Spain)
S. Robert Seitz, M.Ed., RN, NRP (USA)
Matt Sztajnkrycer, MD, PhD, FACEP (USA)

ITLS Editorial Teams

Research Team

Lead: Kyee Han, MBBS, FRCS, FRCEM (UK)
Aftab Ahmed, FRCSEd UK, CCRP (Pakistan)
Pamela Bertone, EMT-P (Mid-Atlantic)
Richard Neville Bradley, MD, EMT-P (Texas)
Gregory R. Brown, NRP, EMT-P (Pennsylvania)
Liz Cloughessy, AM, RN, MHM, FAEN* (Australia)
Sean Davenport, CCEMT, NRP (Kentucky)
Tim Hillier, ACP (Saskatchewan)
Todd Knight, BS, CCEMT-P, FP-C (Tennessee/Alabama)
Ron Kowalik, ACP (Ontario)
David Maatman, NRP/IC (Florida)
Eva Molter, MD (Germany)
Art Proust, MD, FACEP (Illinois)
Eduardo Romero Hicks, MD (Mexico)
Robert Sklar, BS, NRP (Pennsylvania)
Hiroyuki Tanaka, MD (Japan)
Brian Therian, NRP, CCP, MICP (Pennsylvania)
Brian Weston, EMT-P, CCEMT-P, FP-C (Mid-Atlantic)
Jennifer Williams, ACP (Saskatchewan)

Scenario Development Team

Lead: David Maatman, NRP/IC (Florida)
Vice Lead: Terry Hastings, BHSc, ACP (Saskatchewan)
Ma. Karbee Alvendia, RN, NRP (Philippines)
Robert Carpenter, NRP (Pennsylvania)
Derek Chrisco, RN, EMT-P (North Carolina)
Tony Connelly, EMT-P, BHSc, PGCEd.* (Alberta)
Qirong Du, MD (China–Shanghai Xin Hua Hospital)
Billy Eldridge, EMT-P (North Carolina)
Ron Kowalik, BPHE, ACP (Ontario)
Jurij Kryvonos, MD (Poland)
Matt McGurk, ACP (Saskatchewan)
Nick Montelauro, BS, NRP (Indiana)
George W. Murphy, NRP, I/C (Massachusetts)
Wayne Perry, M.Ed, BS, NRP, EMT-P, NCEE (Mid-Atlantic)
Antonio Requena Lopez, MD (Spain)
J.T. Stevens, EMT-P [Ret.] (Georgia)
Susan Wright, ACP (Alberta)

1



(Jack Dagley Photography/Shutterstock)

Introduction to Traumatic Disease

Maia Dorsett, MD
Sabina Braithwaite, MD, FACEP, FAEMS
James H. Creel, Jr., MD, FACEP

Einführung in die Traumatologie
Introducción al Trauma como Enfermedad
Introducción a la Enfermedad Traumática
Uvod u traumatsku bolest
Introdução ao Trauma
Pengantar Pada Penyakit Traumatis
Введение Оценка места происшествия
Introduction aux lésions d'origines traumatiques
Εισαγωγή στο Τραύμα
Bevezetés a sérült ellátásba
外傷性疾患の概要
創傷疾病介紹
Poškodbe

Key Terms

blast injury, *p. 35*
blunt trauma, *p. 27*
committee for tactical emergency casualty care (C-TECC), *p. 26*
disease, *p. 27*
essential equipment, *p. 26*
focused exam, *p. 23*
high-energy event, *p. 28*
index of suspicion, *p. 28*
ITLS Primary Survey, *p. 23*
kinetic energy (KE), *p. 27*
mass casualty incident, *p. 23*
mechanism of injury (MOI), *p. 27*
occupant restraint systems, *p. 30*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Identify the most common causes of death due to traumatic injury.
2. Summarize the components of scene size-up.
3. Describe the role of scene size-up in provider safety and anticipation of patient injuries.
4. Explain the relationship between kinetic injury and injury severity.
5. Identify the three collisions associated with a motor vehicle collision, and relate potential patient injuries to the deformity of the vehicle, interior structures, and body structures.
6. Describe how vehicle safety mechanisms affect anticipated injury patterns.
7. List the factors that predict the type and severity of injury due to fall.

Key Terms (continued)

OPIM, *p. 24*
penetrating trauma, *p. 33*
personal protective equipment (PPE), *p. 24*
preventable death, *p. 36*
rapid trauma survey, *p. 23*
scene size-up, *p. 23*
secondary collision, *p. 30*
secondary insult, *p. 36*
standard precautions, *p. 22*
tactical combat casualty care (TCCC), *p. 36*
temporary cavity, *p. 34*
wound ballistics, *p. 33*
wound track, *p. 34*

Objectives (continued)

8. Describe how bullets cause tissue injury and explain the relationship between bullet characteristics and injury severity.
9. Relate the five injury mechanisms involved in blast injuries to scene size-up and patient assessment.
10. Describe the priorities of prehospital trauma care and relate them to preventable causes of death.
11. Discuss the role of preventative efforts in reducing injury and death due to trauma.

Chapter Overview

Traumatic injury remains a leading cause of death internationally. More than 5 million people die every year secondary to injury, accounting for 9% of the world's deaths (World Health Organization [WHO] 2014). The most common cause of death by injury is road traffic injury, followed by intentional injury, suicide, and falls (WHO 2014). As a result of preventative efforts and changing demographics, the epidemiology of trauma is changing. For example, in developed countries, preventive efforts have reduced death due to traffic injuries by crash avoidance, car safety, and improved medical care (Sise et al. 2014; WHO 2014). Meanwhile, deaths due to falls continue to rise, in part due to aging of the population (Alberdi et al. 2014; Sise et al. 2014).

Death is only one consequence of trauma. Injury leads to substantial health care costs and survivors may have significant physical, psychological, or economic morbidity. This is particularly true for traumatic injury, as it disproportionately impacts young people who have many potential life-years left (WHO 2014). Injuries account for 6% of all years lived with disability (WHO 2014). Therefore, while the ideal intervention is injury prevention, measures to improve trauma care postinjury can minimize death and disability from those events that do occur.

standard precautions: steps each health care worker takes to protect themselves and their patient from exposure to infectious agents; includes treating each patient and him- or herself as if infectious. At a minimum this entails wearing gloves, frequently requires a face shield, and occasionally requires a protective gown.

Situational Awareness

At the scene of an injury, there are certain important steps to perform *before* you begin care of the patient. Failure to perform a scene size-up will subject you and your patient to danger and may cause you to fail to anticipate serious injuries your patient may have sustained. Take **standard precautions** and assess the scene for

Table 1-1: ITLS Patient Assessment

ITLS Primary Survey	Perform a scene size-up Perform initial assessment Perform a **rapid trauma survey** or **focused exam** Make critical interventions and transport decision Contact medical direction
ITLS Secondary Survey	Repeat initial assessment Repeat vital signs and consider monitors Perform a neurological exam Perform a detailed (head-to-toe) exam
ITLS Reassessment Exam	Repeat initial assessment Repeat vital signs and check monitors Reassess the abdomen Check injuries and interventions

dangers first. Determine the total number of patients. Look for stickers or other markers that may indicate a special needs patient. Determine the need for additional emergency care providers or special equipment. If there are more patients than you can manage with available resources, report to dispatch and initiate **mass casualty incident** protocols.

Scene size-up is the first step in the **ITLS Primary Survey** (Table 1-1). It is a critical part of trauma assessment. It begins before you approach the patient, and should even start before arrival on scene by using dispatch information. Failure to perform

rapid trauma survey: a brief exam from head to toe performed to identify life-threatening injuries.

focused exam: an exam used when there is a focused (localized) mechanism of injury or an isolated injury. The exam is limited to the area of injury.

mass casualty incident (MCI): also referred to as a multiple casualty, is an event that produces more casualties than the responding agency has resources to manage.

scene size-up: observations made and actions taken at a trauma scene before actually approaching the patient. It is the initial step in the ITLS Primary Survey.

ITLS Primary Survey: a brief exam to find immediately life-threatening conditions. It is made up of the scene size-up, initial assessment, and either the rapid trauma survey or the focused exam.

Case Presentation

Your ambulance is dispatched along with the fire service to the scene of a road traffic accident. Dispatch advises responding personnel that bystanders report fluid leaking from the vehicle. Upon arrival, the fire department establishes command and orders the ambulance to stage approximately one-half mile (800 meters) upwind of the incident. Two minutes later, the senior fire officer advises medical personnel that the minor petroleum spill is controlled and reports that more than one patient exists: a pedestrian and the driver of the vehicle, who is out walking around. The fire service officer tells you to proceed to the site.

As you arrive with the ambulance, you smell diesel fuel. You see a four-door sedan damaged in the front and left fender with a starred front windshield. Some 30 feet (9 meters) behind it, you see a man on the ground in the roadway, not moving. What are the first steps and decisions you need to make?

Before proceeding, consider these questions:

- Is the scene safe?
- Are responders and/or victims in potential danger?
- What protective clothing is required?
- Other than the spill, are there other potential hazards?
- How many patients do you have?
- What additional equipment may be required?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this emergency.



Table 1-2: Steps of the Scene Size-up

1. Standard precautions (personal protective equipment)
2. Scene safety
3. Initial triage (total number of patients)
4. Need for more help or equipment
5. Mechanism of injury

the preliminary steps of scene size-up may jeopardize your life as well as the life of your patient. Scene size-up includes taking standard precautions to prevent exposure to blood and other potentially infectious material, evaluating the scene for dangers, determining the total number of patients, determining essential equipment needed for the particular scene, and identifying the mechanisms of injury (Table 1-2).

Scene Size-up

Scene size-up begins at dispatch, when you anticipate what you will find at the scene. Based on the nature of the event—such as a hazardous material (hazmat) incident or a scene involving an active shooter—where you stage before you enter the scene can vary. Agencies and jurisdictions will have protocols to help guide your decision as to whether to stage, what location to stage, or whether to enter the scene. At that time, you should think about what equipment you may need and whether other resources (e.g., more units, special extrication equipment, mass casualty incident [MCI] protocols) may be needed. Although information from dispatch is useful to begin to think about a plan, do not overrely on this information. Information given to the dispatcher may not be accurate. Be prepared to change your plan according to your own size-up of the scene.

Standard Precautions

OPIM: short for *other potentially infectious material* to which an emergency care provider may be exposed (other than blood).

personal protective equipment (PPE): equipment that an emergency care provider dons for protection from various dangers that may be present at a trauma scene. At a minimum that entails wearing protective gloves. At a maximum it is a chemical suit and self-contained breathing apparatus.

Emergency care providers are at significant risk of exposure to blood or other potentially infectious material (**OPIM**) when caring for trauma patients. Not only are trauma patients often bloody, but they may also require active airway management under adverse conditions. **Personal protective equipment (PPE)** is necessary at trauma scenes. Protective gloves are always needed, and many situations will also require eye and face protection. It is wise for the emergency care provider in charge of airway management to don a face shield or eye protection and mask. In highly contaminated situations, impervious gowns with mask or face shield may be needed as well. In a toxic environment, chemical suits and gas masks may be needed. Remember to protect your patients from body fluid contamination by changing your gloves between patients.

Scene Safety

Begin sizing up the scene for hazards as you approach in your vehicle. Your first decision is to determine the nearest safe place to park the ambulance or rescue vehicle. You would like the vehicle as close to the scene as possible, and yet it must be far enough away for you to be safe while you are performing the scene size-up. In some situations, you should not enter the scene until it has been cleared by fire personnel, law enforcement, or hazmat technicians. Try to park facing away from the scene, so if dangers arise, you can load the patient and leave quickly. Next, determine if it is safe to approach the patient. Perform a "windshield survey" before leaving your response vehicle. Consider the following:

- *Crash/rescue scenes.* Is there danger from fire or toxic substances? Is there danger of electrocution? Are unstable surfaces or structures present such as ice, water, a slope, or buildings in danger of collapse? Areas with potential for low oxygen

levels or toxic chemical levels (e.g., sewers, ship holds, silos, etc.) should never be entered until you have the proper protective equipment and breathing apparatus. You should never enter such areas without proper training, safety equipment, and appropriate backup support.

- *Hazmat incidents.* Presence of hazardous materials is often indicated by placards on the outside of the vehicle (see Figure 1-1). These will vary depending on the country in which you work. If you observe such indicators, do not approach without proper protective equipment and training. Request specialist resources to assist with the rescue, containment, and possible decontamination.
- *Farms.* Silos are confined spaces and should not be entered without proper equipment and training. Livestock can also pose hazards to emergency care providers. Be aware of the machinery present as well as manure pits or ponds.
- *Crime scenes.* Danger may exist even after a crime has been committed. Be alert for persons fleeing the scene, for persons attempting to conceal themselves, and for persons who are armed or who make threatening statements or gestures. Do not approach a known crime scene if law enforcement personnel are not present. Wait for law enforcement, not only for your own safety and the safety of victims, but also to help preserve evidence. Do not approach the scene if you have not been cleared to enter it by law enforcement.
- *Bystanders.* You and the victims may be in danger from bystanders. Are bystanders talking in loud, angry voices? Are people fighting? Are weapons present? Is there evidence of the use of alcohol or illegal drugs? Is this a domestic-violence scene? Are dangerous animals present? Request law enforcement personnel at any sign of danger from violence.
- *Blast scene.* Explosions are usually associated with industrial accidents, but because the threat of terrorist activity is both common and worldwide, it should be considered when approaching the scene of an explosion. Terrorists often place a second device designed to kill or injure responders. In addition, in some countries

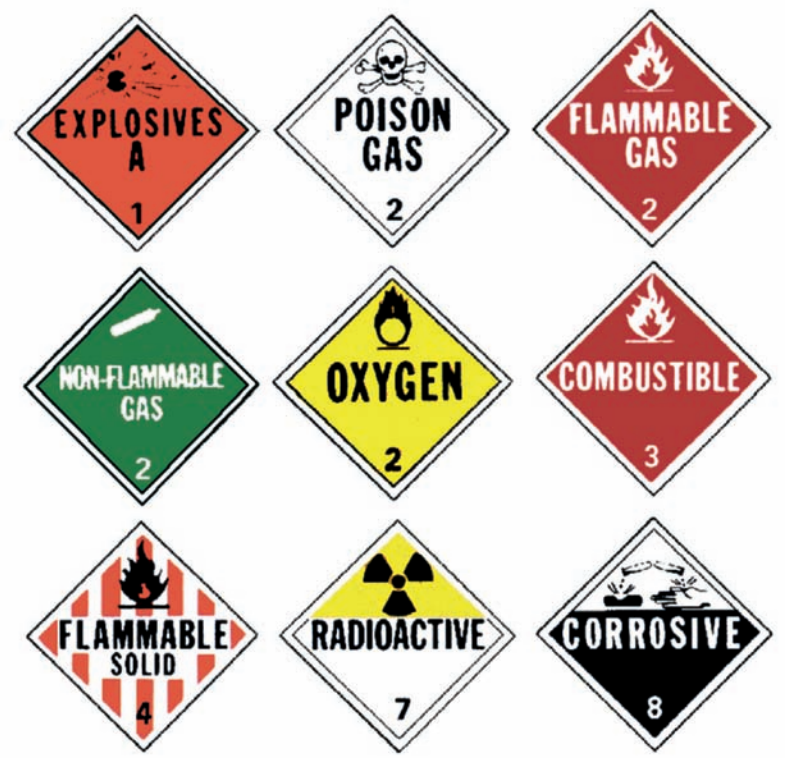


Figure 1-1 Warning placards indicating presence of hazardous material.

the proliferation of illegal methamphetamine labs has been associated with an increased incidence of chemical explosions.

Whatever the cause of an explosion, if possible, law enforcement personnel, along with appropriate specially trained personnel (hazmat technician, bomb technician), should first evaluate the blast scene to make sure it is safe to enter and that no active chemical, biological, or radiological hazards exist. If possible, park your vehicle outside the blast zone (the area where glass is broken). If you are not sure of scene safety, call for ambulatory victims to leave the scene by following a designated emergency responder to a safe area for triage and decontamination.

- *Mass shooting/active shooter events.* An active shooter is an individual who is actively engaged in killing or attempting to kill people in a confined or populated area. Unfortunately, the number of active shooter incidents leading to mass casualty events has increased in recent years, particularly in the United States. Traditionally, emergency care providers have not entered the scene until it was secured by law enforcement, potentially causing significant delays during which victims may die of massive hemorrhage. A number of initiatives have recommended revising these traditional roles and more fully integrating emergency medical services (EMS) into the response to an active shooter in an effort to save as many lives as possible. Rather than staging and waiting for casualties to be brought to the secure part of the scene, EMS responders enter the scene with law enforcement protection to provide care in areas where there is no immediate threat. The goal is to provide only emergent interventions such as control of life-threatening hemorrhage, then rapidly evacuate victims to a more secure area for further assessment and treatment (Jacobs et al. 2013; Joint Committee 2013). This model of rapid assessment medical support, as outlined in the Hartford Consensus, requires cross-disciplinary training between law enforcement and EMS in which law enforcement receives education in hemorrhage control and EMS providers acquire additional operational knowledge of active shooter events and **committee for tactical emergency casualty care (C-TECC)** (CTECC 2015; Joint Committee 2013; Mechem, Bossert, and Baldini 2014).

committee for tactical emergency casualty care (C-TECC): evidenced-based and best-practice trauma care guidelines for civilian high-threat prehospital environments.

essential equipment: equipment that is worn or carried when the team approaches the trauma patient. It includes personal protective equipment, long backboard and strapping, rigid cervical extrication collar, oxygen and airway equipment, and trauma box.

PEARLS

MCI Initial Response

ETHANE

- **Exact** location of the incident
- **Type**: The nature of the incident, includes numbers of vehicles and types, buildings, aircraft, etc. that are involved
- **Hazards**: Identified and possible hazards such as fuel spills, weather, floods
- **Access**: How arriving units should approach and enter the scene
- **Numbers**: Number of casualties including dead on scene; triage categories, if known
- **Emergency services**: Which services are already on scene and which others are required, including special resources such as hazmat, Search and Rescue, etc.

Total Number of Patients

Next, determine the total number of patients. If there are more patients than your team can effectively handle, call for additional resources. Based on dispatch information and additional information received en route, you may need to do this while still responding to the incident. On arrival, medical command must be established. Use the acronym ETHANE to help guide you through the initial steps after arrival.

Remember that you usually need one ambulance for each patient who is seriously injured. If there are many patients, establish medical command and initiate mass casualty incident (MCI) protocols.

When determining the total number of patients, consider this question: Are all patients accounted for? If a patient is unconscious, and there are no witnesses to the incident, look for clues that other patients might be present (e.g., schoolbooks or diaper bag, passenger list in a commercial vehicle). Carefully evaluate the scene for patients. As you do so, not only look toward the vehicle or the center of the scene, but also look outward to see if there are victims behind you. This is especially important at night or if there is poor visibility.

Essential Equipment and Additional Resources

If possible, carry all **essential equipment** to the scene. This prevents loss of time returning to the vehicle. The following equipment are often needed for trauma patients.

- Personal protection equipment: minimum of gloves and goggles
- Patient extrication and transport devices (stretcher, long spine board, vacuum mattress, scoop stretcher, etc.) with effective strapping and head motion-restriction device

- Rigid cervical extrication collar of an appropriate size
- Oxygen and airway equipment, which should include suction equipment and a bag-valve mask (BVM)
- Trauma box (bandage material, hemostatic agent, tourniquet, blood pressure cuff, stethoscope)

Remember to change gloves between patients.

If special extrication equipment, more ambulances, or additional personnel are needed, call as soon as you recognize the need. Be sure to tell additional responders exactly where to respond or stage and of any dangers present on the scene. In larger events, a staging area for ambulances and other responding units may be established. Use of designated radio channels for a specific incident, if available, helps in effective communications.

PEARLS

Equipment

It is wise to invest in a high-intensity tactical flashlight. It is small enough to carry in your shirt pocket but it is many times brighter than regular flashlights.

Mechanism of Injury

A **disease** is an illness that is characterized by specific signs and symptoms. While the term is traditionally applied to afflictions such as infection, cancer, and chronic illness, trauma can be considered a disease as well. Much like a virus has a predictable effect on the body, with signs and symptoms that often present with characteristic patterns, the effect of trauma on the body follows reproducible patterns that can often be predicted by **mechanism of injury (MOI)**.

disease: A dysfunction in the body usually due to an identifiable cause, producing specific signs and symptoms.

mechanism of injury (MOI): the means by which the patient was injured, such as a fall, motor vehicle collision, or explosion.

The absorption of **kinetic energy (KE)** is the major component producing tissue damage in traumatic injury. The law of conservation of energy states that energy is neither created nor destroyed, but is only changed in form. Thus, kinetic energy, whether in the form of a bullet or moving vehicle, must be absorbed. Kinetic energy is proportional to the mass of an object and to the square of the velocity. Therefore, the speed at which a vehicle collision occurs or the speed of a bullet has greater impact on the severity of traumatic injury than the size of the object.

kinetic energy (KE): the energy that an object has as a result of being in motion.

Broadly speaking, the two major types of traumatic injury due to motion are blunt and penetrating, though patients can have both at the same time.

Blunt Trauma

Part of the initial assessment of a trauma scene is identification of clues that signal a high-energy mechanism, as it may help you predict severe injury. To explain the forces involved, consider Sir Isaac Newton's first law of motion: *A body in motion remains in motion in a straight line unless acted on by an outside force*. Motion is created by force (energy exchange), and therefore force will stop motion. If this energy exchange occurs within the body, tissue damage occurs. You should keep in mind that injuries from **blunt trauma** occur as separate events: machine collision, body collision, and organ collision, which are described in the next section (Figure 1-2).

blunt trauma: injury produced by application of force to the body.

Motor Vehicle Collisions

With respect to motor vehicle collisions (MVCs), research has demonstrated that certain features are highly associated with increased injury severity. Some collision features that are associated with increased risk of death include rollover crashes, passenger compartment intrusion, death of another occupant in the vehicle, significant extrication time, ejection from the vehicle, and pedestrian struck (Champion, Lombardo, and Shair 2009; Evans et al. 2009; Haider et al. 2009; Lerner et al. 2011). Understanding the association between mechanism of injury and potentially life-threatening injury is important not just for anticipating the need for prehospital interventions, but also in assisting in determining patient transport destination in systems that have designated trauma centers (Sasser et al. 2012).

The patterns of injuries from collisions with automobiles, motorcycles, all-terrain vehicles (ATVs), personal watercraft, and farm or construction vehicles are varied (Table 1-3).



Figure 1-2 The three collisions of a motor vehicle crash. A. Vehicle collision. B. Body collision. C. Organ collision. *(Photo copyright Mark C. Ide)*

Newton's law is well exemplified in the automobile crash. The kinetic energy of the vehicle's forward motion is absorbed as each part of the vehicle is brought to a sudden halt by the impact. Remember that the body of the occupant is also traveling at the same speed as the vehicle until impacted by some structure within the car when it stops as a result of a collision.

For example, consider approaching an MVC in which an automobile has hit a tree head-on at 40 miles (64 kilometers) per hour. The tree brings the automobile to an immediate stop by transferring the energy into damage to the tree and the automobile (*vehicle collision*). The person inside the vehicle is still traveling at 40 miles per hour until he or she strikes something that stops him or her (such as seat belts, steering wheel, windshield, or dashboard) (*body collision*). At that point, energy transfers into damage to the person and to the surface struck. The organs inside the person are also traveling at 40 miles per hour until they are stopped by striking a stationary object (such as inside of skull, sternum, steering wheel, dashboard) or by their ligamentous attachments (such as the aorta by ligamentum arteriosum) (*organ collision*). In this auto-versus-tree example, appreciation of the rapid forward decelerating mechanism (**high-energy event**) coupled with a high **index of suspicion** should make you concerned that the victim may have life-threatening multisystem trauma.

Utilizing the three-collision concept described previously, check for the presence of the following:

- *Machine collision.* Look for damage to the vehicle at the site of impact, but also in other areas that may indicate rollover or spinning of the vehicle as a result of impact.

high-energy event: a mechanism of injury in which it is likely that there was a large release of uncontrolled kinetic energy transmitted to the patient, thus increasing the chance for serious injury.

index of suspicion: the medical provider's estimate of a disease or injury being present in a patient. A high index of suspicion means there is a high probability the injury is present. A low index of suspicion means there is a low risk of the injury.

Table 1-3: Mechanisms of Motion Injury and Potential Injury Patterns

Mechanism of Injury	Potential Injury Patterns
Frontal impact	• Traumatic brain injury • Cervical spine fracture • Facial injuries • Myocardial contusion • Pneumothorax/hemothorax • Aortic disruption • Spleen or liver laceration • Posterior hip dislocation
Lateral impact (T-bone)	• Contralateral neck sprain • Cervical spine fracture • Pneumothorax • Lung contusion • Laceration of spleen, liver, kidney • Pelvic fracture • Extremity injuries on the side of impact
Rear impact	• Cervical spine injury
Pedestrian versus car	• Head injury • Abdominal visceral injuries • Fracture of the lower extremities and pelvis
Tractor accidents	• Crush injury • Thermal burns
Small-vehicle crashes (motorcycle, all-terrain vehicle, personal watercraft, snowmobile)	• Traumatic brain injury • Facial fractures • Pneumothorax/hemothorax • Extremity and pelvic fractures • Spinal fractures • Degloving injuries • Clothesline injuries with airway compromise • Rectal and vaginal trauma

- *Body collision.* Check the steering wheel for ring fracture and deformity and the steering column for any displacement (thoracic injuries in driver, abdominal injury in passenger); look for broken glass and windshield starring (head/facial injury), dashboard damage (extremity injury, particularly the knees), and airbag deployment (chest, face, arm injury) (Newgard, Lewis, and Kraus 2005).
- *Organ collision.* While outward signs of trauma may be readily visible such as traumatic tattoos of the chest wall and bruising of the abdomen, deeper structures and organs may have occult injuries due to shearing forces, compression forces, and transfer of kinetic energy. Injury to the chest wall itself can cause sternal fractures and rib fractures that can be associated with cardiac contusions and dysrhythmias as well as pneumothorax or simply significant pain with respiration leading to hypoventilation. Organs that are susceptible to shearing injuries due to their ligamentous attachments are the aortic arch, liver, spleen, kidneys, and bowel. With the exception of small-bowel tears, those injuries are sources for major occult bleeds and hemorrhagic shock. Compression injuries are common for the lungs, heart, diaphragm, and urinary bladder. In short, the steering wheel is a lethal weapon capable of producing devastating injuries, many of which are occult. Restraints (seat belts) greatly reduce this type of injury, though do not completely eliminate it and therefore serious thoracic injury should always be suspected when a steering wheel deformity is noted and evidence of steering wheel deformity should be actively sought (Chen and Gabler 2014) (Figure 1-3).



Figure 1-3 Lift the collapsed air bag to note whether or not there is a deformity of the steering wheel. *(Olivier Le Queinec/Shutterstock)*

secondary collision: when an unsecured object continues to move after the vehicle collides with something (primary collision), and the object strikes an occupant (or unsecured occupant strikes vehicle interior).

occupant restraint systems: systems built into a vehicle to prevent the driver and passengers from being thrown about the interior of the vehicle or from being ejected from the vehicle in the event of a collision, such as seat belts and airbags.

Additional collisions other than the three already mentioned may occur. Objects inside the automobile (e.g., books, bags, luggage, other persons) will become missiles traveling at the original speed of the automobile and may strike persons in front of them. These are called **secondary collisions**. For example, an unrestrained monitor in a moving ambulance may strike the EMS provider or patient during an ambulance collision and cause fatal injury.

In cases where the severity of clinical presentation seems out of proportion to the mechanism of injury (e.g., an unresponsive patient following a low-speed MVC), the possibility of a medical etiology (e.g., hypoglycemia, arrhythmia, seizure, stroke, overdose) should also be considered.

Vehicle safety mechanisms have greatly improved survival from motor vehicle collisions. Restrained occupants are more likely to survive a collision because they are protected by **occupant restraint systems** from much of the impact inside the vehicle and are much less likely to be ejected. Passive restraints such as passenger seat belts and airbags are the two occupant restraint systems that are most significant in limiting injury from the body collision component of the MVC. Restrained occupants are still at risk for specific injuries related to the restraints. A lap belt is intended to go across the pelvis (iliac crests), not the abdomen, and is intended to work together with the shoulder belt. If only the lap belt is in place and the victim is subjected to a frontal deceleration crash, the body tends to fold together like a clasp knife (Figure 1-4). The head may still impact the steering wheel or dashboard. Facial, head, or neck injuries are common if the occupant is restrained only with a lap belt or is unrestrained. Abdominal injuries can also occur if the lap belt is positioned improperly. The compression forces that are produced when a body is suddenly folded at the waist may injure the abdomen or the lumbar spine. The three-point restraint or lap and shoulder belt combination (Figure 1-5) secures the body much better than a lap belt alone. The chest and pelvis are restrained, so life-threatening injuries due to contact with the vehicle are much less common. The head is not restrained, and therefore the neck is still subjected to forces that may cause fractures, dislocations, or spinal cord injuries. Clavicle fractures (at the point where the chest strap crosses) are common, as are chest wall injuries. Even in restrained individuals, internal organ damage may still occur due to organ collisions.



Figure 1-4 Clasp-knife effect.



Figure 1-5 Airbag and three-point restraint.

Like belt restraints, airbags will reduce injuries in victims of MVCs in most but not all situations. Airbags are designed to inflate from the center of the steering wheel and the dashboard to protect the front-seat occupants in case of a frontal deceleration crash, but are specifically designed to work together with seat belts. If functioning properly, the seat belts hold the individual in place long enough for the airbag to fully inflate. The airbags can then cushion the head and chest at the instant of impact, thus effectively decreasing (but not eliminating) injury to the face, neck, and chest. Airbags deflate immediately, so they protect against only one impact. The driver whose car hits more than one object loses airbag protection after the initial collision. Airbags also do not prevent "down-and-under" movement, so drivers who are extended (tall drivers and drivers of small, low-slung automobiles) may still impact the dash with their legs and suffer leg, pelvis, or abdominal injuries. Many newer vehicles have airbag systems designed to prevent this type of injury. Side airbags may also be built into the body, seat, or headrest. Just like frontal airbags, they only protect the driver during the initial collision. All vehicles with such systems have warning labels throughout the vehicle.

Airbags are associated with specific injuries. Small drivers who bring the seat up close to the steering wheel may sustain serious injuries when the bag inflates because it does not have adequate space or time to inflate before the body impacts it. Infants in car seats placed in the front seat, especially front-facing car seats, may be seriously injured by deployment of the air bag. The smoke seen with airbag deployment is really powder (talc or cornstarch) that is used to "lubricate" the nylon bag so it slides smoothly during inflation. Abrasions from the nylon bag, corneal abrasions, and superficial burns on exposed skin near the airbag vents have been reported. Emergency care providers should be aware that many new vehicles are equipped with side airbags and air curtains (Figure 1-6).



Figure 1-6 Side airbags and air curtains can pose a hazard to responders if the devices did not activate in the collision. *Note:* See the *Access: First on Scene—Rapid Vehicle Entry Provider Manual* from ITLS for more information about rendering nondeployed airbags safe. *(testing/Shutterstock)*

Remember that airbags may pose a hazard to responders if the safety devices did not activate in the collision. Disconnecting the battery may deactivate some airbag systems. However, some airbags may still be able to deploy after the battery has been disconnected. A good safety rule to follow when working around undeployed airbags is the 5-10-20 rule:

- Stay 5 inches (13 cm) away from side curtain airbags
- Stay 10 inches (25 cm) away from steering wheel airbags
- Stay 20 inches (50 cm) away from passenger side airbags.

Falls

Falls are the second leading cause of unintentional injury deaths worldwide, particularly in children and older adults (WHO 2014). Older people are at risk for falling in part because of age-related changes in mobility, balance, and vision, compounded by medication use. They are simultaneously at risk for more serious injury from lower-energy falls due to bony changes and frequency of anticoagulant use (Ang et al. 2017; Sterling, O'Connor, and Bonadies 2001). In contrast, children are at risk for falls at varying ages because of evolving developmental changes and risk-taking behaviors (Figure 1-7).

The mechanism of injury for falls is vertical deceleration. The type and severity of injuries sustained depend on the following four factors: distance of fall, anatomic area impacted, surface struck, and patient age (Lapostolle et al. 2005). Typical injuries include:

- Head trauma
- Axial loading or hyperextension/hyperflexion injury to the spine
- Extremity fractures
- Hip and/or pelvic injuries
- Vertical deceleration forces to the organs

The greater the height, the greater the potential for injury. With falls greater than 10 feet (3 meters), approximately 1 in 4 patients will have a spinal or intracranial injury, and 1 in 20 will have a serious intra-abdominal injury (Demetriades et al. 2005;

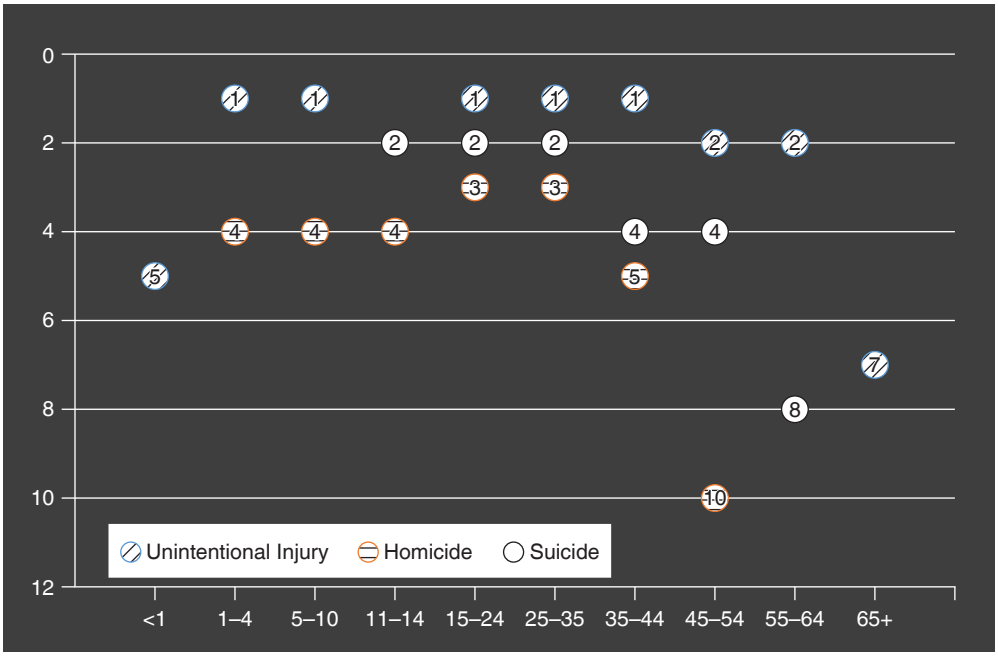


Figure 1-7 Ranked cause of death by trauma as a function of age. *(Data from CDC 2016)*

Velmahos et al. 2006). However, serious injury can occur with a short-distance fall. Ground-level falls in older adults can lead to injuries associated with significant mortality and morbidity, such as intracranial hemorrhage and hip fracture (Spaniolas et al. 2010). The severity of traumatic injury is frequently underestimated in older adults, and a high index of suspicion for serious or life-threatening injury must be maintained when evaluating these patients, especially in those who take oral anticoagulants (Ang 2017; Sterling 2001).

Finally, while a large proportion of falls are mechanical in nature, people often fall as a result of a concurrent medical problem, such as cardiac arrhythmia, hypotension from infection, or stroke. Thus, evaluation of the patient who has undergone a fall includes consideration of *why* the fall occurred so that concurrent acute medical pathology can be addressed. To help assess the cause of a fall, you can use the mnemonic *SPLAT*:

- Symptoms before the fall
- Previous falls
- Location of the fall (home, work, outdoors)
- Activity at time of the fall
- Time of day of the fall

Penetrating Trauma

MVCs remain the largest cause of death for young adults and children. Homicides in the United States are rising, and this has become the leading cause of traumatic death in young males in urban areas. **Penetrating trauma** is often associated with acts of violence. Emergency care providers should exercise caution in such situations. Scene safety is always paramount and, whenever possible, law enforcement should be part of the response. If the scene becomes unsafe, then providers may have to evacuate the scene for a safe area before fully assessing the patient.

Many objects can produce penetrating injuries. Examples include an industrial saw blade that breaks off at a high rate of speed, a foreign body thrown by a lawn mower, as well as common knife and gun wounds. Most high-velocity objects can penetrate the thorax or abdomen.

The severity of a knife wound depends on the anatomic area penetrated, length of the blade, and angle of penetration (Figure 1-8). Knife wounds are low-energy injuries, and tissue damage is confined to the direct path of the blade. Remember, an upper-abdominal stab wound may cause intrathoracic organ injury, and stab wounds below the fourth intercostal space may have penetrated the abdomen.

PEARLS
Basic Ballistics

Know the information offered here, but remember: *Treat the patient, not the weapon.*

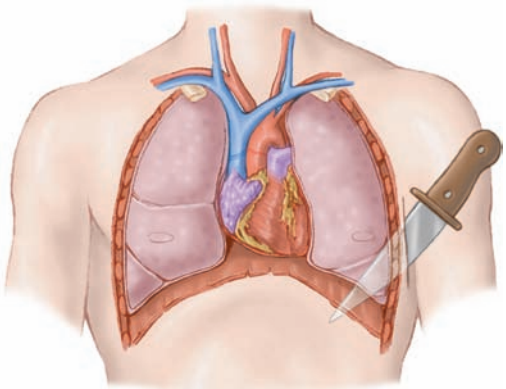
penetrating trauma: an injury produced when an object penetrates the skin, creating an open wound, and possibly damaging deeper structures.

wound ballistics: the study of the behavior of the projectile when it strikes the target and transfers energy to the target.

Wound Ballistics

Most penetrating wounds inflicted by firearms are due to handguns, rifles, and shotguns. In combat situations or terrorist events, penetrating wounds can also result from shrapnel. In terms of firearms, the bullet is the projectile fired from the gun. Bullets vary in size (caliber) and design, which determines whether they fragment on impact and cause massive damage or remain together and travel through the body.

As noted earlier in the chapter, injury to tissue results from the transfer of kinetic energy to the tissue. **Wound ballistics** studies the effect of the kinetic energy from the bullet leading to the crushing, lacerating, stretching, and shearing of tissues (Breeze et al. 2017). Because the kinetic energy produced by a projectile is proportional to the square of the velocity, bullets shot from high-velocity weapons (e.g., military rifle) can be more destructive than those from low-velocity weapons (e.g., some handguns). However, only the energy deposited in the tissue (kinetic energy of the bullet entering minus the kinetic energy on leaving the tissue) causes tissue disruption. Thus, factors that increase the drag on the bullet and stop the bullet in the tissues



Stab wounds at nipple level or below frequently penetrate the abdomen.

Figure 1-8 Stab wounds.

result in complete energy transfer from bullet to tissue. Modifications of bullets such as hollow-point rounds deform in the tissue and create larger wounds. Military rounds are full-metal jacketed, which limits expansion on hitting the target. However, many of them are designed to tumble or break apart on contact with the target, increasing the wounding potential of the round (Breeze et al. 2017; Ragsdale and Sohn 1988).

Bullets cause tissue injury by three mechanisms:

- *Shockwave*: blast effect caused by escape of propellant gases into the tissue
- ***Temporary cavity***: tissue is driven outward away from the path of the bullet, causing stretching and shearing of tissues. This leads to a larger area of damage than may be suggested by the external appearance of the bullet track and results in a vacuum that pulls debris into the wound and increases risk of infection. This mechanism is most important in when dealing with bullets traveling at a high velocity (Figure 1-9A).
- *Permanent* ***wound track***: Direct tissue crush injury inflicted by the bullet as it traverses the tissue, leading to irreversible damage.

temporary cavity: the maximum temporary displacement of tissue due to the hydrostatic shock from a bullet's passage.

wound track: the path through the tissue made by a projectile.

Because the drag force on a bullet is increased with increasing tissue density, tissue damage is proportional to tissue density (Figure 1-9B). Highly dense organs such as bone, muscle, and the liver sustain more damage than less dense organs such as the lungs. Bone damaged by a gunshot can fragment and damage surrounding tissues.

With regard to lethality, the single most important factor is not the bullet design or velocity, but what part of the body is hit by the projectile. It is not the bullet itself that is toxic, but the path that the bullet takes. Effort should be taken to identify the total number of wounds and their location. While medical providers are not forensic experts and should not label whether a bullet wound is entrance or exit, certain features suggest that a wound is an entrance wound, such as abrasion collars, soot, and tattooing. The size of the wound does not always indicate entrance versus exit wounds. The entrance wound can be larger than an exit wound and vice versa. A key factor to remember is that once a bullet enters the body, its trajectory will not always be in a straight line.

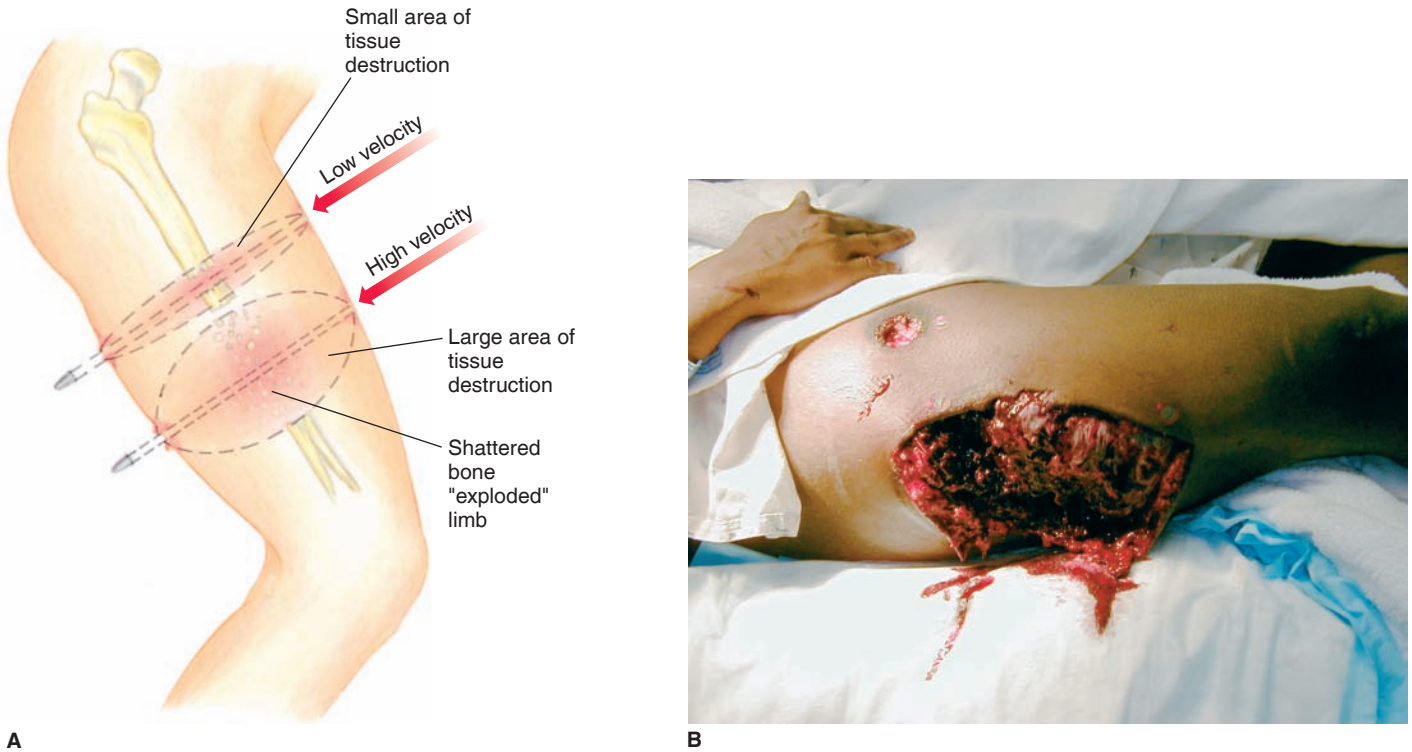


Figure 1-9 A. High-velocity versus low-velocity injury. B. Example of a high-velocity wound of the leg. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Blast Injuries

There are five mechanisms of injury due to blast or explosion (Figure 1-10):

- *Primary.* Caused by the initial air blast, a primary **blast injury** is caused by the direct effect of blast overpressure on tissue. Air is easily compressible, unlike water. As a result, the primary blast injury almost always affects air-filled structures such as the lungs, ears, and gastrointestinal tract. Primary blast injury is less common in the civilian setting than in combat. Injuries due to the primary air blast are almost exclusive to the air-containing organs. The auditory system often involves ruptured tympanic membranes, which renders victims unable to hear. Once thought of as a marker of exposure to blasts sufficient to cause primary injury, recent data suggests that this is not a good triage tool. Lung injuries resulting from primary blast injury can include pneumothorax, parenchymal hemorrhage, and especially alveolar rupture. Alveolar rupture may cause air embolus that may be manifested by strokelike symptoms such as dysarthria, paralysis, or visual disturbances. Gastrointestinal tract injuries may vary from mild intestinal and stomach contusions to frank rupture. Always suspect lung injuries in a blast victim.
- *Secondary.* The secondary blast injury is the result of the patient being struck by material (shrapnel) propelled by the blast force. Injuries caused by secondary factors may be penetrating or blunt. Fragments of shrapnel from an explosion may attain velocities of 14,000 feet (4,270 meters) per second. This is over four times the

blast injuries: injuries commonly produced by the different mechanisms associated with an explosion (air blast, shrapnel, burns, etc.).

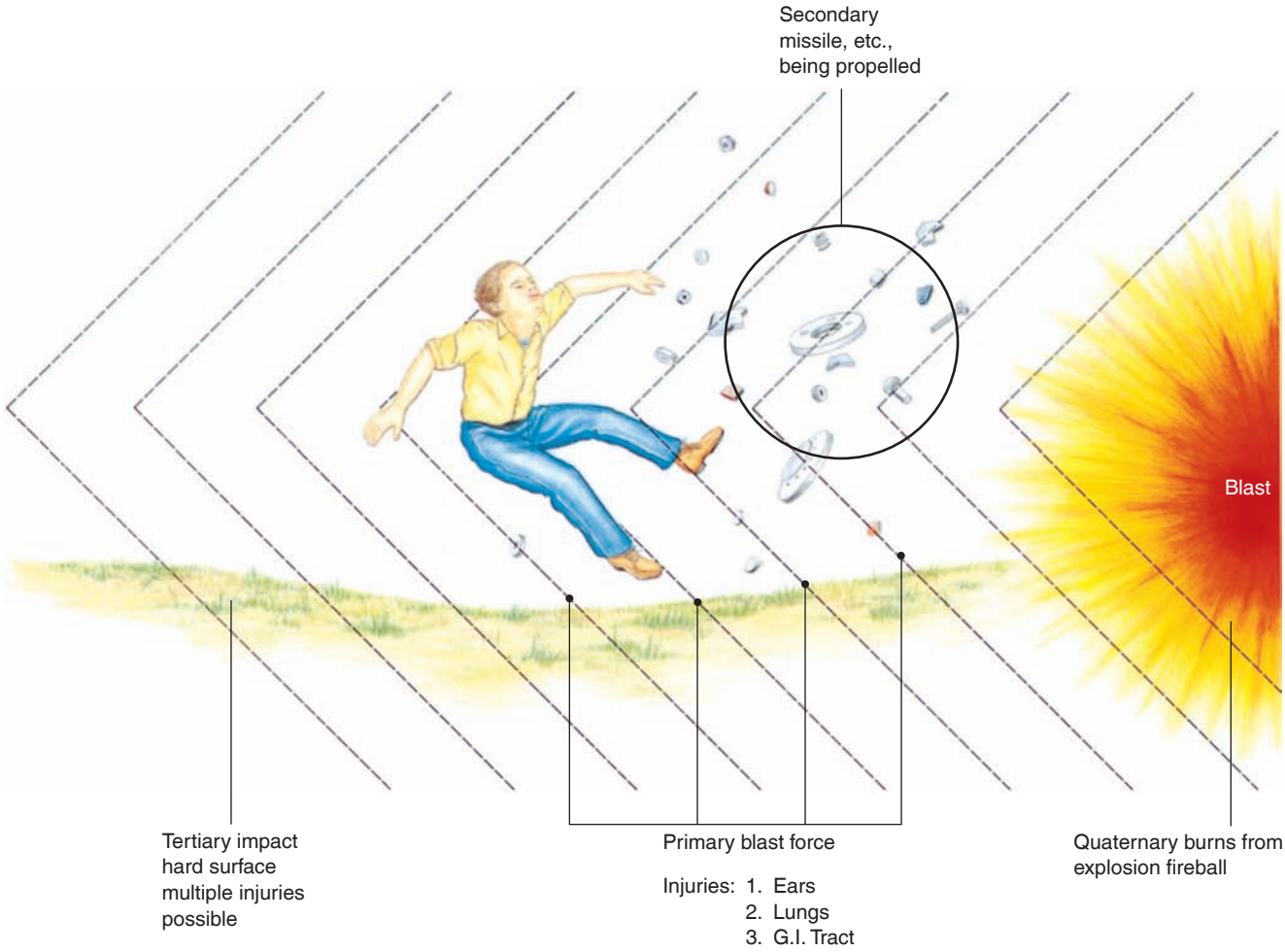


Figure 1-10 Explosions can cause injury with the initial blast, when the victim is struck by debris, or by the victim being thrown against the ground or fixed objects by the blast.

velocity of the most powerful high-velocity rifle bullets. A piece of shrapnel traveling at this velocity would impart more than 16 times the energy of a similarly sized high-velocity rifle bullet.

- *Tertiary.* A tertiary injury is due to the body being thrown, resulting in an impact with the ground or an object. Tertiary injuries are much the same as when a person is ejected from an automobile or has fallen from a height. The blast wave may propel the person at a high velocity for a varying distance. The injuries will depend on what the person impacts (e.g., solid object versus water or soft ground).
- *Quaternary.* As a result of the explosion fireball, the body can sustain thermal burns or an inhalation injury due to toxic dust or fumes. Quaternary injuries are seen when there is a large fireball associated with the explosion or when toxic fumes or dust are produced by the explosion. They are more common when the victim is in an enclosed space or has a previous lung disease such as asthma or emphysema.
- *Quinary.* This injury is the hyperinflammatory state that results from exposure to contaminants in the blast, such as chemical, biological, or radiological material dispersed by the explosion (dirty bomb). This is a delayed type of injury. Quinary injuries are relatively new and reflect a terrorist's attempts to make bombs more deadly by using the explosion to disperse toxic chemicals, biological agents, or radiological agents. Such bombs are called "dirty bombs" for that reason.

Priorities of Trauma Care

The goal of prehospital trauma care is to minimize injury and reduce preventable death. To accomplish these goals, the prehospital care provider must focus on treating the preventable causes of death on scene, minimizing secondary insults, and rapidly transporting to a facility capable of definitively addressing the patient's injuries. The organized evaluation of the trauma patient and treatment of the associated signs and symptoms in a time-sensitive manner can be potentially lifesaving.

Military medicine has played a critical role in identifying best practices in trauma care. Most recently, military operations in Afghanistan and Iraq led to the development of significant advances in trauma care aimed at treating **preventable deaths**. Preventable causes of death on scene are those conditions that will result in patient death prior to arrival at definitive care if they are not addressed. Military studies identified three major preventable causes of death prehospital: (1) exsanguination from massive extremity hemorrhage, (2) airway obstruction, and (3) tension pneumothorax. During United States military operations in Iraq from 2003 until 2006, significantly more patients died of extremity hemorrhage than of airway obstruction (Kelly et al. 2008). **Secondary insults** are those factors that worsen patient outcomes from traumatic injury. Examples include hypoxia, hypotension, and hyperventilation, which worsen neurologic outcomes in patients with traumatic brain injury (refer to Chapter 12), and hypothermia, which worsens traumatic coagulopathy. These priorities of care are emphasized in algorithms borrowed from military **tactical combat casualty care (TCCC)** (MARCHE) and tactical medicine (XABC), as shown in Table 1-4 (also see Appendix G) (Butler, Hagmann, and Butler 1996; Butler and Blackbourne 2012; Eastridge et al. 2012; Holcomb et al. 2007). Extrapolating from military experience, training and focus on management of preventable causes can greatly reduce deaths from traumatic injury (Kotwal et al. 2011).

preventable death: those conditions that will result in patient death prior to arrival at definitive care if they are not addressed.

secondary insult: damage that is not the direct result of the trauma but due to trauma-induced changes in body systems; for example, hypoxia worsening traumatic brain injury.

tactical combat casualty care: Also called TCCC; guidelines for the care of combat casualties developed by the Committee on Tactical Combat Casualty Care (CoTCCC).

Hemorrhage and brain injury account for the majority of deaths from traumatic injury. Definitive treatment of life-threatening hemorrhage and/or brain injury requires resources and personnel that are not typically available in the out-of-hospital environment. Thus, after management of preventable causes of death, the next management priority is expeditious transport to a facility capable of treating the patient's injuries. Most importantly, rapid transport should supersede other interventions that are often performed on scene but that, depending on clinical circumstance, may not

Table 1-4: Priorities of Care

XABC	Explanation/Adaptation to Civilian EMS	MARCHE (TCCC)
E**X**sanguinating hemorrhage	• Identify and treat hemorrhage; treatments including tourniquets, pressure dressings.	**M**assive hemorrhage control
Airway	• Open the airway and ensure adequate ventilation and oxygenation; importantly, this does not necessarily mean invasive airway management and BLS airway maneuvers such as jaw thrust, airway adjuncts (OPA/NPA), and/or BVM are often sufficient.	**A**irway control
Breathing	• Treat tension pneumothorax with needle decompression. • Beware of overventilation, which can decrease cardiac venous return and be harmful in traumatic brain injury.	**R**espiratory support
Circulation	• Assess and treat shock, manifested by hypotension, tachycardia, and/or low capnography. • With the exception of traumatic brain injury, hypotensive resuscitation is favored to reduce further hemorrhage and minimize crystalloid infusion. • Consider TXA and blood product transfusion, if available.	**C**irculation and shock management
	• Minimize hypothermia in order to prevent coagulopathy and increased hemorrhage. • Maintain CNS perfusion and oxygenation.	**H**ypothermia **H**ead injury
	• Environment (hyperthermia, hypothermia) • Eye Injury • Preparation for transport • Pain Control • Antibiotics if indicated	**E**verything else

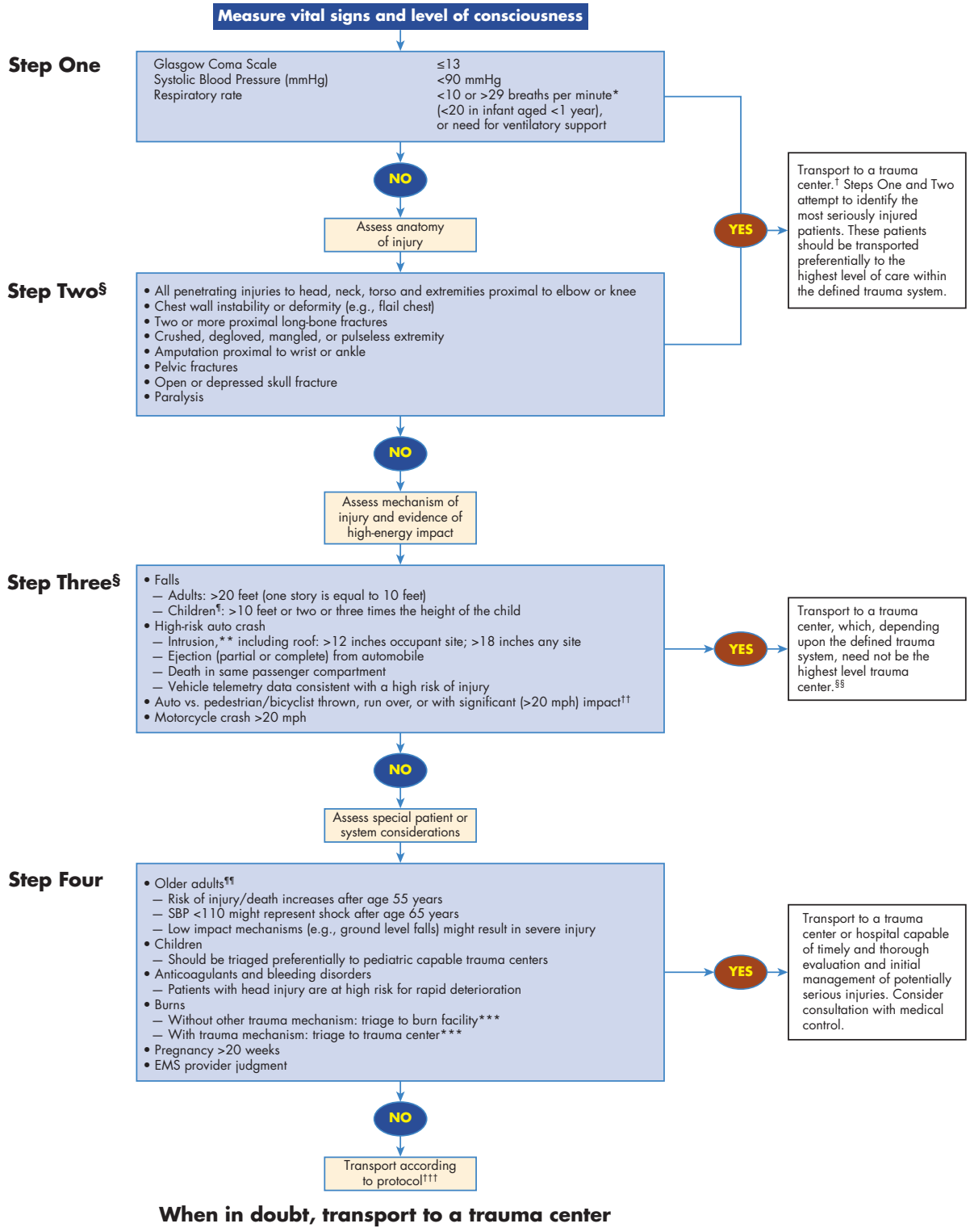
be necessary to patient survival, such as intravenous access or endotracheal intubation (Stiell 2008). Interventions that are not lifesaving, such as intravenous access and pain control, should be performed en route.

Trauma Triage Decisions

Organized trauma systems are associated with improved survival (Gabbe et al. 2012). The challenge for emergency care providers is to determine who needs to be treated at a trauma center and who can be managed at a community-level hospital. Taking all trauma patients to a trauma center (overtriage) will overload the system and impair the ability to provide care for those who need it. Undertriage (not sending patients who require specialized trauma care to a trauma center) results in worse outcome for the patients. Numerous guidelines have been developed over the years to assist in the triage process. Presented here is one developed by the Centers for Disease Control and Prevention, in cooperation with the American College of Surgeons Committee on Trauma and other professional organizations. The chart shown in Figure 1-11 is a stepwise approach using specific factors that can be identified on scene.

Prevention and Public Education

Traditionally, the traumatic injuries described in this text have been thought to be separate entities. In recent years, thinking has shifted to describe trauma itself as a disease, with specific causes, methods of prevention or mitigation, and methods of treatment. While the primary focus of this text is management of traumatic injury once it has occurred, prevention of injury is actually preferred and has a much greater potential for decreasing injury and death. A good example of this has been the campaign to encourage seat-belt use in many countries, which has been associated with a decrease in MVC deaths.



* The upper limit of respiratory rate in infants is >29 breaths per minute to maintain a higher level of overtriage for infants.

† Trauma centers are designated Level I-IV. A Level I center has the greatest amount of resources and personnel for care of the injured patient and provides regional leadership in education, research, and prevention programs. A Level II facility offers similar resources to a Level I facility, possibly differing only in continuous availability of certain subspecialties or sufficient prevention, education, and research activities for Level I designation; Level II facilities are not required to be resident or fellow education centers. A Level III center is capable of assessment, resuscitation, and emergency surgery, with severely injured patients being transferred to a Level I or II facility. A Level IV trauma center is capable of providing 24-hour physician coverage, resuscitation, and stabilization to injured patients before transfer to a facility that provides a higher level of trauma care.

§ Any injury noted in Step Two or mechanism identified in Step Three triggers a "yes" response.

¶ Age <15 years.

** Intrusion refers to interior compartment intrusion, as opposed to deformation which refers to exterior damage.

†† Includes pedestrians or bicyclists thrown or run over by a motor vehicle or those with estimated impact >20 mph with a motor vehicle.

§§ Local or regional protocols should be used to determine the most appropriate level of trauma center within the defined trauma system; need not be the highest-level trauma center.

¶¶ Age >55 years.

*** Patients with both burns and concomitant trauma for whom the burn injury poses the greatest risk for morbidity and mortality should be transferred to a burn center. If the nonburn trauma presents a greater immediate risk, the patient may be stabilized in a trauma center and then transferred to a burn center.

††† Patients who do not meet any of the triage criteria in Steps One through Four should be transported to the most appropriate medical facility as outlined in local EMS protocols.

Figure 1-11 Guidelines for the Field Triage of Injured Patients—U.S. CDC 2011. *(Source: Centers for Disease Control and Prevention)*

The WHO has focused its prevention efforts in several areas, including violence, road safety, drowning, and child injury. For example, road traffic injuries are the leading cause of death worldwide for 15- to 29-year-olds and are projected to result in injury to 20–50 million people and 1.9 million deaths worldwide annually by 2020. To help decrease these injuries, the WHO initiative "Decade of Action for Road Safety (2011–2020)" (*decadeofaction.org*) advocates for specific road and vehicle safety initiatives and improving emergency services. Even small changes can significantly decrease injury and death from trauma within a community. From an EMS standpoint, the WHO recommends integration of prevention and EMS within the health care system and use of universal emergency numbers to access responders, such as 911 (U.S.), 192 (Brazil), 999 (UK), 119 (Japan/Korea), and 112 (GSM Cell phone worldwide).

With the increasing frequency of terrorist and mass injury events in civilian settings, training not only EMS but also lay bystanders to engage when such events occur can promote rapid action to save lives. Techniques such as hemorrhage control and tourniquet use can limit loss of lives in the critical minutes following injury. For example, in its first year, the "Stop the Bleed" public awareness campaign educated over 150,000 U.S. civilians in immediate massive hemorrhage control.

Case Presentation *(continued)*

As you pull up, your scene survey reveals a possible multiple-patient scene with hazards. The senior fire officer assures you that the spill is under control and that other than a slight fuel odor, there is no fire danger or other hazmat threat. He also says that the driver seems uninjured and that "at least the guy from the bike is breathing."

Having donned gloves, you head toward the car. The driver assures you he does not need emergency medical attention, that his neck is "just a little stiff," and that he swerved in order to avoid the pedestrian who ran into the roadway.

The driver is alert, talking normally, and complaining of neck discomfort with tingling in the right arm. "He just swerved into me," he says, "just flew over the hood right into the windshield in front of me. Ripped my side mirror off as he fell past me!"

You request an additional ambulance from the senior fire officer and proceed with the trauma kit to the pedestrian. Your assessment of the pedestrian reveals an unresponsive patient with an airway compromise. Because the nearest trauma center is a considerable distance from the scene, the emergency care provider considers requesting air medical transport (a helicopter).

Summary

- Trauma is a serious disease affecting all ages worldwide. An organized approach to the trauma patient is essential to improve outcomes.
- At the scene of an injury, there are important steps to perform before you begin care of the patient. Failure to perform a scene size-up will subject you and your patient to danger and may cause you to fail to anticipate serious injuries your patient may have sustained. Take standard precautions and assess the scene for dangers first. Then determine the total number of patients and the need for additional emergency

care providers or special equipment. If there are more patients than your team can manage, report to dispatch and initiate multiple-casualty incident protocols.

- Identify the mechanism of injury and consider it as part of the overall management of the trauma patient. Ask yourself: What happened? What type of energy was applied? How much energy was transmitted? What part of the body was affected?
- Information about the high-energy event (e.g., a fall, a vehicle collision) is also important to the emergency physician. Be sure not only to record your findings but also to give a verbal report to the emergency department physician or trauma surgeon when you arrive. With this knowledge and a high index of suspicion, you can give your patient the greatest chance of survival.
- Thorough scene assessment with an understanding of the mechanism of injury is critical to both provider safety and fully assessing the patient's risk of life-threatening injury. As trauma is a disease of time and energy—time to definitive care and the amount of external energy applied to the body—out-of-hospital trauma care should focus on those interventions that limit preventable death and disability.

References and Resources

Alberdi, F., I. Garcia, L. Atutxa, and M. Zabarte. 2014. "Epidemiology of Severe Trauma." *Medicina Intensiva (English Edition)* 38, no. 9 (December): 580–8.

Ang, D., S. Kurek, M. McKenney, S. Norwood, B. Kimbrell, E. Barquist, H. Liu, A. O'Dell, M. Ziglar, and J. Hurst. 2017. "Outcomes of Geriatric Trauma Patients on Preinjury Anticoagulation: A Multicenter Study." *The American Surgeon* 83, no. 6 (June): 527–35.

Becker, L. R., E. Zaloshnja, N. Levick, G. Li, and T. R. Miller. 2003. "Relative Risk of Injury and Death in Ambulances and Other Emergency Vehicles." *Accident Analysis and Prevention* 35, no. 6: 941–48. https://doi.org/10.1016/S0001-4575(02)00102-1

Blake, A. J., K. Morgan, M. J. Bendall, H. Dallosso, S. B. Ebrahim, T. H. Arie, P. H. Fentem, and E. J. Bassey. 1988. "Falls by Elderly People at Home: Prevalence and Associated Factors." *Age Ageing* 17, no. 6 (November): 365–72.

Breeze, M. J., J. G. Penn-Barwell, D. Keene, J. Jeyanathan, and P. F. Mahoney. 2017. *Ballistic Trauma: A Practical Guide*. 4th ed. Cham, Switzerland: Springer International.

Bulger, E. M., M. L. Gestring, and L. M. Jacobs. 2018. "Optimizing Bleeding Control Training for the Public: A National Imperative." *JAMA Surgery*. doi:10.1001/jamasurg.2018.1100 https://jamanetwork.com/journals/jamasurgery/article-abstract/2680069

Butler, Jr., F. K., & L. H. Blackbourne. 2012. "Battlefield Trauma Care Then and Now: A Decade of Tactical Combat Casualty Care." *Journal of Trauma and Acute Care Surgery* 73, no. 6 (December): S395–S402.

Butler, Jr., F. K., J. Hagmann, & E. G. Butler. 1996. "Tactical Combat Casualty Care in Special Operations." *Military Medicine* 161, Suppl. 1 (August): 3–16.

Campbell, A. J., J. Reinken, B. C. Allan, and G. S. Martinez. 1981. "Falls in Old Age: A Study of Frequency and Related Clinical Factors." *Age Ageing* 10, no. 4 (November): 264–70.

Campbell, J., and J. Smith. 2008. *Homeland Security and Emergency Medical Response*. New York: McGraw-Hill.

Chen, R., and H. C. Gabler. 2014. "Risk of Thoracic Injury from Direct Steering Wheel Impact in Frontal Crashes." *Journal of Trauma and Acute Care Surgery* 76, no. 6 (June): 1441–6.

Champion, H. R., L. V. Lombardo, and E. K. Shair. 2009. "The Importance of Vehicle Rollover as a Field Triage Criterion." *Journal of Trauma and Acute Care Surgery* 67, no. 2 (August): 350–7.

Committee for Tactical Emergency Casualty Care. 2015. "TECC Guidelines." Accessed November 2018. http://www.c-tecc.org/images/content/TECC_Guidelines_-_JUNE_2015_update.pdf.

Demetriades, D., J. Murray, C. Brown, G. Velmahos, A. Salim, K. Alo, and P. Rhee. 2005. "High-level Falls: Type and Severity of Injuries and Survival Outcome According to Age." *Journal of Trauma and Acute Care Surgery* 58, no. 2 (February): 342–5.

Downton, J., and K. Andrews. 1991. "Prevalence, Characteristics and Factors Associated with Falls Among the Elderly Living at Home." *Aging (Milano)* 3, no. 3 (September): 219–28.

Eastridge, B. J., R.L. Mabry, P. Seguin, J. Cantrell, T. Tops, P. Uribe, O. Mallett, T. Zubko, L. Oetjen-Gerdes, T.E. Rasmussen, et al. 2012. "Death on the Battlefield (2001–2011): Implications for the Future of Combat Casualty Care." *Journal of Trauma and Acute Care Surgery* 73, no. 6 (December): S431–37.

Evans, S. L., M. L. Nance, K. B. Arbogast, M. R. Elliott, and F. K. Winston. 2009. "Passenger Compartment Intrusion as a Predictor of Significant Injury for Children in Motor Vehicle Crashes." *Journal of Trauma and Acute Care Surgery* 66, no. 2 (February): 504–7.

Gabbe, B. J., P. M. Simpson, A. M. Sutherland, R. Wolfe, M. C. Fitzgerald, R. Judson, and P. A. Cameron. 2012. "Improved Functional Outcomes for Major Trauma Patients in a Regionalized, Inclusive Trauma System." *Annals of Surgery* 255, no. 6 (June): 1009–15.

Haider, A. H., D. C. Chang, E. R. Haut, E. E. Cornwell III, and D. T. Efron. 2009. "Mechanism of Injury Predicts Patient Mortality and Impairment after Blunt Trauma." *Journal of Surgical Research*, 153, no. 1 (May): 138–42.

Holcomb, J. B., N. R. McMullin, L. Pearse, J. Caruso, C. E. Wade, L. Oetjen-Gerdes, H. R. Champion, M. Lawnick, W. Farr, S. Rodriguez, et al. 2007. "Causes of Death in U.S. Special Operations Forces in the Global War on Terrorism: 2001–2004." *Annals of Surgery* 245, no. 6 (June): 986–91.

Jacobs, L. M., N. E. McSwain Jr., M. F. Rotondo, D. Wade, D., W. Fabbri, A. L. Eastman, F. K. Butler Jr., and J. Sinclair. 2013. "Improving Survival from Active Shooter Events: The Hartford Consensus." *Journal of Trauma and Acute Care Surgery* 74, no. 6 (June): 1399–1400.

Joint Committee to Create a National Policy to Enhance Survivability from Mass-Casualty Shooting Events. 2013. "Improving Survival from Active Shooter Events: The Hartford Consensus II." *Bulletin of the American College of Surgeons* 98, no. 6 (September): 14–16.

Kelly, J. F., A. E. Ritenour, D. F. McLaughlin, K. A. Bagg, A. N. Apodaca, C. T. Mallak, L. Pearse, M. M. Lawnick, H. R. Champion, C. E. Wade, et al. 2008. "Injury Severity and Causes of Death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003–2004 vs 2006." *Journal of Trauma* 64, no. 2, Suppl. (February): S21–7.

Kotwal, R. S., H. R. Montgomery, B. M. Kotwal, H. R. Champion, F. K. Butler, R. L. Mabry, J. S. Cain, L. H. Blackbourne, K. K. Mechler, and J. B. Holcomb. 2011. "Eliminating Preventable Death on the Battlefield." *Archives of Surgery* 146, no. 12 (December): 1350–58.

Lapostolle, F., C. Gere, S. W. Borron, T. Pétrovic, F. Dallemagne, A. Beruben, C. Lapandry, and F. Adnet. 2005. "Prognostic Factors in Victims of Falls from Height." *Critical Care Medicine* 33, no. 6 (June): 1239–42.

Lerner, E. B., M. N. Shah, J. T. Cushman, R. A. Swor, C. E. Guse, K. Brasel, A. Blatt, and G. J. Jurkovich. 2011. "Does Mechanism of Injury Predict Trauma Center Need?" *Prehospital Emergency Care* 15, no. 4 (October–December): 518–25.

Levy, M. J., and L. M. Jacobs. 2016. "A Call to Action to Develop Programs for Bystanders to Control Severe Bleeding." *JAMA Surgery* 151, no. 12 (December): 1103–4. doi:10.1001/jamasurg.2016.2789.

Mechem, C. C., R. Bossert, and C. Baldini. 2015. "Rapid Assessment Medical Support (RAMS) for Active Shooter Incidents." *Prehospital Emergency Care* 19, no. 2 (April–June): 213–17.

National Research Council Committee on Trauma, & National Research Council Committee on Shock. 1971. *Accidental Death and Disability: The Neglected Disease of Modern Society*. Washington, DC: National Academies.

Newgard, C. D., R. J. Lewis, and J. F. Kraus. 2005. "Steering Wheel Deformity and Serious Thoracic or Abdominal Injury Among Drivers and Passengers Involved in Motor Vehicle Crashes." *Annals of Emergency Medicine*, 45, no. 1 (January): 43–50.

Prudham, D., and J. Evans. 1981. "Factors Associated with Falls in the Elderly: A Community Study." *Age Ageing* 10, no. 3 (August): 141–46.

Ragsdale, B. D., and S. S. Sohn. 1988. "Comparison of the Terminal Ballistics of Full Metal Jacket 7.62-mm M80 (NATO) and 5.56-mm M193 Military Bullets: A Study in Ordnance Gelatin." *Journal of Forensic Science* 33, no. 3 (May): 676–96.

Ross, E. M., T. T. Redman, J. G. Mapp, D. J. Brown, K. Tanaka, C. W. Cooley, C. U. Kharod, and D. A. Wampler. 2018. "Stop the Bleed: The Effect of Hemorrhage Control Education on Laypersons' Willingness to Respond During a Traumatic Medical Emergency." *Prehospital Disaster Medicine* 33, no. 2: 127–32.

Sakran, J. V., and S. E. Greer. "Care of the Injured Worldwide: Trauma Still the Neglected Disease of Modern Society." *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 20, no. 64 (September). https://doi.org/10.1186/1757-7241-20-64

Sasser, S. M., R. C. Hunt, M. Faul, D. Sugerman, W. S. Pearson, T. Dulski, M. M. Wald, G. J. Jurkovich, C. D. Newgard, E. B. Lerner, et al. 2012. "Guidelines for Field Triage of Injured Patients: Recommendations of the National Expert Panel on Field Triage, 2011." *Morbidity and Mortality Weekly Report: Recommendations and Reports* 61, no. 1 (January): 1–20.

Sise, R. G., R. Y. Calvo, D. A. Spain, T. G. Weiser, and K. L. Staudenmayer. "The Epidemiology of Trauma-Related Mortality in the United States from 2002 to 2010." *Journal of Trauma and Acute Care Surgery* 76, no. 4 (April): 913–20.

Spaniolas, K., J. D. Cheng, M. L. Gestring, A. Sangosanya, N. A. Stassen, and Bankey, P. E. 2010. "Ground Level Falls are Associated with Significant Mortality in Elderly Patients." *Journal of Trauma and Acute Care Surgery* 69, no. 4: 821–25.

Sterling, D. A., J. A. O'Connor, and J. Bonadies. 2001. "Geriatric Falls: Injury Severity is High and Disproportionate to Mechanism." *Journal of Trauma and Acute Care Surgery* 50, no. 1: 116–19.

Stiell, I. G., L. P. Nesbitt, W. Pickett, D. Munkley, D. W. Spaite, J. Banek, B. Field, L. Luinstra-Toohey, J. Maloney, J. Dreyer, et al. 2008. "The OPALS Major Trauma Study: Impact of Advanced Life-Support on Survival and Morbidity." *Canadian Medical Association Journal* 178, no. 9: 1141–52.

Turner, C. D., D. J. Lockey, and M. Rehn. 2016. "Pre-hospital Management of Mass Casualty Civilian Shootings: A Systematic Literature Review" [Review]. *Critical Care* (London, England) 20, no. 1 (November): 362.

Velmahos, G. C., K. Spaniolas, H. B. Alam, M. de Moya, A. Gervasini, L. Petrovick, and A.K. Conn. 2006. "Falls from Height: Spine, Spine, Spine!" *Journal of the American College of Surgeons* 203: 605–11.

Wightman, John M., and Sheri L. Gladish. 2001. "Explosions and Blast Injuries." *Annals of Emergency Medicine* 37, no. 6 (June): 664–78.

World Health Organization. 2014. "Injuries and Violence: The Facts." http://apps.who.int/iris/bitstream/handle/10665/149798/9789241508018_eng.pdf

World Health Organization. n.d. "Falls." Accessed July 27, 2018. http://www.who.int/news-room/fact-sheets/detail/falls

Injury Prevention Resources

Trauma System Agenda for the Future: https://one.nhtsa.gov/people/injury/ems/emstraumasystem03/introduction.htm, https://one.nhtsa.gov/people/injury/ems/emstraumasystem03/appendices-a.htm

CDC Traumatic Injury Prevention: https://www.cdc.gov/niosh/programs/ti/default.html

WHO Violence and Injury Prevention http://www.who.int/violence_injury_prevention/en/, https://www.dhs.gov/stopthebleed, https://stopthebleed.usuhs.edu, https://www.bleedingcontrol.org

2

Trauma Assessment and Management



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

John T. Stevens, NRP
Leon Charpentier, EMT-P
Alexandra Rowe, NRP
John E. Campbell, MD, FACEP

Untersuchung und initiale Maßnahmen bei Traumapatienten
Evaluación y Manejo del Paciente
Pregled i zbrinjavanje ozlijeđene osobe
Abordagem e Gestão da Vítima de Trauma
Pengkajian dan Penatalaksanaan Trauma
Оценка состояния потерпевшего после травмы
Evaluation et gestion des traumatismes
Εκτίμηση και Διαχείριση Τραυματία
Sérültvizsgálat és a kezdő beavatkozások
外傷傷病者の観察と治療
創傷評估與處置
Ocena in obravnava poškodb

Key Terms

AVPU, *p. 49*
DCAP-BLS, *p. 57*
focused exam, *p. 46*
general impression, *p. 49*
ITLS Patient Assessment, *p. 44*
ITLS Primary Survey, *p. 44*
ITLS Reassessment Exam, *p. 44*
ITLS Secondary Survey, *p. 46*
initial assessment, *p. 46*
load-and-go situation, *p. 54*
MIST Report, *p. 59*
rapid trauma survey, *p. 46*
SAMPLE history, *p. 53*
PMS, *p. 55*
TIC, *p. 57*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Outline the steps of the ITLS Trauma Assessment.
2. Describe the ITLS Primary Survey.
3. Explain the initial assessment and how it relates to the rapid trauma survey and the focused exam.
4. Describe when the initial assessment can be interrupted.
5. Identity which patients have critical conditions and how they should be managed.
6. List the 10 critical interventions made during the primary survey and when to make them.
7. List 10 life-threatening injuries that should be identified during the ITLS Primary Survey.
8. Describe the ITLS Reassessment Exam.
9. Describe the ITLS Secondary Survey.

ITLS Patient Assessment: the process by which the emergency care provider evaluates a trauma patient to determine injuries sustained and the patient's physiologic status; made up of the ITLS Primary Survey, ITLS Reassessment Exam, and ITLS Secondary Survey.

ITLS Primary Survey: an evaluation to assess scene safety and to find immediate life-threatening injuries; made up of the scene size-up, initial assessment, and either the rapid trauma survey or the focused exam.

ITLS Reassessment Exam: an abbreviated exam to determine changes in the patient's condition.

Chapter Overview

The **ITLS Patient Assessment** is made up of the **ITLS Primary Survey**, the **ITLS Reassessment Exam**, and the **ITLS Secondary Survey**. The ITLS Primary Survey is composed of the scene size-up, **initial assessment**, and **rapid trauma survey** or **focused exam**. The purpose of the primary survey is to determine if *immediately* life-threatening conditions exist and to identify those patients who should have immediate transport to the hospital. The reassessment exam is designed to identify changes in the patient's condition, and the secondary survey is a detailed evaluation for all injuries, not just life-threatening ones.

The scene size-up will set the stage for how you will perform the rest of the primary survey. If there is a dangerous generalized mechanism of injury (auto crash, fall from a height, etc.) or if the patient is unconscious and the mechanism of injury is unknown, you should extend the primary survey to include a rapid examination of the chest, abdomen, pelvis, extremities, and back. You would then perform interventions, transport, a reassessment exam, and possibly a secondary survey en route to the hospital.

If there is no significant life threat in the mechanism of injury (e.g., amputated big toe) you would do the initial assessment and, if normal, go directly to a focused exam based on the patient's chief complaint. The secondary survey would not be necessary.

To make the most efficient use of time, ITLS prehospital assessment and management of the trauma patient is divided into three exams (primary survey, reassessment exam, and secondary survey), and each exam is made up of certain steps (Figure 2-1). These exams are the foundation on which prehospital trauma care is built.



Case Presentation

You are dispatched to the scene of a single-auto crash. The driver has told police that he swerved to the right to avoid hitting a dog, before losing control, re-crossing the road, and running down a median embankment into a tree. You are told there is one patient. The dog has apparently escaped unharmed.

You arrive to find that police have secured the scene and the fire department crew is with the patient. They assure you that the scene is safe. As you approach, you note that the patient is a young adult male, is awake and in apparent respiratory distress, and is sitting in the driver's seat. A first responder is attempting to apply direct pressure to a large laceration to patient's right forearm.

You also note that the patient is not wearing a seat belt and that the steering wheel is bent.

Before proceeding, consider these questions:

- As you approach the patient, what should you be looking for? What does the mechanism of injury suggest?
- What does your initial impression suggest?
- What is you first treatment priority?
- What injuries is the patient likely to have?
- How can you immediately identify which of these injuries is life-threatening?
- What type of assessment should be performed?
- Is this a load-and-go situation?

Keep these questions in mind as you read through the chapter. Then find out how the emergency providers managed the situation.

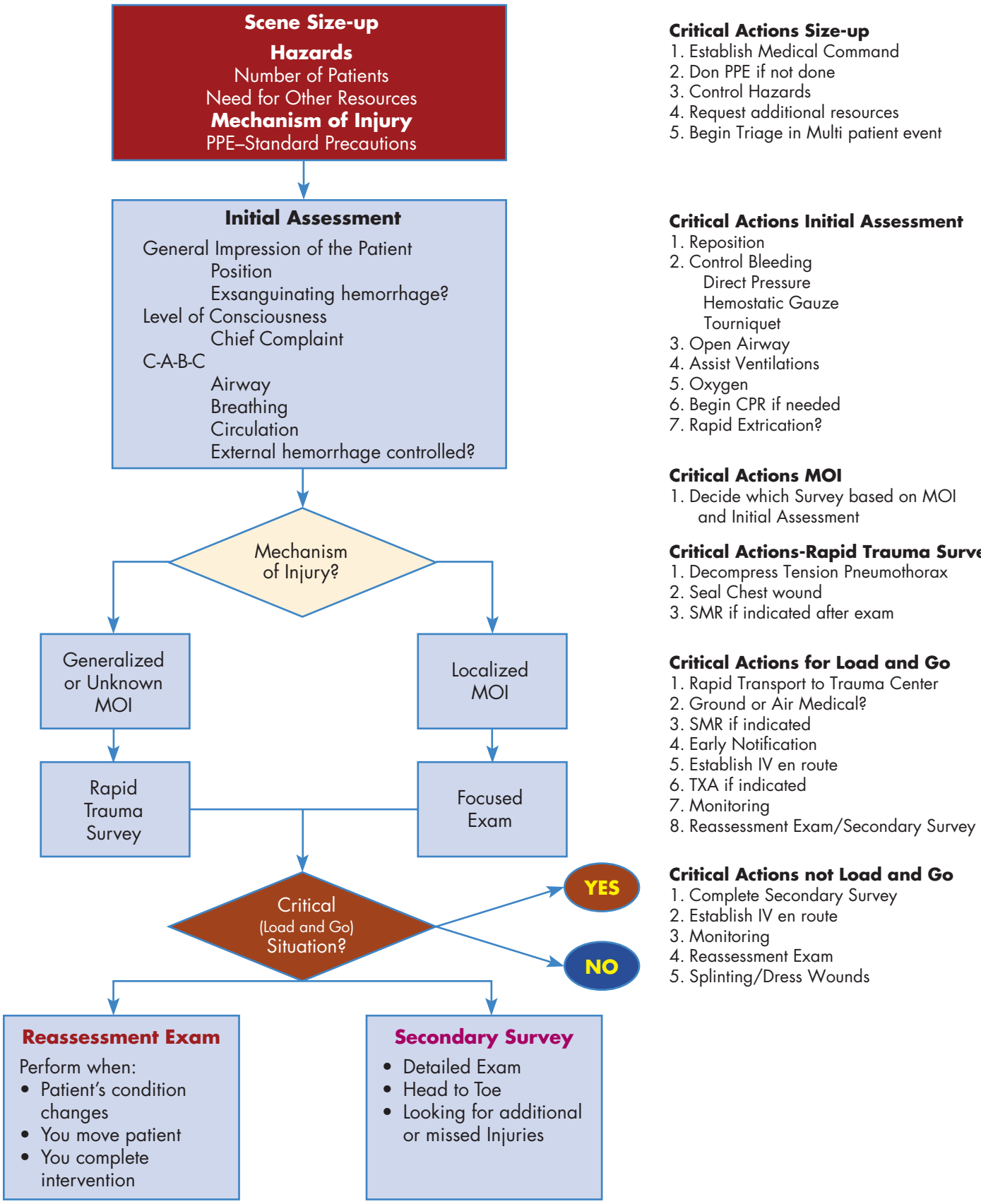


Figure 2-1 Steps in the assessment of the trauma patient.

ITLS Secondary Survey: a comprehensive head-to-toe exam to find additional injuries that may have been missed in the ITLS Primary Survey.

initial assessment: includes a general impression of the patient on approach, his or her level of responsiveness, airway status, breathing, and circulation to prioritize the patient and identify immediately life-threatening conditions; part of the primary survey.

rapid trauma survey: a brief exam from head to toe and back, performed to identify life-threatening injuries.

focused exam: an exam used when there is a focused mechanism of injury or an isolated injury; an exam that is limited to the area of injury.

reassessment exam: an exam performed repeatedly on an ongoing basis. Its purpose is to find any changes in the patient's condition.

ITLS Primary Survey

The ITLS Primary Survey includes an evaluation of the scene and preparation for patient assessment and management. It begins with the scene size-up and then, if the scene is safe to enter, moves to the initial assessment, followed by a rapid trauma survey or focused exam. (Figures 2-2 and 2-3).

Scene Size-up

On-scene assessment begins with certain actions that are performed before you approach the patient. It cannot be stressed enough that failure to perform preliminary actions can jeopardize your life as well as the patient's. Scene size-up begins with the dispatch information regarding the nature of the event. Based on this report, while en route to the scene you can begin to form a plan of action. Remember information provided may not be accurate. Based on this report, additional resources may be requested even before arrival on scene. On arriving, perform a scene size-up described in Chapter 1.

Once you begin your assessment of the critical patient, you may not have time to return to the vehicle for needed equipment. For that reason, always carry essential medical equipment with you to the patient's side. Anticipate that the following equipment may be needed for trauma patients, depending on your level of practice and local protocol.

- Personal
  - —Portable radio
  - —Small, high-intensity light
  - —Personal protective equipment (gloves, goggles)
  - —Spring-loaded punch for window entry
  - —Stethoscope
  - —Pen and pad; felt tip pen (initial triage marker)
- Trauma kit (carried by the team leader)
  - —Airway equipment: suction device, supraglottic airway (SGA), endotracheal intubation (ET) kit (including surgical mask/goggles), cricothyroidotomy set (if allowed under protocol)
  - —Bag-valve-mask device
  - —Oxygen tank, nonrebreather mask, and nasal cannula
- One- and 2-inch tape (2.5- & 5-cm), 10-pack sterile 4 × 4 (10-cm) dressing, 4-inch (10-cm) roller-gauze bandage, two large trauma dressings
  - —Commercial combat-style tourniquet, hemostatic dressings
  - —Seal for sucking chest wound, either commercially made chest seals or Vaseline-impregnated gauze
  - —Device for chest decompression, large-bore catheter (#14 gauge or larger) longer than 3.25 inch (8 cm) or a commercially made decompression catheter
  - —Rescue or warming blanket (may be contained with stretcher)
- Other equipment (may be carried by second or additional care provider)
  - —Spinal motion restriction (SMR) package, including long backboard or scoop stretcher, three to four straps, cervical immobilization device (CID) or sheet rolls and 2-inch (5-cm) tape, and adjustable cervical collar
  - —Stretcher or Stokes basket
  - —Burn sheets/irrigation fluids if MOI indicates burns
  - —Additional trauma dressings

Once the scene is safe to enter, as team leader, you must focus your attention on the rapid assessment of your patient. All decisions on treatment require that you have

PEARLS

Safety

Do not approach the patient before doing a scene size-up. Foolish haste may subtract an emergency care provider and add a patient.



Figure 2-2 The ITLS Primary Survey including the rapid trauma survey.

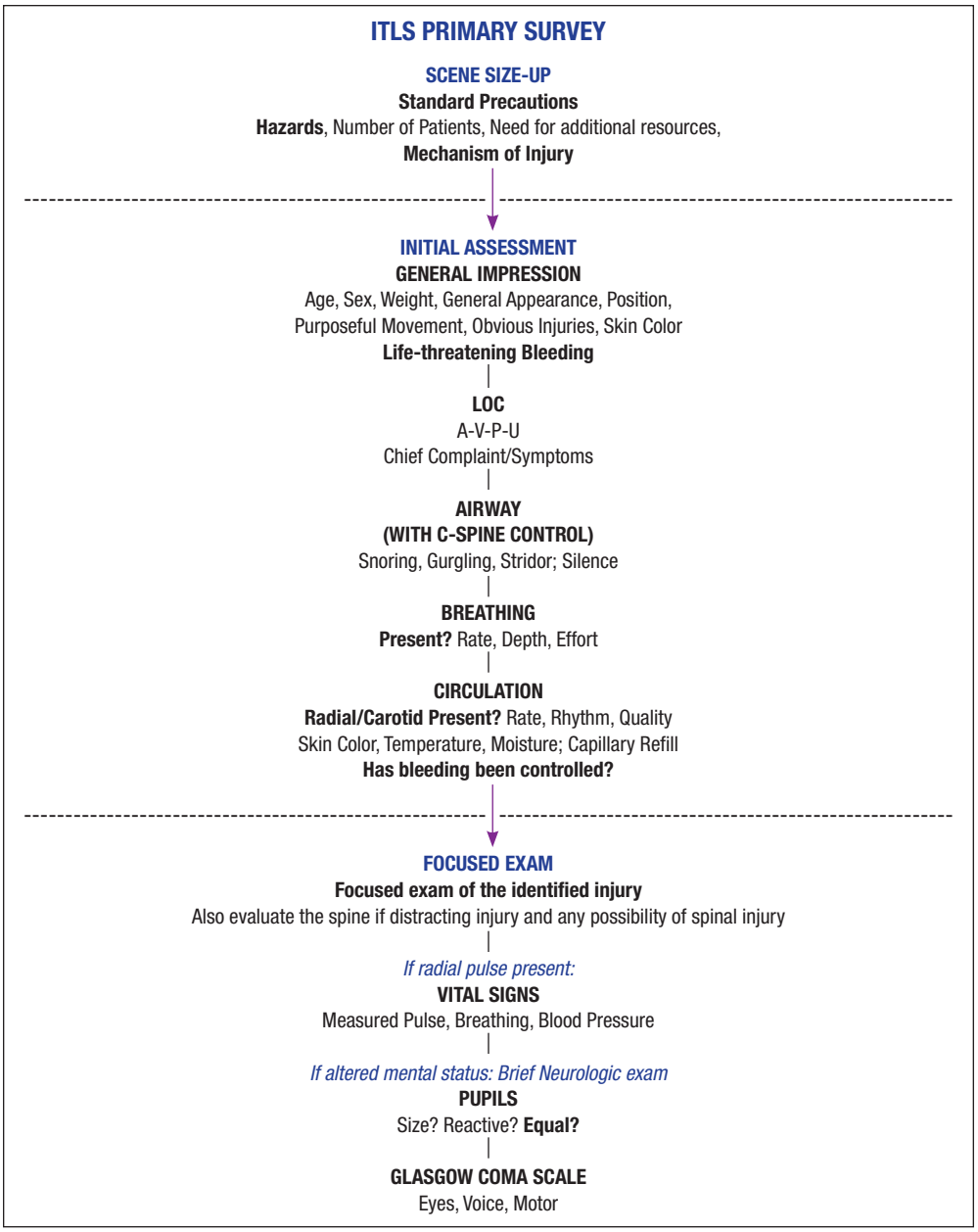


Figure 2-3 The ITLS Primary Survey including the focused exam.

identified life-threatening conditions. Remember, once you begin patient assessment in the ITLS Primary Survey, only four things should cause you to interrupt the assessment sequence. You may do so only if (1) the scene becomes unsafe, (2) you are alone and must treat exsanguinating hemorrhage, (3) you must treat an airway obstruction, or (4) you must treat cardiac arrest. (Management of external hemorrhage, respiratory arrest or dyspnea should usually be delegated to other team members while you continue assessment of the patient.)

For critical patients, the goal should be to complete the ITLS Primary Survey in less than 2 minutes and to have an on-scene time of 5 minutes or less. Therefore, all on-scene interventions should be life-saving. Other interventions in the critical patient should be delayed until the patient is in the ambulance and on the way to the hospital.

Experience has shown that injuries are missed or treatment errors occur because the team leader stops the primary survey to perform interventions and forgets to perform part of the assessment. To prevent this, when immediate interventions are needed,

PEARLS

Interruptions

The team leader should delegate any intervention required during the ITLS Primary Survey and should not interrupt the completion of the survey except for scene danger, exsanguinating hemorrhage, airway obstruction, or cardiac arrest.

delegate them to your team members while you continue your assessment. This is an important concept that immediately addresses problems identified, yet does not interrupt the assessment sequence and does not increase scene time. *Teamwork is essential to good patient outcomes.*

As you perform your assessment, you will identify critical interventions that need to be made immediately. You should clearly instruct other team members to carry out these interventions. Should you be the only one capable of performing chest decompression, have a team member prepare your equipment so that you may insert the device immediately upon completion of the pretransfer portion of the primary survey.

Initial Assessment

The purpose of the initial assessment is to determine if there may be immediate life threats. Once you have determined that it is safe to approach the patient, assessment should proceed quickly and smoothly. It consists of your general impression as you approach the patient, followed by an assessment of the patient's level of consciousness (LOC) as you begin to interact with him or her and take an initial history. The patient's response will also give you information about three other important elements: the status of the airway, breathing, and circulation.

Form a General Impression of the Patient on Approach

As you approach the patient, you will get a **general impression** of the patient. Note the patient's approximate age, sex, weight, and general appearance. Older adults and very young children are at increased risk for missed injuries. Female patients may be pregnant. Observe the position of the patient, both body position and position in relation to his or her surroundings. Note the patient's activity. Are they aware of the surroundings, moving purposefully, anxious, and/or obviously in distress? Does the patient have any obvious injuries? (Be careful not to be distracted by these injuries.) Does the patient have any major external bleeding? If so, direct a team member to immediately apply direct pressure, apply a pressure dressing, or if that fails to control the hemorrhage, apply a tourniquet.

Your observation of the patient in relation to the scene and the mechanism of injury will help you prioritize the patient. Be sure to position patient so he or she can be adequately assessed. If there are several or many patients, rapidly triage them using the ITLS Initial Assessment or the MCI triage algorithm used by your agency.

Evaluate Initial Level of Consciousness While Beginning a History and Assessing the Need for Cervical Spine Stabilization

Assessment begins immediately on your arrival, even if the patient will have to be extricated. If the mechanism of injury, the general impression of the patient, or if the patient complains of spinal pain or tenderness or if the patient with a decreased level of consciousness prevents adequate assessment of the potential for spinal injury, spinal motion restriction beginning with initial manual stabilization of the cervical spine may be indicated.

As you approach the patient, identify yourself: "My name is _____. We are here to help you. Can you tell me what happened?" Try to approach the patient in his or her field of view, so he or she does not turn the neck. The patient's reply gives immediate information about both his or her LOC and the status of the airway. If the patient responds appropriately to questioning, it indicates that the LOC is normal and the airway is open. If the response is not appropriate (the patient is unconscious or awake but confused), make a note of the LOC using the **AVPU** scale (Table 2-1). Anything below "A" (alert) on the scale should trigger a systematic search for the causes of the altered mental status. A decreased LOC can be caused by many things, including obstructed airway, respiratory failure, shock, and increased intracranial pressure, as

general impression: a brief note of the patient's age/sex/weight, position, and any obvious injuries, including life-threatening external bleeding.

AVPU: an abbreviated description of the patient's level of consciousness. AVPU stands for alert, responds to verbal stimuli, responds to pain, and unresponsive.

PEARLS

C-A-B-C-D-E

C–Control life-threatening bleeding
A–Airway
B–Breathing
C–Circulation
D–Disability (neurologic status)
E–Expose injuries and protect from **E**nvironment
Do not confuse the immediate attention to life-threatening bleeding (first C in C-ABC) with the AHA/ILCOR "CAB" for cardiac arrest, where "C" stands for compressions.
Note that tactical medical providers (TCCC and C-TECC) use the MARCHE mnemonic instead:
M–Massive hemorrhage
A–Airway control
R–Respiratory support
C–Circulatory support
H–Hypothermia, head injury
E–Everything else

Table 2-1: Levels of Mental Status (AVPU)
A—Alert (awake, oriented, and obeys commands)
V—Responds to Verbal stimuli (awake but confused or unconscious but responds in some way to verbal stimuli)
P—Responds to Pain (unconscious but responds in some way to touch or painful stimuli)
U—Unresponsive (no gag or cough reflex)

well as drugs or metabolic disorders. The Rapid Trauma Survey will lead you in a systematic, organized way to look for the causes of the altered LOC.

PEARLS

ITLS Recommendations for When to Initiate SMR

Appropriately applied SMR should be considered for patients who fit the following criteria:

- Spinal deformity, pain, or tenderness
- Blunt trauma and altered level of consciousness
- High-energy mechanism of injury
- Altered mental status due to drug or alcohol intoxication
- Focal neurologic complaint
- Cannot be adequately assessed clinically for the presence of spinal injuries

Assess the Airway

If the patient cannot speak or is unconscious, further evaluation of the airway should follow. The presence of airway obstruction is indicated by snoring, gurgling, stridor, or silence. Remember, a need to establish an open airway is one of the four reasons to interrupt the ITLS Primary Survey.

If the patient is snoring, **position the airway**. If there is a risk of cervical injury, avoid extending the neck to open the airway of a trauma patient. Use jaw-thrust or chin-lift.

If there is gurgling, **suction the airway**. Be careful not to elicit a gag reflex if the patient is supine, since vomiting could then easily lead to aspiration.

If the patient has stridor (a high-pitched inspiratory sound), prepare to **intubate**.

If the airway is silent, assess breathing. If apneic, **ventilate**. If unable to achieve chest rise, secure the airway via **intubate or SGA**.

Assess Breathing

Look, listen, and feel for movement of air. If the patient is unconscious, place your ear over the patient's mouth so you can judge both the depth (tidal volume) and rate of ventilations. Look at the movement of the chest (or abdomen), listen to the sound of air movement, and feel both the movement of air on your cheek and the movement of the chest wall with your hand. If the chest is moving but you do not feel air at the mouth or nose, the patient is *not* breathing adequately. Notice if the patient uses accessory muscles to breathe. If ventilation is inadequate (Table 2-2), the emergency care provider should begin to assist ventilation immediately, using his or her knees to restrict

Table 2-2: Normal Vital Signs by Age

Age	Heart Rate	Resp Rate	Systolic BP	Temp (°C)
0 d–1 m	> 205	> 60	< 60	< 36 or > 38
≥ 1 m–3 m	> 205	> 60	< 70	< 36 or > 38
≥ 3 m–1 r	> 190	> 60	< 70	< 36 or > 38.5
≥ 1 y–2 y	> 190	> 40	< 70 + (age in yr × 2)	< 36 or > 38.5
≥ 2 y–4 y	> 140	> 40	< 70 + (age in yr × 2)	< 36 or > 38.5
≥ 4 y–6 y	> 140	> 34	< 70 + (age in yr × 2)	< 36 or > 38.5
≥ 6 y–10 y	> 140	> 30	< 70 + (age in yr × 2)	< 36 or > 38.5
≥ 10 y–13 y	> 100	> 30	< 90	< 36 or > 38.5
> 13 y	> 100	> 16	< 90	< 36 or > 38.5

National Model EMS Clinical Guidelines, Ver. 2.1, NASEMSO, 2017.

movement of the patient's neck if indicated by a possible cervical injury. When assisting or providing ventilation, be sure that the patient gets an adequate ventilatory rate (one breath every 6 seconds) and an adequate tidal volume, *as evidenced by an adequate chest rise* (about 500 mL for an average adult or 6–10 mL/kg for a child). Emergency providers tend to ventilate too fast and too deep when using a bag-valve-mask.

Later, when you are able, monitor ventilation with capnography (recommended); you should maintain the end-tidal CO_2 ($etCO_2$) at about 35–45 mmHg. All patients who are breathing abnormally should receive supplemental oxygen. However, recent studies, primarily in medical patients (McEvoy 2018), suggest that too much oxygen may be harmful, so it would be prudent to try to keep the pulse oximeter reading around 95% rather than 100%.

Circulation

Has the external bleeding been controlled? Most bleeding can be stopped by applying direct pressure and pressure dressings. However, if direct pressure and a pressure dressing fail to stop the bleed, place a tourniquet on the extremity above the wound. If a pressure dressing becomes soaked with blood, remove the dressing and apply pressure directly on the site of bleeding and redress the wound. Hemostatic dressings are useful in this situation (see Chapter 5).

Now note the rate and quality of the pulses at the radial artery (brachial in the infant). Decide whether the rate is too slow (<60 in an adult) or too fast (>120). For pediatric patients, rates vary by age. (See Table 18-2 in Chapter 18.)

Also note its quality (thready, bounding, weak, irregular). While at the wrist, note the capillary return time. Capillary refill may be affected by ambient temperature. Note the skin color, temperature, and condition. Pale, cool, clammy skin, a thready radial pulse, and decreased LOC are all early signs of decreased perfusion (shock).

If the pulse is not palpable at the wrist, check for the presence of a carotid pulse. If absent at the neck (and the patient is not breathing normally), begin CPR immediately unless there is massive blunt trauma or other nonsurvivable injury (see Chapter 16). Address the treatable causes of traumatic cardiac arrest. Remember, this is one of the four reasons to interrupt assessment during the ITLS Primary Survey.

Rapid Trauma Survey or Focused Exam

The choice between performing the rapid trauma survey and the focused exam depends on both the mechanism of injury and the results of the initial assessment. If there is a dangerous generalized mechanism of injury (such as an automobile crash or fall from a height) or any chance of multisystem trauma, you should perform a rapid trauma survey (see Figure 2-2). You should also perform a rapid trauma survey if the patient is unconscious and you do not know the mechanism of injury. If there is a dangerous focused mechanism of injury suggesting an isolated injury (bullet wound to the thigh or amputation of the hand, for example), you may perform a focused exam (see Figure 2-3), which is limited to the area affected by the injury. As a practical matter, with penetrating injuries (stab or bullet wound) where there appears to be only one wound, there may be others of which the patient is not aware. Perform a detailed search for other wounds.

Finally, if there is no significant mechanism of injury (such as a rock dropped on a big toe) and the initial assessment is normal (alert with no history of LOC, normal breathing, radial pulses less than 120, and no complaint of dyspnea, chest, abdominal, or pelvic pain), you may move directly from the initial assessment to a focused exam based on the patient's chief complaint.

You have identified a priority patient if you find any of the following:

- Dangerous mechanism of injury
- High-risk group (very young, very old, chronically ill)

- Initial assessment reveals:
  - —Altered mental status
  - —Abnormal breathing
  - —Abnormal circulation (shock or uncontrolled bleeding)
- History that reveals:
  - —Loss of consciousness
  - —Difficulty breathing
  - —Severe pain of head, neck, or torso

Rapid Trauma Survey

The rapid trauma survey is a brief exam done to find all life threats (see Figure 2-2). A more thorough assessment—the ITLS Secondary Survey—will follow later if time allows.

Having completed the initial assessment, begin the rapid trauma survey by obtaining a brief, targeted history (What happened? Where do you hurt? Does your neck hurt?) while you quickly assess the head and neck for obvious wounds. If the patient complains of neck pain or tenderness or can't feel/move their extremities, consider the need for initial manual control of the cervical spine and possible further spinal motion restriction during extrication and, if indicated, during transport.

Having checked the head and neck for injuries, next evaluate the neck veins, which, if engorged, indicate positive pressure in the chest (suggesting tension pneumothorax or cardiac tamponade). If they are distended, look and palpate at the sternal notch for tracheal deviation. If indicated, a rigid cervical collar should be applied at this time.

Expose and examine the chest. Look to see if it is moving symmetrically. If not, is there paradoxical motion? Are there contusions or abrasions? Are there penetrations or sucking chest wounds? Briefly palpate for tenderness, instability, or crepitation. Then listen to breath sounds to determine if they are present and equal bilaterally. Listen with the stethoscope to the lateral chest at about the forth intercostal space in the midaxillary line on both sides. If breath sounds are not equal (decreased or absent on one side), percuss the chest to determine whether the patient is just splinting from pain or if a tension pneumothorax (hyperresonant) or a hemothorax (dull) is present. If abnormalities are found during the chest exam (flail chest, sucking chest wound, tension pneumothorax) treat them as you discover them. Delegate the appropriate intervention (e.g., seal open chest wound) to another team member. If a tension pneumothorax is identified, (see Chapters 8 and 9) perform chest decompression immediately. Before moving to the abdomen, very briefly notice heart sounds so you will have a baseline for changes, such as development of muffled heart sounds.

Briefly examine the abdomen, looking for bruises, penetrating wounds, impaled objects, or generalized distention. Palpate briefly for tenderness and rigidity. (Tenderness, rigidity, and distension are global signs, not confined to a quadrant. Localized palpation will come later.) Be aware that an unconscious patient or one with a cervical spine injury may have a false-negative abdominal exam.

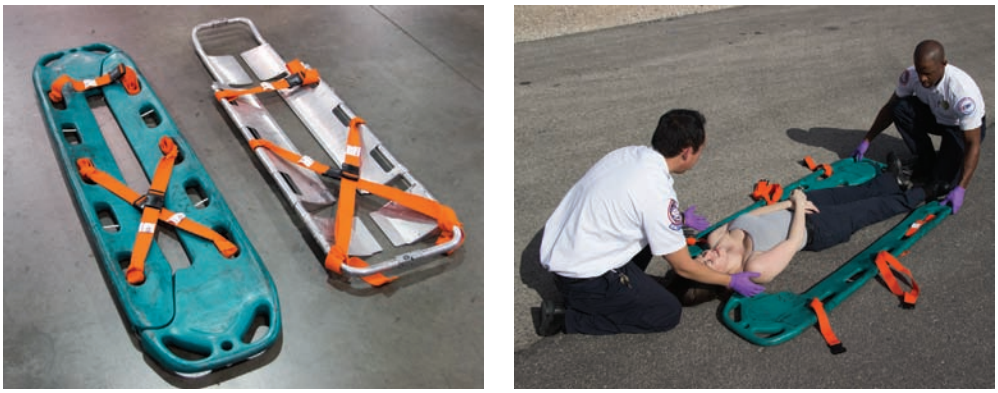
Compress the pelvic girdle by pressing gently on the anterior iliac crests and at the hip joints, and pressing gently down on the symphysis. If the pelvis is unstable, direct a team member to get the scoop stretcher and possibly the pelvic compression device or a sheet. If the pelvis is unstable, do *not* palpate it again.

Very quickly, examine the lower and upper extremities for bleeding, gross deformity or swelling. While doing so, be alert to the existence of any medication patches or medical ID tags. An unstable pelvis and bilateral femur fractures indicate an unstable patient at risk for shock. Before moving your patient, check to make sure they can feel and move their feet and hands. (Note that, in some cases, it will not be necessary to remove the patient's clothing below the abdomen since evidence of life threats is often obvious or assessed by palpation.)

PEARLS

Ten Life-Threatening Injuries

1. Massive hemorrhage (external, hemothorax, abdomen, pelvis/femur)
2. Airway obstruction
3. High C-spine injury
4. Traumatic aortic disruption
5. Flail chest
6. Open pneumothorax
7. Tension pneumothorax
8. Cardiac tamponade
9. Cardiac contusion
10. Traumatic brain injury (increased ICP)



A B

Figure 2-4 Scoop stretchers may be used to transfer patients onto a stretcher.

At this point, transfer the patient to a long backboard, scoop stretcher, or other patient transfer device, while checking the posterior of the patient. If the patient has an unstable pelvis or bilateral femur fractures, to prevent further injuries, use a scoop stretcher (Figure 2-4) to transfer the patient to the ambulance stretcher. A study has demonstrated that a scoop stretcher provides stabilization equal or superior to a rigid backboard, and you may use it instead of a backboard (Krell 2006). Remember that if you use a scoop stretcher, you are still responsible to do your best to evaluate the posterior side of the patient. Transfer your patient to the ambulance as soon as you have him or her secured to the ambulance stretcher. Except for very short transport times to the hospital, remove the backboard and secure the patient to the stretcher before transport.

Once in the ambulance, if the patient has a radial pulse, take the time to obtain baseline vital signs, including blood pressure (bilateral extremities, if possible), pulse and respiratory rate, and the rest of a brief target history (see below).

If the patient has an altered mental status, do a brief neurological exam to identify possible increased intracranial pressure (ICP). This exam should include the reactivity and equality of pupils, the Glasgow Coma Score (GCS) or, at a minimum, the Glasgow Motor Score (Acker et al. 2014; Caterino and Raubenolt 2012), and signs of cerebral herniation (see Chapter 12). It is critical to identify herniation because it will have important implications with respect to (1) the rate at which you provide ventilation, (2) your aggressiveness in treating shock, and very possibly (3) the destination of the patient.

Also look for medical identification devices. Head injury, shock, and hypoxia are not the only things that cause altered mental status; also think about nontraumatic causes such as hypoglycemia and drug or alcohol overdose. Remember that medical events may result in the patient sustaining a traumatic event. Never assume a patient with altered mental status is "just drunk." All patients with altered mental status should have a fingerstick glucose performed during transport and as a part of the neurological assessment.

Once you have completed the ITLS Primary Survey, transport the patient to the nearest *appropriate* facility.

SAMPLE History

At the same time you are performing the physical assessment of the patient, you or one of your team members should obtain a **SAMPLE history** (Table 2-3). This is especially important if you must gather information from bystanders because they will not be going with you when you transport the patient

PEARLS

Bilateral Blood Pressure

Asymmetric reading may be a clue that the patient is suffering a traumatic aortic disruption.

PEARLS

On-Scene Time

Survival of the trauma patient is time-dependent (Brown et al. 2016; Pham 2017) Critical trauma patients often need definitive care in the operating room. Delegate interventions that must be done on scene. If possible, do other interventions during transport.

SAMPLE history: the minimum amount of information needed for a trauma patient; the letters in SAMPLE stand for symptoms, allergies, medications, past medical history, last oral intake, and events preceding the incident.

PEARLS

Life-Saving Interventions That May Be Performed on the Scene

1. Control life-threatening external bleeding
2. Establish/maintain patent airway
3. Ventilate
4. Administer oxygen
5. Initiate CPR
6. Seal sucking chest wound
7. Decompress tension pneumothorax
8. Stabilize impaled objects
9. Spinal motion restriction

Table 2-3: SAMPLE History

S—Symptoms
A—Allergies
M—Medications
P—Past medical history (Other illnesses?)
L—Last oral intake (When was the last time there was any solid or liquid intake?)
E—Events preceding the incident (Why did it happen?)

Remember, the prehospital providers are the only ones who get to experience the scene and also may be the only ones who get to take a history. Patients who are initially alert may lose consciousness before arriving at the hospital. You are not only making interventions to deliver a living patient to the hospital, but you also must be the detective who figures out what happened and why. Pay special attention to the patient's complaints (symptoms) and events prior to the incident (the *S* and *E* of the SAMPLE history). A more detailed history may be taken later while en route. The patient's symptoms can suggest other injuries, and this will affect further examination. It is important to know as much about the mechanism of injury as possible. (Was the patient restrained? How far did he or she fall? What caused him or her to fall?) Look for clues to serious injury such as a history of LOC, shortness of breath, or pain in the neck, back, chest, abdomen, or pelvis.

Critical Interventions and Transport Decision

When you have completed the ITLS Primary Survey, enough information is available to decide if a critical situation is present. Patients with critical situations should be transported immediately. Most treatment interventions will be done during transport.

If your patient has any of the following critical injuries or conditions, you have a **load-and-go situation**. Transport immediately.

load-and-go situation: refers to a critical patient who needs to be transported as soon as possible after the primary survey is completed.

- *Initial assessment reveals:*
  - —Altered mental status
  - —Abnormal breathing
  - —Abnormal circulation (shock or uncontrolled bleeding)
- *Signs discovered during the rapid trauma survey of conditions that can rapidly lead to shock:*
  - —Penetrating wounds to the torso
  - —Abnormal chest exam (flail chest, open wound, tension pneumothorax, hemothorax)
  - —Tender, distended abdomen
  - —Pelvic instability
  - —Bilateral femur fractures
- *Significant mechanism of injury and/or poor general patient health*

Even though the patient appears to be stable, if there is a dangerous mechanism or other dangers (such as age, poor general health, death of another person in the same vehicle), consider early transport.

Contacting Medical Direction/Receiving Hospital

When you have a critical patient, it is extremely important to contact medical direction as early as possible. It takes time to mobilize the necessary resources in place, such as the appropriate surgeon and the operating room team, and the critical patient may have no time to wait after arrival at the hospital. Always notify the receiving facility of your estimated time of arrival (ETA), the condition of the

patient, and any special needs on arrival. Guidelines such as the CDC's Guidelines for Field Triage of Injured Patients (Sasser et al. 2012) will help you determine which type of medical facility your patient should be transported to. Similarly, guidelines exist to help you determine which trauma patients can benefit from air medical transport (Thomas et al. 2014).

ITLS Reassessment Exam

The ITLS Reassessment Exam may be performed a number of times during extended transport. It should be performed and recorded no less than every 5 minutes for critical patients and every 15 minutes for stable patients. This reassessment exam is also indicated as follows:

- Any time the patient's condition changes
- Each time the patient is moved
- Each time an intervention is performed

This exam is meant to find any changes in the patient's condition, so concentrate on reassessing only those things that may change. For example, if you have applied a traction splint, reassess the limb for decreased pain and for the presence of distal pulses, motor function, and sensation (**PMS**). In contrast, if you decompress the chest, you must reassess everything in the initial assessment and a good deal of the rapid trauma survey.

PMS: stands for pulses, motor function, and sensation

Having moved the patient to the ambulance and completed the ITLS Primary Survey, measured vital signs, and performed a brief neurological exam, transport the patient and begin the ITLS Reassessment Exam, completing exposure of the patient if he or she is unstable. In the critical multitrauma patient, the first ITLS Reassessment Exam may essentially repeat the ITLS Primary Survey, including both the initial assessment and the rapid trauma survey.

Procedure

Performing an ITLS Reassessment Exam

The ITLS Reassessment Exam should be performed in the following order (Figure 2-5).

1. Check that all serious external bleeding is controlled. Record time a tourniquet was applied.
2. Ask the patient if there have been any changes in how he or she feels. Complete a SAMPLE history if not already done.
3. Reassess mental status (LOC and pupils). If the patient has an altered mental status, check a fingerstick glucose and recheck the GCS or Glasgow Motor Score. Also consider the possibility of a drug overdose and consider administration of naloxone.
4. Recheck vital signs (BP, pulse, and respiratory rate); check SpO_2; and apply and check a cardiac monitor, $etCO_2$, and temperature.
5. Recheck ABCs.
   a. Reassess the airway; does the patient need to be intubated?
   b. Reassess breathing: rate, depth, effort (labored?)
   c. Reassess circulation: skin color, temperature, moisture; CRT
6. Check the neck: neck vein distension? trachea?
7. Reassess the chest:
   a. Is chest movement symmetrical?
   b. Are breath sounds unequal?
   c. Are heart sounds muffled?
   d. If chest abnormal, does monitor show any cardiac arrhythmias? If so, perform a 12-lead ECG.
8. Recheck the abdomen for tenderness, distension, or rigidity.
9. Recheck all identified injuries, PMS distal to fractures.

Accurately record what you see and do. Record changes in the patient. Record the time of interventions. Extenuating circumstances or significant details should be recorded in your report.

(*continued*)

Procedure *(continued)*

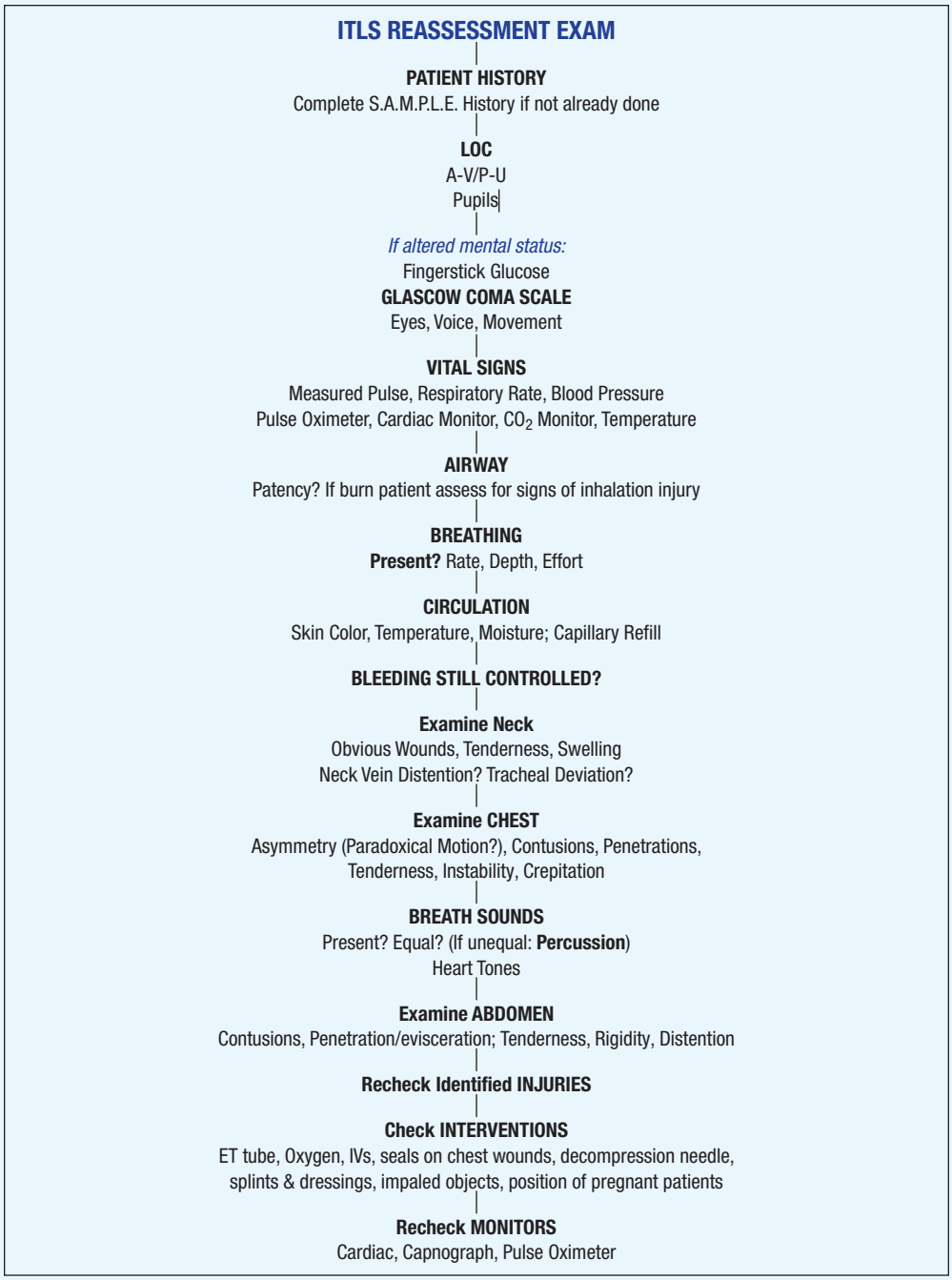


Figure 2-5 ITLS Reassessment Exam.

ITLS Secondary Survey

The ITLS Secondary Survey is a more comprehensive exam designed to identify additional injuries that may have been missed in the brief ITLS Primary Survey, which focused on identifying life threats. This detailed exam also establishes a baseline from which treatment decisions will eventually be made. It is important to record

the information discovered in this assessment. Whether or not to perform an ITLS Secondary Survey depends on the situation:

- If the patient is critical, this assessment should be done during transport rather than on scene.
- If there is a short transport and you must perform interventions, you may not have time to do the ITLS Secondary Survey.
- If the ITLS Primary Survey does not reveal a critical condition, the ITLS Secondary Survey may be performed on scene. Stable patients with no dangerous mechanism of injury and an isolated injury do not require an ITLS Secondary Survey.

When you perform the ITLS Secondary Survey, you should always begin by quickly repeating the Initial Assessment. You can do this as another team member takes vital signs.

DCAP-BLS: short for **D**eformities, **C**ontusions, **A**brasions, **P**enetrations, **B**urns, **L**acerations, **S**welling.

TIC: short for **T**enderness, **I**nstability, **C**repitus.

Procedure

Performing an ITLS Secondary Survey

The exam should contain the following elements (Figure 2-6):

1. Repeat the initial assessment.
2. Use available monitoring (pulse ox, cardiac monitor). These are usually applied during transport.
3. Record vital signs again.
4. Do a brief neurological exam, including LOC (GCS; see Table 2-4), pupils.
5. Perform a detailed head-to-toe exam. Pay particular attention to the patient's complaints and recheck injuries that you found previously. The exam should include inspection, auscultation, and palpation (and sometimes percussion). You will be looking for deformities, contusions, abrasions, penetrations, burns, lacerations, and swelling (**DCAP-BLS**) and palpating for tenderness, instability, and crepitus (**TIC**). When checking the abdomen, gently palpate for tenderness and guarding, as well as generalized rigidity and distension, which would indicate probable blood loss and a potentially life-threatening situation.
6. Visually examine and palpate both lower and upper extremities for injuries, and assess for distal PMS. Do this before and after splinting any fractures. Angulated upper extremities can usually be splinted as found. Most fractures of the lower extremities, especially femur fractures, are gently straightened and then stabilized with traction splints. Critical patients have extremity fractures splinted only en route.

Transport immediately if the ITLS Secondary Survey reveals the development of any critical injuries. (A cardiac contusion may well only be discovered during a reassessment exam or the secondary survey.)

After you finish the secondary survey, you should finish splinting and bandaging.

Table 2-4: Glasgow Coma Scale

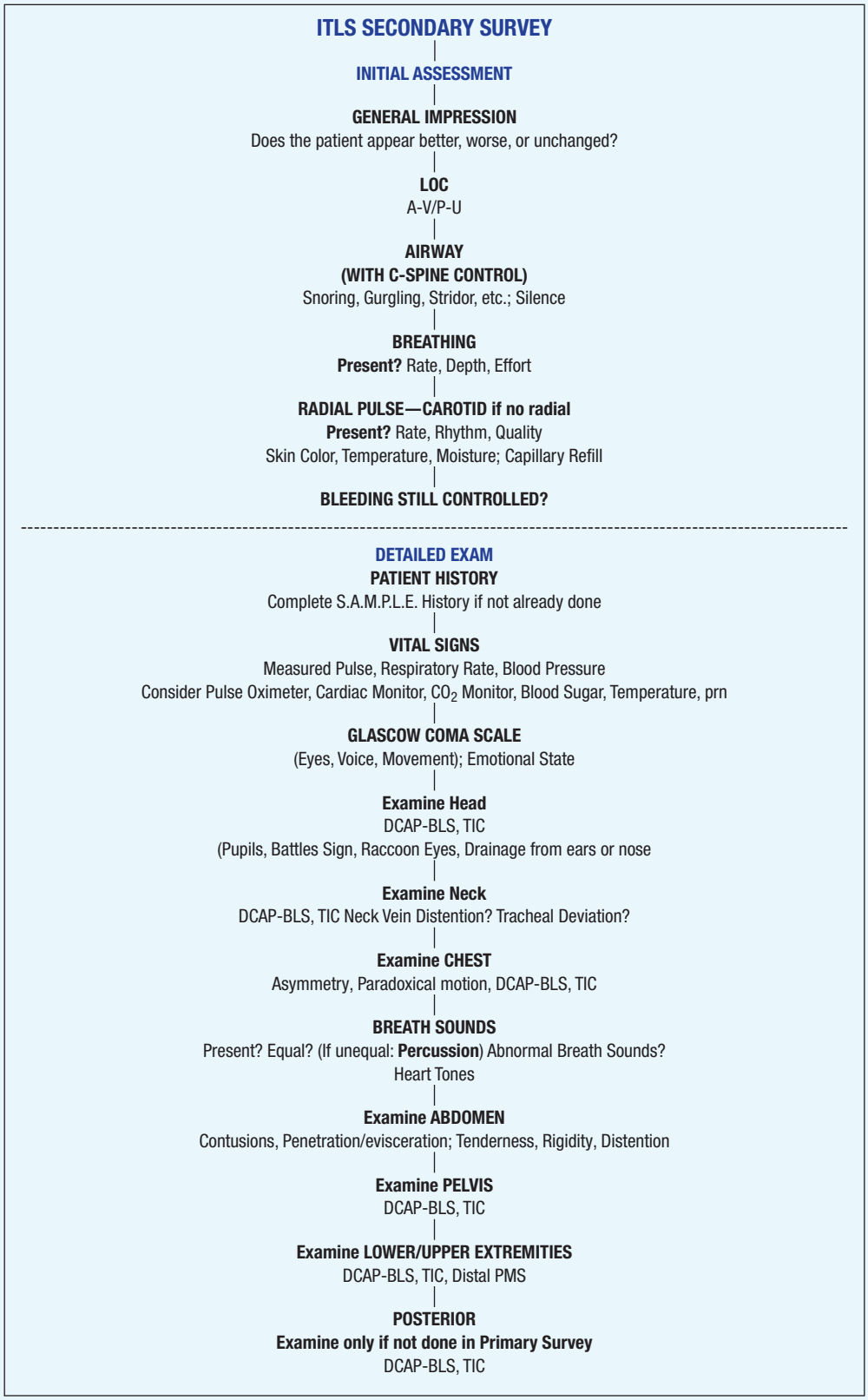
Eye Opening		Verbal Response		Motor Response	
	Points		Points		Points
Spontaneous	4	Oriented	5	Obeys commands	6
To voice	3	Confused	4	Localizes pain	5
To pain	2	Inappropriate words	3	Withdraws	4
None	1	Incomprehensible sounds	2	Abnormal flexion	3*
		Silent	1	Abnormal extension	2**
				No movement	1

** Decorticate posturing to pain.*
*** Decerebrate posturing to pain.*

(*continued*)

Procedure *(continued)*

Figure 2-6 ITLS Secondary Survey.



You should have begun obtaining a SAMPLE history during the ITLS Primary Survey and the reassessment exam, but now you can obtain further information, if needed. Perform your ITLS Secondary Survey while you ore obtaining the rest of the history.

Adjuncts for Trauma Patient Assessment

One of the decisions to be made when assessing a trauma patient is determining the level of trauma center to which to take the patient. Patients with unstable vital signs and those with serious anatomic injuries should be transported to a trauma center, if available, but the decision can be more difficult for patients with normal vital signs and a normal level of consciousness who also have a significant mechanism of injury.

Ideally, the emergency care provider should take the most severely injured patients to the appropriate trauma center as quickly as possible because this has been shown to have the best patient outcomes (Ashely et al. 2015). However, avoid taking every injured patient to a trauma center, as overtriage overloads this resource with patients who do not have critical injuries. New tools are becoming available to help emergency care providers distinguish between patients who have injuries that are either not severe or not time critical and will remain stable and those who appear stable initially and then decompensate later, requiring emergent transfer to a trauma center.

Two adjuncts for trauma assessment that may prove helpful in this situation by distinguishing between the two patient groups: serum lactate and ultrasound. *Serum lactate* is a marker for tissue hypoxia and has been used in the hospital setting to monitor critical patients. In the field it appears to be useful to predict which patients with normal vital signs are having occult internal bleeding and will soon develop hemorrhagic shock. Many EMS systems have been using prehospital fingerstick serum lactate levels to predict who will develop shock (Van Beest et al. 2009).

Portable *ultrasound* can be used to assess for intra-abdominal hemorrhage, pneumothorax, and cardiac tamponade, among other things. Abdominal trauma sonography is very commonly used in the initial assessment of trauma patients in the emergency department and is called the FAST (Focused Assessment with Sonography in Trauma) exam. It is noninvasive and only takes from 1 to 3 minutes to perform. In many emergency departments, FAST has replaced the diagnostic peritoneal lavage in the initial assessment for blood in the abdomen after blunt trauma. Because it is portable and not difficult to learn to use for simple exams, FAST is being used in the field by some ground and air services (especially in Europe), and the information obtained is being used to determine which patients are transported directly to a trauma center and which are transported to a community hospital instead. Initial studies report (Brooke, Walton, and Scott 2010; Korner et al. 2008; Walcher et al. 2006) that it has a very high (90% and higher) predictive value for intra-abdominal bleeding. A review of prehospital ultrasound in all types of patients points out the importance of appropriate training to ensure effectiveness of this tool (Arshad 2018).

Hopefully, those and other assessment adjuncts will prove to give emergency care providers more options to improve patient care and health care resource utilization.

Transfer of Care

It is extremely important for your patient that any time you transfer care of a patient, such as when you arrive at the treating facility, that you provide a clear and concise report of what happened to your patient, what injuries you have identified, and what treatments you have given. It is very easy to overlook key information in the excitement of caring for a critical patient. Personnel should use an organized approach to reporting information at the bedside. Additionally, those who are receiving the patient should pay careful attention to the information provided by the EMS crew, the concept of an EMS "time-out" (Goldberg et al. 2017). One example of a patient information transfer scheme is to use the **MIST Report** format, which is used by many military medical personnel: M, Mechanism of injury or Medical complaint; I, Injuries or Illness identified; S, Signs and symptoms (include vital signs); T, Treatment(s) given (see Figure 2-7).

MIST Report: U.S. and NATO militaries have adopted this format to keep the report brief:

* **M**echanism of Injury/**M**edical Problems identified
* **I**njuries found
* **S**igns/Symptoms/Significant history
* **T**reatment rendered

MIST Report

M	**M**echanism of Injury or **M**edical Complaint Age, Sex (include patient's name for handoff),
I	**I**njuries or **I**llness Identified Time of Injury, list injuries head to toe; (brief medical exam/findings)
S	Vital **S**igns/**S**ymptoms/**S**ignificant PMH Vital Signs: first set and significant changes; include glucose, spO_2, $etCO_2$ For Trauma Highest and Lowest Blood pressure and highest heart rate
T	**T**reatments that have been performed

Figure 2-7 MIST Report.

Case Presentation *(continued)*

As ambulance crew approach the vehicle as part of the general impression, as the lead medic you note that a first responder is with a young male patient sitting in the driver's seat. The driver is apparently awake and in obvious respiratory distress. You observe that the steering wheel is bent and that the patient is not wearing a seat belt. The first responder is attempting to apply direct pressure to a large laceration to the patient's right forearm. You direct your team to provide the first responder with a hemostatic dressing with which to dress the wound.

Your ITLS Initial Assessment reveals a patient who responds to verbal stimuli and is complaining of chest pain and difficulty breathing. He has an open airway and his breathing is labored but felt at the mouth at a rate of 20–30. He has a weak, thready radial pulse at the wrist at a rate of about 120. His skin is pale, cool, and clammy. With the hemostatic dressing applied, you observe that the arm laceration is still bleeding, so order that a tourniquet be applied on the right arm. You also instruct your team to administer oxygen via a non-rebreather mask.

As the lead medic you decide this is a load-and-go situation, and determine to conduct a rapid trauma survey. There is no obvious bleeding to the scalp or face. The patient admits to some tenderness in the area of C-3/4. Given the mechanism of injury, distracting injuries, the head contusion, and neck tenderness, you determine that spinal motion restriction is indicated and order that a cervical collar be applied and a long backboard brought to the patient. You also note that the neck veins are distended. Trachea seems midline. As the C-collar is applied, examination of the chest shows what appears to be a steering wheel impression to the lower anterior chest. The chest is asymmetrical with the left side moving poorly. There is no flail segment and no penetrations. You listen with the stethoscope and determine that breath sounds are absent on the left, and heart tones are present. You percuss both sides and find the left to be hyperresonant. Patient complains of pain on palpation to the left anterior chest, but there is no instability or crepitus.

Based on these findings you direct your team to perform needle decompression of the left chest at the second intercostal space at the midclavicular line. There is a rush of air and the patient's respiratory distress improves. Since he is a critical patient, he is now extricated onto the backboard and onto the stretcher and immediately transferred to the ambulance, where you reassess the patient and complete the rapid trauma survey. You ask one of the first responders to drive the ambulance so your EMS partner can assist you in the back

The abdomen is unmarked but tender to palpation. There is no distension or rigidity. The pelvis is stable without tenderness,

Case Presentation *(continued)*

instability, or crepitus. There is no obvious deformity or swelling to the lower extremities and no tenderness. He is able to feel and move his feet. His upper extremities are unremarkable except for the laceration to the right forearm.

With the tourniquet in place, the bleeding is now controlled. He moves both hands. A quick check of the back reveals no visible trauma and no tenderness. There is no bruising or tenderness of the spine, which was assessed when the patient was moved from the backboard to the ambulance stretcher.

En route to the trauma center, you perform a reassessment exam. Current LOC is patient still responds to verbal stimuli, airway is patient, patient still breathing rapidly at 18 times per minute, pulse rate is 120, and blood pressure is 90. As the only obvious external bleeding is controlled and the patient is showing signs of early shock, you reassess the chest and note that you can still hear breath sounds on the left. No jugular vein distention is present. The abdomen is tender in the left upper quadrant and there is tenderness on palpation of the anterior chest. The pelvis is stable and no long bone fractures have been found.

The patient is placed on the monitor. A peripheral IV is established and 500 cc crystalloid bolus is initiated. While you are giving a report to the trauma center using the MIST format, your partner with you in the back calls your attention to the EKG monitor. The monitor shows sinus tachycardia with frequent PVCs in lead 2. You direct your partner to obtain a 12-lead EKG (including a V4-R). There are no acute ST changes to suggest a myocardial infarction but the frequent PVCs do raise concern for a myocardial contusion. Based on this you update your report after you again reassess.

After the 500 cc crystalloid bolus the pulse rate is 114, but still thready at the wrist. The tourniquet is still functioning, the respiratory rate is 24 and less labored, and a blood pressure is 90/60.

On arrival at the trauma center, patient care is transferred to the trauma team.

Summary

Patient assessment is key to trauma care. The interventions required are not difficult, but timing is often critical. If you know what questions to ask and how to perform the physical exam, you will know when to perform life-saving interventions without unnecessarily prolonging time on scene. This chapter has described a rapid, orderly, and thorough examination of the trauma patient with examination and treatment priorities always is mind. The continuous practice of approaching the patient in the way described will allow you to concentrate on the patient rather than on what to do next. Optimum speed is achieved by teamwork and training. Teamwork is achieved by practice. You should plan regular exercises in patient evaluation to perfect each team member's role. Current research may provide future assessment adjuncts to help us make better decisions about the level of care our patients may need.

References and Resources

Acker, S. N., J. T. Ross, D. A. Partrick, M. Bronsert, and D. D. Bensard. 2014. "Glasgow Motor Scale Alone is Equivalent to Glasgow Coma Scale at Identifying Children at Risk for Serious Traumatic Brain Injury." *Journal of Trauma and Acute Care Surgery* 77, no. 2 (August): 304–9.

Ashely, D. W., E. E. Pracht, R. S. Medeiros, E. V. Atkins, E. G. NeSmith, T. J. Johns, and J. M. Nicholas. 2015. "An Analysis of the Effectiveness of a State Trauma System: Treatment at Designated Trauma Centers is Associated with an Increased Probability of Survival." *Journal of Trauma and Acute Care Surgery* 78, no. 4 (April): 706–14.

Alam, H. B., D. Burris, J. A. DaCorta, and P. Rhee. 2005. "Hemorrhage Control in the Battlefield: Role of New Hemostatic Agents." *Military Medicine* 170, no. 1 (January): 63–9.

Arshad, F. 2018. "Point of Care Ultrasound in the Prehospital Setting." *Journal of Emergency Medical Services* 43, no. 2. Accessed December 2018. https://www.jems.com/articles/print/volume-43/issue-2/features/point-of-care-ultrasound-in-the-prehospital-setting.html

Brooke, M., J. Walton, and D. Scutt. 2010. "Paramedic Application of Ultrasound in the Management of Patients in the Prehospital Setting: A Review of the Literature." *Emergency Medicine Journal* 27, no. 9 (September): 702–7.

Brown, J. B., M. R. Rosengart, R. M. Forsythe, B. R. Reynolds, M. L. Gestring, W. M. Hallinan, A. B. Peitzman, T. R. Billiar, and J. L. Sperry. 2016. "Not All Prehospital Time Is Equal: Influence of Scene Time on Mortality." *Journal of Trauma and Acute Care Surgery* 81, no. 1 (July): 93–100. doi: 10.1097/TA.0000000000000999.

Caterino, J. M., and A. Raubenolt. 2012. "The Prehospital Simplified Motor Score Is as Accurate as the Prehospital Glasgow Coma Scale: Analysis of a Statewide Trauma Registry." *Emergency Medicine Journal* 29, no. 6 (June): 492–6. doi: 10.1136/emj.2010.110437.

Goldberg, S. A., A. Porat, C. G. Strother, N. Q. Lim, H. R. Wijeratne, G. Sanchez, and K. G. Munjal. 2017. "Quantitative Analysis of the Content of EMS Handoff of Critically Ill and Injured Patients to the Emergency Department." *Prehospital Emergency Care* 21, no. 1 (January–February): 14–17.

Jansen, T. C., J. van Bommel, P. G. Mulder, J. H. Rommes, S. J. Schieveld, and J. Bakker. 2008. "The Prognostic Value of Blood Lactate Levels Relative to that of Vital Signs in the Prehospital Setting: A Pilot Study." *Critical Care* 12, no. 6: 160–6.

Korner, M., M. M. Krotz, C. Degenhart, K. J. Pfeifer, M. F. Reiser, and U. Linsenmaier. 2008. "Current Role of Emergency Ultrasound in Patients with Major Trauma." *Radiographics* 28, no. 1 (January–February): 225–42.

Krell, J. M., M. S. McCoy, P. J. Sparto, G. L. Fisher, W. A. Stoy, and D. P. Hostler. 2006. "Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization." *Prehospital Emergency Care* 10, no. 1 (January–March): 46–51.

MacKenzie, E. J., F. P. Rivara, G. J. Jurkovich, A. B. Nathens, K. P. Frey, B. L. Egleston, D. S. Salkever, and D. O. Scharfstein. 2006. "A National Evaluation of the Effect of Trauma-Center Care on Mortality." *New England Journal of Medicine* 354, no. 4 (January): 366–78.

McEvoy, J. W. 2018. "Excess Oxygen in Acute Illness: Adding Fuel to the Fire." *Lancet* 391 (April): 1640. https://doi.org/10.1016/S0140-6736(18)30546-4

Pham, H., Y. Puckett, and S. Dissanaike. 2017. "Faster On-Scene Times Associated with Decreased Mortality in Helicopter Emergency Medical Services (HEMS) Transported Trauma Patients." *Trauma Surgery and Acute Care Open* 2: e000122. doi: 10.1136/tsaco-2017-000122.

Sasser, S. M., R. C. Hunt, M. Faul, D. Sugerman, W. S. Pearson, T. Dulski, M. M. Wald, G. J. Jurkovich, C. D. Newgard, E. B. Lerner, et al. 2012. "Guidelines for Field Triage of Injured Patients: Recommendations of the National Expert Panel on Field Triage, 2011." *Morbidity and Mortality Weekly Report* 61 (RR01) (January). Accessed August 2018. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6101a1.htm

Sochor, M., S. Althoff, D. Bose, R. Maio, and P. Deflorio. 2013. "Glass Intact Assures Safe Cervical Spine Protocol." *Journal of Emergency Medicine* 44, no. 3 (March): 631–6.

Thomas, S. H., K. M. Brown, Z. J. Oliver, D. W. Spaite, B. J. Lawner, R. Sahni, T. S. Weik, Y. Falck-Ytter, J. L. Wright, and E. S. Lang. 2014. "An Evidence-Based Guideline for the Air Medical Transportation of Prehospital Trauma Patients." *Prehospital Emergency Care* 18, Suppl. 1: 35–44. doi: 10.3109/10903127.2013.844872.

van Beest, P. A., P. J. Mulder, S. B. Oetomo, B. van den Broek, M. A. Kuiper, and P. E. Spronk. 2009. "Measurement of Lactate in a Prehospital Setting is Related to Outcome." *European Journal of Emergency Medicine* 16, no. 6 (December): 318–22.

Walcher, F., M. Weinlich, G. Conrad, U. Schweigkofler, R. Breitkreutz, T. Kirschning, and I. Marzi. 2006. "Prehospital Ultrasound Imaging Improves Management of Abdominal Trauma." *British Journal of Surgery* 93, no. 2 (February): 238–42.

3

Assessment Skills



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

John T. Stevens, NRP
Leon Charpentier, EMT-P
Alexandra Rowe, NRP
S. Robert Seitz, M. Ed., RN, NRP

Patientenbeurteilung
Habilidades de Evaluación
Postupak pregleda ozlijeđene osobe
Competências Práticas na Gestão da Vítima de Trauma
Keterampilan Pengkajian
Обучение навыкам оценки потерпевшего
Evaluation du patient traumatisé en pratique
Δεξιότητες στην Εκτίμηση Τραυματία
A sérült megítélése a gyakorlatban
傷病者評価の技術
評估技巧
Pregled poškodovanca

Skills presented in this chapter:

- ITLS Primary Survey
  - Scene Size-up
  - Initial Assessment
- Rapid Trauma Survey
- Focused Exam
- ITLS Reassessment Exam
- ITLS Secondary Survey

Objectives

Upon successful completion of this chapter, you should be able to:

1. Correctly perform the ITLS Primary Survey.
2. Identify within 2 minutes which patients require load and go.
3. Describe when to perform critical interventions.
4. Correctly perform the ITLS Reassessment Exam.
5. Correctly perform the ITLS Secondary Survey.
6. Demonstrate proper communications with medical direction.
7. Demonstrate the proper sequence of rapid assessment and management of the multiple-trauma patient.

Procedure

ITLS Primary Survey

During the ITLS class, short written scenarios will be used along with a model to simulate the patient. You will divide into teams to practice performing the initial assessment, critical interventions, and transport decision. Each member of the team must practice being team leader at least once. The critical information represents the answers you should be seeking at each step of the survey. The Treatment Decision Tree (see Table 3-1, pp. 66–69) represents the actions that should be taken (personally or delegated) in response to your assessment.

PEARLS

ITLS Primary Survey

- Do not approach the patient until you have performed a scene size-up.
- Do not interrupt the ITLS Primary Survey except for immediate threats to life such as life-threatening hemorrhage, airway obstruction, cardiac arrest, or if the scene becomes too dangerous. Team members should perform the necessary critical interventions while you complete the primary survey.
- Give any ventilation or oxygen administration instructions as soon as you complete the breathing assessment.
- Prophylactic hyperventilation is not recommended for patients with decreased LOC. Use it only for head-injury patients who show signs of cerebral herniation syndrome (see Chapter 12).
- Assist ventilations in anyone who has inadequate breathing (less than 10 breaths per minute, moving little or no air, or end-tidal CO_2 [$etCO_2$] of greater than 45 mmHg). Confirm adequate tidal volume based on chest rise and fall.
- Give oxygen to all multiple-trauma patients. If in doubt or a pulse oximeter reading of less than 94% is present, give oxygen.

(*continued on page 66*)

ITLS Primary Survey—Critical Information

If you ask the right questions, you will get the information you need to make the critical decisions necessary in the management of your patient. The following questions are presented in the order in which you should ask yourself as you perform the primary survey. *This is the* minimum *information that you will need as you perform each step of the ITLS Primary Survey* (Figure 3-1).

Scene Size-up

- Have I taken standard precautions?
- Do I see, hear, smell, or sense anything dangerous?
- Has Medical Command been established?
- How many patients?
- Are additional personnel or resources needed?
- Is specialized equipment needed to rescue or care for the patient(s)?
- What is the mechanism of injury (MOI) here?
- Is the MOI generalized or focused?
- Is the MOI potentially life threatening?

Initial Assessment

General Impression

- What is my general impression of the patient as I approach? (Your subjective judgment as to the seriousness of the situation is part of this impression.)
- Is there obvious life-threatening external bleeding that must be addressed now (C-ABC)?

Level of Consciousness (AVPU)

- Introduce yourself and say, "We are here to help you. Can you tell us what happened?"
- Try to stay in the patient's field of view to keep them from turning his or her head.
- From the patient's response, what is the AVPU (alert, voice, pain, unresponsive) rating?

Airway

- Is the airway open and clear?
- Can the patient maintain his or her own airway?
- Do I hear abnormal airway sounds such as snoring, gurgling, or stridor?

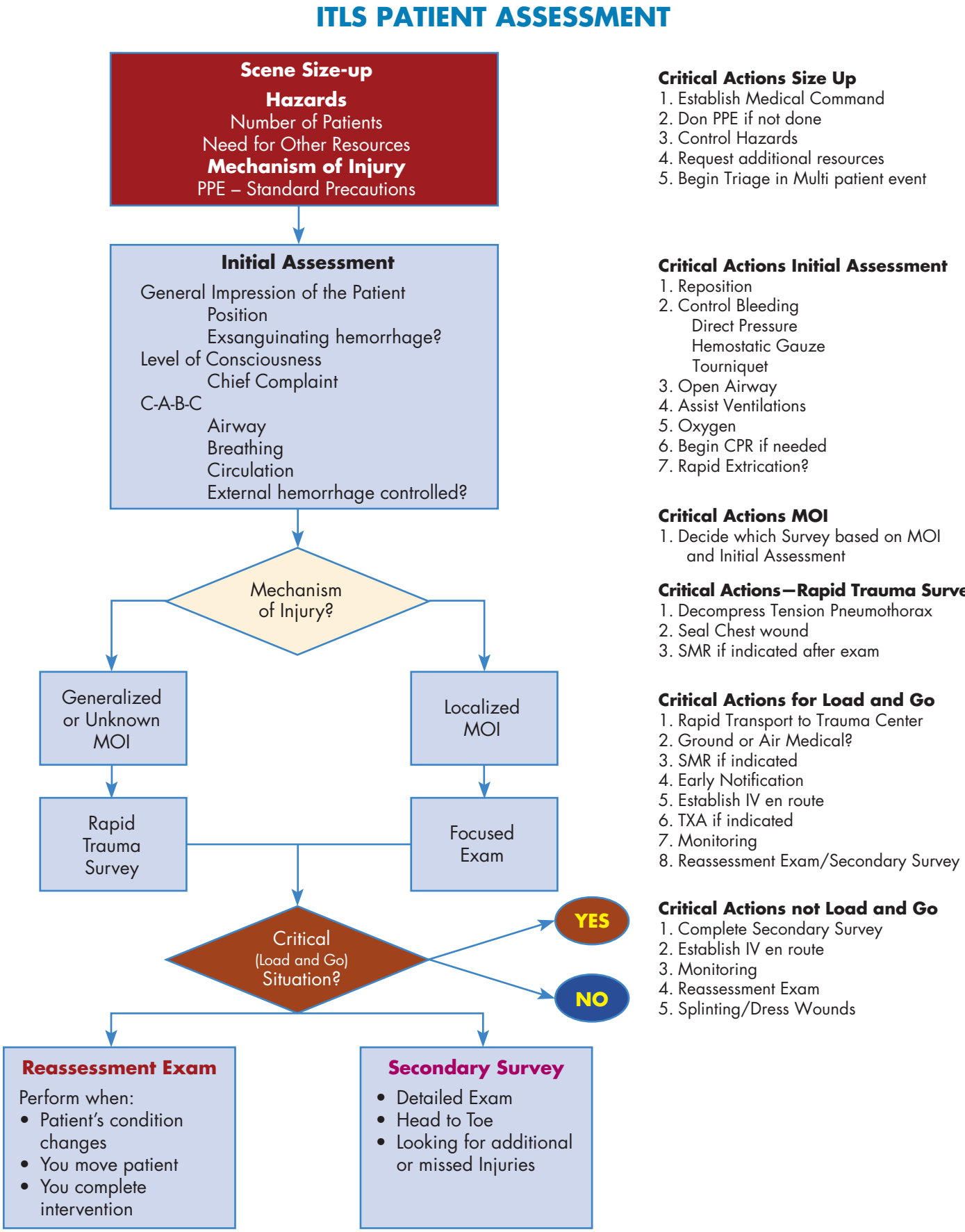


Figure 3-1 Steps in the assessment of the trauma patient.

PEARLS

ITLS Primary Survey
(Continued)

- Endotracheal tubes are the best method to protect the airway and manage ventilatory assistance for the adult patient. Other methods may be effective but are not as secure.
- If spinal motion restriction (SMR) is indicated, transfer the patient to the backboard or scoop stretcher as soon as the ITLS Primary Survey is completed.
- When the ITLS Primary Survey is completed, decide if the patient is critical or stable. Altered mental status, respiratory distress, and/or signs and symptoms of shock indicate a critical condition.
- Communicate with medical direction and the receiving facility early if you have a critical patient.
- If the patient has a critical trauma situation, load them into the ambulance and begin transport. (Transport pregnant patients tilted slightly to the left.)
- If absolutely necessary, certain critical interventions may have to be done before transport. Remember that you are trading minutes of the patient's Golden Period for those procedures. Use good judgment. This may include establishing an airway, ventilation, oxygen administration, control of serious external bleeding, sealing open penetrating chest wounds, decompression of a tension pneumothorax, stabilization of impaled objects, and packaging with use of SMR when indicated.
- For patients in traumatic cardiac arrest, address treatable causes and then determine whether to continue the resuscitation (see Chapter 16).

Breathing

- Is the patient breathing normally?
- What is the rate depth and quality of respiration?

Circulation

- Is life-threatening external bleeding controlled?
- What is the rate and quality of the pulse at the neck and wrist?
- What are the skin color, condition, and temperature?

Decision

- Is this a critical situation?
- Is spinal motion restriction (SMR) indicated?
- Does the mechanism of injury or any initial assessment findings indicate the need for a rapid trauma survey?

Also see Table 3-1.

Table 3-1 Trauma Assessment: Treatment Decision Tree

Assessment	Action
SCENE SIZE-UP	
Safety	Put on gloves, protective clothing; remove hazards or patient from hazards
Number of patients	Call for help, if needed
Extrication/rescue needed	Call for special equipment/resources, if needed
Mechanisms of injury	Suspect appropriate injuries (e.g., cervical spine)
GENERAL IMPRESSION	Begin to establish priorities
Age, sex, weight	
Position (in surroundings, body position/posture)	Reposition as necessary
Activity	
Obvious major injuries	
Major bleeding	Direct pressure +/– hemostatic agent or tourniquet
LEVEL OF CONSCIOUSNESS	
Alert/responsive to voice	Initiate cervical-spine motion restriction, if indicated by dangerous mechanism of injury
Unresponsive to voice	Establish cervical-spine motion restriction
AIRWAY	*You must fix airway problems as you find them!*
Snoring	Modified jaw-thrust
Gurgling	Suction
Stridor	Intubate, confirm tube placement, and apply waveform capnography, if available
Silence	Attempt to ventilate; if unsuccessful: – Reposition; initiate rapid extrication – Visualize

Table 3-1 (*continued*)

Assessment	Action
Silence (*continued*)	– Suction – Consider foreign body removal – Decompression of tension pneumothorax – Initiate bag-mask ventilation and consider SGA or intubation, confirm tube placement, and apply waveform capnography, if available – Consider translaryngeal jet ventilation or cricothyroidotomy
BREATHING	*If ventilation is inadequate, assist ventilations.*
Absent	Ventilate twice (check pulse before continuing ventilation at 10–12 breaths per minute with oxygen)
<8	Assist ventilation at 10–12 breaths per minute with oxygen
Low tidal volume	Assist ventilation at 10–12 breaths per minute with oxygen
Labored	Oxygen by nonrebreather at 15 LPM; assist as needed
Normal or rapid	Consider oxygen
CIRCULATION	
RADIAL PULSE	
Absent	Check carotid pulse (see below); note late shock
Present	Note rate and quality
Bradycardia	Consider spinal shock, head injury
Tachycardia	Consider hypovolemic shock Consider need for pain management Consider cardiac monitor
CAROTID PULSE	Check if no radial pulse
Absent	Initiate CPR and ventilation with oxygen, consider immediate intervention, transport, or termination of resuscitation
Present	Note rate and quality
Bradycardia	Consider spinal shock, head injury
Tachycardia	Consider late shock
SKIN COLOR AND CONDITION	
Pale, cool, clammy	Consider hypovolemic shock
Cyanosis	Reassess ventilatory assistance and consider intubation
BLEEDING	Direct pressure +/− hemostatic agent, tourniquet
HEAD	
Major facial injuries	Consider intubation
NECK	
Swelling, bruising, retracting	Consider intubation
Neck vein distention	Consider tension pneumothorax, cardiac tamponade
Tracheal deviation	Consider tension pneumothorax
Tenderness, deformity, or altered mental status	Apply cervical collar
CHEST	Inspect and palpate
Symmetrical, stable	Continue exam

(*continued*)

PEARLS

ITLS Primary Survey

(Continued)

- The indications to decompress a tension pneumothorax include signs of a tension pneumothorax and more than one of the following: respiratory distress and cyanosis, loss of radial pulse (obvious shock), loss of consciousness, or an obviously decreasing level of consciousness.
- Unless the patient is entrapped or the ambulance has not arrived on scene, start intravenous therapy while transporting the patient to the receiving facility.

Table 3-1 Trauma Assessment: Treatment Decision Tree (*continued*)

Assessment	Action
Bruises, crepitation	Consider early cardiac monitoring
Penetrating wounds	Apply chest seal or occlusive dressing
Paradoxical motion	Stabilize flail; consider early intubation
BREATH SOUNDS	
Present and equal	Continue exam
Unequal	Percuss chest to determine pneumothorax versus hemothorax
	If indicated, initiate needle chest decompression
HEART TONES	Note for comparison later
Muffled with JVD and bilateral breath sounds	Consider pericardial tamponade
ABDOMEN, PELVIS, UPPER LEGS	
If tender abdomen, unstable pelvis, or bilateral femur fractures:	Anticipate development of shock
POSTERIOR	
Injuries identified	Appropriate management of identified injuries
	Transfer to spinal board
	Transport immediately if critical trauma situation present
SAMPLE HISTORY	Obtain and record
VITAL SIGNS	Measure and record level of consciousness, respirations, pulse, blood pressure, pulse oximetry, temperature, and level of discomfort
Systolic <90 with signs of shock	Consider IV fluid therapy en route to hospital
Systolic <80	IV fluid therapy en route to hospital
Systolic <60	Treat profound shock; consider CPR
Increasing systolic blood pressure and decreasing heart rate	Consider increased intracerebral pressure; maintain systolic blood pressure of 110–120; consider adjustment of ventilations to maintain an $etCO_2$ of 30–35 mmHg
PUPILS	
Unequal	Suspect head injury unless patient is alert, then suspect eye injury
Unequal or dilated and fixed with GCS <8	Give 100% oxygen; do not let patient get hypotensive (target systolic BP of 110–120); intubation and hyperventilation at rate to maintain 30–35 mmHg (16–20 breaths per minute if not able to measure $etCO_2$ or at rate to maintain $etCO_2$ of 30–35 mmHg) (unequal pupils or dilated and fixed pupils and GCS <8 are suggestive of cerebral herniation)
Pinpoint (with respiratory rate <8)	Consider naloxone
Dilated/reactive (with GCS <8)	Give 100% oxygen; consider intubation; ventilate at 10–12 breaths per minute or to maintain $etCO_2$ of 35–45
Glasgow Coma Scale score (for decreased LOC) <8	Give 100% oxygen; do not let patient get hypotensive (target systolic BP of 110–120); consider during transport

Table 3-1 (*continued*)

Assessment	Action
	Consider hyperventilation only if patient shows signs of cerebral herniation: – GCS <8 with extensor posturing – GCS <8 with pupillary asymmetry or nonreactivity – GCS <8 with a subsequent drop of more than 2 points
All patients with decreased LOC	Consider oxygenation; check for medical identification devices, note presence of medication patches, and obtain blood-glucose level

Rapid Trauma Survey

(See Figure 3-2.)

Head and Neck

- Are there obvious wounds of the head or neck?
- Is there deformity or tenderness of the neck?
- Are the neck veins distended?
- Does the trachea feel midline or deviated?

Chest

- Is the chest symmetrical?
- If not, is there paradoxical movement?
- Is there any obvious blunt or penetrating trauma?
- Are there any sucking (open) wounds?
- Is there tenderness, instability, or crepitation (TIC) of the chest wall?
- Are the breath sounds present and equal?
- If breath sounds are not equal, is the chest hyperresonant (pneumothorax) or dull (hemothorax) to percussion?
- Are heart sounds normal or abnormal (distant, muffled)?

Abdomen

- Are there obvious injuries or discoloration?
- Is the abdomen tender, rigid, or distended?

Pelvis

- Are there obvious wounds or deformity?
- Is there TIC?

Upper Legs

- Are there obvious wounds, swelling, or deformity?
- Is there tenderness, instability, or crepitation?

Lower Legs and Arms

- Are there obvious wounds, swelling, or deformity?
- Is there tenderness, instability, or crepitation?
- Can the patient feel/move fingers and toes?

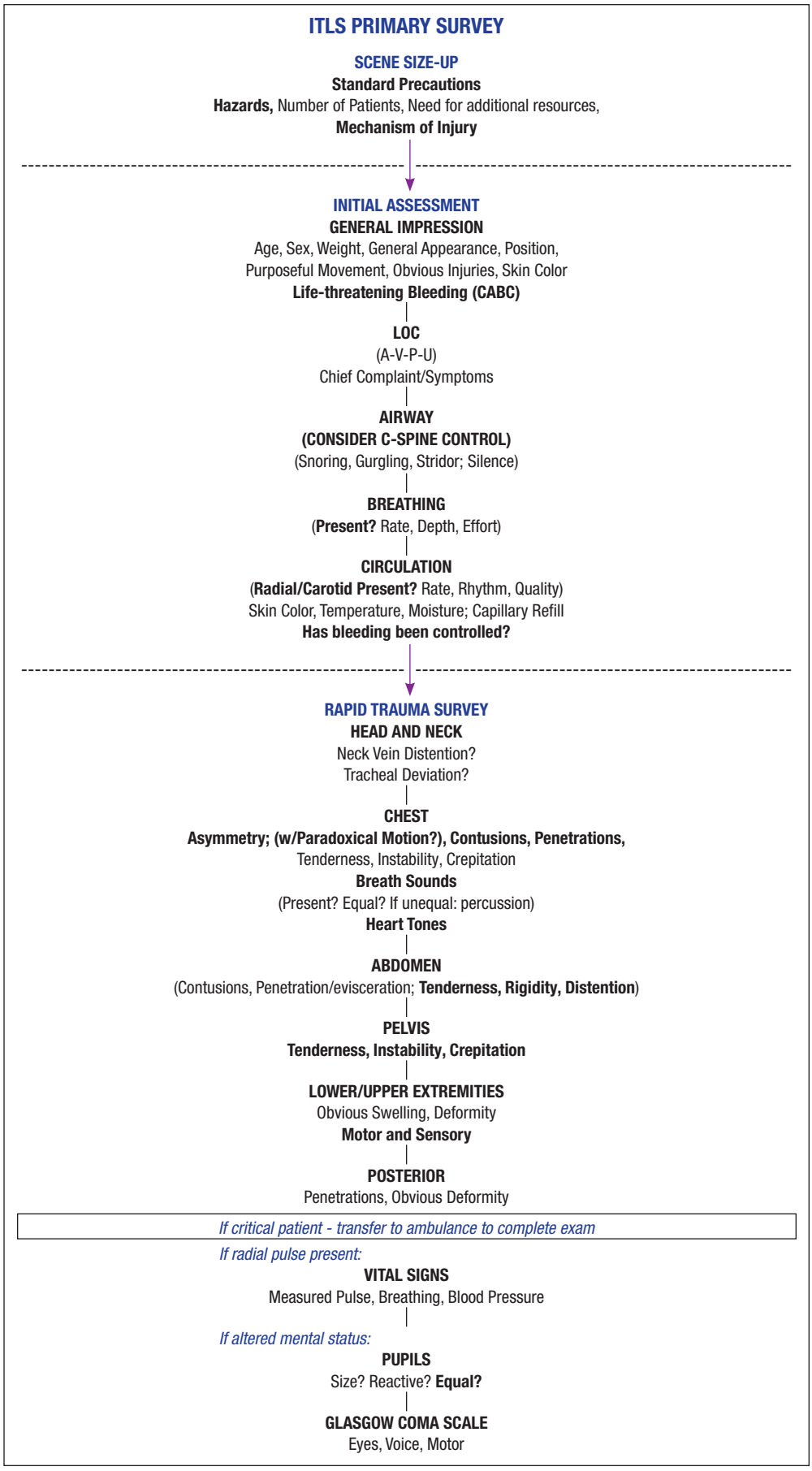


Figure 3-2 The ITLS Primary Survey including the rapid trauma survey.

Posterior

- This exam is performed during transfer to the spine board for SMR or removal from the spine board after movement of the patient.
- Are there any wounds, tenderness, or deformity of the patient's posterior side?

Decision

- Is there a critical situation?
- Does this patient have a tension pneumothorax or penetrating chest wound requiring decompression or applying a chest seal?
- Should I move the patient to the ambulance now?
- Are there interventions that I must delegate or perform now?

History

- What is the SAMPLE history (if not already obtained)?
- Ascertain PQRST, if not done: Provoking, Quality, Radiation, Severity, and Timing

Baseline Vital Signs

- Do the vital signs indicate stable or unstable condition?
- Mental status (AVPU)?
- Respirations
- Pulse
- Blood pressure
- Pulse oximetry and capnography if available
- Temperature
- Level of discomfort/pain

Disability

- Perform this exam now if there is altered mental status (AMS). Otherwise, postpone this exam until you perform the ITLS Secondary Survey.
- If the patient has AMS, are the pupils equal and reactive?
- What is the Glasgow Coma Scale score or Glasgow Motor Score?
- Are there signs of cerebral herniation (unconscious, dilated pupil(s), hypertension, bradycardia, posturing)?
- Does the patient have a medical identification device?
- What is the glucose reading?

Procedure

ITLS Reassessment Exam

During the ITLS class, short written scenarios will be used along with a model to simulate the patient. You will divide into teams to practice performing the ITLS Reassessment Exam, making critical decisions and interventions. Each member of the team must practice being team leader at least once. The critical information represents the answers you should be seeking at each step of the exam.

PEARLS
ITLS Reassessment Exam

- Repeat the ITLS Reassessment Exam:
  - If the patient's condition changes
  - If you make an intervention
  - If you move the patient (scene to ambulance, ambulance to hospital emergency department)
- Remain calm and think. Your knowledge, training, and concern are the most important tools you carry.

ITLS Reassessment Exam—Critical Information

The following questions are presented in the order in which should be asked as you perform the exam. In an unstable multitrauma patient, this is the minimum information that you will need as you perform each step of the exam (Figure 3-3).

Subjective Changes

- Ask the patient if they are feeling better or worse now?

Mental Status

- What is the LOC?
- What is pupillary size? Are they equal? Do they react to light?
- If altered mental status, what is the fingerstick glucose (if not already done) and what is the Glasgow Coma Scale score now?

Reassess ABCs

- Record vital signs (pulse, respiratory rate, and blood pressure)
- Airway
  - Is the airway open and clear?
  - Is the sound of breathing abnormal (snoring, gurgling, stridor)?
  - If there are burns of the face, are there signs of inhalation injury?
- Breathing and circulation
  - What is the rate and depth of respiration?
  - What is the rate and quality of the pulse?
  - What is the blood pressure?
  - What are the skin color, condition, and temperature (capillary refill in children)?
  - Is any external bleeding controlled?
- Neck
  - Are the neck veins normal, flat, or distended?
  - If distended, is the trachea midline or deviated?
  - Is there increased swelling of the neck?
- Chest
  - Are the breath sounds present and equal?
  - If breath sounds are unequal, is the chest hyperresonant or dull?
  - Are heart sounds still normal, or have they become muffled?
- Abdomen (if mechanism suggests possible injury)
  - Is there any tenderness?
  - Is there abdominal guarding, distention, or rigidity?
- Assessment of identified injuries
  - Have there been any changes in the condition of any of the injuries that have been found?
- Check all completed interventions.
  - Is the endotracheal tube still patent and in the correct position?
  - Is the oxygen rate correct?
  - Is the oxygen tubing connected and is there oxygen in the tank?
  - Are the IVs running at the correct rate?
  - Does the IV bag contain the correct fluid?
  - Is the open chest wound still sealed?

- Is the decompression needle still working?
- Are any of the wound dressings blood soaked?
- Are the splints in good position?
- Is the impaled object still well stabilized?
- Is the pregnant patient tilted 20–30 degrees to the patient's left?
- Is the cardiac monitor attached and working?
- Is the pulse oximeter attached and working?
- Is the capnograph attached and working?

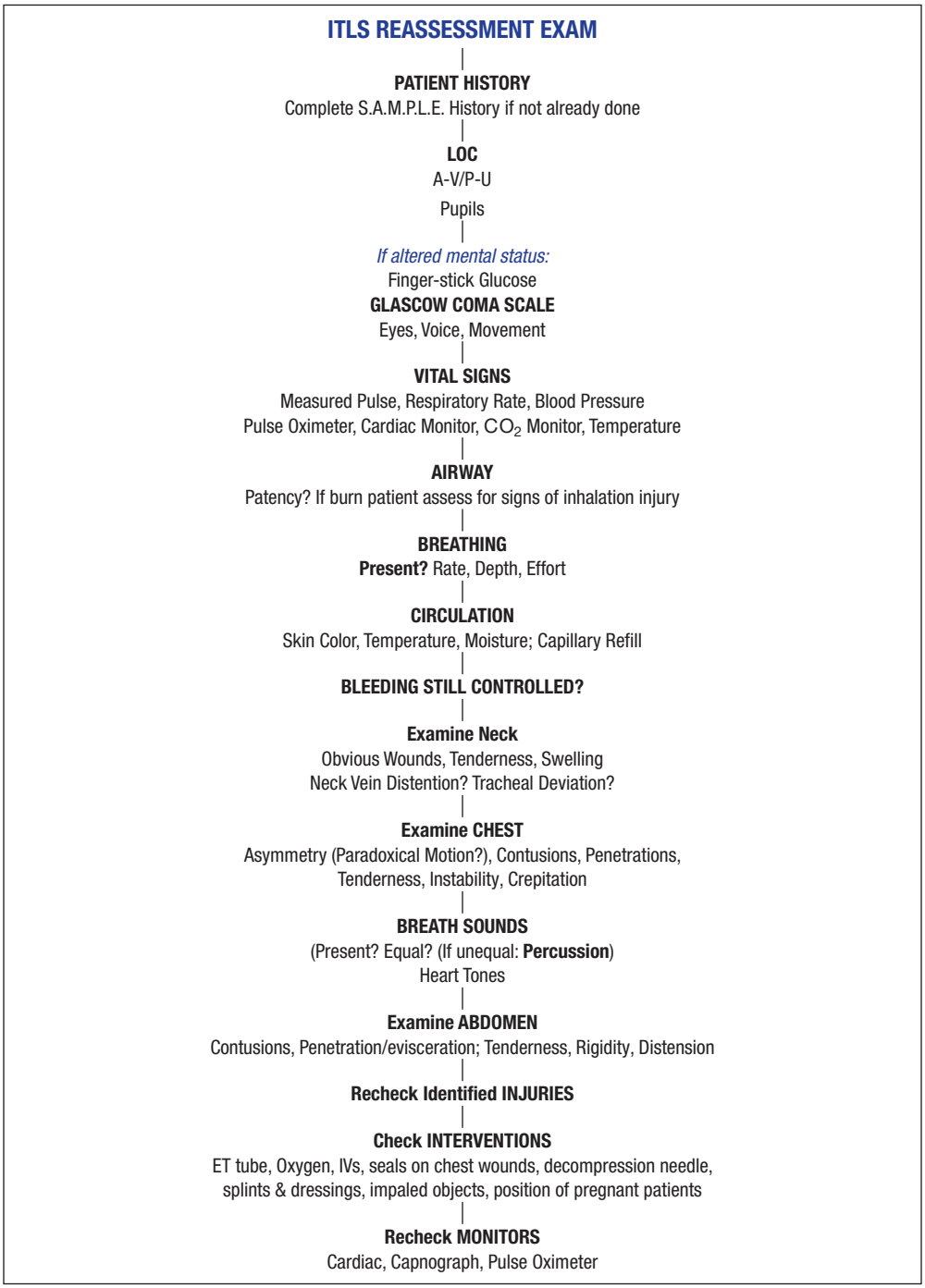


Figure 3-3 The ITLS Reassessment Exam.

Procedure

ITLS Secondary Survey

During the ITLS class, short written scenarios will be used along with a model to simulate the patient. You will divide into teams to practice performing the ITLS Secondary Survey. Each member of the team must practice being team leader at least once. The critical information represents the answers you should be seeking at each step of the exam.

PEARLS
ITLS Secondary Survey

- Critical patients get an ITLS Secondary Survey en route to the hospital, if time permits.
- Stable patients may get an ITLS Secondary Survey at the scene or during transport.
- Transport immediately if your detailed exam reveals *any* of the critical trauma situations.
- Critical patients should not have traction splints applied at the scene, which take too long.

ITLS Secondary Survey—Critical Information

As a general rule, you should quickly repeat the initial assessment before you begin the ITLS Secondary Survey. You can do this as your teammate checks the vital signs. If you ask the right questions, you will get the information you need to make the critical decisions necessary in the management of your patient. The following questions are presented in the order in which you should ask yourself as you perform the secondary survey. This is the minimum information that you will need as you perform each step of the exam (Figure 3-4).

SAMPLE History

Complete the SAMPLE history now if you have not already done so.

- What is the patient's history?
  - During assessment, look for clues about the history of the patient: medical information tags, implanted devices, and medication patches.

Vital Signs and Repeat Initial Assessment

- General impression
  - Does the patient appear better, worse, or unchanged?
- Airway
  - Is the airway open and clear?
  - Is the sound of breathing abnormal (snoring, gurgling, stridor)?
- Breathing
  - What is the rate and depth of respiration?
  - Is the breathing normal?
- Circulation
  - What is the pulse rate and blood pressure?
  - What are the skin color, condition, and temperature (capillary refill in children)?
  - Is all external bleeding still controlled?

Neurological Exam

- What is the LOC?
- If altered mental status, what is the blood glucose (if not already done)?
- Are the pupils equal? Do they respond to light?
- Can the patient move his or her fingers and toes?
- Can the patient feel you touch his or her fingers and toes?
- What is the Glasgow Coma Scale score (if altered mental status)?

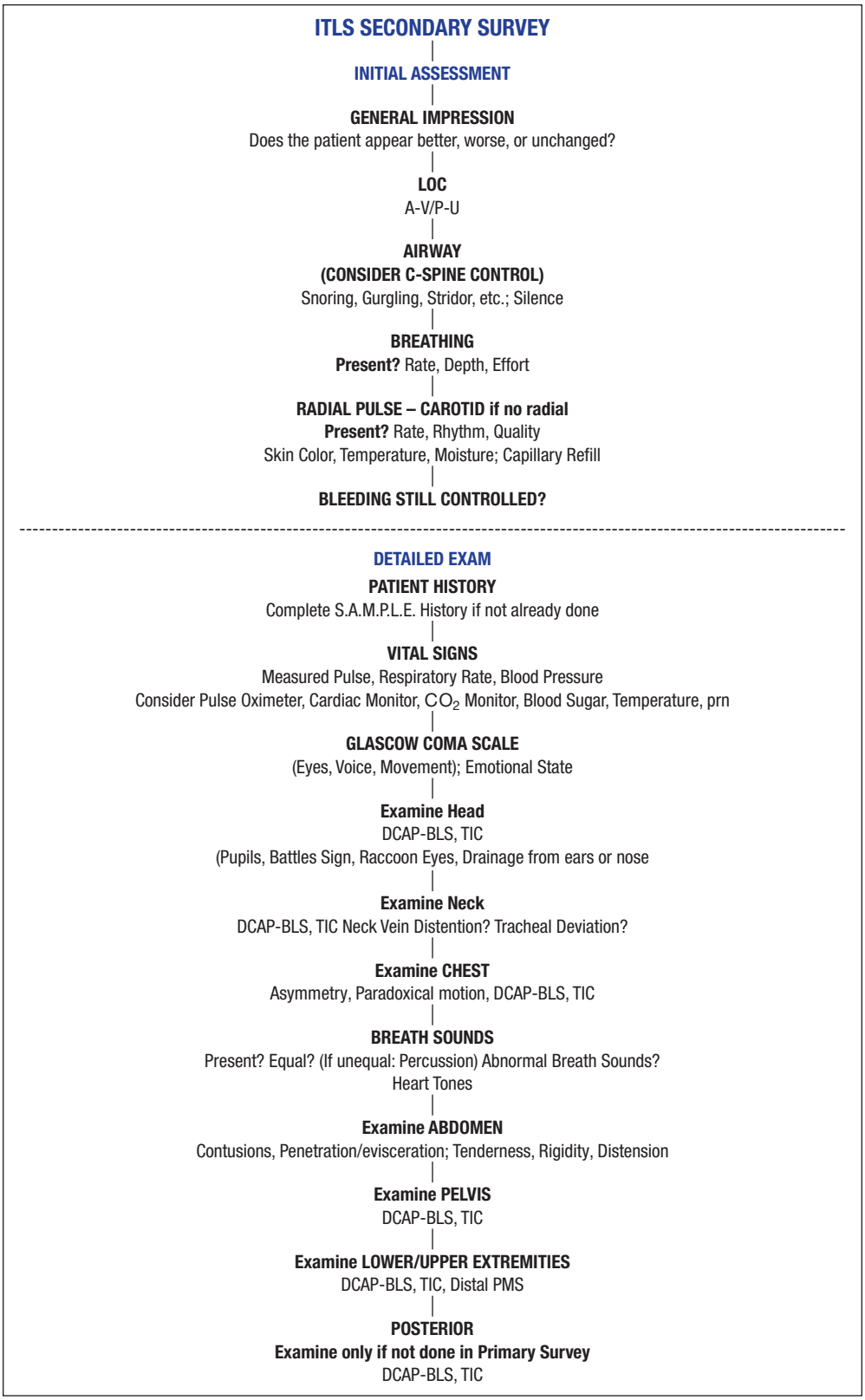


Figure 3-4 The ITLS Secondary Survey.

Detailed Exam

- Head
  - Is there DCAP-BLS or TIC of the face or head?
  - Are Battle's sign or raccoon eyes present?
  - Is there blood or fluid draining from the ears or nose?
  - Is there pallor, cyanosis, or diaphoresis?
- Neck
  - Is there DCAP-BLS or TIC of the neck?
  - Are the neck veins normal, flat, or distended?
  - Is the trachea midline or deviated?
- Chest
  - Is there DCAP-BLS of the chest?
  - Is there any TIC of the ribs?
  - Are there any open wounds or paradoxical movement?
  - Are the breath sounds present and equal?
  - Are there abnormal breath sounds?
  - If breath sounds are not equal, is the chest hyperresonant or dull?
  - Are heart sounds normal or decreased?
  - If patient is intubated, is the endotracheal tube still in good position?
- Abdomen
  - Is there DCAP-BLS of the abdomen?
  - Is the abdomen tender, rigid, or distended?
- Pelvis
  - If the pelvis has already been examined during the ITLS Primary Survey, no further exam should be done.
  - If suspected pelvic injury look for blood at urethral meatus and/or rectum
- Lower extremities
  - Is there DCAP-BLS or TIC of the legs?
  - Is there normal PMS?
  - Is range of motion normal? (optional as appropriate)
- Upper extremities
  - Is there DCAP-BLS of the arms?
  - Is there normal PMS?
  - Is range of motion normal? (optional as appropriate)

Procedure

Patient Assessment and Management

Short written trauma scenarios will be used along with a model to simulate the patient. You will be divided into teams to practice the management of simulated trauma situations using the principles and techniques taught in the course. You will be evaluated in the same manner on the second day of the course. You will be expected to use all the principles and techniques taught in this course while managing these simulated patients. To familiarize yourself with the evaluation procedure, you will be given a copy of a scenario and a grade sheet. Review Chapter 2 and the previous surveys in this chapter.

Ground Rules for Teaching and Evaluation

1. You will be allowed to stay together in several provider groups (different-sized groups are permitted up to four) throughout the practice and evaluation stations.
2. You will have multiple practice scenarios. This allows each member of the team to be team leader at least once.
3. You will be evaluated as team leader at minimum one time.
4. You will assist as a member of the emergency care team during the other scenarios in which another member of your team is being evaluated as team leader. You may assist, but the team leader must perform all assessments. This gives you a total of six scenarios from which to learn: three practices, one evaluation, and two assists while others are evaluated.
5. Wait outside the door until the instructor comes out and gives you your scenario.
6. You will be allowed to look over your equipment before you start your exam.
7. Be sure to ask about scene safety if not provided in the scenario and to apply your personal protective equipment.
8. Ask your instructor what you see as you approach. (What is my general impression?)
9. If you have a live model to simulate the patient, you must talk to that person just as you would a real patient. It is best to explain what you are doing as you examine the patient. Be confident and reassuring.
10. You must ask your instructor for things you cannot find out from your patient. Examples are blood pressure, pulse, and breath sounds.
11. Wounds and fractures must be dressed or splinted just as if they were real. Procedures must be done correctly (such as blood pressure, logrolling, strapping, and splinting).
12. If you need a piece of equipment that is not available, ask your instructors. They may allow you to simulate the equipment.
13. During practice and evaluation, you may be allowed to go (or may be directed) to any station, but you cannot go to the same station twice.
14. You will be graded on the following:
    a. Assessment of the scene
    b. Assessment of the patient
    c. Management of the patient
    d. Efficient use of time
    e. Leadership
    f. Judgment
    g. Problem-solving ability
    h. Patient interaction
15. When you finish your testing scenario, there is to be no discussion of the case. If you have any questions, they will be answered after the faculty meeting at the end of the course.

4

Hemorrhage Control and Shock



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Raymond L. Fowler, MD, FACEP
John T. Stevens, EMT-P
Melanie J. Lippmann, MD, FACEP

Schock und Blutungskontrolle
Control de Hemorragias y Shock
Zaustavljanje krvarenja i šok
Choque e Controlo de Hemorragia
Penanganan Perdarahan dan Syok
Контроль кровотечения и шок
Contrôle des hémorragies et état de choc
Έλεγχος Αιμορραγίας και Καταπληξία
A sokk vizsgálata és ellátása
出血のコントロールとショック
出血控制及休克
Kontrola krvavitev in šok

Key Terms

hemorrhagic shock, *p. 79*
hemostatic agents, *p. 84*
hypovolemic shock, *p. 80*
mechanical and cardiogenic shock, *p. 82*
neurogenic shock, *p. 85*
pulse pressure, *p. 80*
tranexamic acid (TXA), *p. 91*
vasoconstriction, *p. 81*

Objectives

Upon successful completion of this chapter, you should be able to:

1. List the four components of the vascular system necessary for normal tissue perfusion.
2. Describe the symptoms and signs of shock in the order that they develop, distinguishing compensated from uncompensated shock.
3. Describe the three common clinical shock syndromes.
4. Explain and compare the pathophysiology of hemorrhagic, mechanical (obstructive), cardiogenic, and distributive shock.
5. Describe the management of the following:
   a. Hemorrhage that can be controlled
   b. Hemorrhage that cannot be controlled
   c. Nonhemorrhagic shock syndromes
6. Discuss the use of tourniquets and hemostatic agents for uncontrolled extremity hemorrhage.

Objectives (continued)

7. Discuss the current indications for the use of IV fluids and tranexamic acid in the treatment of hemorrhagic shock.
8. Recognize the advantages that may be gained by using such tools as ECG (including 12-lead), end-tidal CO_2 monitoring, and lactate levels.

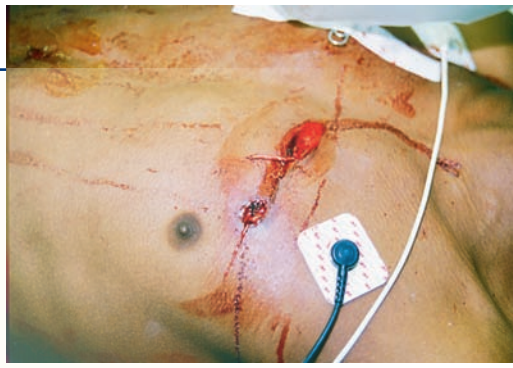
Chapter Overview

The evaluation and management of shock has been the subject of intensive research for decades. As a result, changes continue to be made in the recommendations for prehospital treatment of the patient experiencing shock, especially **hemorrhagic shock**. The experience of the U.S. military and its coalition partners in the Iraq and Afghanistan wars has led to new thinking in the management of life-threatening hemorrhage. This chapter reviews current knowledge of shock. It also offers the results of recent research about the pathophysiology and treatment of shock in the trauma patient and in patients with various other shock states.

hemorrhagic shock: shock caused by insufficient blood within the vascular system.

Shock is defined as a state of tissue hypoxia due to reduced oxygen delivery and/or increased oxygen consumption or inadequate oxygen utilization. This most commonly occurs when there is circulatory failure due to hypotension, which reduces tissue perfusion. Shock may be initially reversible, but it must be recognized and treated immediately to prevent progression to irreversible organ dysfunction. We refer to the three stages of shock as *compensated*, *decompensated*, and *irreversible*.

Case Presentation



An ALS ambulance has been dispatched to a bar where a patron has been stabbed. The scene size-up reveals that the police are on scene, have cleared the bar, and are questioning bystanders. The scene size-up reveals that the fire department is on scene, and there are no other hazards.

Because the scene is safe and the mechanism of injury (stab wound) is known, the team dons personal protective equipment. As they enter the bar, they see a male victim sitting on the floor in a pool of blood. As they approach the patient, each carries essential trauma care equipment.

Before proceeding, consider these questions:

- How would you approach this patient?
- What type of assessment would you perform?
- What would you do first?
- Is this a load-and-go situation?
- What potential injuries could this patient have?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient's care.

PEARLS
C-A-B-C?

Do not confuse the immediate attention to bleeding with the AHA/ILCOR "CABC" for cardiac arrest, where "C" stands for compressions. CONTROL life-threatening hemorrhage.

Pathophysiology of Shock

The normal perfusion of body tissues requires four intact components. They are as follows:

- Adequate volume of fluid in the vascular system: red blood cells and plasma
- Adequate air exchange in the lungs to allow oxygen to enter the blood: oxygenation and pulmonary vasculature.
- An intact, functioning, and unobstructed vascular system to deliver oxygenated blood throughout the body: the blood vessels
- A functioning pump: the heart

If any of these factors are absent, shock will result. We may look at each of these factors as four distinct kinds of shock:

hypovolemic shock: shock caused by insufficient volume (blood or fluid) within the vascular system.

1. **Hypovolemic shock** (absolute hypovolemia)
   a. External hemorrhage–controlled
   b. External hemorrhage–uncontrolled
   c. Internal hemorrhage
   d. Other causes of intravascular volume loss, such as severe diarrhea (e.g., cholera, norovirus, etc.)
2. Distributive shock (relative hypovolemia)
   a. Neurogenic shock
   b. Medical causes (e.g., anaphylaxis, sepsis, overdose)
3. Obstructive shock
   a. Cardiac tamponade
   b. Tension pneumothorax
   c. Massive pulmonary embolism
4. Cardiogenic shock (pump failure)
   a. Cardiac contusion

PEARLS
Basic Rules

Shock kills. Look for early signs of shock, and manage it appropriately. The basic rules of shock management are:

- Maintain the airway.
- Maintain oxygenation and ventilation.
- Control bleeding where possible.
- Maintain circulation through an adequate heart rate and intravascular volume.

We look at those causes commonly associated with trauma, what can cause them, how they present to the emergency care provider, and, based on these differences, how to recognize and treat them.

As mentioned earlier, the stages of the presentation of shock are compensated, decompensated, and irreversible. The third stage, irreversible shock, involves systemic vital organ failure. This stage is more commonly encountered beyond the time that initial responders are in contact with the victim.

Shock produces signs and symptoms that you can observe during patient assessment. The initial diagnosis of the shock state can often be made from the physical exam findings. Although blood pressure should be monitored frequently to help determine whether or not organ perfusion is adequate, hypotension is a late sign. Assessment tools other than measuring the blood pressure must be used to recognize early shock in the trauma patient.

Although the individual response to posttraumatic hemorrhage may vary, many patients will have the following classic patterns of "early" and "late" shock:

pulse pressure: the pressure driving blood through the vascular system. It is calculated by subtracting the diastolic from the systolic blood pressures (SBP – DBP = PP).

- *Early shock:* This is the loss of approximately 15–25% of the blood volume, in the setting of hypovolemia. That is enough to stimulate slight to moderate tachycardia, pallor, narrowed **pulse pressure**, thirst, weakness, and possibly delayed capillary refill. In "early shock," the body is "compensating" for the physical insult that is causing the problem (hemorrhage, dehydration, tension pneumothorax, etc.).
- *Late shock:* Late shock is the loss of approximately 30–45% of the blood volume. It is enough to cause hypotension as well as the other symptoms of shock listed

earlier. When "late shock" occurs, it means the body's ability to compensate for the physical insult has failed. Hypotension is the first sign of "late shock." The hypotensive patient, then, is near death. Aggressive assessment and management must be provided to prevent the death of the patient.

Below are signs and symptoms of early (compensated) and late (decompensated) shock, in this case typical of hemorrhagic shock.

During compensated shock, the body is still able to maintain perfusion by compensatory mechanism and will present with the following signs and symptoms:

Compensated shock

- *Weakness and light-headedness*—caused by decreased blood volume
- *Thirst*—caused by hypovolemia (especially with relatively low fluid amounts in the blood vessels)
- *Pallor* (pale, white color of the skin)—caused by catecholamine-induced **vasoconstriction** and/or loss of circulating red blood cells
- *Tachycardia*—caused by the effect of catecholamines on the heart as the brain increases the activity of the sympathetic nervous system
- *Diaphoresis (sweating)*—caused by the effects of catecholamines on sweat glands
- *Tachypnea (elevated respiratory rate)*—caused by the brain elevating the respiratory rate under the influence of stress, catecholamines, acidosis, and hypoxia
- *Decreased urinary output*—caused by hypovolemia, hypoxia, and circulating catecholamines (important to remember in interfacility transfers)
- *Weakened peripheral pulses*—the "thready" pulse (meaning "threadlike"; arteries actually shrink in width as intravascular volume is lost); caused by vasoconstriction, tachycardia, and loss of blood volume. As a result of the vasoconstriction, you may also see a *narrow pulse pressure* (e.g., 110/90)

PEARLS
Shock Symptoms

Many of the symptoms seen in shock result from the body's efforts to compensate for the poor perfusion state. The sympathetic nervous system is stimulated and the body releases epinephrine, a catecholamine produced by the adrenal gland.

vasoconstriction: the constriction (narrowing) of the small arteries (called arterioles) to maintain the blood pressure and perfusion of vital organs.

Decompensated shock

- *Hypotension*—caused by hypovolemia, either absolute or relative (see later paragraphs for a discussion of relative hypovolemia), by the diminished cardiac output seen in "obstructive" or "mechanical" shock, and/or by vasodilation caused by such conditions as neurogenic shock
- *Altered mental status (confusion, restlessness, combativeness, unconsciousness)*—caused by decreased cerebral perfusion, acidosis, hypoxia, and catecholamine stimulation
- *Cardiac arrest*—caused by critical organ failure secondary to blood or fluid loss, hypoxia, and occasionally arrhythmia caused by catecholamine stimulation and/or low perfusion (which is usually fatal)

PEARLS
Hypotension

Shock is poor perfusion, not just hypotension. Hypotension is a late finding, after the compensation mechanisms have failed.

Evaluation of Tachycardia

One of the first signs of illness, and arguably one of the most common, is that of tachycardia. You will frequently be confronted with the patient with an elevated pulse rate, and you must make some sort of distinction about the cause.

First, remember that you must always attempt to explain why a patient has tachycardia. An elevated pulse rate (generally considered to be above 100 in an adult and higher at younger ages) is never normal. Humans can transiently raise their pulses in the setting of anxiety, but such elevation quickly returns to normal or fluctuates in rate, depending on the waxing and waning of the anxiety state.

Second, remember that an elevated pulse rate is one of the first signs of shock. Thus, any adult trauma patient with a sustained pulse rate above 100 must be

PEARLS
Tachycardia

A persistently elevated pulse rate while at rest must be considered an indication of something medically wrong with the patient, including the possibility of occult hemorrhage. Keep in mind, however, that the absence of tachycardia does not rule out shock.

suspected of having occult hemorrhage until proven otherwise. During the ITLS Primary Survey, a pulse rate greater than 120 should be a "red flag" for possible shock.

Finally, some patients who are in shock may not develop tachycardia. Patients with traumatic hypotension may develop a "relative bradycardia." As many as 20% of patients with bleeding into the abdomen may not show tachycardia. Another point to consider is the injured patient's medications. Can these medications affect the patient's intrinsic heart rate? Beta-blockers or calcium channel blocking medications might prevent them from developing tachycardia even with excessive blood loss. The use of these medications by the patient should always alert the prehospital care provider to evaluate all hemodynamic parameters, not just heart rate alone. So, the absence of tachycardia in an injured patient does not always rule out shock. Children are unable to increase their cardiac stroke volume, so their cardiac output depends on their heart rate alone (cardiac output = stroke volume × heart rate). Children in decompensated shock may develop bradycardia, which can have a devastating effect on their ability to maintain blood flow to their vital organs.

The Shock Syndromes

Earlier, we mentioned four distinct types of shock, four *shock syndromes*. They may be categorized according to their causes as follows:

- *Low-volume shock* (absolute hypovolemia) is caused by hemorrhage or other major body fluid loss (diarrhea, vomiting, and "third spacing" due to burns, peritonitis, and other causes).
- *High-space shock* (relative hypovolemia) is caused by spinal injury, vasovagal syncope, sepsis, anaphylaxis, and certain drug overdoses that dilate the blood vessels and redistribute blood flow to a larger vascular volume.
- **Mechanical shock** (obstructive shock) is caused by conditions preventing the filling of the heart (pericardial tamponade, tension pneumothorax) or something obstructing blood flow through the lungs (massive pulmonary embolism).
- **Cardiogenic shock** (pump failure) is caused by a damaged heart (myocardial contusion or myocardial infarction)

mechanical and cardiogenic shock: shock produced by conditions that affect the ability of the heart to pump blood; caused by a damaged heart (myocardial contusion) or by conditions preventing the filling of the heart (pericardial tamponade, tension pneumothorax).

There are notable differences in the appearance of patients with these conditions, and it is critical that you be aware of the signs and symptoms that accompany each one. Among these differences will be the skin (or mucosal) color, a factor that will lead us to talk about red (or pink), white, and blue shock.

Hypovolemic Shock (Absolute Hypovolemia)

Loss of blood from injury is called *posttraumatic hemorrhage*. In addition to airway issues, hypovolemic shock is a major cause of preventable death from injury. The amount of volume that the blood vessels can hold is many liters more than what actually flows through the vasculature. The sympathetic nervous system (SNS) keeps the vessels constricted, which reduces the volume of the vascular system and maintains blood pressure high enough to perfuse vital organs. If blood volume is lost, "sensors" in the major vessels signal the adrenal gland and the nerves of the SNS to secrete catecholamines. These hormones cause vasoconstriction and thus further shrink the vascular space, maintaining perfusion pressure to the brain and heart. If the blood loss is minor, the SNS can shrink the vascular space enough and raise the heart rate enough to maintain blood pressure. If the loss is severe, the vascular space cannot be shrunk down enough to maintain blood pressure, and hypotension occurs.

Normally, the blood vessels are elastic and are distended by the volume that is in them. This produces a radial artery pulse that is full and wide. Blood loss allows the artery to shrink in width, becoming more threadlike in size. The term *thready pulse* means that the actual width of the artery shrinks, becoming barely wider than a thread.

Hypovolemic shock victims usually have tachycardia, are pale, and have flat neck veins. So, if you find a trauma victim with a fast heart rate that is pale with weak radial pulses and flat neck veins, this patient is probably bleeding from some injury.

Absolute hypovolemic shock may be identified in your patient during the ITLS Primary Survey (Figure 4-1).

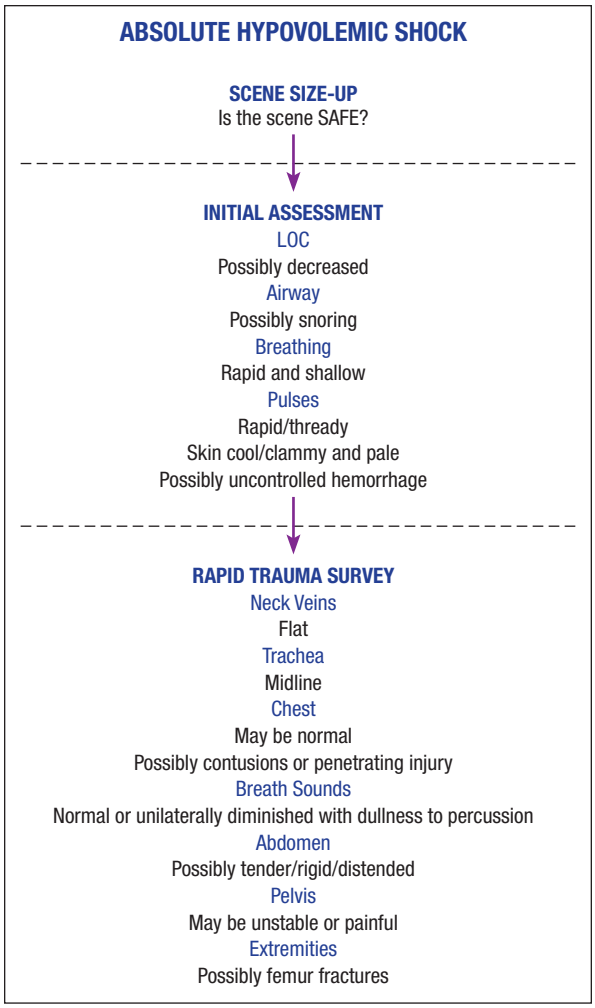


Figure 4-1 Absolute hypovolemic shock may be identified during the ITLS Primary Survey.

Management

Patients in hypovolemic shock due to hemorrhage may be generally thought of as falling into one of the following two categories: those with bleeding that you can control (such as many extremity injuries) and those with bleeding that you cannot control (such as hemorrhage from internal injuries).

Hemorrhage That Can Be Controlled

First, *stop the bleeding!* Note that the assessment of the patient in the ITLS Primary Survey begins with the *initial assessment*, a part of which the responder immediately addresses life-threatening external bleeding by (1) applying direct pressure, and, if necessary, (2) doing so with the aid of a "combat dressing," and if that doesn't work, (3) placing a tourniquet proximal to the extremity bleed. When indicated, all three of these steps will take place during the initial assessment.

If the patient has clinical signs of shock that persist after direct control of the bleeding, you should take the steps outlined in the procedure that follows.

Procedure

Managing Shock When Bleeding Has Been Controlled

1. Put the patient's body in a horizontal position.
2. Administer high-flow oxygen, preferably using a nonrebreather mask with a reservoir.
3. Transport immediately in a safe, rapid manner.
4. Obtain IV access with large-bore catheters (#16 gauge or greater if possible). Consider intraosseous (IO) vascular access if the patient is critical and you are unable to quickly establish an intravenous line.
5. Give crystalloid fluids (such as normal saline or lactated Ringer's) as small boluses of 500 mL (pediatric: 20 mL/kg) IV rapidly and then repeat the ITLS Reassessment Exam. Check for restoration of peripheral pulses. The goal is to restore perfusion, not "normalize blood pressure." If shock symptoms persist, continue to administer fluid in boluses and reassess. In some cases of very severe hemorrhage—because of the substantial loss of red blood cells and markedly impaired oxygen delivery to the tissues—shock symptoms and signs may persist despite hemorrhage control and IV volume infusion. These patients need the rapid transfusion of blood and blood products.
6. Place the patient on an ECG monitor early during evaluation and treatment.
7. Monitor the heart, and apply pulse oximetry and waveform capnography (if available).

External Hemorrhage That Cannot Be Controlled

hemostatic agents: chemical or physical agents that help stop hemorrhage by facilitating clotting of the blood at the bleeding site.

If you cannot stop severe bleeding with pressure and cannot use a tourniquet (such as in groin, axilla, neck, face, and scalp injuries), you may use one of the **hemostatic agents** such as QuikClot® Combat Gauze, Hemcon Dressing, or Celox™, if available. (See Chapter 5.) Pack the hemostatic agent in the wound and hold firm pressure. Always remember that the hemostatic agent is an "adjunct" to assist in controlling hemorrhage, not a hemorrhage control by itself. The agents must be part of an overall "hemorrhage control protocol" authorized by the medical director or by state protocol.

PEARLS

IV Access

Do not waste scene time to establish IV access. Consider the use of IO vascular access if the patient is critical and you cannot obtain IV access.

Gain IV access when en route. Consider IO vascular access if patient is critical and you are unable to establish an intravenous line (humeral head placement of the IO may allow more rapid flow rates). Give only enough normal saline to maintain a blood pressure high enough for adequate peripheral perfusion. Maintaining peripheral perfusion may be defined as producing a peripheral pulse (such as a radial pulse), maintaining consciousness (assuming a traumatic brain injury is not also present), and maintaining an "adequate blood pressure." Certainly most young patients can maintain adequate perfusion with a blood pressure of 80–90 mmHg systolic, but some experts now advocate even lower pressures. Keep in mind that a higher systolic pressure may be required in the setting of a head injury with increased intracerebral pressure and in patients with a history of hypertension. (See Chapter 12.) Rely on local medical direction for guidelines in this situation.

Internal Hemorrhage

The patient with uncontrolled internal hemorrhage is the classic critical trauma victim who will almost certainly die unless you promptly transport to an appropriate facility for rapid operative hemostasis (control of bleeding). The results of the most current medical research on the management of patients with exsanguinating internal hemorrhage is that there exists no substitute for gaining surgical control of bleeding.

Research into the administration of IV fluids to patients with uncontrolled hemorrhage has indicated the following:

- The use of large amounts of IV fluids in the setting of uncontrolled internal hemorrhage may increase internal bleeding and mortality. IV fluids increase the blood pressure and may also dilute clotting factors. Furthermore, IV fluids carry almost no oxygen and are not a replacement for red blood cells. Early blood transfusion is very important in severe cases of hemorrhagic shock.
- Any delay in providing rapid transport of such patients should not occur unless absolutely unavoidable, as in the case of a patient requiring prolonged extrication or in a tactical setting where transport is delayed. Always document such circumstances carefully in the patient care report.
- Moribund trauma patients (ones in very deep shock with blood pressures under 50 mmHg systolic [i.e., no pulses can be felt]) often die, and fluid administration is indicated to maintain some degree of circulation, according to current understanding. Treatment of this extreme amount of hemorrhage may override the concerns for increased hemorrhage secondary to the use of these interventions. However, this approach is still controversial. Local medical direction should guide such therapy pending further research.

The recommendations, therefore, for a patient with probable exsanguinating internal hemorrhage are described as follows.

Procedure

Managing Shock Due to Internal Hemorrhage

1. Transport immediately and in a rapid, safe manner.
2. Place the patient in a horizontal position.
3. Administer high-flow oxygen.
4. Gain IV access with large-bore catheters. Consider IO vascular access if unable to quickly establish an intravenous line.

Administer sufficient normal saline to maintain peripheral perfusion by giving enough fluid—usually in boluses—to return a peripheral pulse, such as a radial pulse. Local medical direction should guide what is acceptable practice in this setting. Recent research suggests that fluid resuscitation be kept to a minimum until hemorrhage control is obtained (operative intervention). Hemostatic agents are not indicated for internal hemorrhage.

5. Monitor the heart, and apply pulse oximetry and waveform capnography (where available).
6. Perform ITLS Reassessment Exams, and observe closely.

Special Situations in Hypovolemic Shock

Head Injury

The patient with traumatic brain injury (TBI) (Glasgow Coma Scale [GCS] score of 8 or less) and shock is a special situation. (See Chapter 12.) Traumatic brain injury is worsened by shock. Therefore, if necessary, adults with suspected hemorrhagic shock in addition to TBI should be fluid-resuscitated to a blood pressure of 110 mmHg systolic to maintain a cerebral perfusion pressure of at least 60 mmHg. (See Chapter 12.)

High-Space Shock (Relative Hypovolemia)

The average-size adult has around 5 liters of blood in the vascular system. However, the vascular system could hold as many as 25 liters of blood, if the arterioles were to fully dilate. It is the steady-state action of the SNS that keeps the arterioles of the vascular bed constricted in the normal state, keeping most of the blood in the arteries and maintaining perfusion to the heart and brain. Anything that interrupts the outflow from the SNS and causes the loss of this normal vasoconstriction allows the vascular space to dilate, becoming much "too large" for the amount of blood in the vascular system. If blood vessels dilate, the 5 liters or so of blood flowing through the normal adult's vascular space may not be sufficient to maintain blood pressure and vital tissue perfusion. The condition causing the vascular space to be too large for a normal amount of blood has been called distributive shock, "high-space shock," or relative hypovolemia. Although several causes of high-space shock exist (such as sepsis syndrome and drug overdose), **neurogenic shock** is addressed here because it may be caused by trauma.

The nerves of the SNS come off the spinal cord in the thoracic (chest) and lumbar area. Neurogenic shock occurs most typically after an injury to the spinal cord at the sixth thoracic vertebrae or above. An injury to the spinal cord in the neck or upper thoracic spine can prevent the brain from being able to send out SNS signals. Thus, the spinal cord injury prevents the brain from raising the pulse rate, from raising the strength

PEARLS

Mechanical or High-Space Shock

Look for signs of mechanical or high-space shock, especially if there is no bleeding.

neurogenic shock: shock caused by spinal injury in which the spinal connections to the adrenal glands and to the blood vessels are interrupted and the vasoconstrictors, epinephrine and norepinephrine, are not produced. Without the vasoconstrictors the blood vessels dilate and redistribute blood flow to a larger vascular volume, causing relative hypovolemia, and the heart muscle cannot be stimulated to contract harder and faster.

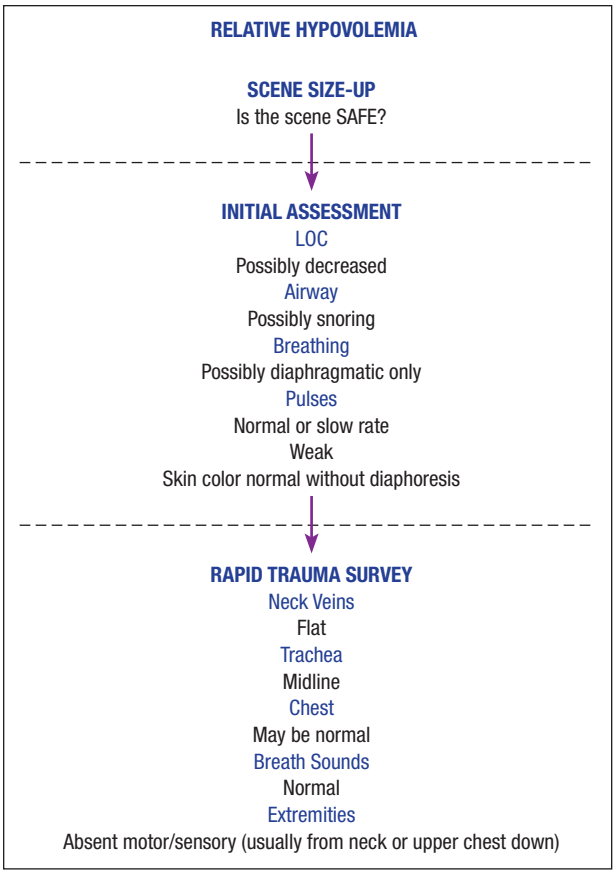


Figure 4-2 Relative hypovolemia due to neurogenic (spinal) shock may be identified during the ITLS Primary Survey.

of the heart's contraction, or from constricting the peripheral arterioles (the vessels that maintain blood pressure). Although circulating catecholamines already present in the bloodstream may preserve the blood pressure for a short time, the disruption of the SNS outflow from the spinal cord results in loss of the normal vascular tone and in the inability of the body to compensate for any accompanying hemorrhage.

The clinical presentation of neurogenic shock differs from hemorrhagic shock in that there is no catecholamine release and thus no pallor (due to vasoconstriction), tachycardia, or sweating. The patient will have a decreased blood pressure, but the heart rate will be normal or slow, and the skin is usually warm, dry, and pink. The patient also may have accompanying paralysis and/or sensory deficit corresponding to the spinal cord injury. The important point is that a patient with spinal cord injury may not have the typical picture of hemorrhagic shock, even when associated with severe bleeding. The neurologic assessment is therefore very important, and you should not rely solely on typical shock symptoms and signs to suspect internal bleeding or accompanying hemorrhage-associated shock. Neurogenic shock patients may "look better" than their actual condition really is and can be some of the most difficult patients to accurately assess. Relative hypovolemia due to neurogenic (spinal) shock may be identified in your patient during the ITLS Primary Survey (Figure 4-2).

Obstructive Shock

The heart is a pump. In the normal adult's resting state, the heart pumps out about 5 liters of blood per minute. This means, of course, that the heart also must take in about 5 liters of blood per minute. Therefore, any traumatic or medical condition that slows or prevents the venous return of blood can cause shock by lowering cardiac output and thus oxygen delivery to the tissues. Likewise, anything that obstructs the flow of blood to or through the heart can cause shock.

Obstructive shock can be caused by tension pneumothorax or cardiac tamponade. It may also be caused by a massive pulmonary embolism, though this generally occurs hours to days after a traumatic event, and thus is not generally considered in the prehospital assessment of obstructive shock.

Tension Pneumothorax

Tension pneumothorax is so named because of the high air tension (pressure) that may develop in the pleural space (between the lung and chest wall) due to a lung or chest wall injury. If there is a hole from the lung into the pleural space, air will escape into the pleural space as the lung collapses. If air is then trapped in the pleural space, pressure will gradually increase in the chest cavity.

In order to understand what happens next, it is critical to understand that blood returns to the chest largely because of *negative pressure* that results when the individual inhales. In the absence of this negative pressure, blood return will be decreased. This very high positive pressure also collapses the low-pressure superior and inferior vena cava, preventing the return of venous blood to the heart. The resulting "backup" of blood presents as distended neck veins. Shifting of mediastinal structures also may lower venous return by impinging on the superior and inferior vena cava, also causing a deviation of the trachea away from the affected side (rarely

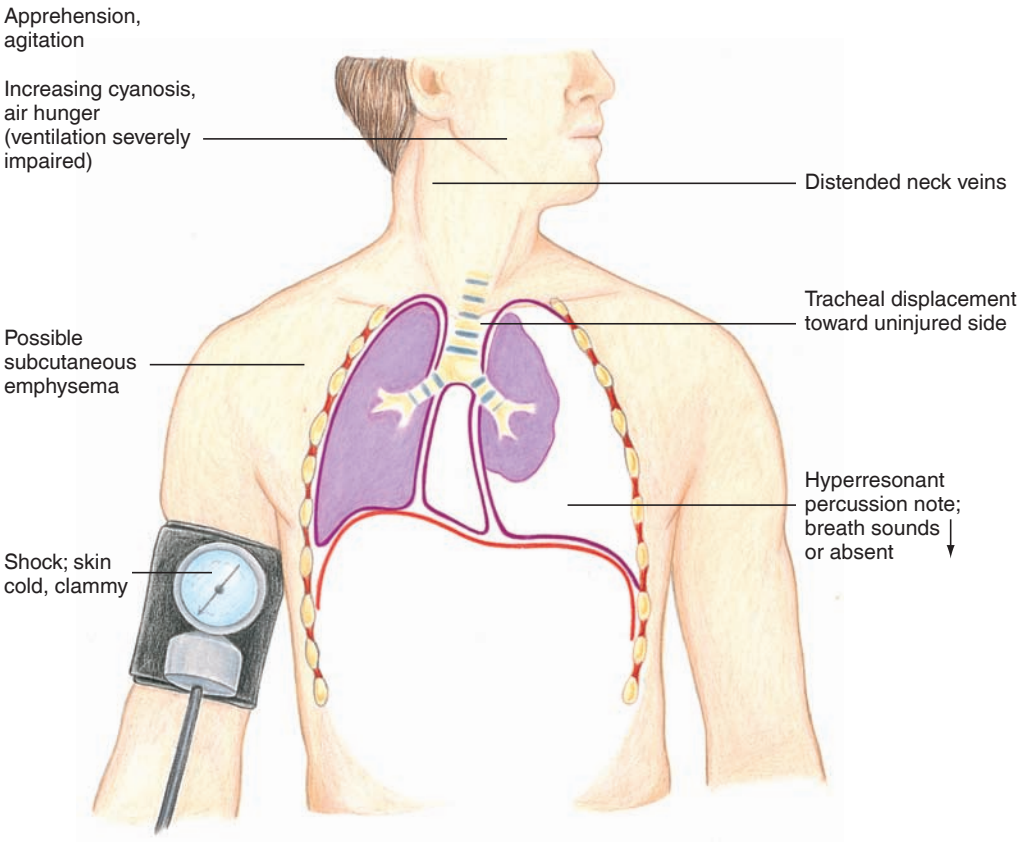


Figure 4-3 Physical findings of tension pneumothorax.

seen clinically). Decreased venous return results in lower cardiac output and the development of shock.

In addition to presenting the classical signs and symptoms of shock described earlier, given the backup of venous blood, the patient will eventually develop cyanosis, especially noticeable around the lips and nail beds. Thus, the hallmarks of tension pneumothorax as it becomes severe are (1) decreased or absent breath sounds on the affected side, together with (2) hyperresonance to percussion, (3) elevated neck veins, perhaps a (4) deviated trachea, (5) cyanosis, and ultimately a decreased level of consciousness.

Tension pneumothorax may be identified during the ITLS Primary Survey (Figure 4-3).

In addition to maintenance of the airway and assisting ventilation when presented with poor tidal volume and giving high-flow oxygen, patients with tension pneumothorax are candidates for prompt needle decompression when they exhibit the following: (1) absent radial pulses, (2) cyanosis, and (3) loss of consciousness. (See Chapter 8.)

Cardiac Tamponade

Cardiac tamponade, or "pericardial tamponade," occurs when blood fills the "potential" space between the heart and the pericardium, squeezing the heart and preventing the heart from filling (Figure 4-4). Like the "squeezing" of the superior and inferior vena cava we saw with tension pneumothorax, the resultant backup caused by squeezing shut the chambers of the heart present as distended neck veins and cyanosis. This decreased filling of the heart causes cardiac output to fall, resulting in the development of shock.

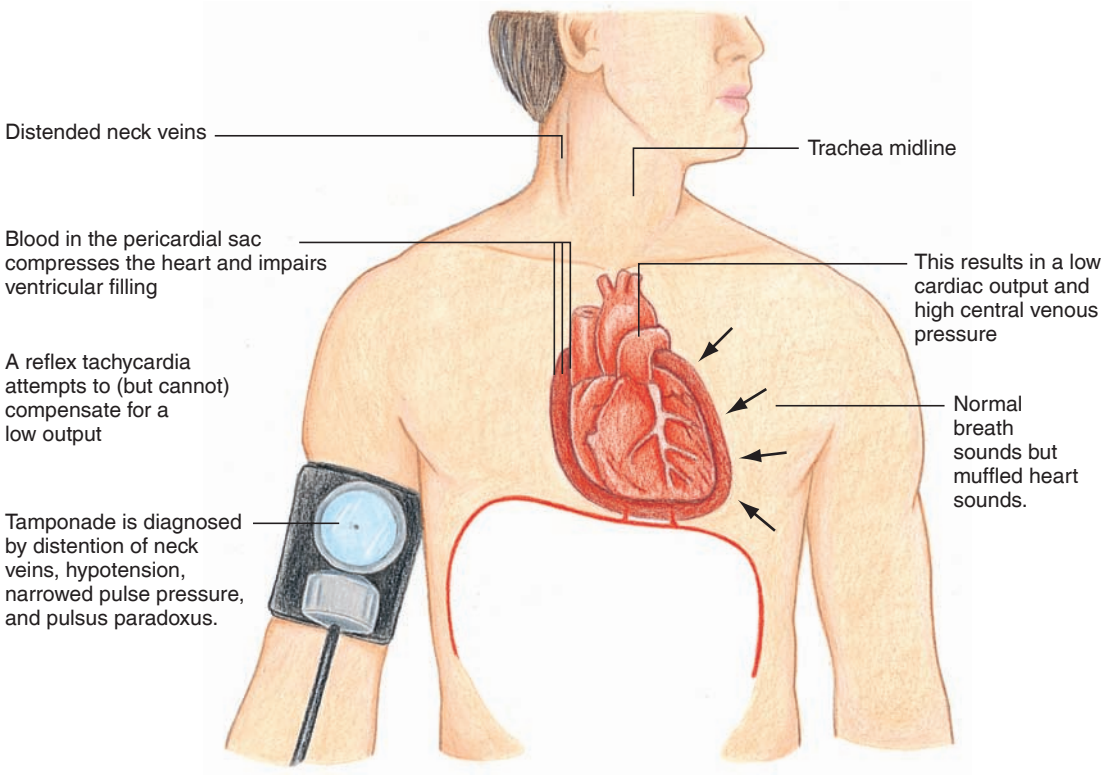


Figure 4-4 Pathophysiology and physical findings of cardiac tamponade.

Pericardial tamponade may occur in more than 75% of cases of penetrating cardiac injury. The signs of tamponade have been labeled "Beck's triad," consisting of distended neck veins, muffled heart tones, and pulsus paradoxus. On-scene interventions should be avoided if this diagnosis is suspected because any time wasted on scene could result in death of the patient. Using intravenous fluids to increase filling pressure of the heart may possibly be of some value, but IV fluids could also worsen the condition if there is an additional internal exsanguinating injury. (See Chapter 8 for a more complete discussion.)

Signs and symptoms of cardiac tamponade may be identified during the ITLS Primary Survey (see Figure 4-4). If these are present and your scope of practice permits, pericardiocentesis should be performed.

Cardiogenic Shock

As discussed earlier, the heart is a pump, and the pumping action produces the output of blood into the vascular system. The typical cardiac output of blood in the normal resting adult is 5 liters of blood per minute. If some condition causes the heart to lose pumping strength, then the amount of blood being circulated would be reduced. This is precisely what happens when the heart muscle itself is damaged. Pumping strength is reduced, cardiac output falls, and the blood pressure goes down. Such a condition is called *cardiogenic shock*.

Cardiac Contusion

Because of how the heart is situated in the chest, with the right ventricle more anterior than the left, the right ventricle is a common location for myocardial contusion.

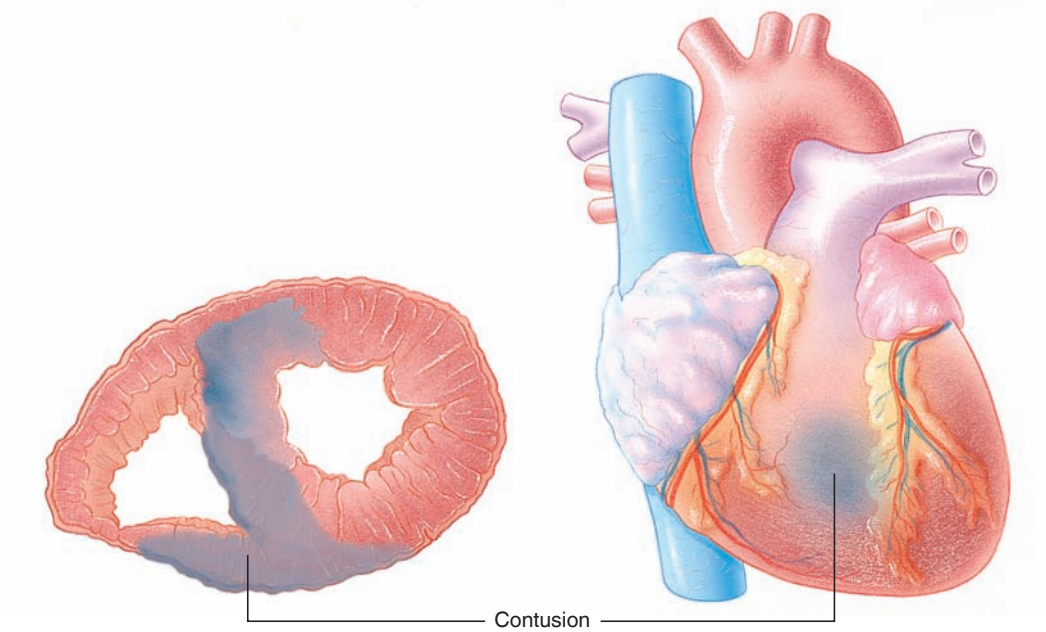


Figure 4-5 Myocardial contusion most frequently affects the right atrium and ventricle as they collide with the sternum.

Myocardial contusion can result not only in diminished strength of contraction of the right ventricle, leading to a lower volume in the left, it can also cause dysrhythmias, which can also cause a slowing of the heart rate, further exacerbating the cardiac output.

The recognition of cardiac contusion is difficult because the symptoms are often nonspecific. The most important clue to its possibility is a history of severe blunt trauma to the chest resulting from a sudden deceleration injury. Most common are motor vehicle crashes and falls (Figure 4-5).



Figure 4-6 Myocardial contusion may cause ventricular ectopy.

If the patient complains of chest pain, is found to have an otherwise unexplained irregular pulse, and exhibits neck vein distension, especially in the presence of blunt-force trauma to the anterior chest (bruised or flail sternum), cardiac contusion should be suspected.

Those signs are similar to pericardial tamponade and may not be differentiated in the field so are treated the same. If available, a 12-lead ECG should be performed, which may indicate an injury pattern to the right ventricle (ST elevation myocardial infarction (STEMI) in inferior and right-sided leads; may develop new right bundle branch block). Presence of ventricular arrhythmia on monitor may be the only EKG abnormality (Figure 4-6).

There is one more thing to consider. When the patient presents with or develops the symptoms of a cardiac injury *without a mechanism of injury to suggest a traumatic cause*, consider the possibility that the chest pain may be due to an acute MI, which in turn may have caused the incident (Figure 4-7).

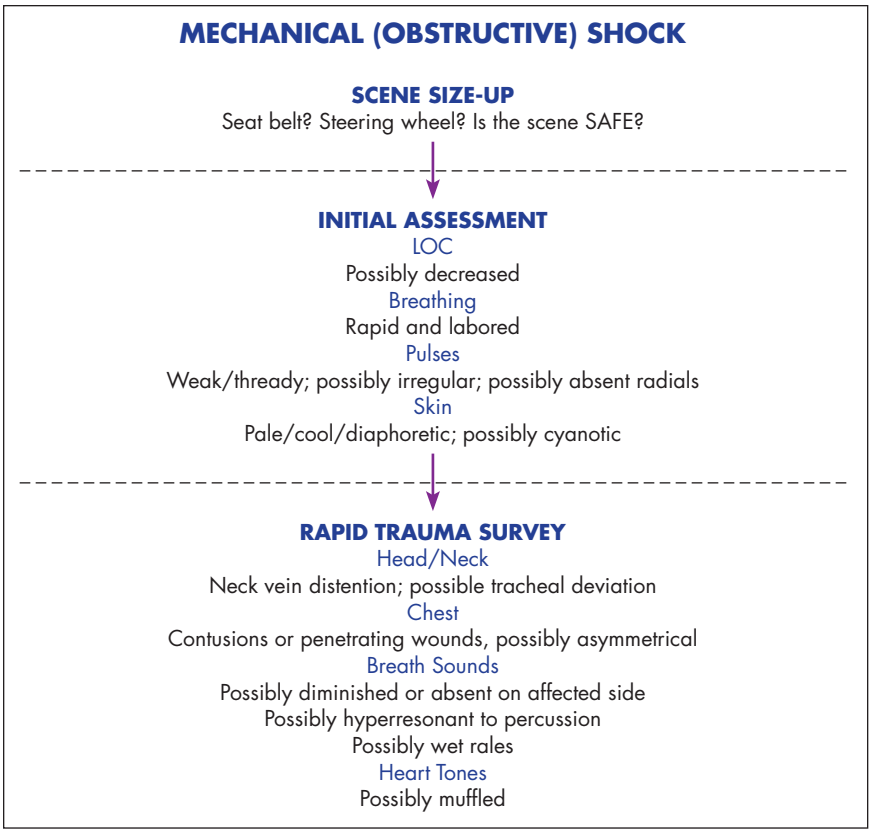


Figure 4-7 Mechanical (obstructive) shock may be identified during the ITLS Primary Survey.

Current Thinking in the Treatment of Shock

Stop the Bleed

No matter how rapid the arrival of professional emergency responders, bystanders may be first on the scene. A person who is bleeding can quickly die from blood loss; therefore, it is important to quickly stop the bleeding.

Upon the arrival of EMS, an assessment of external bleeding should be a part of the *general impression*. If first responders are unsuccessful at stopping life-threatening external hemorrhage, EMS crews should be equipped with and provide *combat dressings* with which to assist direct-pressure efforts. If the end of the initial assessment has not controlled external hemorrhage, there should be no delay in applying a commercial tourniquet if an extremity is involved. Uncontrolled hemorrhage of any kind mandates transport without unnecessary delay.

PEARLS

Hemorrhage

Control hemorrhage. If it cannot be done in the field, the patient needs to be in the operating room as soon as possible.

Prevent Hypothermia

Hypothermia worsens outcomes in trauma patients. Any fluids given should be warmed and patients covered to prevent heat loss.

Fluid Therapy for Uncontrolled Hemorrhage

Ongoing, uncontrolled hemorrhage requires early recognition and, as stated above, prompt transport to the appropriate facility (trauma center). It also mandates limiting fluid resuscitation to the level of restoring perfusion (hypotensive resuscitation), generally

considered to mean sufficient fluid to restore a radial pulse or a systolic pressure of 80–90 mmHg. Excessive fluid resuscitation with crystalloid can cause acidosis and dilute clotting factors, leading to coagulopathy (Blanchard et al. 2017).

Tranexamic Acid

Tranexamic acid (TXA) is an antifibrinolytic drug that has been used for many years to assist with the management of spontaneous hemorrhaging in the hemophilia patient. This agent has also been used in combat settings for management of severe hemorrhage. The scientific logic behind the use of TXA is that when bleeding occurs, the body tries to stop the bleeding by forming blood clots at the bleeding sites. Eventually these clots dissolve by normal clot breakdown activities of the body. TXA works by preventing these newly formed clots from breaking down by blocking the body's clot breakdown process.

tranexamic acid (TXA): a synthetic analog of the amino acid lysine. An antithrombolytic agent, it works by blocking the activation of plasminogen to plasmin, which normally breaks down clots in the body. It has been used in surgery to reduce blood loss, particularly in obstetric, gynecologic, and orthopedic procedures. Recently, there has been interest in the use of this medication to reduce bleeding in trauma.

One of the most significant findings in a large study that looked at the use of tranexamic acid in trauma (the CRASH-2 study) was that the use of TXA was associated with a 1.5 absolute risk reduction for death from hemorrhage. Other studies showed that TXA was most effective if given within 3 hours of the injury and, indeed, may be detrimental if given after that time. Studies have also shown that the patients who benefit most from TXA are in severe hemorrhagic shock and receive TXA early.

Medical oversight should review current literature and develop prehospital EMS protocols in regard to appropriate use of TXA. Implementation of this protocol should be monitored and supervised through a quality assurance program.

ITLS believes that there is sufficient evidence to support the use of TXA in the management of traumatic hemorrhage in the adult patient, pursuant to system medical control approval. Following initial resuscitation including control of external bleeding and stabilization of the airway, consideration should be given to administration of TXA during early stages of treatment and transport.

There seems to be some benefit of the use of TXA in patients with severe extracranial hemorrhage as stated above. However, the effectiveness and safety of TXA in traumatic brain injury is uncertain, and randomized trials have been established to investigate this problem. At this time the authors recommend that patients with isolated traumatic brain injury should not receive TXA outside the context of a research trial.

A suggested approach for the administration of TXA in the setting of major trauma is as follows:

- In adult patients with severe hemorrhagic shock, defined as less than 75 mmHg, 1 gram of TXA may be administered over 10 minutes. An additional gram should be administered over the following 8 hours.
- TXA should only be administered less than 3 hours from the time of injury.
- Guidelines for the use of TXA should be established by the medical director of the EMS system in collaboration with representatives of the trauma system of the area.

Capnography

Waveform capnography is not just useful for confirming endotracheal tube placement, or for assessing respiratory function. It is also useful for assessing for shock.

PEARLS

Capnography

Falling height of the capnography waveform may be one of the first indicators that a patient is going into a shock state.

The heart delivers oxygen and nutrients to the cells of the body by way of blood vessels. The cells "burn" the nutrients in the presence of oxygen to produce energy, water, and carbon dioxide (CO_2). The water and CO_2 move into the bloodstream, the CO_2 being carried to the lungs by the red blood cells for excretion during exhalation. CO_2, then, is the exhaled by-product of metabolism. Put another way, the level of exhaled CO_2 indicates how brightly the fire of metabolism is burning in the cells. When measured moment to moment at the airway, the level of CO_2 being excreted

may be graphed as a waveform and can give some measure of the patient's underlying metabolic rate.

Devices are now commonly available, either separately or on ECG monitors, that measure CO_2 levels and display them as a waveform. The typical exhaled CO_2 is in the range of 35–45 mmHg. Falling measured CO_2 indicates either that the patient is hyperventilating (from anxiety or acidosis) or that the amount of oxygen being supplied to the cells is falling. You might say it this way: A falling exhaled CO_2 level suggests that the "fire of metabolism" in the patient may be burning low.

Patients in shock have decreased oxygen being supplied to their cells. This is either because they have lost blood through hemorrhage or the heart is not circulating it effectively. Thus, if you are monitoring a patient either in shock or at risk of going into shock, monitor the level of exhaled CO_2 as part of your overall care. A level of exhaled CO_2 that falls much under 35—especially if it falls into the 20s or below—indicates poor peripheral perfusion.

Early Administration of Blood and Blood Products

Patients who are hemorrhaging are losing blood and the best fluid with which to replace that loss is blood. Whole blood has not only red cells that carry oxygen but also contains clotting factors and platelets. Blood that has been banked has had the red cells separated (packed red cells [PRBCs]) from platelets and plasma. Transfusion of packed cells only plus the administration of large volumes of crystalloid can lead to a dilutional coagulopathy. In addition, most blood products are refrigerated for storage and, unless rewarmed, can lead to hypothermia. Coupled with the consumption of the patient's own clotting factors, the patient's ability to clot is compromised. To address this situation, patients who are receiving massive transfusions (greater than 10 units in 24 hours) should be given PRBCs plus platelets plus fresh frozen plasma (FFP) at a ratio of 1:1:1 to address the coagulopathy (Holcomb et al. 2016).

Administration of blood in the prehospital setting is now taking place in some EMS and air medical systems. The challenges of maintaining the blood and rewarming it are challenges that systems must address, but there are some encouraging improvements in outcomes (Escott et al. 2017).

Resuscitative Endovascular Balloon Occlusion of the Aorta

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is a procedure that allows control of noncompressible bleeding below the diaphragm. It has been described as an alternative to cross-clamping of the aorta to control intra-abdominal bleeding. It involves passage of an intravascular balloon through a femoral arterial puncture. The balloon is inflated above the level of the bleeding and occludes the aorta. It can be rapidly performed and has the potential to be performed outside of the hospital. There is a limited period following occlusion before organs suffer ischemic damage and requires significant training. REBOA is undergoing clinical trials in both the military and civilian settings at the time of publication of this text (King 2019).

Case Presentation *(continued)*

An ALS ambulance has been dispatched to a bar where a patron has been stabbed. The scene size-up reveals that the police are on scene, have cleared the bar, and are questioning bystanders.

Because the scene is safe and the mechanism of injury (stab wound) is known, the team dons personal protective equipment. As they enter the bar, they see a male victim sitting on the floor in a pool of blood. As a part of the *General Impression*, in addition to the pool of blood, the team leader sees that the external bleeding is coming from a large slash in the victim's right forearm, which the bartender has been trying to control with a large towel. The team leader immediately instructs her partner to apply direct pressure with the aid of a combat dressing.

As the team leader continues her initial assessment, the patient complains of pain in his chest, where he points to a large stab wound located at the level of the right fifth intercostal space at the anterior axillary line. He is alert, his airway is patent, his breathing is rapid but with good air movement, and his radial pulse is rapid (~100–110) and strong. His face is sweaty and flushed.

The second emergency care provider reports he is having trouble controlling the bleeding from the arm, so the team leader decides to place a tourniquet on the right arm. Having ascertained that the patient says he has no other injuries, except as found above, the team leader decides to perform a focused exam.

With no obvious injury to the head, she examines the neck and finds the neck veins flat. She exposes the chest to find it is moving asymmetrically, with decreased movement on the right, and the 4–5 cm puncture wound as noted above. The second emergency care provider, having correctly applied a tourniquet to the right arm, is instructed to apply a chest seal to the chest wound and start the patient on high-flow oxygen. He sees no other injury. Breath sounds are possibly diminished on the right, and there is dullness to percussion. Heart tones are clearly audible. The abdomen is nontender without rigidity or distension.

Based on the penetrating injury to the chest, the team leader determines this to be a critical load-and-go situation. The patient is placed on a stretcher and moved immediately to the ambulance.

Once in the ambulance, one of the firemen who had arrived on the scene is asked to drive. In preparation for transport, the second emergency care provider obtains a set of vital signs while the team leader completes her rapid trauma survey by noting that her patient, while still awake, doesn't open his eyes when spoken to, complains of increasing difficulty breathing, and is now complaining of abdominal pain. His Glasgow Coma Scale score is 14. Vital signs are BP, 90/50; R, 24; and P, 120. The driver is instructed to head for the trauma center, a 30- to 40-minute trip.

Once en route, the team leader begins her reassessment exam. The patient now appears to be in obvious distress, with an open airway but rapid, shallow respirations and a thready pulse at the wrist. He is now quite pale with cool, clammy skin. There is no cyanosis. His neck veins are still flat. His chest is now moving very poorly on the right, still dull to percussion, and breath sounds are now absent on that side. His abdomen is now tender to palpation.

While the second emergency care provider attaches a monitor and pulse ox, the team leader repeats a set of vital signs, finding that the patient's BP has dropped to 82/60, pulse barely palpable at ~132, and respirations at ~30. The second care provider "burps" the chest seal, with no air escape or change in the patient status. A needle decompression of the right side does not have any air escape.

Case Presentation *(continued)*

The second care provider reports that the SpO_2, initially at 94, now won't register. The patient's ECG shows sinus tachycardia and his $etCO_2$ is 32 mmHg. As the team leader starts an IV of normal saline, the second emergency care provider obtains a fingerstick glucose that reads 138.

The team leader calls the trauma center and reports on the patient, his now controlled external bleed, and the apparent uncontrolled bleed in the right chest and possible involvement of the liver. She completes her patient report by estimating a 30- to 35-minute ETA and asks if she should initiate TXA.

While medical control consults with the receiving surgeon, she repeats the vital signs, which with 250 mL of normal saline yields a BP of 84/64 and a GCS score of 10. Given the okay to initiate TXA, she begins a loading dose of 1 g over 10 minutes, to be followed by the initiation of another 1 g over 8 hours.

The team leader continues to reassess the patient and, with time, goes ahead and performs a detailed, head-to-toe secondary survey. She finds no unidentified injuries and no medical alert tags, but does find a medical information section on the patient's smartphone, which lists no medicines or medical history but does report allergies to egg whites and shellfish.

Upon arrival, the team is directed to take the patient directly to the surgical suite.

Summary

A patient in shock must be diagnosed early. Though the early signs and symptoms may be subtle, it is important to maintain a high level of suspicion when the mechanism of injury suggests the possibility. Careful assessment for the presence of shock cannot be overemphasized.

Control of external exsanguinating hemorrhage must be a priority, and thus is a part of the initial assessment's general impression. When direct pressure is not readily successful, the aid of a combat dressing is important, and if that is not successful in the presence of extremity bleeding, the early application of a tourniquet is indicated.

Understanding the different shock syndromes is critical, since it may lead to the early intervention of life-saving management. In addition, knowing how to treat uncontrolled hemorrhage is extremely important in order to "do no harm." In addition to not overhydrating your patient, knowing when to consider TXA is an important new step in the effort of prehospital personnel to help in the battle to get patients in shock to definitive care before it is too late. Rely on regular educational updates as well as your EMS system's medical director or EMS agency protocols to help keep you current on the standard of care in the treatment of shock.

References and Resources

Baraniuk, S., B. C. Tilley, D. J. del Junco, E. E. Fox, G. van Belle, C. E. Wade, J. M. Podbielski, A. M. Beeler, J. R. Hess, E. M. Bulger, et al. 2014. "Pragmatic Randomized Optimal Platelet and Plasma Ratios (PROPPR) Trial: Design, Rationale, and Implementation." *Injury* 45, no. 9 (September): 1287–95.

Bickell, W. H., M. J. Wall Jr., P. E. Pepe, R. R. Martin, V. F. Ginger, M. K. Allen, and K. L. Mattox. 1994. "Immediate Versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injury." *New England Journal of Medicine* 331, no. 17 (October): 1105–9.

Blanchard, I. E., A. Ahmad, K. L. Tang, P. E. Ronksley, D. Lorenzetti, G. Lazarenko, E. S. Lang, C. J. Doig, and H. T. Stelfox. 2017. "The Effectiveness of Prehospital Hypertonic Saline for Hypotensive Trauma Patients: A Systematic Review and Meta-Analysis." *BMC Emergency Medicine* 17, no. 35. https://doi.org/10.1186/s12873-017-0146-1

Bulger, E. M., S. May, J. D. Kerby, S. Emerson, I. G. Stiell, M. A. Schreiber, K. J. Brasel, S. A. Tisherman, R. Coimbra, S. Rizoli, et al. 2011. "Out-of-Hospital Hypertonic Resuscitation After Traumatic Hypovolemic Shock: A Randomized, Placebo Controlled Trial." *Annals of Surgery* 253, no. 3 (March): 431–41.

Champion, H. R. 2003. "Combat Fluid Resuscitation: Introduction and Overview of Conferences." *Journal of Trauma* 54, Suppl. 5 (May): S1–S12.

Chiara, O., P. Pelosi, L. Brazzi, N. Bottino, P. Taccone, S. Cimbanassi, M. Segala, L. Gattinoni, and T. Scalea. 2003. "Resuscitation from Hemorrhagic Shock: Experimental Model Comparing Normal Saline, Dextran, and Hypertonic Saline Solutions." *Critical Care Medicine* 31, no. 7 (July): 1915–22.

CRASH-2 Trial Collaborators. 2010. "Effects of Tranexamic Acid on Death, Vascular Occlusive Events, and Blood Transfusion in Trauma Patients with Significant Hemorrhage (CRASH-2): A Randomized, Placebo-Controlled Trial." *Lancet* 376, no. 9734 (July): 23–32.

CRASH-2 Trial Collaborators. 2011. "The Importance of Early Treatment with Tranexamic Acid in Bleeding Trauma Patients: An Exploratory Analysis of the CRASH-2 Randomised Controlled Trial." *Lancet* 377, no. 9771 (March): 1096–101.

Demetriades, D., L. S. Chan, P. Bhasin, T. V. Berne, E. Ramicone, F. Huicochea, G. Velmahos, E. E. Cornwell, H. Belzberg, J. Murray, et al. 1998. "Relative Bradycardia in Patients with Traumatic Hypotension." *Journal of Trauma* 45, no. 3 (September): 534–9.

Dunn, C. J., and K. L. Goa. 1999. "Tranexamic Acid: A Review of Its Use in Surgery and Other Indications." *Drugs* 57, no. 6 (June): 1005–32.

Escott, M. E. A., E. A. Bank, F. M. Mehkri, and B. J. Monroe. 2017. "Considerations for Using Blood Products for Prehospital Trauma Patients." *Journal of Emergency Medical Services* 42, no. 4 (March). https://www.jems.com/articles/print/volume-42/issue-3/features/considerations-for-using-blood-products-for-prehospital-trauma-patients.html

Haut, E. R., B. T. Kalish, D. T. Efron, A. H. Haider, K. A. Stevens, A. N. Kieninger, E. E. Cornwell III, and D. C. Chang. 2010. "Spine Immobilization in Penetrating Trauma: More Harm Than Good?" *Journal of Trauma* 68, no. 1 (January): 115–21.

Holcomb, J. B., B. C. Tilley, S. Baraniuk, E. E. Fox, C. E. Wade, J. M. Podbielski, D. J. del Junco, K. J. Brasel, E. M. Bulger, R. A. Callcut, et al. 2015. "Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients with Severe Trauma: The PROPPR Randomized Clinical Trial." *Journal of the American Medical Association* 313, no. 5 (February): 471–82.

King, D. R. 2019. "Initial Care of the Severely Injured Trauma Patient." *New England Journal of Medicine* 380: 763–70.

Kowalenko, T., S. Stern, S. Dronen, and X. Wang. 1992. "Improved Outcome with Hypotensive Resuscitation of Uncontrolled Hemorrhagic Shock in a Swine Model." *Journal of Trauma* 33, no. 3 (September): 349–53.

Kragh, J. F., M. L. Littrel, J. A. Jones, T. J. Walters, D. G. Baer, C. E. Wade, and J. B. Holcomb. 2011. "Battle Casualty Survival with Emergency Tourniquet Use to Stop Limb Bleeding." *Journal of Emergency Medicine* 41, no. 6 (December): 590–7.

Mapstone, J., I. Roberts, and P. Evans. 2003. "Fluid Resuscitation Strategies: A Systematic Review of Animal Trials." *Journal of Trauma* 55, no. 3 (September): 571–89.

Mattox, K. L., W. Bickell, P. E. Pepe, J. Burch, and D. Feliciano. 1989. "Prospective MAST Study in 911 Patients." *Journal of Trauma* 29, no. 8 (August): 1104–12.

Moore, E. E. 2003. "Blood Substitutes: The Future Is Now." *Journal of the American College of Surgeons* 196, no. 1 (January): 1–16.

Morrison, J. J., J. J. Dubose, T. E. Rasmussen, and M. J. Midwinter. 2012. "The Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study." *Archives of Surgery* 147, no. 2 (February): 113–9.

Neeki, M. M., F. Dong, J. Toy, R. Vaezazizi, J. Powell, D. Wong, M. Mousselli, M. Rabiei, A. Jabourian, N. Niknafs, et al. 2018. "Tranexamic Acid in Civilian Trauma Care in the California Prehospital Antifibrinolytic Therapy Study." *Western Journal of Emergency Medicine* 19, no. 6 (November): 977–86.

Pena, S. B., and A. R. Larrad. 2012. "Does the Trendelenburg Position Affect Hemodynamics?: A Systematic Review." *Emergencias* 24, no. 2 (April): 143–50

Roberts, I., H. Shakur, K. Ker, and T. Coats, on behalf of the CRASH-2 Trial Collaborators. 2012. "Antifibrinolytic drugs for acute traumatic injury." *Cochrane Database of Systematic Reviews*, Issue 12. Art. No. CD004896. DOI: 10.1002/14651858.CD004896.pub3

Schriger, D. L., and L. J. Baraff. "Capillary Refill—Is It a Useful Predictor of Hypovolemic States?" 1991. *Annals of Emergency Medicine* 20, no. 6 (June): 601–5.

Warner, K. J., J. Cuschieri, B. Garland, D. Carlbom, D. Baker, M. K. Copass, G. J. Jurkovich, and E. M. Bulger. 2009. "The Utility of Early End-Tidal Capnography in Monitoring Ventilation Status After Severe Injury." *Journal of Trauma* 66, no. 1 (January): 26–31.

Valle, E. J., C. J. Allen, R. M. Van Haren, J. M. Jouria, H. Li, A. S. Livingstone, N. Namias, C. I. Schulman, and K. G. Proctor. 2014. "Do All Trauma Patients Benefit from Tranexamic Acid?" *Journal of Trauma and Acute Care Surgery* 76, no. 6 (June): 1373–8.

5

Shock and Hemorrhage Control Skills



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Donna Hastings, EMT-P
Kyee Han, MD, FRCS, FCEM

Maßnahmen zur Blutungskontrolle
Habilidades para el Control de Hemorragias y Shock
Vještine zbrinjavanja šoka i zaustavljanja krvarenja
Competências Práticas no Choque e Controlo de Hemorragia
Keterampilan Penanganan Syok dan Perdarahan
Обучение навыкам контроля кровотечения и помощь при шоке
Contrôle des hémorragies et état de choc en pratique
Δεξιότητες στον Έλεγχο της Αιμορραγίας και της Καταπληξίας
Volumenpótlás- gyakorlati készségek
ショックと出血のコントロールに関する手技
休克及出血之控制技巧
Veščine zaustavljanja krvavitev ter obravnave šoka

Skills presented in this chapter:

- External jugular venous access
- Intraosseous access
  - EZ-IO® device
  - Manual
  - FAST Responder™ device
- Length-based resuscitation tape to estimate child's weight
- Wound packing
- Tourniquet application
- Hemostatic agent application

Objectives

Upon successful completion of this chapter, you should be able to:

1. Perform the technique of cannulation of the external jugular vein.*
2. Describe indications for the use of intraosseous infusion.
3. Perform intraosseous infusion using appropriate devices.
4. Use length-based resuscitation tape to estimate the weight of a child.
5. Demonstrate how to properly apply a tourniquet for life-threatening bleeding.
6. Control hemorrhage using direct pressure with and without hemostatic gauze.
7. Demonstrate on a mannequin model how to pack a wound to control bleeding.

**All advanced students of this course are expected to be familiar with the technique of inserting an IV cannula in the veins of the lower arm or antecubital space; thus, these sites are not discussed here.*

Cannulation of the External Jugular Vein

The external jugular vein runs in a line from the angle of the jaw to the junction of the medial and middle third of the clavicle (Figure 5-1). This vein is usually easily visible through the skin. Pressing on it just above the clavicle will make it more prominent. It runs into the subclavian vein.

Indication for cannulation of the external jugular vein is the pediatric or adult patient who needs IV access and in whom no suitable peripheral vein is found.

Procedure

Performing External Jugular Cannulation

1. The patient must be in the supine position, preferably head down, to distend the vein and to prevent air embolism.
2. If no suspicion of cervical-spine injury exists, turn the patient's head to the opposite side. If there is a danger of cervical-spine injury, one emergency care provider must stabilize the head (it must not be turned) while the IV is being started. The cervical collar should be opened or the front removed during the procedure.
3. Quickly prepare the skin with an antiseptic and then align the cannula with the vein. The needle will be pointing toward the clavicle at the junction of the middle and medial thirds.
4. With one finger, press on the vein just above the clavicle. This should make the vein more prominent.
5. Insert the needle into the vein at about the midportion and cannulate in the usual way.
6. If not already done, draw a 30 mL sample of blood and store it in the appropriate tubes (if the hospital will accept blood drawn in the field).
7. Connect the intravenous cannula, and tape down the line securely. If there is danger of cervical spine injury, a cervical collar can be applied over the IV site.

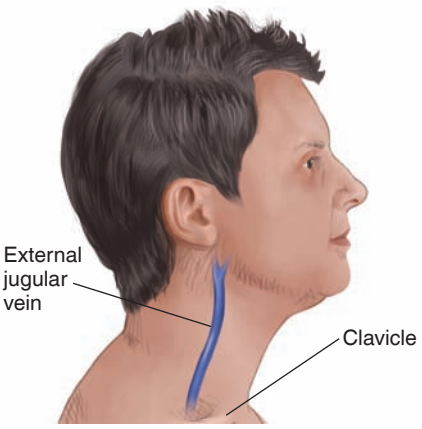


Figure 5-1 Anatomy of the external jugular vein.

Intraosseous Infusion

The technique of bone marrow infusion of fluid and drugs is not new. It was first described in 1922 and in the 1930s and 1940s was used commonly as an alternative to IV infusion of crystalloids, drugs, and blood. The technique was "rediscovered" in 1985 by Dr. James Orlowski on a trip to India. Studies have confirmed it to be a fast, safe, and effective route to infuse medications, fluids, and blood. It is an established standard in pediatric advanced life support and now is a recommended primary vascular access site in the American Heart Association and European Resuscitation Council Guidelines.

Intraosseous (IO) infusion can be used for giving medications in both adults and children. It is the fastest way to achieve vascular access in a patient with massive bleeding or shock. With pressures of 300 mmHg applied to the infusion bag or by a pump, adequate flow rates of up to 150 mL/minute can be achieved for crystalloids. IO infusion has the advantage of being quick and simple to perform while providing a stable (anchored in bone) access that is not easily dislodged during transport.

Indications

Indications for the use of IO infusion include the pediatric or adult patient who is in cardiac arrest or shock and in whom you cannot quickly obtain peripheral venous access or the patient with hypovolemic shock and difficult intravenous placement. It is indicated for any patient who needs drugs or fluids rapidly when a peripheral intravenous cannula cannot be placed in two attempts or 90 seconds.

Contraindications

Contraindications for intraosseous infusion include local infection or burns at selected site for insertion, fractures in the selected limb, a prosthesis, recent (24 hours) IO access in the same extremity, osteogenesis imperfecta, and the absence of anatomical landmarks or excessive tissue at the site of insertion.

Recommended Sites

Sites recommended for an intraosseous infusion include the following:

- *Proximal tibia*, approximately 2 cm below the patella and approximately 2 cm (depending on the patient's anatomy) medial to the tibial tuberosity, or one finger breadth medial to the tibial tuberosity. This is often the easiest site to locate.
- *Proximal humerus*, laterally over most prominent aspect of the greater tubercle. Positioning of the patient is important. Ensure that the patient's hand is resting on the abdomen and that the elbow is adducted. Slide your thumb up the anterior shaft of the humerus until you feel the greater tubercle; this is the surgical neck. The insertion site is approximately 1 cm (depending on the patient's anatomy) above the surgical neck.
- *Distal tibia*, for pediatric patients, the site is two finger breadths or 3 cm proximal to the most prominent aspect of the medial malleolus. Place one finger over the medial malleolus. Move approximately 2 cm (depending on the patient's anatomy) proximal and palpate the anterior and posterior borders of the tibia to ensure that your insertion site is on the flat central aspect of the bone.

Potential Complications

Complications are rare. However, good aseptic technique is important, just as it is with IV therapy. Potential complications of IO infusion include extravasation, compartment syndrome, dislodgment, fracture, failure (device or user in origin), pain, and infection (adult infection rates < 0.6%; retrospective analysis).

There are numerous IO systems on the market. Procedures for two of the systems are presented in detail here. (This in no way implies an endorsement of the product(s) by ITLS.) Other systems on the market have been shown to be effective. Providers should be familiar with the IO system used by their agency. Prior to use, the provider should review the training materials provided by the manufacturer.

PEARLS

Low Infusion

- If infiltration occurs (rare), do not reuse the same bone. Another site must be selected because fluid will leak out of the original hole made in the bone. If this occurs, apply a pressure dressing and secure it with an elastic bandage.
- Never place an IO line in a fractured extremity. If the femur is fractured, use the other leg.

Procedure

Performing IO by Use of EZ-IO® Device (Adult or Child)

The equipment needed to perform IO by use of the EZ-IO device is as follows:

- EZ-IO driver
- EZ-IO AD, EZ-IO LD, or EZ-IO PD needle set
- Antiseptic swab, such as alcohol or Betadine®.
- EZ-Connect® or standard extension set
- Two 10 mL syringes
- Normal saline (or suitable sterile fluid)
- Pressure bag or infusion pump
- 2% lidocaine for IV/IO use (preservative free, epinephrine free)

Procedure

Insertion of IO Needle by Use of the EZ-IO System

Determine the need for this procedure. Obtain permission from medical direction, if required. If the patient is conscious, advise them of emergent need for this procedure and obtain verbal informed consent. To perform the insertion (Scan 5-1):

1. Wear approved personal protective equipment (PPE).
2. Determine EZ-IO AD, EZ-IO LD, or EZ-IO PD indications.
3. Rule out contraindications.
4. Locate an appropriate insertion site.
5. Prepare the insertion site, using aseptic technique, and then allow it to dry.
6. Prepare the EZ-IO driver (power or manual) and the appropriate needle set.
   a. EZ-IO 15 mm for 3–39 kg (less than 16 pounds)
   b. EZ-IO 25 mm for 40 kg and greater (greater than 16 pounds)
   c. EZ-IO 45 mm for 40 kg and greater with excessive tissue
7. Stabilize the site to prepare to insert the appropriate needle set.
8. Remove the needle cap. Insert the EZ-IO needle into the selected site. (Keep your hand and fingers away from the needle.) Position the driver at the insertion site with the needle set at a 90-degree angle to the bone surface.
9. Gently pierce the skin with the needle until the needle touches the bone. The black line on the needle should be visible. Penetrate the bone cortex by squeezing the driver's trigger and applying gentle, consistent, steady downward pressure. (Allow the driver to do the work.) Do not use excessive force. In some patients insertion may take 10 seconds. If the driver sounds like it is slowing down during insertion, reduce the pressure on the driver to allow the RPMs of the needle tip to do the work. If the battery fails, you may manually finish inserting the needle just as you would a manual IO needle.
10. Release the driver's trigger and stop the insertion process when a sudden "give or pop" is felt on entry into the medullary space or when desired depth is obtained.
11. Remove the EZ-IO driver from the needle set while stabilizing the catheter hub.
12. Remove the stylet from the catheter by turning counterclockwise. Place the stylet in the shuttle or an approved sharps container.
13. Confirm placement. Connect the primed EZ-Connect. Syringe bolus (flush) the EZ-IO catheter with the appropriate amount of normal saline (10 mL for adults and 5 mL for children). Remember: no flush = no flow!
14. If the patient is responsive to pain or complains of pain when you flush the marrow cavity, slowly (in 0.2 mL increments) administer the appropriate dose of preservative-free (for IV/IO use) lidocaine 2% (20 mg/mL) IO to anesthetize the IO space. (IO infusion causes severe pain in alert patients.)
    a. 2–4 mL (20–40 mg) for adults
    b. 0.5 mg/kg (0.025 mL per kg) for children

    Then wait 15–30 seconds for the lidocaine to take effect.
15. Begin the infusion. Utilize pressure—up to 300 mmHg (pressure bag or infusion pump)—for continuous infusion.
16. Dress the site, apply stabilizer if inserted in humeral site, secure the tubing, and apply the wristband (document time and date) included with the kit.
17. Monitor the EZ-IO site and the patient's condition.

To remove the catheter, start by supporting the patient's leg. Simultaneously, connect a sterile Luer-Lok™ syringe to the hub of the catheter. Once connected, rotate the syringe and catheter clockwise while gently pulling. When the catheter has been removed, immediately place it in an appropriate biohazard container. Do not leave the EZ-IO catheter in place for more than 24 hours.

SCAN 5-1 Insertion of IO Needle by Use of EZ-IO System



5-1-1 Identify insertion site. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



5-1-2 Prepare site using aseptic technique and allow to dry. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



5-1-3 Insert the needle at a 90-degree angle to the bone surface. Keep your hand and fingers away from the needle. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



5-1-4 While stabilizing the catheter hub, remove the stylet from the catheter by turning counterclockwise. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



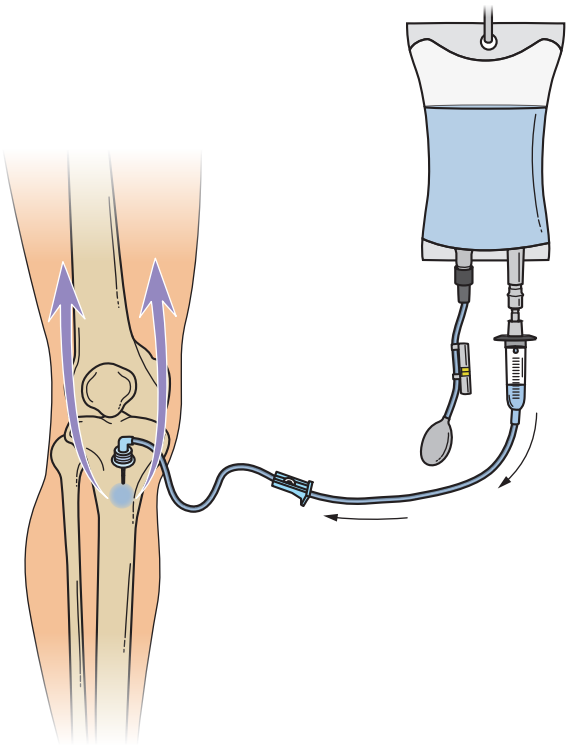
5-1-5 Attach the EZ-Connect® and secure the needle. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



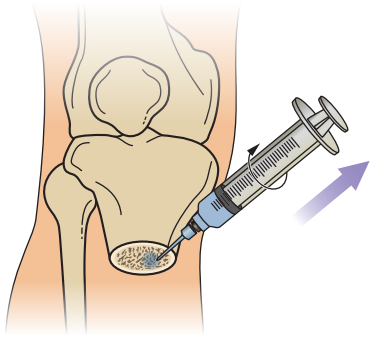
5-1-6 Confirm the placement of the needle by aspirating blood from the marrow cavity. You may not be able to aspirate marrow; however, if the catheter flushes easily and without infiltration, it is okay to use. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

(*continued*)

SCAN 5-1 Insertion of IO Needle by Use of EZ-IO (*continued*)



5-1-7 Connect IV infusion.



5-1-8 To remove the catheter, support the leg while simultaneously connecting a sterile Luer-Lok syringe to the hub of the catheter. Rotate the syringe and catheter clockwise while gently pulling.

Procedure

Performing Manual IO Infusion

1. Determine the need for this procedure. Obtain permission from medical direction, if required.
2. Have all the equipment needed ready prior to bone penetration.
   a. #16- to #18-gauge IO needles
   b. 5-mL and 10-mL syringes
   c. Antiseptic solution to prep the skin
   d. IV tubing and IV fluids
   e. Tape and dressing material to secure the IO needle
   f. Blood pressure cuff or commercial pressure device to infuse fluid under pressure
3. Identify the site, which is the proximal tibia, two finger breadths below the tibial tuberosity, either midline or slightly medial to the midline (Figure 5-2).
4. Prep the skin with an appropriate antiseptic (very important).
5. Obtain the proper needle. The needle must have a stylet so that it does not become plugged with bone. The preferred needle is a #14- to #18-gauge IO needle, but bone marrow aspiration needles can also be used.
6. Using aseptic technique, insert the needle into the bone marrow cavity perpendicular to the skin (Figure 5-2). Advance it to the periosteum. Penetrate the bone with a slow boring or twisting motion until you feel a sudden "give or pop" (decrease in resistance) as the needle enters the marrow cavity. This can be confirmed by removing the stylet and aspirating blood and bone marrow (Figures 5-3 and 5-4). You may not be able to aspirate marrow; however, if the catheter flushes easily and without infiltration, it is okay to use.
7. Syringe bolus (flush) the IO catheter with 5 mL of normal saline. Remember: no flush = no flow!
8. If the patient is responsive to pain or complains of pain when you flush, slowly (0.2-mL increments) administer a 0.5 mg/kg (0.025 mL per kg) dose of preservative-free (for IV/IO use) lidocaine 2% (20 mg/mL) IO to anesthetize the IO space.

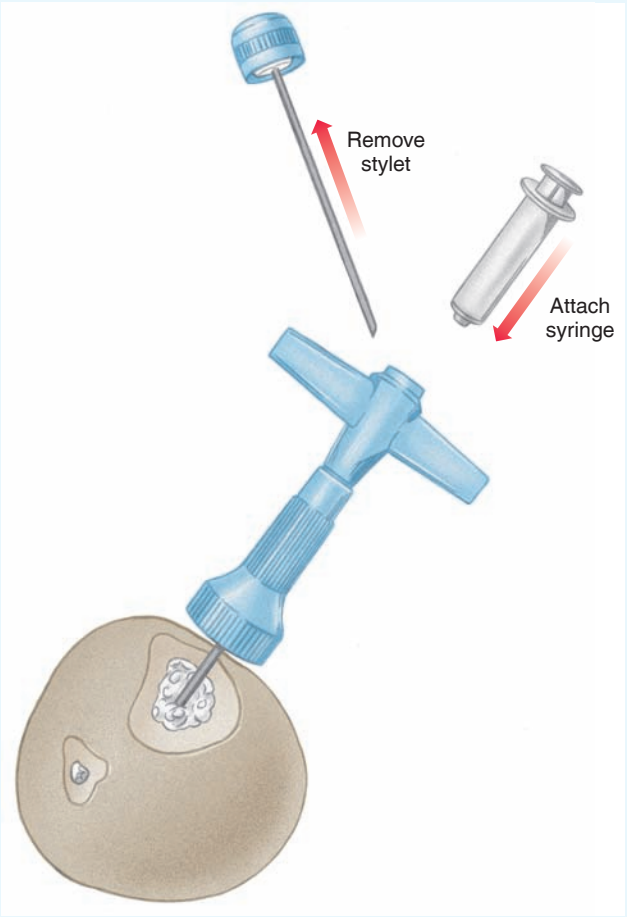


Figure 5-3 Remove stylet from the needle and attach syringe.



Figure 5-2 Insertion site for intraosseous infusion needle in the proximal tibia. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

(*continued*)

Procedure *(continued)*

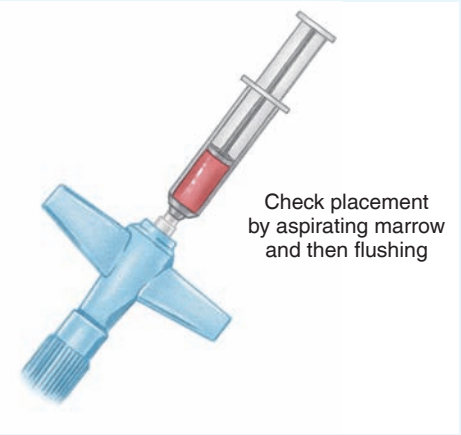


Figure 5-4 To check needle placement, aspirate approximately 1 mL of bone marrow.

A 10-kg child would get 0.25 mL (5 mg of 2% lidocaine). Wait 15–30 seconds for the lidocaine to take effect. Assess for potential IO complications.

9. Attach standard IV tubing and infuse the fluid and/or medications (Figure 5-5). You may have to infuse fluid under pressure (blood pressure cuff blown up around IV bag) to obtain an adequate infusion rate.
10. Tape the tubing to the skin and secure the bone marrow needles as if to secure an impaled object. (Use gauze pads taped around the insertion site.)



Figure 5-5 Intraosseous needle in child's tibia being used for fluid infusion. *(Photo courtesy of Bob Page, MEd, NRP, CCP, NCEE)*

FAST Responder™ Intraosseous Device

The FAST Responder intraosseous device is designed for rapid sternal intraosseous access for the purpose of infusing fluid and medication directly into the bone marrow of the manubrium. Bone marrow flows into the vascular system and the manubrium is especially effective due to close proximity to central circulation. It does feature a depth control that reduces risk of overpenetration.

Indications are similar to other intraosseous devices in patients 12 years of age and older (adolescent to adult).

The insertion site is the manubrium of the sternum, 15 mm below the sternal notch in the midline. The bone thickness at the insertion site is 13.30 mm, and the risk of overpenetration is less than 1 in 1,000,000.

The device relies on operator force only. It is not spring-loaded, battery dependent, or pneumatic. Its downward force pushes the steel infusion tube tip through soft tissue into bone and when the steel tip is just inside marrow space, the infusion tube automatically separates from the introducer. The bone probe needle ensures proper depth control only; it does not enter the bone. This mechanism prevents overpenetration.

Procedure

Inserting the FAST Responder Intraosseous Device

1. Expose the sternum and locate the sternal notch.
2. Clean the insertion site with an antiseptic.
3. Remove the adhesive liner with the locking pin.
4. Position yourself. Stand/kneel at the head or the side of the patient, or as you are comfortable.
5. Place the device. Align the target foot notch with the patient's sternal notch and the introducer (the device handle) perpendicular to the manubrium. Verify placement in the correct location.
6. Push the FAST Responder down perpendicular to the sternum completely to deploy the infusion tube.
7. Pause and pull back. Withdraw the FAST Responder device straight back while holding down the target foot. Support comes out with the infusion tube.
8. Discard the device following your contaminated sharps protocols.
9. Prepare. Connect the IV line directly to the luer, and clip the strain relief hook to the target foot.
10. *Optional:* According to local protocol, flush with fluid to clear line, and confirm placement by aspiration.
11. *Optional:* Remove the liner from the protective dome, and apply the dome over the target foot infusion site.

    Remember the six Ps:

    position yourself relative to the patient,

    place the device,

    push to deploy,

    pause (hold target foot),

    pull back the device, and

    prepare (connect fluid source).

Fluid flow rates are as follows: gravity, 30–80 mL/minute; pressure infuser to 120 mL/minute; syringe, 150–250 mL/minute.

Procedure

Removing the FAST Responder Intraosseous Device

1. Remove the protective dome from the target foot.
2. Turn off the source of fluid and disconnect IV line.
3. Grasp the infusion tube with your fingers or clamp and pull perpendicular to the manubrium until the entire infusion tube emerges from the patient's chest. Using the tube to pull, pull in one continuous motion until infusion tube is removed.
4. Peel off the target foot following your contaminated sharps protocol.

Precautions/warnings include all of the following: trauma, infection, or burns at the insertion site may preclude use of the FAST device. Safety with very severe osteoporosis has not been proven. Use in patients who have had a recent sternotomy may prove less effective. The function of the device may be affected by fracture of the sternum or vascular injury, which may compromise the integrity of the manubrium or its vascularization.

Length-Based Resuscitation Tapes

Calculation of the volume of fluid resuscitation or the dose of an IV medication for the pediatric patient depends on the patient's weight. In an emergency situation the age and weight of a child may not be known. The weight of a child is directly related to his or her length, and resuscitation tapes (Broselow® tape or SPARC system) have been developed to estimate a child's weight by measuring his or her length. The tapes list precalculated doses of IV fluids and emergency drugs for each weight range (Figure 5-6). They also include the correct sizes of emergency equipment and supplies for each weight range. Other methods for calculating pediatric drug dosages are covered in Chapter 18.

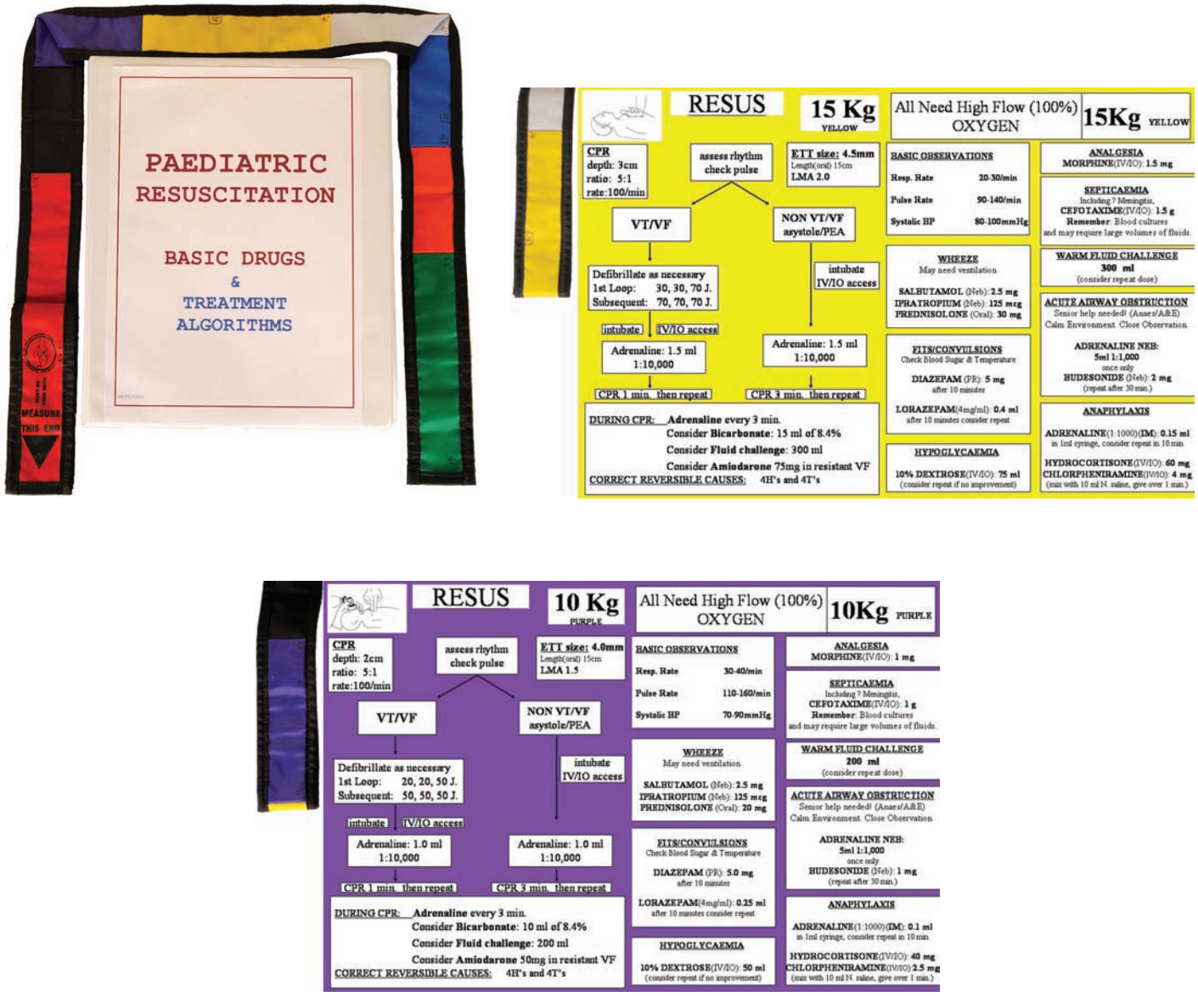


Figure 5-6 SPARC system has color-coded tape and booklet of precalculated doses of fluids and medications. *(Photos courtesy of Kyee Han, MD)*

Procedure

Estimating a Child's Weight with a Length-Based Resuscitation Tape

1. Place the patient in the supine position.
2. Using the tape, measure the patient from the crown to the heel. The red end with an arrow goes at the child's head. (See Figure 5-7.)
3. Note the box on the tape where the child's heel falls. With the SPARC system, match the color of the tape where the child's heel falls with the same colored area of the booklet.
4. If the measurement falls on a line, the box or colored panel proximal to the line is used to generate the fluid volume, drug doses, and sizes of equipment needed for resuscitation.
5. The tape may be disinfected if it becomes contaminated.



Figure 5-7 Measure the patient from crown to heel to read precalculated doses of fluids and medications. *(Photo courtesy of James Broselow, MD)*

Control of Life-Threatening Hemorrhage

The immediate control of massive, life-threatening bleeding from external injuries is vital to the survival and recovery of the trauma patient. Although varying definitions of massive bleeding exist, it may be identified by bleeding that cannot be controlled by the conventional method of direct pressure. During your approach to the patient and as part of your ITLS Primary Survey, assess for life-threatening bleeding. If it is present and you are unable to immediately control it with direct pressure, do not delay applying a tourniquet to the bleeding extremity.

Direct pressure is widely accepted as a standard of practice for the control of all levels of injury severity. In the past, basic and advanced-level provider education presented various methodologies to control external bleeding, including direct pressure, elevation of an extremity in conjunction with direct pressure, and direct pressure over pressure points. Pressure points are not effective in controlling hemorrhage.

Currently, if direct pressure is unsuccessful, the recommendation is to immediately apply a tourniquet, if control of bleeding is in a location where the tourniquet may be applied. For large and/or deep wounds, external pressure may not be sufficient to stop the bleeding. Pressure must be applied directly to the source of bleeding, often deep in the wound (Scan 5-2). This is contrary to the old teaching of not placing anything into the wound.

In the more proximal portions of the extremity (axilla and groin), it may not be possible to apply a tourniquet. Note that several "junctional tourniquets" have been developed for this situation, but availability in the civilian sector remains limited. If a tourniquet cannot be applied, a hemostatic dressing along with direct pressure should be utilized immediately. If a hemostatic gauze is not available, the wound can be packed with plain gauze. It may be necessary to kneel on the wound in order to provide sufficient pressure.

Procedure

Wound Packing

1. Put on gloves and other PPE.
2. Apply direct pressure to the wound. Push gauze (with or without hemostatic agent) dressing into wound with your fingers. Try to compress bleeding vessel against bone.
3. With your other hand, begin to push more gauze into the wound while you keep pressure with your first hand. Push dressing against the bleeding vessel with the gloved hand in the wound.
4. Keep feeding gauze into wound until you are not able to pack any more in.
5. Maintain pressure on packed wound for at least 3 minutes. Then if bleeding has stopped, apply a pressure dressing.
6. If bleeding continues, you may have to repack the wound. Most manufacturers of hemostatic gauze recommend repacking. If you must repack, do so while transporting to the trauma center.

SCAN 5-2 Wound Packing



5-2-1 Apply pressure with the fingers directly on the bleeding vessel. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*



5-2-2 Begin feeding end of hemostatic gauze (or plain gauze) into wound. Briefly raise fingers applying pressure to get gauze against vessel and then push gauze down again. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*

SCAN 5-2 Wound Packing (*continued*)



5-2-3 Keep feeding gauze into wound, pressing it against vessel. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*



5-2-4 Repeat this process until the wound is completely filled with the gauze dressing. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*



5-2-5 Once the wound is packed, maintain pressure on the packing with your fingertips for at least 3 minutes. To apply sufficient pressure you may have to lean or kneel on the wound, depending on location. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*



5-2-6 Once bleeding has been controlled, place a pressure dressing on the wound. *(Courtesy of Jennifer Achay, Centre for Emergency Health Sciences, Spring Branch, Texas)*

Application of Tourniquets

Injuries to extremities, such as avulsions, amputations, and lacerations, with bleeding that is not quickly controlled by direct pressure meet the criteria for the application of a tourniquet. Tourniquets provide circumferential compression to the vascular structures just proximal to the wound, inhibiting distal blood flow. Data accumulated during recent conflicts and civilian incidents show marked improvement in survival for wounded soldiers who had prompt application of tourniquets.

Commercial Devices

The ideal tourniquet occludes the injured arteries effectively, is easy to use, and is lightweight, compact, and of rugged construction. Key elements of the tourniquet design must address the width of the occluding strap/pneumatic band and its ability to overcome soft-tissue resistance to compression. The combination of appropriate mechanical assistance and width designs of two inches or greater appears to provide adequate soft-tissue compression and stop bleeding at lower pressures, decreasing tissue damage and discomfort at the tourniquet site. The issue of expense is applicable to EMS, and thus the addition of cost consideration is appropriate to this list. It should be noted that compared to commercially available devices, most improvised tourniquets are not wide enough nor have sufficient mechanical force to compress the artery.

Multiple types of tourniquet devices are now commercially available. Relatively low in cost and easy to use, tourniquets are now included by many militaries and law enforcement units as part of the basic kit carried by all personnel. Studies have shown that some designs are more effective than others. It is recommended that all agencies within a system use the same model of device to reduce confusion and improve speed of application.

The Combat Application Tourniquet® (CAT) is manufactured by Composite Resources and is designed with a self-adherent Velcro band, friction adaptor buckle, and a windlass rod and clip (Figure 5-8). The self-adherent Velcro band is reportedly made from a nonstretch material long enough for application on large and obese extremities. The surface area width is sufficient for distributing the application of pressure circumferentially around an extremity.

Application of the CAT is accomplished by feeding the Velcro band around an extremity and inserting the free-running end through the buckle. Insertion into the buckle locks the band in place on the extremity. Turning the windlass rod creates



Figure 5-8a Combat Application Tourniquet (CAT). *(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 5-8b CAT applied to amputation; note second tourniquet applied to fully control bleeding (CAT). *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

circumferential tightening and is locked into place with the clip and secured with a small strap after bleeding has been controlled. A location on the top of the windlass strap is available to note the time of application. Included is an independent internal band and clip that permit one-handed or self-application.

The Emergency and Military Tourniquet® (EMT) by Delfi Medical is a pneumatic-based device with an inflatable bladder and a hand bulb inflator permanently attached to the bladder by way of a flexible hose. A twist-type air-release valve is included between the hand bulb inflator and the bladder to allow deflation of the bladder. The clamp secures a portion of the bladder around the limb and seals the bladder across its width, such that the portion of the bladder surrounding the limb inflates and the remaining portion of the bladder does not inflate. This Delfi tourniquet is available in one size and is able to encircle a 3- to 34-inch circumference around an extremity. A blood pressure cuff may be used in exactly the same way.

A third class of tourniquet device is a "band" type that is wrapped around the extremity multiple times to achieve compression of the artery, as exemplified by the SWAT-T. These types are harder to apply and if not applied correctly will serve simply as a constriction band. They can, however, be used on pediatric patients, which is not an option with the CAT.

Both the CAT and EMT tourniquets advocate use of minimal pressure to control bleeding and include mechanisms for increasing and decreasing the pressure exerted by the devices. In the absence of a purpose-designed tourniquet, a blood pressure cuff may be used, though it must be monitored closely because it can lose effectiveness if the pressure in the cuff drops.

Numerous tourniquets are available on the market. Several types are mentioned by name in this text. (This in no way implies an endorsement of the product(s) by ITLS.) Other systems on the market have been shown to be effective. Providers should be familiar with the tourniquet used by their agency. Prior to use the provider should review the training materials provided by the manufacturer.

Procedure

Applying a Tourniquet

Regardless of the device used, the following procedure may be employed for a hemorrhage that cannot be controlled with conventional methods of direct pressure and is anatomically appropriate to tourniquet application:

1. Identify massive extremity bleeding caused by avulsions, amputations, and lacerations.
2. If not immediately life threatening, attempt direct pressure to control bleeding. If the patient appears to be exsanguinating or if you are unable to control bleeding quickly with direct pressure, proceed immediately to application of the tourniquet.
3. Position the tourniquet just proximal (2–3 inches or 5–8 cm) to the source of bleeding, avoiding application over any joints on the extremity.
4. Secure the tourniquet in place and apply circumferential pressure by a method recommended by the tourniquet manufacturer.
5. Tighten the tourniquet until distal pulses are no longer felt (bleeding should stop).
6. Secure the tourniquet windlass in place.
7. Note the time of application. Because all medical providers look at the patient's face, some advocate marking the patient's forehead with the time of tourniquet placement.
8. Do not cover the tourniquet.
9. Frequently reassess for bleeding or presence of distal pulse. Increase tourniquet pressure as needed.
10. Contact receiving facility and notify them of the application of a tourniquet.

The use of a tourniquet is not a benign procedure. Application of a tourniquet can cause extreme pain and discomfort at and distal to the site of application. When appropriate, consider the use of analgesic medications to decrease pain. Complications such as inappropriate positioning and device malfunction can occur. In addition, necrosis to the muscle at and distal to the application, compartment syndrome, and nerve palsy are all possible. Ischemic time (time without blood perfusion) before permanent damage can be up to four hours at room temperature. Ideally, to prevent these secondary injuries, efforts should be made to limit the time the tourniquet is in place to 2–3 hours. Unless extreme circumstances exist where delivery to definitive care is delayed, the removal of a tourniquet or reperfusion of an extremity following tourniquet application should be carried out only on orders of medical direction.

Massive bleeding in the groin and axilla presents a special challenge to the emergency care provider. The vessels in these regions are very large, and it is extremely difficult to apply a tourniquet to these areas. Recently, several manufacturers have developed "junctional tourniquets" (Sam® Junctional Tourniquet; Abdominal, Aortic, and Junctional Tourniquet® [AAJT] are examples). Junctional tourniquets and others are being used currently and the results are very encouraging, especially when used along with hemostatic agents, which are discussed in the next section.

Use of Hemostatic Agents

Injuries where the control of massive bleeding is not successful with direct pressure and the use of a tourniquet, or where the application of a tourniquet is not possible, such as at the neck, axilla, or groin, the use of a hemostatic agent in combination with direct pressure is warranted as an additional resource to control bleeding. Laboratory studies and field trials conducted by the U.S. military and limited research completed by EMS agencies indicate hemostatic agents have benefit when used in conjunction with existing methods of bleeding control.

Hemostatic Agent Types

This is a technology that is rapidly changing, and there are many competing hemostatic products. Various chitosan, mineral, and nonmineral-based hemostatic agents are currently available to EMS personnel. Product names such as Celox™, QuikClot Combat Gauze®, X-Stat®, HemCon®, and TraumaDex™ promote clotting (with different degrees of effectiveness) through various mechanisms of action. Most hemostatic agents are available in powder, granular, or bandage form. The U.S. military is currently using QuikClot Combat Gauze as well as the X-Stat.

Common to each currently approved hemostatic agent regardless of application form is the requirement to make direct contact with the primary source of bleeding and for the emergency care provider to exert external compression directly to the source of bleeding. Clotting time based on blood vessel type, size, and level of exsanguination presenting may vary, with 2 minutes of direct pressure required to facilitate cessation of bleeding. These agents are not to be used for internal bleeding. Some of the powder-based agents may have a higher rate of thromboembolic events later in the course of care.

Hemostatic Agent Application

The following procedure may be used for hemorrhage that cannot be controlled with conventional methods of direct pressure, when the injury is anatomically inappropriate for the application of a tourniquet, or when bleeding does not stop following direct pressure and tourniquet application.

Procedure

Applying a Hemostatic Agent

1. Identify massive bleeding caused by avulsions, amputations, or lacerations.
2. Attempt direct pressure to control bleeding. If you are unable to facilitate rapid cessation of bleeding, proceed immediately to application of the tourniquet for anatomically appropriate locations.
3. If bleeding is not controlled or in an area where a tourniquet cannot be applied, apply a hemostatic agent directly to the source of the bleeding.
4. With fingertip pressure and a 4 × 4 or trauma dressing, compress the wound and hemostatic agent for at least 2 minutes. Failure to apply pressure directly to the source of the bleeding may delay or prevent cessation of bleeding.
5. While leaving the 4 × 4 or trauma dressing in place, evaluate for cessation of bleeding. If bleeding has stopped, dress the wound as appropriate.
6. If bleeding continues, remove the 4 × 4 or trauma dressing and reapply the hemostatic agent and the dressing. Confirm direct pressure is being placed on the source of bleeding.

Complications include ineffectiveness of the hemostatic agent, continued bleeding (recognized and unrecognized), and tissue damage secondary to the type of hemostatic agent used. Any bleeding that cannot be controlled must be considered life threatening. Do not delay transportation for reapplication of tourniquets or hemostatic agents. Immediately package and transport the patient upon completion of the rapid survey and continue interventions en route to definitive care.

Resources

Acheson, E. M., B. S. Kheirabadi, R. M. Deguzman, E. J. Dick, and J. B. Holcomb. 2005. "Comparison of Hemorrhage Control Agents Applied to Lethal Extremity Arterial Hemorrhages in Swine." *Journal of Trauma* 59, no. 4 (October): 865–75.

Adams, D. B., and C. W. Schwab. 1988. "Twenty-One-Year Experience with Land Mine Injuries." *Journal of Trauma* 28, Suppl. 1 (January): S159–62.

Alam, H. B., D. Burris, J. A. DaCorta, and P. Rhee. 2005. "Hemorrhage Control in the Battlefield: Role of New Hemostatic Agents." *Military Medicine* 170, no. 1 (January): 63–9.

Alam, H. B., G. B. Uy, D. Miller, E. Koustova, T. Hancock, R. Inocencio, D. Anderson, O. Llorente, and P. Rhee. 2003. "Comparative Analysis of Hemostatic Agents in a Swine Model of Lethal Groin Injury." *Journal of Trauma* 54, no. 6 (June): 1077–82.

American Heart Association. 2010. "2010 Guidelines for Cardiopulmonary Care Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) Science." *Circulation* 122, no. 18, Suppl. 3 (Pt. 8 and Pt. 14) (November).

Bledsoe, B., R. Porter, and R. Cherry. 2017. *Paramedic Care: Principles and Practices*. 5th ed. Upper Saddle River, NJ: Pearson.

Brown, M., M. R. Daya, and J. A. Worley. 2009. "Experience with Chitosan Dressings in a Civilian EMS System." *Journal of Emergency Medicine* 37, no. 1 (July): 1–7.

Bulger, E. M., D. Snyder, K. Schoelles, C. Gotschall, D. Dawson, E. Lang, N. D. Sanddal, F. K. Butler, M. Fallat, P. Taillac, et al. 2014. "An Evidence-based Prehospital Guideline for External Hemorrhage Control: American College of Surgeons Committee on Trauma." *Prehospital Emergency Care* 18, no. 2 (April–June): 163–73. doi: 10.3109/10903127.2014.896962.

Carr, M. E., Jr. 2004. "Monitoring of Hemostasis in Combat Trauma Patients." *Military Medicine* 169, Suppl. 12 (December): 11–15.

Cooper, B. R., P. F. Mahoney, T. J. Hodgetts, and A. Mellor. 2007. "Intra-osseous Access (EZ-IO®) for Resuscitation: UK Military Combat Experience." *Journal of the Royal Army Medical Corps* 153, no. 4 (December): 314–6.

Cotton, B. A., R. Jerome, B. R. Collier, S. Khetarpal, M. Holevar, B. Tucker, S. Kurek, N. T. Mowery, K. Shah, W. Bromberg, et al. 2009. "Guidelines for Prehospital Fluid Resuscitation in the Injured Patient." *Journal of Trauma* 67, no. 2 (August): 389–402.

Day, M. W. 2011. "Intraosseous Devices for Intravascular Access in Adult Trauma Patients." *Critical Care Nurse* 31, no. 2 (April): 76–89.

Fowler, R., J. V. Gallagher, S. M. Isaacs, E. Ossman, P. Pepe, and M. Wayne. 2007. "The Role of Intraosseous Vascular Access in the Out-of-Hospital Environment (Resource Document to NAEMSP Position Statement)." *Prehospital Emergency Care* 11, no. 1 (January–March): 63–6.

Kapoor, D., and M. Singh. 2011. "Novel Rapid Infusion Device for Patients in Emergency Situations." *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine* 19 (June): 35.

Kheirabadi, B. S., E. M. Acheson, R. M. Deguzman, J. L. Sondeen, K. L. Ryan, A. P. Delgado, E. J. Dick, and J. B. Holcomb. 2005. "Efficacy of Two Advanced Dressings in an Aortic Hemorrhage Model in Swine." *Journal of Trauma* 59, no. 1 (July): 25–35.

King, R. B., D. Filips, S. Blitz, and S. Logsetty. 2006. "Evaluation of Possible Tourniquet Systems for Use in the Canadian Forces." *Journal of Trauma* 60, no. 5 (May): 1061–71.

Kovar, J., and L. Gillum. 2010. "Alternate Route: The Humerus Bone—A Viable Option for IO Access." *Journal of Emergency Medical Services* 35, no. 8 (August): 52–9.

Kragh, J. F. Jr., T. J. Walters, D. G. Baer, C. J. Fox, C. E. Wade, J. Salinas, and J. B. Holcomb. 2008. "Practical Use of Emergency Tourniquets to Stop Bleeding in Major Limb Trauma." *Journal of Trauma* 64, Suppl. 2 (February): S38–S50.

Lawton, G., J. Granville-Chapman, and P. J. Parker. 2009. "Novel Haemostatic Dressings." *Journal of the Royal Army Medical Corps* 155, no. 4 (December): 309–14.

Lee, C., K. M. Porter, and T. J. Hodgetts. 2007. "Tourniquet Use in the Civilian Prehospital Setting." *Emergency Medicine Journal* 24, no. 8 (August): 584–7.

Myers L. A., C. S. Russi, and G. M. Arteaga. "Semiautomatic Intraosseous Devices in Paediatric Prehospital Care Replacing a Manual Intraosseous (IO) Device Improves the Success Rate for Attempts at Vascular Access." *Prehospital Emergency Care*, Vol. 15, Issue 4 (October–December, 2011): 473–6.

Naimer, S. A., M. Tanami, A. Malichi, and D. Moryosef. 2006. "Control of Traumatic Wound Bleeding by Compression with a Compact Elastic Adhesive Dressing." *Military Medicine* 171, no. 7 (July): 644–7.

Neuffer, M. C., J. McDivitt, D. Rose, K. King, C. C. Cloonan, and J. S. Vayer. 2004. "Hemostatic Dressings for the First Responder: A Review." *Military Medicine* 169, no. 9 (September): 716–20.

Pasley, J., C. Miller, J. DuBose, S. Shackelford, R. Fang, K. Boswell, C. Halcome, J. Casey, M. Cotter, M. Matsuura, et al. 2015. "Intraosseous Infusion Rates Under High Pressure: A Cadaveric Comparison of Anatomic Sites." *Journal of Trauma and Acute Care Surgery* 78, no. 2 (February): 295–9. doi: 10.1097/TA.0000000000000516.

Paxton, J. H., T. E. Knuth, and H. A. Klausner. 2009. "Proximal Humerus Intraosseous Infusion: A Preferred Emergency Venous Access." *Journal of Trauma* 67, no. 3 (September): 606–11.

Payne, E. K., D. Berry, and R. Seitz. 2014. "Educating the Educator: Use of Advanced Bleeding Control Mechanisms in Athletic Training: A Shift in the Thought Process of Prehospital Care–Part 2: Hemostatic Agents." *Athletic Training Education Journal* 9, no. 4 (October–December): 193–201.

Pusateri, A. E., J. B. Holcomb, B. S. Kheirabadi, H. B. Alam, C. E. Wade, and K. L. Ryan. 2006. "Making Sense of the Preclinical Literature on Advanced Hemostatic Products." *Journal of Trauma* 60, no. 3 (March): 674–82.

Revell, M., K. Porter, and I. Greaves. 2002. "Fluid Resuscitation in Prehospital Trauma Care: A Consensus View." *Emergency Medicine Journal* 19, no. 6 (November): 494–8.

Soreide, E., and C. D Deakin. 2005. "Pre-hospital Fluid Therapy in the Critically Injured Patient: A Clinical Update." *Injury* 36, no. 9 (September): 1001–10.

Sunde, G. A., B. E. Heradstvert, B. H. Vikenes, and J. K. Heltne. 2010. "Emergency Intraosseous Access in a Helicopter Emergency Medical Service: A Retrospective Study." *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine* 18 (October): 52.

Walters, T. J., and M. C. Mabry. 2005. "Issues Related to the Use of Tourniquets on the Battlefield." *Military Medicine* 170, no. 9 (September): 770–5.

Walters, T. J., J. C. Wernke, D. S. Kauvar, J. G. McManus, J. B. Holcomb, and D. G. Baer. 2005. "Effectiveness of Self-Applied Tourniquets in Human Volunteers." *Prehospital Emergency Care* 9, no. 4 (October): 416–22.

Wampler, D. A., Shumaker, J, Manifold, C., S. Bolleter, and J. Frandsen. 2010. "Humeral Intraosseous Access Success Rate in Adult Out-of-Hospital Cardiac Arrest." *Annals of Emergency Medicine* 56, no. 3, Suppl. (September): S88–S89.

Ward, K. R., M. H. Tiba, W. H. Holbert, C. R. Blocher, G. T. Draucker, E. K. Proffitt, G. L. Bowlin, R. R. Ivatury, and R. F. Diegelmann. 2007. "Comparison of a New Hemostatic Agent to Current Combat Hemostatic Agents in a Swine Model of Lethal Extremity Arterial Hemorrhage." *Journal of Trauma* 63, no. 2 (August): 276–84.

Wedmore, I., J. G. McManus, A. E. Pusateri, and J. E. Holcomb. 2006. "A Special Report on the Chitosan-Based Hemostatic Dressing: Experience in Current Combat Operations." *Journal of Trauma* 60, no. 3 (March): 655–8.

Wenke, J. C., T. J. Walters, D. J. Greydanus, A. E. Pusateri, and V. A. Convertino. 2005. "Physiological Evaluation of the U.S. Army One-Handed Tourniquet." *Military Medicine* 170, no. 9 (September): 776–81.

6

Airway Management

Nicholas Sowers, MD, FRCPC
Kirk Magee, MD, MSc, FRCPC
The authors wish to thank Ronald D. Stewart, OC, BA, BSc, MD, FRCPC, for his contributions to previous editions of this chapter.



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Atemwegsmanagement
Manejo de la Vía Aérea
Dišni put u traumi
Gestão da Via Aérea
Penatalaksanaan Jalan Napas
Обеспечение проходимости дыхательных путей
Gestion des voies aériennes
Διαχείριση Αεραγωγού
Kezdeti légútbiztosítás
気道管理
氣道處理
Prosta dihalna pot

Key Terms

alveolar shunt, *p. 129*
capnography, *p. 121*
drug-assisted intubation (DAI), *p. 126*
external laryngeal manipulation (ELM), *p. 120*
hypoventilation, *p. 128*
LEON, *p. 126*
lung compliance, *p. 123*
minute volume, *p. 128*
normal ventilation, *p. 128*
patent airway, *p. 121*
pulse oximeter, *p. 129*
rapid sequence airway (RSA), *p. 127*
rapid sequence intubation (RSI), *p. 127*
supraglottic airway (SGA), *p. 125*
tidal volume, *p. 123*
ventilation, *p. 117*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe the anatomy and physiology of the respiratory system.
2. Explain the importance of observation as it relates to airway control.
3. Describe methods to deliver supplemental oxygen to the trauma patient.
4. Briefly describe the indications, contraindications, advantages, and disadvantages of the following airway adjuncts:
   a. Nasopharyngeal airways
   b. Oropharyngeal airways
   c. Bag-valve masks
   d. Supraglottic airway
   e. Endotracheal intubation
5. State the predictors of difficult mask ventilation and endotracheal intubation.
6. Describe apneic oxygenation and external laryngeal manipulation.
7. List the essential components of an airway kit.

Chapter Overview

Airway management is an immediate priority of trauma care in the prehospital environment as initial maneuvers to open the airway and support oxygenation and **ventilation** are critical to reduce patient morbidity and mortality. These steps cannot wait until emergency department arrival, and so it is paramount that emergency responders master these skills. Airway management in trauma patients can be challenging in any setting, but it is particularly so in the sometimes austere environment of the field due to poor lighting, patient location and positioning, and the often chaotic or hostile environment surrounding a traumatic event.

ventilation: the movement of air or gases into and out of the lungs.

Despite these challenges, patients who are cyanotic, underventilated, or both, are in need of immediate help—help that only you can give them in the initial stages of care. It falls to you, then, as the first contact emergency care provider, to be familiar with the basic structure and function of the airway and respiratory system, to have the skills to achieve and maintain an open airway, and to have the ability to oxygenate and ventilate a patient.

Trauma patients who are in respiratory distress are generally hypoxemic for one of (or a combination of) four reasons: upper airway obstruction, hypoventilation, pulmonary shunt, and/or pneumothorax. An understanding of the anatomy and physiology related to each of these will allow the emergency care provider to have a systematic approach to initiating oxygenation and ventilation in often stressful situations.

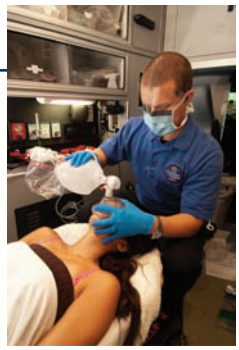
The field environment is unpredictable, and you may be called on to provide airway management in almost every conceivable situation: in wrecked cars, dangling above rivers, in the middle of a shopping center, or at the side of a busy highway. You therefore need an easily remembered approach as well as a variety of options and alternative techniques from which to choose. Techniques that will help one patient may not work for another. One patient may require a simple jaw-thrust maneuver to open an airway, whereas another may require a surgical procedure to prevent impending death.

The objective of all airway management is to support oxygenation and ventilation (Hung and Murphy 2010). It is not simply "passing the tube," and in many situations attempting to establish a definitive airway via endotracheal intubation (i.e., ETT) in the field in a patient who is maintaining an acceptable oxygenation has the potential to cause harm and should be delayed until that patient can be extracted from an unfavorable environment (Davis et al. 2005). Interventions often labeled as "basic" are anything but; they are skills, that when performed at an advanced level early in resuscitation may ultimately do more to improve patient outcomes than the more advanced airway maneuvers either performed suboptimally or when these patients reach the hospital.

This chapter begins with a review of airway anatomy and physiology as it relates to the four causes of hypoxemia seen in trauma patients and progresses through the concepts of the patent airway and initial techniques for supporting oxygenation and ventilation and on to advanced airway techniques and monitoring devices. It then reinforces what you have learned by allowing you to practice those techniques in the airway management skill station (Chapter 5).

Case Presentation

You are the lead emergency care provider in an ambulance transporting a seriously injured assault victim to the hospital. You found the patient unresponsive after being hit in the head and chest several times with a pipe. The ITLS Primary Survey and a rapid trauma survey identified a blunt chest injury with rib fractures on the right and a suspected traumatic brain injury. The patient was placed in SMR and given supplemental oxygen. The patient initially localized to painful stimuli but now does not respond at all.



Case Presentation *(continued)*

Before proceeding, consider these questions:

- What is your first priority?
- What do you believe is the cause of this developing problem?
- What would you do next?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

Anatomy and Physiology

The airway begins at the nose and the lips and ends at the alveolocapillary membrane, through which gas exchange takes place between the air sacs of the lung (the alveoli) and the lung's capillary network. The airway consists of the upper airway (above the larynx) and the lower airway (trachea, bronchi, bronchioles, and ends in the alveoli), which conduct air with its 21% oxygen content, to the alveoli where oxygen is exchanged across the alveolar membrane and carbon dioxide diffuses from the blood into the alveoli to be exhaled.

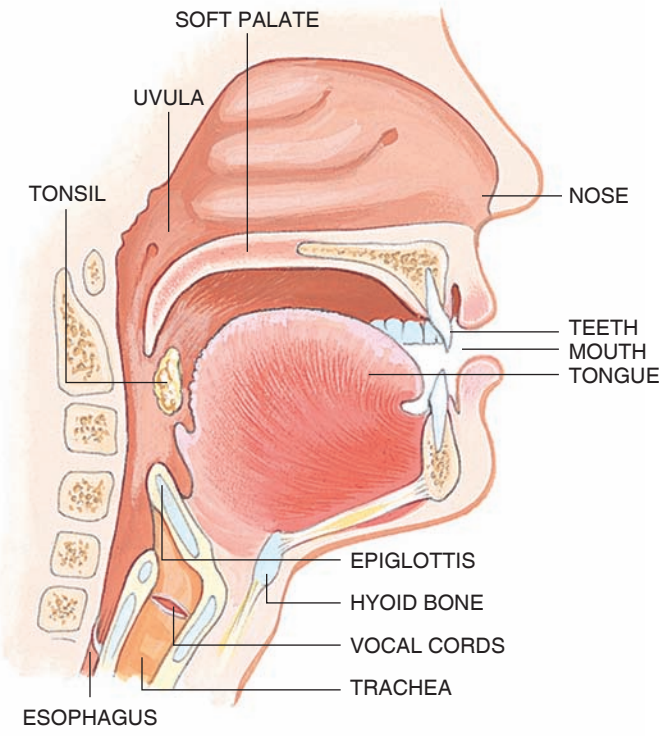


Figure 6-1 Anatomy of the upper airway. Note that the tongue, hyoid bone, and epiglottis are attached to the mandible by a series of ligaments. Lifting forward on the jaw will therefore displace all these structures anteriorly, opening the airway.

Nasopharynx

The beginning of the respiratory tract (the nasal cavity and oropharynx) is lined with moist mucous membranes (Figure 6-1). This lining is delicate and highly vascular with a tendency to bleed from even minor trauma that may occur during the placement of nasopharyngeal airways (NPAs) and endotracheal tubes (ETTs). The nasal cavity contains a midline septum and "shelves" on the lateral walls called the *turbinates*. The pathway through the nose to the airway is along the floor of the nose, perpendicular to the patient's face. Difficulty in placing NPAs is frequently encountered when providers mistakenly follow a trajectory parallel with the bridge of the nose, with trauma and bleeding often the result. Carefully sliding a well-lubricated NPA/ETT along the floor of the nasal cavity against the septum will usually prevent traumatizing the turbinates and allow successful placement.

Oropharynx

The teeth are the first obstruction met in the oropharynx. They may be more obstructive in some patients than in others. In any case, the same general principle always applies: Patients should have the same number and condition of teeth at the end of an airway procedure as they had at the beginning.

The tongue is mostly muscle and represents the next potential obstruction. It is attached to the jaw anteriorly and through a series of muscles and ligaments to the hyoid bone, a wishbone-like structure just under the chin from which the cartilage skeleton (the larynx) of the upper airway is suspended. The epiglottis is also connected to the hyoid, so elevating the

hyoid will lift the epiglottis upward and open the airway further. When the patient is unconscious, the tongue loses muscle tone and can fall back against the posterior pharynx and obstruct the airway.

Hypopharynx

The hypopharynx begins at the base of the tongue. The epiglottis is one of the main anatomic landmarks in the airway. You must be familiar with it and be able to identify it by sight and by touch. It appears as a floppy piece of cartilage covered by mucosa—which is exactly what it is—and it feels like the tragus, the cartilage at the opening of the ear canal. It is thought to block the glottic opening when swallowing and is an important landmark when you must assume control of the airway.

In the unconscious patient, the tongue can produce some airway obstruction by falling back against the soft palate and even the posterior pharyngeal wall. However, it is the epiglottis that will produce complete airway obstruction in the supine unconscious patient whose jaw is relaxed and whose head and neck are in the neutral position. In such patients the epiglottis will fall down against the glottic opening and obstruct.

It is essential to understand this crucial anatomy when managing the airway. To ensure an open (patent) airway in an unconscious supine patient, lift the hyoid anteriorly by lifting forward on the jaw (chin-lift, jaw-thrust) or by pulling on the tongue. This will lift the tongue out of the way. It will also keep the epiglottis elevated and away from the posterior pharyngeal wall and glottic opening (Figure 6-2). Both nasotracheal and orotracheal intubation require elevation of the epiglottis, either by lifting the jaw forward (nasotracheal) or by using a laryngoscope or the fingers when performing direct laryngoscopy or digital intubation.

Larynx

On either side of the epiglottis is a recess called the *pyriform fossa*. An endotracheal tube tip can end up in either one. Pyriform fossa placement of an endotracheal tube can be identified easily by "tenting" of the skin on either side of the superior aspect of the laryngeal prominence (Adam's apple) or by transillumination if a lighted stylet (or "lightwand") is being used to intubate.

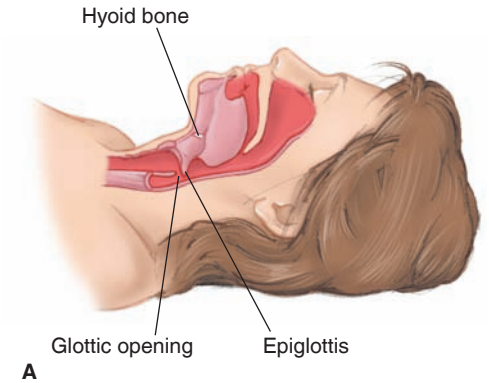


Figure 6-2a The epiglottis is attached to the hyoid and then to the mandible. When the mandible is relaxed and falls back, the tongue falls upward and against the soft palate and the posterior pharyngeal wall, whereas the epiglottis falls over the glottic opening.

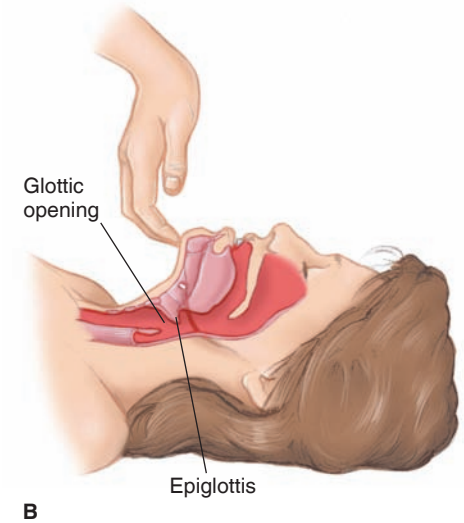


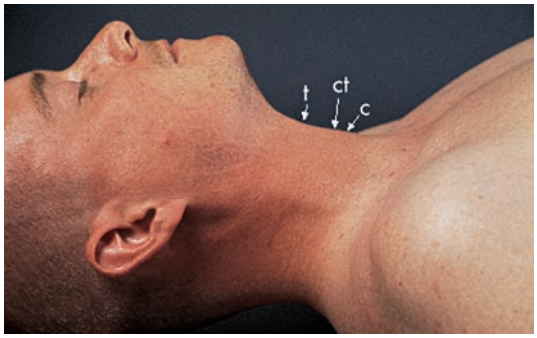
Figure 6-2b Extension of the head and lifting the chin will pull the tongue and the epiglottis upward and forward, exposing the glottis opening and ensuring the patent airway. In the trauma patient, only the jaw, or chin and jaw, should be displaced forward, and the head and neck should be kept in alignment.

external laryngeal manipulation (ELM): a maneuver to improve visualization of the vocal cords during endotracheal intubation. Also called BURP (back-up-right pressure).

The vocal cords are protected anteriorly by the thyroid cartilage, a boxlike structure shaped like a *C*, with the open part of the *C* representing its posterior wall. That wall is covered with muscle. In some patients, the cords can close entirely in laryngospasm, producing complete airway obstruction. The thyroid cartilage can easily be seen in most people on the anterior surface of the neck as the laryngeal prominence. Manipulating the thyroid cartilage can help bring the vocal cords into view during endotracheal intubation. This is called **external laryngeal manipulation (ELM)**. The process is to gently press the thyroid cartilage backward against the esophagus and then upward and slightly to the patient's right side. This is also known as the BURP (back-up-right pressure) maneuver and is different from the Sellick maneuver that was previously used to occlude the esophagus.

Inferior to the thyroid cartilage is the cricoid cartilage. The cricoid cartilage can be palpated as a small bump on the anterior surface of the neck inferior to the laryngeal prominence. The esophagus is just behind the posterior wall of the cricoid cartilage. Sellick's maneuver, pressure applied on the cricoid at the front of the neck, has traditionally been thought to occlude the esophagus and prevent insufflation of the stomach and subsequent aspiration of gastric contents. Increasing evidence has called this practice into question (Smith et al. 2003). Additionally, at the time Sellick's maneuver was initially described, it was routine to provide patients with large tidal volume ventilations with an inspiratory pressure that would easily overcome the upper esophageal sphincter. Current practice of ventilating patients with smaller tidal volumes and maintaining an inspiratory airway pressure <20 cm H_2O likely reduces the risk of gastric insufflation more so than partially occluding the esophagus with cricoid pressure. Consideration must also be given to the increasing recognition that the application of cricoid pressure may worsen the operator's view during laryngoscopy. *The totality of the current evidence suggests that the Sellick maneuver should not be used.*

Connecting the inferior border of the thyroid cartilage with the superior aspect of the cricoid is the cricothyroid membrane. This membrane is the advocated location for an emergency surgical airway as it is easily accessible through a vertical midline skin incision and is located below the vocal cords (Frerk et al. 2015). You can palpate the cricothyroid membrane by finding the most prominent part of the thyroid cartilage, then sliding your index finger down until you feel a second "bump," just before your finger palpates the last depression before the sternal notch. That second bump is the cricoid cartilage. At its upper edge is the cricothyroid membrane (Figure 6-3). In some patients, especially those who have a thick neck, you may find the cricoid cartilage



A

Figure 6-3a External view of the anterior neck, showing the surface landmarks for the thyroid cartilage (laryngeal) prominence, the cricothyroid membrane, and the cricoid cartilage.



B

Figure 6-3b Cutaway view showing the important landmarks of the larynx and upper airway: hyoid, thyroid cartilage, cricothyroid membrane, and cricoid cartilage.

more easily by going from the sternal notch upward until you feel the first prominent cartilage "bump." Just over the "top" of this bump is the cricothyroid membrane. For some patients it may be impossible to identify the cricothyroid membrane through intact skin, and in the event that a surgical airway is needed, the cricothyroid membrane may only be reliably identified after a skin incision is created.

Trachea and Bronchi

The tracheal rings (C-shaped cartilaginous supports for the trachea) continue beyond the cricoid cartilage. The trachea soon divides into the left and right mainstem bronchi. The point at which the trachea divides is called the *carina*. It is important to note that the right mainstem bronchus takes off at an angle slightly more in line with the trachea. As a result, ETTs or other foreign bodies usually end up in the right mainstem bronchus. One of the goals of a properly performed endotracheal intubation is to avoid a right (or left) mainstem bronchus intubation. For the average patient, an ETT placed to a depth (ETT mark at the teeth) of three times the ETT diameter will be adequate, though thorough postintubation assessment is always required.

Extension or flexion of the head of an intubated patient will move the endotracheal tube up or down as much as 2–2.5 cm. As a result, ET tubes can easily become dislodged during patient movement. Detection of displacement can be difficult unless you are monitoring oxygen saturation and end-tidal CO_2 ($etCO_2$). Taping the head down or guarding against movement will lessen the risk of ETT displacement. (This is even more important in children.)

A foreign object within the trachea such as an ETT will result in a cough reflex that attempts to expel the ETT (with the resultant stimulation of the cardiovascular system and elevation of ICP). These reflexes can be overcome with the appropriate use of postintubation sedation.

The Lungs

The lungs are the organs through which gas exchange takes place. They are contained within a "cage" formed by the ribs and usually fill up the thoracic cavity. They are surrounded by a membrane, the pleura, which has both a visceral component covering the lungs and a parietal component, which lines the interior portion of the thoracic cage. Between these two pleural membranes is the pleural space, which is the potential space. The lungs have only one opening to the outside, the glottic opening, which is the space between the vocal cords. Expansion of the chest wall (the cage) and movement of the diaphragm downward cause the lungs to expand (because the pleural space is airtight), and as the pressure inside the chest is now lower than that outside the body, air rushes in through the glottis. The air travels down the smaller and smaller bronchi and bronchioles to the alveoli, where gas exchange (respiration) takes place. The volume of air that is in the trachea and bronchi, where no gas exchange takes place, is called "dead space." Conditions such as pulmonary contusion (hemorrhage) or pulmonary edema, which can fill the alveoli with fluid, can also prevent oxygen exchange.

The Patent Airway

One of the first maneuvers essential to caring for a trauma patient is ensuring a patent or open airway. Without a **patent airway**, all other care is of little use. This must be done quickly as patients cannot tolerate hypoxia for more than a few minutes before sustaining irreversible anoxic brain injury and cardiac arrest. Patients suffering from traumatic brain injury (TBI) not only may have hypoxic brain damage from airway compromise but may also build up high levels of carbon dioxide that can cause dilation of the cerebral vessels, leading to swelling and increased intracranial pressure. These risks are compounded in trauma patients who frequently also have inadequate perfusion (see Chapter 12).

PEARLS

Preventing Deaths

- Become skilled at recognizing when:
  - — Active airway management is necessary. The need to intubate is not the same as the need to ventilate!
  - — The patient needs assistance with ventilation.
- Use **capnography** to ensure adequate ventilation and prevent inadvertent hypoventilation when:
  - — An airway device is placed incorrectly.
  - — An airway device that was placed correctly has become displaced. (The pulse oximeter and capnography are critical for this.)
- Become competent in intubating the trachea. Be prepared to use a rescue airway (supraglottic airway or oral airway and BVM) if you are unable to intubate.
- Prevent aspiration of gastric contents. Suction must be immediately available. Be prepared for equipment failure by having backup equipment available.
- Failure to manage the airway can be a fatal error.

capnography: a noninvasive device that detects or measures the amount of carbon dioxide in the expired breath of a patient.

patent airway: an open airway.



A

Figure 6-4a Opening the airway using a modified jaw-thrust maneuver. Maintain in-line stabilization while pushing up on the angle of the jaw.



B

Figure 6-4b Chin lift used to open the airway. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Ensuring a patent airway in a patient can be a major challenge in the prehospital setting. Not only can trauma disrupt the anatomy of the face and airway, but bleeding is common, which can lead to airflow obstruction and obscure airway landmarks. Add to this the risk of cervical-spine injury in trauma patients, and the challenge is readily apparent. You also must remember that some airway maneuvers, including suction and insertion of nasopharyngeal and oropharyngeal airways, can stimulate a patient's protective reflexes and increase the likelihood of vomiting and aspiration, cardiovascular stimulation, and increased intracranial pressure.

The first step in providing a patent airway in the unconscious patient is to ensure that the tongue and epiglottis are lifted forward off the posterior pharyngeal wall and maintained in that position. This is done by using the modified jaw-thrust maneuver (Figure 6-4). As all unconscious trauma patients should be presumed to have an unstable C-spine injury, hyperextension of the neck to open the airway should be avoided, if possible. A jaw-thrust can be effectively done without manipulation of the cervical spine as the provider displaces the mandible (and attached tongue) anteriorly from a maintained in-line cervical spine.

Once a patent airway has been achieved, an oropharyngeal airway (OPA) or NPA can be placed in the patient to facilitate the direction of airflow. OPAs should be cautiously placed in patients with intact gag reflexes to avoid vomiting. Traditional teaching has suggested avoiding the placement of NPAs in patients with facial trauma to avoid inadvertent intracranial misplacement of the NPA. There is little evidence, however, to support this sweeping statement and provided that NPAs are placed gently along the floor of the nose with proper technique (discussed previously), this may be an appropriate intervention for a hypoxemic patient even in the presence of significant facial trauma.

Constant vigilance and care are required to maintain a patent airway in your patient. The following are essentials for this task:

- *Observation*. Continual observation of the patient to anticipate decompensation, frequently requiring monitoring devices such as pulse oximetry and capnography. Although close observation of pulse oximetry is important, the earliest warning of

inadequate ventilation (potentially from airway obstruction) is a loss of the $etCO_2$ waveform tracing.

- *Suction*. An adequate suction device with large-bore tubing and attachment
- *Airway adjuncts.*

Observation

The patient who is injured is at risk of airway compromise even if completely conscious and awake. This is partially because many trauma patients are kept supine with full stomachs, are anxious, and are bleeding into their oropharynx, all which make these patients prone to vomiting. These concerns dictate that when possible one team member must be responsible for airway control, observation, and adequate ventilation for any patient who might be at risk of airway compromise.

The general appearance of a patient, the respiratory rate, and any complaints must be noted and addressed. In a patient who is breathing spontaneously, you must check frequently for adequate **tidal volume** by feeling over the mouth and nose and by observing chest wall movements. Baring the chest—at least below the breasts—is a good rule to follow. Check the supplemental oxygen line periodically to ensure that oxygen is being delivered to the patient at a given flow rate or percentage. If available, end-tidal capnography can be applied to spontaneously breathing patients as an objective early marker of respiratory status.

tidal volume: the amount of air that is inspired and expired during one respiratory cycle.

Always clear blood and secretions immediately. Alert patients can be given the rigid suction catheter to clear their own secretions, an element of control that may help alleviate some anxiety. You also must be alert for sounds that indicate trouble. *Remember:* Noisy breathing is obstructed breathing.

If the patient has an endotracheal tube in place, monitor **lung compliance** and search for the cause of any change in compliance. In trauma patients this is usually due to a tension pneumothorax. Use of waveform capnography is becoming the standard for monitoring ET tube placement during transport of critically ill patients and is strongly recommended in all intubated patients. A trending decrease in the expired CO_2 waveform can result from either hyperventilation of the patient or when the ventilation rate is maintained and indicates that the patient is having issues with perfusion. In contrast, the abrupt loss of capnographic waveform suggests either extubation, obstruction, or cardiac arrest. A rise in $etCO_2$ will cause a rise in the waveform and can indicate hypoventilation. The use of capnography and pulse oximetry is recommended in all trauma patients. (See Chapter 7.)

lung compliance: the "give" or elasticity of the lungs

Suction

All patients who are injured and who have cervical motion-restriction devices in place should be considered at high risk for airway compromise. In addition, one of the greatest threats to the patent airway is that of vomiting and aspiration, particularly in patients who have recently eaten a large meal. As a result, portable suction devices are essential airway equipment for field trauma care. A portable suction device should have the following characteristics (Figure 6-5):

- It can be carried in an airway kit with the oxygen cylinder and other airway equipment. It should not be separated or stored remotely from oxygen. If it is, it would represent an "extra" piece of equipment requiring extra hands.
- It can be hand powered or battery powered rather than oxygen driven. You should always have a hand-powered suction as a backup if you use a battery-powered suction.
- It can generate sufficient suction and volume displacement to remove pieces of food, blood clots, and thick secretions from the oropharynx.
- It has tubing of sufficient diameter (0.8–1 cm) to handle whatever is suctioned from the patient.



Figure 6-5 Example of a suction apparatus.

Suction tips should be of large bore, such as the rigid tonsil-tip suction catheters that can handle most clots and bleeding. In some cases, the suction tubing itself can be used to withdraw large amounts of blood or gastric contents. A 6-mm endotracheal tube can be used with a connector as a suction tip. The ETT's side hole removes the necessity for a proximal control valve to interrupt suction. Usually, the second emergency care provider (see Chapter 2) assumes responsibility for the airway.

Airway Adjuncts

Equipment to help ensure a patent airway may include various nasopharyngeal airways, oropharyngeal airways, supraglottic airways, and endotracheal tubes. Insertion of these devices must be reserved for patients whose protective reflexes are sufficiently depressed to tolerate them and care must be taken to avoid provoking vomiting or gagging (see Chapter 7).

Nasopharyngeal Airways

Nasopharyngeal airways should be soft and of appropriate length. They are designed to prevent the tongue and epiglottis from falling against the posterior pharyngeal wall. (See Chapter 7 for insertion technique.) A field-expedient adult NPA can be made by cutting a 6.0 or 6.5 ETT to the correct length. With light lubrication and gentle insertion, there should be few problems with this airway (Figure 6-6), however, bleeding and trauma to the nasal mucosa may occur. Mild hemorrhage from the nose after insertion of the airway is not an indication to remove it. In fact, it is likely better to keep an NPA in place so as not to disturb the clot or reactivate the bleeding. The NPA will be better tolerated than the oropharyngeal airway adjunct and thus can usually be used in patients who still have a gag reflex. Note that patients on anticoagulants are at increased risk for nasal bleeding with insertion.

Oropharyngeal Airways

Oropharyngeal airways are designed to keep the tongue off the posterior pharyngeal wall and thereby help maintain a patent airway (Figure 6-7) when used in conjunction with an anterior jaw-thrust. Successful placement of an OPA should not give



A

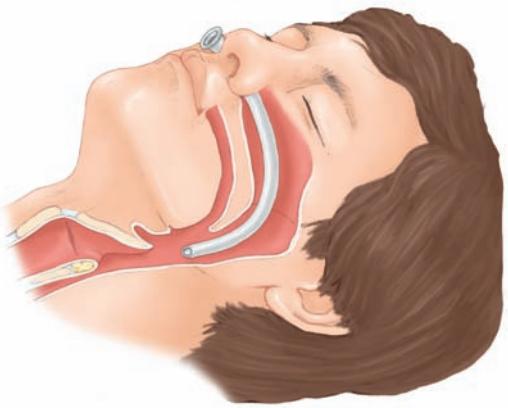
Figure 6-6a The nasopharyngeal airway is inserted with the bevel slid along the septum or floor of the nasal cavity.

you a false sense of security as patients who tolerate an OPA are likely patients who will require endotracheal intubation because their protective reflexes are so depressed, they cannot protect their lower airways from aspiration.

Supraglottic Airways

King LT-D™ airway, intubating laryngeal airway (ILA)™, AIR-Q™, i-gel™, laryngeal mask airway (LMA™), and esophageal tracheal combitube (Combitube®) are some examples of the many **supraglottic airways (SGAs)** currently available. These devices are placed blindly in patients with an appropriately depressed level of consciousness.

supraglottic airway (SGA): an airway that can be inserted without having to visualize the larynx. Previously called blind insertion airway device (BIAD).



B

Figure 6-6b The nasopharyngeal airway rests between the tongue and the posterior pharyngeal wall.

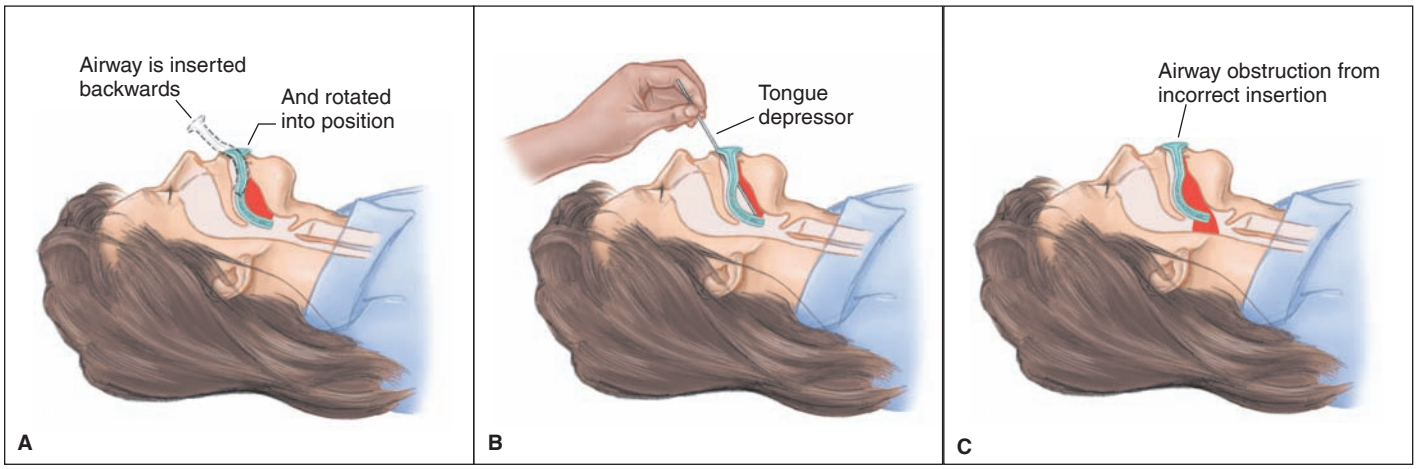


Figure 6-7 Insertion of an oropharyngeal airway.

SGAs can be properly inserted without providers having to visualize the larynx and can be effectively placed without manipulating the cervical spine in trauma patients (see Chapter 7).

Supraglottic airways are not as effective as endotracheal intubation in preventing aspiration but do provide effective oxygenation and ventilation. They are easier and faster to insert than an endotracheal tube, making them an ideal airway to oxygenate a patient in the prehospital environment. They have the additional benefit of being able to be placed without interrupting other interventions such as chest compressions during CPR. In cardiac arrest, they are now the initial invasive airway recommended in medical cardiac arrests by the American Heart Association and the International Liaison Committee on Resuscitation (Wang et al. 2018). While SGAs were previously regarded as a rescue airway to be used when unable to intubate, in many jurisdictions, supraglottic airway use is now a basic-level skill. Experience suggests that single-tube devices such as the King LT-D, i-gel, LMA, and others may be better suited for the prehospital environment than the more complicated dual-lumen tubes.

Endotracheal Tubes

Endotracheal intubation is the gold standard of airway management and could be considered in the prehospital setting when all other preceding options have failed to support the patient's oxygenation and ventilation. This decision should not be taken lightly, however, as several problems may be encountered when you decide to intubate a trauma patient. Due to the possibility of unstable cervical spine injuries, all trauma patients should be intubated supine with in-line cervical stabilization, a practice that makes all trauma intubations potentially difficult.

Placement of an ETT can safely occur under three scenarios: cardiac arrest during which no pharmacology is required, following administration of a sedative and paralytic as part of a **drug-assisted intubation (DAI)**, or during an awake intubation facilitated with appropriate topical airway medications (not typically an option in the prehospital environment), Attempting to place an ETT in a patient with depressed loss of consciousness (LOC) with intact reflexes and muscle tone is a difficult and dangerous endeavour with a well-documented incidence of increased difficulty (Frerk et al. 2015).

drug-assisted intubation (DAI): a technique to improve the likelihood of intubating a difficult patient by administering a sedative and paralytic agent. Previously called rapid sequence intubation (RSI).

DAI refers to the use of sedative and paralytic agents to quickly facilitate ETT placement and to minimize the risk of aspiration. Administration of a paralytic is the only intervention shown to improve first-attempt success rates with intubation, with the additional benefit of improving compliance of bag-valve mask (BVM) and placement of SGA. The procedure is covered in detail in Chapter 7.

Intubation is a difficult procedure to develop and maintain competence in, particularly when it is encountered infrequently in the prehospital environment. Additionally, the unrecognized esophageal intubation (often delayed in the prehospital environment due to equipment limitations ($etCO_2$) or the profound shock states of patients) will quickly lead to critical hypoxemia and cardiac arrest. Given these considerations, endotracheal intubation is a procedure that should be deferred when possible until the patient is in a more stable environment with more experienced personnel and more equipment and monitoring capabilities, considering again that the overall objective is oxygenation and ventilation, not "passing the tube."

Providers must be very familiar with the predictors of difficult laryngoscopy and intubation before deciding to intubate a patient who is already breathing on his or her own. Remember, patients who have spontaneous yet inadequate respiratory effort are often better off with noninvasive support than the patient who has been given a paralytic and can neither be intubatex nor mask-ventilated.

LEON: technique for predicting when a patient will be difficult to intubate. LEON means Look for abnormal anatomy, Evaluate 3-3-2 rule, check for Obstructions, Neck mobility.

Although it is not possible to guess correctly every time, certain physical features allow you to predict which patients might potentially have difficult laryngoscopy and intubation. The mnemonic **LEON** has been proposed to identify these features:

L *Look externally.* Look for abnormal facial structure; jaw overbite or underbite; obese neck; and facial, oral, or neck trauma.

E *Evaluate the 3-3-2 rule.* Mouth opening of at least three fingers, distance from hyoid bone to mandible symphysis of three fingers and distance from hyoid bone to thyroid cartilage of two fingers.

O *Obstruction.* Look for foreign bodies, blood, vomitus, and facial or neck pathology such as masses. This is particularly important because upper airway obstructive pathology, often evidenced by stridor, is a relative contraindication.

N *Neck mobility compromised.* Trauma patients often need spinal motion restriction, decreasing the ability to extend the head at the atlanto-occipital junction to achieve the "sniffing position," which can aid in visualizing the vocal cords.

As for all practitioners responsible for emergency airway management, the appropriate decision regarding whom and how to intubate will ultimately be related to several factors. These include the assessment of the patient and the particular clinical presentation, the skill set of the individual health care professionals present, and the system in which they work. An additional factor unique to the prehospital setting is time. A patient who is maintaining oxygenation and ventilation is often better transported, with continuous observation for deterioration, out of an austere environment for definitive airway management to occur in a hospital or other monitored setting. Ventilation with a BVM or SGA and immediate transport of the patient may be a better option in certain instances than taking the additional time required to perform **rapid sequence intubation (RSI)**. A spontaneously breathing patient with an appropriate O_2 saturation is always better than an ill-equipped RSI.

Rapid sequence intubation (RSI): a process in which endotracheal intubation is performed on a patient at high risk for aspiration, by providing sedation, paralysis, and limiting manual ventilation after paralysis until intubation is completed.

Once the decision to intubate has been made, emergency care providers must identify an appropriate approach for that patient, with consideration given to alternative techniques available should difficulty be encountered.

Although direct-vision orotracheal intubation is considered the primary method of placing an ETT in the trachea, the procedure is not always easy. In the management of trauma patients particularly, options must be available to permit successful intubation in even the most challenging of situations and patients. There is evidence that the technique of direct-vision orotracheal intubation results in some movement of the head and neck, the clinical significance of which is unclear (Robitaille et al. 2008). Although intubation of supine trauma patients using direct laryngoscopy is a safe option with a high success rate, emergency care providers must consider that if difficulty is encountered it may be from an inability to optimally align the oral–pharyngeal–laryngeal axis due to C-spine immobilization. As such, alternative intubating approaches such as the use of a video laryngoscope (VL) designed to "look around the corner" should be considered. VL, however, in the soiled or bloody airway may be impossible relative to direct laryngoscopy.

The use of a bougie or intubating stylet, which is placed into the trachea under observation and the endotracheal tube passed down the guide, is another tool available for the difficult airway. It can also be used to guide the tube during a cricothyrotomy (see Appendix J).

In situations of significant craniofacial trauma with an obstructed airway, rapidly moving to an emergency surgical airway may be required, even in the prehospital environment. The indication for a surgical airway is the inability to secure an airway by any other means, and the provider should perform a cricothyrotomy using a bougie, scalpel, and a small-caliber ETT (Frerk et al. 2015). (See Appendix J.)

Those with a low risk of cervical spine injury can be intubated in the conventional way, using a direct laryngoscope. Intubation by video laryngoscopy, the nasotracheal route, the tactile or transillumination methods, or a combination should be reserved for patients with specific indication for alternative techniques. In short, the method of intubation should be suited to each patient on a case by case basis. (See Chapter 7.)

Supplemental Oxygen

Patients who are injured and hypoxemic need supplemental oxygen, particularly when there is concern for significant TBI, as early hypoxemia is a major predictor of poor long-term outcomes. Supplemental oxygen can be supplied by a nasal cannula at 2–5 liters per minute (LPM) for awake patients, at >15 LPM for those who have altered LOC, or by a simple face mask run at 10–12 LPM. A simple face mask can provide the patient with about 40–50% oxygen. Nonrebreathing masks with a reservoir bag and oxygen flow rates into the bag of 12–15 LPM can provide 60–90% oxygen to the patient. They are recommended for all trauma patients requiring supplemental oxygen, especially if hypoxic. These are all examples of "open systems," meaning that while supplemental FiO_2 is being provided to the patient, as they are spontaneously breathing they are able to freely mix supplied oxygen with room air, diluting the actual FiO_2 they are exposed to at an alveolar level.

Bag-valve mask devices or resuscitator bags with a large (2.5 liters) reservoir bag and an oxygen flow rate of 12–15 LPM will increase the delivered oxygen from 21% (air) to 90 or 100%. Adding a reservoir bag to a bag-valve mask will increase the delivered oxygen from 40 or 50% to 90 or 100%, and thus always should be used.

By obtaining a two-handed mask seal with a BVM and two sources of oxygen (>15 L/min into the BVM and >15 L/min via nasal prongs under the mask), patients are exposed to a closed system of ventilation without entrainment of room air and dilution of the FiO_2 they are receiving. Providers must ensure that the volume of oxygen delivered is more than the patient's minute ventilation to ensure that this is the case (discussed later). For patients undergoing DAI, maintain high-flow oxygen by nasal cannula after paralytic administration to entrain oxygen into the airway and reduce risk of hypoxia during the procedure. This is referred to as *apneic oxygenation*.

Supplemental oxygen must be used to ensure adequate oxygenation when you perform positive-pressure ventilation. Oxygenation should be supplemented during mouth-to-mask ventilation by running oxygen at 10–12 LPM through the oxygen nipple attached to most masks or by placing the oxygen tubing under the mask and running it at the same rate.

Recent research, primarily in nontrauma patients, raises concerns that too much oxygen may be detrimental or even increase mortality (Chu et al. 2018). *This does not appear to apply to trauma patients.* It is well established that hypoxia, especially in patients with a head injury, can increase mortality. During the acute resuscitation phase, especially if the patient is hypoxemic, supplying large quantities of oxygen is appropriate; however, it should also be a priority for practitioners to titrate down oxygen to the lowest dose required to maintain appropriate oxygen saturation.

Ventilation

Normal Ventilation

minute volume: the volume of air breathed in and out in 1 minute. This varies from 5 to 12 liters per minute.

normal ventilation: the movement of air into and out of the lungs is able to maintain the carbon dioxide level between 35 and 45 mmHg.

hypoventilation: the movement of air into and out of the lungs is unable to maintain the carbon dioxide level below 45 mmHg.

The movement of air or gases in and out of the lungs is called *ventilation*. This should not be confused with respiration, which is the exchange of oxygen at the alveoli. At rest, adults normally take in about 400–600 cc air with each breath. This is called the *tidal volume*. Multiplying that value by the number of breaths per minute (the respiratory rate) gives the **minute volume**, the amount of air breathed in (and, of course, out) each minute. This is an important value and is normally 5–12 LPM. **Normal ventilation** by healthy lungs will produce an oxygen level of about 100 mmHg in the blood and a carbon dioxide level of 35–45 mmHg. A carbon dioxide level below 35 mmHg indicates hyperventilation, and values greater than 45 mmHg indicate **hypoventilation**. Patients who are critically ill will increase not only their respiratory rate but also their tidal volume for an overall increased minute ventilation (i.e., they breathe faster and take bigger breaths) to compensate for hypoxemia or acidosis.

The clinical terms *hypoventilation* and *hyperventilation* do not refer to oxygenation but to the level of carbon dioxide maintained. It is easier for carbon dioxide to diffuse across the alveolocapillary membrane of the lungs than it is for oxygen to do so. This makes it easier to excrete carbon dioxide than to oxygenate the blood. Thus, if the chest or lungs are injured, the body may be able to maintain normal levels of carbon dioxide in the blood and yet be hypoxic. A patient with a contused lung might have a respiratory rate of 36, a carbon dioxide level of 30 mmHg, and an oxygen level of only 80 mm Hg. Although hyperventilating, this person is still hypoxic.

A major impairment to gas exchange is the presence of **alveolar shunt** physiology. Alveolar shunt is any process that obstructs the alveoli and prevents oxygen from reaching the alveoli and prevents adequate gas exchange, resulting in persistent hypoxemia refractory to increasing levels of supplemental FiO_2. Examples of conditions that may cause arteriovenous shunt physiology include pulmonary contusion, atelectasis, congestive heart failure (CHF), pneumonia, and acute respiratory distress syndrome (ARDS). To achieve gas exchange in these abnormal lung states, positive pressure needs to be administered to splint open alveoli, as it is only when alveoli are open that gas exchange occurs. Oxygenation is generally a factor of the mean airway pressure (the inspiratory pressure generated by the patient or via ventilatory support and the end expiratory pressure). Positive end expiratory pressure (PEEP) can be provided to these patients using disposable PEEP valves that will attach to standard BVMs. These valves deliver upward of 20 cm H_2O of pressure to maintain alveolar patency and facilitate continuous gas exchange. As a rule, if a patient is receiving a FiO_2 of 40% (6L NC) and remains hypoxemic, this suggests the presence of pulmonary shunt (Weingart 2011). Providers need not worry about complications such as barotrauma during the initial resuscitation phase, as barotrauma is generally a complication of prolonged ventilation at higher pressures than disposable valves will generate (Weingart 2011).

alveolar shunt: any process that obstructs the alveoli and prevents oxygen from reaching the alveoli and adequate gas exchange, resulting in persistent hypoxemia refractory to increasing levels of supplemental FiO_2.

Devices to measure oxygen saturation (**pulse oximeters**) have been available for several years and expired CO_2 monitors (capnographs) are now available for prehospital use. Pulse oximeters measure oxygen saturation and should be used on almost all trauma patients, whereas CO_2 monitors are most useful for continuously monitoring adequacy of ventilation as well as endotracheal tube placement. (These devices are discussed in Chapter 7.)

pulse oximeter: a noninvasive device for measuring the oxygen saturation of the blood.

Positive-Pressure (Artificial) Ventilation

Normal breathing takes place because the negative pressure inside the (potential) pleural space "draws" air in through the upper airway from the outside. In any patient who is unable to do this, or whose airway needs protecting, you may need to actively force air or oxygen in through the glottic opening. This is called *intermittent positive-pressure ventilation (IPPV)*. IPPV in trauma patients can take various forms, BVM-endotracheal tube ventilation to use of transport ventilators. Note that simply "pumping" air into the oropharynx is no guarantee that it will go through the glottic opening and into the lungs.

Although many critically ill patients require some degree of active ventilation support, this also represents the major opportunity to expose the patient to harm. It is common during stressful situations that even the most experienced provider will hyperventilate or overventilate patients in an attempt to correct low oxygen saturations. Pressure in the oropharynx of greater than 25 cm H_2O will open the upper esophageal sphincter and cause gastric insufflation, a complication often not appreciated until the patient vomits and aspirates.

When you need to ventilate a patient using IPPV, you should know approximately what the delivered volume is in order to provide patients with appropriate tidal volumes (500–600 cc in the adult). Delivered volume is how much air volume you provide with each breath you give. You can estimate the minute volume by multiplying

delivered volume by the ventilatory rate. BVM ventilation has similar challenges because pressures generated by squeezing the bag may equal or exceed 60 cm H_2O. Steady compression of the bag compared to very forceful, rapid compression results in lower peak airway pressures and reduces insufflation of air into the stomach. Manometers are now available to connect to BVMs, which will allow providers to ensure they are not ventilating with inspiratory pressures >20 cm H_2O.

When performing IPPV with a mask, keep the following essentials in mind:

- Supplemental oxygen must be provided for the patient during IPPV, ideally with both >15 L/min into the BVM and >15 L/min via high-flow nasal prongs under the mask, if a second oxygen source is available.
- Suction, with large bore suction catheter, must be immediately available.
- Ventilation must be done carefully to avoid gastric distention and to reduce the risk of regurgitation and possible aspiration. You can help prevent these complications by timing ventilation with the patient's own respiration.
- Pulse oximetry and end-tidal CO_2 monitoring (capnography) are the most reliable methods of monitoring oxygenation and ventilation in the prehospital environment. The pulse oximeter measures the oxygen saturation of the blood, and the capnograph measures the CO_2 level in the expired air. Use the end-tidal CO_2 level to judge whether to increase or decrease the rate of ventilation. If you adjust your respiratory rate to keep the expired CO_2 level between 35 and 45 mmHg, you can be sure you are neither hypo- nor hyperventilating the patient.

In the case of one-handed BVM ventilation, up to 40% mask leak can be expected. Balloon-mask designs can reduce this, and a two-person technique, in which one rescuer holds the mask in place with both hands while a second squeezes the bag, may better ensure adequate delivered volumes.

During the stress of an emergency situation, it is common to ventilate patients at an increased rate. Your target ventilation rate is once every 5–6 seconds in an adult so that ventilation rates should be 10–12 times per minute or less. With high-flow FiO_2 and a closed-system BVM with a two-hand hold and PEEP valve, providers need only deliver an initial three to four breaths to ensure that alveoli are effectively splinted open, allowing continuous gas exchange even without active ventilation. Your pulse oximeter and end-tidal CO_2 monitor are important in getting the correct rate and volume for each patient. Your objective is to avoid hypoventilation and hyperventilation. The key numbers for airway management are keeping oxygen saturation at about 95%, an $etCO_2$ of 35–45 mmHg and an inspiratory airway pressure <20 cm H_2O.

Compliance

When air is delivered by positive pressure into the lungs of a patient, the "give," or elasticity, of the lungs and chest wall will influence how easy it will be for the patient to breathe. If you are performing mask ventilation, a normal elasticity of the lungs and chest wall will allow air to enter the glottic opening, and little gastric distention should result. However, if the elasticity is poor, ventilation will be harder to achieve and gastric distention more likely. The ability of the lungs and chest wall to expand and therefore ventilate a patient is known as *compliance*. (It is simpler to speak of "good compliance" or "poor compliance" rather than "high" or "low" compliance because the latter terms can be somewhat confusing. When there is "poor" compliance, the chest acts as if it is stiff and requires more force to move and ventilate.)

Compliance is an important concept because it governs whether or not you can adequately ventilate a patient. Compliance can become poor in some disease states of the lung such as bronchospasm or pulmonary fibrosis or in patients who have an injury to the chest wall or have developed a tension pneumothorax. This makes ventilating the patient all the more difficult, that is, it takes more force to push the air into the

lungs with the BVM. With an endotracheal tube in place, the patient's compliance becomes an important clinical sign and may reveal airway problems. Keep in mind that with an endotracheal tube in place and with BVM ventilation, you have a kind of "pressure-detection" device, that is, you can feel compliance worsening or improving with your fingers and hand on the BVM. A worsening of compliance may be the first sign of evolving pathology such as a tension pneumothorax. When ventilating a trauma patient with a BVM and compliance becomes poor, you must rule out a tension pneumothorax and airway obstruction.

Ventilation Techniques

Mouth-to-Mouth

Mouth-to-mouth ventilation is an old and effective method, with the advantage of requiring no equipment and a minimum of experience and training. Delivered volumes are consistently adequate because mouth seal is effectively and easily maintained. In addition, compliance can be felt more accurately, and high oropharyngeal pressures are therefore less likely. This method is rarely used because of the concern of disease transmission; however, it is appropriate for some patients, especially those with whom you are familiar (such as family members). Because of its effectiveness and universal availability, all providers should be familiar with the technique.

Mouth-to-Mask

Though not quite as effective as mouth-to-mouth ventilation, mouth-to-mask ventilation can overcome the slight risk of disease transmission by interposing a face mask between your mouth and that of the patient. Commercially designed pocket face masks, which fold into a small case that can be carried in your pocket, are particularly suited for the initial ventilation of many types of patients. Some have a side port for supplemental oxygen.

Bag-Valve Mask Device

The BVM, a descendant of the anesthesia bag, is a fixed-volume ventilator with an average delivered volume of 500–600 cc of air or oxygen. It should be used with a reservoir bag or tubing and connected to an oxygen source.

A major problem associated with the BVM device is the volume delivered. Mask leak is a serious problem (with single-handed technique), decreasing the volume delivered to the oropharynx by sometimes 40% or more. In addition, old masks of conventional design have significant dead space beneath them, thus increasing the challenge to provide an adequate volume to the patient. Newer mask designs reduce dead space beneath the mask and provide an improved seal over the nose and mouth. It has been shown in mannequin studies to decrease mask leak and to improve ventilation. These types of masks are a better choice, if available, versus older conventional masks (Figure 6-8).



Figure 6-8 Appropriate hand placement for bag-valve mask ventilation.

A better seal can sometimes be obtained and sufficient volumes delivered with a two-person technique where one person holds the mask seal and another ventilates; this is another way to improve ventilations where mask seal is an issue or hand size is small. In many EMS situations, the number of personnel available prevents the use of the two-person technique. Capnography should be used to ensure adequate ventilation and prevent inadvertent hyperventilation during mask ventilation.

Effective ventilation with a BVM requires a high degree of skill and is not without difficulty. Prehospital personnel must



Figure 6-9 Align external auditory canal with suprasternal notch in larger patients to improve visualization during intubation and to make mask ventilation easier (blue line). Note that raising head of ambulance cot still keeps spine straight (orange line).
(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

be prepared for situations where mask ventilation is difficult and be able to respond to these challenges. Predictors of difficult mask ventilation can be remembered using the "BOOTS" mnemonic:

B—Beards
O—Obesity
O—Older patients
T—Toothlessness
S—Snores or stridor

All these signs suggest that the patient will not be easy to mask-ventilate. Facial hair and the lack of teeth make mask seal more difficult. Obesity increases chest compliance and atelectasis when supine. Angling the head of the stretcher such that the external auditory canal is level with the suprasternal notch can help. In older patients and in those in whom cervical spine control is necessary, it is more difficult to get proper head and neck positioning. Finally, the presence of snoring or stridor or wheezes should alert the rescuer to the presence of airway obstruction and the need to extend expiratory time for patients with obstructed airway disease (Figure 6-9).

If unable to ventilate a patient using a BVM, the first step should be to reposition the airway by performing an aggressive jaw-thrust or, if not contraindicated by possible neck injury, an exaggerated head-tilt/chin-lift. Insert an OPA or NPA. If you are still unsuccessful, the next step is to initiate two-person BVM ventilation with extra emphasis on the jaw-thrust maneuver to maximize airway opening. Consider changing the mask size or type. Continued problems with mask ventilation should prompt the consideration of airway obstruction as a potential cause. Ultimately, the placement of a "rescue" ventilation device such as an SGA or endotracheal tube may be required to definitively ventilate the patient in the worst-case scenario (Figure 6-10). Remember that if you encounter difficulty ventilating or oxygenating the patient, simply "trying harder" is not an option—you must change what you are doing.

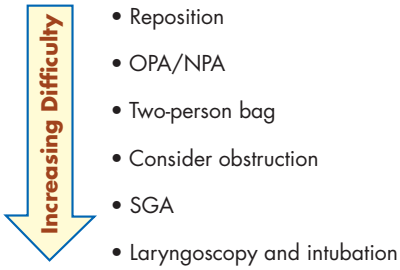


Figure 6-10 Response to difficult bag-valve mask ventilation.

Airway Equipment

The most important rule to follow in regard to airway equipment is that it should be in good working order and immediately available. It will do the patient no good if you have to run back to the ambulance to get the suction apparatus. In other words, be prepared. This is not difficult. The following five basic pieces of equipment are necessary for the initial response to all prehospital trauma calls:

- Personal protection equipment (see Chapter 1)
- Patient transfer device (backboard or scoop)
- Appropriate-sized rigid cervical extrication collar
- Airway kit (see the following information)
- Trauma box (see Chapter 1)



Figure 6-11 An airway kit containing the essentials for airway management. Note that portable suction is included in this design. The total weight (with aluminum "D" oxygen cylinder) is approximately 10 kg (22 lb), about the same as a steel "E" cylinder.

The airway kit should be completely self-contained and should contain everything needed to secure an airway in any patient. Equipment now available is lightweight and portable. Oxygen cylinders are aluminum, and newer suction devices are less bulky and lighter. It is no longer acceptable to have suction units that are bulky and stored separately from a source of oxygen. Suction units should be contained in a kit with oxygen and other essential airway tools. A lightweight airway kit should consist of the following (Figure 6-11):

- Portable oxygen cylinder, preferably aluminum
- Portable battery-powered and hand-powered suction units
- Oxygen cannula and masks for adult and pediatric patients
- Oropharyngeal and nasopharyngeal airways
- Endotracheal intubation kit, with both adult and pediatric laryngoscope blades and ET tubes
- Gum elastic bougie
- Supraglottic airways
- Bag-valve mask ventilating device (with reservoir bag)
- Pulse oximeter
- End-tidal CO_2 monitor (preferably a waveform capnography device)
- Cricothyrotomy kit, either surgical or needle
- Video laryngoscopy system, if available

The contents of the airway kit are critical. Check all equipment each shift, and have a card attached to be initialed by the person checking it.

Case Presentation *(continued)*

You are the lead emergency care provider in an ALS ambulance transporting a seriously injured assault victim to the trauma center. The patient is unresponsive. Noting the change in mental status along with a decrease in tidal volume in your patient, you immediately have your partner set up suction and begin to assist respirations with a bag-valve mask, while preparing to perform orotracheal intubation. (If you were not trained in this procedure, you would immediately contact online medical direction for advice on the nearest facility capable of handling this problem.) You also have equipment ready for your backup airway.

Case Presentation *(continued)*

After testing your equipment, you administer DAI medications per your agency protocol. You maintain high-flow nasal oxygen while waiting for the paralytic to take effect and insert the laryngoscope, confirm the absence of a gag reflex, visualize the vocal cords, pass a bougie through the cords, and then thread the ETT down the bougie into the trachea. Then, instructing your partner to ventilate the patient, you listen with your stethoscope first over the epigastrium, where you hear no sounds, and then in the axilla where you hear good breath sounds on the left side. Causes of the diminished breath sounds on the right include possible pneumothorax from the probable rib fractures.

With the airway checked by auscultation, you confirm placement with end-tidal CO_2, secure the tube, and instruct your partner to assist ventilations with 100% oxygen at one 500 cc breath every 5–6 seconds. You check a pulse oximeter reading, and monitor blood pressure. Your goal is to provide ventilation to achieve an $etCO_2$ of 35–40 mm Hg.

You then reassess the patient, prepare to decompress the tension pneumothorax should the patient deteriorate and recontact the trauma center to update them on his status and your ETA.

Summary

Trauma patients provide a significant challenge in airway management, particularly in the prehospital environment. To be successful you must have a clear understanding of the anatomy of the airway and be proficient in techniques to open and maintain your patient's airway and support oxygenation and ventilation. You must have the correct equipment organized in a kit that is immediately available when you begin assessment of the trauma patient. To provide adequate ventilation for your patient, you must understand the concepts of tidal volume, minute volume, and lung compliance. Finally, you must become familiar with the various options for monitoring and control of the airway and develop and maintain expertise in performing them.

References and Resources

Birenbaum, A., D. Hajage, S. Roche, A. Ntouba, M. Eurin, P. Cuvillon, A. Rohn, V. Compere, D. Benhamou, M. Biais, et al. 2018. "Effect of Cricoid Pressure Compared with a Sham Procedure in the Rapid Sequence Induction of Anesthesia: The IRIS Randomized Clinical Trial." *JAMA Surgery*. doi:10.1001/jamasurg.2018.3577

Chu, D. K., L. H. Kim, P. J. Young, N. Zamiri, S. A. Almenawer, R. Jaeschke, W. Szczeklik, H. J. Schünemann, J. D. Neary, and W. Alhazzani. 2018. "Mortality and Morbidity in Acutely Ill Adults Treated With Liberal Versus Conservative Oxygen Therapy (IOTA): A Systematic Review and Meta-Analysis." *The Lancet* 391 (April): 1693–705.

Davis, D. P., J. Stem, M. J. Sise, and D. B. Hoyt. 2005. "A Follow-up Analysis of Factors Associated with Head Injury Mortality After Paramedic Rapid Sequence Intubation." *Journal of Trauma* 59, no. 2 (August): 486–90.

Frerk, C., V. Mitchell, A. F. McNarry, C. Mendonca, R. Bhagrath, A. Patel, E. P. O'Sullivan, N. M. Woodall, and I. Ahmad. 2015. "Difficult Airway Society 2015 Guidelines for Management of Unanticipated Difficult Intubation in Adults." *British Journal of Anaesthesia* 115, no. 6 (December): 827–48.

Hung, O., and M. Murphy. 2010. "Context Sensitive Airway Management." *Anesthesia and Analgesia* 110, no. 4 (April): 982–3.

Kovacs, G., and N. Sowers. 2018. "Airway Management in Trauma." *Emergency Medicine Clinics of North America* 36, no. 1 (February): 61–84.

Law, J. A. 2016. "Deficiencies in Locating the Cricothyroid Membrane by Palpation: We Can't and the Surgeons Can't, So What Now for the Emergency Surgical Airway?" *Canadian Journal of Anesthesia* 63 (July): 791–6.

Lundstrom, L. H., C. H. V. Duez, A. K. Norskov, C. V. Rosenstock, J. L. Thomsen, A. M. Moller, S. Strande, and J. Wetterslev. 2018. "Effects of Avoidance or Use of Neuromuscular Blocking Agents on Outcomes in Tracheal Intubation: A Cochrane Systematic Review." *British Journal of Anesthesia* 120, no. 6 (June): 1381–93.

Roberts, K., H. Whalley, and A. Bleetman. 2005. "The Nasopharyngeal Airway: Dispelling Myths and Establishing the Facts." *Emergency Medicine Journal* 22 (June): 394–6.

Robitaille, A., S. R. Williams, M. H. Tremblay, F. Guilbert, M. Thériault, and P. Drolet. 2008. "Cervical Spine Motion During Tracheal Intubation with Manual In-Line Stabilization: Direct Laryngoscopy Versus GlideScope Videolaryngoscopy." *Anesthesia & Analgesia*. 106, no. 3 (March): 935–41.

Smith, K. J., J. Dobranowski, G. Yip, A. Dauphin, and P. T. Choi. 2003. "Cricoid Pressure Displaces the Esophagus: An Observational Study Using Magnetic Resonance Imaging." *Anesthesiology* 99, no. 1 (July): 60–4.

Wang, H. E., R. H. Schmicker, M. R. Daya, S. W. Stephens, A. H. Idris, J. N. Carlson, M. R. Colella, H. Herren, M. Hansen, N. J. Richmond, et al. 2018. "Effect of a Strategy of Initial Laryngeal Tube Insertion vs Endotracheal Intubation on 72-Hour Survival in Adults with Out-of-Hospital Cardiac Arrest: A Randomized Clinical Trial." *Journal of the American Medical Association* 320, no. 8 (August): 769–78.

Weingart, S. 2011. "Preoxygenation, Reoxygenation and Delayed Sequence Intubation in the Emergency Department." *Journal of Emergency Medicine* 40, no. 6 (June): 661–7.

Weingart, S., and R. Levitan. 2012. "Preoxygenation and Prevention of Desaturation During Emergency Airway Management." *Annals of Emergency Medicine* 59, no. 3 (March): 165–75.

7

Airway Skills

S. Robert Seitz, MEd, RN, NRP
Bob Page, BAS, CCEMT-P, NCEE
Roy L. Alson, PhD, MD, FAEMS



(Pearson Education)

Maßnahmen zum Atemwegsmanagement
Habilidades para el Manejo de la Vía Aérea
Zbrinjavanje dišnog puta u traumi
Competências Práticas na Gestão da Via Aérea
Keterampilan Penatalaksanaan Jalan Napas
Техники обеспечения проходимости дыхательных путей
Gestion des voies aériennes en pratique

Δεξιότητες στην Διαχείριση Αεραγωγού
A légútbiztosítás gyakorlata
気道管理手技
氣道設置技巧
Vzpostavitev proste dihalne poti

Skills presented in this chapter:

- Patient positioning
- Airway suctioning
- Airway adjuncts
  - Nasopharyngeal
  - Oropharyngeal
  - Pocket mask with supplemental oxygen
  - Bag-valve mask
  - Supraglottic airway
    - King LT-D airway
    - i-gel supraglottic airway
    - Laryngeal mask airway
- Orotracheal intubation
  - Laryngoscopic
  - Using bougie
- Tube placement
  - Confirming
  - Reconfirming ET tube position
  - Confirming and monitoring ET tube placement with capnography

Objectives

Upon successful completion of this chapter, you should be able to:

1. Suction the airway.
2. Insert a nasopharyngeal and oropharyngeal airway.
3. Use the pocket mask.
4. Use the bag-valve mask.
5. Use the pulse oximeter.
6. Perform airway management utilizing supraglottic airway devices.
7. Prepare for endotracheal intubation.
8. Perform laryngoscopic orotracheal intubation.
9. Confirm placement of the endotracheal tube (ETT).
10. Use capnography to confirm placement of the ETT.
11. Secure the ETT.
12. Understand the use of medications to assist with intubation.

Chapter Overview

Loss of airway is one of the leading causes of preventable trauma death. It is imperative that emergency care providers know how to assess and manage the airway in the trauma patient. This chapter reviews the necessary skills to open and stabilize the airway of the trauma patient. It is essential that during airway management all team members communicate clearly with each other to ensure a smooth process and successful outcome. One should never be in a rush to secure an airway; finesse is often more important than force during airway procedures.

In managing the airway, emergency care providers should always plan for an alternative approach in case the current approach does not work. There are several schemes that have been developed to assist emergency care providers (ECPs) in approaching the trauma airway. ECPs should regularly practice the management of the trauma airway so that the team maintains competency and confidence.

It is essential for the ECP to watch for and prevent development of hypoxia during airway management. Hypoxia is associated with worse outcomes, especially in patients with traumatic brain injury.

Basic Airway Management

Procedures

Positioning the Patient

Maintaining spinal motion restriction (SMR) is a key component of care of the trauma patient. SMR can increase difficulty in managing and securing the airway. Removal of the cervical collar and application of manual inline stabilization can help. Intubating the patient in the supine position also presents challenges. If the patient is on an ambulance stretcher, the head of the stretcher can be angled up to better align the airway axes. As with managing the airway in obese patients, the goal is to align the external auditory meatus with the suprasternal notch (Figure 7-1).



A B

Figure 7-1 A. In the supine patient the pharyngeal axis and the tracheal access do not align. B. Positioning of patient to improve successful airway management. Align external auditory meatus with suprasternal notch, which better aligns the trachea and the pharynx. Notice that the spine remains straight as the head of the ambulance cot is raised. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

(*continued*)

Procedures *(continued)*

Suctioning the Airway

1. Attach the suction connecting tubing to the suction machine.
2. Turn the device on and test it.
3. Insert the suction tip through the nose (soft or whistle tip catheter) or mouth (soft or rigid) without activating the suction.
4. Activate the suction and withdraw the suction tube.
5. Repeat the procedure as necessary.

Note that although the intent is to suction foreign matter (Figure 7-2), air and oxygen also are being suctioned out of the patient. Never suction for greater than 15 seconds. After suctioning, reoxygenate the patient as soon as possible.



Figure 7-2 Suctioning material from the oropharynx using a Yankauer suction tip.

Inserting the Nasopharyngeal Airway

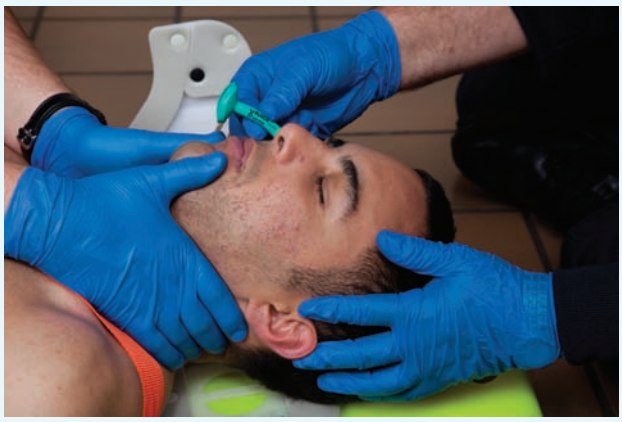
The nasopharyngeal airway (NPA) is designed to go into the right nostril. Consider using an alternative to the NPA if the patient has facial fractures or raccoon eyes; however, brain injury or facial fractures are not an absolute contraindication to use the NPA. To insert the NPA into the patient's right nostril, follow these steps:

1. Choose the appropriate size. It should be as large as possible but still fit easily through the patient's external nares. The size of the patient's little finger can be used as a rough guide (Figure 7-3).
2. Measure the NPA from the nares to the tip of the earlobe to ensure it is the correct length.
3. Lubricate the tube with a water-based lubricant.
4. Insert the tube straight back through the right nostril along the floor of the nose with the beveled edge of the airway toward the septum.
5. Gently pass it into the posterior pharynx with a slight rotating motion until the flange rests against the nares.

Note that if resistance to passage of the NPA is felt, *do not force* the NPA in, as injury may occur.



A



B

Figure 7-3 The nasopharyngeal airway should be the largest size that will easily fit through the external nares. *(Photos courtesy of Lewis B. Mallory, MBA, REMT-P)*

Procedures *(continued)*



Figure 7-4 Opening the airway using a modified jaw-thrust maneuver. Maintain in-line stabilization while pushing up on the angle of the jaw.

Remove NPA and attempt insertion in the other nostril. To insert the NPA into the left nostril:

1. Turn the airway upside down so that the bevel is toward the septum.
2. Insert straight back through the nostril until you reach the posterior pharynx.
3. Turn the airway over 180 degrees and insert it down the pharynx.

Note that if the tongue is occluding the airway, a jaw-thrust or chin-lift must be performed to allow the nasopharyngeal airway to go under the tongue (Figure 7-4).

Inserting the Oropharyngeal Airway

1. Choose the size oropharyngeal airway (OPA) that is appropriate for the patient. The distance from the corner of the mouth to the lower part of the external ear or to the angle of the jaw is a good estimate (Figure 7-5).
2. In the unresponsive patient, open the mouth with a scissor maneuver (Figure 7-6), a jaw lift (Figure 7-7), or a tongue blade. If placing fingers in the mouth, caution should be utilized as broken teeth and biting may cause injury.



Figure 7-5 The distance from the corner of the mouth to the lower part of the external ear or to the angle of the jaw is a good estimate for the correct-size oropharyngeal airway. *(Photo courtesy of Lewis B. Mallory, MBA, REMT-P)*



Figure 7-6 Scissors maneuver being used to open mouth for suctioning. Use same maneuver to open mouth to insert an oropharyngeal airway. *(Courtesy of International Trauma Life Support for Emergency Care Providers)*



Figure 7-7 Chin lift being used to allow placement of SGA. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

(*continued*)

Procedures *(continued)*

3. Insert the airway gently without pushing the tongue back into the pharynx. (See Chapter 6, Figure 6-7.)
   a. Insert the airway under direct vision, using a tongue blade. This is the preferred method and is safe for adults and children.
   b. Insert the airway upside down or sideways and rotate into place after tip of airway passes the tongue. This method should *not* be used for children.
4. If the OPA causes gagging, remove it and replace it with an NPA. The presence of a gag reflex is a contraindication to use of an OPA.

Using a Pocket Mask with Supplemental Oxygen

1. Stabilize the patient's head in a neutral position.
2. Connect the oxygen tubing to the oxygen cylinder and the mask.
3. Open the oxygen cylinder, and set the flow rate to a minimum of 15 liters per minute
4. Open the patient's mouth.
5. Insert an OPA or NPA, if available. Otherwise use the chin-lift or jaw-thrust maneuver to open the airway.
6. Place the mask on the face, and establish a good seal. Make sure the mask is the proper size for your patient. The mask should cover the nose and mouth and make a good seal. Facial hair, lack of teeth, obesity, or advanced age may make it difficult to get a good mask seal.
7. Ventilate mouth-to-mask with enough volume (10–12 mL per kg body weight) *to cause adequate chest rise*. Ventilate at a rate of 10–12 breaths per minute. The inspiratory phase should last 1.5–2 seconds. Let the patient exhale before giving the next breath.

Using the Bag-Valve Mask

1. Stabilize the patient's head in a neutral position.
2. Connect the oxygen, connecting tubing to the bag-valve mask (BVM) system and oxygen cylinder.
3. Attach the oxygen reservoir to the BVM.
4. Open the oxygen cylinder, and set the flow rate to a minimum of 15 liters per minute.
5. Select the proper-size mask, and attach it to the BVM device. The mask should go from the bridge of the nose to the chin.
6. Open the patient's mouth.
7. Insert an OPA (or an NPA, if the patient has a gag reflex).
8. If available, apply a capnography cannula or attach an airway adapter between the bag and the mask (Figure 7-8).
9. Place the mask on the patient's face, and have your partner establish and maintain a good seal. Facial hair, lack of teeth, obesity, or advanced age might make it difficult to get a good mask seal.
10. Using both hands, ventilate at a rate of 10–12 breaths per minute. If you are getting good bilateral chest rise, you are giving adequate tidal volume. Calculated tidal volume is 8 mL per kg body weight. Use capnography to ensure adequate ventilation and prevent inadvertent hyperventilation.As a general rule, keep the end-tidal CO_2 ($etCO_2$) between 35 and 45 mmHg.



Figure 7-8 A capnography nasal cannula can be placed under the mask of the BVM. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Procedures *(continued)*

11. If you are the only emergency care provider available to manage the airway, use one hand to maintain a face seal and the other hand to squeeze the bag. This may decrease the volume of ventilation because less volume is produced by only one hand squeezing the bag. Watch for chest rise to ensure adequate ventilation volume. To make a proper seal, place the thumb on the mask over the nose and index finger on the mask over the chin while the rest of the fingers are in contact with the mandible (Figure 7-9).



Figure 7-9 To make a proper seal, place the thumb over the nose and index finger over the chin while the rest of the fingers are in contact with the mandible. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

The Pulse Oximeter

A pulse oximeter is a noninvasive photoelectric device that measures the oxygen saturation of hemoglobin and the pulse rate in the peripheral circulation. It consists of a portable monitor and a sensing probe that clips onto the patient's finger, toe, or earlobe (Figure 7-10). The probe sends two beams of light, red and infrared, and saturation is then calculated based on the nonabsorbed light that reaches the photodetector.



Figure 7-10 Portable pulse oximeter.

The device displays the pulse rate and the arterial oxygen saturation in a percentage value (% SaO_2). This useful device should be used on all patients who have any type of respiratory compromise. The pulse oximeter is useful to assess the patient's respiratory status, the effectiveness of oxygen therapy, and the effectiveness of BVM ventilation.

Remember that the device measures percentage of hemoglobin carrying oxygen (SaO_2), not the arterial partial pressure of oxygen (PaO_2). The hemoglobin molecule is so efficient at carrying oxygen that it is 90% saturated (90% SaO_2) when the partial pressure of oxygen in the blood is only 60 mmHg (80–100 mmHg is normal). If you are accustomed to thinking about PaO_2 (where 80–100 mmHg is normal), then you may be fooled into thinking that an SaO_2 pulse oximeter reading of 90% is normal when it is actually critically low. As a general rule, any pulse oximeter reading below 92% is cause for concern and requires some sort of intervention (e.g., opening the airway, suction, oxygen, assisted ventilation, intubation, decompression of tension pneumothorax). A pulse oximeter reading below 90% is critical and requires immediate intervention to maintain adequate tissue oxygenation. Try to maintain a pulse oximeter reading of 94% or higher. However, do not withhold oxygen from a patient with a pulse oximeter reading above 95% who also shows signs and symptoms of hypoxia or difficulty breathing.

The following are conditions that make the pulse oximeter reading unreliable:

- *Poor peripheral perfusion* (shock, vasoconstriction, hypotension). Do not attach the sensing probe onto an injured extremity. Try not to use the sensing probe on the arm you are using to monitor blood pressure. Be aware that the pulse oximeter reading will go down while the blood pressure cuff is inflated.
- *Hyperventilation*. An $etCO_2$ less than 25 mmHg can lead to alkalosis, causing oxygen to bind tightly to hemoglobin and not releasing it for use. This leads to tissue hypoxia with a falsely high (even 100%) pulse oximetry reading.
- *Hypoventilation*. High $etCO_2$ (above 50 mmHg) can lead to acidosis. Acidosis causes oxygen to bind loosely and reduces the amount carried to the cells. This gives a low pulse oximeter reading that does not respond to O_2 therapy.
- *Severe anemia or exsanguinating hemorrhage*.
- *Hypothermia*. Vasoconstriction causes decreased blood flow to the probe site on the extremities.
- *Excessive patient movement*.
- *High ambient light* (bright sunlight, high-intensity light on area of the sensing probe).
- *Nail polish or a dirty fingernail*, if you are using a finger probe. Use acetone to clean the nail before attaching the probe.
- *Carbon monoxide poisoning*. This will give falsely high readings because the sensing probe cannot distinguish between oxyhemoglobin and carboxyhemoglobin. If carbon monoxide poisoning is suspected, you must use a specific monitor and sensor to measure levels (see Chapter 17).
- *Cyanide poisoning*. Cyanide poisons at the cellular level prevent the cells from using oxygen to make energy. Because the body is not using oxygen, the circulating blood will usually be 95–100% saturated. However, the patient will still be dying from lack of oxygen (at the cellular level).

To use the pulse oximeter, turn on the device, clean the area that you are to monitor (earlobe, fingernail, or toenail), and attach the sensing clip to the area. Remember that although very useful, the pulse oximeter is just another tool to help you assess the patient. Like all tools, it has limitations, as noted earlier, and should not replace careful physical assessment.

Supraglottic Airways

Introduced in the early 1970s, blind insertion airway devices (BIADs) were designed for use by EMS personnel who were not trained to intubate the trachea. Now commonly called *supraglottic airways (SGAs)*, emergency care providers now routinely use these devices in managing airways. Reasons for use include ease of placement as an initial advanced airway intervention or as a backup device for failed endotracheal intubation attempts. Devices such as i-gel™, Rusch Easy Tube™, LMA™, LMA™ Supreme, King LT-D™, and Combitube™ airway are classified as single- or double-lumen devices. This list is not all inclusive and numerous devices reach the market each year. We discuss insertion of representative devices of the single- and double-lumen type. Providers should be familiar with the specifics of the device used by their agencies.

The devices are all designed to be inserted into the pharynx without the need for a laryngoscope to visualize where the tube is going. Many of them have a tube with an inflatable cuff that is designed to seal the esophagus, thus helping to prevent vomiting and aspiration of stomach contents, as well as preventing gastric distention during BVM ventilation. Others use the distal end of the device to occlude the esophagus. It also was thought that by sealing the esophagus, more air would enter the lungs, and ventilation would be improved.

The devices have their own challenges and require careful evaluation to be sure they are in the correct position. None of the SGAs are equal to the ETT, which has become the invasive airway of choice for advanced EMS providers. In many systems, basic life support–level providers are permitted to use SGAs.

King LT-D Airway

The King LT-D airway is a single-lumen device inserted into the esophagus. It is designed with an esophageal and pharyngeal cuff, which inflate simultaneously. Once inflated, the patient is ventilated through the single tube (Figure 7-11). With the airway in place, you may be able to insert a bougie or a fiberoptic bronchoscope through the ventilating tube and swap the airway for an ETT, though it is not always successful. There is also an LTS-D™ airway that has a port through which you can insert a gastric tube to decompress the stomach. It is inserted in exactly the same way as the King LT-D airway. When using the King LT-D, just as you would any SGA, you must be sure that you are ventilating the lungs and not the stomach. The King LT-D is available in five sizes for patients greater than 35 inches (90 cm) to 6 feet (183 cm) or more in height.

Essential Points You must remember six essential points about the King LT-D airway:

- Use the King LT-D airway only in patients who are unresponsive and without protective (gag) reflexes.
- Do not use it in any patient with injury to the esophagus (such as caustic ingestions).
- Use the appropriate size for your patient, as indicated on the device.
- Pay careful attention to proper placement. Unrecognized intratracheal placement of the tube is a rare but lethal complication that produces complete airway obstruction. Such an occurrence is not always easy to detect, and the results are catastrophic. Capnography is recommended for confirmation of all supraglottic airway placement.
- You must insert it gently and without force.
- If the patient regains consciousness, you must remove the airway because it will cause retching and vomiting.



Figure 7-11 King LT-D airway.
(King Systems LTD/Ambu, Inc)

Procedure

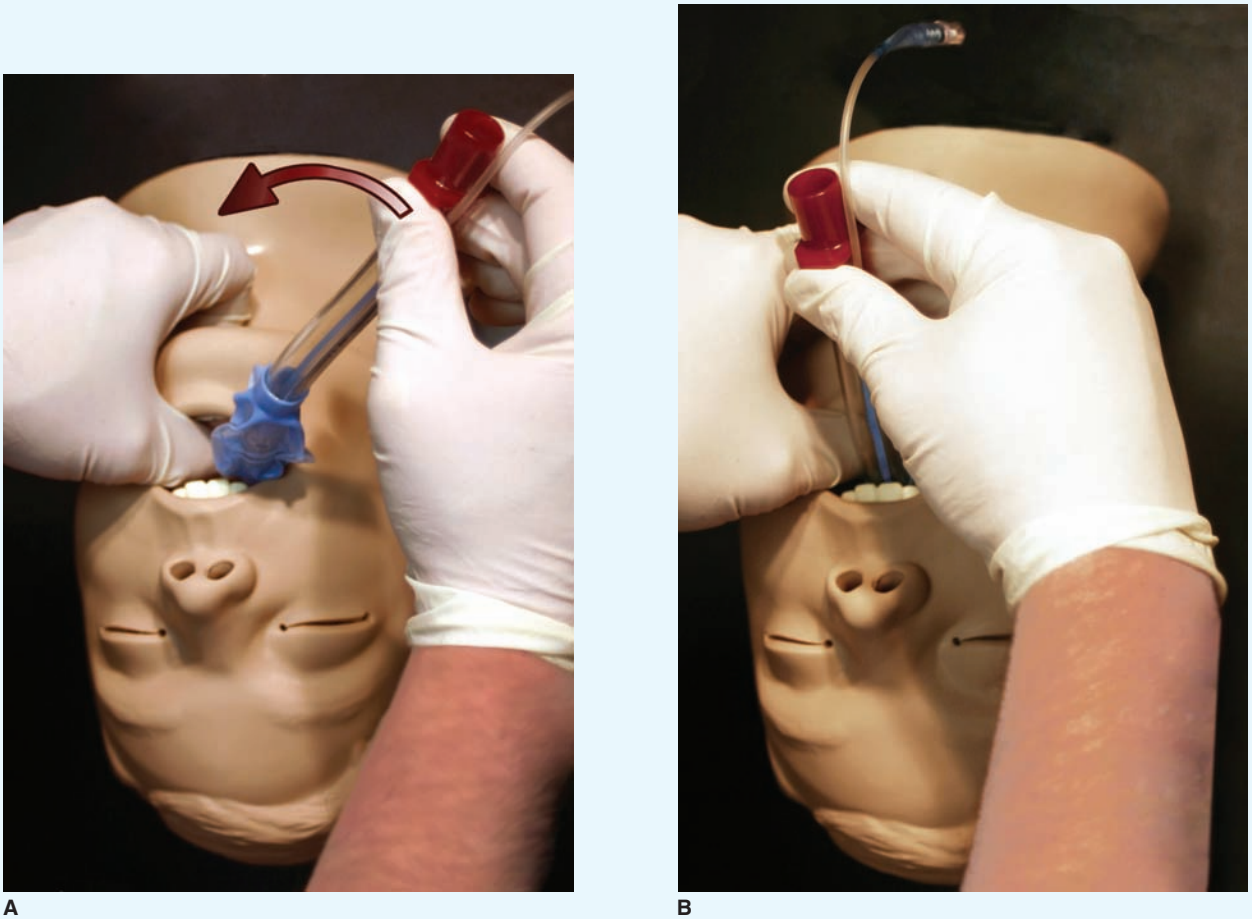
Inserting the King LT-D Airway

1. Select the correct-size King LT-D airway.
   - Size 2 (green connector color) is for children 35–45 inches (90–115 cm) in height or who weigh 12–25 kg.
   - Size 2.5 (orange connector color) is for children 41–51 inches (105–130 cm) in height or who weigh 25–35 kg.
   - Size 3 (yellow connector color) is for adults 4–5 feet (122–155 cm) in height.
   - Size 4 (red connector color) is for adults 5–6 feet (155–180 cm) in height.
   - Size 5 (purple connector color) is for adults greater than 6 feet (>180 cm) in height.
2. Test the cuff inflation system for air leaks.
3. Apply a water-soluble lubricant to the distal tip.
4. Hold the airway at the connector with your dominant hand. With the neck stabilized in a neutral position, hold the mouth open and apply a chin-lift with your nondominant hand. Using a lateral approach, introduce the tip into the mouth (Figure 7-12).
5. Advance the tip behind the base of the tongue while rotating the tube back to the midline so that the blue orientation line faces the chin of the patient (Figure 7-13).
6. Without exerting excessive force, advance the tube until the base of the connector is aligned with the patient's teeth or gums (Figure 7-14).
7. Hold the KLT 900™ cuff pressure gauge in the nondominant hand, and inflate the cuffs of the King LT-D with air to a pressure of 60 cm H_2O (Figure 7-15). If a cuff pressure gauge is not available and a syringe is being used to inflate the King LT-D, inflate cuffs with the minimum volume necessary to seal the airway at the peak ventilatory pressure employed (just seal volume). Typical sizing and inflation volumes are:
   - Size 2 (green), 35–45 inches (90–115 cm), 25–35 mL
   - Size 3 (orange), 41–51 inches (105–130 cm), 30–40 mL
   - Size 3 (yellow), 4–5 feet (122–155 cm), 45–60 mL
   - Size 4 (red), 5–6 feet (155–180 cm), 60–80 mL
   - Size 5 (purple), greater than 6 feet (>180 cm), 70–90 mL
8. Attach the resuscitator bag to the airway. While bagging the patient, gently withdraw the tube until ventilation becomes easy and free-flowing (Figure 7-16). Adjust cuff inflation, if necessary, to obtain a seal of the airway at the peak ventilatory pressure employed. You must see the chest rise, hear breath sounds, feel good compliance,



Figure 7-12 Hold the KLT-D with dominant hand. With nondominant hand, open mouth and apply chin lift. Using a lateral approach, introduce tip into mouth.

Procedure *(continued)*



A B

Figure 7-13 Advance the tip behind the base of the tongue while rotating the tube back to the midline so that the blue orientation line faces the chin of the patient.

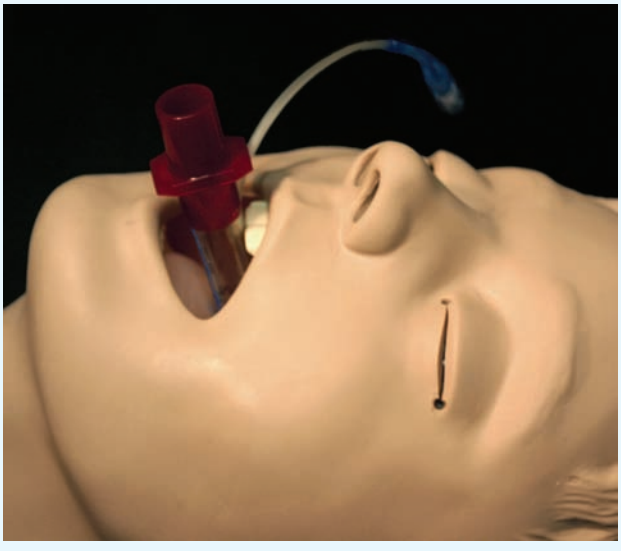


Figure 7-14 Gently advance the tube until the base of the connector is aligned with the teeth or gums.



Figure 7-15 Holding the KLT 900 Cuff Pressure Gauge in non-dominant hand, inflate the cuffs of the King LT-D with air to a pressure of 60 cm H_2O.

(*continued*)

Procedure *(continued)*



Figure 7-16 Attach the bag-valve mask to the airway. While bagging the patient, gently withdraw the tube until ventilation becomes easy. Adjust cuff inflation, if necessary, to obtain a seal of the airway.

and hear no breath sounds over the epigastrium to be sure that the King LT-D airway is correctly placed. However, capnography remains the most reliable way to confirm and monitor the position of the tube (Figure 7-17).



Figure 7-17 Capnography used on a King Airway®. *(Photo courtesy of Bob Page, BAS, CCEMT-P, NCEE)*



Figure 7-18 i-gel Airway. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Like the other SGAs, if the patient becomes conscious, you must remove the airway. Extubation is likely to cause vomiting, so be prepared to suction the pharynx and turn the patient on his or her side.

i-gel Airway Insertion

This section describes the insertion of the i-gel supraglottic airway (Figure 7-18). There are various other devices available that utilize a similar approach by placing a mask over the glottic opening. The user should follow the recommendations from the manufacturer for insertion of the device he or she is using.

Procedure

Inserting the i-gel Supraglottic Airway

Scan 7-1 illustrates this procedure.

1. Choose correct size of i-gel based on manufacturer's guidelines. Lubricate the i-gel along the front and back of the mask, per manufacturer's recommendations. *Do not* overlubricate.
2. Hold the device by the integral bite block (tube portion of the device). In a trauma patient, use either a jaw-thrust or chin-lift. If no spinal injury is suspected, place in sniffing position.
3. Position i-gel so cuff is facing patient's chin. Gently press down on chin to open mouth.
4. Introduce soft tip of device toward the hard palate.
5. Using gentle pressure guide the device along hard palate and into the hypopharynx until *definitive resistance* is felt. Do not apply excessive force.
6. The tip of the device should be at the upper esophageal opening with the mask cuff against the larynx.
7. If difficulty is encountered in passing the i-gel, reinsert with a 90-degree rotation as the device passes the tongue and then rotating back to standard position once resistance is felt (Kim et al. 2014).
8. Confirm position of the i-gel using auscultation, observation, and capnography. Secure the i-gel using a commercial tube holder or taping. If the i-gel model used has a side port, pass an NG tube to decompress the stomach.

SCAN 7-1 Insertion of i-gel



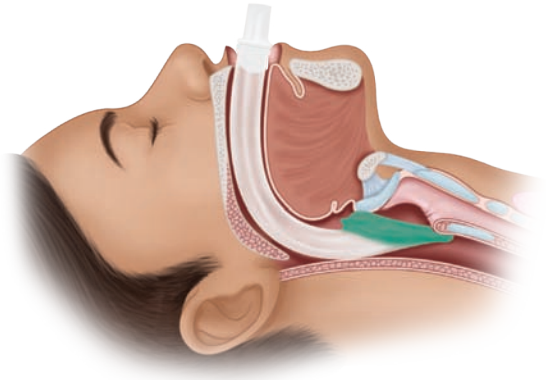
7-1-1 Choose appropriate-sized device based on manufacturer's guidelines. Lubricate the cuff per instructions.



7-1-2 Have your partner maintain SMR. Using a chin-lift to open the mouth, slide the back of the i-gel along the hard palate. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

(*continued*)

SCAN 7-1 Insertion of i-gel (*continued*)



7-1-3 Use gentle pressure to advance the device until it stops. It is now in the proper position. Confirm that the airway is patent using the techniques described in Chapters 6 and 7.



7-1-4 Secure the tube to prevent displacement.

Laryngeal Mask Airway

This section describes the insertion of the laryngeal mask airway (LMA). Various other devices are available that utilize a similar approach by placing a mask over the glottic opening. The user should follow the recommendations from the manufacturer for insertion of the device they are using.

The LMA was developed for use as an alternative to the face mask for achieving and maintaining control of the airway during routine anesthetic procedures in the operating room. Because it does not protect the airway against vomiting and aspiration, the LMA was meant to be used in patients who had been fasting and thus had an empty stomach. It was later found to be useful in an emergency situation when intubation is not possible and the patient cannot be ventilated with a bag-valve mask. It may prevent a surgical procedure to open the airway. A newer model, the LMA Supreme™, includes a port to allow suctioning of stomach contents.

Essential Points

- Use the LMA only in patients who are unresponsive and without protective reflexes. If the patient still has a gag reflex, the LMA may cause laryngospasm or vomiting.
- Do not use it in any patient who has injury to the esophagus (such as caustic ingestions)
- Lubricate only the posterior surface of the LMA to avoid blockage of the aperture or aspiration of the lubricant.
- Patients should be adequately monitored (constant visual monitoring, cardiac monitor, and, if possible, pulse oximeter) at all times during LMA use.
- To avoid trauma to the airway, force should never be used during LMA insertion.
- Never overinflate the cuff after insertion. Overinflation may cause malposition, loss of seal, or trauma. Cuff pressure should be checked periodically, especially if nitrous oxide is used.
- If airway problems persist or ventilation is inadequate, the LMA should be removed and reinserted or an airway established by other means.
- The LMA does not prevent aspiration if the patient vomits. The presence of a nasogastric tube does not rule out the possibility of regurgitation and may even make it more likely because the tube makes the esophageal sphincter incompetent.
- If the patient regains consciousness, you must remove the LMA because it will cause retching and vomiting.

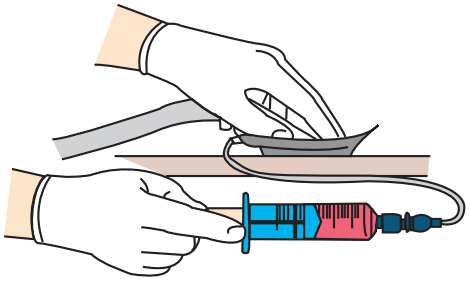
Procedure

Inserting the Laryngeal Mask Airway

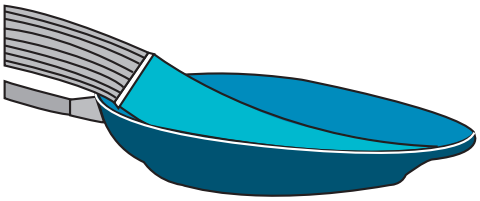
Scan 7-2 illustrates this procedure.

1. With the neck stabilized in a neutral position, ventilate with a mouth-to-mask or BVM technique. Suction the pharynx before insertion of the airway.
2. Remove the valve tab and check the integrity of the LMA cuff by inflating with the maximum volume of air (Table 7-1).
3. Using the syringe included with the LMA, the cuff of the LMA should be tightly deflated, so that it forms a flat oval disk with the rim facing away from the aperture. This can be accomplished by pressing the mask with its hollow side down on a sterile flat surface (Scan 7-2-1). Use the fingers to guide the cuff into an oval shape and attempt to eliminate any wrinkles on the distal edge of the cuff. A completely flat and smooth leading edge facilitates insertion, avoids contact with the epiglottis, and is important to ensure success when positioning the device (Scan 7-2-2).
4. Lubricate the posterior surface of the LMA with a water-soluble lubricant just before insertion.
5. Preoxygenate (do not hyperventilate) the patient.
6. If there is no danger of spine injury, position the patient with the neck flexed and the head extended. If the mechanism of injury suggests the potential for spine injury, the patient's head and neck must be maintained in a neutral position.
7. Hold the LMA like a pen, with the index finger placed at the junction of the cuff and the tube (Scan 7-2-3). Under direct vision, press the tip of the cuff upward against the hard palate and flatten the cuff against it (Scan 7-2-4). The black line on the airway tube should be oriented anteriorly toward the upper lip.
8. Use the index finger to guide the LMA, pressing upward and backward toward the ears in one smooth movement (Scan 7-2-5). Advance the LMA into the hypopharynx until definite resistance is felt (Scan 7-2-6).
9. Before removing the index finger, gently press down on the tube with the other hand to prevent the LMA from being pulled out of place (Scan 7-2-7).
10. Without holding the tube, inflate the cuff with just enough air to obtain a seal. The maximum volumes are shown in Table 7-1. When inflating, the LMA may move slightly as it seats. Holding the tube will prevent this movement and not allow a seal over the glottic opening.
11. Connect the LMA to the BVM and employ manual ventilation of less than 20 cm H_2O. As with the supraglottic airways, you must see the chest rise, hear breath sounds, feel good compliance, and hear no breath sounds over the epigastrium to be sure that the LMA is correctly placed. However, this confirmation method can be unreliable, so use of capnography to confirm and monitor tube position is recommended.
12. Insert a bite block (not an oropharyngeal airway), and secure the LMA with tape or a commercial tube holder (Scan 7-2-8). Remember that the LMA does not protect the airway from aspiration. If the patient becomes conscious, the LMA must be removed. Extubation is likely to cause vomiting, so be prepared to suction the pharynx and turn the backboard.

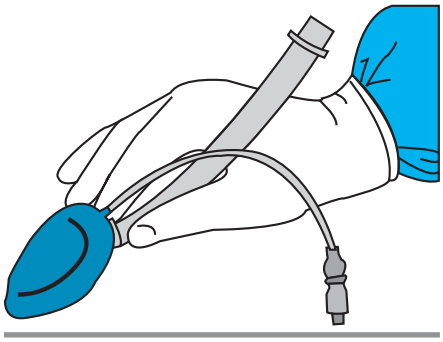
SCAN 7-2 Insertion of the Laryngeal Mask Airway



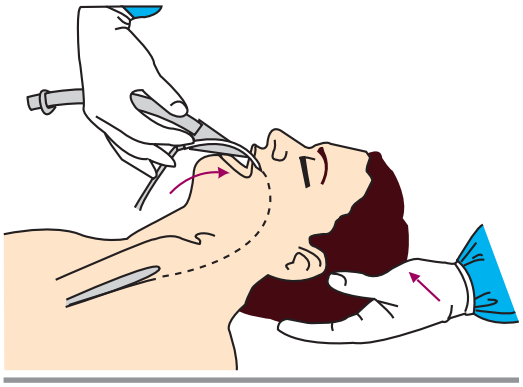
7-2-1



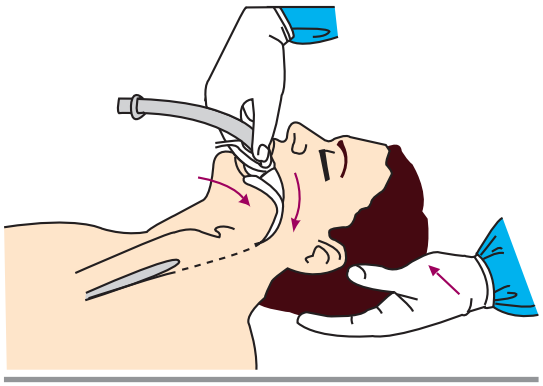
7-2-2



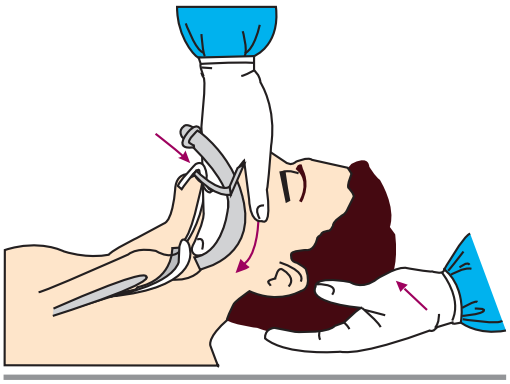
7-2-3



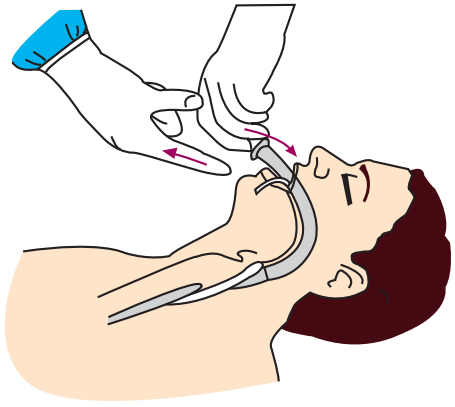
7-2-4



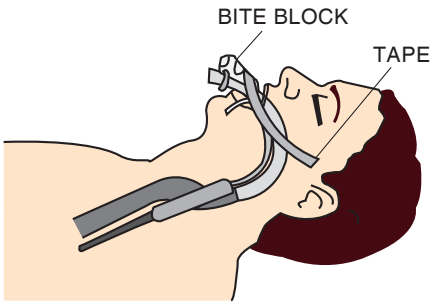
7-2-5



7-2-6



7-2-7



7-2-8

Table 7-1: Cuff Volumes for LMA Pro Seal™

LMA Size	Patient Size	Maximum Cuff Volumes (Air Only)
1	Newborn and infants up to 5 kg or 11 lb	4 mL
1.5	Infants 5–0 kg or 11–22 lb	7 mL
2	Children 10–20 kg or 22–44 lb	10 mL
2.5	Children 20–30 kg or 22–65 lb	14 mL
3	Children >30 kg (65 lb) and small adults	20 mL
4	Normal and large adults	30 mL
5	Large adults	40 mL

Adapted from *LMA™ Quick Reference Guide*. 2013. San Diego, CA: LMA North America.

Pharmacologically Assisted Laryngeal Mask Insertion

Airway management is a key intervention to ensure good patient outcome. Accumulating information from studies suggests that intubation in the field can in some populations worsen outcomes. This is felt to be due to hypoxia occurring during prolonged intubation techniques. As previously mentioned, SGAs can provide effective airways in trauma patients. A major contraindication for their use is an intact gag reflex. In the pharmacologically assisted laryngeal mask (PALM) technique, sedation (induction agent such as etomidate or ketamine) is administered to achieve conditions that allow the insertion of an SGA.

The assessment for a difficult airway is the same as with intubation, as is the preparation of the device, medications, rescue airway plan, and preoxygenation. (See section on drug-assisted intubation that follows.) The emergency care provider must be absolutely sure that the airway can be maintained with a BVM in case insertion of the SGA is unsuccessful.

Confirmation of the airway is best achieved by use of capnography, as described elsewhere in the text. A major advantage to this technique is that it is more rapid than endotracheal intubation, decreasing the risk of hypoxia.

Advanced Airway Management

Preparation for Intubation

Whatever the method of intubation used, both patients and emergency care providers should be prepared for the procedure. The following equipment is considered basic to all intubation procedures (Figure 7-19):

- *Gloves.* Protective gloves such as latex or nitrile examining gloves (not necessarily sterile) should be worn for all intubation procedures.
- *Eye protection.* Providers must wear goggles or face shield.
- *Oxygenation devices.* All patients should be ventilated by way of a BVM or should breathe high-flow oxygen (at least 12 liters per minute) for several minutes prior to the attempt, using either a face mask or via nasal cannula. This will "wash out" residual nitrogen in the lungs and decrease the risk of hypoxia during the intubation process. Apneic oxygenation is discussed in the section on drug-assisted intubation.

Check all oxygenation devices, and keep them at hand in an organized kit (Figure 7-20). For laryngoscopic intubation, the ETT should be held in a C-shaped curve or a "field hockey stick" or open "J" shape by a malleable stylet that is first lubricated and inserted until the distal end is just proximal to the side hole of the ETT. Check the cuff

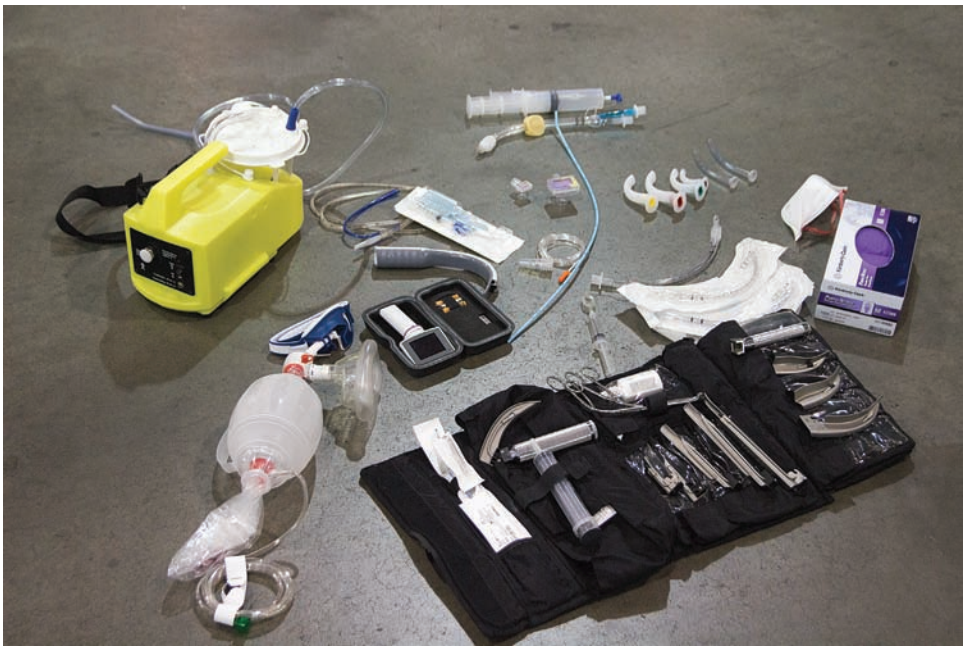


Figure 7-19 Equipment necessary for intubation.



Figure 7-20 An intubation wrap contains the essentials for carrying out endotracheal intubation. The kit folds on itself and is compact and portable. When opened, it provides a clean working surface.

of the ETT by inflating it with 10 cc of air (Scan 7-3-1 and 7-3-3). Completely remove the air, and leave the syringe filled with air attached to the pilot tube. Lubricate the cuff and distal end of the tube.

Have the capnography unit turned on and the waveform visible on the monitor. Record the baseline waveform and CO_2 levels while oxygenating the lungs prior to intubation.

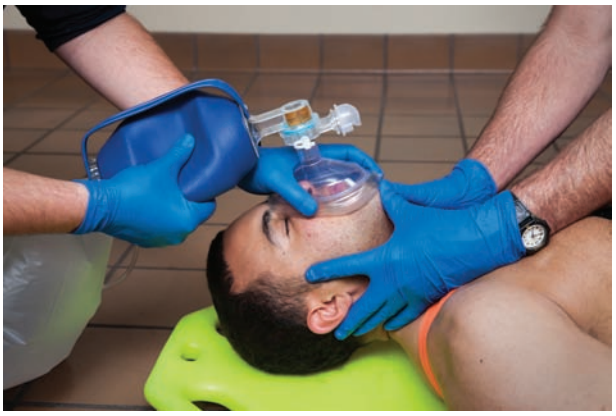
The suction unit must be immediately at hand.

An assistant should be available to help in the procedure. The assistant can help hold the head and neck in a neutral position or perform external laryngeal manipulation to help make the cords visible to the emergency care provider.

SCAN 7-3 Laryngoscopic Orotracheal Intubation



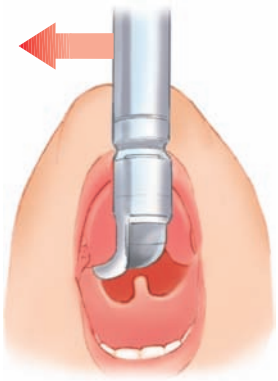
7-3-1 Assemble, prepare, and test all equipment. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-2 Position the patient's head and ventilate with 100% oxygen. Do not hyperventilate. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-3 Insert the laryngoscope blade. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-4 Lift the tongue and epiglottis to bring the glottic opening into view.



7-3-5 Visualize the cords and glottic opening, and insert the ET tube with stylet through the cords.



7-3-6 When the tube is in place and firmly held, remove the stylet. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*

(*continued*)

SCAN 7-3 Laryngoscopic Orotracheal Intubation (*continued*)



7-3-7 Continuing to hold the tube firmly, inflate the cuff with 5–10 cc of air. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-8a A. If capnography is not available, begin ventilation with colorimetric CO_2 detector. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



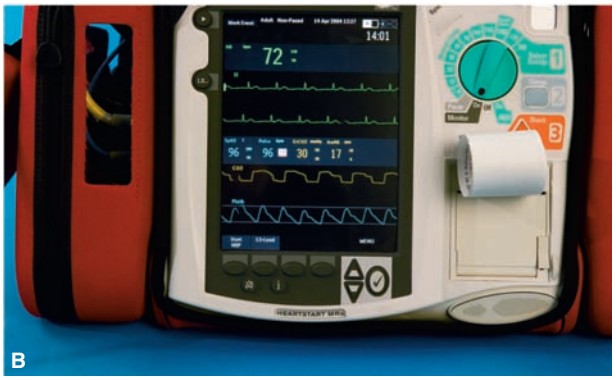
7-3-8b B. If capnography is available, begin ventilation with capnography monitor. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-9 Perform manual confirmation of tube position using a stethoscope. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-10a A. Secure the tube in place and continue ventilating. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*



7-3-10b B. Monitor with capnography, if it is available. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*

Laryngoscopic Orotracheal Intubation

For laryngoscopic orotracheal intubation, the upper airway and the glottic opening are visualized, and the tube is slipped gently through the cords. The advantages of this method include the ability to see obstructions and to visualize the accurate placement of the tube. It has the disadvantage of requiring a relatively relaxed patient without anatomic distortion and with minimal bleeding or secretions.

The equipment needed for a laryngoscopic orotracheal intubation includes the following:

- Straight (Miller) or curved (Macintosh) blade and laryngoscope handle, all in good working order (checked daily), in multiple sizes including pediatric sizes.
- Transparent ETT, 28–33 cm in length and 7, 7.5, or 8 mm in internal diameter for the adult patient. Pediatric-size tubes should also be available.
- Stylet to help mold the tube into a configuration to make insertion easier
- Water-soluble lubricant. There is no need for it to contain a local anesthetic.
- 10 or 12 mL syringe for inflating the balloon
- Magill forceps
- ETT holder or tape and tincture of benzoin
- Suction equipment in good working order with catheters and Yankauer or other large-bore tonsil sucker
- Pulse oximeter and capnography unit
- A bougie (tracheal tube introducer) for difficult intubations

Procedure

Laryngoscopic Orotracheal Intubation

Intubation in the trauma patient differs from the usual endotracheal intubation in that the patient's neck must be stabilized in the neutral position during the procedure. This does make it more difficult to visualize the vocal cords during laryngoscopy. After ventilation and initial preparations, the following steps should be carried out (Figure 7-21; Scan 7-3):

1. An assistant stabilizes the head and neck and counts slowly aloud to 30 (at your request).
2. In the supine patient, lift the chin and slide the blade into the right side of the patient's mouth. Push the tongue to the left, and "inch" the blade down along the tongue in an attempt to see the epiglottis. A key maneuver must be performed here: The blade must pull forward (up) on the tongue to lift up the epiglottis and bring it into view.
3. Use the laryngoscope blade to lift the tongue and epiglottis up and forward in a straight line. "Levering" the blade is an error and can result in broken teeth and other trauma. The laryngoscope is essentially a "hook" to lift the tongue and epiglottis up and out of the way so that the glottic opening can be identified. Remember that the Miller (straight) blade is used to lift the epiglottis directly, whereas the Macintosh (curved) blade is inserted into the vallecula and lifts the epiglottis indirectly.
4. Advance the tube along the right side of the oropharynx once the epiglottis is seen. When the glottic opening (or even just the arytenoid cartilages) is identified, pass the tube through to a depth of about 5 cm beyond the cords. The mark on the tube that is even with the teeth should be three times the diameter of the ET tube. Thus, an 8.0 mm tube in an adult should be at 24 cm.

(*continued*)

Procedure *(continued)*

5. While the tube is still held firmly, remove the stylet, inflate the cuff, attach a BVM, and check the tube for placement using the immediate confirmation protocol given in the paragraphs that follow.
6. Begin ventilation using adequate oxygen concentration and tidal volume. Maintain an $etCO_2$ level between 35 and 45 mmHg.

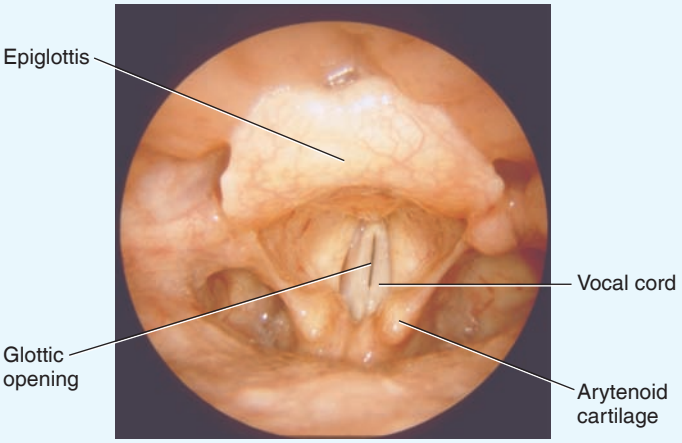


Figure 7-21 Landmarks during intubation.

For difficult intubations where you cannot see the cords or where the angle is such that it is difficult to advance the tube through the cords, a tracheal tube introducer (also called a bougie or gum elastic bougie) can be very helpful (Scan 7-4). Insert the bougie through the cords, and then slip the tube over the bougie and slide it down through the cords. This technique works best when the intubating emergency care provider keeps the blade inserted and the assistant threads the ET tube onto the bougie and holds the end of the bougie. The intubating emergency care provider then threads the ET tube down the bougie through the cords. By maintaining direct visualization, the chance of the ET tube becoming caught on the tongue or epiglottis is reduced. Then remove the bougie and perform the procedural steps 5 and 6 listed earlier.

If still having difficulty visualizing the vocal cords, the emergency care provider must take his or her right hand and, using gentle pressure, manipulate the thyroid (laryngeal) cartilage to bring the vocal cords into view. This process is known as *external laryngeal manipulation (ELM)*. The assistant is then instructed to maintain the positioning of the cartilage, and the emergency care provider passes the tube. (See Figure 7-22.)



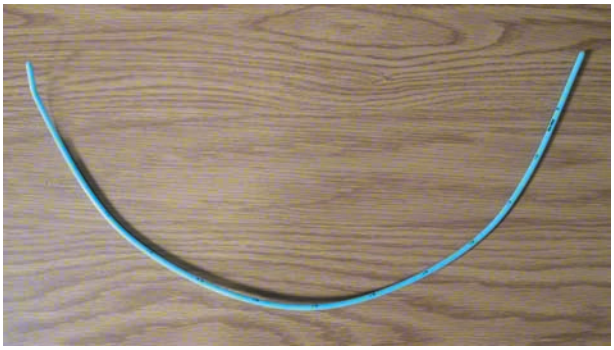
Figure 7-22 External laryngeal manipulation. Grasp the thyroid cartilage, and move the larynx around to better visualize the vocal cords. *(Photo courtesy of Bob Page, BAS, CCEMT-P, NCEE)*

Face-to-Face Intubation

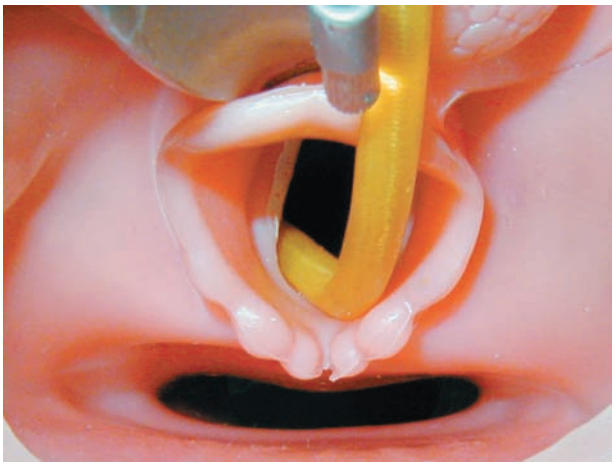
On occasion the location of the patient may prevent access to his or her head to allow for intubation from the conventional position. A face-to-face approach (also called the tomahawk method) has been described and used successfully. Using this method, the emergency care provider faces the patient and usually utilizes the Macintosh (curved) laryngoscope blade. An assistant maintains a neutral position of the cervical spine, if possible. The emergency care provider holds the laryngoscope in his or her hand with the blade end of the handle emerging from the thumb side of the fist, so that the blade can "hook" the tongue.

Preparation of equipment is as previously mentioned, including having mechanical suction immediately available.

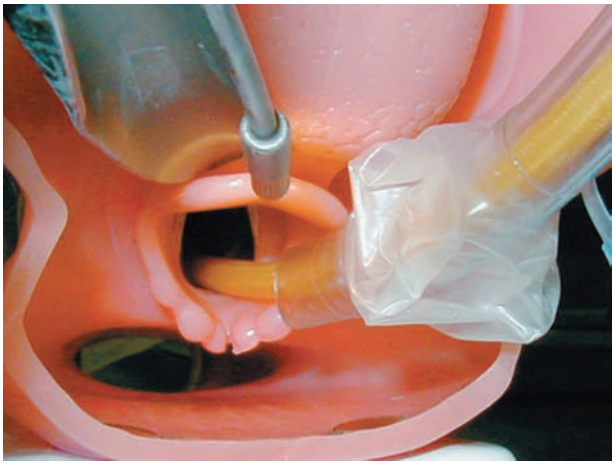
SCAN 7-4 Orotracheal Intubation Using Bougie



7-4-1 Bougie. *(Photo courtesy of Stanley Cooper, EMT-P)*



7-4-3 The bougie going between the cords and through the glottic opening. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



7-4-5 Sliding the ET tube down the bougie and through the cords. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



7-4-2 Inserting the bougie into the trachea. *(Photo courtesy of Stanley Cooper, EMT-P)*



7-4-4 While holding the bougie firmly, slide the ET tube over the bougie and into the trachea. *(Photo courtesy of Stanley Cooper, EMT-P)*

Entering from the right side of the mouth, the tongue is swept to the left of the mouth, and the jaw and tongue are pulled toward the emergency care provider, allowing for visualization of the larynx and insertion of the ET tube. This technique is very effective with patients in a seated position, such as one trapped in a motor vehicle. However, bear in mind that an SGA may be easier to pass in this situation and can often be placed faster. It also can be used with morbidly obese patients on whom the emergency care provider is not able to generate sufficient leverage to move the jaw forward.

Confirmation of Tube Placement

One of the greatest challenges of intubation is ensuring the correct intratracheal placement of ETTs. An unrecognized esophageal intubation is a lethal complication of this life-saving procedure. Every effort must be made to avoid this catastrophe, and a strict protocol must be followed to reduce the risk. The emergency care provider should remain vigilant in noting the depth marking at the mouth or nose and to continually reassess the tube to ensure that it has not moved or become dislodged. The emergency care provider should perform ongoing confirmation of the tube placement and also document this on the appropriate form.

Although the most reliable method of ensuring proper placement is actually visualizing the tube passing through the glottic opening, even this is not 100% sure. In fact, it is only reliable for the moment you see it. The gold standard for confirming and monitoring ETT placement is waveform capnography. (See later discussion.) If you do not have capnography available, the following protocol may be used but is not 100% reliable. When you use this protocol, you should recognize the unreliable nature of auscultation as the sole method of confirming intratracheal placement.

Correct intratracheal placement is indicated by the following initial signs:

- An anterior displacement of the laryngeal prominence is visible or felt as the tube is passed distally.
- Adequate chest rise occurs with each ventilation.
- Auscultation of breath sounds as described later.
- There is coughing, bucking, or straining on the part of the patient who is not sedated and paralyzed. *Note:* Phonation—any noise made with the vocal cords—is absolute evidence that the tube is in the esophagus, and the tube should be removed immediately.
- There is normal compliance with bag ventilation. (The bag does not suddenly "collapse," but rather there is some resilience to it and resistance to lung inflation.)
- No cuff leak is seen after inflation. (Persistent leak indicates esophageal intubation until proven otherwise.)
- There is breath condensation on the tube with each ventilation—not a very reliable method.

The following procedure should then be carried out immediately to prove correct placement.

Procedure

Confirming Tube Placement

1. Auscultate three sites as shown in Figure 7-23.
   a. Epigastrium—the most important—should be silent, with no breath sounds heard.
   b. Right and left midaxillary lines to confirm equal breath sounds and to ensure tube is not in right mainstem bronchi.

Procedure *(continued)*

2. Inspect for full movement of the chest with ventilation.
3. Check position using one of the CO_2 detecting devices or a suction bulb or syringe AKA esophageal detector device (EDD).
4. Watch for any change in the pulse oximeter reading or in the patient's skin color. Also observe the ECG monitor for changes.

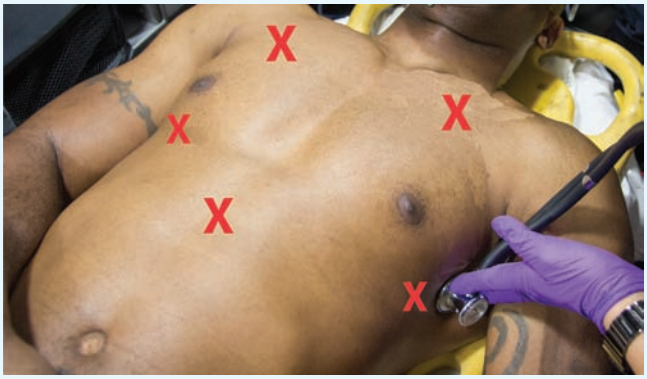


Figure 7-23 Sites to auscultate when performing immediate confirmation of ET tube placement are marked by a red *X*. They include the lateral chest, anterior chest, and epigastrium.

Commercial suction bulbs or EDDs have been used for confirmation of tube placement (Figure 7-24). Recent research suggests that they are less reliable than capnography, which has become the gold standard for confirming initial tube placement. (Capnography is the best method for confirming ET placement and allows for constant monitoring of tube position.)

To use a bulb detector, squeeze the bulb and insert the end onto the 15-mm adapter on the ETT. Release the bulb. If the tube is in the trachea, the bulb will expand immediately. If the tube is in the esophagus, the bulb will remain collapsed. If you are using a syringe with an adapter to the ETT, you will be able to withdraw the syringe plunger easily when the tube is in the trachea, but you will not be able to withdraw the plunger if the tube is in the esophagus.

Note that the literature about the bulb detector and the EDD warn that patients with obstructed airway diseases, congestive heart failure, obesity, pregnancy, or right mainstem intubation may have a false-positive reading due to decreased air available for aspiration. Some studies have shown poor sensitivity with children under 1 year of age and with patients in cardiac arrest.



A B

Figure 7-24 A. Esophageal intubation detector device, bulb style. B. Esophageal intubation detector device, syringe style.

Commercial CO_2 detectors are also available to attach in-line between the ETT and the BVM. Three different kinds are available: qualitative (colorimetric) CO_2 detectors, quantitative CO_2 monitors, and quantitative waveform CO_2 monitors. (See the detailed discussion of the monitors in the section, "Using Capnometry and Capnography to Confirm and Monitor ET Tube Position.")

Apply the protocol for confirmation of tube placement immediately following intubation. If you are using a quantitative CO_2 monitor or quantitative waveform CO_2 monitor, then you may continue monitoring ET tube position with those devices. If you are not using one of those devices, then repeat the ET tube position reconfirmation protocol after several minutes of ventilation. Thereafter, repeat the reconfirmation protocol after movement of the patient from the ground to the stretcher, after loading onto the ambulance, when you perform the ITLS Secondary Survey and ITLS Ongoing Exam, and immediately prior to arrival at the hospital.

Procedure

Reconfirming ET Tube Position

1. Auscultate the sites shown in Figure 7-25.
   a. Epigastrium—should be silent with no sounds heard
   b. Right and left midaxillary lines
   c. Right and left apex
   d. Sternal notch—"tracheal" sounds should be readily heard here
2. Inspect the chest for full movement of the chest with ventilation.
3. Use adjuncts such as CO_2 detectors (or a suction bulb, if part of local protocol) to help confirm placement.

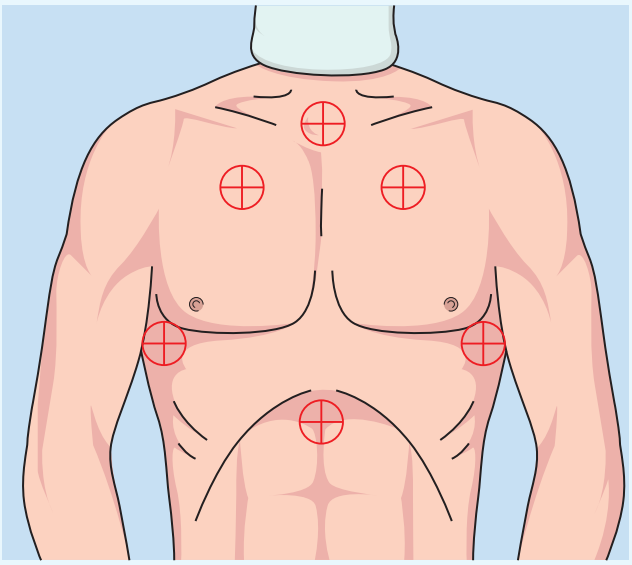


Figure 7-25 Sites to auscultate when performing reconfirmation of ET tube placement.

Any time placement is still in doubt despite the preceding protocol, visualize directly or remove the tube. Never assume that the tube is in the right place. Always be sure, and record that the protocol has been carefully followed.

Using Capnometry and Capnography to Confirm and Monitor ET Tube Position

Capnometry represents a major clinical upgrade in the assessment and monitoring of the ventilatory status of the patients. It is important for you to understand the differences between simple detection of $etCO_2$ called *colorimetric* or *qualitative capnometry*, *quantitative capnometry* (a value without a waveform), and the most useful and diagnostic form known as *quantitative waveform capnography*.

Colorimetric CO_2 detectors (qualitative capnometry) are simple devices designed to detect $etCO_2$ (Figure 7-26). They do not accurately measure the amount of CO_2. Typically, the devices use a special piece of "litmus paper" that changes color from purple to yellow as it detects CO_2. If a device of this type is used as a confirming device, you must be aware of the following:

- It may not be accurate in poor perfusion states, such as shock or cardiac arrest, due to very small amounts of CO_2 returning to the lungs. In those cases, another confirming device is necessary. In cases of cardiac arrest, best results will be obtained if good compressions are being done at the time the device is used.
- While the device will change color upon exposure to CO_2, to ensure any trapped CO_2 in the stomach is purged, the provision of six ventilations before confirmation of being from the trachea is necessary.
- If the device gets wet with gastric contents, blood, and/or secretions, it will no longer function correctly.
- Once intubated, the device may be used intermittently as part of the confirmation process only because it will stay yellow after a few minutes of continuous exposure to CO_2.
- Because the device only detects $etCO_2$ and does not provide a quantifiable measure, it cannot be used to monitor ventilation.



Figure 7-26 Colorimetric CO_2 detector. *(Image used by permission from Nellcor Puritan Bennett LLC, Boulder, Colorado, doing business as Covidien)*

Quantitative capnometry actually measures the amount of CO_2 in expired air ($etCO_2$). More than just detection, the device can be used to monitor the adequacy of ventilations and help the provider to accurately "titrate" the $etCO_2$ levels in patients where CO_2 levels are critical, such as those with closed head injuries. They are often combined with a pulse oximeter. Quantitative capnometry refers to $etCO_2$ measurement without a waveform. If the devices are used to confirm tube placement, you must be aware of the following limitations:

- Cardiac-arrest patients have a low $etCO_2$ that is commonly <20 mmHg, depending on how long they have been in arrest and how effective resuscitation efforts are.
- Colorimetric devices can detect esophageal CO_2, so six breaths are necessary to actually confirm tracheal position with CO_2 from the lung.
- In cases of cardiac arrest, best results are obtained if good compressions are being performed while the device is being used.

Quantitative waveform capnography is the ultimate confirmation device and is a standard of care in surgical suites and many EMS systems. The devices not only detect and measure the $etCO_2$ but also provide you with a diagnostic waveform that can confirm (by the shape of the waveform) endotracheal placement even in low perfusion states. The waveforms will appear within 2 seconds of the actual breath. Furthermore, the devices can be built into existing cardiac monitors, which will allow you to continuously monitor the waveform and value (Figure 7-27). They also will allow you to print out a real-time waveform that is time- and date-stamped for absolute documentation of correct tube placement.



Figure 7-27 Quantitative waveform CO_2 monitor incorporated into cardiac monitor. *(Image used by permission from Nellcor Puritan Bennett LLC, Boulder, Colorado, doing business as Covidien)*

Capnography has many other uses in nonintubated patients, including perfusion monitor, airway monitor, and ventilation monitor. In using capnography to confirm ETT placement, you must be aware of the following limitations:

- Like all CO_2 detection devices, low perfusion states will result in low CO_2 readings and subsequently small waveforms (Figure 7-28). In arrest situations, good compressions should be done as the waveforms are being evaluated. This will increase the size of the waveform.

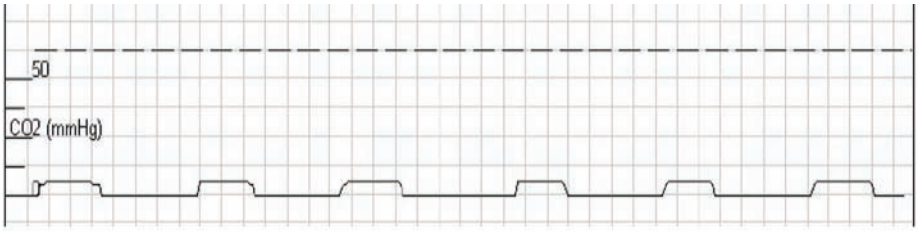


Figure 7-28 Small capnography means poor perfusion.

- To use the devices in conjunction with cardiac monitors, you must enable the waveform display on the monitor screen before intubation. A delay of 10–30 seconds for warm-up (depending on the monitor) will result if you wait to activate it after placing the tube. For best results, have the capnography waveform default when the monitor is turned on.

Procedure

Confirming and Monitoring ET Tube Placement with Capnography

1. Prepare all equipment for intubation. Turn on the monitor, and attach the capnography filter line or wires to it. (This will vary depending on the brand of capnograph.) It is advisable to apply and record baseline capnography during preoxygenation prior to an intubation attempt to prevent inadvertent hyperventilation.
2. Place the ETT, and inflate the cuff. In cases of arrest, compressions should *not* be interrupted to perform this procedure.
3. Attach the capnography airway adapter on the ETT, and then attach the BVM to the airway adapter (Figure 7-29).
4. Ventilate the patient, and observe the waveform. The presence of a "square" pattern confirms tracheal placement (Figure 7-30). Print out the waveform, if possible (for documentation). If the waveform is nonexistent or appears in gross and irregular waveform patterns, the tube is possibly in the esophagus or hypopharynx.
5. Listen for breath sounds midaxillary on each side to rule out right mainstem intubation.
6. Secure the tube, and continually monitor the waveforms during transport. Carefully watch the $etCO_2$ value to avoid inadvertent hypo- or hyperventilation (Figure 7-31).



Figure 7-29 A capnography airway adapter is placed between the mask and the bag. This allows continuous measurement and reduces risk of hypoventilation or hyperventilation. *(Photo courtesy of Bob Page, BAS, CCEMT-P, NCEE)*

Procedure *(continued)*

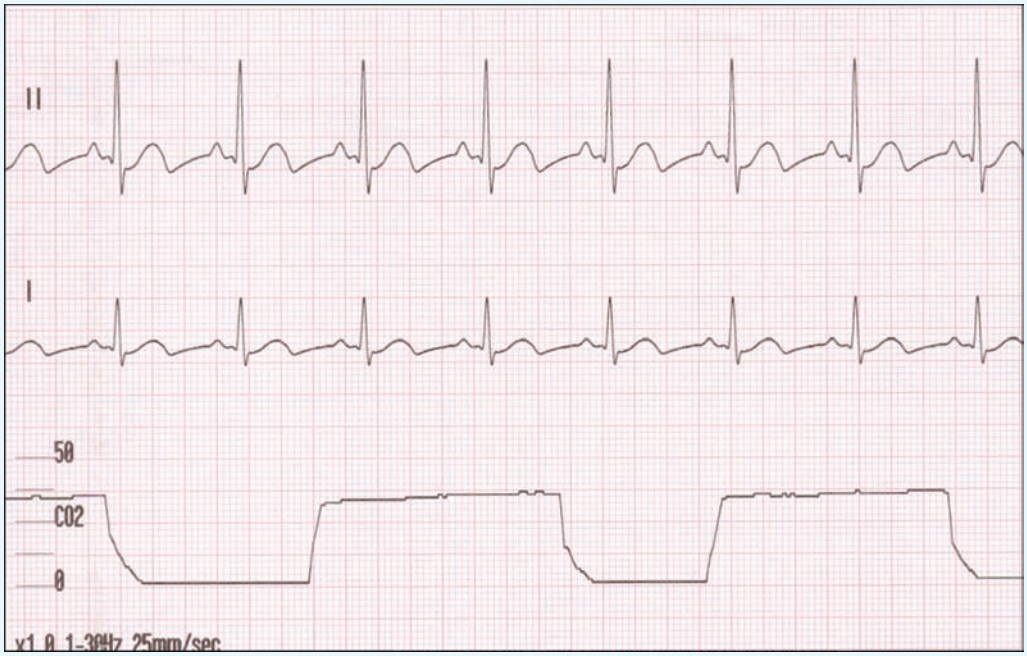


Figure 7-30 "Square" waveform is normal.

7. On arrival at the receiving facility, print out another waveform (if available) to prove correct placement at the time of patient transfer.
8. On your run report, document the visualization of the vocal cords, attach the waveform printout(s) or document the presence, or upload the data to your electronic patient care record, if your EMS service uses such devices, and document equal breath sounds.



Figure 7-31 Monitoring the intubated patient.

Capnography can also be used on a SGA such as King Airway, LMA, i-gel, Combitubes, or others to confirm those and to monitor ventilations through these devices.

Troubleshooting While Monitoring

- *Complete loss of waveform*. Apnea, or tube is dislodged or obstructed, or air may be leaking around the cuff.
- *Waveforms and values getting smaller*. Hyperventilation (check the depth and rate of ventilation) or hypoperfusion (shock or loss of pulses). Remember, it is very easy to hyperventilate an intubated patient. It is expected that hypoperfusion will have hypocapnia. However, rarely will you have hypoperfusion with normal or high etCO_2.

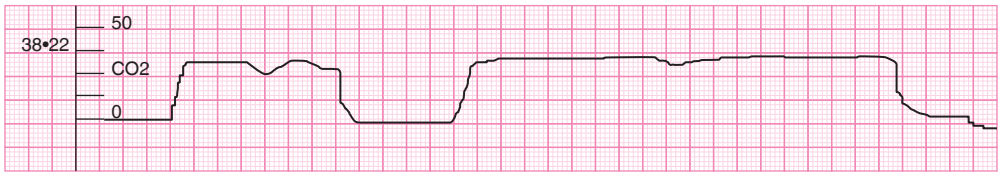


Figure 7-32 Capnogram showing a curare cleft. This may not be visible on the monitor, so it is important to print out the waveform. *(Photo courtesy of Bob Page, BAS, CCEMT-P, NCEE)*

- *Waveform with a "curare cleft."* Note the undulation in the waveform. This represents the diaphragm starting to recover from the effects of a neuromuscular blockade. This sign should alert you that the patient will probably need to be sedated (Figure 7-32).

Anchoring the Endotracheal Tube

Anchoring an ETT can be a frustrating exercise. Not only does it require some fine movements of the hands when you appear to be all thumbs, but it is also difficult to perform when ventilation, movement, or extrication is being carried out. Keep one thing in mind: There is no substitute for the human anchor. That is, an emergency care provider is assigned to ensure that the ETT is held fast and that it does not migrate in or out of the airway. To lose a tube can be a catastrophe, especially if the patient is rather inaccessible or the intubation was a difficult one to perform.

Fixing the ETT in place is important for several reasons. First, movement of the tube in the trachea will produce more mucosal damage and may increase the risk of postintubation complications. In addition, movement of the tube will stimulate the patient to cough, strain, or both, leading to cardiovascular and intracranial pressure changes that could be detrimental. Most important, there is a greater risk in the prehospital setting of dislodging a tube and losing control of the airway if it is not anchored solidly in place.

The ETT can be secured in place by either tape, umbilical made of woven cotton, or a commercially available tube holder. Although taping a tube in place is convenient and relatively easily done, it is not always effective. There is often a problem with the tape not sticking to skin wet with rain, blood, airway secretions, or vomitus. If you are using tape, several principles should be followed:

- Insert an oropharyngeal airway to prevent the patient from biting down on the tube.
- Dry the patient's face and apply tincture of benzoin to better ensure proper adhesion of the tape.
- Carry the tape right around the patient's neck when anchoring the tube. Do not move the neck. Do not tie it so tight that it occludes the external jugular veins. Alternatively, you can secure the tube to the maxilla with the tape.
- Anchor the tube at the corner of the mouth, not in the midline.



Figure 7-33 A commercial endotracheal tube holder.

Because of the difficulty of fixing the tube in place with tape, it may be better to use a commercial ETT holder that uses a strap to fix the tube in a plastic holder, which also acts as a bite block (Figure 7-33). Because flexion or extension of the patient's head can move the tube in or out of the airway by 2 or 3 cm, it is good practice to restrict head and neck movement of any patient who has an ETT in place. (This is even more important in children.) If the patient is spinal motion restricted because of the risk of cervical spine injury, flexion and extension of the neck should be less of a concern.

Drug-Assisted Intubation

Also known as medication assisted airway management (MAAM) or rapid sequence intubation (RSI), drug-assisted intubation (DAI) uses medications to sedate and relax the patient, allowing for better visualization of the airway and increased success in intubating the patient. However, because the patient is rendered apneic, the emergency care provider must be able to provide airway and ventilation for the patient. Not all EMS systems allow use of paralytic drugs and may instead utilize sedation only to assist with intubation.

The importance in appropriately managing the airway of the trauma patient cannot be overemphasized. Loss of airway remains the leading cause of early preventable trauma deaths, and hypoxia has been shown to worsen outcomes for trauma patients, especially those with closed head injury. The indications for active airway management and the options managing the airway are well covered in Chapter 6. All emergency care providers should be familiar with the material in Chapter 6 and this chapter and be able to apply the care described.

When EMS first began performing endotracheal intubation, it was essentially performed on "dead" patients, patients who were unresponsive and apneic. Not all patients fit this situation, and airway management of patients who were agitated, were combative, or had airway trauma had to wait until they deteriorated and became unresponsive.

It is important to remember that all airways managed in the field meet the American Society of Anesthesiology's definition of a difficult airway. Thus, the emergency care provider must have many tools in the toolbox available to manage the airway of the trauma patient.

For many years EMS has made use of DAI to address such issues as the agitated and combative patient needing active airway management. The old term *rapid sequence intubation* is a misnomer because the procedure is certainly not rapid (Figure 7-34). Because of this, it can adversely affect patient outcome by prolonging scene time. Unless there is a critical need, the procedure should be performed during transport. In the urban setting where there are short transport times, the need for a definitive airway should be balanced against use of other airway methods and the impact on transport times.

A variant of the practice of RSI used by anesthesiologists when confronted with a nonfasting patient, the DAI technique allows the emergency care provider to achieve conditions that improve the likelihood of intubating the patient, while minimizing the risks of aspiration by rapidly administering a sedative and paralytic to improve intubating conditions. In some jurisdictions, a paralytic is not used, and benzodiazepines and opiates in combination are administered to achieve intubating conditions.

Multiple studies have shown that EMS personnel can be effectively taught to use DAI and apply it in the field setting. Other studies have shown a potential for prolonged hypoxia during this procedure, so constant recording of pulse oximetry reading should be done, and there should be a strict quality improvement program that monitors intubation time, oxygenation of the patient, and scene time.

The actual technique of DAI is quite simple. The difficult part for EMS personnel is to recognize the patient who should not undergo DAI. The worst thing you can do in airway management is take a spontaneously breathing patient and place him or her into a "can't intubate and can't ventilate" situation. All personnel who utilize DAI should be familiar with and able to use one of the many SGAs and should also be able to perform a cricothyroidotomy if unable to ventilate or intubate the patient.

Last (but most important of all), all EMS personnel should be able to manage an airway using a BVM. Remember, BLS comes before ALS. Some EMS providers erroneously

Sample Drug Assisted Intubation with Paralytic Protocol

Based on North Carolina Office of EMS Patient Care Treatment Protocols, Developed by NC College of Emergency Physicians
www.NCEMS.org/protocols revised 5/17

Indications for Drug Assisted Airway
- Failure to protect the airway
- Unable to oxygenate
- Unable to ventilate
- Impending airway compromise

- **Preoxygenate 100% O_2**
- IV/IO Procedure
- Assemble Airway Equipment
- Suction equipment
- Alternative Airway Device
- Cardiac Monitor
- Pulse Oximeter

Hypoxic or Hypotensive or Combative?

YES

- **Correct Hypoxia**
- **Correct Hypotension**
- **Airway management**
  Ketamine 1.5–2 mg/kg IV/IO
- **Combative needing airway**
  Ketamine 300–400 mg IM or
  Ketamine 1.5–2 mg/kg IV/IO

NO

SEDATION
- Etomidate 0.3 mg/kg IV/IO or
- Ketamine 1.5–2.0 mg/kg IV/IO
- Propofol 1.0–1.5 mg/kg IV/IO

Paralytic
- Succinylcholine 1.5 mg/kg IV/IO or
- Rocuronium 1 mg/kg IV/IO

May repeat x 1 if needed

- **Intubate Trachea**
- Confirm position by exam and capnography (waveform preferred)
- Secure tube
- Consider placing NG tube

Maintain Sedation and Paralysis During Transport

ANALGESIA
- Fentanyl 1–2 mcg/kg up to 100 mcg per dose
- Morphine 0.1 mg/kg to max 10 mg per dose

SEDATION
- Midazolam 0.2 mg/kg to maximum dose of 3 mg

Paralytic
- Rocuronium 1 mg/kg IV/IO or
- Vecuronium. 0.1 mg/kg

If First intubation attempt fails, make an adjustment and try again. Consider change of provider in addition to equipment:
- Different laryngoscope blade
- Different ETT size
- Align external auditory canal with sternal notch/proper positioning
- Change head positioning
- Consider applying ELM maneuver
- Consider use of Supraglottic Airway

NOTE: This protocol is for example purposes only and does not convey permission to perform without local authorization. Choice of medications is dependent on local medical oversight and regulations.

Figure 7-34 Steps in drug-assisted intubation.

see the use of DAI and even intubation as a measure of prestige. It is simply one of many tools available to manage an airway. The real trick is to choose the right one for your patient and correctly apply it. The other key to airway management is to have a backup plan ready to go if the first approach does not work.

Performance of DAI in the field remains controversial. Some studies have shown worse outcomes in patients (especially serious brain injuries) who undergo DAI in the field, and this is attributed to longer scene times as well as hypoxia during intubation. Other studies question whether this delay is significant. There is also the related issue of transport times. Short times to definitive trauma care may allow for less-invasive airway management, as long as the airway can be kept open and adequate ventilation and oxygenation ensured.

Other concerns raised with this technique include skill retention on the part of field providers, something that is an issue for many of the advanced procedures performed by EMS.

The decision to implement the use of DAI by an EMS system should be carefully reviewed, especially with respect to issues of skill retention, transport times, and the availability of alternative airway methods. Any system using DAI must have in place a strong educational and quality improvement program.

The ideal approach uses the six Ps—preparation, preoxygenation, premedicate, paralyze, pass the tube, and confirm position—explained as follows:

- *Preparation.* First, evaluate the difficulty you may experience when you try to intubate. Do this by using the LEON assessment (see Chapter 6, p. 127). If the patient appears to be particularly difficult to intubate, you (and the patient) would be better served using a SGA or BVM than struggling with a paralyzed, apneic, hypoxic patient. If you decide to perform DAI, you should have a plan for an escape airway should intubation be unsuccessful. All necessary equipment, including suction, should be readily available and checked.

  Proper positioning is an important part of preparation. Although the EMS environment often precludes placing the patient at a good height on a stretcher in the sniffing position, any steps you can take to better position yourself so that you have the best view are helpful. Given that many of your patients are in spinal motion restriction, one positioning step you can take, just prior to intubation, is to remove or loosen the cervical collar and apply in-line stabilization. This will allow you to move the jaw forward and improve visualization of the cords.

  For obese patients, elevating the head of the bed while maintaining in-line spinal alignment may improve visualization of the airway and a successful intubation. Attempt to position the patient with the head of the bed elevated so that the suprasternal notch of the sternum is level with the opening of the ear canal.
- *Preoxygenation.* Because the patient will be rendered apneic, hypoxia will rapidly follow. To extend the time for intubation, nitrogen in the lungs is "washed out" by having the patient breathe 100% oxygen for 2–3 minutes or eight full tidal breaths. Washout of the nitrogen allows the patient to tolerate up to 5 minutes of apnea (only 2–3 minutes in children) during intubation without becoming hypoxic. In patients with airway compromise or other problems, ventilations can be assisted, though care should be made not to ventilate with too much force, thus reducing the risk of insufflating air into the stomach and thus regurgitation of stomach contents, leading to aspiration. Previously, application of cricoid pressure (Sellick's maneuver) was thought to help reduce this, as well as reduce the risk of aspiration as the lower esophageal sphincter relaxes after administration of paralytics. Recent studies have questioned the utility of cricoid pressure, and so it should not be used. All patients should be placed on a cardiac monitor, a pulse oximeter, and a capnometer at this time, if not previously done.

Another useful technique to increase the time until the patient becomes critically hypoxic is *apneic oxygenation*. Instilling oxygen via a nasal cannula (>12 liters per minute) maintains a high oxygen concentration gradient from the nasopharynx down to the alveoli. As oxygen is absorbed in the alveoli, more oxygen moves down this gradient into the alveoli, even if there is no ventilation. However, because there is no ventilation, carbon dioxide levels in the blood do rise, and with the hypercarbia, the patient does become acidotic.

- *Premedicate.* Both the act of intubation and some paralytics can raise intracranial pressure. Though advocated in the past, use of IV lidocaine prior to intubation has been found to be of no benefit in the field setting. Remember also in the pediatric patient that the use of a length-based system, such as the Broselow™ tape or the HandTevy™ system, can decrease dosing errors. Depolarizing paralytic agents like succinylcholine can cause fasciculations, which can cause a rise in both intracranial pressure and intraocular pressure as well as be uncomfortable for the patient. A nondepolarizing blocking agent such as vecuronium at 0.01 mg per kg body weight can be given at 3 minutes prior to administering the paralytic agent. *Because it adds time to the process in what is often a time-critical situation, many field providers omit this step.*

  The last premedication is the sedative. This ensures that the patient is not awake while paralyzed. Benzodiazepines such as versed at 0.1 mg per kg body weight can be used, although etomidate (0.3 mg per kg body weight) is a more common sedative agent and has the advantage of having minimal effects on hemodynamics. Some trauma centers prefer not to use etomidate due to reported adrenal suppression, even with a single dose.

  Ketamine, a dissociative anesthetic agent, is another useful sedation agent for intubation. It is given at 1–2 mg per kg body weight. It is very effective with agitated patients, has some analgesic effects, and is less likely to depress the patient's respirations compared to other sedatives. Increased intracranial pressure is considered a relative contraindication to the use of ketamine, but as stated in Chapter 10, hypoxia markedly worsens the outcome of traumatic brain injuries.
- *Paralyze.* Two types of paralytics are available. A depolarizing agent, such as succinylcholine, is the preferred agent due to rapid onset of action and rapid degradation. At a dose of 1–1.5 mg per kg body weight (2 mg per kg body weight in children), intubating conditions are achieved within 90 seconds of administration and is cleared within 5 minutes. Contraindications to use of depolarizing agents are listed in Table 7-2.

  Nondepolarizing agents have a longer onset and paralysis lasts longer. The fastest-acting non-depolarizing agent is rocuronium (0.5 mg per kg body weight in adults; 0.75 mg per kg body weight in children). Vecuronium 0.1 mg per kg body weight can be used to maintain paralysis after intubation is successful. To reduce

Table 7-2: Contraindications for Use of Succinylcholine

• History of malignant hyperthermia
• Burns >24 hours old
• Crush injury >24 hours old
• Stroke, cord injury >7 days, <6 months
• Sepsis >7 days
• Myopathies, denervating diseases

fasciculation, a preadministration dose of 0.01 mg/kg may be delivered prior to the administration of a depolarizing agent.

- *Pass the tube.* Once intubating conditions are achieved, pass the tube. Aids in the process include the use of a stylet, gum elastic bougie, and external laryngeal manipulation (ELM).
- *Confirm position.* Use techniques previously described. Use of capnography is mandatory so that inadvertent tube dislodgement can be detected.

Fiberoptic and Video Intubation

In the last decade there has been an exponential growth in the number and type of devices designed to improve visualization of the larynx and cords during intubation. For example, fiberoptic endoscopic intubation has been used for many years in the operating room. However, the size and complexity of the equipment limited its applicability in the field setting. Some of today's new systems use a variant of the optical scopes, which allows direct visualization of the cords and passage of the ET tube off the scope into the cords (Figure 7-35). Other systems make use of newly developed miniature video cameras that have the image projected on a screen that is either attached to the scope or adjacent to it (Figure 7-36).

Studies have shown an excellent success rate with many of the devices, and they have been proven to be very helpful in intubation of patients with difficult airways. They provide a clearer view of the glottic opening and cords versus direct laryngoscopy. The major drawback with many of the systems has been the cost of the equipment. However, as more manufacturers enter the market, the cost per unit continues to decrease, and with that, more of those types of devices are now in field use.

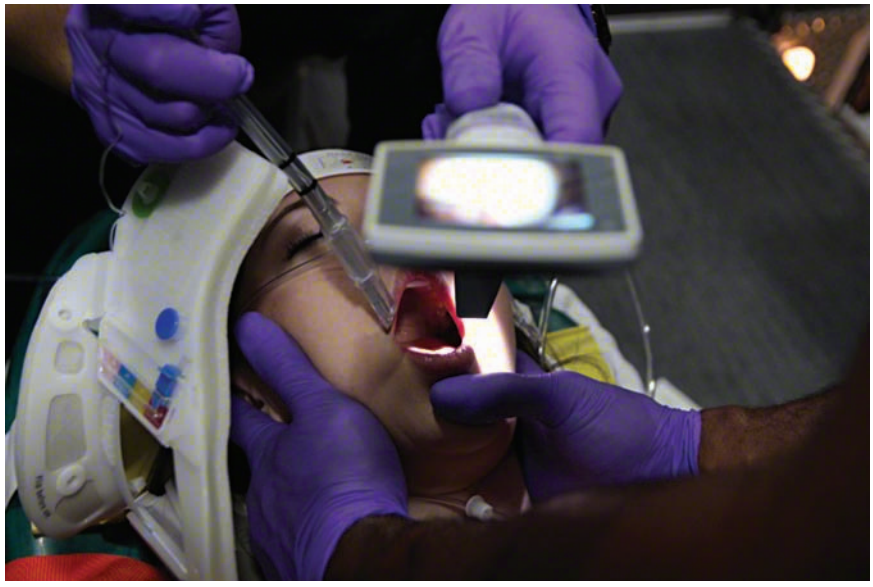
At this time, the use of the devices is not considered a standard of care in the field setting nor do the authors of this text favor any particular system. For emergency response organizations that have adopted intubating devices, their use should be



Figure 7-35 Example of fiberoptic intubation device (Airtraq Optical Laryngoscope). *(Airtraq® is a registered trademark of Prodol Meditec S.A. Las Arenas Vizcaya Spain)*



A



B

Figure 7-36 A. Example of video intubation device (Glidescope Ranger). *(Photo courtesy of Verathon©).* B. Example of a provider utilizing a King Vision Video Laryngoscope™

incorporated into airway management protocols. If available during training courses, personnel should be trained in the use of the devices, so long as such training does not detract from the instruction in the conventional devices used for airway management and stabilization.

References and Resources

Birenbaum, A., D. Hajage, S. Roche, A. Ntouba, M. Eurin, P. Cuvillon, A. Rohn, V. Compere, D. Benhamou, M. Biais, et al. 2018. "Effect of Cricoid Pressure Compared with a Sham Procedure in the Rapid Sequence Induction of Anesthesia: The Iris Randomized Clinical Trial." *JAMA Surgery*. doi:10.1001/jamasurg.2018.3577.

Davis, D. P., D. B. Hoyt, M. Ochs, D. Fortlage, T. Holbrook, L. K. Marshall, and P. Rosen. 2003. "The Effect of Paramedic Rapid Sequence Intubation on Outcome in Patients with Severe Traumatic Brain Injury." *Journal of Trauma* 54, no. 3 (March): 444–53.

Jarvis, J. 2019. "The Perils of Peri-Intubation Hypoxia." *EMS World*. Accessed January 15, 2019. https://www.emsworld.com/article/1221763/perils-peri-intubation-hypoxia

Kim, H. C., D. H. Yoo, H. J. Kim, Y. T. Jeon, J. W. Hwang, and H. P. Park. 2014. "A Prospective Randomised Comparison of Two Insertion Methods for i-gel™ Placement in Anaesthetised Paralysed Patients: Standard vs Rotational Technique. *Anaesthesia* 69, no. 7 (July): 729–34.

McGill, J. 2007. "Airway Management in Trauma: An Update." *Emergency Medicine Clinics of North America* 25, no. 3 (August): 603–22.

Moss, R., K. Porter, I. Greaves, and Consensus Group Faculty of Pre-Hospital Care. 2013. "Pharmacologically Assisted Laryngeal Mask Insertion: A Consensus Statement." *Emergency Medicine Journal* 30, no. 12 (December): 1073–5.

Orebaugh, S. L., and P. E. Bigeleisen. 2012. *Atlas of Airway Management: Tools and Techniques*. Philadelphia: Lippincott Williams and Wilkins.

Robinson, N., and M. Clancy. 2001. "In Patients with Head Injury Undergoing Rapid Sequence Intubation, Does Pretreatment with Intravenous Lignocaine/Lidocaine Lead to an Improved Neurological Outcome?: A Review of the Literature." *Emergency Medicine Journal* 18, no. 6 (November): 453–7.

Sivestri, S., G. A. Ralls, B. Krauss, J. Thundiyil, S. G. Rothrock, A. Senn, E. Carter, and J. Falk. 2005. "The Effectiveness of Out-of-Hospital Use of Continuous End-Tidal Carbon Dioxide Monitoring on the Rate of Unrecognized Misplaced Intubation Within a Regional Emergency Medical Services System." *Annals of Emergency Medicine* 45, no. 5 (May): 497–503.

Takeda, T., K. Tanigawa, H. Tanaka, Y. Hayashi, E. Goto, and K. Tanaka. 2003. "The Assessment of Three Methods to Verify Tracheal Tube Placement in the Emergency Setting." *Resuscitation* 56, no. 2 (February): 153–7.

Walls, R. M, and M. F. Murphy. 2017. *Manual of Emergency Airway Management*. 5th ed. Philadelphia: Lippincott Williams and Wilkins.

Wang, H. E., D. P. Davis, R. E. O'Connor, and R. M. Domeier. 2006. "Drug Assisted Intubation in the Prehospital Setting (Joint Position Statement by NAEMSP and ACEP)." *Prehospital Emergency Care* 10, no. 2 (April–June): 261–71.

Wang, H. E., D. F. Kupas, D. Hostler, R. Cooney, D. M. Yealy, and J. R. Lave. 2005. "Procedural Experience with Out-of-Hospital Endotracheal Intubation." *Critical Care Medicine* 33, no. 8 (August): 1718–21.

Weingart, S. D., and R. M. Levitan. 2012. "Preoxygenation and Prevention of Desaturation During Emergency Airway Management." *Annals of Emergency Medicine* 59, no. 3 (March): 165–75.

8

Thoracic Trauma

Graciela M. Bauzá, MD, FACS
Andrew B. Peitzman, MD, FACS



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Thoraxtraumata
Trauma Torácico
Ozljede prsnog koša
Trauma Toraks
Травма грудной клетки
Traumatismes thoraciques

Τραύμα Θώρακος
Mellkasi sérülések
胸部創傷
Poškodbe prsnega koša

Key Terms

Beck's triad, *p. 185*
flail chest, *p. 177*
massive hemothorax, *p. 181*
mediastinum, *p. 174*
open pneumothorax, *p. 179*
paradoxical pulse, *p. 185*
pericardial tamponade, *p. 184*
pleural space, *p. 174*
simple pneumothorax, *p. 190*
tension pneumothorax, *p. 182*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe the signs and symptoms of thoracic trauma.
2. List the immediate life-threatening thoracic injuries.
3. Define flail chest in relation to associated physical findings and management.
4. Explain the pathophysiology and management of an open pneumothorax.
5. Explain the hypovolemic and respiratory compromise, pathophysiology, and management due to a massive hemothorax.
6. Describe the clinical signs of a tension pneumothorax in conjunction with appropriate management. Contrast those with the clinical signs of massive hemothorax.
7. List the indications to perform emergency chest decompression.

Objectives (continued)

8. Identify the physical findings (including Beck's triad) of cardiac tamponade.
9. Explain the cardiac involvement and management associated with blunt injury to the chest.

Chapter Overview

The thoracic cage protects multiple vital organs, including the lungs, heart, great vessels, and spinal cord, as well as the liver, stomach, spleen, pancreas, kidneys, and transverse colon. Injury to those organs can result in early death. However, when thoracic injuries are recognized and treated appropriately, many patients will survive.

Injuries to the chest may be caused by motor-vehicle collisions (MVCs), motorcycle collisions (MCCs), falls, firearms, knives, crush, and other blunt and penetrating mechanisms. It is common in the multiple-trauma patient and responsible for 20–25% of all trauma-related deaths. When the mechanism suggests thoracic trauma, you must quickly assess for life-threatening injuries (causing hypoxia or hemorrhage) using the ITLS Primary Survey, perform life-saving maneuvers, and transport the patient to the appropriate trauma center without delaying care. This chapter discusses critical injuries to the chest and associated organs and the interventions that may give the patient the best chance for survival.

Case Presentation



You are caring for a window washer who fell off the scaffolding while cleaning the third-floor windows of an office building. He fell against an awning, sustaining a penetrating injury to the left upper arm from a piece of pipe, and hit the sidewalk. You found him unresponsive except to deep pain, with gasping respirations and a rapid, thready pulse. Your initial assessment suggests a flail chest with possible left pneumothorax, major hemorrhage from the left arm wounds, head and spinal injury, as well as blunt abdominal trauma. The patient's airway is initially managed with a BIAD and BVM ventilation with supplemental oxygen. The end-tidal CO_2 waveform shape is normal, and breath sounds are adequate on the right and diminished on the left. The ventilation rate is titrated to maintain end-tidal CO_2 between 35 and 40 mm Hg. A tourniquet is placed on the left upper arm, achieving adequate hemostasis. IV access is obtained, but no bolus is given as the patient's blood pressure is adequate. During an ongoing exam, you note that the patient appears to be somewhat more cyanotic, and your partner notes it is progressively more difficult to ventilate the patient with the BVM. Before proceeding, consider these questions:

- How would you approach this situation?
- Since the patient's condition seems to have changed, what is the next thing you would do?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

The Thorax

Anatomy

The ribs, 12 pairs of them, encircle the thoracic organs from spine to sternum (Figure 8-1). The chest wall is comprised of skin, subcutaneous tissue, muscle, ribs, and the neurovascular bundle (Figure 8-2). Note that the neurovascular bundle runs

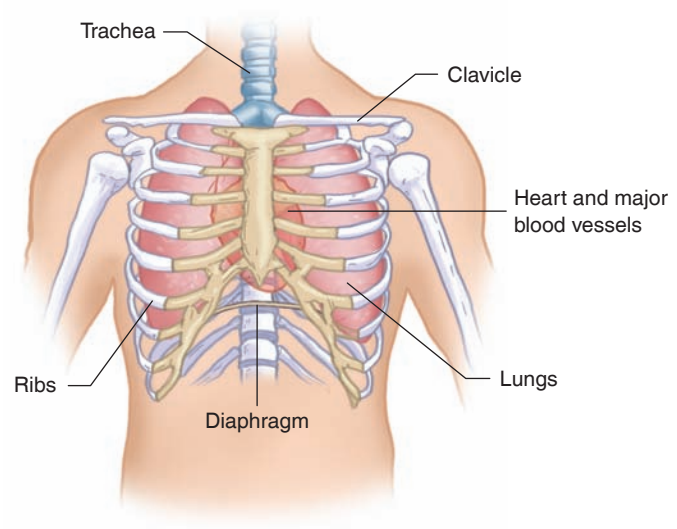


Figure 8-1 Thoracic anatomy.

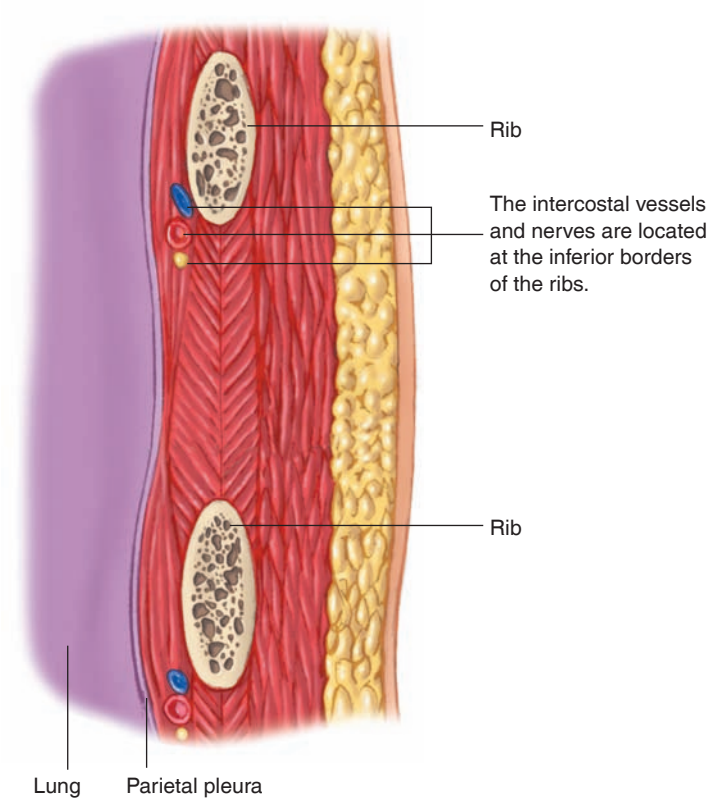


Figure 8-2 Rib with intercostal vessels and nerves.

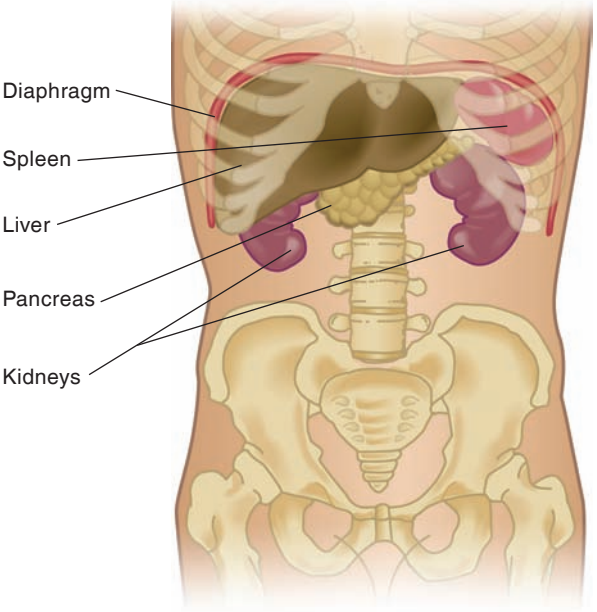


Figure 8-3 Intrathoracic abdomen.

around the lower border of the rib. This is an important anatomical feature if you have to perform needle decompression of the chest.

The structures within the chest but above the diaphragm include the lungs, the lower trachea and main stem bronchi, the heart and great vessels, and the esophagus. The adult thoracic cavity can hold up to 3 liters of blood on each side. This means that half of the circulating blood volume (6 liters or 12 units) can end up in either the right or left hemothorax without any sign of external bleeding.

The lungs are a pair of spongy and elastic organs lined by the pleura, a thin, slippery membrane. The visceral pleura overlies the lungs directly, whereas the parietal pleura makes up the inner lining of the chest wall. Together, they form the **pleural space**, a potential space in which air (pneumothorax), fluid, or blood (hemothorax) can accumulate.

Within the midline of the thoracic cavity is the **mediastinum**, which includes the heart, the aorta and pulmonary artery, superior and inferior vena cava, trachea, major bronchi, and the esophagus. Penetrating injuries that traverse the mediastinum have a high potential to be fatal, as the heart, great vessels, and tracheobronchial structures are close together in this area. Penetrating injuries to the anterior chest, between the nipples, below the clavicles, and above the costal margins have a high chance of injuring the important mediastinal organs. Deceleration injuries such as in head-on collisions or falls from a height are also of concern because they can result in fatal thoracic aortic injuries from the shearing forces involved. Prompt management and transport of these patients can be lifesaving.

The lower aspect of the chest protects the upper abdominal organs (stomach, spleen, liver, kidneys, and pancreas), which are divided from the thoracic cavity by the diaphragm (Figure 8-3). The diaphragm (a thin sheet of muscle) has its origin on the lower six ribs and the xiphoid process of the sternum. Its main function is respiration

pleural space: the potential space between the visceral and parietal pleura within the thorax. In disease or injury states this space can fill with air, fluid, or blood.

mediastinum: the anatomic region within the thorax, located between the lungs, that contains the heart and great vessels, trachea, major bronchi, and esophagus.

and is innervated by the phrenic nerve, which begins at cervical levels C3 to C5. This is very important because a cervical spinal cord injury below the fifth cervical vertebrae will cause paralysis from the neck down, yet allow the victim to continue to breathe using the diaphragm only. In contrast, a spinal cord injury above the third cervical vertebrae will render the patient unable to breathe at all due to loss of innervation of the phrenic nerve. Because of the movement of the diaphragm with respiration, any blunt or penetrating injury between the nipples (T4, or fourth intercostal space) and the 12th rib may cause both intrathoracic and intra-abdominal injuries, depending on where the diaphragm is in the respiratory cycle when the injury occurs.

PEARLS

Penetrating Chest Wounds

Patients who have penetrating chest trauma and shock are at the top of the list of load-and-go patients. Nothing should delay transport.

Pathophysiology

In the trimodal distribution of trauma deaths (immediate, hours, and weeks after injury), injuries to the chest are responsible for many deaths at the scene (immediate deaths) and those within a few hours (early deaths). Deaths at the scene (immediate deaths) usually involve disruption of the heart or great vessels. The second peak of deaths (early deaths) is usually due to airway obstruction, tension pneumothorax, hemorrhage, or cardiac tamponade. Only 10–15% of patients with chest trauma will require operative intervention. This means that timely prehospital care can save lives.

Chest injury may be the result of different mechanisms. Blunt trauma is the result of rapid deceleration, shearing forces, and crush injuries. Typically, the aorta, lungs, ribs, and less commonly the heart and esophagus can be injured in predictable fashion from blunt trauma. Conversely, penetrating trauma injuries are unpredictable. A bullet can be erratic and cause damage beyond its path, depending on the energy transferred, bullet path, and deformation. (See Chapter 1.) The depth and direction of knife wounds are difficult to assess on external examination alone. However, obvious trajectory of a penetrating injury can at least suggest the organs most likely to be at risk of injury.

When evaluating the trauma patient, always follow the ITLS Primary Survey, as discussed in Chapter 2. The ITLS Primary Survey is designed to identify life-threatening injuries, of which thoracic injuries make up the majority. Injuries to the organs within the thoracic cavity may result in decreased oxygenation and massive hemorrhage, both of which can lead to tissue hypoxia (shock) and death. Tissue hypoxia can result from the following chest injuries:

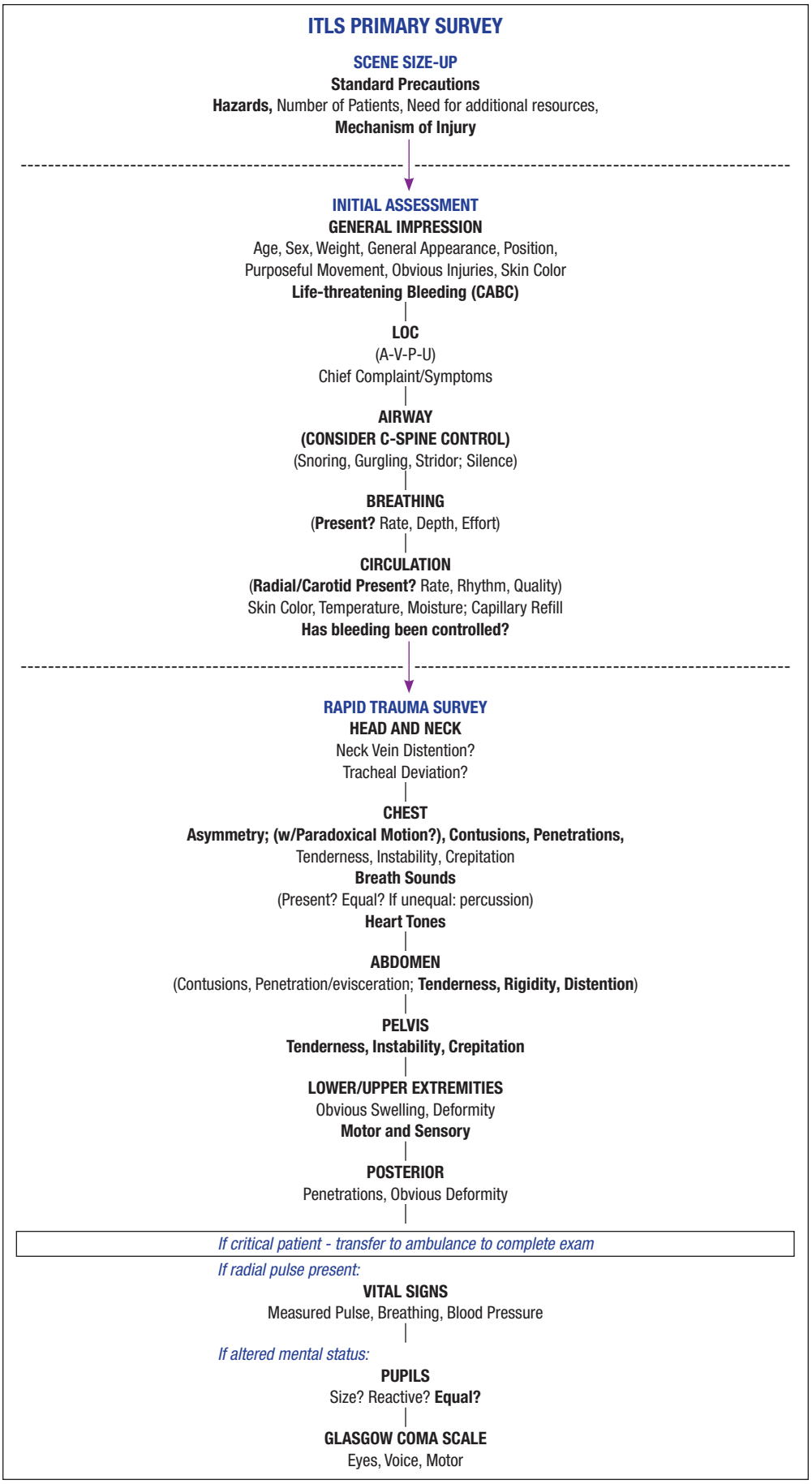
- Inadequate oxygen delivery to the tissues secondary to airway obstruction
- Hypovolemia from blood loss
- Ventilation/perfusion mismatch from lung parenchymal injury
- Compromise of ventilation and/or circulation from a tension pneumothorax
- Pump failure from severe myocardial injury or pericardial tamponade

Emergency Care of Chest Injuries

The major symptoms of chest injury are shortness of breath and chest pain. The signs indicative of chest injury found upon inspection include chest wall contusion, open wounds, subcutaneous emphysema, hemoptysis, distended neck veins, tracheal deviation, asymmetrical chest movement including paradoxical motion, cyanosis, and shock. In addition, palpation may reveal tenderness, instability, and crepitus (TIC). Listen to the lung fields for the presence and equality of breath sounds. Using the ITLS Primary Survey, including the rapid trauma survey, will guide you in an organized fashion to discovery of those injuries (Figure 8-4).

Life-threatening thoracic injuries should be identified during the ITLS Primary Survey. Major thoracic injuries to identify are listed next and may be remembered as the "deadly dozen:"

Figure 8-4 ITLS Primary Survey.



ITLS Primary Survey

- Airway obstruction
- Flail chest
- Open pneumothorax
- Massive hemothorax
- Tension pneumothorax
- Cardiac tamponade

ITLS Secondary Survey or During Hospital Evaluation

- Myocardial contusion
- Traumatic aortic rupture
- Tracheal or bronchial tree injury
- Diaphragmatic tears
- Pulmonary contusion
- Blast injuries

Airway Obstruction

Airway management remains a major challenge in the care of any multiple-trauma patient. Hypoxia secondary to airway obstruction (foreign body, tongue, aspiration of vomitus, or blood) is a common cause of preventable trauma death. Management of the airway is reviewed in Chapter 6.

Flail Chest

A **flail chest** occurs with the fracture of two or more adjacent ribs in two or more places (Figure 8-5), causing instability of the chest wall and paradoxical movement of the "flail segment" in a spontaneously breathing patient. The unstable section of ribs will suck in when the patient breathes in and will push out when the patient breathes out (Figure 8-6). Positive-pressure ventilation reverses the movement of the flail segment. Flail segments are not usually seen in the posterior chest because the heavy back muscles usually prevent movement of a flail segment. Patients with a flail chest are at risk for development of a hemothorax or pneumothorax. Because of the forces involved to cause a flail chest, these patients usually develop a pulmonary contusion (Figures 8-7 and 8-8).

Large flails decrease the ability of the patient to create a negative intrathoracic pressure, and thus the patient may not be able to adequately ventilate and may be in marked respiratory distress. Movement of broken ribs is very painful and will

PEARLS

Rib Fractures

Multiple rib fractures with or without flail chest can cause hypoxia from mechanical ventilatory problems as well as pulmonary contusion. The patient, especially the older patient, must be closely monitored for hypoxia and respiratory failure. Monitoring with pulse oximetry and capnography is very helpful.

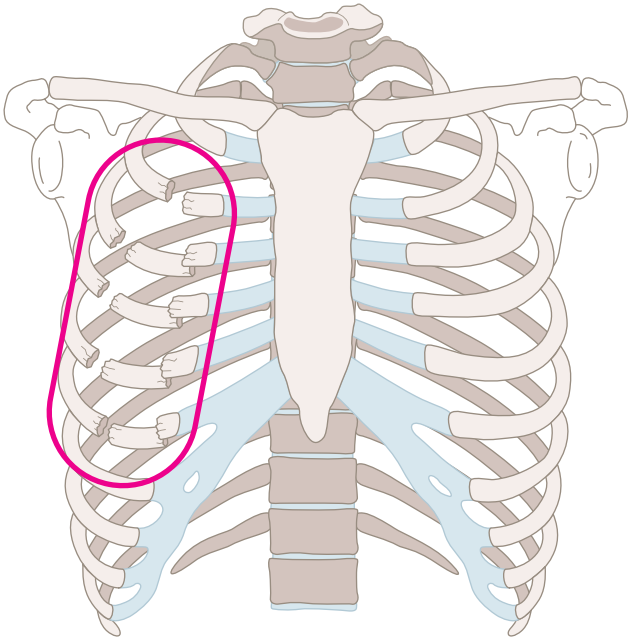


Figure 8-5 Flail chest occurs when two or more adjacent ribs fracture in two or more places.

flail chest: the fracture of two or more adjacent ribs in two or more places, causing instability of the chest wall and paradoxical movement of the "flail segment" in a spontaneously breathing patient.

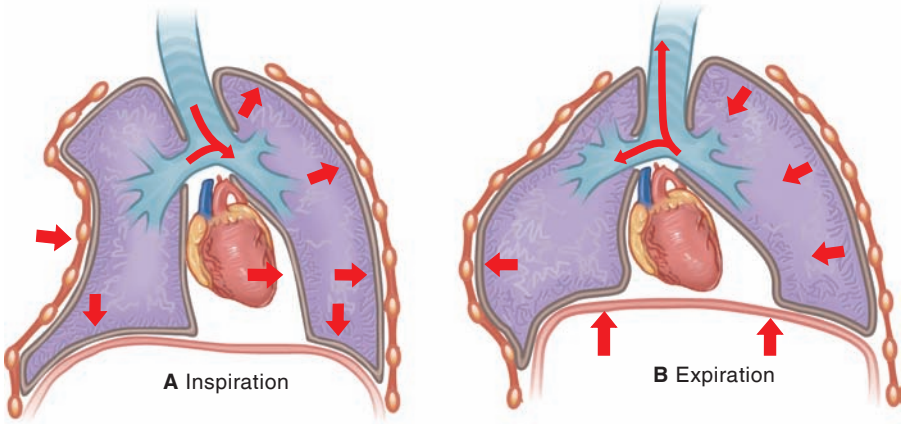


Figure 8-6 Pathophysiology of flail chest showing paradoxical motion.

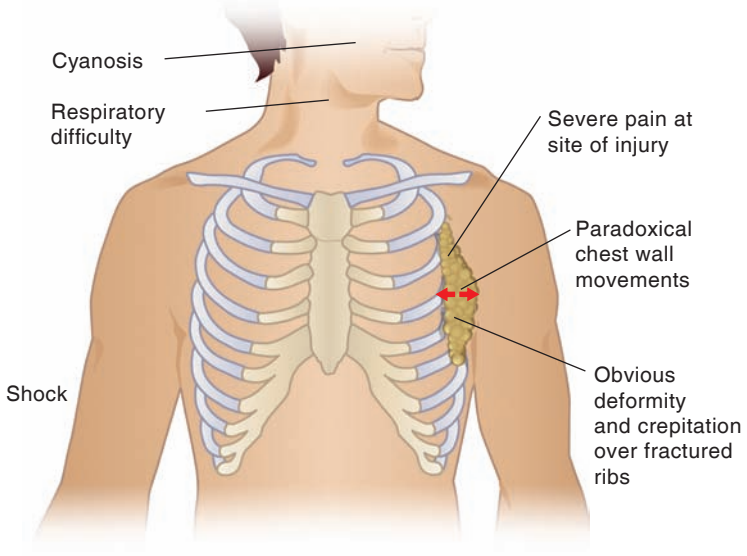


Figure 8-7 Physical findings of flail chest.

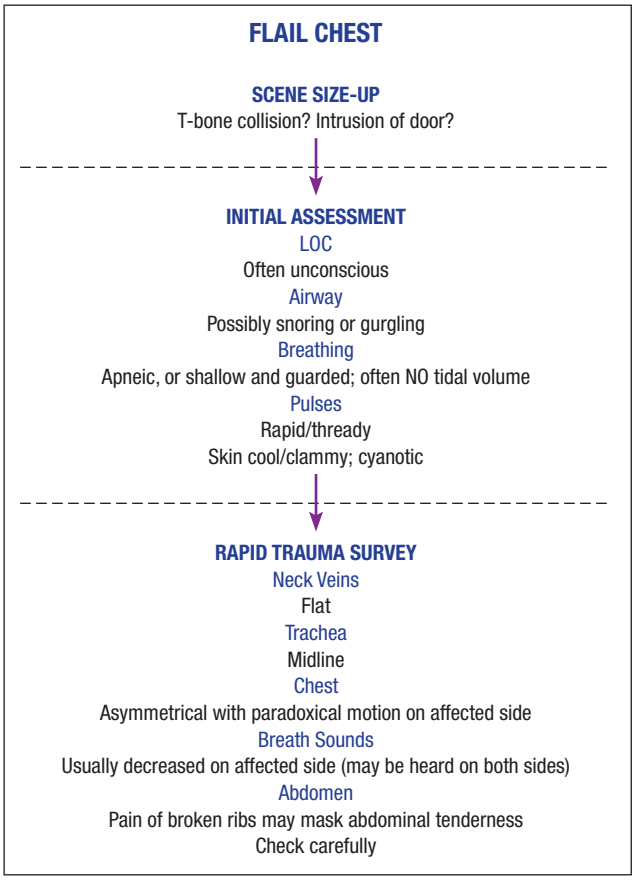


Figure 8-8 Flail chest may be identified during the ITLS Primary Survey.

contribute to the difficulty with ventilation. Analgesia is an important component of care. Narcotics or ketamine may be needed to achieve adequate pain control. Large flails are best treated with endotracheal intubation and assisted ventilation with positive end-expiratory pressure (PEEP). Continuous positive airway pressure (CPAP) had previously been suggested to stabilize such injuries, but be alert for the development of a tension pneumothorax if CPAP is used.

Procedure

Management of Flail Chest

1. Ensure an open airway.
2. Assist ventilation, if inadequate.
3. Administer high-flow oxygen.
4. Patients with a flail chest should be "load and go."
5. Transport rapidly to the appropriate hospital.
6. Notify medical direction early.
7. Consider intubation early to provide PEEP.
8. Administer adequate pain relief, avoiding respiratory depression based on system guidelines.
9. If shock is present, use care to prevent fluid overload, which could worsen hypoxemia.

Remember that intubation and positive-pressure ventilation are the best way to stabilize a flail chest, but this may be very difficult in the field if the patient still has a gag reflex. Drug-assisted intubation (DAI) is useful here, if available. Also keep in mind that a pneumothorax and pulmonary contusions are associated with a flail chest which can worsen hypoxemia. Be alert for development of tension pneumothorax and/or hypoxia.

Open Pneumothorax

A *pneumothorax* is the result of accumulation of air in the potential space between the visceral and parietal pleura secondary to injury. This results in at least a partial collapse of the lung. As the lung tightly adheres to the pleura, it is rare for the lung itself not to have some damage from a penetrating chest wound.

An **open pneumothorax** or sucking chest wound (>3 cm in diameter) remains open to the atmosphere. The persistent open wound equalizes intrathoracic pressure and atmospheric pressures, resulting in partial or complete lung collapse. The size of the pneumothorax and resultant symptoms are usually proportional to the size of the chest wall defect (Figures 8-9 and 8-10). Normal ventilation involves the creation of negative intrathoracic pressure by diaphragmatic contraction to draw air into the airways and lungs. If the open wound is greater than two-thirds the diameter of the trachea, air will follow the path of least resistance through the chest wall defect into the intrathoracic space, resulting in severe hypoxia and hypoventilation as the chest bellows is compromised.

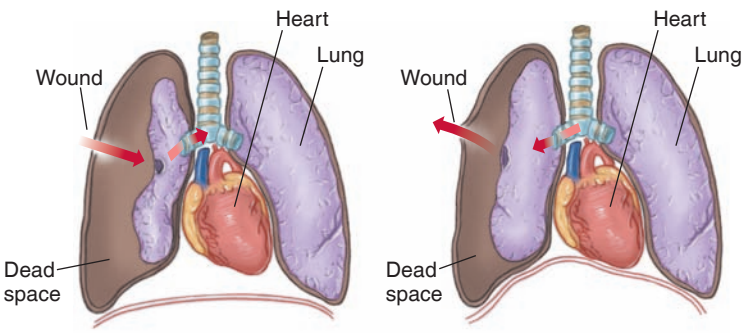


Figure 8-9 Open pneumothorax. If the chest wound is larger than the diameter of the trachea, air will preferentially go into the pleura space rather than the lung.

PEARLS

C-spine and Penetrating Chest Trauma

Spinal motion restriction (SMR) is not indicated in patients with isolated penetrating chest and abdominal trauma, unless it involves the bony spine. Performing cervical-spine motion restriction increases scene time and can worsen outcome.

open pneumothorax: accumulation of air in the pleural space secondary to penetrating injury presenting as an open or sucking chest wound (>3 cm in diameter).

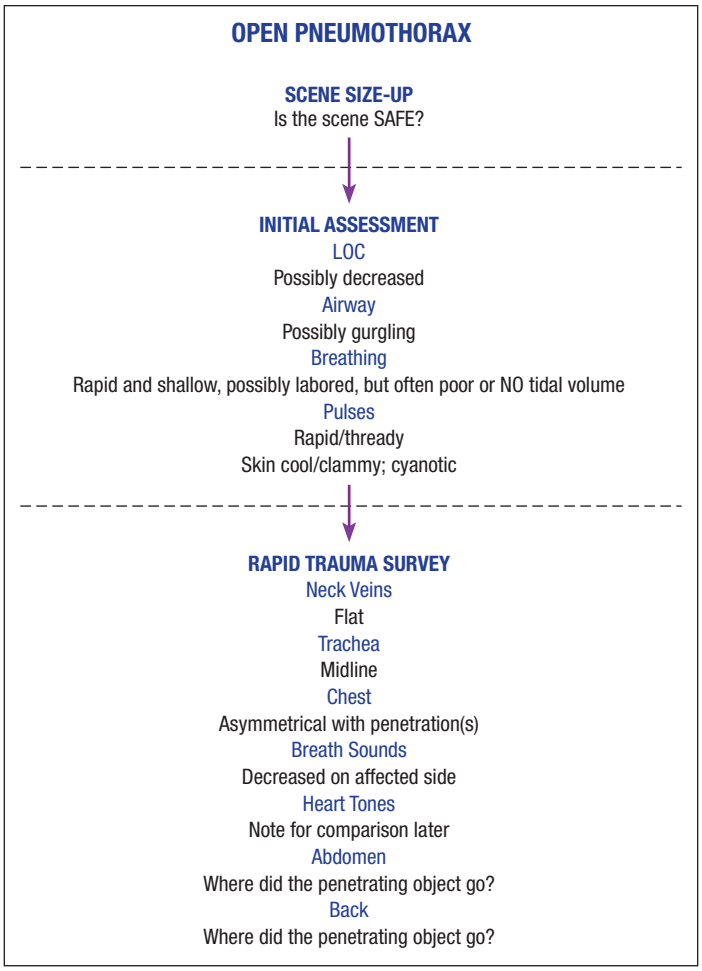


Figure 8-10 Open pneumothorax may be identified during the ITLS Primary Survey.

Procedure

Management of Open Pneumothorax

1. Ensure an open airway.
2. Administer high-flow oxygen. Assist ventilation as necessary.
3. Initially, seal the wound with your gloved hand. Then place a commercial chest seal over the defect (Figure 8-11). (A chest seal with an exit valve is preferred, such as Sentinel, Russell, Hyfin, SAM, Bolin, or H&H vent). Chest seals with laminated vent channels have experimentally been shown to allow effective evacuation of blood and air from the pleural cavity. Alternatively, you may make a seal from a sterile occlusive dressing taped on four sides or use an automated external defibrillator (AED) pad (Figure 8-12).
4. Load and go.
5. Insert a large-bore IV en route to the hospital.
6. Monitor the heart and note heart tones for comparison later.
7. Monitor oxygen saturation with a pulse oximeter and expiratory CO_2 with capnography, if available.
8. Transport rapidly to the appropriate hospital.
9. Notify medical direction early.

Procedure *(continued)*



Figure 8-11 Application of a chest seal. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 8-12 Treatment of sucking chest wound with improvised seal taped on four sides. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Massive Hemothorax

Blood in the pleural space is a hemothorax (Figure 8-13). A **massive hemothorax** occurs as a result of at least a 1,000 mL blood loss into the pleural space within the thoracic cavity. Each thoracic cavity may hold up to 3,000 mL of blood. Massive hemothorax

massive hemothorax: the presence of at least 1,000 mL of blood loss into the pleural space of the thoracic cavity.

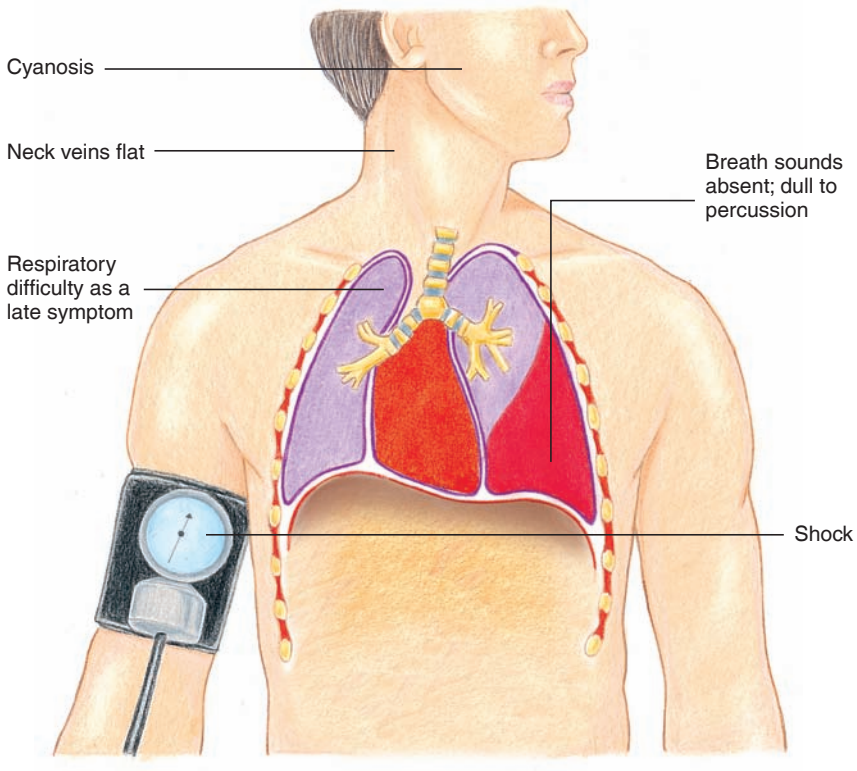


Figure 8-13 Physical findings of massive hemothorax.

Table 8-1: Primary Survey of Tension Pneumothorax Contrasted with Massive Hemothorax

	Tension Pneumothorax	Massive Hemothorax
Scene size-up	Seat belt? Steering wheel?	Scene safe? Penetrating vs. blunt trauma
Level of consciousness	Decreased	Decreased
Breathing	Rapid/shallow; labored	Rapid/shallow; labored
Pulses	Weak/thready; absent radials	Weak/thready; absent radials
Skin	Cool/clammy/diaphoretic; cyanotic	Cool/clammy/diaphoretic; pale/ashen
Neck	Neck vein distension; possible tracheal deviation (rare)	Neck veins flat; trachea midline
Breath sounds	Decreased or absent breath sounds on affected side	Decreased or absent breath sounds on affected side
Percussion note	Hyperresonant on affected side	Dull on affected side

is more common after penetrating trauma than to blunt trauma, but either injury may disrupt a major pulmonary or systemic vessel. As blood accumulates within the pleural space, the lung on the affected side is compressed.

Signs and symptoms of massive hemothorax are produced by both hypovolemia and respiratory compromise. The patient may be hypotensive from blood loss and compression of the great veins. Clinical signs of shock may be apparent, including loss of radial pulses. The neck veins are usually flat secondary to profound hypovolemia, but may very rarely be distended due to mediastinal compression. Other signs of hemothorax include absent or decreased breath sounds and dullness to percussion on the affected side. The massive hemothorax may be identified during the ITLS Primary Survey. (See Table 8-1 for comparison of tension pneumothorax and massive hemothorax.)

Procedure

Management of Massive Hemothorax

1. Secure an open airway.
2. Administer high-flow oxygen.
3. Load and go.
4. Notify medical direction early.
5. Treat for shock. Replace volume carefully after IV insertion en route. Try to keep the blood pressure high enough to maintain perfusion. Target blood pressure is 80–90 mmHg systolic. Although the major problem in massive hemothorax is usually hemorrhagic shock, elevating the blood pressure will increase the bleeding into the chest. Consider administration of tranexamic acid (TXA) if protocols allow.
6. Observe closely for the possible development of a tension hemopneumothorax, which would require acute chest decompression.

tension pneumothorax: a condition in which air continuously leaks out of the lung into the pleural space. The air continues to accumulate without means of exit, resulting in increasing intrathoracic pressure on the affected side and eventual collapse of the superior and inferior vena cava as well as the lung.

Tension Pneumothorax

A pneumothorax is accumulation of air in the potential space between the visceral and parietal pleura, resulting in complete lung collapse. In a **tension pneumothorax**, air continues to accumulate without means of exit, resulting in increasing intrathoracic

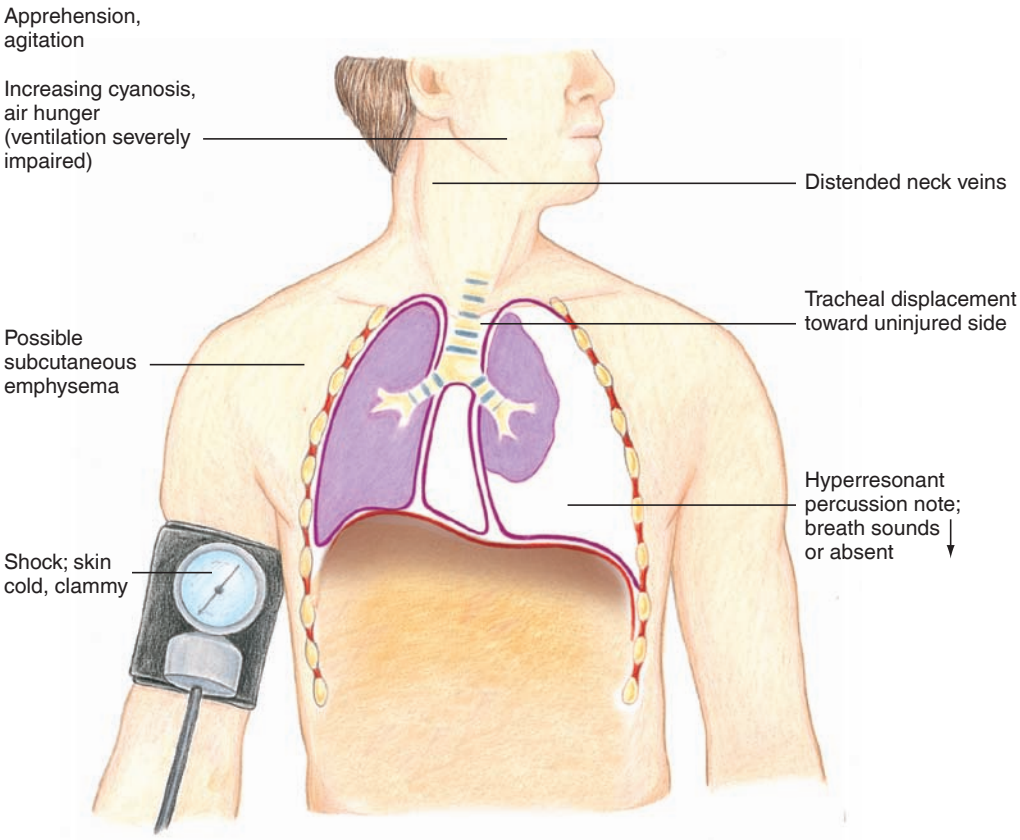


Figure 8-14 Physical findings of tension pneumothorax.

pressure on the affected side, displacing the heart and trachea to the opposite side, and collapsing the superior and inferior vena cava, thus occluding venous return to the heart (Figure 8-14).

Clinical signs of a tension pneumothorax include dyspnea, anxiety, tachypnea, distended neck veins, and possibly tracheal deviation away from the affected side. Auscultation will reveal diminished breath sounds on the affected side. It may be hard to hear breath sounds on scene or in a moving vehicle. Hyperresonance may be noted when the chest is percussed (Figure 8-15). Shock with hypotension often follows development of a tension pneumothorax. Tracheal deviation is best assessed by feeling for the trachea at the suprasternal notch. If present, it is a late sign of a tension pneumothorax. In a retrospective review of EMS patients diagnosed with tension pneumothorax and requiring needle decompression, none were observed to have tracheal deviation, so one must rely on the other physical findings of tension pneumothorax as well as mechanism of injury.

The development of decreased lung compliance (difficulty in squeezing the bag-valve mask) in the intubated patient should always alert you to the possibility of a tension pneumothorax. Intubated patients with a history of chronic obstructive pulmonary disease or asthma are at increased risk for development of tension pneumothorax from positive-pressure ventilation.

TENSION PNEUMOTHORAX

SCENE SIZE-UP
Seat belt? Steering wheel?

INITIAL ASSESSMENT
LOC
Decreased
Airway
Open? Movement of air?
Breathing
Rapid/shallow; labored
Pulses
Weak/thready →Absent radials
Skin cool/clammy, cyanotic

RAPID TRAUMA SURVEY
Head/Neck
Neck vein distention; possible tracheal deviation
Chest
Absent or decreased breath sounds on affected side
Hyperresonant on affected side

Figure 8-15 The tension pneumothorax may be identified during the ITLS Primary Survey.

Procedure

Management of Tension Pneumothorax

1. Establish an open airway.
2. Administer high-flow oxygen.
3. Decompress the affected side of the chest, if indicated. The indication for performing emergency chest decompression is the presence of a tension pneumothorax with decompensation, as evidenced by one of the following:
   a. Respiratory distress with or without cyanosis
   b. Loss of the radial pulse (late shock)
   c. Decreasing level of consciousness
4. Load and go.
5. Rapidly transport to the appropriate hospital.
6. Notify medical direction early.

If you are not authorized to decompress the chest, the patient must be transported rapidly to the hospital so decompression can be performed. A chest tube will be necessary on arrival to the hospital. Needle decompression is a temporary, but lifesaving, measure. (See Chapter 9.) An alternative, if permitted by your scope of practice, is to perform a finger thoracostomy.

Cardiac Tamponade

pericardial tamponade: the rapid collection of blood between the heart and pericardium from a cardiac injury. The accumulating blood compresses the ventricles of the heart, preventing the ventricles from filling between contractions and causing cardiac output to fall.

The pericardial sac is an inelastic membrane that surrounds the heart. If blood collects rapidly between the heart and pericardium from a cardiac injury, the ventricles of the heart will be compressed, making the heart less able to refill, and cardiac output falls. A small amount of pericardial blood (as little as 50 mL) may compromise cardiac filling and cause signs of **pericardial tamponade** (Figure 8-16).

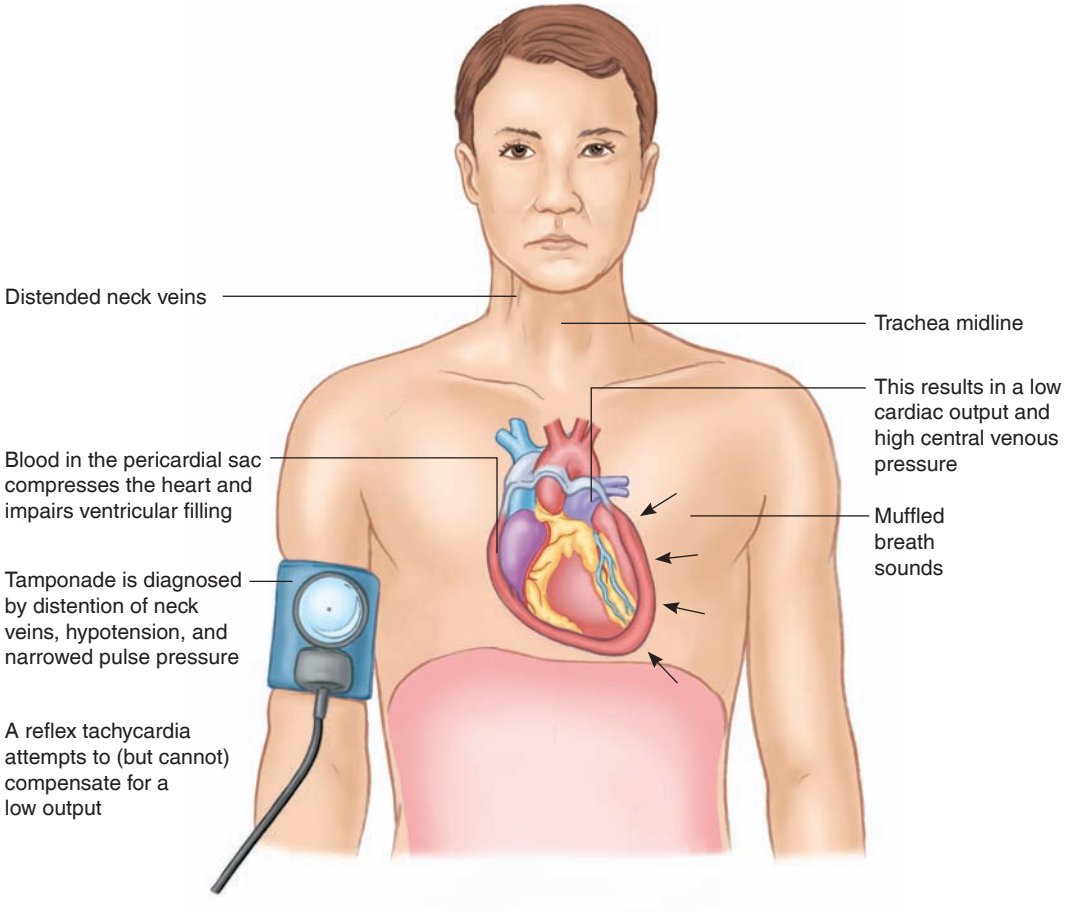


Figure 8-16 Pathophysiology and physical findings of cardiac tamponade.

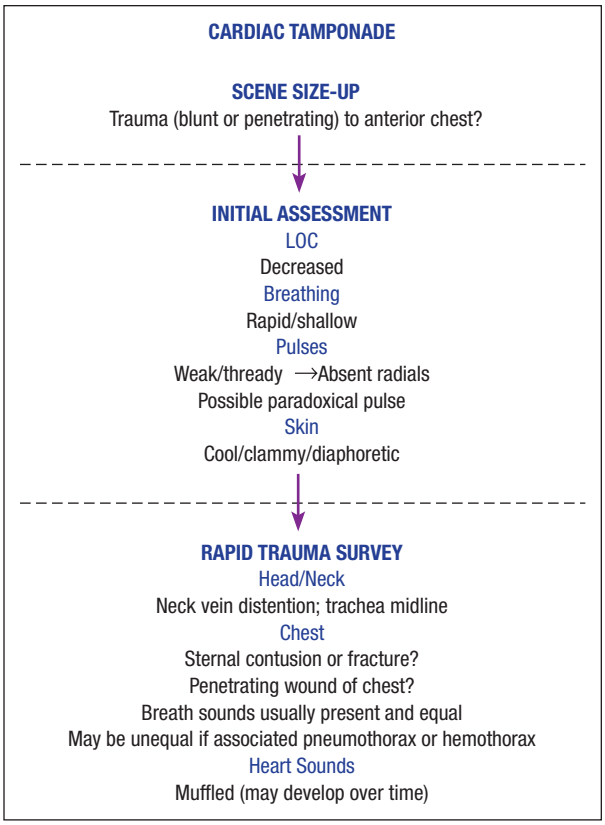


Figure 8-17 Cardiac tamponade may be identified during the ITLS Primary Survey.

Clinical identification of cardiac tamponade classically relies on the presence of hypotension with narrow pulse pressure, and **Beck's triad**, a combination of distended neck veins, muffled heart sounds, and hypotension. Muffled heart sounds may be very difficult to appreciate in the prehospital setting, but if you briefly listen to the heart when performing the ITLS Primary Survey, you may notice a change later. Beck's triad is seen in fewer than half of patients with cardiac tamponade, so maintain a high index of suspicion in patients with the appropriate mechanism. With cardiac tamponade, you may note a decrease in the pulse pressure, which is the difference between the systolic and diastolic blood pressures, as the tamponade progresses. Pulsus paradoxus or **paradoxical pulse** may be noted. This is where the radial pulse is not felt with inspiration. Ultrasound can be used to look for fluid in the pericardial sac, which would indicate a tamponade, in the right clinical situation.

Beck's triad: the three clinical signs of cardiac tamponade (distended neck veins, muffled heart sounds, and hypotension).

paradoxical pulse: a clinical sign of cardiac tamponade. It is an exaggeration of the normal variation of the strength of the pulse during the inspiratory phase of respiration, in which the blood pressure decreases as one inhales and increases as one exhales. The paradox is that, in the case of a pericardial tamponade with decreased cardiac output, the palpated radial pulse disappears during inspiration. Also called *pulsus paradoxus*.

The major differential diagnosis in the field is tension pneumothorax. With cardiac tamponade, the patient will be in shock with equal breath sounds and a midline trachea (Figure 8-17), unless there is an associated pneumothorax or hemothorax.

Other life-threatening thoracic injuries in the sections that follow may not be apparent during the ITLS Primary Survey, or at all in the prehospital environment. However, you should remain alert for clues.

Procedure

Management of Cardiac Tamponade

1. Ensure an open airway.
2. Administer high-flow oxygen.
3. Load and go.
4. Transport rapidly to the appropriate hospital.
5. Notify medical direction early.
6. Monitor the heart early, especially with chest pain or an irregular pulse.
7. Treat for shock. An intravenous infusion (en route) may increase the filling of the heart and increase cardiac output. However, because there may be associated intrathoracic bleeding, give only enough fluid to maintain perfusion. Target blood pressure is 80–90 mmHg systolic.
8. If available, perform a 12-lead ECG (including V4R). Electrical alternans, if present in the EKG, suggests tamponade. If available, perform ultrasound looking out for pericardial effusion.
9. Treat dysrhythmias as they present per advanced cardiac life support/International Liaison Committee on Resuscitation guidelines.
10. Watch for other complications, including hemothorax and pneumothorax.
11. If permitted under your scope of practice, pericardiocentesis can be lifesaving in cardiac tamponade.

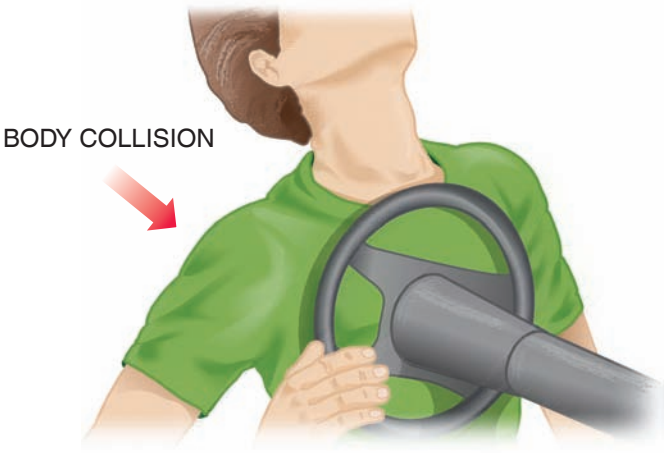


Figure 8-18 Pathophysiology of blunt cardiac injury, a collision of the heart against the sternum.

Myocardial Contusion

Blunt cardiac injury includes a number of diagnoses, including myocardial contusion, dysrhythmias, acute heart failure, valvular injury, or cardiac rupture. The mechanism is blunt trauma to the anterior chest as in a deceleration MVC or a fall from a height. Among them, myocardial contusion is something that you may suspect and possibly identify as a result of your ITLS Secondary Survey.

Myocardial contusion is a potentially lethal lesion that is the result of a blunt chest injury. Blunt force to the anterior chest is transmitted via the sternum to the right ventricle, which lies immediately posterior to it (Figure 8-18). Cardiac injuries from this mechanism may include valvular rupture, pericardial tamponade, or cardiac rupture, but contusion of the right atrium and right ventricle occurs most commonly (Figure 8-19). This bruising of the heart is a similar injury to the heart as an acute myocardial infarction and likewise presents with chest pain, dysrhythmias, and rarely cardiogenic shock. It may not develop immediately after injury but may develop over time.

Cardiac contusion should be suspected if the patient complains of chest pain, has an otherwise unexplained irregular pulse, and exhibits neck vein elevation, especially in the presence of blunt-force trauma to the anterior chest (bruised or flail sternum). Those signs are similar to pericardial tamponade and cannot be differentiated in the field, so are treated the same. If available, a 12-lead ECG should be performed, which may indicate an injury pattern to the right ventricle (ST elevation myocardial infarction [STEMI] in leads II, III, AVF, V1, and V4R). Presence of a new right bundle branch block may indicate a cardiac contusion. Premature ventricular contractions are the most common dysrhythmia seen on the monitor with a myocardial contusion. Ultrasound of the heart has not been shown to help identify myocardial contusion.

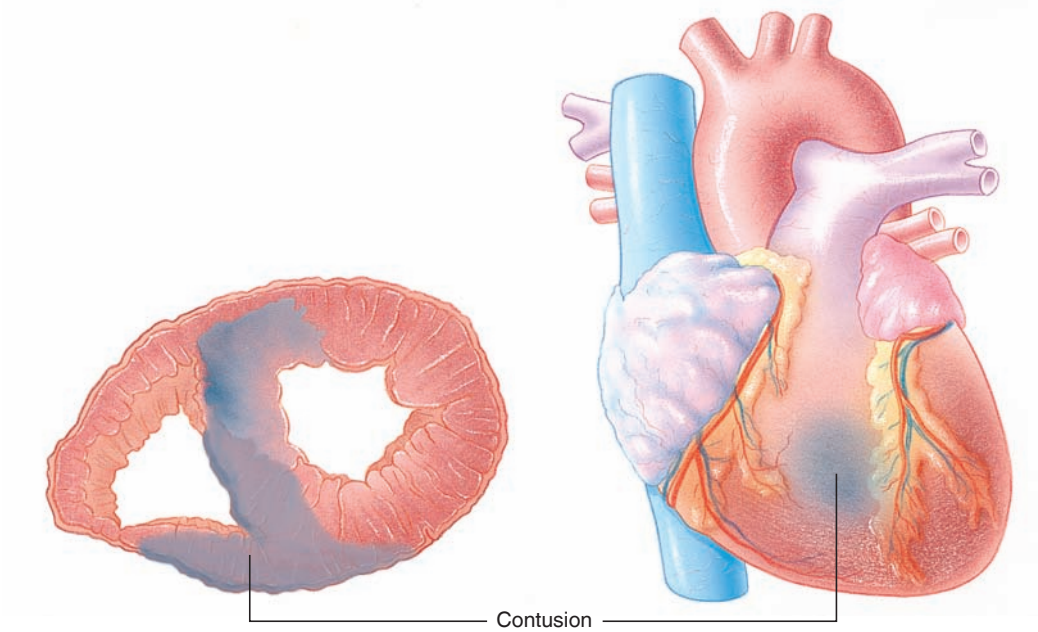


Figure 8-19 Myocardial contusion most frequently affects the right atrium and ventricle as they collide with the sternum in the "third collision." This can cause cardiac dysrhythmia.

Procedure

Management of Cardiac Contusion

1. Ensure an open airway.
2. Administer high-flow oxygen.
3. Load and go.
4. Transport rapidly to the appropriate hospital.
5. Notify medical direction early.
6. Apply cardiac monitor, especially with chest pain or an irregular pulse.
7. If available, perform a 12-lead ECG (including V4R).
8. Treat for shock. Intravenous crystalloids (en route) may increase the filling of the heart and increase cardiac output. However, because there may be associated intrathoracic bleeding, give only enough fluid to maintain a pulse (80–90 mmHg systolic).
9. Treat dysrhythmias as they present.
10. Watch for other complications, including hemothorax and pneumothorax.

Traumatic Aortic Rupture

Traumatic aortic rupture is a tear in the wall of the aorta. Eighty-five percent of tears occur at the aortic arch (ligamentum arteriosum or the take-off of the left subclavian artery). Most patients with traumatic aortic rupture (80%) die at the scene. These are usually free ruptures. For the 10–20% who do not exsanguinate immediately, the aortic tear will be contained temporarily by surrounding tissue and adventitia. However, usually this will rupture within hours unless recognized and surgically repaired. Identifying a contained thoracic aortic laceration is impossible in the field, so you should have a high index of suspicion for it if the patient has a mechanism of rapid deceleration.

This injury should be suspected in patients with a blunt mechanism associated with rapid deceleration, such as falls from a height and high-speed MVC (front and lateral impacts, ejected occupants). There may be no symptoms, or the patient may complain of chest pain or scapular pain. Be suspicious if the patient has asymmetric blood pressure measurements in upper extremities or upper-extremity hypertension, widened pulse pressure, and diminished lower-extremity pulses.

Procedure

Management of Potential Aortic Tears

1. Ensure an open airway.
2. Administer high-flow oxygen.
3. Rapidly transport to the appropriate hospital.
4. Control external hemorrhage.
5. Establish vascular access, but limit fluid administration.
6. Monitor the heart. The mechanism of injury is the same as for myocardial contusion.
7. If available, perform a 12-lead ECG (including V4R)
8. Notify medical direction early.

Tracheal or Bronchial Tree Injury

Tracheobronchial injuries may result in partial or complete disruption of the airway. Injury is localized within 2 cm of the carina in up to 80% of cases. These injuries usually cannot be diagnosed in the field but will present with dyspnea and pneumothorax. Patients may suffer a penetrating or blunt mechanism such as MVC or crush injury to the chest and exhibit dyspnea, subcutaneous emphysema, associated hemo/pneumothorax, and deformed chest.

Diaphragmatic Tears

Tears in the diaphragm may result from a severe blow to the abdomen. A sudden increase in intra-abdominal pressure, such as a seat-belt injury or a kick to the abdomen, may tear the diaphragm and allow herniation of the abdominal organs into the thoracic cavity. This occurs more commonly on the left than the right because the liver protects the right hemidiaphragm. Blunt trauma produces large radial tears in the diaphragm. Penetrating trauma may also produce holes in the diaphragm, but these tend to be small.

Traumatic diaphragmatic hernia is difficult to diagnose even in the hospital. The herniation of abdominal contents into the thoracic cavity may cause marked respiratory distress. Upon examination, the breath sounds may be diminished and, infrequently, bowel sounds may be heard when the chest is auscultated. The abdomen may appear scaphoid (sunken) if a large quantity of abdominal contents is in the chest. If traumatic diaphragmatic rupture is suspected and the patient requires a needle decompression for a tension pneumothorax, perform the decompression at the second intercostal space, midclavicular line, not at the lateral site.

Procedure

Management of Diaphragmatic Rupture

1. Ensure an open airway.
2. Assist ventilation as necessary
3. Administer high-flow oxygen.
4. Transport the patient to the appropriate hospital.
5. Treat for shock. Insert an IV en route. Associated injuries are common and hypovolemia may occur.
6. Notify medical direction early.

Pulmonary Contusion

Pulmonary contusion is a very common chest injury. It is caused by hemorrhage into lung parenchyma secondary to blunt-force trauma or penetrating injury such as a missile. It is seen commonly with flail segment or multiple rib fractures. A pulmonary contusion develops slowly and rarely develops during prehospital care, unless there is a very long transport, a secondary transport for transfer to a trauma center, or delayed discovery of the victim. Children may have severe pulmonary contusions without rib fractures due to the flexibility of the chest wall. Contusion of the lung may produce marked hypoxemia.

Management consists of oxygen administration; intubation and/or assisted ventilation, if indicated; transport; and IV insertion.

Blast Injuries

With the increase in terrorism, understanding blast injury is important. The magnitude of the blast wave depends on the size of the explosion and the environment in which it occurs. Closed spaces, such as buses, produce highly lethal blast injuries. (See Chapter 1.)

The mechanism of injury by explosion is due to five factors:

- *Primary.* This is the initial air blast. A primary blast injury is caused solely by the direct effect of blast overpressure on tissue. Air is easily compressible, unlike water. As a result, a primary blast injury almost always affects air-filled structures such as the lungs, ears, and gastrointestinal tract. Depending on the pressure wave, there may be pulmonary contusions, pneumothorax, tension pneumothorax, or arterial gas embolus.
- *Secondary.* The patient is struck by material (shrapnel) propelled by the blast force. These are penetrating injuries.
- *Tertiary.* The patient's body is thrown by the pressure wave and impacts the ground or another object. This is classic blunt-force trauma. These injuries, including crush injury, are also seen from structural collapse.
- *Quaternary.* These can be thermal burns from the explosion, radiation from radiological material that was dispersed by the explosion (dirty bomb), or respiratory injuries from inhalation of toxic dust or fumes.
- *Quinary.* This is reported as a hyperinflammatory state caused by chemicals used in making a bomb or added to the bomb (another form of dirty bomb).

Procedure

Management of the Patient with a Blast Injury

1. Place yourself, other responders, and equipment in a safe location. Be aware of secondary devices placed to attack responders.
2. Triage patients per multiple-casualty injury (MCI) protocol. Patients who have primary blast injury have a high mortality.
3. Ensure an open airway.
4. Administer high-flow oxygen. Be aware that positive-pressure ventilation may lead to or worsen pneumothorax or tension pneumothorax.
5. Load and go critical patients to appropriate level of care.
6. Manage the other injuries found.
7. Obtain venous access.
8. Notify medical direction.



Figure 8-20 Traumatic asphyxia. *(Photo courtesy of Effron)*

Other Chest Injuries

Impaled Objects

Penetrating objects, such as a knife, may remain impaled in the chest. With the exception of the face (cheek), where the object causes airway compromise, impaled objects should not be removed in the field. Stabilize the impaled object, ensure an airway, insert an IV, and transport the patient. If available, perform a 12-lead ECG (including V4R).

Traumatic Asphyxia

Traumatic asphyxia is an important set of physical findings (Figure 8-20). However, the term *traumatic asphyxia* is a misnomer because the condition is not caused by asphyxia. The syndrome results from a severe compression injury to the chest, such as from a steering wheel, conveyor belt, or heavy object. The sudden compression of the heart and mediastinum transmits this force to the capillaries of the neck and head. The patients appear similar to those who have been strangulated, with cyanosis and swelling of the head and neck. The tongue and lips are swollen, and conjunctival hemorrhage is evident. The skin below the level of the crush injury to the chest will be normal in appearance unless there are other problems.

Traumatic asphyxia indicates the patient has suffered a severe blunt thoracic injury, and major thoracic injuries are likely to be present. Management includes airway maintenance, IV access, treating other injuries, and rapid transport.

Simple Pneumothorax

simple pneumothorax: the presence of air in the pleural space that causes the lung to separate from the chest wall and can compromise the mechanics of breathing.

Simple pneumothorax may result from blunt or penetrating trauma. Fractured ribs are the usual cause in blunt trauma. Pneumothorax is caused by accumulation of air within the potential space between the visceral and parietal pleura. The lung may be totally or partially collapsed as the air continues to accrue in the thoracic cavity. In a healthy patient this should not acutely compromise ventilation, as long as a tension pneumothorax does not evolve. Patients with less respiratory reserve may not tolerate even a simple pneumothorax.

Clinical findings that suggest a pneumothorax include pleuritic chest pain, dyspnea, decreased breath sounds on the affected side, and tympany to percussion. Close observation is required in anticipation of the patient developing a tension pneumothorax. Any patient with a simple pneumothorax who undergoes intubation and positive-pressure ventilation must then be treated as a tension pneumothorax.

PEARLS

Simple Pneumothorax

Reassess patients with chest injuries frequently to prevent progression of a simple pneumothorax or open pneumothorax to a tension pneumothorax. The pulse oximeter and waveform capnography can be helpful.

Sternal Fractures

Sternal fractures indicate the patient has had severe blunt force applied to the anterior chest. These patients should be presumed to have a myocardial contusion as the right ventricle is behind the sternum. Palpation of the sternum produces pain during the chest exam.

Simple Rib Fracture

Simple rib fracture is the most frequent injury to the chest. If the patient does not have an associated pneumothorax or hemothorax, the major problem is pain. This pain will prevent the patient from breathing adequately. Upon palpation, the area of rib fracture will be tender and may be unstable. Give oxygen and monitor for pneumothorax or hemothorax while encouraging the patient to breathe deeply. It is reasonable to give medication for pain management. Older adults with multiple rib fractures have an increased risk for hypoxemia.

Case Presentation *(continued)*

As part of the ongoing exam, you note that the patient has lost his peripheral pulses and is becoming progressively more tachycardic with increasing respiratory distress and cyanosis in spite of oxygen supplementation. Although it is progressively more difficult to ventilate the patient with the BVM, the end-tidal CO_2 waveform remains normal in shape. Looking under the C-collar reveals newly distended neck veins. Reassessment of the chest reveals that the left side is hyperresonant to percussion, with absent breath sounds.

You conclude that the patient has progressed to a tension pneumothorax, and with the decreased level of consciousness, the cyanosis, and the evidence of hemodynamic collapse (including loss of radial pulses), he requires emergent needle chest decompression. After identifying the left second intercostal space, you insert the special chest decompression needle just above the left third rib in the midclavicular line. A loud hiss of air is heard, indicating successful decompression. An immediate improvement is noted in lung compliance and the ability to ventilate. The cyanosis resolves, and the patient regains peripheral pulses. Breath sounds remain diminished on the left. An updated report is provided to the receiving trauma center.

Summary

Chest injuries are common in multiple-trauma patients. Many of the injuries are life-threatening. If you follow the ITLS Primary Survey, you will be able to identify most of them. These are often load-and-go patients. Primary goals in treating the patient with chest trauma are the following:

- Ensure an open airway while protecting the cervical spine.
- Administer high-flow oxygen and ventilate, if necessary.
- Seal sucking chest wounds.
- Decompress the chest, if needed.
- Load and go.
- Obtain venous access.
- Transport to appropriate level of care.
- Notify medical direction.

The thoracic injuries discussed are life-threatening, but treatable by prompt intervention and transport to the appropriate level of care. Early recognition along with appropriate interventions and rapid transport may be lifesaving.

References and Resources

American College of Surgeons Committee on Trauma. 2018. "Thoracic Trauma." In *Advanced Trauma Life Support*, 10th ed. Chicago: American College of Surgeons.

Arnaud, F., E. Maudlin-Jeronimo, A. Higgins, B. Kheirabadi, R. McCarron, D. Kennedy, and G. Housler. 2016. "Adherence Evaluation of Vented Chest Seals in a Swine Skin Model." *Injury* 47, no. 10 (October): 2097–104. doi: 10.1016/j.injury.2016.05.041.

Asensio, J. A., F. N. Mazzini, and T. Vu. 2013. "Thoracic Injuries." In *The Trauma Manual: Trauma and Acute Care Surgery*, 4th ed., edited by A. B. Pietzman, M. Rhodes, C. W. Schwab, D. M. Yealy, and T. C. Fabian, 327–66. Philadelphia: Lippincott Williams and Wilkins.

Ball, C. G., A. D. Wyrzykowski, A. W. Kirkpatrick, C. J. Dente, J. M. Nicholas, J. P. Salomone, G. S. Rozycki, J. B. Kortbeek, and D. V. Feliciano. 2010. "Thoracic Needle Decompression for Tension Pneumothorax: Clinical Correlation with Catheter Length." *Canadian Journal of Surgery* 53, no. 3 (June): 184–8.

"CDC Blast Injury Mobile Application." CDC Emergency Preparedness and Response Web page. Accessed August 2018. http://emergency.cdc.gov/masscasualties/blastinjury-mobile-app.asp

DePalma, R. G., D. G. Burris, H. R. Champion, and M. J. Hodgson. 2005. "Blast Injuries." *New England Journal of Medicine* 352 (March): 1335–42.

Dubose, J. A, J. V. O'Connor, and T. M. Scalea. 2017. "Lung, Trachea and Esophagus." In *Trauma*, 8th ed., edited by E. E. Moore, D. V. Feliciano, and K. L. Mattox, 479–92. New York: McGraw-Hill.

Gunduz, M., H. Unlugenc, M. Ozalevli, K. Inanoglu, and H. Akman. 2005. "A Comparative Study of Continuous Positive Airway Pressure (CPAP) and Intermittent Positive Pressure Ventilation (IPPV) in Patients with Flail Chest." *Emergency Medicine Journal* 22, no. 5 (May): 325–9.

Harcke, H. T., L. A. Pearse, A. D. Levy, J. M Getz, and S. R. Robinson. 2007. "Chest Wall Thickness in Military Personnel: Implications of Needle Thoracentesis in Tension Pneumothorax." *Military Medicine* 172, no. 12 (December): 1260–3.

Kheirabadi, B. S., I. B. Terrazas, N. Miranda, A. N. Voelker, F. Arnaud, H. G. Klemcke, F. K. Butler, and M. A. Dubick. 2017. "Do Vented Chest Seals Differ in Efficacy?: An Experimental Evaluation Using a Swine Hemopneumothorax Model." *Journal of Trauma Acute Care Surgery* 83, no. 1 (July): 182–9. doi: 10.1097/TA.0000000000001501.

Littlejohn, L. F. 2017. "Treatment of Thoracic Trauma: Lessons From the Battlefield Adapted to All Austere Environments." *Wilderness and Environmental Medicine* 28 (June): S69–S73.

Lee, C., M. Revell, K. Porter, and R. Steyn. 2007. "The Prehospital Management of Chest Injuries: A Consensus Statement; Faculty of Pre-hospital Care, Royal College of Surgeons of Edinburgh." *Emergency Medicine Journal* 24, no. 3 (March): 220–4.

Netto, F. A., H. Shulman, S. B. Rizoli, L. N. Tremblay, F. Brenneman, and H. Tien. 2008. "Are Needle Decompressions for Tension Pneumothoraces Being Performed Appropriately for Appropriate Indications?" *American Journal of Emergency Medicine* 26, no. 5 (June): 597–602.

9



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

Thoracic Trauma Skills

S. Robert Seitz, MEd, RN, NRP
Roy L. Alson, MD, PhD, FAEMS
Art Proust, MD, FACEP

Maßnahmen bei Thoraxtraumata
Habilidades para el Trauma Torácico
Zbrinjavanje ozljeda prsnog koša
Competências Práticas no Trauma Torácico
Keterampilan Trauma Toraks
Травма грудной клетки – практические навыки
Traumatismes thoraciques en pratique

Δεξιότητες στην Διαχείριση Τραύματος Θώρακος
Gyakorlati készségek a mellkasi sérülések ellátásában
胸部外傷の手技
胸部創傷處理技巧
Obravnava poškodb prsnega koša

Skills presented in this chapter:

Needle decompression
- Anterior approach
- Lateral approach

Chest seal placement

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe the indications for emergency decompression of a tension pneumothorax.
2. Explain the advantages, disadvantages, and complications of needle decompression of a tension pneumothorax by the anterior approach and the lateral approach.
3. Perform needle decompression of a tension pneumothorax by either the anterior or lateral approach.
4. Apply chest seal to open chest wounds.

Chapter Overview

Thoracic trauma, whether blunt or penetrating, is a significant cause of trauma deaths. Prompt recognition of those conditions that can be corrected in the field setting can improve survival. While most chest trauma encountered by emergency care providers is due to blunt force, primarily from motor-vehicle collisions, the rise of attacks and other violence around the world increases the likelihood that providers will encounter penetrating trauma. Scene safety must be stressed at all times, given the volatility of such situations.

Chest Decompression

For many years needle decompression of a tension pneumothorax has been advocated as a lifesaving procedure and the anterior approach (second or third intercostal space, midclavicular line) has been most commonly used by prehospital providers. Multiple studies have also been published showing that the catheters being used with the anterior approach were too short to decompress the chest. It is recommended the anterior approach utilize a catheter needle being large bore (8 French or about #14 gauge) and 6–9 cm long (2.5–3.5 inches). Ideally, this should be a purpose-designed needle decompression catheter to reduce risk of kinking or dislodgement.

Tactical medicine courses that emphasize management of penetrating injuries associated with tension pneumothorax have recommended performing needle chest decompression laterally. This is for two reasons: first, the belief that a lateral approach is more likely to ensure successful entry of the catheter into the pleural space and, second, the ability to perform the procedure quickly without removal of body armor in a tactical or combat environment. The indications for needle chest decompression are the same, regardless of tactical or civilian environment. Tactical Combat Casualty Care (TCCC) has updated their guidelines to use the fourth intercostal space (between the fourth and fifth ribs) in the anterior axillary line as the lateral site of insertion.

Prehospital systems utilizing ultrasound have the advantage of performing an E-FAST (extended Focused Assessment with Sonography for Trauma) to look for a pneumothorax. The presence of a sliding lung sign rules out a pneumothorax, thereby reducing unnecessary needle chest decompression.

Because there are advantages and disadvantages to each decompression site, this chapter covers lateral and anterior anatomical positions. However, the anterior approach is preferred for civilian (nontactical) emergency medical services (EMS) performing a needle decompression. Follow your EMS system protocol or consult your service medical director for guidance about which site to use routinely. The important thing is to correctly identify the site, reducing the risk of complications, and to rapidly decompress the chest, which can be lifesaving.

Indications to Perform Chest Decompression

As with all advanced procedures, this technique must be permitted by local protocol or you must obtain medical direction before performing the procedure. The conservative management of tension pneumothorax is oxygen, ventilatory assistance, and rapid transport. The indication for performing emergency decompression is the presence of a tension pneumothorax with decompensation as evidenced by *any* of the following:

- Respiratory distress and cyanosis
- Signs of shock
- Decreasing level of consciousness

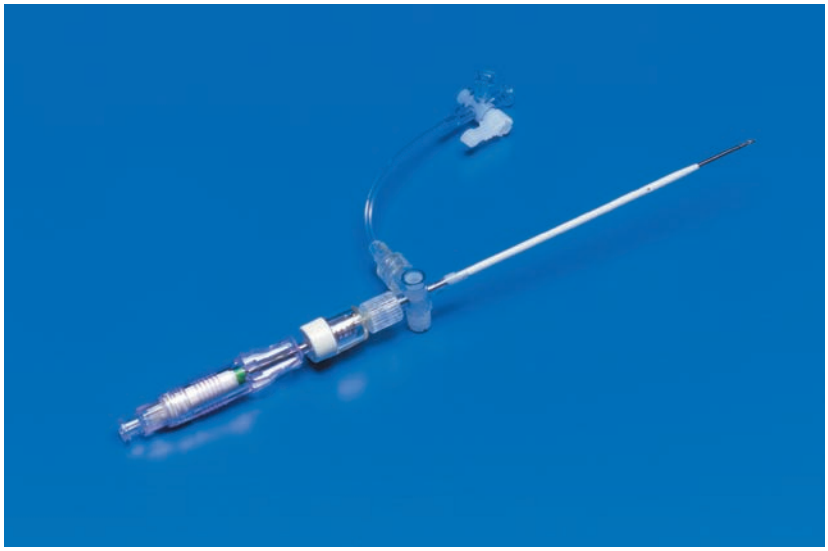
Performing a Chest Decompression by the Anterior Approach

Advantages

- The anterior site is preferred by many because, in the supine patient, air in the pleural space tends to accumulate anteriorly. Thus, there is a better chance of having the air in the pleural space removed when decompressing using the anterior approach. It is also easier to access with the patient on the ambulance stretcher.
- Monitoring of the site is easier if performed in the anterior site because the catheter is not as likely to be unintentionally dislodged when the patient is moved or if the patient moves his arm.

Disadvantages and Complications

- Unless a needle of proper length is used, it is likely that the needle will not reach the pleural space, and the tension pneumothorax will not be decompressed. The recommended catheter length is 6–9 cm (2.5–3.5 inches) (Figure 9-1).
- If the insertion of the needle is medial to the midclavicular line (nipple line), there is danger of cardiac puncture or great-vessel laceration.
- Laceration of the intercostal vessels may cause hemorrhage. The intercostal artery and vein run around the inferior margin of each rib. Poor needle placement can lacerate one of these vessels.
- Creation of a pneumothorax may occur if not already present. If your assessment was incorrect, you may give the patient a simple pneumothorax when you insert the needle into the chest.
- Laceration of the lung is possible. Poor technique or inappropriate insertion (no pneumothorax present) can cause laceration of the lung, with subsequent bleeding and an air leak.
- Risk of infection is a consideration. Adequate skin preparation with an antiseptic will usually prevent this.



A

Figure 9-1a Examples of catheters long enough to decompress a tension pneumothorax: In this photo, a Turkel safety needle. *(Courtesy of Covidien. Covidien and ™ marked brands are trademarks of Covidien AG)*



B

Figure 9-1b An ARS needle for decompression. *(© 2020 North American Rescue, LLC)*



C

Figure 9-1c A Cook pneumothorax needle (has wire coil inside to prevent kinking). *(Courtesy of Stanley Cooper, EMT-P)*

Procedure

Decompression by the Anterior Approach

1. Assess the patient to make sure that his or her condition is due to a tension pneumothorax. Signs of tension pneumothorax are:
   a. Absent or decreased breath sounds on the affected side
   b. Respiratory distress; tachypnea
   c. Weak/thready pulses; possible absent radial pulse
   d. Skin cool, clammy, diaphoretic; pale or cyanotic
   e. Neck vein distention (may not be present if there is associated severe hemorrhage)
   f. Possible tracheal deviation away from the side of the injury (late sign and often not present)
   g. Decreased level of consciousness (LOC) resulting from hypoxia and/or hypoperfusion
   h. Tympanic sound (hyperresonance) to percussion on the affected side
2. Give the patient high-flow oxygen and ventilatory assistance.
3. Determine that indications for emergency decompression are present. Then, if required, obtain medical direction to perform the procedure.
4. Expose the side of the tension pneumothorax and identify the second intercostal space on the anterior chest at the midclavicular line. This may be done by feeling for "angle of Louis," the bump located on the sternum about a quarter of the way from the suprasternal notch (Figure 9-2). The insertion site should be slightly lateral to the midclavicular line (nipple line) to avoid cardiac or major vascular complications in the mediastinum.
5. Quickly prepare the area with an antiseptic.
6. Remove the plastic cap from a #14-gauge or larger catheter 6–9 cm long (8 French, 9-cm Turkel safety needle; #14-gauge, 8.25-cm ARS decompression needle; 8.5 French, 6-cm Cook pneumothorax needle; or #14-gauge, 8-cm angiocath) and insert the needle into the second intercostal space at a 90-degree angle at the superior border of the third rib to avoid the neurovascular bundle (Figure 9-3). Direction of the bevel of the needle is irrelevant to successful results. Be very careful not to angle the needle toward the mediastinum (medially). As the needle enters the pleural space,

Procedure *(continued)*



Figure 9-2 Determine the patient has a tension pneumothorax and locate the site for needle decompression using the anterior approach. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

you may be able to feel a "pop." In the presence of a tension pneumothorax a hiss of air may be audible as the thoracic pressure is relieved. When using an over-the-needle catheter, advance the catheter into the chest (Figure 9-4). Remove the needle and leave the catheter in place. To avoid dislodgement the catheter hub may be stabilized to the chest with tape.

7. Place a one-way valve on or over the decompressing needle to protect the needle from accidental dislodgment. (*A needle through the finger of a rubber glove will not work as a one-way valve.*) Younger healthy patients will tolerate having no valve at all on the decompressing needle.
8. Leave the plastic catheter and secure in position until it is replaced by a chest tube at the hospital.
9. Intubate the patient, if indicated. Monitor closely for recurrence of the tension pneumothorax and repeat decompression procedure if signs redevelop.



Figure 9-3 Insert the catheter at a 90-degree angle over the superior border of the third rib into the second intercostal space.



Figure 9-4 Advance the catheter into the chest. There may be a rush of air as the pressure is relieved. Secure the catheter with tape.

Performing a Chest Decompression by the Lateral Approach

Advantages

- The military and tactical medics prefer the lateral approach because in a tactical situation it has the advantage of allowing decompression while keeping body armor in place.
- The lateral chest wall can be thinner based on body habitus, so reaching the pleural space with the needle is more likely.

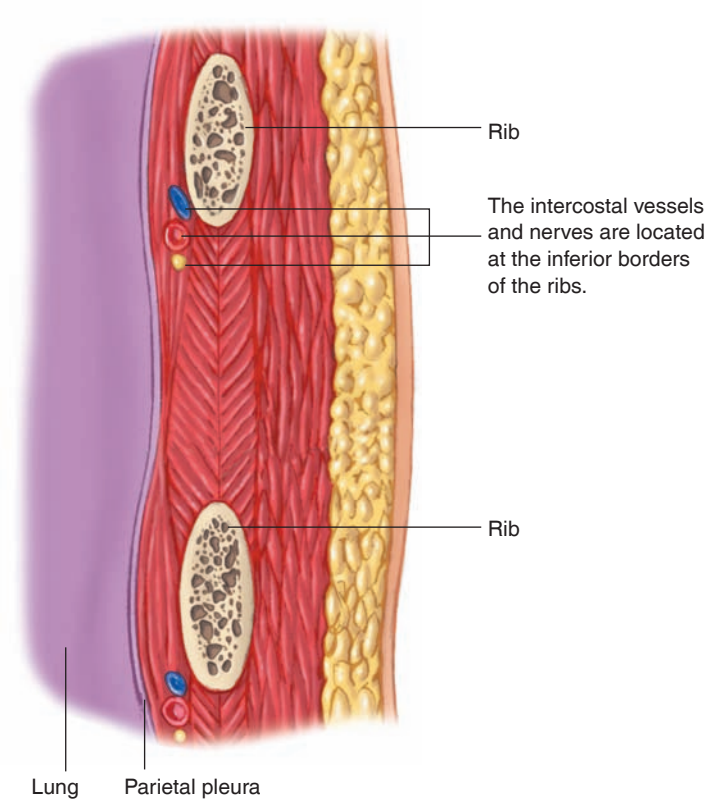


Figure 9-5 Rib with intercostal vessels and nerves.

Disadvantages and Complications

- The decompression catheter is more likely to be dislodged when moving the patient or if the patient moves his or her arm. Using the chest seal for a one-way valve will also provide some protection against dislodgement of the decompression catheter.
- It can be difficult to reach this area when the patient is in the ambulance (especially if the tension pneumothorax is on the right).
- Laceration of the intercostal vessels may cause hemorrhage any time a needle decompression is performed. The intercostal artery and vein run around the inferior margin of each rib (Figure 9-5). Poor needle placement can lacerate one of these vessels.
- If performing the lateral approach, inserting the needle too low may lacerate the liver or spleen, and inserting the needle too high may lacerate the axillary artery or vein.
- Laceration of the lung is possible. Poor technique or inappropriate insertion (no pneumothorax present) can cause laceration of the lung, with subsequent bleeding and an air leak.
- Increased risk of the catheter kinking has been reported with this approach, partially and/or temporarily occluding the catheter during transport. This may contribute to the re-development of the tension pneumothorax.
- Risk of infection is a consideration. Adequate skin preparation with an antiseptic will usually prevent this.

Procedure

Performing a Chest Decompression by the Lateral Approach

1. Assess the patient to make sure that their condition is due to a tension pneumothorax. Signs of tension pneumothorax are:
   a. Absent or decreased breath sounds on the affected side
   b. Respiratory distress; tachypnea
   c. Weak/thready pulses; possible absent radial pulse
   d. Skin cool, clammy, diaphoretic; pale or cyanotic
   e. Neck vein distention (may not be present if there is associated severe hemorrhage)
   f. Possible tracheal deviation away from the side of the injury (late sign and often not present)
   g. Decreased level of consciousness (LOC) resulting from hypoxia and/or hypoperfusion
   h. Tympanic sound (hyperresonance) to percussion on the affected side
2. Give the patient high-flow oxygen and ventilatory assistance, if needed.
3. Determine that indications for emergency decompression are present. Then, if required, obtain medical direction to perform the procedure.
4. Lateral site for decompression: Expose the side of the tension pneumothorax and identify the intersection of the nipple (fourth rib) and anterior

Procedure *(continued)*

axillary line on the same side as the pneumothorax (Figure 9-6).

5. Quickly prep the area.
6. Remove the plastic cap from a #14-gauge catheter needle at least 2.5 inches or 6 cm long and insert the needle into the intercostal space at a 90-degree angle to the superior border of the fifth rib to avoid the neurovascular bundle (Figure 9-7). If the patient is muscular or obese, you may need to use a longer catheter needle. Direction of the bevel is irrelevant to successful results. As the needle enters the pleural space, there will be a "pop" sound. If a tension pneumothorax is present, there will be a hiss of air as the pneumothorax is decompressed. If using an over-the-needle catheter, advance the catheter into the chest. Remove the needle and leave the catheter in place. *The catheter hub must be stabilized to the chest with tape or a chest seal.*
7. Place a one-way valve on or over the decompressing needle. The chest seal can be placed over the needle and provide a one-way valve and will protect the needle from accidently being dislodged. (*A needle through the finger of a rubber glove will not work as a one-way valve.*) Young, healthy patients will tolerate having no valve at all on the decompressing needle.
8. Leave the plastic catheter and secure in position until it is replaced by a chest tube at the hospital.
9. Intubate the patient, if indicated, and monitor with capnography when available. Monitor closely for recurrence of the tension pneumothorax as an increase in the CO_2 is an early sign the catheter is kinked or a tension pneumothorax is reoccurring.



Figure 9-6 Determine the patient has a tension pneumothorax and mark the site for needle decompression using the lateral approach. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 9-7 Needle decompression by the lateral approach. Advance the catheter into the chest and secure with tape. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Management of Open Pneumothorax

Spontaneous breathing depends on both the diaphragm and chest wall expanding, which then expands the lung, creating negative pressure in the chest and causing air to enter via the respiratory tree. If the integrity of the chest wall is compromised, air may enter into the pleural space, impairing the "bellows" effect of chest wall expansion and creating a pneumothorax. Initial field treatment of an "open" pneumothorax (also known as a "sucking" chest wound) is to seal the wound with an occlusive dressing, which prevents air from passing in and out of the wound. Traditionally, EMS has improvised such dressings with petroleum jelly–coated gauze, aluminium foil (including the petroleum jelly–coated gauze package), plastic wrap, etc. Classic teaching was to prevent pressure buildup and the development of a tension pneumothorax, only

three sides of this occlusive dressing were taped to the skin, allowing the wound to "burp" when pressure rose inside the chest cavity. This is no longer recommended by TCCC guidelines

Due to blood, body hair, and so on, these improvised seals did not always stay sealed. Based on experience from military operations, there are a number of commercially available chest seals that can be rapidly applied and that are designed to stick even to bloody skin. They are available as either vented or unvented seals. Either type will seal adequately, though vented seals eliminate the need to "burp" the seal and have decreased the incidence of developing a tension pneumothorax. In an emergency, a field-expedient unvented chest seal may be made from an automatic external defibrillator (AED) pad.

Procedure

Placement of Chest Seal for Penetrating Chest Wound

1. Assess the patient and identify that they have an open chest wound.
2. Give the patient high-flow oxygen and ventilatory assistance, if needed.
3. Clean the area around the chest wound to remove gross contaminants that may interfere with the seal sticking to the skin.
4. Apply the seal to the site of the wound, being sure that if you are using a vented seal that the vent is over the wound to allow air to escape.
5. If there is more than one chest wound, seal all wounds found. Remember to check the back.
6. Secure the airway, if indicated, and monitor with capnography when available. Monitor closely for the development of a tension pneumothorax, especially if patient is receiving positive-pressure ventilation.
7. If a commercial chest seal is not available, a field-expedient occlusive dressing may be made from petroleum jelly–coated gauze, a foil or plastic dressing wrapper, or other impervious material. Place the dressing over the wound. Secure the wound to the chest wall with tape, placed along four sides of the dressing. (See Figure 8-12.) If a chest seal is applied and the patient begins to develop a tension pneumothorax, remove the seal to allow air to escape ("burp the seal"). If that does not relieve the tension pneumothorax, the patient will need chest decompression, if in your scope of practice.

References and Resources

American College of Surgeons Committee on Trauma. 2018. "Chest Trauma Management." In *Advanced Trauma Life Support*, 10th ed., 62–81. Chicago: American College of Surgeons.

Assensio, J., F. Massini, and T. Vu. 2013. "Thoracic Injuries." In *The Trauma Manual: Trauma and Acute Care Surgery*, 4th ed., by A. B. Pietzman, C. W. Schwab, D. M. Yealy, M. Rhodes, and T. C. Fabian, 327–66. Philadelphia: Lippincott Williams and Wilkins.

Ball, C. G., A. D. Wyrzkowski, A. W. Kirkpatrick, C. J. Dente, J. M. Nicholas, J. P. Salomone, G. S. Rozycki, J. B. Kortbeek, and D. V. Feliciano. 2010. "Thoracic Needle Decompression for Tension Pneumothorax: Clinical Correlation with Catheter Length." *Canadian Journal of Surgery* 53, no. 3 (June): 184–8.

Beckett, A., E. Savage, D. Pannell, S. Acharya, A. Kirkpatrick, and H.C. Tien. 2011. "Needle Decompression for Tension Pneumothorax in Tactical Combat Casualty Care: Do Catheters Placed in the Midaxillary Line Kink More Often Than Those in the Midclavicular Line?" *Journal of Trauma* 71, no. 5(Suppl. 1) (November): S408–12.

Blivas, M. 2010. "Inadequate Needle Thoracostomy Rate in the Prehospital Setting for Presumed Pneumothorax: An Ultrasound Study." *Journal of Ultrasound Medicine* 29, no. 9 (September): 1285–9.

Butler, F. K. 2010. "Tactical Combat Casualty Care: Update 2009." *Journal of Trauma* 69, no. 1 (Suppl.) (July): S10–3.

Butler, F. K., J. J. Dubose, E. J. Otten, D. R. Bennett, R. T. Gerhardt, B. S. Kheirabadi, K. R. Gross, A. P. Cap, L. F. Littlejohn, E. P. Edgar, et al. 2013. "Management of Open Pneumothorax in Tactical Combat Casualty Care: TCCC Guidelines Change 13-02." *Journal of Special Operations Medicine* 13, no. 3 (Fall): 81–6.

Butler, F. K., J. Holcomb, S. Shackelford, H. R. Montgomery, S. Anderson, J. S. Cain, H. R. Champion, C. W. Cunningham, W. C. Dorlac, B. Drew, et al. "Management of Suspected Tension Pneumothorax in Tactical Combat Casualty Care: TCCC Guidelines Change 17-02." *Journal of Special Operations Medicine* 18, no. 2 (Summer): 19–35.

Harcke, H. T., L. A. Pearse, A. D. Levy, J. M. Getz, and S. R. Robinson. 2007. "Chest Wall Thickness in Military Personnel: Implications of Needle Thoracentesis in Tension Pneumothorax." *Military Medicine* 172 (December): 1260–3.

Laan, D. V., T. D. Vu, C. A. Thiels, T. K. Pandian, H. J. Schiller, M. H. Murad, and J. M. Aho. 2016. "Chest Wall Thickness and Decompression Failure: A Systematic Review and Meta-Analysis Comparing Anatomic Locations in Needle Thoracostomy." *Injury* 47, no. 4 (April): 797–804. doi: 10.1016/j.injury.2015.11.045.

Lee, C., M. Revell, K. Porter, R. Steyn, and Faculty of Pre-hospital Care, Royal College of Surgeons of Edinburgh. 2007. "The Prehospital Management of Chest Injuries: A Consensus Statement. Faculty of Pre-hospital Care, Royal College of Surgeons of Edinburgh." *Emergency Medicine Journal* 24 (March): 220–4.

Moy, P. 2015. "Evidence -Based EMS: Needle Decompression." Accessed September 27, 2018. https://www.emsworld.com/article/12041960/what-s-the-best-site-for-needle-decompression

Netto, F. A., H. Schulman, S. B. Rizoll, L. N. Tremblay, F. Brenneman, and H. Tien. 2008. "Are Needle Decompressions for Tension Pneumothoraces Being Performed Appropriately for Appropriate Indications?" *American Journal of Emergency Medicine* 26 (June): 597–602.

10

Spinal Trauma and Spinal Motion Restriction



(Cheryl Casey/Shutterstock)

Roy L. Alson, MD, PhD, FAEMS
James J. Augustine, MD, FACEP

Wirbelsäulentraumata und Bewegungseinschränkung der Wirbelsäule
Trauma Espinal y Restricción de Movilidad Espinal
Ozljede kralježnice i ograničavanje pokretljivosti kralježnice
Traumatismo Vertebro-Medular e Imobilização
Trauma Tulang Belakang dan Spinal Motion Restriction
Спинальная травма и ограничения движения позвоночника
Traumatismes rachidiens et immobilisation du rachis
Τραύμα Σπονδυλικής Στήλης και Ακινητοποίηση Σπονδυλικής Στήλης
Gerincsérülések és rögzítés
脊椎・脊髄損傷と脊椎運動制限
脊椎創傷及脊椎減移術.
Poškodbe hrbtenice in metode omejevanja premikov hrbtenice

Key Terms

emergency rescue, *p. 212*
neutral alignment, *p. 213*
paresthesia, *p. 210*
primary spinal cord injury, *p. 210*
rapid extrication, *p. 212*
secondary spinal cord injury, *p. 210*
spinal column, *p. 206*
spinal cord, *p. 207*
spinal motion restriction (SMR), *p. 203*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Explain the normal anatomy and physiology of the spinal column and spinal cord.
2. Define spinal motion restriction and its relationship to patient safety.
3. Describe elements of injury, history, and assessment that may assist in determining which patients will benefit from spinal motion restriction.
4. Explain the difference between emergency rescue and rapid extrication techniques and describe the appropriate utilization of each.
5. Using the clinical evaluation, differentiate neurogenic shock from hemorrhagic shock.

Chapter Overview

Spinal cord injury is a devastating and life-threatening result of modern trauma. In the United States it is likely that 1 million patients have injuries each year that will require emergency care providers to consider the risk of spine injury. Fortunately, only about 2% of those injuries actually injure the spinal column, and most are stable and not associated with spinal cord injury. The management of trauma patients requires continuous vigilance for injuries to the spinal column and to the spinal cord and expedient treatment for the complications of those injuries.

This chapter reviews the process of evaluating the injured patient and providing appropriate treatment, transportation to the hospital, and protection from problems that will have life-long implications. Spinal cord damage represents an injury that may not be obvious upon initial evaluation but requires emergency medical services (EMS) management to prevent further damage. This preventive care is called **spinal motion restriction (SMR)** and includes techniques and equipment that help to minimize movement of the spine. It most accurately defines the process used in the field because in certain patients, the spine cannot be completely immobilized.

spinal motion restriction (SMR): techniques and equipment primarily used in the field that help to minimize movement of the spine in cases where the patient's spine cannot be completely immobilized.

Over the last decade the approach to SMR has changed significantly, moving from predominantly mechanism of injury to one that focuses on the patient, his or her condition, and the mechanism of injury. Emergency care responders must assess the mechanism of injury and the patient to provide a structured assessment and to treat, package, and transport patients with known or potential spinal cord injuries.

Case Presentation



You are dispatched to the scene of a two-vehicle collision involving a car and a small truck that has rolled over. The patients in the car are an elderly couple, with the man in the driver's seat alert, talking normally, and complaining of left arm and left ankle pain. The driver of the truck is walking around and complaining of a stiff neck. You approach the truck driver as your partner checks the elderly couple in the car. Your partner notices that the windshield on the passenger side of the car is damaged and the woman is holding the back of her neck.

Before proceeding, consider these questions:

- Is this a high-risk or low-risk mechanism for spine injury in the truck driver?
- Are there clues from the scene that help guide you to find possible injuries in the female front-seat passenger?
- Does the age of the victims influence the assessment for spine injury?
- What are the indications for active spinal motion restriction?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed these patients.

Evolution of Spinal Motion Restriction

Relationship to Patient Safety

Since reports of spine injury began 50 years ago, rescuers have performed a highly ritualized immobilization of patients on hard boards, using straps and tape to provide a firm attachment of the patient to the board. This continues to be done despite research that clearly shows a very low incidence of unstable injuries, the likelihood of significant complications related to this positioning, and incredible discomfort caused to patients. For certain groups of patients, such as those with penetrating injuries to the torso, immobilization on a long board is associated with higher levels of mortality (Hauswald 2013).

The recognition of the dangers of overimmobilization has resulted in an attempt to identify patients who will benefit from SMR and the publication of papers that encourage a much more focused use of the procedure with patients at highest risk of an unstable injury that can worsen during emergency treatment and transportation. A position paper summarizing this advocacy for selective use of immobilization was released by the American College of Surgeons Committee on Trauma and the National Association of EMS Physicians in 2013 and updated in 2018. The American College of Emergency Physicians 2015 position paper on this topic strongly recommends SMR be applied only when there is a clinical indication, not simply based on mechanism of injury.

There was one study done on an international cohort of patients that shows limited use of SMR results in better patient outcomes. Combined with the studies showing higher mortality in patients with penetrating trauma when standard immobilization was done, many emergency care providers have sought to change the process of packaging for trauma patients, particularly related to SMR.

Many EMS systems have adopted this approach and have modified their protocols to focus the use of SMR, and to use tools that only restrict the area of the spine at risk for bony or soft-tissue injury. These protocols are patient centered, focusing on the comfort of the patient and reducing the risks of secondary injury from full restriction on a rigid board. Implementation of protocols that reduce the use of full SMR requires coordination among EMS providers, emergency department personnel, and surgeons who participate in the regional systems of trauma care.

Patient-Specific and Appropriate Spinal Motion Restriction

The selective use of SMR in prehospital care is based on the following principles:

- Acute spine injuries that are unstable and have not already caused irreversible damage are the primary reason to place a patient on a rigid board. These situations are extraordinarily rare.
- Patients who have spinal column (bony) injuries are more common. The vast majority are already stable due to bony fragments forming an immovable complex due to swelling in the surrounding tissues, spasm of nearby muscles, and the patient's own ability to recognize injury and associated pain, particularly with movement.
- Injuries to the spinal column, even if they are unstable, are adequately stabilized with a simple process at the site of the injury and do not require SMR of the entire spine.
- Spine injury can occur at multiple sites in high-speed and impact mechanisms of injury, particularly if associated with head injury and an altered level of consciousness. Those victims will be most safely extricated and transported with SMR.
- Patients on spine boards report an increase of pain over time on the board. Many patients are at risk for significant and life-threatening complications of SMR, including respiratory insufficiency, loss of airway, aspiration and vomiting, as well as skin breakdown.

Based on the mechanism of trauma, SMR should be applied using protocols that account for the principles noted previously.

On arrival at the scene, as information is being gathered, it is appropriate to ask the patient to place and maintain his or her head and neck in a neutral position. Patients with high-velocity or high-impact injuries and those who are unconscious should be placed or maintained in a neutral position and prepared for SMR of the entire spine. Failing to prevent a spine injury that causes disability of the patient is among the greatest concerns of emergency care providers. These types of injuries almost always occur in patients who are already complaining about pain or loss of function or who are unconscious.

The patient complaining of pain along the spinal column should be examined and prepared for packaging of the area of the spine that is uncomfortable. Devices that reduce movement during prehospital treatment and transportation should not produce pain and should not distract any injury already present in the spinal column. The use of a comfortably firm, high-friction surface is rational, as is a surface that will dissipate energy during transport and movement. A vacuum mattress or the pad on a stretcher is ideal for this purpose, with straps applied to maintain the patient on the surface should collision or rapid change in direction of the transport vehicle occur. The patient should have his or her airway in a position where it can be assessed and protected and where respiratory effort is minimized. For many larger patients, elevation of the head of the stretcher 30–45 degrees (semi-Fowler's position) while maintaining SMR is the position of choice.

Rigid boards may be very useful to move the patient for short distances away from the emergency scene or in vertical movement of the patient out of a structure. The patient then may be transferred from the rigid board to the stretcher pad or mattress for transportation. ***The rigid spine board is a transfer, not a transport, device.***

For the many patients who have neck pain related to an injury event, cervical spine motion restriction with a short board or a cervical immobilization device may be utilized. Vehicle damage can predict those at highest risk for cervical spine injury and for injuries to the thoracic and lumbar spine and who will need complete SMR. Cervical spine motion restriction can be performed with lateral supports, the head being the most important element of care. A well-fitted anterior neck support will prevent gross flexion of the head should sudden movement occur.

Cervical collars decrease visible motion of the head and neck and provide immediate feedback to the patient that the rescuers want to minimize any gross movements of the cervical spine. Cervical collars do present some potential drawbacks, however. The collars do transfer movement to the ends of the device, and in unstable cervical injuries can cause the injured segments to distract. Tight collars can compromise the airway, may increase intracranial pressure, and decrease blood flow to the brain. Therefore, some patients have a collar placed during initial extrication, which is then removed when the patient is placed on an ambulance stretcher (or rigid board) with lateral cervical supports.

Lower-risk patients can have cervical spine motion restriction provided with an appropriate collar. There are many different collar configurations, divided into one- and two-piece designs, with features that can restrict motion higher or lower on the back, posterior scalp, and chest wall. None of the collar designs have proved to be any more effective in patient-oriented outcomes, so choice of a device should be based on patient comfort.

Patients with injuries to the thoracic area of the spine generally have injuries that are mechanically stable and best treated by placing the patient in a position of comfort that allows safe treatment and transportation. These patients may be very uncomfortable when placed on a rigid backboard, and older patients may develop skin breakdown in a short period of time.

The lateral recumbent position reduces the risk of aspiration versus the supine position. A patient may be placed in SMR and on the ambulance cot in the lateral position by appropriately padding the space between the side of the head and then securing the patient to the cot.

Patients with lumbar spine injuries can again be placed in a position of comfort on a stretcher pad or mattress and have their pelvises strapped to provide stability during transportation. Patients with isolated low-back injuries often express a preference as to how their lower backs can be positioned to reduce pain and how they wish to have their legs flexed or extended. Some injured patients will request placement on a rigid board, as long as they have some support to the tissue surfaces of the low back and buttocks.

Multiple studies have documented the increased mortality of patients with penetrating trauma who undergo complete spinal immobilization (Vanderlan et al. 2009; Velopulos et al. 2018). A number of medical organizations (American College of Emergency Physicians, American College of Surgeons Committee on Trauma [COT], National Association of EMS Physicians [NAEMSP]) have written statements that support limited SMR, except for the very rare patient who has a neurologic deficit or wound to the spinal area that is noted on prehospital evaluation. These patients require protocols that prioritize airway protection, optimize ventilation, protect from vomiting and aspiration, and require short prehospital times.

Complete SMR is important for the multiple trauma patient and victims of high-impact and high-velocity events. Unconscious trauma patients have a much higher incidence of spine injury. Current consensus (NAEMSP and COT) guidelines suggest that if transport times are short, such patients can be packaged on a long board to prevent movement of the spinal column during initial treatment and transportation. Patients with neurologic deficits should have them assessed carefully to determine if time and immobilization are preventing any further deterioration. If the spine is already deformed, it should be immobilized in the position found.

Summary of Patient-Centered Spinal Motion Restriction

Selective patient spine immobilization protocols have been developed and studied. Recent literature provides even greater support for use of limited SMR to improve patient comfort and the outcomes of a larger number of adult trauma patients. Children with significant head injuries are very difficult to evaluate in the prehospital environment, and it is wise for EMS providers to provide SMR while maintaining the airway and treating other traumatic injuries.

Not all trauma patients must be treated with complete SMR during prehospital treatment and transport. Many patients do not have spine injuries and therefore do not require any intervention for SMR. All patients who are being transported must be safe during movement in the vehicle, so securing them to an ambulance stretcher is mandatory. Trauma patients must have consideration of airway, respiratory function, and perfusion, and these are priority areas. For the conscious patient, selective immobilization will allow emergency care to be more comfortable for the patient and reduce injuries that result from strapping patients onto rigid boards.

The Normal Spinal Column and Cord

Spinal Column

spinal column: the 33 vertebrae that house and protect the spinal cord.

It is important to differentiate the **spinal column** from the spinal cord. The spinal column is a bony tube composed of 33 vertebrae (Figure 10-1). It supports the body in an upright position, allows the use of the extremities, and protects the delicate spinal cord. The column's 33 vertebrae are identified by their locations: seven cervical

(the C-spine), 12 thoracic (the T-spine), five lumbar (the L-spine), and the remainder fused together as the posterior portion of the pelvis (five sacral and four coccygeal). The vertebrae are numbered in each section, from the head down to the pelvis. The third cervical vertebra from the head is designated C3, the sixth is called C6, and so forth. The thoracic vertebrae are T1 through T12, and each attaches to one of the 12 pairs of ribs. The lumbar vertebrae are numbered L1 through L5, with L5 being the last vertebra above the pelvis.

The vertebrae are each separated by a fibrous disc that acts as a shock absorber. The alignment is maintained by strong ligaments between the vertebrae and by muscles that run along the length of the bony column from head to pelvis. (Those are the muscles strained when one lifts improperly.) The spinal column is aligned in a gentle S-curve that is most prominent at the C5–C6 and T12–L1 levels in adults, making those areas the most susceptible to injury.

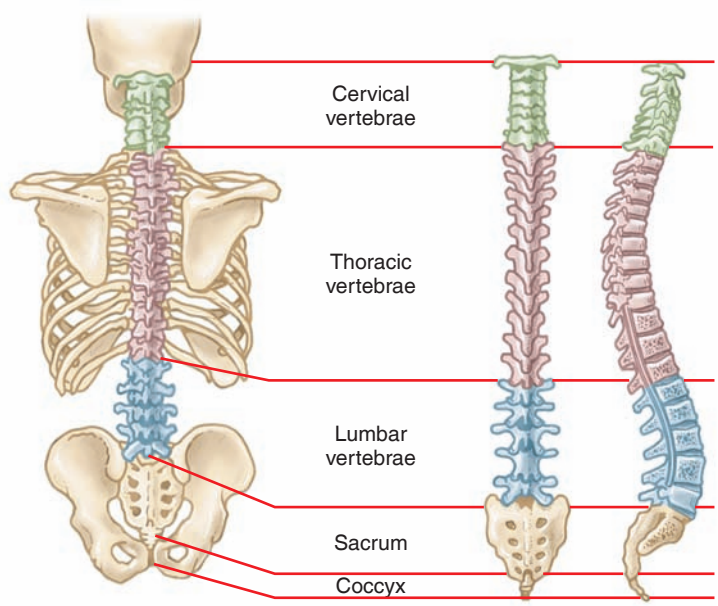


Figure 10-1 Anatomy of the spinal column.

Spinal Cord

The **spinal cord** is an electrical conduit that serves as an extension of the brainstem. In the adult, it is continuous down to the level of the first lumbar vertebra (L1) and at that point separates into nerves. The cord is 10–13 mm in diameter and is suspended in the middle of the vertebral foramen (Figure 10-2). The cord is soft and flexible like a cotton rope and is surrounded and bathed by cerebrospinal fluid along its entire length. The fluid and the flexibility provide some protection to the cord from injury.

The cord is composed of specific bundles of nerve tracts that are arranged in a predictable manner, much as a rope is composed of individual strands of fiber. The spinal cord passes down the vertebral canal and gives off pairs of nerve roots that exit at each vertebral level (Figure 10-3). The roots lie next to the intervertebral discs and the lateral part of the vertebrae, making the nerve roots susceptible to injury when trauma occurs in these areas (Figure 10-4). The nerve roots carry sensory signals from the body to the spinal cord and then to the brain.

spinal cord: an electrical conduit composed of specific bundles of nerve tracts. It connects the brain to the muscles and organs of the body.

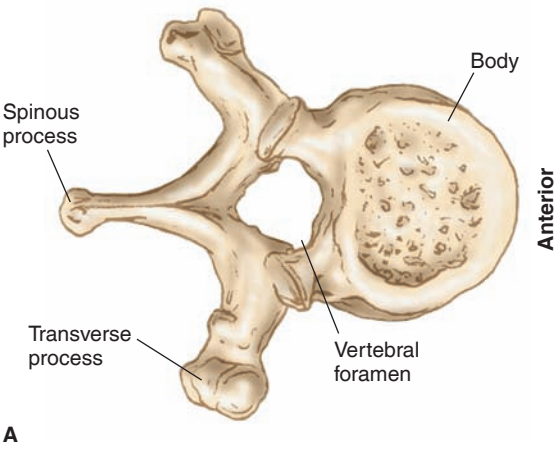


Figure 10-2a Vertebra viewed from above. The spinal cord passes through the vertebral foramen.

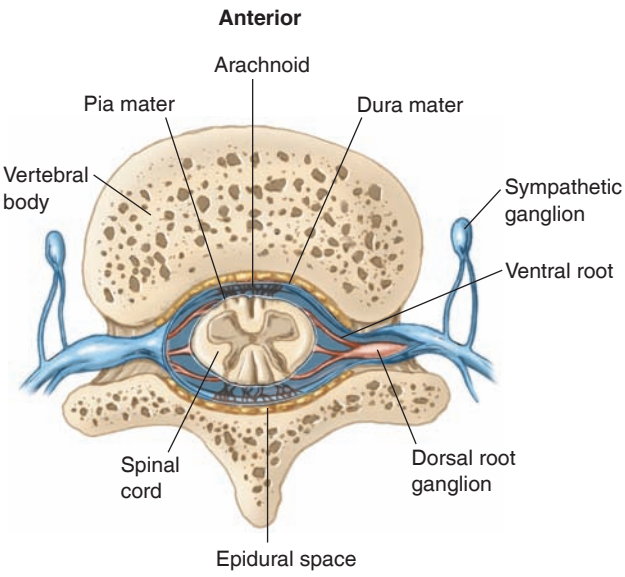


Figure 10-2b Vertebra with spinal cord in place.

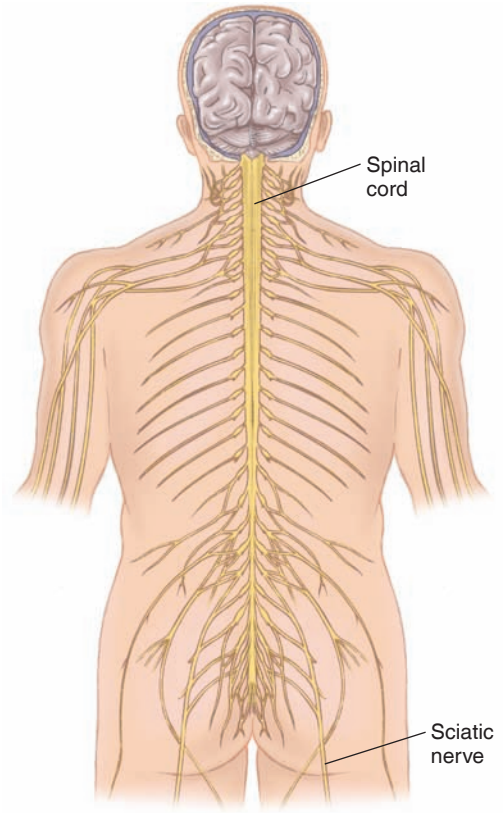


Figure 10-3 The spinal cord is a continuation of the central nervous system outside the skull.

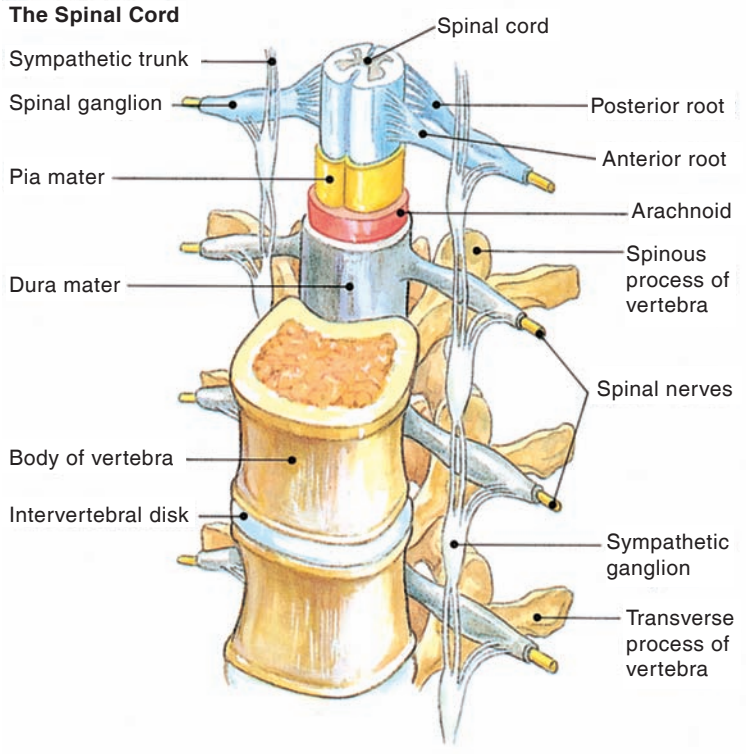


Figure 10-4 Relationship of the spinal cord to the vertebrae. Note how the nerve roots exit between the vertebrae.

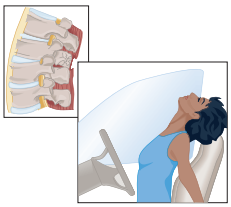
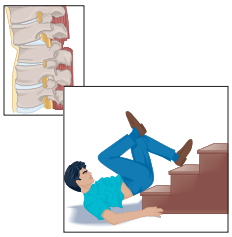
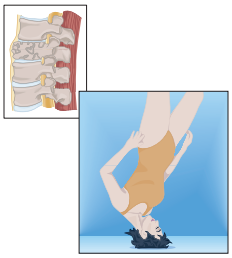
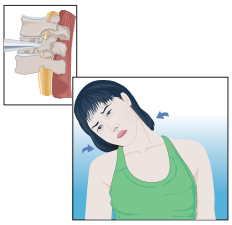
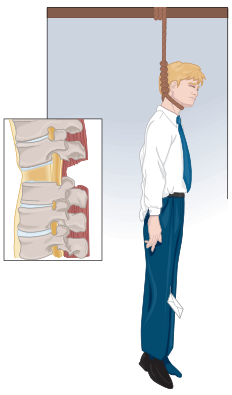
The roots also carry signals from the brain to specific muscles, causing them to move. Those signals pass back and forth rapidly, and some are strong enough to cause actions on their own, called *reflexes*. This reflex system can be demonstrated by tapping the patella tendon below the knee, causing the lower leg to jerk. If you accidentally put your finger on a hot burner, your reflex system causes your hand to move even before your brain receives the warning message.

The integrity of spinal cord function is tested by motor, sensory, and reflex functions. The level of sensory loss is most accurate for predicting the level of spinal cord injury. Muscle strength is another function that is easy to assess in the conscious patient. Reflexes are helpful for distinguishing complete from partial spinal cord injuries, but are best left for hospital assessment. The spinal cord is also an integrating center for the autonomic nervous system, which assists in controlling heart rate, blood vessel tone, and blood flow to the skin. Injury to this component of the spinal cord results in neurogenic shock (commonly called *spinal shock*), which is discussed later.

Spinal Injury

A normal healthy spinal column can be severely stressed and maintain its integrity without damage to the spinal cord. However, certain mechanisms of trauma can overcome the protective properties, injuring the spinal column and cord. The most common mechanisms are hyperextension, hyperflexion, compression, and rotation. Less commonly, lateral stress or distraction will injure the cord. Those mechanisms and their subsequent injuries are illustrated in Table 10-1.

Table 10-1: Mechanisms of Blunt Spinal Injury

Description		Examples
Hyperextension (excessive posterior movement of the head or neck)		Face into windshield in motor-vehicle collision (MVC) Older adult falling to the floor Football tackler Dive into shallow water
Hyperflexion (excessive anterior movement of head onto chest)		Rider thrown off horse or motorcycle Dive into shallow water
Compression (weight of head or pelvis driven into stationary neck or torso)		Dive into shallow water Fall of greater than 10–20 feet onto head or legs
Rotation (excessive rotation of the torso or head and neck, moving one side of the spinal column against the other)		Rollover MVC Motorcycle crash
Lateral stress (direct lateral force on spinal column, typically shearing one level of cord from another)		"T-bone" MVC Fall
Distraction (excessive stretching of column and cord)		Hanging Child inappropriately wearing shoulder belt around neck Snowmobile or motorcycle under rope or wire

Mechanisms of Blunt Spinal Column Injury

The head is a relatively large ball perched on top of the neck. Sudden movement of the head or trunk will produce stresses that can damage the bony or connective tissue components of the spinal column. Injury to the spinal column is similar to injury to any other bone in the body. It requires a significant amount of force, unless there is a preexisting weakness or defect in the bone. For that reason, older adults and those with severe arthritis are at higher risk for spine injuries.

Like with other bone injuries, pain is the most common symptom of blunt spinal column injury, but it may be unnoticed by the patient, especially if the patient has other very painful injuries. At the site of a bone injury, local muscle spasm may occur. Injury to individual nerve roots can result from bony spinal column injury, with resulting localized pain, paralysis, or sensory loss. Therefore, signs that indicate spine injury include back pain, tenderness along the spinal column, pain with movement of the back, obvious deformity or wounds of the back, paralysis, weakness, or **paresthesia** (tingling or burning feeling to the skin).

paresthesia: abnormal sensation; a "tingling" or "burning" sensation.

Fortunately, spinal column injury can occur without injuring the spinal cord. In the cervical spine region it is much more common to have cord injury associated with column injury, with almost 40% of column injuries also having cord damage. The converse is also possible, in that cord injuries can occur in the absence of obvious spinal column damage. This is particularly true in children and is referred to as *spinal cord injury without radiographic abnormality (SCIWORA)*.

Pathophysiology of Spinal Cord Injury

Spinal cord injury results in a defective signal-conducting function, presenting as a loss of motor function and reflexes, loss or change in sensation, or neurogenic shock. The delicate structure of the spinal cord's nerve tracts makes it very sensitive to any form of trauma. What is termed **primary spinal cord injury** occurs at the time of the trauma itself. Primary spinal cord injury results from the cord being cut, torn, or crushed or by its blood supply being cut off. The damage is usually irreversible despite the best trauma care. **Secondary spinal cord injury** occurs from poor perfusion, generalized hypoxemia, injury to blood vessels, swelling, compression of the cord from surrounding hemorrhage, or injury to the cord from movement of an unstable spinal column. Emergency efforts are directed at preventing secondary spinal cord injury through attention to the ABCs, medications, and careful packaging of the patient.

primary spinal cord injury: injury to the spinal cord that occurs at the time of the trauma itself. This injury results from the cord being cut, torn, or crushed or by its blood supply being cut off.

secondary spinal cord injury: injury to the spinal cord that occurs from hypotension, generalized hypoxia, injury to blood vessels, swelling, compression of the cord from surrounding hemorrhage, or injury to the cord from movement of a damaged and unstable spinal column.

Neurogenic Shock

Injury to the cervical or thoracic spinal cord can produce shock as a result of a relative hypovolemia (see Chapter 4). Neurogenic shock results from the malfunction of the autonomic nervous system in regulating blood vessel tone and cardiac output. Classically, neurogenic shock results in hypotension, with normal skin color and temperature and an inappropriately slow heart rate in contrast to the tachycardia normally seen with hypovolemic shock.

In the healthy patient, blood pressure is maintained by the controlled release of catecholamines (epinephrine and norepinephrine) from the adrenal glands, as well as signals from autonomic nerves innervating the arteries. Sensors in the aortic and carotid arteries monitor the blood pressure. Catecholamines cause constriction of the blood vessels, increase the heart rate, increase the strength of heart contractions, and stimulate sweat glands. The brain and spinal cord signal the adrenal glands to release catecholamines to keep the blood pressure in the normal range. In pure hemorrhagic shock, those sensors detect the hypovolemic state and compensate by constricting the blood vessels and speeding the heart rate. The high levels of catecholamines cause pale skin, tachycardia, and sweating.

The mechanism of shock from spinal cord injury is just the opposite. There is no significant blood loss, but the injury to the spinal cord destroys the ability of the brain

PEARLS

High-Space Shock

Injury to the spinal cord can produce high-space shock, with the patient experiencing hypotension, normal skin color and temperature, and an inappropriately slow heart rate.

to regulate the release of catecholamines from the adrenals (no messages reach the adrenals), so no catecholamines are released. In addition, direct signals to the arteries are lost. When the levels of catecholamines drop, the blood vessels dilate, lowering peripheral vascular resistance. Venous vessels also dilate, resulting in a lowered venous return. This drop in preload of the heart causes the blood pressure to fall. The brain cannot correct this because it cannot get the message to the adrenal glands.

The patient with neurogenic shock cannot show the signs of pale skin, tachycardia, and sweating because the cord injury prevents release of catecholamines. Intra-abdominal injury is difficult to evaluate because the patient with neurogenic shock usually has a spinal cord injury above the level of the abdomen so there is no sensation in the abdomen. The multiple-trauma patient may have both neurogenic shock and hemorrhagic shock. Neurogenic shock is a diagnosis of exclusion, after all other potential causes of shock have been ruled out.

Treatment of neurogenic shock, in the field, is focused on fluid resuscitation to maintain perfusion and prevent secondary injury to the nervous system. Because concurrent hemorrhage cannot be ruled out in the field, the use of vasoactive agents is not usually recommended, especially before fluid resuscitation is completed. (See Chapter 4.)

Assessment of the Trauma Patient

Assessing for Possible Spinal Injury

All trauma patients are evaluated in the same manner using the ITLS Primary Survey, of which evaluation of spinal cord function is a part. Clues to spinal cord injury are given in Table 10-2. Parts of the neurological exam are performed during the ITLS Primary Survey, and the remainder of the neurological exam is performed during the ITLS Secondary Survey. This is frequently done after the patient is loaded into the ambulance.

PEARLS

Motor and Sensory Function

Perform brief motor and sensory checks in the upper and lower extremities before and after moving any patient.

Table 10-2: Clues to Spinal Cord Injury Revealed During Patient Assessment

Mechanism of Injury
Blunt trauma above the clavicle
Diving accident
Motor-vehicle or bicycle crash
Fall
Stabbing or impalement anywhere near the spinal column
Shooting or blast injury to the torso
Any violent injury with forces that could act on the spinal column or cord
Patient Complaints
Neck or back pain
Numbness or tingling
Loss of movement or weakness
Signs Revealed During Assessment
Pain on movement of back or spinal column
Obvious deformity of back or spinal column
Guarding against movement of back
Loss of sensation
Weak or flaccid muscles
Loss of bladder or bowel control
Erection of the penis (priapism)
Neurogenic shock

Focused Evaluation of the Spinal Cord

All unconscious trauma patients should be treated as if they have spine injuries. Conscious and cooperative patients can be assessed for potential spine injury by asking about pain, numbness, unusual sensations, and ability to move. Trauma patients who report new symptoms of weakness or numbness of arms or legs must be assumed to have spine injuries and treated as such. The examination of the patient includes these elements:

- *Pain.* The patient may be aware of pain in an area around the spine and of blunt or penetrating injuries near the spine.
- *Numbness.* Rescuers should examine the suspected area and report any areas where the patient reports no feeling or where the patient does not feel the rescuer touching the area.
- *Tenderness.* Emergency care providers should examine the suspected area and report any associated pain with touching or movement of the area around the spine.
- *Painful movement.* If the patient tries to move the area of potential injury, the pain may increase. In patients with potential spine injuries, it is not necessary for emergency care providers to have the patient move the spinal area.
- *Deformity.* Deformity is rare, although there may be an abnormal bend or bony prominence.
- *Lacerations, holes, or skin wounds such as bruises.* Patients with injuries in the area of the spine may have wounds in the back or abdomen.
- *Paralysis.* The patient is unable to move or hold a part of the body against gravity.

emergency rescue: the immediate removal, without use of SMR, of a patient from an immediately life-threatening situation.

rapid extrication: the rapid removal of a patient from a dangerous position or situation using modified SMR.

The patient who requires extrication is a special situation. Before beginning extrication, rescuers should check sensory and motor function in the hands and feet and document the findings later in the written report. Not only does this pre-extrication neurological exam give an indication of spinal injury, but it also provides documentation on whether or not there was loss of function before extrication. Sadly, there are a few reports of patients who have claimed that their spinal injuries were caused by their rescuers. In patients who require **emergency rescue** and in some of the patients needing **rapid extrication** (discussed later), there will not be sufficient time to perform a pre-extrication neurologic exam.

The ITLS Primary Survey must be time-efficient. If the conscious patient can move his or her fingers and toes, the motor nerves are intact. Anything less than normal sensation (tingling or decreased sensation) is suspicious for cord injury. The unconscious patient may withdraw from a pinch of the fingers and toes. If so, the patient has demonstrated intact motor and sensory nerves and thus an intact cord. All unconscious trauma patients should be placed in SMR. Flaccid paralysis and no reflexes or withdrawal, even in the unconscious patient with a head injury, strongly suggests spinal cord injury. Document those important findings. (The neurologic exam is described in more detail in Chapters 2 and 12.)

PEARLS

Emergency Rescue

Emergency rescue is reserved for those situations in which there is immediate (within seconds) environmental threat to the life of the victim and/or rescuer. Patients should be moved to a safe area in a manner that places the rescuer at the least risk.

Rapid extrication should be considered for patients whose medical conditions or situations require fast intervention (1 or 2 minutes—but not seconds) to prevent death.

Management of the Trauma Patient

Minimizing Spinal Movement

Two types of situations require modification of the usual SMR. The patient who is in immediate danger of death in a hostile environment or in an immediate life-threatening position in a structure or vehicle may require emergency rescue. An example would be the patient who is in a motor-vehicle collision and the auto is on fire. In this situation, even a few seconds can mean the difference between life and death, and rescuers are justified in saving the patient in any way possible. Any time this manner of rescue is used, document the reason and notify the staff at the emergency department where the patient is transported.

Some examples of situations that might require emergency rescue are when scene size-up identifies a condition that could immediately endanger you or the patient, such as:

- Fire or immediate danger of fire or explosion
- Hostile environment, gunfire, or the presence of other weapons
- Danger of being carried away by rapidly moving water
- Structure in immediate danger of collapse
- Continuing immediately life-threatening toxic exposure

The second situation that requires modification of usual SMR is for patients whose ITLS Primary Survey indicates a critical degree of ongoing danger that requires an intervention within 1 or 2 minutes. Indications for rapid extrication are the following:

- Airway obstruction that cannot be relieved by a modified jaw-thrust maneuver or a finger sweep
- Cardiac or respiratory arrest
- Chest or airway injuries requiring ventilation or assisted ventilation
- Deep shock or bleeding that cannot be controlled

Rapid extrication requires multiple rescuers who remove the patient along the long axis of the body, using their hands to minimize movement of the spine (see skills in Chapter 11). When the rapid extrication technique is used, the written report should be carefully reviewed to ensure appropriate documentation of the technique and its indication.

The most easily applied and readily available method of cervical motion restriction is with the rescuer's hands or knees. Hands should be placed to stabilize the patient's neck in **neutral alignment** to the long axis of the spinal column (Figure 10-5). "Pulling traction" is not a prehospital option, and the term *traction* is not an appropriate description for motion restriction of the spine. Traction usually results in further instability of any spinal column injury. The correct approach is stabilization, with no pulling on the neck. When packaging the body on a stretcher (or backboard), the neutral in-line position allows the most room for the spinal cord, so that is the optimal position for SMR.

PEARLS

Traction

Do not apply traction to the head and neck. Maintain in-line stabilization of the head, neck, and spine.

neutral alignment: aligning the patient according to the baseline physiologic spinal position.

Emergency care providers can place an appropriately sized cervical collar on the patient as airway assessment is being done. The one- or two-piece collars are not definitive devices for restricting cervical spine motion, but should be used only as a reminder that SMR is necessary and to prevent gross neck movement. The rescuer's hands can be removed only when the patient (head and body) has been secured to the transport device with an attached head-motion restriction device.

For the conscious patient, having the head and neck in a position of comfort is a good guideline. Adequate strapping must secure the head, torso, and upper legs to the stretcher. Inadequate strapping will torque the neck against the body if the patient moves, rolls, or is dropped or rotated.

Placing and strapping a patient on the stretcher effectively eliminates the patient's ability to protect the airway. Once a patient is secured to the transport device, a rescuer must be present and capable of rolling the patient if the patient begins to vomit or loses his or her airway. This rule continues in effect in the emergency department, where an emergency department staff person must assume responsibility for airway protection.

PEARLS

Protecting the Airway

A patient in SMR is at risk for aspiration and other problems. You are responsible for checking and maintaining the airway.

Definitive SMR occurs when the body is strapped securely to the stretcher (or board with cushions, blanket, or towel rolls), maintaining the head, cervical spine, torso, and pelvis in line. Sandbags are not useful in the field for this purpose. When applied properly, such devices allow removal of the front portion of the cervical collar and observation of the neck, as in the patient with open neck wounds.

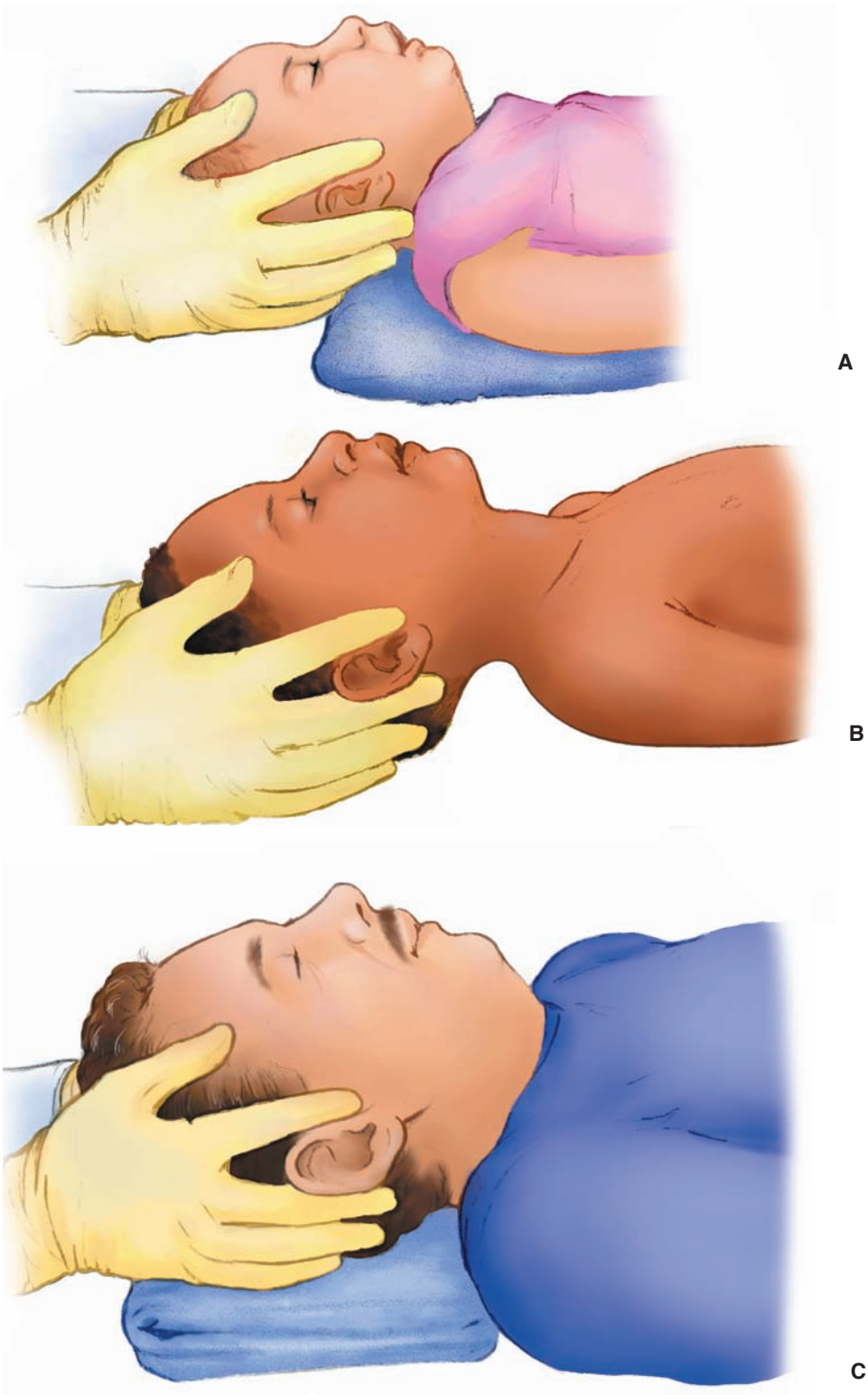


Figure 10-5 Neutral spinal positioning for infant, child, and adult patients. A. Due to the large heads of younger children, you may need to raise the shoulders with padding. B. In older children, obtain neutral positioning with shoulders and head on a flat surface. C. With adults, elevate the head one to two inches.

Some patients (frightened children and patients with altered mental status) will struggle so violently that they defeat any attempts to eliminate movement of the spine. There may be no good solution to this. The Reeves™ sleeve (see Figure 10-8A) is one device to restrict spinal motion in the combative adult patient. Always carefully document those situations in which the patient refuses to cooperate with SMR.

Older adult patients whose necks have a natural flexed posture will require posterior padding. This is accomplished with the head pad on a cervical-motion restriction device or the padding used when placed on a stretcher. Because their heads are proportionately larger, children usually require padding under the shoulders to prevent neck flexion when supine.

Spinal Motion Restriction in the Trauma Patient

Full SMR is not indicated in every trauma patient. SMR should be applied appropriately to a patient who has indicators that they may have sustained or are high risk for spine injuries or who cannot be adequately assessed clinically due to an altered level of consciousness. Emergency care providers should apply the appropriate guideline in these situations (see Figure 10-6) and apply a cervical collar, if needed. SMR is accomplished when the trauma patient is appropriately secured to the mattress or, rarely, to a rigid backboard. SMR can be accomplished without the patient being on a long spine board.

The long rigid board is primarily an extrication device designed to move a patient to a transport stretcher. Having the patient remain on the board for prolonged periods can produce discomfort, pressure sores, and respiratory compromise. Patients should be removed from the long spine board when it is safe and practical to do so in order to minimize negative occurrences.

Immobilization onto a long backboard is not indicated in penetrating wounds of torso, neck, or head unless there is clinical evidence of a spine injury.

Research points out that emergency care providers should not apply any neck traction or allow the cervical collar or device to purposely, accidentally, or unintentionally extend the neck upward during application, adjustment, or tightening. This is particularly true for patients who could have very unstable injuries to the spinal column. In those patients, traction would pull the spinal cord apart or worsen an existing injury.

In certain situations, once the patient is packaged onto the backboard, the board and patient might have to be rolled up onto the side (Figure 10-7) for prevention of aspiration. Careful strapping can prevent lateral movement of the spine in this situation, but use of the vacuum backboard is far superior.

Also, recent research (Hyldmo et al. 2017) shows that SMR may be maintained with the patient in a lateral position.

Patients with airway problems who are not intubated are better transported on their side. This is especially critical when there is uncontrolled bleeding into the airway or if there is massive face or neck trauma. In those situations gravity helps drain fluids out of the airway and could prevent aspiration if the patient vomits. Because of the danger of vomiting and aspiration, especially in unconscious patients who are not intubated, an emergency care provider should remain with them at all times.

The Log Roll

The log-roll technique is used for moving a patient onto a backboard. It is commonly used because it is easy to perform with a minimum number of rescuers. As yet, no technique has been devised that maintains complete spinal immobilization while moving a patient onto a backboard. Properly performed, the log-roll technique minimizes movement of the spinal column as safely and efficiently as any other technique for moving a patient onto a backboard.

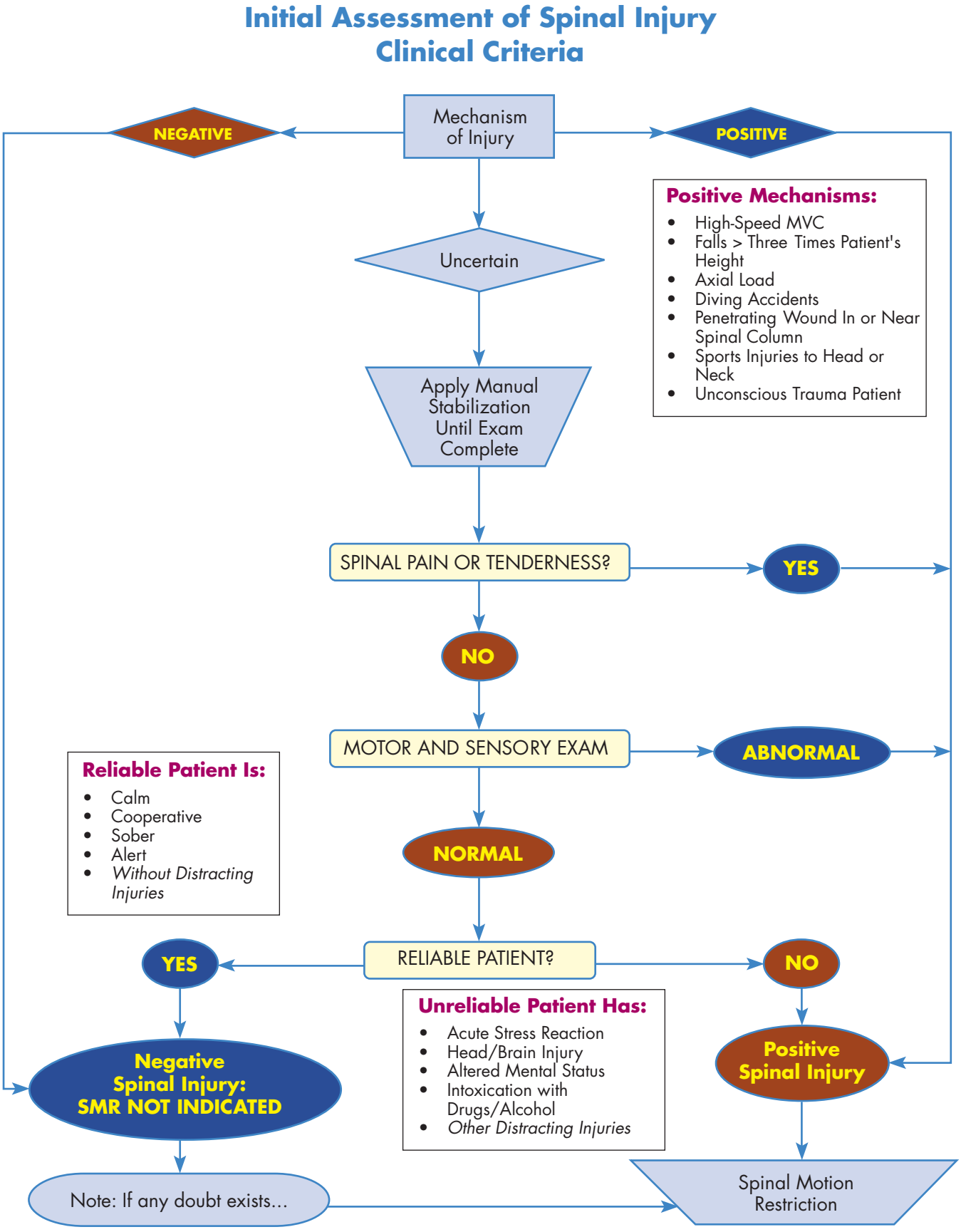


Figure 10-6 Decision tree for spinal motion restriction. *(Reprinted by permission of Peter Goth, MD)*

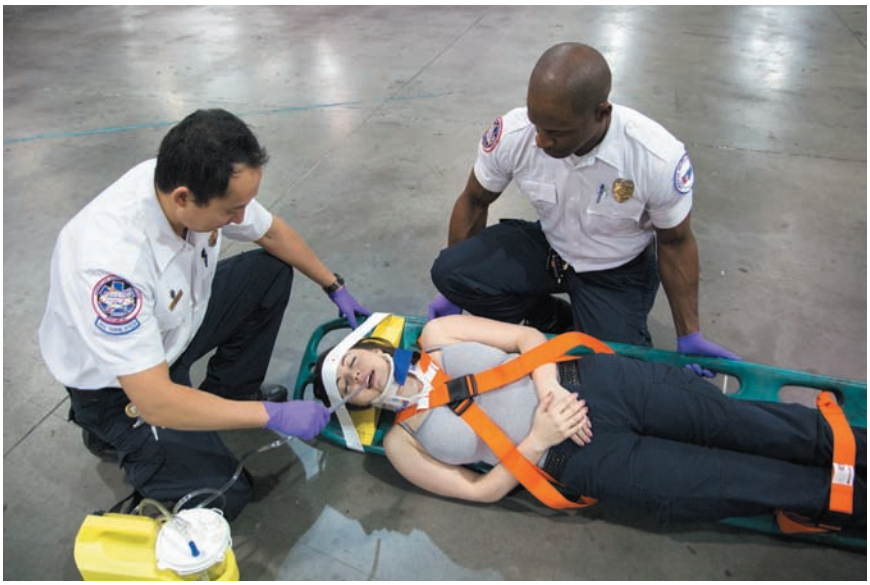


Figure 10-7 Patient on backboard turned on side.

The log-roll technique moves the spinal column as a single unit with the head and pelvis. It can be performed on patients lying prone or supine. Using three or more rescuers—controlled by the rescuer at the patient's head—the patient (with the arms at his or her side) is rolled onto the uninjured side, a board is slid underneath her, and the patient is rolled face up onto the board. The log-roll technique is then completed when the patient's chest, pelvis, and head are secured to the board.

The log roll may be modified for patients with painful arm, leg, and chest wounds who need to be rolled onto their uninjured side. The side to which you turn the patient during the log-roll procedure is not critical and can be changed in situations in which you can only place the backboard on one side of the patient.

The log-roll technique is useful for most trauma patients, but for patients with an unstable fractured pelvis, rolling their weight onto the pelvis could aggravate the injury. If the pelvic fracture appears stable, the log roll should be carefully performed, turning the patient onto the uninjured side (if it can be identified). Patients with obviously unstable pelvic fractures should not be log-rolled, but should be lifted carefully onto a board by four or more rescuers (straddle slide). The straddle slide is another technique to lift the patient from the ground onto a transport device. The scoop stretcher could also be used to move patients with unstable pelvic fractures onto the backboard.

Spinal Motion Restriction Devices

A wide range of devices that provide SMR for injured patients is available in the marketplace (Figure 10-8). No device has yet been proven to excel over all others, and no device will ever be produced that can be used to provide SMR for all patients. No device is better than the crew using it. Training with the available tools is the most critical factor in providing good patient care.



A



B



C



D



E

Figure 10-8 A. Reeves™ sleeve; B. Miller body splint; C. pediatric SMR device; D. Kendrick extrication device; E. short backboard.

Complications of Spinal Motion Restriction

There are complications of strapping a patient to a board. The patient will be uncomfortable and will often complain of head and low-back pain that is directly related to being strapped onto the hard backboard. The head and airway are in a fixed position, which can produce airway compromise and aspiration if the patient vomits. Obese patients and those with congestive heart failure can suffer life-threatening hypoxia. On a rigid board there is uneven skin pressure that can result in pressure sores. Lifting the patient and the board can cause injuries to rescue personnel. SMR should be applied appropriately to those who will most likely benefit, and it should be avoided if not necessary.

Airway Intervention

When the rescuer performs SMR in any manner, the patient loses some of his or her ability to maintain the airway. As mentioned earlier, the rescuer must then assume this responsibility until the patient has a controlled airway or has the spinal column cleared in the emergency department and is released from the motion-restricting equipment (Figure 10-9). This is particularly critical in children, who have a greater potential for vomiting and aspiration after a traumatic injury.



Figure 10-9 Suctioning of airway while secured on a backboard.

Airway manipulation in the trauma patient requires careful application. Current research indicates that any airway intervention will cause some movement of the spinal column, but it is likely that movement will not worsen any injury that is present. Obtaining and controlling an airway is clearly a priority compared to the small risk of a spine injury. In-line manual stabilization is the most effective manner for minimizing this movement.

Nasotracheal and orotracheal intubations or a cricothyrotomy all induce some bony movement. The ITLS Primary Survey should include manual stabilization followed by the use of the airway control method you are most skilled at performing. When weighing the risks and benefits of each airway procedure, recall that the risk of dying with an uncontrolled airway is greater than the risk of inducing spinal cord damage using a careful approach to intubation.

Special Spinal Motion Restriction Situations

Rescuers must stabilize the spinal column of all patients who sustain major trauma. In some patients (see the following sections), traditional techniques must be modified to provide safe and effective SMR.

Closed-Space Rescues

Closed-space rescues are performed in a manner appropriate for the clinical condition of the patient. The only general rules that can be applied to these rescues are to prevent gross spinal movement and to move patients in line with the long axis of the body (Figure 10-10). Safety of the rescuer is of prime importance in all closed-space rescues. Asphyxia, toxic gases, and structure collapse are dangers of closed-space rescue and may require the use of emergency rescue. Rescuers should never enter a closed space unless properly trained, equipped (air pack, safety line, and so on), and sure of scene safety.

Water Emergencies

Water rescues are performed by moving the patient in line, thereby preventing gross spinal movement. When the rescuers are in a stable position for performing SMR, the backboard is floated under the patient, and the patient is then secured and removed from the water (Scan 10-1). Safety of both rescuers and patients is of paramount



Figure 10-10 Patient entrapped in trench cave-in being lifted out along the long axis of the body. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

importance. Rescuers should not attempt to rescue victims in hazardous situations such as deep or swift water without proper training or equipment.

Prone, Seated, and Standing Patients

Prone, seated, and standing patients are stabilized in a manner that minimizes spinal column movement, ending with the patient in the conventional supine position. (See Chapter 11 for techniques.)

- Prone patients are either log-rolled onto a backboard, with careful coordination between the emergency care providers performing it, or moved using a scoop stretcher.
- Seated patients may be stabilized using short backboards if they have an indication for SMR. Used appropriately, short backboards can provide initial stabilization of the cervical and thoracic spine and can be used to transfer the patient onto the transport stretcher.
- Standing patients do not need to be placed on a spine board, especially if they are ambulatory on the scene. If a standing patient has an indication for SMR, he or she may be assisted to sit on the ambulance stretcher while maintaining manual SMR.



Figure 10-11 Most children require padding under back and shoulders to keep the cervical spine in a neutral position. *(Photo courtesy of Bob Page, NREMT-P)*

Pediatric Patients

It is best to provide initial SMR of the pediatric patient with the rescuer's hands, and then use cushions or towel rolls to help secure the child on an appropriate board or device. Some pediatric trauma specialists suggest padding beneath the back and shoulders on the board in a child under the age of 3 years. (See Figures 10-5 and 10-11.) Those children normally have a relatively large head that flexes the neck when placed on a straight board. Padding under the back and shoulders will prevent this flexion and also make the child more comfortable.

SCAN 10-1 Water Rescue





Figure 10-12 Infant secured in car seat. *(Photo courtesy of Andrey Kekyalyaynen/Alamy)*

Previously it was believed that children who are involved in a motor-vehicle collision while restrained in a child safety seat but have no apparent injuries may be packaged in the safety seat for transport to the hospital. Recently released guidance from the National Association of State EMS Officials (NASEMSO) states that patients transported in an ambulance should be secured to an age- and size-appropriate restraint system that is properly secured to the ambulance or ambulance stretcher. If there is a consideration of spine injuries, which would be very rare, rescuers can use towel or blanket rolls to secure the child in an EMS supplied safety seat that is properly secured to the ambulance or ambulance stretcher (Figure 10-12).

When the child is in a car seat that is damaged, or in a built-in child-restraint seat that cannot be removed, the child must be removed for SMR. Children in such situations will have to be carefully extricated onto a pediatric SMR device using manual stabilization. For the child who is frightened and struggling, there may be no good way to obtain SMR. Careful reassurance, the presence of a comforting family member, and gentle management will help prevent more complications and further struggling.

PEARLS

Car Seats

Children should be transported in the ambulance using a size- and age-appropriate restraint system, properly secured to the ambulance cot or stretcher.

If the child is uninjured and there is no other appropriate restraint system available, the child's car seat can be used, as long as it is undamaged and properly secured in the ambulance. Consult local guidelines and protocols for definitive guidance.

Older Adult Patients

Older adult patients require flexibility in packaging techniques. Many older patients have arthritic changes of the spine and thin, frail skin. Such patients will be very uncomfortable when placed supine. Some arthritic spines are so rigid that the patient cannot be laid straight on the stretcher, and some older patients have rigid flexion of the neck that will result in a large gap between the head and the stretcher. You can make use of towels, blankets, and pillows to pad these patients and prevent movement and discomfort on the backboard (Figure 10-13). This is a situation in which the vacuum backboard (which conforms to the shape of the patient) works very well.



Figure 10-13 Additional padding, such as rolled blankets or towels behind the head, may be needed to keep the head in a neutral, in-line position.

Patients in Protective Gear

Large helmets used in sports and cycling must be removed at some point to permit complete assessment and care. Helmets used in different sports present different management problems for rescuers. Football and ice hockey helmets are custom-fitted to the individual. Unless special circumstances exist, such as respiratory distress coupled with an inability to access the airway, the helmet may not need to be removed in the prehospital setting.

Athletic helmet design will generally allow easy airway access once the face guard is removed. The best way to remove a face guard is with a screwdriver. (A cordless screwdriver is best.) One should be on every response vehicle. However, sometimes the screw slot strips out, and the face guard will have to be cut off. There are commercial devices that can do this, but they cost 10–20 times as much as plain anvil pruning shears. The anvil pruning shears are just as satisfactory for removing a face guard (Figure 10-14).



Figure 10-14a The face guard of a football helmet can be removed with a screwdriver or pruning shears. *(Photo courtesy of Jeff Hinshaw, MS, PA-C, NREMT-P)*



Figure 10-14b Anvil pruning shears (*left*) or a face mask extractor (*right*) can be used to remove a football helmet face guard. *(Photo courtesy of Jeff Hinshaw, MS, PA-C, NREMT-P)*

The athlete wearing football shoulder pads usually has his neck in a neutral position when on the stretcher or backboard with the helmet in place. If the helmet is removed, padding must be inserted under the head to keep the neck from extending (Figure 10-15). After arrival at the emergency facility, the cervical spine can be x-rayed with the helmet in place. Once the spine is evaluated, the helmet can be removed by stabilizing the head and neck, removing the cheek pads, releasing the air inflation system, and then sliding the helmet off in the usual manner.

For prehospital providers, field removal of an athletic helmet is best performed in coordination with the athletic trainer and should be considered in certain patient-care situations. The four main reasons to consider field athletic helmet removal are:

- Face mask cannot be removed in a timely fashion.
- Airway cannot be controlled due to the design of the helmet and chin strap.
- Helmet and chin straps do not hold the head securely.
- Helmet prevents stabilization for transport in an appropriate position.

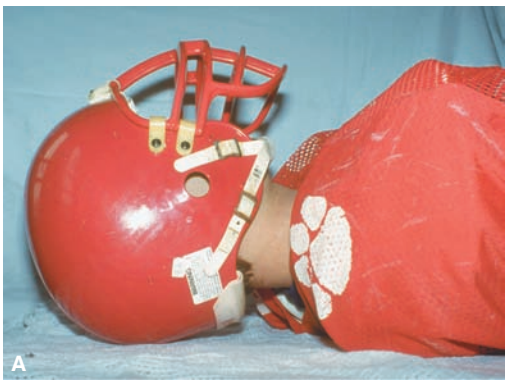




Figure 10-15 A. Patients with shoulder pads and helmets are usually best immobilized with the helmet in place. The spine is maintained in a neutral position with a minimum of movement. *(Photo courtesy of Bob Page, NREMT-P)* B. Patients with shoulder pads must have padding under the head to maintain a neutral position if the helmet is removed.



Figure 10-16 Full-face helmets obstruct access to the patient's airway. Notice that the helmet flexes the neck in a patient who is not wearing shoulder pads.
(Photo courtesy of Bob Page, NREMT-P)

When removing an athletic helmet, it is imperative to cut the chin strap and not attempt to unsnap or unbuckle the device.

Football shoulder pad removal is often linked to helmet removal in the athletic setting. Not only is this done routinely with helmet removal, but it is also done when faced with the inability to maintain neutral cervical spine alignment (often due to ill-fitting shoulder pads), when you are unable to secure the athlete to the stretcher or spine board, and when you need access to the chest for resuscitation efforts. Most shoulder pads can be removed by cutting the axillary straps and the laces on the front of the appliance, opening the appliance from the core outward (like a clam shell), and sliding the appliance out from under the athlete.

In contrast, motorcycle helmets are usually removed in the prehospital setting. The removal technique is modified to accommodate the different designs. Motorcycle helmets are often designed with a continuous solid face guard that limits airway access. Those helmets are not custom-designed and are frequently poorly fitted to the patient. Their large size will usually produce significant neck flexion if left in place when the patient is positioned on a backboard or ambulance stretcher (Figure 10-16). The motorcycle helmet can make it difficult to stabilize the neck in a neutral position, obstruct access to the airway, and hide injuries to the head or neck. It should be removed in the prehospital setting, using the techniques described in Chapter 11.

Very Large or Obese Patients

Very large or obese patients, also known as bariatric patients, might not fit appropriately in standard equipment. Many agencies have modified stretchers to accommodate such patients. Rescuers may have to improvise SMR devices such as towel rolls or blankets to perform SMR. Any immobilized large patient should have the head of the stretcher elevated (semi-Fowler's position) to help prevent respiratory compromise. Larger patients who do not have spine injuries should be transported in an upright position, which is typically the position of comfort. In cold climates, patients in bulky warm clothing will need to be snugly secured to prevent excessive movement.

Patients with Neck Wounds

Patients with penetrating and disfiguring wounds of the neck or lower face must be continually observed. Cervical collars should not be used because they will prevent continued examination of the wound site and could compromise the airway in wounds with expanding hematomas or subcutaneous air. If the mandible is fractured, the collar might again cause airway compromise. Therefore, for patients with such injuries, it may be wise to avoid collars and use instead manual stabilization and head cushion devices or blanket rolls for cervical motion restriction.

Case Presentation *(continued)*

You are at the scene of a two-vehicle collision involving a car and a small truck that has rolled over. You are asked to check on the driver of the overturned tanker, who extricated himself from the truck and is standing, talking to a police officer.

All emergency care providers have donned personal protective equipment. The fire department has informed you that all hazards are controlled. You approach the truck driver from his front and ask him not to move his head. You note that he is ambulatory and says he is alright. He says his neck is stiff. Because he is speaking, answering questions, and walking, you conclude that his primary survey is intact. He has no pain on palpation of his cervical spine or the paraspinal muscles and he has been moving his neck without problems before you reached him to start your assessment. At this point you conclude he does not require spinal motion restriction and you begin your secondary assessment, which is remarkable only for some abrasions. At this point the driver states he does not wish to go to the hospital and you begin to discuss refusal of care with him.

Your partner, who has been assessing the female patient in the front passenger seat of the car, now asks you to help. She has a damaged windshield in front of her. Your partner has placed her in manual SMR. She reports some tingling in her arms. She speaks in full sentences and denies shortness of breath or chest pain. No reported loss of consciousness. Primary survey shows intact airway, no evidence of chest or abdominal trauma. Secondary survey shows contusion on top of her head. She has tenderness to palpation of the mid portion of her cervical spine. No focal neurologic deficits except for tingling in both her arms and weakness of her grips compared to lower-extremity strength. Vital signs are pulse, 75; blood pressure, 166/96; and respirations, 14. Her pupils are equal and reactive.

Given the mechanism of injury and the exam findings, this patient is at risk for a significant spine injury and you and your partner decide to place her into SMR. A correctly sized cervical collar is applied and with the assistance of the fire department she is placed onto a long spine board for extrication from the vehicle and onto the ambulance stretcher. Once in the ambulance, given the distance to the trauma center, it is decided to remove her from the long spine board and secure her to the ambulance stretcher. While performing the log roll (as described in Chapter 11), the remainder of her spine is palpated and no tenderness is noted. She is placed on a nasal cannula. Reassessment en route remains unchanged.

Subsequently, evaluation at the trauma center showed spinal cord contusion upon magnetic resonance imaging but no fractures of the spinal column. She recovered from her injury uneventfully.

Summary

Spinal cord injury is a devastating consequence of trauma. Unstable or incomplete damage to the spinal column or cord is not completely predictable. Therefore, trauma patients who are unconscious or who have any dangerous mechanism of injury affecting the head, neck, or trunk should have SMR. Less severely injured and cooperative patients can be packaged and transported with less restrictive devices, such as a cervical collar. Special trauma situations may require special SMR techniques. Once SMR is performed, the patient loses some ability to control his or her airway, so EMS providers must be prepared at all times to intervene should the airway become compromised. Above all, the emergency care provider must understand that SMR is not only the application of a long spine board, but a series of steps to match patient needs with appropriate interventions.

References and Resources

American College of EMS Physicians Board of Directors. 2015. "EMS Management of Patients with Potential Spinal Injury." *Practice Management Policy Statement*. Accessed March 1, 2015. http://www.acep.org/Physician-Resources/Policies/Policy-Statements/EMS-Management-of-Patients-with-Potential-Spinal-Injury

Anderson, R. C., P. Kan, M. Vanaman, J. Rubsam, K. W. Hansen, E. R. Scaife, and D. L. Brockmeyer. 2010. "Utility of a Cervical Spine Clearance Protocol After Trauma in Children Between 0 and 3 Years of Age." *Journal of Neurosurgery Pediatrics* 5, no. 3 (March): 292–6.

Augustine, Jim. 2004. "Failure on the Board." *Emergency Medical Services* 33, no. 5 (2004): 52–3.

Ben-Galim, P., N. Dreiangel, K. L. Mattox, C. A. Reitman, S. B. Kalantar, and J. A. Hipp. 2010. "Extrication Collars Can Result in Abnormal Separation Between Vertebrae in the Presence of a Dissociative Injury." *Journal of Trauma and Acute Care Surgery* 88, no. 1 (August): 447–50.

Bernhard, M., A. Gries, P. Kremer, and B. W. Böttiger. 2005. "Spinal Cord Injury (SCI): Prehospital Management." *Resuscitation* 66, no. 2 (August): 127–39.

Burton, J. H., M. G. Dunn, N. R. Harmon, T. A. Hermanson, and J. R. Bradshaw. 2006. "A Statewide Prehospital Emergency Medical Service Selective Patient Spine Immobilization Protocol." *Journal of Trauma* 61, no. 1 (July): 161–7.

Cordell, W. H., J. C. Hollingsworth, M. L. Olinger, S. J. Stroman, and D. R. Nelson. 1995. "Pain and Tissue-Interface Pressures During Spine-Board Immobilization." *Annals of Emergency Medicine* 26, no. 1 (July): 31–6.

DeVivo, M. J., B. K. Go, and A. B. Jackson. 2002. "Overview of the National Spinal Cord Injury Statistical Center Database." *Journal of Spinal Cord Medicine* 25, no. 4 (Winter): 335–8.

Domeier, R. M., R. A. Swor, R. W. Evans, J. B. Hancock, W. Fales, J. Krohmer, S. M. Frederiksen, E. J. Rivera-Rivera, and M. A. Schork. 2002. "Multicenter Prospective Validation of Prehospital Clinical Spinal Clearance Criteria." *Journal of Trauma* 53, no. 4 (October): 744–50.

Dunn, T. M., A. Dalton, T. Dorfman, and W. W. Dunn. 2004. "Are Emergency Medical Technician–Basics Able to Use a Selective Immobilization of the Cervical Spine Protocol?: A Preliminary Report." *Prehospital Emergency Care* 8, no. 2 (April–June): 207–11.

Ehrlich, P. F., C. Wee, R. Drongowski, and A. R. Rana. 2009. "Canadian C-Spine Rule and the National Emergency X-Radiography Utilization Low-Risk Criteria for C-Spine Radiography in Young Trauma Patients." *Journal of Pediatric Surgery* 44, no. 5 (May): 987–91.

Farrington, J. D. 1967. "Death in a Ditch." *Bulletin of the American College of Surgeons* 52, no. 3: 121.

Farrington, J. D. 1968. "Extrication of Victims: Surgical Principles." *Journal of Trauma* 8, no. 4: 493–512.

Fischer, P. E., D. G. Perina, T. R. Delbridge, M. E. Fallat, J. P. Salamone, J. Dodd, E. M. Bulger, and M. L. Gestring. 2018. "Spinal Motion Restriction in the Trauma Patient–A Joint Position Statement." *Prehospital Emergency Care* 22, no. 6 (November–December): 659–61.

Garton, H. J., and M. R. Hammer. 2008. "Detection of Pediatric Cervical Spine Injury." *Neurosurgery* 62, no. 3 (March): 700–8.

Hauswald, M. 2013. "A Re-conceptualization of Acute Spinal Care." *Emergency Medicine Journal* 30, no. 9 (September): 720–3.

Hauswald, M., G. Ong, D. Tandberg, and Z. Omar. 1998. "Out-of-Hospital Spinal Immobilization: Its Effect on Neurological Injury." *Academic Emergency Medicine* 5, no. 3 (March): 214–9.

Haut, E. R., B. T. Kalish, D. T. Efron, A. H. Haider, K. A. Stevens, A. N. Kieninger, E. E. Cornwell III, and D. C. Chang. 2010. "Spine Immobilization in Penetrating Trauma: More Harm Than Good?" *Journal of Trauma* 68, no. 1 (January): 115–21.

Hoffman, J. R., W. R. Mower, A. B. Wolfson, K. H. Todd, and M. I. Zucker. 2000. "Validity of a Set of Clinical Criteria to Rule Out Injury to the Cervical Spine in Patients with Blunt Trauma: National Emergency X-Radiography Utilization Study Group." *New England Journal of Medicine* 343, no. 2 (July): 94–9.

Hutchings, L., O. Atijosan, C. Burgess, and K. Willett. 2009. "Developing a Spinal Clearance Protocol for Unconscious Pediatric Trauma Patients." *Journal of Trauma* 67, no. 4 (October): 681–6.

Hyldmo, P. K., M. Horodyski, B. P. Conrad, S. Aslaksen, J. Røislien, M. Prasarn, G. R. Rechtine, and E. Søreide. 2017. "Does the Novel Lateral Trauma Position Cause More Motion in an Unstable Cervical Spine Injury than the Logroll Maneuver?" *American Journal of Emergency Medicine* 35, no. 11 (November): 1630–5.

Katz, J. S., C. O. Oluigbo, C. C. Wilkinson, S. McNatt, and M. H. Handler. 2010. "Prevalence of Cervical Spine Injury in Infants with Head Trauma." *Journal of Neurosurgery Pediatrics* 5, no. 5 (May): 470–3.

Kossuth, L. C. 1965. "The Removal of Injured Personnel from Wrecked Vehicles." *Journal of Trauma* 5, no. 6: 703–8.

Kossuth, L. C. 1967. "The Initial Movement of the Injured." *Military Medicine* 132, no. 1 (1967): 18–21.

Krell, J. M., M. S. McCoy, P. J. Sparto, G. L. Fisher, W. A. Stoy, and D. P. Hostler. 2006. "Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization." *Prehospital Emergency Care* 10, no. 1 (January–March): 46–51.

Kwan, I., F. Bunn, and I. G. Roberts. 2008. "Spinal Immobilisation for Trauma Patients (Review)." *Cochrane Library* 2008: 1–19.

Manoach, S., and L. Paladino. 2007. "Manual In-Line Stabilization for Acute Airway Management of Suspected Cervical Spine Injury: Historical Review and Current Questions." *Annals of Emergency Medicine* 50, no. 3 (September): 236–45.

Milby, A. H., C. H. Halpern, W. Guo, and S. C. Stein. 2008. "Prevalence of Cervical Spinal Injury in Trauma." *Neurosurgical Focus* 25, no. 5 (2008): E10.

NASEMSO, Safe Transport of Children by EMS: Interim Guidance March 7, 2017 *https://nasemso.org/wp-content/uploads/Safe-Transport-of-Children-by-EMS-InterimGuidance-03Mar2017.pdf* Last access 16 May 2019.

Pieretti-Vanmarcke, R., G. C. Velmahos, M. L. Nance, S. Islam, R. A. Falcone Jr., P. W. Wales, R. C. Brown, B. A. Gaines, C. McKenna, F. O. Moore, et al. 2009. "Clinical Clearance of the Cervical Spine in Blunt Trauma Patients Younger than 3 Years: A Multi-Center Study of the American Association for the Surgery of Trauma." *Journal of Trauma* 67, no. 3 (September): 543–50.

Sochor, M., S. Althoff, D. Bose, R. Maio, and P. Deflorio. 2013. "Glass Intact Assures Safe Cervical Spine Protocol." *Journal of Emergency Medicine* 44, no. 3 (March): 631–6.

Stroh, G., and D. Braude. 2001. "Can an Out-of-Hospital Cervical Spine Clearance Protocol Identify All Patients with Injuries?: An Argument for Selective Immobilization." *Annals of Emergency Medicine* 37, no. 6 (June): 609–15.

Theodore, N., B. Aarabi, S. S. Dhall, D. E. Gelb, R. J. Hurlbert, C. J. Rozzelle, T. C. Ryken, B. C. Walters, and M. N. Hadley. 2013. "Transportation of Patients with Acute Traumatic Cervical Spine Injuries." *Neurosurgery* 72, no. 3 (Suppl. 2) (March): 35–9.

Theodore, N., M. N. Hadley, B. Aarabi, S. S. Dhall, D. E. Gelb, R. J. Hurlbert, C. J. Rozzelle, T. C. Ryken, and B. C. Walters. 2013. "Prehospital Cervical Spinal Immobilization After Trauma." *Neurosurgery* 72, no. 3 (Suppl. 2) (March): 22–34.

Vanderlan, W. B., B. E. Tew, and N. E. McSwain Jr. 2009. "Increased Risk of Death with Cervical Spine Immobilization in Penetrating Cervical Trauma." *Injury* 40, no. 8 (August): 880–3.

Velopulos, C. G., H. M. Shihab, L. Lottenburg, M. Feinman, A. Raja, J. Salomone, and E. R. Haut. 2018. "Prehospital Spine Immobilization/Spinal Motion Restriction in Penetrating Trauma: A Practice Management Guideline from the Eastern Association for the Surgery of Trauma (EAST). *Journal of Trauma and Acute Care Surgery* 84, no. 5 (May): 736–44.

11

Spine Management Skills



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

S. Robert Seitz, MEd, RN, NRP
Darby L. Copeland, EdD, RN, NRP

Maßnahmen zur Bewegungseinschränkung der Wirbelsäule
Habilidades para el Trauma Espinal
Zbrinjavanje ozljeda kralježnice
Competências Práticas na Gestão de Traumatismos Vertebro-Medular
Keterampilan Pengelolaan Trauma Tulang Belakang
Спинальна травма – практические навыки
Immobilisation du rachis en pratique
Δεξιότητες Διαχείρισης Σπονδυλικής Στήλης
Gyakorlati készségek a gerincsérültek ellátásában
脊椎管理手技
脊椎處理技巧
Obravnava poškodb hrbtenice

Skills presented in this chapter:

- Cervical collar application
- Kendrick extrication device application
- Rapid extrication
- Placing and removing patient from backboard
  - Log-rolling from supine and prone positions
- Use of scoop stretcher
- Helmet removal
  - Sports helmet
  - Motorcycle helmet

Objectives

Upon successful completion of this chapter, you should be able to:

1. List the goals and principles of spinal motion restriction (SMR).
2. Describe indications to apply SMR.
3. Explain when to perform an emergency rescue and a rapid extrication.
4. Perform SMR on a supine and a seated patient.
5. Transfer patient to ambulance stretcher using long spine board or scoop stretcher.
6. Properly secure a patient to a stretcher or backboard.
7. Stabilize a patient's head and neck when a neutral position cannot be safely attained.
8. Perform a rapid extrication.
9. Explain when helmets should and should not be removed from injured patients.
10. Properly remove a motorcycle helmet.

Essential Components of Spinal Motion Restriction

All trauma patients are evaluated in the same manner, using the ITLS Primary Survey, which includes a brief neurologic assessment. Traditionally, the prehospital management of trauma patients has equated the provision of spinal motion restriction (SMR) with use of a long backboard. Studies suggest that not all trauma patients require SMR and that every patient does not need to be strapped onto a rigid backboard.

In addition, the published positions of the American College of Emergency Physicians, the National Association of EMS Physicians (NAEMSP), and the American College of Surgeons (ACS) agree that the benefit of long backboard immobilization is largely unproven and its utilization during transport should be judicious so that the potential benefits outweigh the risks. In addition, the Faculty of Prehospital Care of the Royal College of Surgeons of Edinburgh (UK) consensus group also published consensus statements related to SMR that are in alignment with the aforementioned positions.

Given the backboard is primarily a transfer device, not a transport device, patients who are placed on a backboard or other rigid device should be removed as expeditiously as possible. When the backboard is used as part of an SMR procedure, it along with other components serve to restrict body movement. The additional essential components necessary to perform full SMR system are as follows:

- *Cervical collar.* Though cervical collars do not immobilize the neck, they provide some support and can serve to remind the patient to keep the neck still. Several types are available. Personnel should be familiar with the type of collar(s) used by their system.
- *Straps.* Strapping systems are used to bind the patient's body to the stretcher or backboard to restrict movement of the spinal column. The straps should be positioned to decrease patient movement from side to side and from sliding up and down on the stretcher or backboard. Several different systems are available.
- *Head motion-restriction device.* These devices attach to the backboard and are used to restrict movement of the patient's head after the patient's body has been strapped to the backboard. When the head motion-restriction device has been applied, the cervical collar may be removed, if necessary. There are several different types of the devices. Remember that the patient is secured to the stretcher via the head motion-restriction device only *after* the rest of the patient is secured to the stretcher.
- *Airway management kit.* When you strap someone's body and head to a stretcher, you must assume responsibility for his or her airway. You must have the airway kit immediately available, and you must have the skills to use it. Airway management is a priority consideration with SMR. So, airway management skills and equipment are necessary components.

Principles of SMR

The goal of SMR is to reduce or prevent secondary injury to the spine during transport. SMR should be applied appropriately to those patients who may have sustained or are at high risk for spine injuries and cannot be adequately assessed clinically for the presence of such injuries. Where indicated, maintenance of in-line spinal alignment when moving the patient and appropriately securing him or her to the transport stretcher remains a critical component of SMR.

Patients whose cervical spine has been cleared by a physician or advanced practice clinician in the emergency department or who do not meet SMR requirements and are being transferred between facilities for additional care do not need to be placed or remain on a long backboard during the transfer. If it is necessary to remove a patient from a long backboard, either the traditional log roll or lift-and-slide technique should be used. The decision to utilize one method opposed to the other should be made based on the situation and with guidance from your local medical direction. Note that

current research suggests the lift-and-slide technique reduces the motion between C5 and C6. Perform these moves as follows (Scan 11-1):

- *Log roll*. One team member manually maintains the cervical spine while one at the shoulders, one at the hips, and one at the legs log-roll the patient 90 degrees. Once the patient is on his or her side, the backboard is slid away to the side of the patient. The patient is then log-rolled back to the supine position.
- *Lift-and-slide technique (six-person lift)*. One team member manually maintains the cervical spine, while additional team members align on both sides of the long backboard at the shoulders, hips, and legs and lift the patient 4 inches (10 cm). While the patient is lifted, another team member slides the backboard out from the foot end of the patient. The patient is then slowly lowered to a supine position.
- *Straddle slide*. One team member maintains cervical SMR. Two team members straddle the patient, one at the chest and one below the pelvis, both facing toward the head. Each team member places hands under shoulders or hips from the sides. On command of the team member holding the head, the patient is lifted about 4 inches (10 cm) and the last team member slides the board up from the feet under the patient. The patient is then lowered onto the board.

SCAN 11-1 Patient Removal from Backboard



11-1-1 Utilize the appropriate number of resources to ensure patient safety. Lock the stretcher in place, and position the backboard slightly to the left or right side of the stretcher.



11-1-2 Have a team member manage the head in a neutral position and unstrap the patient from the backboard.



11-1-3 Prepare the backboard by removing the straps or securing them under the backboard.



11-1-4 Log-roll the patient off the backboard onto the stretcher. Inspect the patient's posterior surface as needed during transfer to the stretcher.

(*continued*)

SCAN 11-1 Patient Removal from Backboard (*continued*)





11-1-5 A. Remove the backboard from under the patient; B. roll the patient back onto the center of the stretcher.





11-1-6 A. Reposition the patient as needed; B. secure him or her to the stretcher.



11-1-7 When limited resources exist, the use of a scoop stretcher may be the preferred method of transferring the patient to the stretcher.

The principles of SMR are:

- It should be applied only to those patients in whom there are clinical indicators or in whom it is not possible to assess for spinal injury and have a high-risk mechanism of injury (see the following).
- Stabilization of the spine must be done so the patient is in the anatomical (neutral) position. Padding is frequently required to achieve this position.
- Straps should be placed over stable bony structures. Avoid placing straps over the neck, navel, and knees.
- Patients placed in SMR are at risk for airway problems and should be monitored by an emergency care provider at all times.

Applying the principles of SMR helps the emergency care provider adapt to the various situations in which patients are found. Understand that SMR precautions are taken to minimize the potential of secondary trauma during the prehospital phase of a patient encounter. Though SMR decreases the patient's risk for such injury, studies have demonstrated that prolonged time on a rigid backboard can be detrimental to the patient and can impair respiratory effort, increase the risk of aspiration, or result in pressure sores. Strapping the patient to a backboard "as a precaution" may not be best for the patient.

Patients that require SMR and are placed on an ambulance stretcher may have the head of the stretcher raised slightly to assist with respiratory care, as long as spinal management is maintained (Figure 11-1).

Applying SMR

Patients Requiring SMR

Appropriately applied SMR should be considered for patients that fit the following criteria (Figure 11-2):

- Spinal deformity, pain, or tenderness
- Blunt trauma and altered level of consciousness (LOC)
- High-energy mechanism of injury with altered LOC including intoxication
- Focal neurologic complaint



Figure 11-1 Head of ambulance cot can be raised to decrease respiratory effort while still maintaining SMR. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

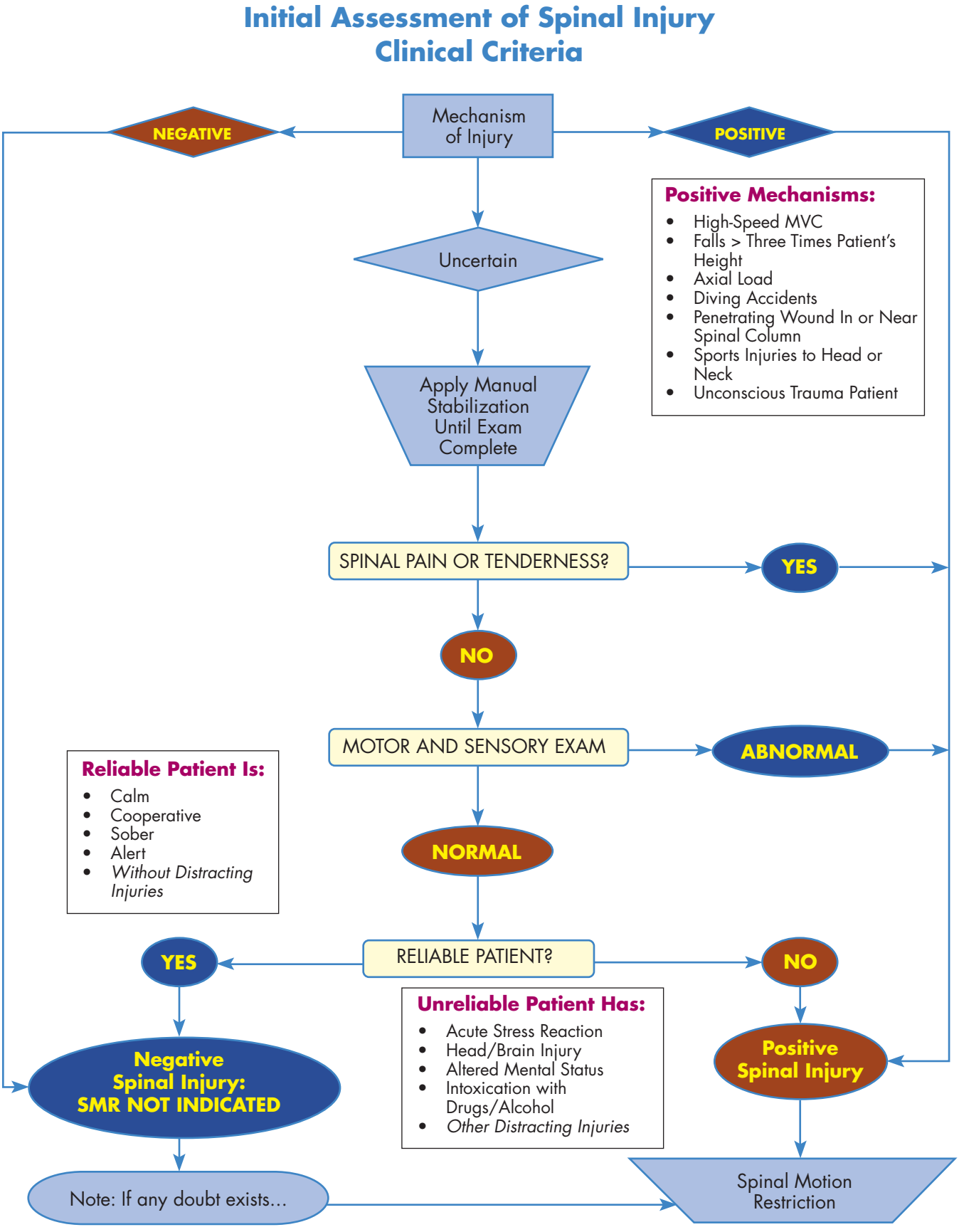


Figure 11-2 Decision tree for spinal motion restriction. *(Reprinted by permission of Peter Goth, MD)*

Additionally, SMR should be applied to patients who cannot be adequately assessed clinically for the presence of such injuries.

Patients requiring SMR must have the procedure completed before they are moved in any way. In the case of a motor-vehicle collision, you must stabilize the spine before removing the patient from the wreckage. More patient movement is involved in extrication than at any other time, so you must carefully stabilize the neck and spine before beginning extrication. If SMR is indicated, stabilize the spine, do not pull on it. Except in situations requiring emergency rescue or rapid extrication, always try to document pulse, motor function, and sensation in the extremities before and after you move the patient.

Any patient who has the clinical indications to be placed in SMR, as listed previously, should have an appropriate-sized cervical collar placed to reduce motion of the cervical spine. Scan 11-2 illustrates the placement of a cervical collar.

SCAN 11-2 Cervical Collar Placement



11-2-1 Establish manual stabilization by holding the head between the two hands of emergency care provider 1. Application of the semi-rigid cervical collar is best accomplished when the patient is in a supine position. If necessary, emergency care provider 1 may attempt to reposition the head if the patient is unresponsive and not in a midline neutral position.



11-2-2 Emergency care provider 2 measures the patient to identify an appropriate-sized semi-rigid collar. While the angle of the mandible and the trapezius are the most common anatomical points for measuring the size of the collar needed, providers must refer to the individual manufacturer instructions for application.



11-2-3 Emergency care provider 2 applies the cervical collar and secures it in place.

PEARLS

The Short Extrication Device

- When placing the straps around the legs on a male patient, be careful not to compress the genitals with the straps.
- Do not use the device as a "handle" to move the patient. Move patient and device as a unit. Many short extrication devices come with built-in handles. For safety purposes, these are not to be used alone to move a patient.
- You may need to modify your strapping techniques, depending on the injuries.

SMR with a Short Extrication Device

A short extrication device is used for patients who are in a position that does not permit use of the long backboard (such as in a motor vehicle). There are several different devices of this type. Some have strapping mechanisms different from the one explained here. Become familiar with your equipment before employing it in an emergency. (See Scan 11-3 for directions on how to apply one type of short extrication device.)

Emergency Rescue and Rapid Extrication

Patients left inside vehicles following a collision are often stabilized on a short extrication device and then transferred onto a long backboard. Although this was felt to be the safest way to extricate anyone with a possible spine injury, there are certain situations in which a more rapid method must be used. There are several studies looking at spinal motion when extricating patients from vehicles that suggest that allowing patients who are able to self-extricate wearing cervical collars may experience less spine motion than if removed by responders (Dixon, O'Halloran, and Cummins 2014; Shafer and Naunheim 2009).

Note: International Trauma Life Support offers a 1-day course called "Access" on basic extrication from motor vehicles using basic hand tools. Call 888-495-4857 for more information (international, call 630-495-6442).

Situations Requiring Emergency Rescue

Emergency rescue is used only in situations in which the patient's life is in immediate danger because of environmental hazards. In some of these situations you may not have time to use any technique other than pulling the patient to safety. When possible, the force of the pull should be along the long access of the body (Figure 11-3, p. 238). This is an example of "desperate situations demanding desperate measures." Use good judgment. Do not sacrifice your life in a dangerous situation. Whenever you use this procedure, it should be noted in the written report, and you should be prepared to defend your actions at a review by your medical director.

SCAN 11-3 Applying a Kendrick Extrication Device



11-3-1 The Ferno Kendrick Extrication Device (KED).
(©Ferno Corporation)



11-3-2 After a cervical collar has been applied, slip the KED behind the patient and center it.

SCAN 11-3 Applying a Kendrick Extrication Device (*continued*)



11-3-3 Properly align the device, then wrap the vest around the patient's torso.



11-3-4 When the device is tucked well up into the armpits, secure the chest straps.



11-3-5 Bring each leg strap around the ipsilateral (same-side) leg and back to the buckle on the same side. Fasten snugly.



11-3-6 Secure the patient's head with the Velcro head straps. Apply padding as needed to maintain a neutral position.



11-3-7 Tie the hands together or secure arms and hands to side of patient with straps.



11-3-8 Turn the patient and device as a unit then lower the patient onto a stretcher or long backboard. Loosen the leg straps and allow the legs to extend out flat. Finally, secure the patient and device to the stretcher.



Figure 11-3 A rescue drag.

Perform an emergency rescue if the scene size-up identifies a condition that could immediately (within seconds) endanger you or the patient, such as (Figure 11-4):

- Fire or immediate danger of fire or explosion
- Hostile environment, gunfire, or other weapons
- Danger of being carried away by rapidly moving water
- Structure in immediate danger of collapse
- Continuing and immediate life-threatening toxic exposure

Situations Requiring Rapid Extrication

You should perform a rapid extrication (Scan 11-4) if your ITLS Primary Survey of a patient identifies a critical degree of ongoing danger that requires an intervention within 1–2 minutes. In such a situation, you must act immediately and rapidly, but you can still stabilize the patient to some degree as you extricate him or her. Example situations that may require rapid extrication are:

- Airway obstruction that you cannot relieve by a jaw-thrust maneuver or a finger sweep
- Cardiac or respiratory arrest
- Chest or airway injuries requiring ventilation or assisted ventilation
- Late shock or bleeding that you cannot control

SMR with the Long Backboard

The traditional way to apply SMR to a patient with a suspected spine injury is to secure the patient from head to toe to a long backboard. Moving the patient onto the backboard must be accomplished in a careful, coordinated way that protects him or her from any further injury using the log roll.

PEARLS

The Long Backboard

- Unless transport times are extremely short, patients should be removed from the back board and secured to the ambulance stretcher–*long backboards* are a transfer, not transport, device.
- When you are applying the upper horizontal strap around a woman, place the upper strap above her breasts and under her arms, not across the breasts.
- When you are applying the lower horizontal strap on a pregnant woman, place it across the pelvis, not across the uterus.
- You may need to modify your strapping techniques, depending on the injuries.
- Secure the patient well enough so that little or no motion of the spine will occur if the board is turned on its side. Do not make straps so tight that they interfere with breathing.



Figure 11-4 Example of a situation in which you may have to perform an emergency rescue. *(Photo courtesy of Bonnie Meneely, EMT-P)*

SCAN 11-4 Rapid Extrication



11-4-1 Stabilize the neck and perform the initial assessment. Apply a semi-rigid extrication collar.



11-4-2 A second emergency care provider stands beside the open door of the vehicle and takes over control of the cervical spine. Slide the long backboard onto the seat and slightly under the patient. Carefully supporting the neck, torso, and legs, the emergency care providers turn the patient.



11-4-3 Stabilize the cot under the board. Begin to lower the patient onto the board.



11-4-4 The legs are lifted, and the back is lowered to the backboard. Carefully slide the patient to the full length of the backboard. The patient is immediately moved away from the vehicle and into the ambulance, if available. Secure the patient to the backboard as soon as possible.

See Scan 11-5 for log-rolling a supine patient onto a long backboard. In contrast, the prone patient most commonly has his or her head turned to one side. In that case, emergency care providers will need to bring the head into neutral alignment. This can be done in one of three ways:

- Just before the log roll, bring the patient's head into the neutral position (nose down).
- During the log roll, gradually bring the patient's head into a neutral position.
- Keep the head turned in the direction the body is moving during the log roll. Upon completion of the log roll, bring the head into a neutral position.

SCAN 11-5 Log-Rolling a Supine Patient onto a Long Backboard



11-5-1 Establish and maintain in-line manual stabilization while applying a semi-rigid cervical collar.



11-5-2 With the long board positioned beside the patient, emergency care providers 2, 3, and 4 assume their positions at the patient's side opposite the board, leaving space to roll the patient toward them.



11-5-3 Emergency care provider 1 or emergency care provider 2 may direct the other team members to roll the patient as a unit onto the side toward the emergency care providers.



11-5-4 After assessing the patient's posterior surface from occiput to heels, the emergency care provider at the waist reaches over, grasps the backboard, and pulls it into position against the patient. This can also be done by a fifth emergency care provider. Emergency care provider 1 or 2 instructs the other emergency care providers to roll the patient onto the backboard.

The status of the airway in a prone patient is critical for decisions about the order in which a log roll is performed. There are three clinical situations that dictate how to proceed. The first is for the patient who is not breathing or who is in severe respiratory difficulty. They must be log-rolled immediately so you can manage the airway. Unless the backboard is already positioned, you must log-roll the patient, manage the airway, and then transfer the patient to the backboard (in a second log-rolling step) when ready to transport.

SCAN 11-5 Log-Rolling a Supine Patient onto a Long Backboard (*continued*)



11-5-5 Position the patient midline on the backboard and secure the patient's body to the board with straps. Manage the extremities and hands appropriately so as not to allow uncontrolled movement.



11-5-6 Use a head/cervical immobilization device to secure the patient's head to the backboard after securing the body and extremities.



11-5-7 Transfer the patient and the backboard as a unit to the stretcher and proceed to load the patient into the ambulance.

The second clinical situation occurs when a patient with profuse bleeding of the mouth or nose must not be turned to the supine position. Profuse upper-airway bleeding in a supine patient is a guarantee of aspiration. This patient will have to have careful SMR and be transported prone or on his or her side, allowing gravity to help keep the airway clear. The vacuum backboard could be very useful in this situation as it allows turning the patient as a single unit.

The third clinical situation occurs when the patient with an adequate airway and respiration must be log-rolled directly onto a backboard.

Procedure

Log-Rolling the Prone Patient with an Adequate Airway onto a Long Backboard

1. Emergency care provider 1 stabilizes the neck. When placing the hands on the patient's head and neck, the emergency care provider's thumbs always point toward the patient's face (Figure 11-5). This prevents having the emergency care provider's arms crossed when the patient is log-rolled. An initial assessment and exam of the backside is done. Then a semi-rigid extrication collar should be applied.
2. The patient is placed with his or her legs extended in the normal manner and his or her arms (palms inward) extended by his sides. The patient will be rolled up on one arm, with that arm acting as a splint for the body.
3. The long backboard is positioned next to the patient's body on the side of the first emergency care provider's lower hand. (If the first emergency care provider's lower hand is on the patient's right side, the backboard is placed on the patient's right side.) If the patient's arm next to the backboard is the one injured, carefully raise it above the patient's head so he or she does not roll on the injured arm.
4. Emergency care providers 2 and 3 kneel at the patient's side opposite the board.

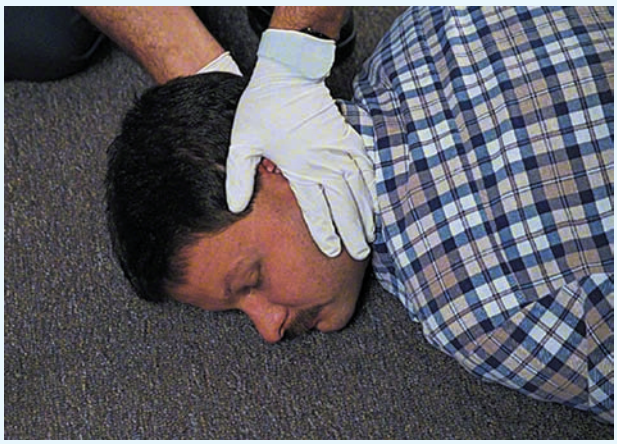


Figure 11-5 When stabilizing the neck of the prone (or supine) patient, your thumbs should always point toward the face (not the occiput). This prevents having your arms crossed when the patient is rolled over.

5. Emergency care provider 2 is positioned at the midchest area. Emergency care provider 3 should be beside the patient's upper legs.
6. Emergency care provider 2 grasps the shoulder and the hip. Usually, it is possible to grasp the patient's clothing (if not too loose) to help with the roll.
7. Emergency care provider 3 grasps the hip (holding the near arm in place) and the lower legs (holding them together).
8. When everyone is ready, emergency care provider 1 or emergency care provider 2 gives the order to log-roll the patient.
9. Emergency care providers 2 and 3 roll the patient away from them and onto his side. The patient's arms are kept locked to his or her side to maintain a splinting effect. The head, shoulders, and pelvis are kept in line during the roll.
10. The backboard is now positioned next to the patient and held at a 30- to 45-degree angle by emergency care provider 4. If there are only three emergency care providers, the board is pulled into place by emergency care provider 2 or 3. The board is left flat in this case.
11. When everyone is ready, emergency care provider 1 or 2 gives the order to roll the patient onto the backboard. This is accomplished by keeping the head, shoulders, and pelvis in line.
12. If the patient is not centered on the backboard, use a "Z move" to align them in the board center. Under command of the person stabilizing the neck, providers move the patient down the board toward the feet. Then the patient is brought back toward the top and center of the board in the second move. An alternative is to have the top of the board 18 inches (40 cm) higher than the patient's head when you first log-roll him or her onto the board and as you pull him or her to the top, you are able to center the patient while only pulling on the long axis (Grayson 2011).
13. The ITLS Primary Survey should now be completed.

Special Considerations

The patient with chest or abdominal injuries should be log-rolled onto his or her uninjured side. Do it quickly so lung expansion is not compromised. In the case of a patient with injuries to the lower extremities, position emergency care provider 2 at the feet of the patient to provide in-line support to the injured leg during the log roll. Again, try to roll the patient onto the uninjured side. In general, the side to which you turn a patient during a log roll is not critical and can be changed in situations where you can only place the backboard on one side of the patient.

Though the log-roll technique is useful for most trauma patients, it could aggravate a fractured pelvis. If the pelvic fracture appears stable, the log roll should be carefully performed, turning the patient onto the uninjured side, if this can be identified. Patients with obviously unstable pelvic fractures should not be log-rolled but instead should be lifted carefully onto a board using four or more emergency care providers.

The scoop stretcher is another device that could help move the patient onto the backboard when specific injuries complicate log rolling. Some newer scoop stretchers have been found to provide equal or superior stabilization when compared to the long backboard, and may be used in place of a long backboard to transfer the patient to the stretcher.



Figure 11-6 A vacuum mattress.

Scan 11-6 outlines the application of the scoop stretcher as a transfer device. If it is being used as part of the SMR procedure, manual stabilization of the head along with application of a cervical collar should occur prior to initiating placement onto the scoop stretcher.

Another device that can be used for SMR is the vacuum mattress. More commonly used in Europe, these devices have a lower risk of pressure sores and better patient comfort (Figure 11-6).

Securing the Patient to the Stretcher or Backboard

When securing the patient to the stretcher or backboard, appropriate strapping must be used. It should be wide enough (2 in. or 5 cm minimum) so as not to pinch. The torso should be secured first, then the legs, and finally the head. Straps should cross the pelvis and chest and should be set to prevent the patient from sliding if there are sudden changes in the ambulance speed. Secure the legs next, making sure the straps do not cross over any fractures. Once the torso and legs are secured to the ambulance stretcher, then the head can be secured. As with all equipment, you should become familiar with your strapping system before using it in emergency situations.

There are numerous commercial devices for full-body immobilization that are useful in special and rescue situations, including the Ferno Paraguard, the Sked stretcher, the Reeves sleeve, and the Miller body splint.

The Reeves sleeve is a heavy-duty sleeve into which a standard backboard will slide. Attached to this sleeve are the following:

- Head motion-restriction device
- Heavy vinyl-coated nylon panels that go over the chest and abdomen and are secured with seat belt–type straps and quick-release connectors
- Two full-length leg panels to secure the lower extremities
- Straps to hold the arms in place
- Six handles for carrying the patient
- Metal rings (2,500-pound strength) for lifting the patient by rope

SCAN 11-6 Application of the Scoop Stretcher



11-6-1 Placement of the head immobilization device and head restraint strap occurs following securing the patient to the scoop stretcher.



11-6-2 Separate the scoop stretcher into two halves.



11-6-3 Place on either side of the patient, being careful not to pass the scoop stretcher directly over the patient.



11-6-4 Adjust height of scoop halves to match, ensuring the head and heels will be positioned within the scoop area.

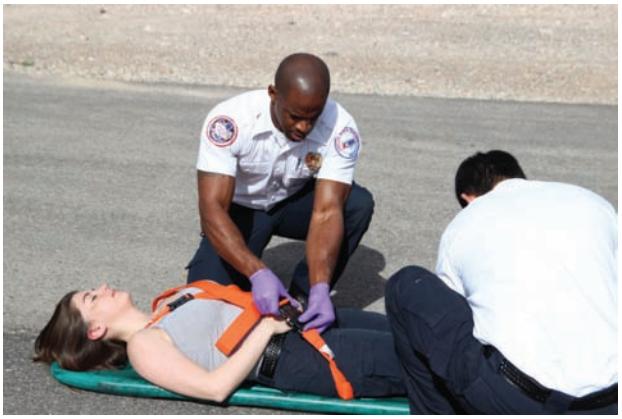


11-6-5 Reattach the head end of the scoop stretcher first. This may require repositioning the patient's shoulder.



11-6-6 Carefully close the foot end of the scoop stretcher so as not to pinch the patient's posterior tissue and reattach.

SCAN 11-6 Application of the Scoop Stretcher (*continued*)



11-6-7 Secure the patient to the scoop stretcher utilizing an appropriate number of straps to ensure patient safety while moving.



11-6-8 Confirming the head and foot ends of the scoop stretcher are locked together, transfer of the patient may now occur.



11-6-9 Removal of the patient from the scoop stretcher is completed by reversing the steps of application.



11-6-10 Once removed, the patient may be secured to the stretcher.

When the patient is in the Reeves sleeve, they remain immobilized when lifted horizontally, vertically, or even carried on the side (like a suitcase) (Figure 11-7).

The Miller body splint is a combination backboard, head immobilizer, and body immobilizer. (See Figure 10-8b in Chapter 10.) Like the Reeves sleeve, it does an excellent job of SMR with a minimum of time and effort. However, they do have the same problems for the patient when left on these devices for prolonged periods.

Special Considerations for the Head and Neck

Stabilizing the head and neck in a neutral position sometimes cannot be accomplished safely. If the head or neck is held in an angulated position and the patient complains of pain upon any attempt to straighten it, you should stabilize it in the position found. The same is true of the unconscious patient whose neck is held to one side and does not easily straighten with a gentle attempt. The use of a commercially available head motion-restriction device that permits cervical collar application in other than a midline position of the head may be considered or the use of a blanket roll carefully taped to stabilize the head and neck in the position found is warranted.

PEARLS

Protective Equipment

- Patients wearing both helmets and shoulder pads usually can have their spines maintained in a more neutral position by leaving the helmet in place and padding and taping the helmet to the ambulance stretcher or backboard.
- Patients wearing helmets but no shoulder pads usually can have their spines maintained in a more neutral position by removing the helmet.
- Sports helmet face guards can be removed with screwdrivers or pruning shears.
- Full-face motorcycle-type helmets must be removed to evaluate and manage the airway.



Figure 11-7 Reeves sleeve as an optional motion-restriction/confined-space extrication device. Patient's arms are enclosed within the panels and straps.

Helmet Management

Motorcycle helmet management for a trauma patient is shown in Scans 11-7 and 11-8. The primary reason to remove the helmet is to permit management of the airway, especially in those helmets designed with integral face guards. In the supine position the motorcycle helmet will cause flexion of the neck and make SMR difficult.

SCAN 11-7 Removing a Motorcycle Helmet



11-7-1 One emergency care provider applies stabilization by placing hands on each side of the helmet with fingers on the patient's mandible. This prevents slippage if the strap is loose.



11-7-2 A second emergency care provider loosens the strap at the D-rings while stabilization is maintained.

SCAN 11-7 Removing a Motorcycle Helmet (*continued*)



11-7-3 The second emergency care provider places one hand on the mandible at the angle, thumb on one side, long and index fingers on the other.



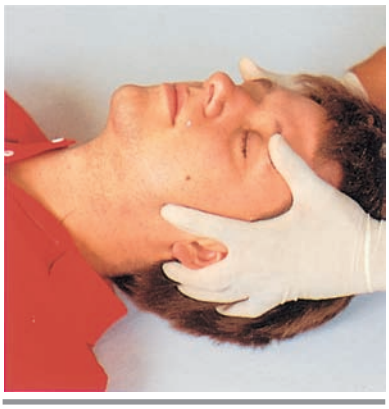
11-7-4 With the other hand, the second emergency care provider holds the occipital region. This maneuver transfers the stabilization responsibility to the second emergency care provider. The emergency care provider at the top removes the helmet in two steps, allowing the second emergency care provider to readjust his or her hand position under the occipital region. Three factors should be kept in mind: (1) The helmet is egg-shaped and therefore must be expanded laterally to clear the head; (2) if the helmet provides full facial coverage, glasses must be removed first; and (3) if the helmet provides full facial coverage, the nose will prevent removal. To clear the nose, the helmet must be tilted back and raised over it.



11-7-5 Throughout the removal process, the second emergency care provider maintains in-line stabilization from below to prevent head tilt.



11-7-6 After the helmet has been removed, the emergency care provider at the top replaces his or her hands on either side of the patient's head with the palms over the ears, taking over stabilization.



11-7-7 Stabilization is maintained from above until SMR is completed.

SCAN 11-8 Alternate Procedure for Removing a Motorcycle Helmet



11-8-1 Apply steady stabilization in neutral position.



11-8-2 Remove the chin strap.



11-8-3 Remove the helmet by pulling gently on each side.



11-8-4 Apply a suitable cervical collar and secure the patient to a long backboard as warranted.

References and Resources

Dixon, M., J. O'Halloran, and N. M. Cummins. 2014. "Biomechanical Analysis of Spinal Immobilisation During Prehospital Extrication: A Proof of Concept Study. *Emergency Medicine Journal* 31, no. 9 (June): 745–9.

Grayson, K. 2011. "A Better Way to Backboard." Accessed February 2019. https://www.ems1.com/ems-products/Patient-Immobilization/articles/1029653-A-better-way-to-backboard/

Horodyski, M., B. P. Conrad, G. Del Rossi, C. P. DiPaola, and G. R. Rechtine II. 2011. "Removing a Patient from the Backboard: Is the Lift and Slide Safer Than the Log Roll?" *Journal of Trauma* 70, no. 5 (May): 1282–5.

Johnson, D. R., M. Hauswald, and C. Stockhoff. 1996. "Comparison of a Vacuum Splint Device to Rigid Backboard for Spinal Immobilization." *American Journal of Emergency Medicine* 14, no. 4 (July): 369–72.

Kleiner, D. M., A. Pollak, and C. McAdam. 2001. "Helmet Hazards: Do's and Don'ts of Football Helmet Removal." *Journal of Emergency Medical Services* 26, no. 7 (July): 36–44, 46–8.

Krell, J. M., M. S. McCoy, P. J. Sparto, G. L. Fisher, W. A. Stoy, and D. P. Hostler. 2006. "Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization." *Prehospital Emergency Care* 10, no. 1 (January–March): 46–51.

Rozzelle, C. J., B. Aarabi, S. S. Dhall, D. E. Gelb, R. J. Hurlbert, T. C. Ryken, N. Theodore, B. C. Walters, and M. N. Hadley. 2013. "Management of Pediatric Cervical Spine and Spinal Cord Injuries." *Neurosurgery* 72 (Suppl. 2) (March): 205–26.

Shafer, J., and R. S. Naunheim. 2009. "What Extrication Technique Causes Least Spine Movement?" *Western Journal of Emergency Medicine* 10, no. 2 (May): 74–8.

Theodore, N., M. N. Hadley, B. Aarabi, S. S. Dhall, D. E. Gelb, R. J. Hurlbert, C. J. Rozzelle, T. C. Rhken, and B. C. Walters. 2013. "Prehospital Cervical Spinal Immobilization After Trauma." *Neurosurgery* 72 (Suppl. 2) (March): 22–34.

12



(Cheryl Casey/Shutterstock)

Head Trauma and Traumatic Brain Injury

David E. Manthey, MD, FAAEM, FACEP
Shin Tsuruoka, MD
Roy L. Alson, PhD, MD, FACEP, FAEMS

Schädel-Hirn-Traumata
Trauma Encefálico y Lesión Cerebral Traumática
Ozljede glave i traumatska ozljeda mozga
Traumatismo Crânio-Encefálico
Kepala dan Cedera Otak Traumatis
Черепно–мозговая травма (ЧМТ)
Traumatismes crâniens et lésions cérébrales post traumatiques
Τραύμα Κεφαλής και Κρανιοεγκεφαλική Κάξωση
Koponya- agysérülések
頭部外傷と外傷性脳損傷
頭部 創傷及創傷性腦損傷
Poškodbe glave in možganov

Key Terms

cerebral herniation syndrome, *p. 254*
cerebral perfusion pressure (CPP), *p. 253*
contracoup, *p. 252*
coup, *p. 252*
Cushing's reflex, *p. 253*
drug-assisted intubation (DAI), *p. 262*
intracranial pressure (ICP), *p. 253*
mean arterial pressure (MAP), *p. 253*
Monro-Kellie Doctrine, *p. 251*
no-reflow phenomenon, *p. 258*
primary brain injury, *p. 252*
secondary brain injury, *p. 252*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe the anatomy of the head and brain.
2. Describe the pathophysiology of traumatic brain injury.
3. Explain the difference between primary and secondary brain injury.
4. Describe the mechanisms for the development of secondary brain injury.
5. Describe the assessment of the patient with a head injury.
6. Describe the prehospital management of the patient with a traumatic brain injury.
7. Recognize and describe the management of cerebral herniation syndrome.
8. Identify potential problems in the management of the patient with a traumatic brain injury.

Chapter Overview

Head injury or, more specifically, traumatic brain injury (TBI), is a major cause of death and disability in multiple-trauma patients worldwide. Of all multiple-system trauma patients, 40% have a central nervous system (CNS) injury. Those patients have a death rate twice as high (35% versus 17%) as that of patients with no CNS injuries. Traumatic brain injuries account for an estimated 25% of all trauma deaths and up to one-half of all motor-vehicle collision fatalities. Prevention remains the most effective treatment. Medical personnel can help reduce this major epidemic by encouraging the use of helmets in sports/motorcycle use and restraint devices in vehicles.

As an emergency care provider, you may encounter head injuries that can range from the trivial to the immediately life-threatening. By recognizing injuries that need immediate intervention and providing transport to the appropriate facility, you can significantly improve the chances for a patient to have a good outcome. Not every injury to the head results in a TBI. An injury above the clavicle should prompt the emergency care provider to look for TBI and cervical spine injury.

Because it is not possible to perform a field clearance of the cervical spine in a patient with altered mental status, you must always assume that a serious head injury is accompanied by an injury to the cervical spine and spinal cord and provide appropriate spinal motion restriction (SMR), as described in Chapter 10.

Material included in this chapter has been based on the recommendations of the Brain Trauma Foundation (BTF), a multidisciplinary organization dedicated to improving care of TBI victims by use of evidence-based treatment.



Case Presentation

You and your partner are transporting a seriously injured bicyclist, who crashed into a parked vehicle, to a trauma capable hospital. The primary and rapid trauma assessments reveal life threatening bleeding from the left lower thigh. A tourniquet has been applied and has stopped the bleeding. The patient has possible head, chest, and extremity injuries and an inability to move the lower extremities. You find the patient unresponsive with a Glascow Coma Score (GCS) of 4 with decerebrate posturing of upper extremities and responding to painful stimuli. Respirations are 6–8 breaths per minute, and the pulse rate is 44. His left pupil is dilated and not responding to light.

Before proceeding, consider the following questions:

- What is happening to the patient?
- Why does he have a decreased level of consciousness?
- Will an ITLS Reassessment Exam reveal anything?
- Did you ever check a fingerstick blood sugar?

Keep these questions in mind as you read through the chapter.

Anatomy of the Head

To most effectively manage the patient with a head injury, one must understand the basic anatomy and physiology of the head and brain. The head (excluding the face and facial structures) includes the following (Figure 12-1):

- Scalp
- Skull
- Fibrous coverings of the brain (meninges: dura mater, arachnoid mater, pia mater)
- Brain parenchyma
- Cerebrospinal fluid
- Vascular compartments

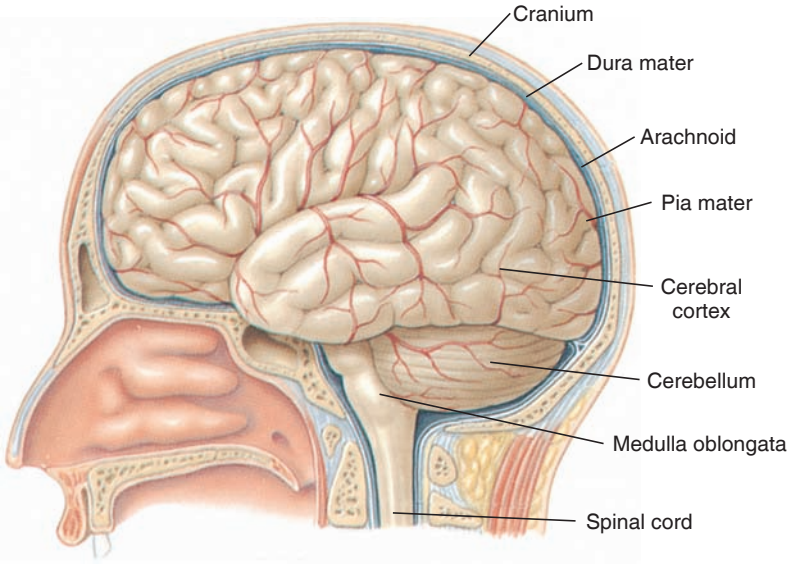


Figure 12-1 Anatomy of the head.

The cutaneous tissue covering the skull, referred to as the scalp, is very vascular and therefore bleeds freely when lacerated. The rigid and unyielding bony skull protects the brain from direct injury, but its irregular inner contour contributes to deceleration injury. Parts of the skull are quite thin and easily fractured, such as the temporal bone. The fibrous coverings of the brain include the dura mater ("tough mother"), which carries the vascular structures and separates the sections of the brain; the thinner pia arachnoid (called simply the *arachnoid*), which lies underneath the dura and in which are suspended both arteries and veins; and the very thin pia mater ("soft mother"), which lies underneath the arachnoid, following the contour as it is adherent to the surface of the brain. The cerebrospinal fluid (CSF) is found between the arachnoid and pia mater.

PEARLS

Cervical Spine Injury

Always treat as if there is a cervical spine injury in the patient with a head injury.

Because the brain "floats" inside the CSF and is anchored at its base, there is greater movement at the top of the brain than at the base. On impact, the brain is able to move within the skull and can strike bony prominences within the cranial cavity. (This is the "third collision" often described in mechanisms of injury in Chapter 1.)

The intracranial volume is composed of the brain, the CSF, and the blood in the blood vessels, which completely fill the cranial cavity. Thus, any increase in one of the components is at the expense of the other two. This concept (called the **Monro-Kellie Doctrine**) is of great importance in the pathophysiology of head trauma. Following injury, the brain will swell. Because of the fixed space within the rigid skull, as the brain tissue swells, it takes up more volume. Initially, with the brain swelling, blood and CSF volumes inside the skull decrease and compensate for the rise in pressure. As brain swelling continues, however, compensation fails, and intracranial pressure (ICP) begins to rise. As the ICP increases, the amount of blood that can enter the skull and perfuse the brain decreases, leading to further brain injury. As the ICP continues to rise, the only significant opening through which the pressure can be released is the foramen magnum at the base of the skull. A significant rise in ICP can cause the brain to herniate through the foramen magnum, with devastating results. Atrophy—due to age or alcoholism, for example—gives additional space in the intracranial vault, allowing more blood or swelling to occur before the patient becomes symptomatic.

Monro-Kellie Doctrine: states that the contents of the skull—brain, blood, and CSF—are at a fixed volume and a change in volume of one is compensated by a decrease in the other two.

Cerebrospinal fluid (also called *spinal fluid*) is a nutrient-rich fluid that bathes the brain and spinal cord. Spinal fluid is continually created within the ventricles of the brain at a rate of 0.33 mL/minute. The arachnoid granulations protruding into the superior sagittal sinus are the major site of absorption of spinal fluid. Anything obstructing the outflow of spinal fluid, such as traumatic blood in the ventricles or subarachnoid space, will cause an accumulation of spinal fluid within the brain (hydrocephalus) and an increase in ICP.

Pathophysiology of Head Trauma

Head injuries are either open or closed, depending on whether or not the dura mater is breached. Brain injury processes can also be divided into two components: primary and secondary.

Primary and Secondary Brain Injuries

primary brain injury: the immediate damage to the brain tissue that is the direct result of an injury force.

Primary brain injury is the immediate damage to the brain tissue that is the direct result of the mechanical force and is essentially fixed at the time of injury. Primary brain injury is better managed by prevention, using measures such as the use of occupant restraint systems in motor vehicles; the use of helmets in sports, work, and cycling; and firearms education.

Most primary brain injuries occur either as a result of external forces applied against the skull or from movement of the brain inside the skull. In deceleration injuries, the head usually strikes an object such as the windshield of an automobile, which causes a sudden deceleration of the skull. The brain continues to move forward, impacting first against the skull in the original direction of motion ("third" collision of a motor-vehicle collision) and then rebounding to hit the opposite side of the inner surface of the skull (a "fourth" collision). Thus, injuries may occur to the brain in the area of original impact ("**coup**") or on the opposite side ("**contracoup**"). The interior base of the skull is rough (Figure 12-2), and movement of the brain over this area may cause various degrees of injury to the brain tissue or to the blood vessels supporting the brain.

coup: an injury to the brain in the area of original impact.

contracoup: an injury to the brain on the opposite side of the original impact.

secondary brain injury: an injury to the brain that is the result of hypoxia and/or decreased perfusion of brain tissue after a primary injury.

Secondary brain injury is the result of hypoxia and/or decreased perfusion of brain tissue. Good prehospital care can help prevent the development of secondary brain injury. In response to the primary insult, swelling can cause a decrease in perfusion. As a consequence of other injuries, hypoxia, hypercapnia, acidosis, or hypotension may occur, with each insult damaging to brain tissue. Bruising or injury of the brain

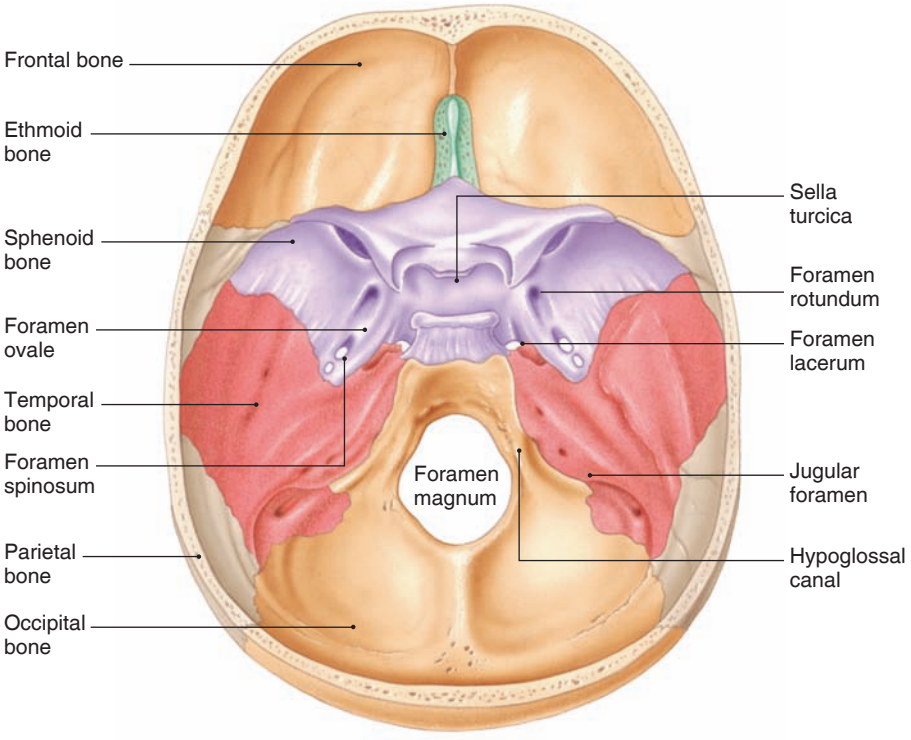


Figure 12-2 The rough inner base of the skull.

results in vasodilatation with increased blood flow to the injured area. Because there is no extra space inside the skull (barring atrophy), swelling of the injured area or newly formed intracerebral hematoma increases intracerebral pressure. This leads to a decreased cerebral blood flow that causes secondary brain injury. The increase in cerebral water (edema) does not occur immediately but develops over hours. Early efforts to prevent the accumulation of edema and to maintain perfusion of the brain can be lifesaving.

The brain normally adjusts its own blood flow in response to metabolic needs. The metabolic autoregulation of blood flow is adjusted based on the level of carbon dioxide (CO_2) in the blood. The normal level of CO_2 is 35–45 mmHg. An increase in the level of CO_2 (hypoventilation) promotes vasodilatation of vessels supplying the brain, whereas lowering the level of CO_2 (hyperventilation) causes vasoconstriction and decreases blood flow to the brain. In the past, swelling was believed to be worsened if there was increased blood flow to the injured brain. Therefore, hyperventilation was recommended to prevent the swelling and the associated increase in ICP due to the swelling of the brain. This increased pressure would in turn decrease blood flow to the brain, adding insult to injury.

Research has shown that hyperventilation actually has only a slight effect on brain swelling, instead causing a significant decrease in cerebral perfusion due to vasoconstriction resulting in cerebral ischemic hypoxia. Thus, both hyperventilation and hypoventilation can cause cerebral ischemia and increased mortality in the patient with TBI. Maintaining normal ventilation to maintain an $etCO_2$ of 35–45 is therefore very important. *Prophylactic hyperventilation for TBI is no longer recommended*.

PEARLS

Hypoxia and Hypotension

- Patients with serious head injuries cannot tolerate hypoxia or hypotension. Give high-flow oxygen and monitor oxygenation with a pulse oximeter.
- Pediatric patients usually have a better recovery from TBI. However, hypoxia and hypotension appear to eliminate any neuroprotective mechanism normally afforded by age. If the child with a serious brain injury is allowed to become hypoxic or hypotensive, the chance of recovery is even worse than an adult with the same injury.

Intracranial Pressure

Brain tissue, cerebrospinal fluid, and blood reside within the skull and fibrous coverings of the brain. An increase in the volume of any one of those components must be at the expense of the other two because the adult skull (a rigid box) cannot expand. Although there is some displacement volume of cerebrospinal fluid and venous blood, it accounts for little space and cannot offset rapid brain swelling. The pressure within the skull is termed **intracranial pressure (ICP)**. Blood supply will be decreased by increased ICP, and because the brain requires a constant supply of blood (oxygen and glucose) to survive, brain swelling can be rapidly catastrophic.

intracranial pressure (ICP): the pressure of the brain and contents within the skull.

ICP is considered dangerous when it rises above 15 mmHg; cerebral herniation may occur at pressures above 25 mmHg. The net-pressure gradient causing blood flow through the brain is termed the **cerebral perfusion pressure (CPP)**. Its value is obtained by subtracting the intracranial pressure from the **mean arterial pressure (MAP)**.

cerebral perfusion pressure (CPP): the net pressure gradient causing blood flow through the brain.

mean arterial pressure (MAP): the sum of the diastolic blood pressure plus one-third (systolic blood pressure minus diastolic blood pressure).

$$\text{MAP} = \text{Diastolic BP} + \frac{1}{3}(\text{Systolic BP} - \text{Diastolic BP})$$

$$\text{CPP} = \text{MAP} - \text{ICP}$$

If the brain swells or if bleeding occurs inside the skull, ICP increases and the CPP may decrease (depending on MAP), resulting in cerebral ischemia (hypoxia). In the late stage, hypertension, bradycardia, and irregular respiration known as **Cushing's reflex** occurs, which is associated with markedly elevated ICP, indicating imminent herniation. When ICP increases, the systemic blood pressure increases to try to preserve blood flow to the brain. The body senses the rise in systemic blood pressure, and this triggers a drop in the pulse rate as the body tries to lower the systemic blood pressure by lowering cardiac output. With severe injury or ischemia, the pressure within the skull continues in an upward spiral until a critical point at which ICP approaches the MAP and there is no cerebral perfusion. Because CPP depends on both the arterial pressure and ICP, hypotension will also have a devastating effect if ICP is high.

Cushing's reflex: a reflex in which the body responds to markedly elevated ICP by raising both the diastolic and systolic blood pressure, reduction of heart rate, and irregular respiration. Also called *Cushing's response*, this happens late in the course of the head injury.

As stated earlier, the injured brain loses the ability to autoregulate blood flow. In this situation perfusion of the brain is directly dependent on arterial blood pressure. You must maintain a CPP of 60–70 mmHg (see earlier formula), which requires maintaining a MAP of greater than 70 mmHg in the patient with severe TBI. Hypotension due to TBI alone is rare, occurring in about 5% of patients with isolated severe TBI (Glasgow Coma Scale [GCS] score of <9). A patient with a significant TBI who is hypotensive is bleeding from somewhere or has a spinal cord injury causing neurogenic shock. Overly aggressive attempts to maintain CPP above 70 mmHg with fluids alone may lead to the development of acute respiratory distress syndrome (ARDS). Pressors may also be helpful if fluid resuscitation does not restore perfusion, but may be detrimental in the multiple-trauma patient. Remember, hypotension and the associated poor perfusion is devastating to the injured brain.

Cerebral Herniation Syndrome

When the brain swells or intracranial hemorrhage occurs, particularly after a blow to the head, a sudden rise in ICP may occur. This may force portions of the brain downward, through the tentorium cerebelli (uncal herniation). This leads to obstruction of the flow of CSF and the herniated brain applies significant pressure to the brainstem, resulting in **cerebral herniation syndrome**. The classic findings of this specific life-threatening herniation are a decreasing level of consciousness (LOC) that rapidly progresses to coma, dilation of the pupil and an outward–downward deviation of the eye on the side of the injury, paralysis of the arm and leg on the side opposite the injury, or decerebrate posturing (arms and legs extended). As the cerebral herniation is occurring, the vital signs frequently reveal increased blood pressure and bradycardia (Cushing's reflex). This syndrome often follows an acute epidural or subdural hemorrhage.

If these signs are developing in a patient with TBI, cerebral herniation is imminent, and aggressive therapy is needed. As noted earlier, hyperventilation will decrease the size of the blood vessels in the brain and briefly decrease ICP. In this situation the danger of immediate herniation outweighs the risk of cerebral ischemia that can follow hyperventilation. Cerebral herniation syndrome is the only situation in which hyperventilation is still indicated. (You must ventilate every 3 seconds [20/minute] for adults, every 2.5 seconds [25/minute] for children older than 1 year, and every 2 seconds [30/minute] for infants younger than 1 year.) If you have waveform capnography, attempt to keep the $etCO_2$ at about 30–35 mmHg. If capnography is not available, the rates shown in Table 12-1 can help guide ventilation of the patient with TBI.

To simplify knowing when to hyperventilate in the field, the clinical signs of cerebral herniation in the patient who has had hypoxemia and hypotension corrected are any one (or more) of the following:

- TBI patient with a GCS score <9 with extensor posturing (decerebrate posturing)
- TBI patient with a GCS score <9 with asymmetric, dilated, or nonreactive pupils
- TBI patient with an initial GCS score <9 that then drops his or her GCS by more than two points

For the preceding, "asymmetric pupils" means 1 mm (or more) difference in the size of one pupil and "fixed" means no response (<1 mm of response) to bright light. Bilateral dilated and fixed pupils are usually are a sign of brainstem injury and are associated with 91% mortality. A unilateral dilated and fixed pupil has been associated with good recovery in up to 54% of patients. Remember that hypoxemia, orbital trauma, substance use, lightning strike, and hypothermia also affect pupillary reaction, so take this into account before beginning hyperventilation. Flaccid paralysis usually means spinal cord injury.

PEARLS

Cerebral Herniation Syndrome

A patient who, after correction of hypoxia and hypotension, shows rapid progression of brain injury (e.g., unresponsive with dilated pupil, decerebrate posturing, or drop in GCS score of >2 with an initial GCS score of <9) should be transported rapidly to a trauma center capable of managing severe TBI patients. This is the only situation in which hyperventilation is still indicated. Hyperventilation, although known to cause ischemia, may decrease brain swelling temporarily. Although a desperate measure, this might buy enough time to get the patient to surgery that might be lifesaving. Call ahead so that a neurosurgeon can be available and the operating room prepared by the time you arrive at the hospital.

cerebral herniation syndrome: a critical syndrome in which swelling of the brain forces portions of the brain tissue down through the opening at the base of the skull, squeezing the brainstem and causing coma, dilatation of pupils, contralateral paralysis, elevated blood pressure, and bradycardia.

Table 12-1: Normal Ventilation Rates and Hyperventilation Rates

Age Group	Normal Ventilation Rate	Hyperventilation Rate
Adult	10–12 breaths/minute ($etCO_2$ 35–45)	20 breaths/minute ($etCO_2$ about 30–35)
Children	15 breaths/minute ($etCO_2$ 35–45)	25 breaths/minute ($etCO_2$ about 30–35)
Infants	20 breaths/minute ($etCO_2$ 35–45)	30 breaths/minute ($etCO_2$ about 30–35)

The Arizona Excellence in Prehospital Injury Care Traumatic Brain Injury (EPIC-TBI) project reports that because it is very difficult to identify herniation without a CT scan, some patients in the field receive hyperventilation when not necessary, which can cause harm. The EPIC guidelines stress maintaining cerebral perfusion (systolic blood pressure >110 mmHg), keeping $etCO_2$ at 35 mmHg, and keeping blood glucose above 70 mg/dL.

ITLS guidelines, as of the date of publication of this edition, continue to follow BTF recommendations, including mild hyperventilation in the presence of cerebral herniation. ITLS advocates maintaining systolic blood pressure of at least 110 mmHg in the patient with TBI to ensure adequate perfusion, which is higher than the BTF guidelines but consistent with those put forth by EPIC. As more data becomes available, these recommendations will be updated and made available on the ITLS website.

Head Injuries

The head is made up of the face, scalp, skull, and brain. Serious injuries can occur to any one of these components. The head is the heaviest part of a young child's body, so children involved in falls or other deceleration trauma frequently strike their head.

Facial Injuries

Facial wounds can range from minor contusions, abrasions, and lacerations to wounds that can be fatal from airway compromise or hemorrhagic shock due to rich vascularity of the face. Most bleeding can be controlled by direct pressure. Some hemorrhage from the nose or pharynx can be life-threatening and difficult to control in the prehospital setting.

Nasal fractures are the most common fractures of facial bones and are rarely associated with severe hemorrhage. Fractures of the bones of the face and jaw are common, and the greatest danger is airway compromise caused by swelling and bleeding or loss of facial stability.

Injuries to the eyes are not life-threatening but can be severely disabling. Treatment of eye trauma in the field should be gentle irrigation with normal saline, if needed, for chemicals and then application of an eye shield. If there is a possible open globe, characterized by an irregularly shaped pupil, do not irrigate. Cover with an eye shield. Do not allow any pressure on the globe itself to prevent extrusion of the eye contents. Elevate the head of the stretcher if possible.

Scalp Wounds

The scalp is highly vascular and often bleeds briskly when lacerated. Because many of the small blood vessels are suspended in an inelastic matrix of supporting tissue, the normal protective vasospasm that would limit bleeding is inhibited, which may lead to prolonged bleeding and significant blood loss. Though an uncommon cause of shock in an adult, a child may develop shock from a briskly bleeding scalp wound, due to a smaller blood volume.

PEARLS

Shock

Any unexplained shock in a patient with head injury is hypovolemic until proven otherwise. Treat hypotension.

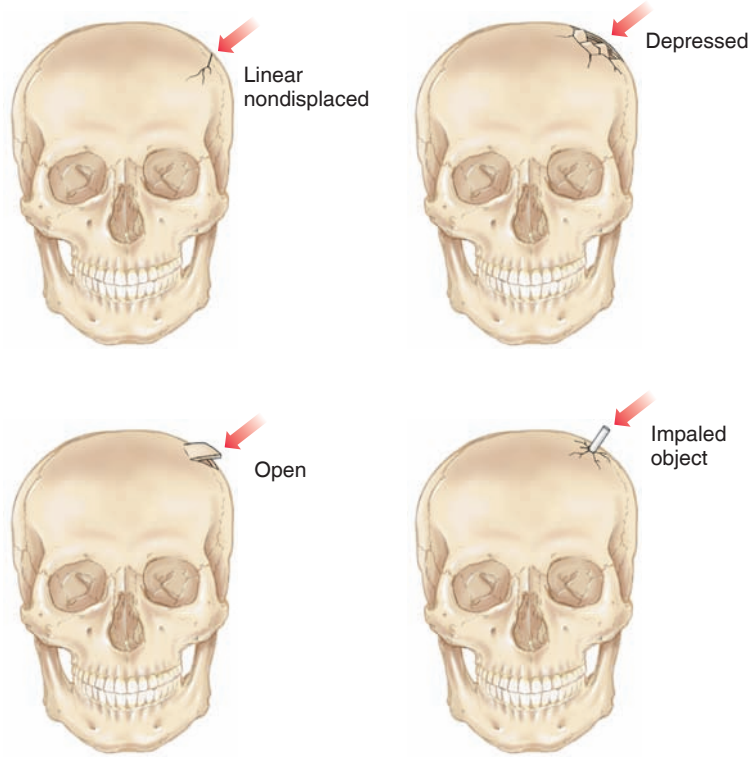


Figure 12-3 Types of skull fractures.

As a general rule, if you have an adult patient who is in shock, look for a cause other than the scalp wound, such as internal bleeding. Most bleeding from the scalp can be easily controlled in the field with direct pressure if your exam reveals no unstable fractures under the wound.

Skull Injuries

Skull injuries can be linear nondisplaced fractures, depressed fractures, or compound fractures (Figure 12-3). Suspect an underlying skull fracture in adults who have a large contusion or darkened swelling of the scalp. There is very little that can be done for skull fractures in the field except to avoid placing direct pressure on an obvious depressed or compound skull fracture. The real concern is that the amount of force that can cause a skull fracture may cause a brain injury.

Open skull fractures should have the wound dressed, but avoid excess pressure when controlling bleeding. Penetrating objects in the skull should be secured in place (not removed) and the patient transported immediately.

Consider child abuse when you find a child with a head injury and no clear explanation of the cause. Suspect possible abuse if the story about the injury is inconsistent with the injury or the responsible adult suggests the child performed an activity that a child of this age is not physically capable of performing. Pay particular attention to the setting from which you rescued the child. Request police or social service assistance if the circumstances are suspicious for child abuse.

Brain Injuries

There are multiple types of injuries to the brain and associated blood vessels. They are discussed here, beginning with the least severe and progressing through to life-threatening injuries.

Concussion

A concussion implies no structural injury to the brain that can be demonstrated by current imaging techniques.

Classically, there is a history of trauma to the head with a variable period of unconsciousness or confusion and then a return to normal consciousness. There may be amnesia following the injury, which usually extends to some point before the injury (retrograde short-term amnesia), rendering the patient unable to remember the events leading to the injury. Short-term memory is often affected, and the patient may repeat questions over and over as if he or she has not been paying attention to your answers. Patients also may report dizziness, headache, ringing in the ears, or nausea.

Concussion is not a benign injury. Long-term effects of concussion, although variable, can be devastating to the individual, especially if a patient has had multiple episodes, such as seen in athletes involved in contact sports, such as boxers, American football players, and rugby players. Any person who sustains a concussion while playing sports or other activities should not be allowed to return to that activity that day and should not resume playing until cleared by a physician. Better protective equipment can reduce the occurrence of concussion. Additional information and

guidelines for postconcussive assessment and return to play are available from the Centers for Disease Control and Prevention and the American Academy of Neurology websites. The Fédération Internationale de Football Association (FIFA) has developed the Sport Concussion Assessment Tool—5th Edition (SCAT-5), which is available for download at *https://resources.fifa.com/image/upload/scat5-sport-concussion-assessment-tool.pdf?cloudid=y0qwvjew3zzz0bxx0a0h* and will help the emergency care provider assess the status of a concussed athlete and determine when he or she may be able to return to play.

Cerebral Contusion

A patient with cerebral contusion (bruised brain tissue) will usually have a history of prolonged unconsciousness or serious alteration in LOC (e.g., profound confusion, persistent amnesia, abnormal behavior). Although rare, brain swelling may be rapid and severe. The patient may have focal neurologic signs (weakness, speech problems) and appear to have suffered a cerebrovascular accident (stroke). Depending on the location of the cerebral contusion, the patient may have personality changes such as inappropriate or rude behavior or agitation.

Diffuse Axonal Injury

A diffuse axonal injury is a result of severe blunt head trauma (Figure 12-4). The brain is injured so diffusely that there is generalized edema. Usually, there is no evidence of a structural lesion such as a hematoma on cerebral computerized tomography (CAT) scan. The patient presents unconscious, due to disruption of nerve fibers between the cortex and brainstem with no focal motor deficits.

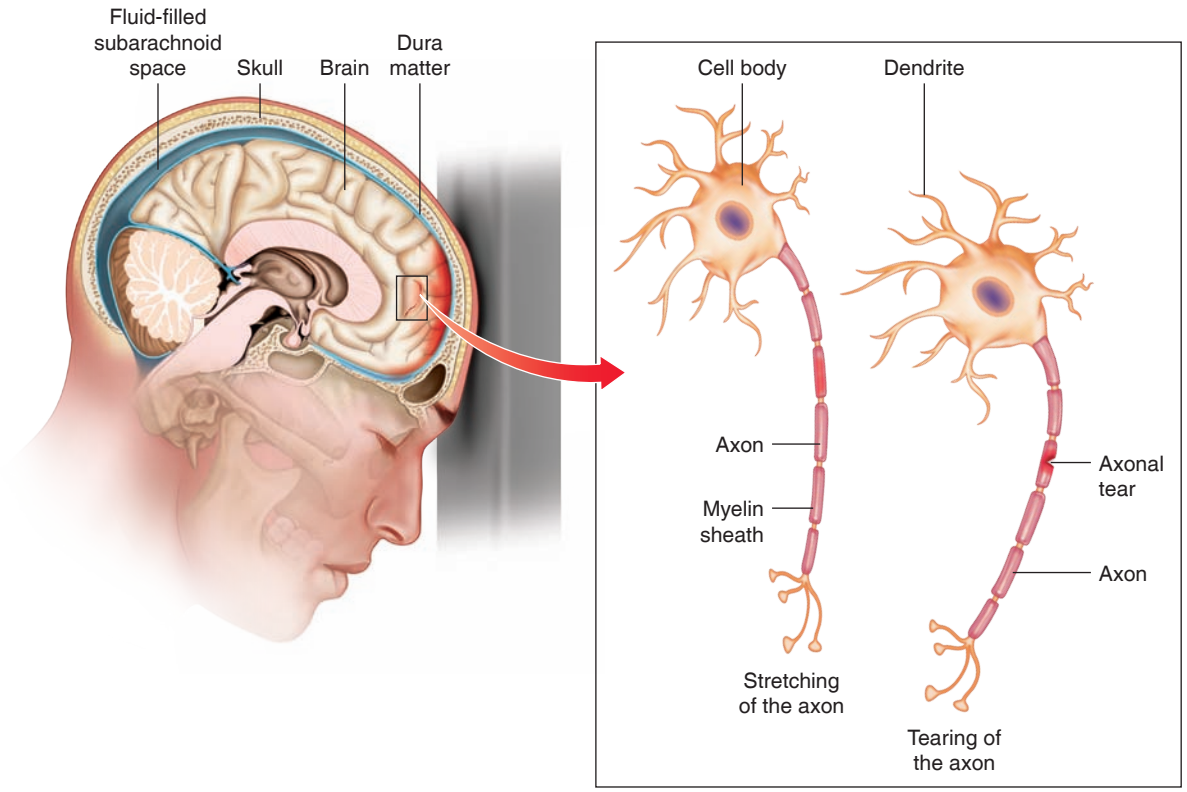


Figure 12-4 Diffuse axonal injury from shearing forces, which results from rapid deceleration or acceleration of the brain damaging the nerve axons. They are no longer able to carry nerve signals. Cerebral edema often follows, further damaging the brain.

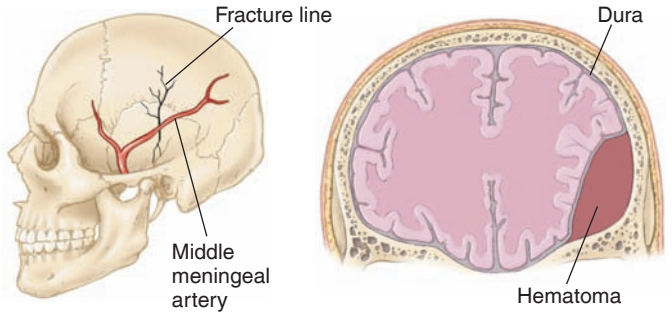
Anoxic Brain Injury

Injuries to the brain can also occur from diseases that cause a lack of oxygen (such as from cardiac arrest, airway obstruction, or near-drowning). Following an anoxic episode, perfusion of the cortex is interrupted due to spasm that develops in the small cerebral arteries. After 4–6 minutes of anoxia, restoring oxygenation and blood pressure will not restore perfusion of the cortex (**no-reflow phenomenon**), and there will be continuing anoxic injury to the brain cells; irreversible damage almost always occurs.

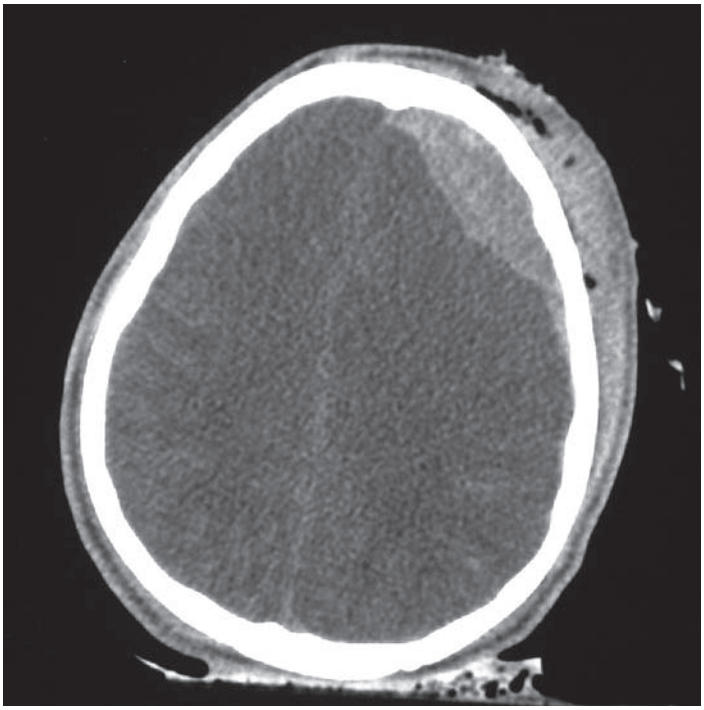
no-reflow phenomenon: the inability of restoring oxygenation and blood pressure to restore perfusion to the cortex after an anoxic episode of 4–6 minutes or more.

Hypothermia seems to protect against this phenomenon, and there have been reported cases of hypothermic patients being resuscitated after almost an hour of anoxia.

Research on medical cardiac arrest patients shows improved neurologic outcome when some resuscitated patients are treated with controlled hypothermia. This has yet to be established in the trauma patient with a head injury. Initiation of hypothermia in the field for TBI patients is not part of current guidelines. Ongoing research is directed toward finding medications that either reverse the persistent postanoxic arterial spasm or protect against the anoxic injury to the cells.



A



B

Figure 12-5 A. Acute epidural hematoma. This hemorrhage may follow injury to the extradural arteries. The blood collects between the fibrous dura and the periosteum. B. Note the lens shape of the bleed in the CAT scan.

Intracranial Hemorrhage

Hemorrhage can occur between the skull and dura (the fibrous covering of the brain), between the dura and the arachnoid, beneath the subarachnoid, or directly in the brain tissue.

Acute Epidural Hematoma An acute epidural hematoma is most often caused by a tear in the middle meningeal artery that runs along the inside of the skull in the temporal region. The arterial injury is often caused by a linear skull fracture in the temporal or parietal region (Figure 12-5). Because the bleeding is usually arterial (although it may be venous from one of the dural sinuses), the bleeding and rise in ICP can occur rapidly, and death may occur quickly.

Symptoms of an acute epidural hematoma include a history of head trauma with initial loss of consciousness, often followed by a period during which the patient is conscious and coherent (the "lucid interval"). After a period of a few minutes to several hours, the patient will develop signs of increasing ICP (vomiting, headache, altered mental status), lapse into unconsciousness, and develop body paralysis on the side opposite the head injury (see the earlier section on cerebral herniation syndrome). There is often a dilated and fixed (no response to bright light) pupil on the side of the head injury. The signs are usually followed rapidly by death. Be aware that not every epidural patient will show this lucid interval and that return to lucidity does not mean that there is no structural damage. Family and friends should be warned to monitor the patient for signs of altered mental status if no CT scan is done to rule out this disease. Surgical removal of the blood and control of bleeding before herniation occurs often allows for full neurologic recovery.

Acute Subdural Hematoma This is the result of bleeding from bridging veins and/or cortical arteries (Figure 12-6). In the case of bleeding from veins, ICP increases slowly, and the diagnosis is often not apparent until hours or days after the injury. If the bleeding is from the arteries, the symptoms will develop earlier.

Signs and symptoms include headache, fluctuations in LOC, and focal neurologic signs (such as weakness of one extremity or one side of the body, altered deep tendon reflexes, and slurred speech). Because of the likelihood of underlying brain tissue injury, prognosis is often poor. Mortality is very high (60–90%) in patients who are comatose when found.

Use of anticoagulants increases the risk of subdural bleeding. Atrophy of the brain causes the bridging veins to stretch and therefore the patient is at higher risk of injury. Therefore, those with alcoholism and older adults are at higher risk for this injury after a deceleration injury. They may not show signs and symptoms until many days after injury as the same atrophy affords space for the hematoma to grow before becoming symptomatic.

Subarachnoid Hemorrhage

Traumatic subarachnoid hemorrhage rarely occurs alone; it is most commonly associated with subdural hematoma or cerebral contusion. The massive amount of subarachnoid blood causes irritation that results in intravascular fluid "leaking" into the brain and causing more edema as well as spasm of the small arteries, which can reduce cerebral perfusion (Figure 12-7). Severe headache, coma, and vomiting are common findings. Patients rarely have significant brain swelling and may develop cerebral herniation syndrome.

PEARLS

Altered Mental Status

Remember that hypoglycemia, hypoxia, cardiac dysrhythmias, and drugs can cause altered mental status. When narcotic abuse is a possibility, administer naloxone to any patient with altered mental status. Monitor the heart and oxygenation, and check the blood glucose level on all patients with altered mental status. If you cannot perform a glucose determination but suspect hypoglycemia (diabetics and alcoholics), give glucose or thiamine and glucose.



Figure 12-6 Acute on chronic subdural hematoma. Bleeding is usually from dural veins and onset of symptoms can be very gradual. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

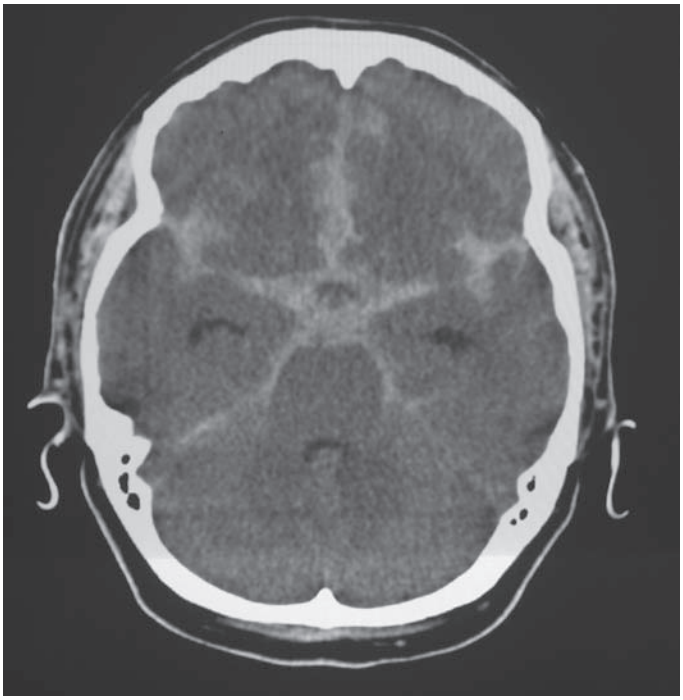
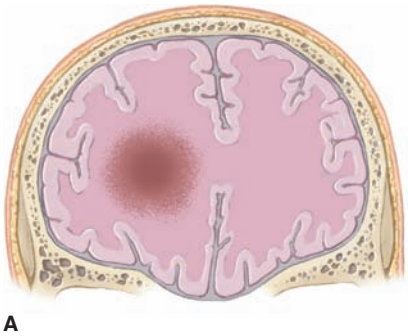
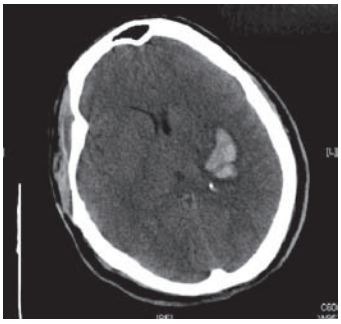


Figure 12-7 Acute subarachnoid hemorrhage. Blood collects in the basilar cistern and gives a five-pointed star pattern. *(Courtesy of David Effron)*



A



B

Figure 12-8 Intracerebral hemorrhage.

Intracerebral Hemorrhage Intracerebral hemorrhage is bleeding within the brain tissue (Figure 12-8). Traumatic intracerebral hemorrhage may result from blunt or penetrating injuries to the head. The signs and symptoms depend on the regions involved and the degree of injury. They occur in anatomical patterns similar to those from a stroke in the same area of the brain. Alteration in LOC is commonly seen. Awake patients may complain of headache and vomiting. Unfortunately, surgery is often not helpful.

Evaluation of the Patient with Traumatic Brain Injury

Determining the exact type of TBI or hemorrhage cannot be done in the field because it requires imaging techniques such as a CAT scan. It is more important that you recognize the presence of a brain injury and be ready to provide supportive measures while transporting the patient to the appropriate facility. Patients with TBI can be difficult to manage because they are often uncooperative and may be under the influence of alcohol or drugs. As an emergency care provider, you must pay extraordinary attention to detail and never lose your patience with an uncooperative patient.

ITLS Primary Survey

Remember that every trauma patient is initially evaluated in the same sequence (Figure 12-9).

Scene Size-up

The results of the scene size-up will begin to determine if you have a load-and-go patient. Dangerous generalized mechanisms (motor-vehicle collision, fall from a height) will require a complete examination (rapid trauma survey). Dangerous focused mechanisms (hit in the head with a baseball bat) will allow you to "focus" your exam (ABCs, with head, neck, and neurologic exams) rather than having to perform a complete exam.

Initial Assessment

The goals of the initial assessment are to determine the priority of the patient and to find immediate life threats. The initial assessment in the patient with head trauma is used to determine quickly if the patient is brain injured and, if so, if the patient's condition is deteriorating. Obviously, a patient with a history and physical examination that indicate a loss of consciousness following a lucid period postinjury (possible epidural hematoma) should be transported with more urgency than one who is alert and oriented after being knocked out (possible concussion). It is very important that all observations be recorded (but do not interrupt patient care to do this) because later treatment is often dictated by detection of the deterioration of clinical stability.

All patients with trauma above the clavicle and an *altered LOC* should be assumed to have a cervical spine injury until proven otherwise. It is not possible to clear the cervical spine in a patient with an altered LOC. Spinal motion restriction should accompany airway and breathing management.

During the initial assessment your neurologic exam is limited to LOC and any obvious paralysis. LOC is the most sensitive indicator of brain function. Initially, the AVPU (alert, responds to verbal stimuli, responds to pain, and unresponsive) method is adequate. (See Chapter 2.) If there is a history of trauma to the head, or if the initial exam reveals altered mental status, then the rapid trauma survey will include a more complete neurologic exam. A decrease in LOC is an early indicator of a brain injury or rising ICP.

Control of the airway cannot be overemphasized. The supine, restrained, and unconscious patient is prone to airway obstruction from the tongue, blood, vomit, or other secretions. Vomiting is very common within the first hour following a head injury. Airway management is the most important task. Suction should be immediately available.

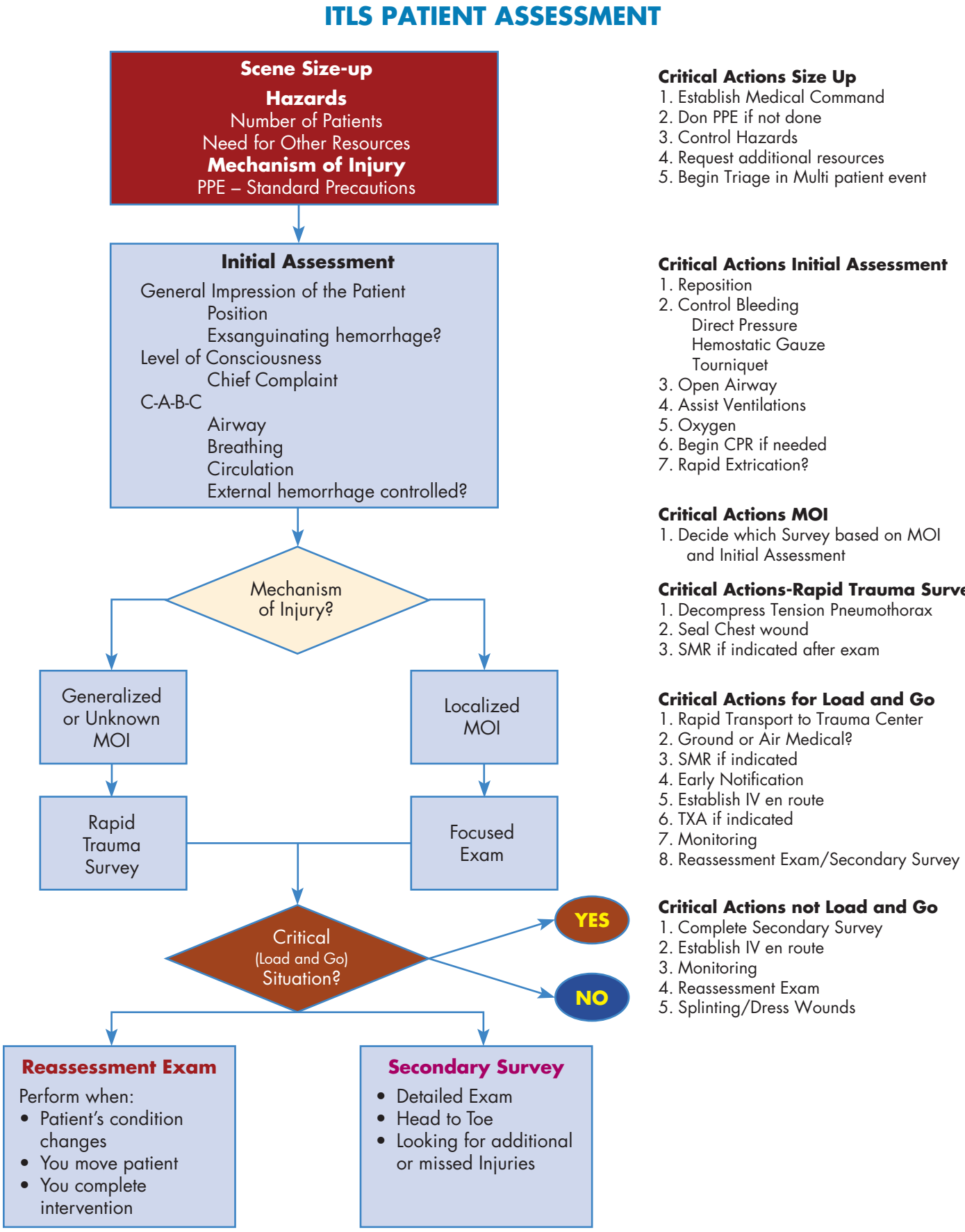


Figure 12-9 The ITLS Primary Survey.

PEARLS

Vomiting

Patients with head trauma frequently vomit. You must remain alert to prevent aspiration. If the patient is unconscious, with loss of protective reflexes, you should insert an endotracheal tube. Otherwise, keep mechanical suction available and be prepared to log-roll the patient onto his or her side (maintaining motion restriction of the spine).

Protect the airway of the unconscious patient who cannot protect his or her airway by endotracheal intubation. Alternatively, place an oropharyngeal or nasopharyngeal airway and perform frequent suctioning. Perform endotracheal intubation of the unconscious patient with a head injury as rapidly and smoothly as possible to avoid patient agitation, straining, and breath-holding, which may contribute to elevated ICP. Use of intravenous lidocaine when intubating patients with a head injury is no longer recommended. These patients may seize from their injury or have their teeth and jaws clenched, making intubation difficult. Attempting to force an artificial airway into such a patient may cause additional injury.

Drug-Assisted Intubation

Before beginning intubation, ventilate (do not hyperventilate) with high-flow oxygen. (See Chapters 6 and 7.) Do not allow the patient with TBI to become hypoxic, as this can increase mortality. Be aware that **drug-assisted intubation (DAI)** of patients with TBI in the field has been reported to increase mortality. This is thought to be due to the patient becoming hypoxic during the intubation attempt. If you can adequately manage the patient's airway noninvasively and transport times are short, consider deferring intubation until arrival at the hospital.

drug-assisted intubation (DAI): the administration of a sedative and paralytic agent to improve the ability to intubate a patient. This is also called *rapid sequence intubation (RSI)*.

As stated earlier, it is important to note the patient's basic neurologic status prior to DAI because the medications given can prevent a complete neurologic assessment in the hospital.

Rapid Trauma Survey

Perform a rapid trauma survey on all patients who have an abnormal LOC. (See Chapter 2.)

Head When the initial assessment (CABCD) is completed, perform a rapid trauma survey guided by the mechanism of injury. Begin with the scalp and quickly, but carefully, examine for obvious injuries such as lacerations or depressed or open skull fractures. The size of a laceration is often misjudged because of the difficulty in assessment through hair matted with blood. Feel the scalp gently for obvious unstable areas of the skull. If none are present, you may safely apply a pressure dressing or hold direct pressure on a bandage to stop scalp bleeding. If the patient bleeds through the bandage, you do not have control of the bleeding and need to reassess the wound for direct pressure to control bleeding. Do not continue to add bandages over the original ones, as you are only collecting the blood, not stopping it at the source. You can consider hemostatic gauze or bandage.

A basilar skull fracture may be indicated by any of the following: bleeding from the ear or nose, clear or serosanguineous fluid running from the nose or ear, swelling and/or discoloration behind the ear (Battle's sign), and discoloration around both eyes (raccoon eyes; Figure 12-10). Raccoon eyes are a sign of anterior basilar skull fracture that may go through the thin cribriform plate in the upper nasal cavity and allow spinal fluid and blood to leak out. Raccoon eyes with or without drainage from the nose are relative contraindications to inserting a nasopharyngeal airway, a nasogastric tube, or performing nasotracheal intubation. The tube can go through the fractured cribriform plate and into the brain.

Pupils The pupils (Figure 12-11) are controlled in part by the third cranial nerve. This nerve takes a long course through the skull and is easily compressed by brain swelling and thus may be affected by increasing ICP. Following a head injury, if both pupils are dilated and do not react to light, the patient probably has a brainstem injury, and the prognosis is grim. If the pupils are dilated but still react to light, the injury is often still reversible, so every effort should be made to transport the patient quickly to a facility capable of treating a head injury. A unilaterally dilated pupil that remains reactive to light may be the earliest sign of cerebral herniation. The development of a unilaterally dilated, nonreactive pupil ("blown pupil") while you are observing



A

Figure 12-10a Battle's sign—evidence of a posterior basilar skull fracture. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



B

Figure 12-10b Raccoon eyes—evidence of an anterior basilar skull fracture. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

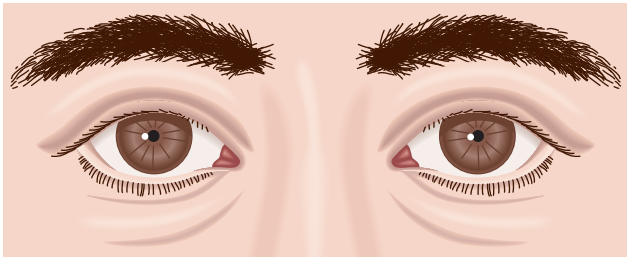
the comatose patient is an extreme emergency and mandates rapid transport and hyperventilation. Other causes of dilated pupils that may or may not react to light include hypothermia, lightning strike, anoxia, optic nerve injury, drug effect, or direct trauma to the eye. Fixed and dilated pupils signify increased ICP only in patients with a decreased LOC. If the patient has a normal LOC, the dilated pupil is not from head injury (more likely due to eye trauma or drugs such as atropine).

Fluttering eyelids may be seen with emotional disorders. Slow lid closure (like a curtain falling) is usually caused by brain injury or effect of toxins (such as alcohol or other sedatives). Testing for a blink response (corneal reflex) by touching the cornea with the edge of a gauze pad or cotton swab, or by applying overly noxious stimuli to a patient to test for response to pain, are techniques that are unreliable and do not contribute to prehospital assessment.

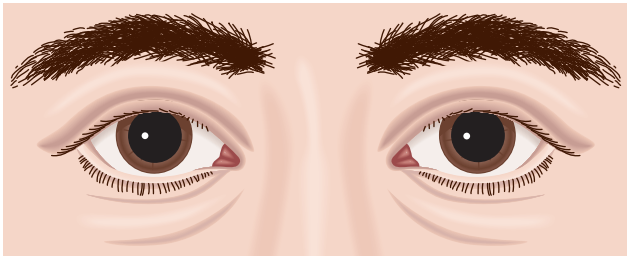
Extremities Test sensation and motor function in the extremities. If patients have a decreased LOC, note their response to pain. If they withdraw or localize to the pinching of the fingers and toes, they have grossly intact sensation and motor function. This usually indicates that there is normal or only minimally impaired cortical function.

Both decorticate posturing or rigidity (arms flexed, legs extended) and decerebrate posturing or rigidity (arms and legs extended) are ominous signs of deep cerebral hemispheric or upper brainstem injury (Figure 12-12). Decerebrate posturing is worse and usually signifies cerebral herniation. It is one of the indications for hyperventilation. Flaccid paralysis usually denotes spinal cord injury.

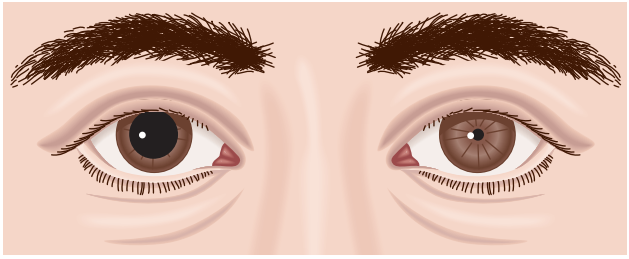
Neurologic Exam To apply the revised trauma score and other field triage scoring systems, you should be familiar with the GCS score. It is simple, easy to use, and has good prognostic value for eventual outcome (Table 12-2). In the patient with TBI, a GCS score of 8 or less is considered



Constricted pupils



Dilated pupils



Unequal pupils

Figure 12-11 Examination of pupils.



A



B

Figure 12-12 A. Decorticate and, B. decerebrate posturing.

evidence of a severe brain injury. The initial GCS score determined in the field serves as the baseline for the patient; be sure to record it. You should note that early GCS assessment may not reflect the severity of the head injury itself because systemic causes (hypoxia, hypotension, hypoglycemia, alcohol, etc.) may cause altered mental status. Evaluation after the correction of those factors represents the severity of brain damage correctly. Record the score for each part of the GCS, not just the total score. Recent studies suggest that the motor component of the GCS score is just as effective as the complete GCS (Acker et al. 2014; Caterino and Raubenolt 2012).

Vital Signs Vital signs should be obtained by another team member while you are performing the exam. Vital signs are extremely important in following the course of a patient with head trauma. Most important, they can indicate changes in ICP (Table 12-3). Observe and record vital signs at the end of the ITLS Primary Survey, during the detailed exam, and each time you perform the ITLS Reassessment Exam. In the patient with TBI, look for the following:

- *Respiration.* Increasing ICP can cause the respiratory rate to increase, decrease, and/or become irregular. Unusual respiratory patterns may reflect the level of brain or brainstem injury. Just before death, the patient may develop a rapid, noisy respiratory pattern called *central neurogenic hyperventilation*. Because respiration is affected by so many factors (such as fear, emotional disorders, chest injuries, hypoxia, spinal cord injuries, diabetes), it is not as useful an indicator as are the other vital signs in monitoring the course of head injury. Abnormal respiratory patterns may indicate a chest injury or other problem that could lead to hypoxia, if untreated.

Table 12-2: Glasgow Coma Scale

Eye Opening		Verbal Response		Motor Response	
	Points		**Points**		**Points**
Spontaneous	4	Oriented	5	Obeys commands	6
To voice	3	Confused	4	Localizes pain	5
To pain	2	Inappropriate words	3	Withdraws	4
None	1	Incomprehensible sounds	2	Abnormal flexion	3*
		Silent	1	Abnormal extension	2**
				No movement	1

* Decorticate posturing to pain.
** Decerebrate posturing to pain.

Table 12-3: Comparison of Vital Signs in Shock and Head Injury

	Shock	Head Injury with Increased Intracranial Pressure
Level of consciousness	Decreased	Decreased
Respiration	Increased	Varies but frequently decreased
Pulse	Increased	Decreased
Blood pressure	Decreased	Increased
Pulse pressure	Narrows	Widens

- *Pulse.* Increasing ICP causes the pulse rate to decrease only as a very late sign of Cushing's response. Tachycardia may be a sign of shock or pain.
- *Blood pressure.* Increasing ICP causes increased blood pressure. This hypertension is usually associated with a widening of the pulse pressure (systolic minus diastolic pressure). Other causes of hypertension include fear and pain. Hypotension in the presence of a head injury is usually caused by hemorrhagic shock. It is very rare to have hypotension due solely to a TBI. Keep in mind that the injured brain does not tolerate hypotension. A single instance of hypotension (90 mmHg systolic) in an adult with a brain injury may increase the mortality rate by 150%. The increase in mortality rate for hypotension and severe TBI is even worse in children. Give IV fluids to maintain a blood pressure of at least 100–110 mmHg systolic in the adult patient with a severe head injury (GCS score 8 or less), even if the patient has associated penetrating trauma with hemorrhage. As noted earlier, the goal is to maintain CPP above 60 mmHg, as recommended by the BTF. If not responsive to fluids, children with severe TBI should have their blood pressure maintained at the normal range for their age.

History Begin obtaining the history before and continue during the rapid trauma survey. It is essential to obtain as thorough a history about the event as possible. The circumstances of the head injury may be extremely important for patient management and may be of prognostic importance to the ultimate outcome. Pay particular attention to reports of near-drowning, electrocution, lightning strike, drug abuse, smoke inhalation, hypothermia, and seizures. Always inquire about the patient's behavior from the time of the head injury until the time of your arrival. Try to obtain the past medical history. Nontraumatic events can also cause an alteration in LOC. A blood glucose should always be checked in patients with altered mental status.

ITLS Secondary Survey

Suspected TBI patients with altered mental status are load-and-go situations. The ITLS Secondary Survey will be done during transport (or not at all, if a short transport). (See Chapter 2.)

ITLS Reassessment Exam

Each time you perform the ITLS Reassessment Exam, record the LOC, the pupil size and reaction to light, the GCS score, and the development (or improvement) of focal weakness or paralysis. This, along with the vital signs, provides enough information to monitor the condition of the patient with a brain injury. Decisions on the management of the patient with TBI are based on the changes in all the parameters of the physical and neurologic examination.

Management of the Patient with TBI

Your job is to prevent secondary brain injury. It is extremely important to make a rapid assessment and then transport the patient to a facility capable of managing TBI. Appropriate triage of the patient to facilities capable of managing TBI can have a significant impact on the outcome of the patient. The important points of management in the prehospital phase are listed here.

BTF fourth guidelines are classified as follows:

- Level I recommendations, supported by Class I scientific evidence (formerly called *Standards*)
- Level II recommendations, supported by Class II scientific evidence (formerly called *Guidelines*)
- Level III recommendations, supported by Class III scientific evidence (formerly called *Options*)

PEARLS
Seizures

Seizures in patients with TBI are usually caused by hypoxia. If the patient has an open airway and you are already ventilating with 100% oxygen, you may be ordered to administer IV medication to control the seizures. Seizures should always cause you to recheck the airway, ventilation, and oxygenation of your patient.

PEARLS
Hyperventilation

Emergency care providers tend to assist respiration at too fast a rate. Use of an $etCO_2$ monitor can prevent this.

Procedure

Managing the Patient with Head Trauma

1. Provide good oxygenation. The injured brain does not tolerate hypoxia, so every patient with TBI should receive 100% oxygen. If possible, monitor the oxygen saturation with a pulse oximeter. Do not allow the SaO_2 to become less than 90% (Level II). It is best to maintain a level at about 95%.

   Maintain good ventilation (not hyperventilation) at a rate of about one breath every 6–8 seconds (8–10 breaths per minute). Studies have found that emergency medical providers tend to hyperventilate the critical patient without realizing it. You can prevent this if you have an $etCO_2$ monitor. Try to keep the CO_2 between 35 and 45 mmHg.

   Endotracheal intubation is still recommended for adults if the airway cannot be maintained or if you cannot maintain adequate oxygenation with supplemental oxygen. There is no reason to routinely intubate patients who are maintaining their airway and have normal oxygen saturation, despite a decrease LOC. Some studies have found a decreased survival rate for TBI patients who have been intubated in the field. Possible causes of this are unrecognized hypoxemia, hyperventilation, or esophageal intubation. Use of capnography will help prevent those problems. (See Chapter 6.) BTF guidelines recommend capnography, pulse oximetry, and blood pressure monitoring as critical monitoring procedures for all intubated TBI patients (Level III).

   There is no evidence to support out-of-hospital endotracheal intubation over bag-valve mask ventilation of pediatric patients with TBI (Level II).

   Because TBI patients are prone to vomiting, be prepared to log-roll the motion-restricted patient and to suction the oropharynx, particularly if an endotracheal tube has not been placed. Try to avoid use of antiemetics because some may decrease LOC.

2. Apply spinal motion restriction based on the mechanism of injury as the status of the spine cannot be clinically assessed in a patient with a head injury and altered mental status. (See Chapter 10.) When possible, elevate the head of the stretcher about 30 degrees to help reduce ICP.

3. Agitated and combative patients fighting against restraints or ventilations can raise their ICP, as well as place themselves at risk for further cervical spine injury. Consider sedation in this situation, though be aware that sedation will complicate the neurologic evaluation and airway management of your patient.

   Careful use of benzodiazepines (Diazepam 2–5 mg IV, midazolam 1–3 mg IV; watch respirations) can decrease agitation without dropping blood pressure. An added benefit to the use of benzodiazepines is that they prevent seizures. Haloperidol (5 mg IV or IM in adult) can also be utilized for agitation.

4. Record vital signs (describe rate and pattern of breathing), LOC, the pupils (size and reaction to light), the GCS score, and the development (or improvement) of focal weakness or paralysis every 5 minutes.

5. Every patient with altered mental status should have a fingerstick glucose checked and recorded.

6. Insert two large-bore IV catheters. Fluid resuscitation (crystalloid) in patients with TBI should be administered to avoid hypotension and/or limit hypotension to the shortest duration possible (Level II). The danger of increasing brain swelling by giving fluids is much less than the danger of allowing the patient to be hypotensive.

7. Hyperventilation is recommended for use only in treating the patient with signs of cerebral herniation after correcting hypotension or hypoxia (Level III). If you have capnography available, try to maintain the $etCO_2$ level at about 35–40 mm Hg. If you have to hyperventilate the patient, keep the $etCO_2$ between 30 and 35 mm Hg (Stocchetti et al. 2005).

8. If the patient develops hypotension, assume it is due to hemorrhage, or rarely spinal cord injury. Hypertonic saline solutions versus crystalloids for treatment of hypotension in TBI patients has not been shown to improve outcomes (DeWall 2010).

9. Routine administration of steroids for TBI is not recommended.

10. Mannitol is an osmotic diuretic that is thought to decrease ICP. A Cochrane review reports insufficient data to support use of mannitol in the prehospital setting (Wakai 2013).

11. Guidelines recommend initiation of antiepileptics early in the course of treatment of TBI. Agents such as Phenytoin and Levetiracetam are effective but require continuous infusion to load the patient. Use of benzodiazepines may be better suited to the EMS setting, as they provide seizure protection and sedation.

Case Presentation *(continued)*

You and your partner are transporting a seriously injured bicyclist, who crashed into a parked vehicle, to a trauma capable hospital. The primary and rapid trauma assessments reveal life threatening bleeding from the left lower thigh. A tourniquet has been applied and has stopped the bleeding. The patient has possible head, chest, and extremity injuries and an inability to move the lower extremities.

The ITLS ongoing exam was performed, revealing an unresponsive patient with a GCS of 4 with decerebrate posturing of upper extremities. Respirations were irregular and slow, so the patient was intubated and is being assisted at 10 breaths per minute. Bleeding is under control and circulation assessed with a pulse of 70, blood pressure of 108/50, $etCO_2$ of 38, and SPO_2 of 95%. The left pupil is dilated and non-reactive.

Due to a GCS of less than 9 with posturing and unequal pupils, you are concerned about severe increased intracranial pressure and possible herniation. You instruct your partner to increase ventilations to a target $etCO_2$ of 30–35mm/hg and maintain the blood pressure with IV fluids to keep the BP above 100 systolic. You notify the hospital of the changes and the interventions you have performed. The neurosurgeon is present at the hospital on arrival.

The classic herniation syndrome is characterized by hypertension, bradycardia, and irregular respirations. However, this patient has other injuries that could prevent these classic signs. The patient is hypovolemic from the bleeding from his leg. You would expect tachycardia, but the patient does not show this sign as the possibility of a spinal cord injury may have prevented it. The loss of blood and the loss of vascular tone due to the spinal injury could cause further deterioration and further cerebral ischemia. Management priorities for the deteriorating head injury include management of hypoxia and hypotension and prevention of hyper or hypo ventilation.

A CT scan shows a subdural hematoma to the L side with a midline shift and a cerebral contusion. The neurosurgeon was able to successfully decompress this after the patient's shock had been stabilized. Spinal imaging showed a compression fracture of the first thoracic vertebrae with retropulsion of fragments into the spinal cord. This was surgically repaired and the patient regained motion in the lower extremities.

Summary

Head injury is a serious complication of trauma. To give your patient the best chance of recovery, you should be familiar with the important anatomy of the head and central nervous system and understand how trauma to the various areas presents clinically. The most important steps in the management of a patient with a head injury are rapid assessment, good airway management, prevention of hypotension and hypoxia, rapid transport to a trauma center, and frequent ITLS Reassessment Exams. Implementation of BTF guidelines leads to significant improvement in outcome of patients with severe head injury. In no other area of trauma care is the recording of repeated assessments so important to future management decisions.

References and Resources

Acker, S. N., J. T. Ross, D. A. Patrick, N. A. Nadlonek, M. Bronert, and D. D. Bensard. 2014. "Glasgow Motor Scale Alone is Equivalent to Glasgow Coma Scale at Identifying Children at Risk for Serious Traumatic Brain Injury." *Journal of Trauma and Acute Care Surgery*. 77(2) (August): 304–9.

Badjatia, N., N. Carney, T. J. Crocco, M. E. Fallat, H. M. Hennes, A. S. Jagoda, S. Jernigan, P. B. Letarte, E. B. Lerner, T. M. Moriarty, et al. 2008. "Guidelines for Prehospital Management of Traumatic Brain Injury 2nd Edition." *Prehospital Emergency Care* 12 (Suppl. 1): S1–S52.

Brain Trauma Foundation, American Association of Neurological Surgeons/College of Neurological Surgeons, Joint Section on Neurotrauma and Critical Care. 2017. "Guidelines for the Management of Severe Head Injury, 4th Edition." https://www.braintrauma.org/coma/guidelines

Caterino, J. M. and A. Raubenolt 2012. "The Prehospital Simplified Motor Score is as Accurate as the Prehospital Glasgow Coma Scale: Analysis of a Statewide Trauma Registry." *Emergency Medicine Journal*. 29(6) (June):492-6. doi: 10.1136/emj.2010.110437. Epub 2011 Jul 27.

Chestnut, R. M., L. F. Marshall, M. R. Klauber, B. A. Blunt, N. Baldwin, H. M. Esenbert, J. A. Jane, A. Marmarou, and M. A. Foulkes. 1993. "The Role of Secondary Brain Injury in Determining Outcome from Severe Head Injury." *Journal of Trauma* 34, no. 2 (February): 216–22.

Davis, D. P., J. V. Dunford, M. Ochs, K. Park, and D. B. Hoyt. 2004. "The Use of Quantitative End-Tidal Capnometry to Avoid Inadvertent Severe Hyperventilation in Patients with Head Injury After Paramedic Rapid Sequence Intubation." *Journal of Trauma—Injury, Infection, and Critical Care* 56, no. 4 (April): 808–14.

Davis, D. P., J. V. Dunford, J. C. Poste, M. Ochs, T. Holbrook, D. Fortlage, M. J. Size, F. Kennedy, and D. B. Hoyt. 2004. "The Impact of Hypoxia and Hyperventilation on Outcome After Paramedic Rapid Sequence Intubation of Severely Head-Injured Patients." *Journal of Trauma* 57, no. 1 (July): 1–8.

Davis, D. P., D. B. Hoyt, M. Ochs, D. Fortlage, T. Holbrook, L. K. Marshall, and P. Rosen. 2003. "The Effect of Paramedic Rapid Sequence Intubation on Outcome in Patients with Severe Traumatic Brain Injury." *Journal of Trauma—Injury, Infection, and Critical Care* 54, no. 3 (March): 444–53.

DeWall, J. 2010. "Evidence Based Guidelines for Adult Traumatic Brain Injury Care." *Journal of Emergency Medical Services* 35, no. 4 (March). https://www.jems.com/articles/print/volume-35/issue-4/patient-care/evidence-based-guidelines-adul.html

Franschman, G., S. M. Peerdeman, S. Greuters, J. Vieveen, A. C. Brinkman, H. M. Christiaans, E. J. Toor, G. N. Jukema, S. A. Loer, C. Boer, et al. 2009. "Prehospital Endotracheal Intubation in Patients with Severe Traumatic Brain Injury: Guidelines versus Reality." *Resuscitation* 80, no. 10 (October): 1147–51.

Hopkins, E., S. M. Green, M. Kiemeney, and J. S. Haukoos. 2018. "A Two-Center Validation of 'Patient Does Not Follow Commands' and Three Other Simplified Measures to Replace the Glasgow Coma Scale for Field Trauma Triage." *Annals of Emergency Medicine* 72, no. 3 (September): 259–69.

Langlois, J. A., W. Rutland-Brown, and M. A. Wald. 2006. "The Epidemiology and Impact of Traumatic Brain Injury: A Brief Overview." *Journal of Head Trauma Rehabilitation* 21, no. 5 (September–October): 375–8.

McCrory, P., W. Meeuwisse, K. Johnston, J. Dvorak, M. Aubry, M. Molloy, and R. Cantu. 2009. "Consensus Statement on Concussion in Sport: The 3rd International Conference on Concussion in Sports held in Zurich, November 2008." *British Journal of Sports Medicine* 43 (Suppl. 1) (May): i76–90.

Pigula, F. A., S. L. Wald, S. R. Shackford, and D. W. Vane. 1993. "The Effect of Hypotension and Hypoxia on Children with Severe Head Injuries." *Journal of Pediatric Surgery* 28, no. 3 (March): 310–6.

Stocchetti, N., A. I. Maas, A. Chieregato, and A. A. van der Plas. 2005. "Hyperventilation in Head Injury: A Review." *Chest* 127, no. 5 (May): 1812–27.

Stolz, U., K. Denninghoff, D. Spaite, et al. 2015. "Association Between Lowest Prehospital Systolic Blood Pressure and Non-Mortality Outcomes in Major Traumatic Brain Injury: Is There a 'Hypotension' Threshold?" *Prehospital Emergency Care* 19, no. 1 (January–March): 143.

Wakai, A., A. McCabe, I. Roberts, and G. Schierhout. 2013. "Mannitol for Acute Traumatic Brain Injury." *Cochrane Database Systematic Reviews* 2013, no. 8: CD001049.

Wang, H. E., A. B. Peitzman, L. D. Cassidy, P. D. Adelson, and D. M. Yealy. 2004. "Out-of-Hospital Endotracheal Intubation and Outcome After Traumatic Brain Injury." *Annals of Emergency Medicine* 44, no. 5 (November): 439–50.

13



(Courtesy of Kyee Han, MD)

Abdominal Trauma

Ingrid Bloom, MD
Melissa White, MD, MPH
Arthur H. Yancey II, MD, MPH, FACEP

Abdominaltraumata
Ozljede trbuha
Trauma Abdominal
Trauma Abdomen
Травмы живота
Traumatismes abdominaux

Τραύμα Κοιλίας
Hasi traumák
腹部外傷
腹部創傷
Poškodbe trebuha

Key Terms

evisceration, *p. 273*
intrathoracic abdomen, *p. 271*
peritoneum, *p. 273*
retroperitoneal abdomen, *p. 271*
seat-belt sign, *p. 273*
true abdomen, *p. 271*
viscus, *p. 272*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Identify the basic anatomy of the abdomen and explain how abdominal and chest injuries may be related.
2. Differentiate between blunt and penetrating injuries and identify characteristic complications associated with each.
3. Describe the treatment required for the patient with protruding viscera.
4. Describe how to identify and stabilize a pelvic fracture and why this is important.
5. Describe the findings indicating possible intra-abdominal injuries based on history, physical examination, and mechanism of injury.
6. List the critical interventions for patients with abdominal injuries.

Chapter Overview

Injury to the abdomen can be a difficult condition to evaluate in the hospital setting. In the field it can be even more challenging. Nevertheless, because hemorrhage from intra-abdominal injury is one of the major causes of preventable traumatic death, the possibility of intra-abdominal injury must be recognized, addressed, and documented immediately. Penetrating abdominal injuries often require immediate surgical intervention. Blunt injuries (contact sports, motor-vehicle collisions, assault) may be more subtle, but potentially just as deadly.

Whether caused by blunt or penetrating trauma, an abdominal injury can result in life-threatening conditions such as hemorrhage and infection. Hemorrhage has immediate consequences, so you must be vigilant in assessing the signs and symptoms of shock in all patients with abdominal injury. Infection, which presents late, may be just as lethal, but does not require field intervention beyond prevention of gross contamination.

The role of the emergency care provider in the management of abdominal trauma has evolved over time. Studies in the mid-1980s demonstrated that appropriate and timely intervention by well-trained Paramedics could improve the hemodynamic status of critically injured patients who have wounds to the abdomen. Subsequent studies (e.g., Bickell et al. 1994) demonstrated that pneumatic antishock garment (PASG) application and/or vigorous intravenous (IV) fluid resuscitation in the prehospital setting may do more harm than good for patients who have penetrating torso injuries. For blunt trauma, the effects of aggressive fluid resuscitation are now felt to be detrimental by interfering with clotting (see Chapter 8).

In the field, rapid patient assessment and early treatment of shock, along with prompt and safe transport to definitive care, are critical aspects in the management of the patient with abdominal trauma.



Case Presentation

Your ambulance is dispatched to a construction site where a worker has fallen from the scaffolding on the second floor. This happened about an hour ago, and he was able to stand with the help of his friends and tried to go back to work. He reports some abdominal pain on his left side. When he raised his shirt, he noticed bruising on his lower abdomen. He also reports passing blood when he urinated. He states he became nauseated and lightheaded when he stood up.

Before proceeding, consider these questions:

- What elements in the history and mechanism of injury (MOI) indicate possible internal injuries?
- What critical signs would you search for in your primary and secondary surveys?
- Does this patient require spinal motion restriction (SMR)? What treatment should you provide?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

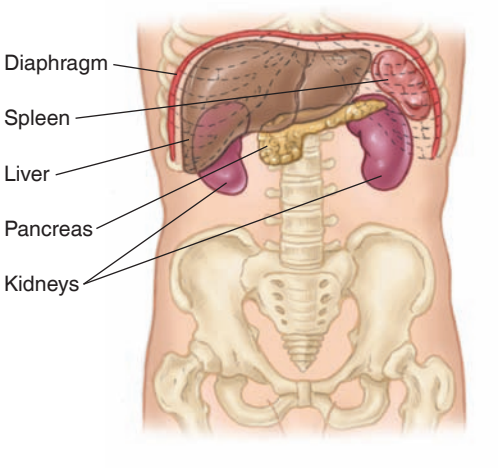


Figure 13-1 Intrathoracic abdomen.

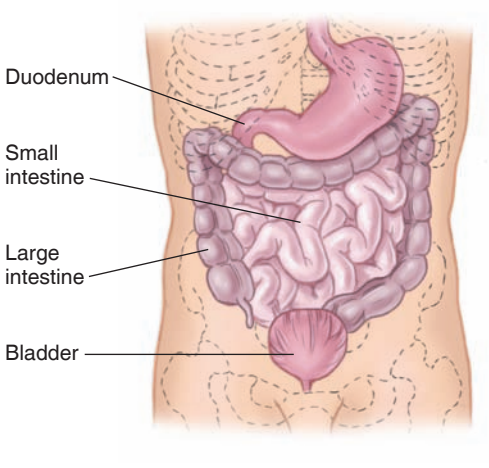


Figure 13-2 True abdomen.

Anatomy of the Abdomen

The abdomen is traditionally divided into three regions: the **intrathoracic abdomen** (Figure 13-1), the **true abdomen** (Figure 13-2), and the **retroperitoneal abdomen** (Figure 13-3).

Although hemorrhage in the true abdomen may cause the anterior abdominal wall to become distended, hemorrhage severe enough to cause shock can occur in the retroperitoneal space without this dramatic sign. Because of its location away from the anterior body surface, retroperitoneal injuries are difficult to evaluate in the field. The iliac blood vessels and their branches, located in the pelvic portion of the retroperitoneal abdomen, may be damaged by abdominal trauma or pelvic fracture, resulting in serious hemorrhage with minimal localized or external symptoms.

Types of Abdominal Injuries

Injuries to the abdomen are categorized as either blunt or penetrating trauma, but a combination of the two can also occur. Blunt trauma is the most common mechanism of abdominal injury and has relatively high mortality rates of 10–30%. This is probably due to the frequency of accompanying injuries to the head, chest, pelvis, and/or an extremity in as many as 70% of motor-vehicle collision victims.

Blunt abdominal injury may be from direct compression of the abdomen against a fixed object with resulting tears or subcapsular hematomas involving the solid organs (spleen/liver/pancreas). Injury may also arise from deceleration forces, with tearing of organs and their blood vessels at fixed areas within the abdominal region. This is particularly true of the liver and the renal arteries. Hollow organs (typically the small intestine) may rupture due to increased intraluminal pressures.

The patient who has experienced blunt abdominal trauma may have no pain and little external evidence of injury, which may give a false sense of security. Patients with multiple lower rib fractures are notorious for having intra-abdominal injuries without significant abdominal pain. The severe pain from the rib fractures becomes a distracting injury for the less noticeable abdominal pain. As a result, the patient may have a poor outcome because abdominal injuries are not recognized early enough for definitive treatment.

intrathoracic abdomen: the part of the abdomen located under a thin sheet of muscle, called the *diaphragm*, and enclosed by the lower ribs; contains the liver, gallbladder, spleen, stomach, and transverse colon.

true abdomen: the part of the abdomen from the lower ribs and including the pelvis but anterior to the retroperitoneum; contains the large and small intestines, a portion of the liver, and the bladder. In a female, the uterus, fallopian tubes, and ovaries are also part of the true abdomen.

retroperitoneal abdomen: the part of the abdomen behind the thoracic and true portions of the abdomen, separated from the other abdominal regions by a thin retroperitoneal membrane; includes the kidneys, ureters, pancreas, posterior duodenum, ascending and descending colon, abdominal aorta, and the inferior vena cava.

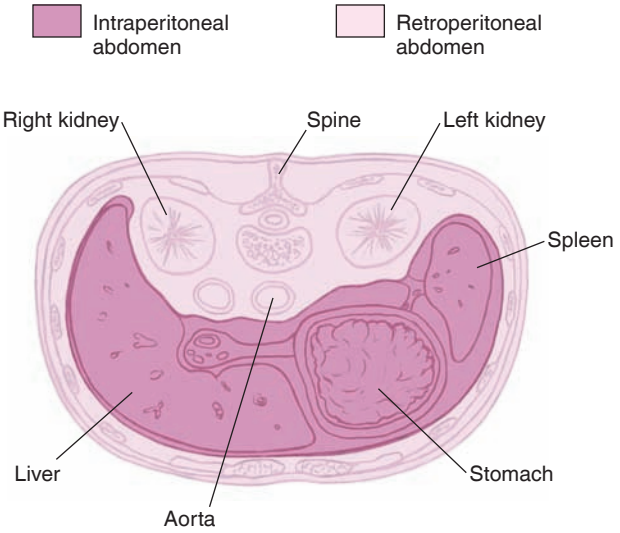


Figure 13-3 Retroperitoneal abdomen.

PEARLS

Abdominal Injury

When the mechanisms of trauma or associated injuries, such as lower rib fractures or gluteal penetrating wounds, suggest possible intra-abdominal injury, do not be fooled by the patient's lack of abdominal pain or tenderness. Be prepared to treat hypovolemic shock from occult intra-abdominal bleeding. The patient who has sustained blunt trauma to the abdomen and has abdominal pain and/or tenderness probably has serious abdominal injuries and is likely to develop shock quickly (even if vital signs are initially normal). Load and go and prepare to treat the development of hemorrhagic shock en route to the hospital.

Diaphragmatic rupture can occur following either blunt or penetrating trauma. Abdominal contents will herniate into the chest cavity, most commonly on the left side. The liver tends to buttress the diaphragm on the right. Based on the volume of abdominal contents that enter the chest, the patient may experience respiratory difficulty and bowel sounds may be heard in the chest

Most penetrating injuries encountered by EMS are the result of gunshots or stab wounds. Gunshot wounds to the abdomen may include direct trauma to an organ and vasculature through penetration from the bullet, its fragments, or the energy transmitted from the bullet's mass and velocity. This is known as *cavitation*. (See Chapter 1.)

As a general rule, most patients with gunshot wounds to the abdomen will require definitive treatment in the operating room and should be transported to a trauma center, if available. These patients have mortality rates between 5 and 15% because of a greater incidence of injury to abdominal viscera from the higher energy imparted to the intra-abdominal organs than that imparted by stab wounds. (See Chapter 1.)

The mortality rate from abdominal stab wounds is relatively low compared to gunshot wounds. Unless the knife penetrates a major vessel or organ, such as the liver or spleen, the patient may not initially appear to be in shock at the scene. In addition to shock, patients can develop life-threatening peritonitis over the next few hours or days as a result of penetration of the intestines. Those wounds need to be carefully evaluated at the hospital because approximately one-third of stab-wound patients require surgery for intra-abdominal bleeding or perforation of a hollow **viscus** with spilling of gastrointestinal contents, leading to peritonitis.

viscus: internal body organ; plural: viscera.

Because the path of the penetrating object might not be readily apparent from the wound location, any penetrating wound of the chest could also have penetrated the abdomen, and vice versa. The course of a bullet may pass through numerous structures in different body locations. Inspection of the patient's entire posterior surface is necessary because penetrating trauma in the gluteal area (iliac crests to the gluteal folds, including the rectum) is associated with as many as 50% of significant intra-abdominal injuries.

Assessment and Stabilization

Scene Size-up

One can glean important information from the scene by noting the circumstances surrounding the patient's injury. An accurate but rapid size-up of the scene will usually guide the emergency care provider to the possibility of intra-abdominal trauma. For example, do circumstances on the scene suggest that the patient has fallen from a height or been hit by a passing vehicle? Has there been an explosion that could have hurled the patient against immobile objects or transmitted blast pressure to organs inside the abdomen? Did the passenger in an automobile crash have the shoulder strap under the arm rather than over the shoulder? Or was the lap belt worn too high over the unprotected, soft true abdomen instead of correctly across the bony pelvis? Many of these clues can be found at the scene.

If the patient was involved in a motor-vehicle crash, during scene size-up, quickly observe the damage to the vehicle, such as passenger compartment intrusion, airbag deployment, broken windows, bent steering wheel/steering column, and location of occupants. If the patient needs to be extricated, note the location of the safety belts. Although they certainly save lives, safety belts incorrectly worn can cause blunt abdominal injuries by compressing the intra-abdominal organs against the spine. Remember that for the same reason, lap belt–only restraints, especially in the adolescent age group, may predispose the passenger to intra-abdominal injuries in a motor-vehicle crash.

The patient who is stabbed or shot may be able to give some idea of the size of the weapon used and its trajectory. With gunshot wounds, it is also important to know (if possible) the caliber, the range from which the gun was fired, and the number of rounds fired. A bystander or the police may be able to provide such information. Remember, however, to "treat the wound and not the weapon."

On arrival at the hospital (optimally, a trauma center), be sure to report any mechanism that suggests abdominal injury. However, while at the scene, it is important not to spend a great deal of time attempting to obtain a history. The major cause of preventable mortality in abdominal trauma is delayed diagnosis and treatment.

Patient Assessment

As in treating any injured patient, the patient with an injured abdomen should first undergo the ITLS Primary Survey. During the rapid trauma survey, the essence of the prehospital abdominal exam is rapid visualization and palpation of both the chest and abdomen. Quickly inspect the chest and abdomen for deformities, contusions, abrasions, punctures, **evisceration**, and distention.

evisceration: the protruding of intestinal organs through a wound.

The chest is only one thin muscle sheet (the diaphragm) away from the abdominal cavity. Abdominal organs are enclosed within the lower ribs, thus injury to both chest and abdomen is not uncommon. Blunt or penetrating injuries to the chest below the nipple line (fourth or fifth rib) should lead to concern for the possibility of both chest and abdominal injuries. Rib fractures may suggest hepatic, splenic, and diaphragmatic trauma. Splenic injury may present with referred left posterior shoulder pain (*Kehr's sign*), and a liver injury may present with referred right posterior shoulder pain. The presence of a **seat-belt sign**, which is a large bruise or abrasion across the abdomen, is indicative of intra-abdominal injury in approximately 25% of cases.

seat-belt sign: a bruise or abrasion across the abdomen from an improperly positioned lap belt. It can be a clue to blunt intra-abdominal injury.

Observation of the abdomen may reveal periumbilical bruising (*Cullen's sign*), raising suspicion for retroperitoneal hemorrhage, but be mindful that this finding usually takes several hours to develop. Grey-Turner's sign, which is a flank hematoma, can develop, particularly after retroperitoneal injuries (Figure 13-4). Significant amounts of blood may be lost into the retroperitoneal space without any abdominal signs, as discussed in the following text. The great vessels (aorta, vena cava) and the kidneys all lie in the retroperitoneal space and if injured can have significant hemorrhage.

peritoneum: a thin serous membrane that lines the abdominal cavity and covers the organs of the abdomen.

Palpate the patient's abdomen for distention, tenderness, or rigidity. To palpate the abdomen, use light but firm pressure with the fingers against the abdominal wall, looking for tenderness or rigidity. Be sure to assess all four quadrants. Then repeat using more pressure (using both hands may be more effective) to deeply palpate for tenderness. Distention of the abdomen should be interpreted as a sign of severe intra-abdominal trauma with likely hemorrhage. Tenderness or guarding over the abdominal wall, especially away from wounds, is also usually a sign of intra-abdominal injury. If tenderness or guarding is present in the prehospital setting, there is usually significant extravascular, or free, blood in the abdomen from hemorrhage, causing irritation of the **peritoneum**. This is an indication that shock may be imminent. (See Chapter 4.)



Figure 13-4 Flank hematoma (Grey Turner's sign). *(Courtesy of David Effron)*

The lower portion of the abdomen extends into the pelvis. The pelvis is a ring of six bones connected posteriorly to the sacrum. The femurs attach to the pelvis at the hip joints. The ilium forms the "wings" of the pelvis, with the pubic bones making up the anterior portion of the ring and ischium the lower portion. In the lower abdomen, the aorta splits into the femoral arteries and the vena cava is formed by the joining of the femoral veins. Fractures of the pelvis, like any major bone, can lead to bleeding, from the fracture itself or from damage to major vessels that lie adjacent to the pelvic bones. As a result, pelvic fractures frequently result in hemorrhagic shock.



Figure 13-5 Palpation of the pelvis. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

To assess for a pelvic fracture in the field, gentle palpation (downward pressure) of the iliac crests (pelvic wings) and pubis of the pelvis may reveal signs associated with fractures, including tenderness, bony crepitation, or instability (Figure 13-5). If pain is elicited, assume the pelvis is fractured. For the pelvis to be unstable, the pelvic ring must be disrupted (fractured) in two places. *Note*: The pelvis should not be compressed, as this can cause clot dislodgement or possible worsening of a fracture, nor should more than one emergency care provider palpate the pelvis for instability. The perineum (genitalia and buttocks) should be visualized for bruising or hemorrhage during the ITLS Secondary Survey.

Auscultation of the abdomen in the field usually does not offer reliable information. Abdominal wounds should never be probed with a finger or an instrument. Blind probing of a wound may extend a superficial wound into the peritoneum. *If clothing must be removed to visualize injury, try to preserve important potential legal evidence by cutting around (rather than through) areas of clothing that have signs of possible penetration.*

Stabilization

Interventions should follow priorities established by the ITLS Primary Survey. They should proceed in the same order in which assessment occurred: (C) control exsanguinating bleeding, (A) airway, (B) breathing, and (C) circulation. For the patient in whom only intra-abdominal injury is suspected, give supplemental oxygen by the most appropriate method and be sure breathing is adequate and then address the issue of shock or potential shock.

The patient should be readied for immediate transport with appropriate SMR, if indicated. Of note, penetrating trauma to the abdomen or chest with no signs of neurologic deficit does not require SMR.

Time to definitive care at the trauma center is critical. Unnecessary intervention on scene should be avoided. Once en route to an appropriate trauma center, establish two large-bore IV lines of normal saline. If the patient's blood pressure drops below 90 mmHg systolic with signs of shock, then the IV fluids should be titrated to maintain the systolic blood pressure at 80–90 mmHg. (See Chapter 4.) However, keep in mind that overly aggressive fluid resuscitation might dislodge protective clots and/or dilute clotting factors, both of which lead to worsening hemorrhage.

Gently cover any organ or viscera protruding from a wound with gauze moistened with sterile saline or water. If long transport time is anticipated, also apply over the gauze a nonadherent material, such as plastic wrap or aluminum foil, to prevent drying of the applied gauze and underlying intestines (Scan 13-1). If the intestines are allowed to dry, they may become irreversibly damaged. Do not push abdominal contents protruding from a wound back into the abdomen. Similarly, if a foreign body (such as a knife or glass shard) is impaled in the abdomen, do not attempt to remove or manipulate it because it may precipitate uncontrollable hemorrhage. Carefully stabilize the object in place without moving it. (Pregnant patients deserve the special considerations addressed in Chapter 20.)

Although difficult to assess for, if a pelvic fracture resulting from high-energy blunt trauma (motor-vehicle collision) is suspected on prehospital exam, a pelvic binder (or circumferential bed sheet) can be placed to help stabilize and decrease pelvic volume en route, which can help to minimize further blood loss into the pelvis or retroperitoneum. If using a sheet, it should be folded to a width of 8–12 inches (20–30 cm) and centered over the greater trochanters, positioned beneath the patient, then crossed anteriorly before pulling tightly and tying the ends into a knot. Avoid wrinkles and do not pull too tightly. Be sure to reexamine the patient's neurovascular

SCAN 13-1 Caring for an Evisceration



13-1-1 Remove clothing to fully expose the abdominal wound. Keep patient supine and flex the knee and hip to decrease intra-abdominal pressure, if not contraindicated.



13-1-2 Cover the wound with a sterile gauze dressing soaked with normal saline.



13-1-3 Cover the moistened sterile dressing with an occlusive dressing (such as plastic wrap) to prevent evaporative drying.

status distally. (Please see Chapter 15 for more information on application of pelvic binding.)

Early application of pelvic binding has been shown to improve survival and lessen need for transfusion (Hsu et al. 2017). There is concern for possible worsening of injury with isolated acetabular fracture, but it is difficult to identify these in the field (Auston and Simpson 2015).

New Trends in Managing Abdominal Trauma

Deciding which patient(s) should be taken to a local community hospital and which should be taken directly to a trauma center can be a difficult decision, with only a patient history, scene size-up, and patient assessment to guide it. Better tools are

needed to distinguish between patients who have injuries that are neither severe nor time-critical and will remain stable, and those who have a significant mechanism and/or signs of injury who appear stable initially but are at risk for decompensation or subsequently do decompensate, requiring emergent transfer to a trauma center. Diagnostic tools and the procedures to use them that are quickly performed on scene or en route in the ambulance would advance field triage immensely because they have the potential to predict which apparently stable patients might deteriorate. Current studies using focused assessment with sonography in trauma (FAST exam) in the field show promise in enabling providers to detect internal hemorrhage.

FAST is an ultrasound scan and triage tool routinely performed in the emergency department to assess patients presenting with blunt abdominal trauma. A potential benefit of FAST exam use in the prehospital setting is accelerated diagnosis of intraperitoneal hemorrhage from blunt abdominal trauma. A study on the feasibility of a real-time mobile telesonography system found that it can perform point-of-care ultrasound and transmit real-time data obtained in a prehospital setting to experts in the hospital. The use of the FAST exam in the prehospital setting may allow patients to be triaged to a higher acuity level with blunt abdominal trauma. By alerting emergency departments with the transmission of ultrasound images, trauma centers could be better prepared to allocate resources in anticipation of the patient's arrival. An early diagnosis in the prehospital setting may also give the physician knowledge enough to prioritize relevant treatment. Ultrasound in the prehospital setting is becoming more common in systems in Europe and the United States, especially as size and cost of units have decreased in the past few years. Studies have shown ultrasound can also be used to help detect the presence of pneumothoraces, tamponade, and endotracheal tube position in the field as well as help with IV access and to assess for cardiac activity during management of cardiac arrest. It must be stressed that a FAST exam should not delay transport of trauma patients to the appropriate facility.

Management of abdominal trauma in the field not only focuses on rapid transport to an appropriate facility, but also on the identification of internal bleeding. Exsanguination is a common cause of death in trauma patients. If a patient has sustained an abdominal injury that is causing hemorrhage, there are few helpful prehospital management options. Because tranexamic acid (TXA) reduces bleeding in patients undergoing elective surgery, investigators in two different studies sought to evaluate the use of this drug to help with clotting in trauma patients. Based on the Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage (CRASH-2) trial, researchers found the importance of using TXA in bleeding trauma patients (Roberts et al. 2013). The effectiveness and safety of early administration of TXA has been studied and its use decreases mortality. No benefit is seen if given beyond 3 hours after the time of initial injury. In the United Kingdom, the standard is now to give TXA within the first hour of injury. If given later, outcomes are worse. The Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTER) study showed, with use of TXA after combat injury, a decrease in total blood products transfused along with an increase in survival, especially among patients requiring massive transfusion (Morrison et al. 2012). (Please see Chapter 4 for further discussion on the management of internal hemorrhage.)

Lactate has been shown to be a biochemical marker of developing shock. Newer systems to measure lactate levels at the bedside have been developed and are proving useful to identifying patients in shock before clinical symptoms develop. This may be another clue to ongoing internal hemorrhage, which would be an indication to transport directly to a trauma center or other facility capable of managing internal trauma.

Prompt diagnosis and treatment of patients with abdominal trauma is considered essential in the successful management of the trauma patient. Continued study of these and other innovative prehospital diagnostics and treatment options is needed.

Case Presentation *(continued)*

Your ambulance responds to a construction site where a worker fell two floors. The patient is in no acute distress, speaking in full sentences, and answering questions appropriately. His primary survey was noted to be intact. The patient complains of left-side abdominal pain, left shoulder pain, and some nausea and reports passing blood when he urinated. On exam his neck is found to be nontender. His chest is clear and nontender. Palpation of his abdomen produces tenderness in the left upper quadrant, where his contusion is noted, and he complains of pain on palpation.

Vital signs show a pulse rate of 110, blood pressure of 110/72 and respirations are 10 and unlabored. He reports a history of congenital heart disease and takes warfarin because of his mechanical heart valve. While getting on to the stretcher, he has an episode of vomiting but no blood is noted. After your rapid trauma survey, you perform an E-FAST exam using the portable ultrasound unit just placed on your unit and on which you have completed your training. You are worried about what you think is free fluid near his spleen and transmit the image to the hospital.

You establish a peripheral IV while en route to the hospital. You administer ondansetron, 4 mg IV. Because of his continued pain, you also administer 4 mg morphine sulfate IV per protocol.

The ITLS Ongoing Survey shows no changes en route to the hospital. Subsequent evaluation in the emergency department shows the patient has a small splenic hematoma and a bladder contusion, but no free fluid. Both the hematuria and the subcapsular splenic hematoma are likely related to his use of anticoagulants for his heart valve. He was managed nonoperatively and discharged the following day. This case illustrates that intra-abdominal injury can sometimes be delayed in presentation.

Summary

Effective prehospital management of the patient who has abdominal trauma entails the following:

- Scene size-up for mechanisms of injury and pertinent history from the patient and/or witnesses
- Rapid patient assessment
- Rapid transport to the appropriate hospital (optimally, a trauma center)
- IV lines, pelvic binding, and other interventions as needed (usually performed en route)

The enemies of the abdominal trauma patient are bleeding and time elapsed from injury until hemostasis from optimal emergency and surgical care. If on-scene delays can be minimized, this will help to maximize the patient's chances for survival.

References and Resources

Aprahamian, C., B. M. Thompson, J. B. Towne, and J. C. Darin. 1983. "The Effect of a Paramedic System on Mortality of Major Open Intra-abdominal Vascular Trauma." *Journal of Trauma* 23, no. 8 (August): 687–90.

Auston, D. A., and B. R. Simpson. 2015. "Initial Treatment of 'Pelvic Injuries' with Commercially Available Pelvic Binders Results in Displacement of Acetabular Fractures: A Report of Three Cases." *JBJS Case Connector* 5, no. 1 (March): e20–4. doi:10.2106/JBJS.CC.N.00073.

Bickell, W. H., M. J. Wall Jr., P. E. Pepe, R. R. Martin, V. F. Ginger, M. K. Allen, and K. L. Mattox. 1994. "Immediate Versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injuries." *New England Journal of Medicine* 331, no. 17 (October): 1105–9.

Brooke, M., J. Walton, and D. Scutt. 2010. "Paramedic Application of Ultrasound in the Management of Patients in the Prehospital Setting: A Review of the Literature." *Emergency Medicine Journal* 27, no. 9 (September): 702–7.

Collopy, K. T., and G. Friese. 2010. "Abdominal Trauma: A Review of Prehospital Assessment and Management of Blunt and Penetrating Abdominal Trauma." *EMS Magazine* 39, no. 3 (March): 62–6, 68–9.

French, L. K, S. Gordy, and O. J. Ma. Boswell. 2016. "Abdominal Trauma." In *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 8th ed., by J. E. Tintinalli, J. S. Stapczynski, O. J. Ma, D. Yealy, G. D. Meckler, and D. M. Cline. New York: McGraw-Hill. https://accessmedicine.mhmedical.com/content.aspx?aid=1121516742

Heegaard, W., D. Hildebrandt, D. Spear, K. Chason, B. Nelson, and J. Ho. 2010. "Prehospital Ultrasound by Paramedics: Results of Field Trial." *Academic Emergency Medicine* 17, no. 6 (June): 624–30.

Hoyer, H. X., S. Vogl, U. Schiemann, A. Haug, E. Stolpe, and T. Michalski. 2010. "Prehospital Ultrasound in Emergency Medicine: Incidence, Feasibility, Indications, and Diagnoses." *European Journal of Emergency Medicine* 17, no. 5 (October): 254–9.

Hsu, S. D., C. J. Chen, Y. C. Chou, S. H. Wang, and D. C. Chan. 2017. "Effect of Early Pelvic Binder Use in the Emergency Management of Suspected Pelvic Trauma: A Retrospective Cohort Study." *International Journal of Environmental Research and Public Health* 14, no. 10: 1217. doi:10.3390/ijerph14101217.

Jansen, T. C., J. van Bommel, P. G. Mulder, H. Johannes, H. Rommes, J. M. Schieveld, and J. Bakker. 2008. "The Prognostic Value of Blood Lactate Levels Relative to That of Vital Signs in the Prehospital Setting: A Pilot Study." *Critical Care* 12, no. 6: R160–6.

Korner, M., M. M. Krotz, C. Degenhart, K. J. Pfeifer, M. F. Reiser, and U. Linsenmaier. 2008. "Current Role of Emergency Ultrasound in Patients with Major Trauma." *Radiographics* 28, no. 1 (January–February): 225–42.

Legome, E. L., S. M. Keim, and J. P. Salomone. 2014. "Blunt Abdominal Trauma." Accessed January 2015. http://emedicine.medscape.com/article/821995-overview

Martin, R. S., and J. W. Meredith. 2011. "Management of Acute Trauma." In *Sabiston Textbook of Surgery: The Biological Basic of Modern Surgical Practice*, 19th ed., edited by C. M. Townsend Jr., R. D. Beauchamp, B. M. Evers, and K. L. Mattox, 408–48. Philadelphia: Saunders.

Melville, S., and D. Melville. 2011. "Abdominal Trauma." In *Current Diagnosis and Treatment Emergency Medicine*, 7th ed., edited by G. K. Stone and R. L. Humphries, 363–74. New York: McGraw-Hill.

Morrison, J. J., J. J. Dubose, T. E. Rasmussen, and M. J. Midwinter. 2012. "Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study." *Archives of Surgery* 147, no. 2 (February): 113–9.

Newgard, C. D., R. J. Lewis, and J. F. Kraus. 2005. "Steering Wheel Deformity and Serious Thoracic or Abdominal Injury Among Drivers and Passengers Involved in Motor Vehicle Crashes." *Annals of Emergency Medicine* 45 (January): 43–50.

Ogedegbe, C., H. Morchel, V. Hazelwood, W. F. Chaplin, and J. Feldman. 2012. "Development and Evaluation of a Novel, Real Time Mobile Telesonography System in Management of Patients with Abdominal Trauma: Study Protocol." *BMC Emergency Medicine* 12, no. 19 (December): 12–9.

Pepe, P. E., V. N. Mosesso, and J. L. Falk. 2002. "Prehospital Fluid Resuscitation of the Patient with Major Trauma." *Prehospital Emergency Care* 6, no. 1 (January–March): 81–91.

Rajab, T. K., W. J. Weaver, and J. M. Havens. 2013. "Videos in Clinical Medicine: Technique for Temporary Pelvic Stabilization After Trauma." *New England Journal of Medicine* 369, no. 17 (October): 369.

Roberts, I., H. Shakur, T. Coats, B. Hunt, E. Balogun, L. Barnetson, L. Cook, T. Kawahara, P. Perel, D. Prieto-Merino, et al. 2013. "The CRASH-2 Trial: A Randomised Controlled Trial and Economic Evaluation of the Effects of Tranexamic Acid on Death, Vascular Occlusive Events, and Transfusion Requirement in Bleeding Trauma Patients." *Health Technology Assessment* 17, no. 10 (March): 1–79.

Scott, I., K. Porter, C. Laird, I. Greaves, and M. Bloch. 2013. "The Prehospital Management of Pelvic Fractures: Initial Consensus Statement." *Emergency Medicine Journal* 30, no. 12 (December): 1070–2.

Smith, J. 2010. "Focused Assessment with Sonography in Trauma (FAST): Should Its Role Be Reconsidered?" *Postgraduate Medical Journal* 86, no. 1015 (May): 285–91.

Strode, C. A., B. J. Ruba, R. T. Gerhardt, J. R. Bulgrin, and S. Y. Boyd. 2003. "Wireless and Satellite Transmission of Prehospital Focused Abdominal Sonography for Trauma." *Prehospital Emergency Care* 7, no. 3 (July–September): 375–9.

Taylor, J., K. McLaughlin, A. McRae, E. Lang, and A. Anton. 2014. "Use of Prehospital Ultrasound in North America: A Survey of Emergency Medical Services Medical Directors." *BMC Emergency Medicine* 14, no. 6 (March). doi:10.1186/1471-227X-14-6.

Todd, S. R. 2004. "Critical Concepts in Abdominal Injury." *Critical Care Clinics* 20 (January): 119–34.

van Beest, P. A., P. J. Mulder, S. B. Oetomo, B. van den Broek, M. A. Kuiper, and P. E. Spronk. 2009. "Measurement of Lactate in a Prehospital Setting Is Related to Outcome." *European Journal of Emergency Medicine* 16, no. 6 (December): pp. 318–22.

14

Extremity Trauma

Sabina Braithwaite, MD, MPH, FACEP
S. Robert Seitz, MEd, RN, NREMT-P



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

Extremitätentraumata
Trauma en Extremidades
Ozljede ekstremiteta
Traumatismo de Extremidades
Trauma das Extremidades
Травмы конечностей

Key Terms

amputation, *p. 285*
closed fracture, *p. 282*
compartment syndrome, *p. 287*
crepitation, *p. 288*
crush syndrome, *p. 287*
impaled object, *p. 287*
joint dislocation, *p. 284*
neurovascular injury, *p. 281*
open-book pelvic fracture, *p. 295*
open fracture, *p. 282*
sprain, *p. 286*
strain, *p. 286*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Prioritize extremity trauma in the assessment and management of life-threatening injuries.
2. Discuss the major immediate and short-term complications and treatment of the following extremity injuries:
   a. Fractures
   b. Dislocations
   c. Open wounds
   d. Amputations
   e. Neurovascular injuries
   f. Sprains and strains
   g. Impaled objects
   h. Crush injuries

Objectives (continued)

3. Discuss the pathophysiology of compartment syndrome and which extremity injuries are most likely to develop this complication.
4. Describe the potential amount of blood loss from pelvic and femur fractures.
5. Discuss major mechanisms of injury, associated injuries, potential complications, and management of injuries to the following:
   a. Clavicle and shoulder
   b. Elbow
   c. Forearm and wrist
   d. Femur
   e. Hand or foot
   f. Hip
   g. Knee
   h. Pelvis
   i. Tibia and fibula (including ankle)

Chapter Overview

Emergency care providers should never allow a deformed or injured extremity to divert their attention from more life-threatening injuries that may also be present. Extremity injuries often have a dramatic appearance that can be seen as you approach the patient. Such injuries may be disabling and can occasionally be life-threatening. But do not be distracted by the injuries that are easily visible. It is important to remember that the movement of air through the airway, the mechanics of breathing, the maintenance of circulating blood volume, and the appropriate treatment of shock must always come before fracture or dislocation management.

Hemorrhagic shock is a potential danger with major musculoskeletal injuries. Lacerations of arteries or fractures of the pelvis or femur can cause major bleeding. Unfortunately, that bleeding is often internal and may not be detectable upon physical examination until enough blood is lost and the patient develops signs and symptoms of shock. (See Chapter 4.) Injuries to the nerves or the blood vessels that serve the hands and feet are common complications of fractures and dislocations. Such injuries cause the loss of function or sensation, which is included in the term *neurovascular compromise*, or **neurovascular injury**. Thus, evaluation of pulses, motor function, and sensation (PMS) distal to fractures is a very important component of the evaluation of the injured patient. Significant injury to the vessels can lead to loss of the limb.

neurovascular injury: an injury that involves nerves and blood vessels. Also called *neurovascular compromise*.



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Case Presentation

You are dispatched to a serious motor vehicle collision involving a motorcycle and a car. You are an emergency care provider on the second unit dispatched to the scene. The motorcyclist was critically injured and has already been transported to the hospital by the time you arrive. Hazards are already controlled, and the police guide you to the car that was in the collision and has damage down the driver's side and a cracked windshield. You find a young male driver with a cervical collar that was placed by the fire department personnel. He is cradling his left arm, complaining of shoulder pain, and tells you he also has pain in his left ankle. You see the airbag deployed during the incident. The driver states he tried to stand but could not due to ankle pain.

Before proceeding, consider these questions:

- What should the emergency care provider do?
- What injuries should he suspect?
- What additional injuries might also have occurred?
- How should he assess and treat this patient?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

Injuries to Extremities

Injuries to the extremities may include fractures, dislocations, open wounds, amputations, neurovascular injuries, sprains and strains, impaled objects, compartment syndrome, and crush injuries and crush syndrome.

Fractures

A fracture may be open, with the broken end of the bone still protruding or having once protruded through the skin, or it may be closed, with no communication to the outside (Figure 14-1). Fractured bone ends are extremely sharp and can cut the tissues that surround the bone. Because nerves, veins, and arteries frequently travel either near the bone, generally across the flexor side of joints, or very near the skin (hands and feet), they are easily injured. Such neurovascular injuries may be due to direct injury from bone fragments, or the injuries may be indirect, from pressure due to swelling or hematoma following a fracture.

closed fracture: a break in a bone in which there is no break in the continuity of the overlying skin.

open fracture: a broken bone in which a piece of the bone is protruding through the overlying skin.

A **closed fracture** can be just as dangerous as an **open fracture** because injured soft tissues often bleed profusely. It is important to remember that any break in the skin near a fractured bone may be considered an opening for contamination. All broken bones bleed and a closed fracture of one femur can cause the loss of 1–2 liters (2 to 4 units) of blood. Thus, bilateral femur fractures can cause life-threatening hemorrhage (Figure 14-2).

A fractured pelvis can cause extensive bleeding into the abdomen or the retroperitoneal space. An unstable pelvis is usually fractured in at least two places and may have caused more than 1 liter of associated blood loss (2 units of blood). Depending on the location of the pelvic fracture, there may be associated injury to the urinary tract, bladder, or bowel. Posterior pelvic fractures or fracture-dislocations, which may include the sacroiliac joints, can damage the large pelvic blood vessels and result



A

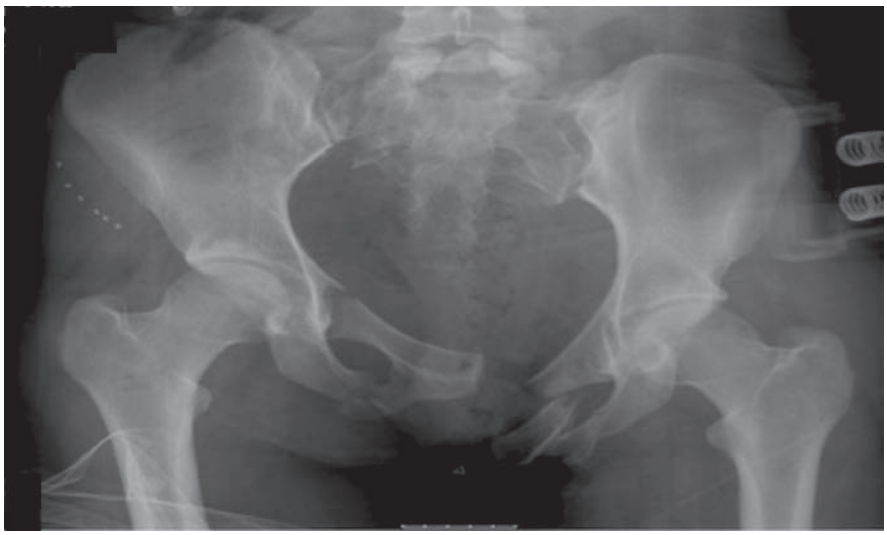


B

Figure 14-1 A. Open ankle fracture. B. Closed forearm fracture. (This is a good example of a Colles fracture of the wrist, which can result from a fall on an outstretched hand.) *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



A



B

Figure 14-2 Internal blood loss from fractures. A. May lose up to 2 units of blood from closed femur fracture. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)* B. May lose 2 units up to complete blood volume in closed pelvic fractures. This pelvic fracture, while usually a closed fracture, is called an "open-book" fracture because the pelvic symphysis is pulled apart like an open book. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

in massive retroperitoneal or intra-abdominal hemorrhage. Because of the significant force needed to fracture the pelvis, one-third of all patients with pelvic fractures have associated intra-abdominal injuries. Remember, multiple fractures can cause life-threatening hemorrhage without any external blood loss.

Open fractures add the dangers of wound contamination and subsequent infection to the risk of external hemorrhage. If protruding bone ends are pulled back into the skin when the limb is splinted, bacteria-contaminated debris will be introduced into the wound. Infection from such debris may slow or prevent healing of the bone. Be sure to notify the receiving hospital if there is a possibility of the fracture being open because the wound may be hidden by splints and dressings applied to stabilize the fracture.

Generally, fractures are quite painful. Once you have fully assessed and stabilized the patient, your management should include splinting of the fracture not only to avoid further injury, but also for patient comfort. Control of pain is an important part of emergency care. Unless there is a specific contraindication such as hypotension, you should also provide analgesic medication, if your protocols and the patient's situation allow.

Dislocations

joint dislocation: a complete disruption of a joint with total loss of contact between the joint's articular surfaces.

A **joint dislocation** is an extremely painful injury. It is generally easy to identify because normal joint anatomy is significantly distorted (Figure 14-3). Although major joint dislocations are not life threatening, they are still true emergencies because of the neurovascular compromise that can lead to significant disability and even amputation if not recognized and treated promptly. Because of this, it is critical to assess for PMS distal to major joint dislocations; to reassess following splinting, reduction, or movement; and to document your findings.



Figure 14-3 Ankle dislocation and fracture. Note tenting of the skin, which can become necrotic if the ankle is not promptly reduced.
(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Ordinarily, dislocations and fractures should be splinted in the position in which they are found with adequate padding and stabilization. As with fractures, pain management should be considered for patients with dislocations, if that option is available. There are certain exceptions to the general rule of splinting injuries in the position found, including when loss of distal pulse is noted. In that case, especially if you have a long transport time to the appropriate hospital, apply gentle traction in an effort to bring the injured extremity into a more anatomic position and restore the distal pulse. Ideally, this should occur after administration of analgesics and/or sedation for the patient.

Open Wounds

If the initial assessment (C-ABC) of the ITLS Primary Survey shows exsanguinating bleeding, apply a tourniquet to the affected extremity immediately. Most bleeding can be controlled with direct pressure or pressure dressings. It is important to apply direct manual pressure on the site of the bleeding, not just the area of injury. However, if the patient has severe bleeding from an extremity injury and you cannot stop the bleeding with pressure dressings, you should not hesitate to use a tourniquet. If you have bleeding that cannot be stopped with pressure or with a tourniquet, such as injuries to the axilla, neck, or groin, you should use a hemostatic dressing or one of the junctional tourniquets, if available. (See Chapter 5.)

When used correctly, hemostatic agents or dressings along with direct pressure or tourniquets can be effective in stopping bleeding from penetration and laceration-type injuries. Note that hemostatic agents are not to be used in open abdominal or chest wounds, and some agents may require modification of the shape of the dressing to conform to the irregular shape of a wound. Patients with severe hemorrhage should be transported immediately after the ITLS Primary Survey. With obvious

life-threatening hemorrhage, the order of the initial assessment changes to C-ABC (control bleeding, airway, breathing, and circulation). (See Chapter 2.) It is very rare for a tourniquet not to control severe extremity bleeding. Consider application of a second tourniquet in this situation. Do not take the first tourniquet down to reapply it.

For an open wound from a fracture, where bleeding is controlled, carefully cover it with a moist sterile dressing and bandage. Gross contamination, such as leaves or gravel, should be removed from the wound, if possible. For patients with very long transport times, such as for a wilderness rescue, consider irrigation of the wound to remove smaller pieces of contamination, based on consultation with medical direction and local protocols. Perform this irrigation in the same manner you would irrigate a chemically contaminated eye. Patients with open fractures should receive antibiotics as soon as practical. This can be initiated during transport. First-generation cephalosporin antibiotics are a good initial choice. Other agents can be added at the hospital after assessment of the wound and mechanism. Tetanus status should be updated after arrival at the hospital.

Amputations

An **amputation** is a disabling and often life-threatening injury that may present as a partial or complete loss of a body part. Although an amputation has the potential for massive hemorrhage, usually the bleeding can be controlled with direct pressure applied to the stump. The stump should be covered with a damp sterile dressing and an elastic wrap that will apply uniform, reasonable pressure across the entire stump. If life-threatening bleeding cannot be controlled with direct pressure, a tourniquet should be applied (Figure 14-4). A tourniquet can be lifesaving with this type of injury, when the proximal extremity is involved.

amputation: an open injury caused by the cutting or tearing-away of a limb, body part, or organ.

Make an effort to find the amputated part and bring it to the hospital with the patient. However, do so only as long as the patient is stable and there is no significant delay in transporting the patient. Bringing the amputated part is sometimes a neglected detail that can have serious future implications for the patient. It is difficult to determine in the field whether an amputated part can be replanted, revascularized, or used for tissue grafting as part of the amputation repair. So, it is important to transport the amputated parts even if replantation seems impossible. Note, for example, that digits have been successfully replanted many hours following injury.

Small amputated parts should be rinsed off, wrapped in saline-moistened sterile gauze, and placed in a plastic bag (Figure 14-5). Label the bag with the patient's name, date, time the amputation happened, and time the part was wrapped and cooled.



Figure 14-4 Combat application tourniquet. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 14-5 Amputated parts should be put in a plastic bag, sealed, and the bag placed in water that contains a few ice cubes. *(Photo courtesy of Stanley Cooper, EMT-P)*

If ice is available, place the sealed bag in a larger bag or container containing ice and water. *Never* immerse the amputated part in water or saline or use ice directly on the amputated part, and never use dry ice. Cooling the part slows the metabolic processes and will increase the part's viable time for replantation. Patients with amputations should be transported directly to a facility that has the ability to perform replantation when possible.

Neurovascular Injuries

The nerves and major blood vessels generally run beside each other, usually in the flexor area of the major joints. They may be injured together, and loss of circulation or sensation can be due to disruption, swelling, or compression by bone fragments or hematomas. Foreign bodies or broken bone ends may well impinge on delicate structures and cause them to malfunction. Always check for distal PMS before and after any extremity manipulation, application of a splint, or traction.

If there is loss of sensation or circulation in an extremity, the patient should be promptly transported to a hospital with emergency orthopedic care available. If extremity position is causing the deficit, you may or may not be able to correct it in the field. Generally, it is best to splint the injured limb in the position found if transport time is not prolonged. If splinting or traction has caused the deficit, then the splint or traction should be removed or repositioned until pulse is restored.

PEARLS

Sprains and Strains

In the field, sprains cannot be differentiated from fractures. Treat them as though they were fractures. Strain injuries can usually be differentiated from factures, but may be splinted for comfort.

Sprains and Strains

sprain: a sudden twist of a joint with stretching or tearing of ligaments.

strain: a stretching or partial tearing of a muscle or musculotendinous unit.

A **sprain** is a stretching or tearing of ligaments of a joint because of a sudden twist. It will cause pain and swelling. In the field, sprains cannot be differentiated from a fracture, so they should be splinted as if they were fractures.

A **strain** is a stretching or tearing of a muscle or musculotendinous unit that will cause pain and, often, swelling. The injured limb can be splinted for comfort. Strains can often (but not always) be differentiated from a fracture, but by splinting, you have protected the patient even if a fracture is present. Application of ice, if available, can reduce the swelling.

Impaled Objects

Do not remove objects impaled in extremities. The skin is a pivot point in these situations, and any motion of the **impaled object** outside the body is translated or magnified within the tissues, where the end of the object inside the body can lacerate or cause additional harm to sensitive structures. So, secure the object in place with bulky padding. Then transport the patient.

impaled object: an injury in which an object is embedded in the body tissue.

Note that objects impaled in the cheek that obstruct the airway are exceptions and must be removed or the patient could die from airway loss or hypoxia. Removal of the impaled object could cause severe hemorrhage, and careful pressure plus hemostatic agents may be needed to control it. Impaled objects in the cheek can usually be safely removed because you can apply pressure from both inside and outside the wound. This allows you to control the airway, if needed.

Compartment Syndrome

The extremities contain muscles and other structures surrounded by tough membranes, known as *fascia*. These membranes do not stretch, but instead create multiple closed spaces known as *compartments*. Crush injuries, as well as closed (and some open) fractures, can cause bleeding and swelling. When this bleeding or swelling is contained within the muscle by the fascia, pressure in the compartments can rise. This results in what is called the **compartment syndrome**.

compartment syndrome: a condition in which increased tissue pressure in a muscle compartment results in decreased blood flow, leading to tissue hypoxia and possible muscle, nerve, and vessel impairment; can be permanent if the cells die.

Lower leg injuries have the greatest risk of developing compartment syndrome, although it can occur in the forearm, thigh, hand, and foot as well. As the injured area swells, pressure compresses all the structures within the compartment, including arteries, veins, nerves, and muscle. At a certain point, the pressure prevents venous return. Then, as pressure continues to increase, it cuts off arterial circulation. The nerves are also compromised by the effect of the pressure and the lack of blood flow.

Because these processes take some time, compartment syndrome does not present immediately, but tends to develop over several hours following the initial injury. It is very important if performing a transfer of a trauma patient between medical facilities to perform the ITLS Reassessment Exam and assess distal neurovascular function. Elevation of the injured extremity and application of ice can be used to manage suspected compartment syndrome in the field. Adequate control of pain is an important part of care of compartment syndrome.

Late signs and symptoms of compartment syndrome are the "five Ps": pain, pallor, pulselessness, paresthesia, and paralysis. The early symptoms are usually pain, typically described as pain out of proportion to the injury, and paresthesia (numbness and tingling). Treatment of compartment syndrome requires emergent surgical compartment decompression by a fasciotomy. As with shock, a high degree of suspicion is important. One should consider this diagnosis before the later symptoms develop and likely result in permanent damage.

Crush Injury and Crush Syndrome

Crushing injuries result from application of external force on the body. Crush injuries to the torso can cause traumatic asphyxia and death. Crush injuries to the extremities can cause direct damage to the tissues, especially muscles, and compromise circulation. The injured tissues swell, further decreasing perfusion. Because of poor perfusion and a lack of oxygen delivery, the tissues switch to anaerobic metabolism, which results in the buildup of toxic metabolites such as lactic acid. In addition, the damaged cells can leak potassium and myoglobin, a protein from muscle. Most extremities can tolerate up to 4 hours of ischemia due to compromised flow before cell death occurs, although tissue injury can happen in as little as an hour of circulatory compromise.

crush syndrome: a systemic condition that results from crushing injury to muscles with cell death. The release of toxic products, including myoglobin, results in development of shock and acute renal failure and eventual death. Also known as traumatic rhabdomyolysis.

When circulation is restored, those toxic products are carried throughout the body and affect many organ systems. This is known as **crush syndrome**. The heart pumps less effectively due to the acidosis and hyperkalemia; myoglobin, as it is filtered by

the kidney, causes acute renal failure. Crush syndrome is a significant problem in earthquakes and other types of structural-collapse events.

Management of crush syndrome is directed toward management of immediate life threats, as identified in the ITLS Primary Survey, followed by fluid resuscitation. The goal is to maintain urine output at 0.5–1 cc/kg body weight per hour. Alkalinization of the urine (urine pH 6.5–7.5) by administering intravenous sodium bicarbonate may be helpful by increasing the excretion of myoglobin and reduce risk of renal failure. If possible, fluid administration should begin before the patient is pulled from the collapsed structure.

Assessment and Management

Scene Size-up and History

When assessing the patient with extremity trauma, it is especially important to get a history because the mechanism of injury may not be apparent in your scene size-up. The mechanism of injury and your assessment of the extremity may give you important clues to the potential severity of the injury. If there are enough emergency care providers, one can obtain the history while you are performing the ITLS Primary Survey. If additional help is not available, you should *not* attempt to obtain a detailed history until you have assessed the status of the patient's airway, breathing, and circulation. For the conscious patient, obtain most of the history at the end of the ITLS Primary Survey.

Foot injuries from long jumps (falls landing on the feet) often have associated lumbar-spine injuries. Any injury to the knee, when the patient is in the sitting position, can have associated injuries to the hip. Similarly, hip injuries can refer pain to the knee. So the knee and the hip are intimately connected and must be evaluated together rather than separately.

Falls onto the wrist frequently injure the elbow, and so the wrist and elbow must be evaluated together. The same is true of the ankle and the proximal fibula of the outside of the lower leg. Shoulder pain may be from the joint itself, or may be due to injury to the neck, chest, or even abdomen.

Fractures of the pelvis, which require a high-energy impact, are often associated with very large amounts of blood loss. Whenever a fracture in the pelvis is identified, shock must be suspected and proper treatment begun immediately.

crepitation: the sound or feel of broken fragments of bone grinding against each other.

PEARLS

Priorities

- First assess and treat the ABCs and do not be distracted by obvious extremity trauma.
- Exsanguinating hemorrhage is the exception to the previous (follow CABC rather than ABC), but you must not forget to assess airway and breathing.
- Be alert to the mechanism of injury so that you know what fractures to suspect and you can predict possible complications.

Assessment

During the ITLS Primary Survey, focus on identifying immediate life threats as well as obvious fractures to the pelvis and large bones of the extremities. You should also find and control major external bleeding from the extremities.

During the ITLS Secondary Survey, quickly assess the full length of each extremity, looking for deformity, contusions, abrasions, penetrations, burns, tenderness, lacerations, and swelling (DCAP-BTLS). Feel for instability and **crepitation**. (See Chapters 2 and 3.) Check the joints for pain and spontaneous movement if there is no obvious deformity or pain. Check and record distal pulses, motor function, and sensation. Pulse location may be marked with a pen to identify the area where the distal pulse is best felt (Figure 14-6).

Crepitation or grating of bone ends is a definite sign of fracture. Once identified, the bone ends should be stabilized to prevent further soft-tissue injury. Checking for crepitation should be done very gently, especially when checking the pelvis, to avoid further injuries.

Management of Extremity Injuries

Proper management of fractures and dislocations will decrease the incidence of pain, disability, and serious complications. Treatment in the prehospital setting is



A B C

Figure 14-6 Taking pulses distal to an injury. A. Palpate the radial artery. B. Palpate the dorsalis pedis pulse. C. Palpate the posterior tibial pulse.

directed at immobilization of the injured part by the use of an appropriate splint and padding. Pain control with appropriate analgesics is another major component of the care of injured extremities.

Purpose of Splinting

The objective of splinting is to prevent motion of the broken bone ends. The nerves that cause the most pain in a fractured extremity lie next to the bone. The broken bone can injure the nerves, causing very deep, severe pain. Splinting not only decreases pain, but also limits further damage to muscles, nerves, and blood vessels by preventing further motion of the broken bone ends.

When to Splint

There is no simple rule for splinting that determines the precise sequence to follow in every patient. Patients with serious injuries should be rapidly transported rather than delaying departure to splint extremity fractures. Extremity fractures can be temporarily stabilized by careful packaging on the long backboard for patients who require a load-and-go approach, with short transport times. This does not mean that you should *not* identify and protect extremity fractures. After addressing priorities such as hemorrhage control, airway and shock management and packaging the patient on the transport stretcher, perform additional splinting en route to the hospital. It is never appropriate to spend time splinting a limb to prevent disability when that time may be needed to save the patient's life. Conversely, if the patient appears to be stable, extremity fractures should be splinted before moving the patient for all the reasons noted earlier.

PEARLS

The Golden Period

- Do not waste the Golden Period. Be cautious but be rapid, and prioritize life over limb.
- Splint at an appropriate time. The axial skeleton is splinted after the ITLS Primary Survey. If a critical situation exists, extremities should be splinted en route if time allows.

PEARLS

Pulses, Motor Function, Sensation

Always assess and record distal pulses, motor response, and sensation initially and after any manipulation, particularly splinting.

Procedure

Rules of Splinting

- You must adequately expose the injured part. Clothing should be removed, preferably by cutting it off, to allow adequate assessment of the injury and proper immobilization.
- Check and record distal pulses, motor function, and sensation before and after splinting. To check motor function distal to the fracture, ask the conscious patient to wiggle his or her fingers, or you can observe motion in an unconscious patient when a painful stimulus is applied. Pulses may be marked with a pen to identify where they were palpated.
- If the extremity is severely angulated, pulses are absent, and you have a long transport to the appropriate hospital, apply gentle traction in an attempt to straighten the extremity (Figure 14-7). If you encounter significant resistance, splint the extremity in the position found. When you are attempting to straighten an extremity, it is very important to be honest with yourself with regard to resistance. It takes very little force to lacerate the wall of a vessel or to interrupt the blood supply to a large nerve. If the appropriate hospital is near, it is probably best to splint in the position found.

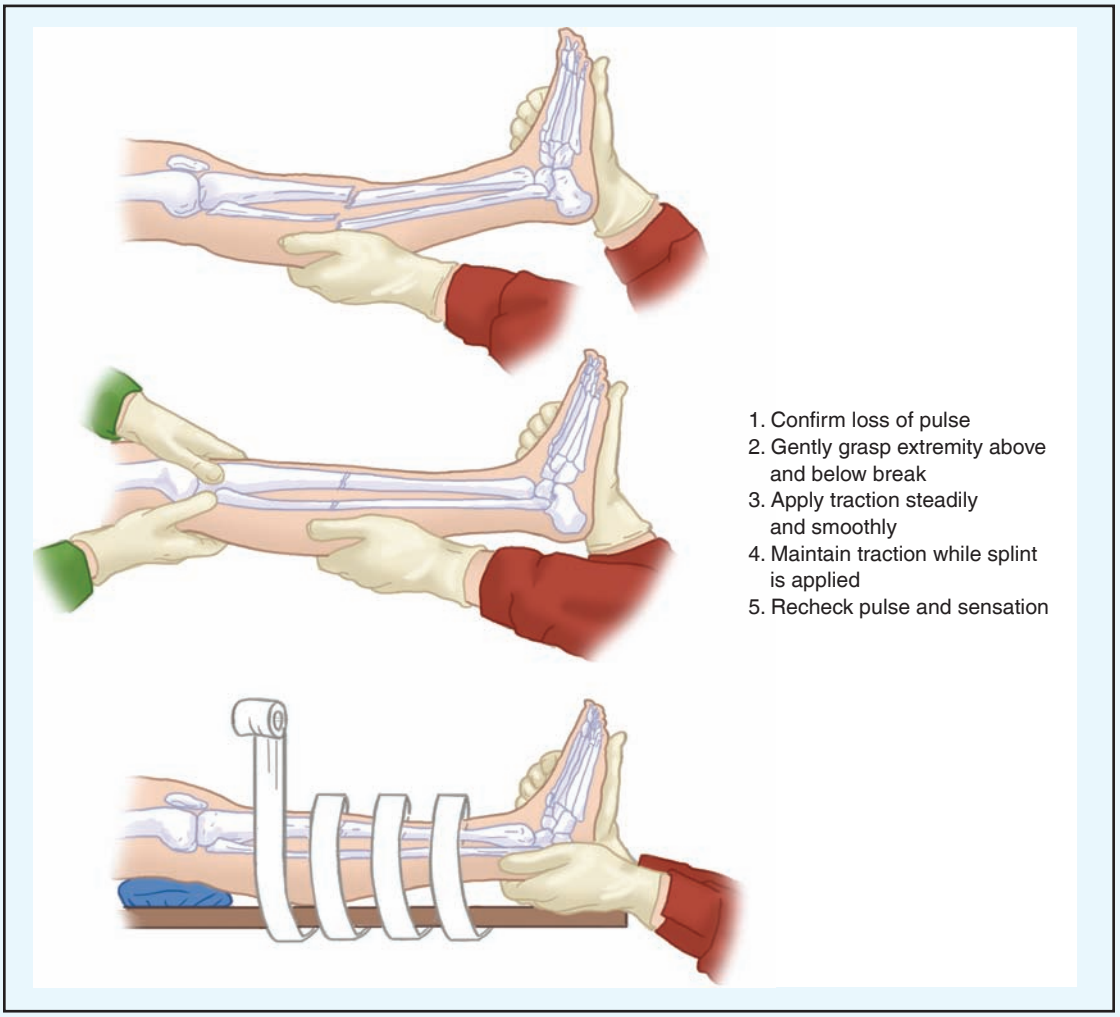


Figure 14-7 Straightening angulated fractures to restore pulses.

Procedure *(continued)*

- Cover open wounds with a moist, sterile dressing before you apply the splint. Whenever possible, splints should be applied on the side of the extremity away from any open wounds. At the hospital, notify the staff of any open wounds.
- Use a splint that will immobilize one joint above and one joint below the injury site.
- Pad the splint well. This is particularly true if there is any skin defect or if bony prominences might press against a hard splint and cause additional pain or injury to the skin.
- Do not attempt to push bone ends back under the skin. If you apply traction and the bone end retracts back into the wound, do not increase the amount of traction. Do not try to pull the bone ends back out. It is important to be sure to notify the receiving physician that the bone ends were visible. Carefully cover bone ends with moist, sterile bandages. If transport is prolonged, this will help improve bone healing.
- In a life-threatening situation, injuries may be splinted while the patient is being transported. When the patient appears stable, splint fractures or deformities before moving him or her.
- If in doubt, splint a possible injury.

Types of Splints

For examples of splinting extremities, please see Figure 14-8.

Rigid Splints Rigid splints can be made from many different materials, including cardboard, hard plastic, metal, or wood. The type of splint that is made rigid by evacuating air from a moldable splint (vacuum splint) is also classified as a rigid splint. Rigid splints should be well padded over bony prominences and should always immobilize one joint above and one joint below the fracture.

Soft Splints Soft splints include pillows, sling- and swathe-type splints, and air splints. Pillows make good splints for injuries to the ankle or foot, providing immobilization as well as padding to the injured area. Used with a sling and a swathe, they are useful for stabilizing a dislocated shoulder.

The sling and swathe are excellent for immobilizing injuries to the clavicle, shoulder, upper arm, elbow, and sometimes the forearm. They utilize the chest wall as a solid foundation and splint the arm against it. Some shoulder injuries cannot be brought close to the chest wall without applying significant force. In those instances, pillows are used to bridge the gap between the chest wall and the upper arm.

Air splints may be useful for fractures of the lower arm and lower leg. They are light and easily carried. Disadvantages include increasing pressure as the temperature rises or the altitude increases, inability to monitor distal pulses, and potential pain with removal. They should not be used on angulated fractures because they apply straightening pressure as they are inflated.

To apply an air splint, it must be inflated by mouth or by pump (never by compressed air) until it provides good support, yet is still able to be dented easily with slight pressure from a fingertip. When using air splints, you must frequently check the pressure to be sure the splint is not getting too tight or too loose. (They often leak.)

Traction Splints The traction splint is designed to stabilize fractures of the midfemur. They should not be used in hip fractures or if there is more than one fracture in the lower extremity. The traction splint holds the fracture immobile by application of a steady pull on the ankle while applying countertraction to the ischium and the groin. This steady traction overcomes the tendency of the very strong thigh muscles to spasm. If traction is not applied, the pain worsens because the bone ends tend to impact or override. Traction also prevents free motion of the ends of the femur, which could lacerate the femoral nerve, artery, or vein.

PEARLS

Shock

Be prepared for hemorrhagic shock when there is a pelvic or femur fracture.



Figure 14-8a Splinting materials.



Figure 14-8b Sling and swathe.



Figure 14-8c Rigid splint with swathes.



Figure 14-8d Traction splint.



Figure 14-8e Fixation or rigid splint with a sling and swathe.



Figure 14-8f Injured elbow immobilized in a bent position.



Figure 14-8g Injured elbow immobilized in a straight position.



Figure 14-8i Immobilization of an injury to lower leg and ankle with SAM splint. *(Pearson Education, Inc.)*



Figure 14-8k A high femur fracture immobilized in a fixation splint.



Figure 14-8h Immobilization of an injury to the forearm, wrist, or hand.



Figure 14-8j A tongue depressor used as a splint and then taped to an adjoining finger for stabilization.



Figure 14-8l A splinted knee.



Figure 14-8m Blanket-roll splint of the ankle and foot.

Many designs and types of splints are available to apply traction to the lower extremity (Figure 14-9). Several of them are reviewed in Chapter 15. As with other splints, traction splints must be carefully padded and applied with care to prevent excessive pressure on the soft tissues around the pelvis.

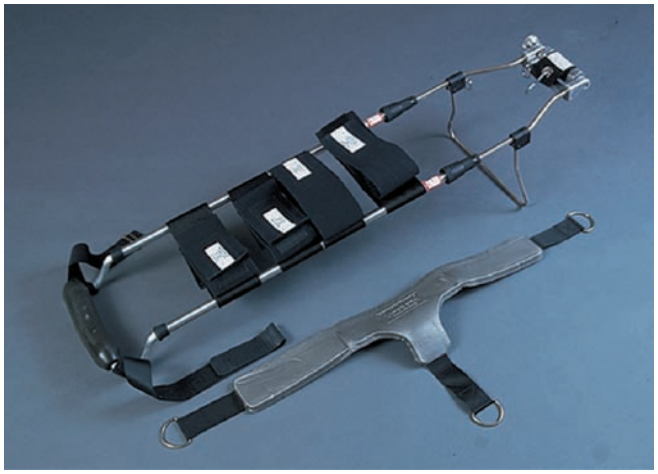
Tourniquets

Tourniquets have returned to common use in both the military and tactical settings for uncontrollable extremity hemorrhage. (See also Chapter 4.) They have been shown to improve survival and outcomes in those settings and are regaining acceptance in civilian use as well. Tourniquet use has been shown to be lifesaving in patients with shock due to massive blood loss from extremity injuries, allowing for circulatory resuscitation. There is a potential for ischemic injury if a tourniquet is left on too long, but that risk must be balanced against the tourniquet's ability to stop life-threatening hemorrhage. Ideally, tourniquets should not be used for longer than 2–4 hours. Complications can increase if left on longer. The ability to salvage the injured limb also decreases with long periods of ischemia (no blood flow).

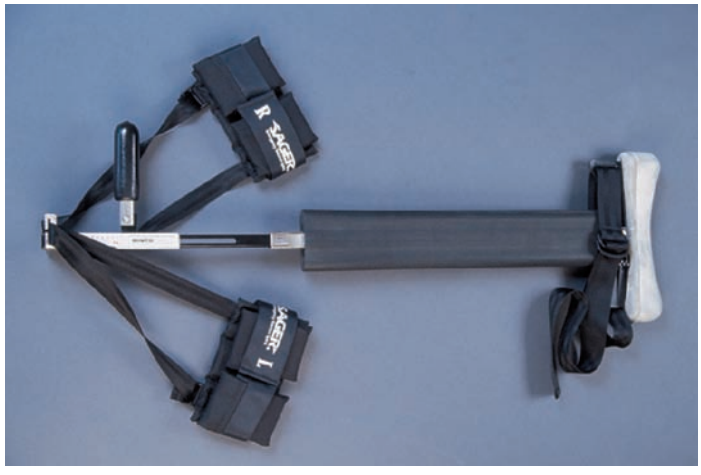
Recommended indications for tourniquet use include significant extremity bleeding together with other ITLS Primary Survey issues (such as the need for airway or breathing intervention or shock), hostile environment, a mass-casualty event, or the inability



A



B



C

Figure 14-9 A. Kendrick traction device. *(Photo courtesy of Eduardo Romero Hicks, MD)* B. Hare traction splint. C. Sager traction splint.

to manage bleeding with pressure dressings. In general, you should not remove a tourniquet you have placed for the indications noted.

Follow the specific guidelines for the commercial tourniquet you are using. One of the most important factors is to ensure that all providers are aware that a tourniquet has been applied to the patient. One method is to write "TK" and the time of application on the patient's forehead. Never cover a tourniquet. Commercial tourniquets are preferable to improvised tourniquets because their design better distributes the pressure and limits damage to the tissues. Once you have placed a tourniquet, you should expedite transport to the trauma center.

Hemostatic Agents

For bleeding that is uncontrollable with direct pressure or the use of tourniquets, hemostatic agents have demonstrated the ability to reduce or stop bleeding through the promotion of clot formation. The form of hemostatic agent available (dressing, powder, packets, and so on) depends on the specific product used. Regardless, direct application of the agent and pressure to the source of the bleeding vessel, not just the area of the wound, is required to maximize effectiveness of hemostatic agents. Powder agents are less commonly used versus impregnated gauzes or dressings. There have been reports of increased systemic thrombus formation with use of powdered agents.

Direct pressure should be maintained for a minimum of 4 minutes or until bleeding is controlled. Following cessation of bleeding, the application of a pressure dressing or gauze to the wound is recommended. To maximize effectiveness, it is recommended that prior to using a hemostatic agent, EMS personnel should become familiar with and follow the application instructions for each type of product used in practice.

Management of Specific Injuries

Spine Injuries

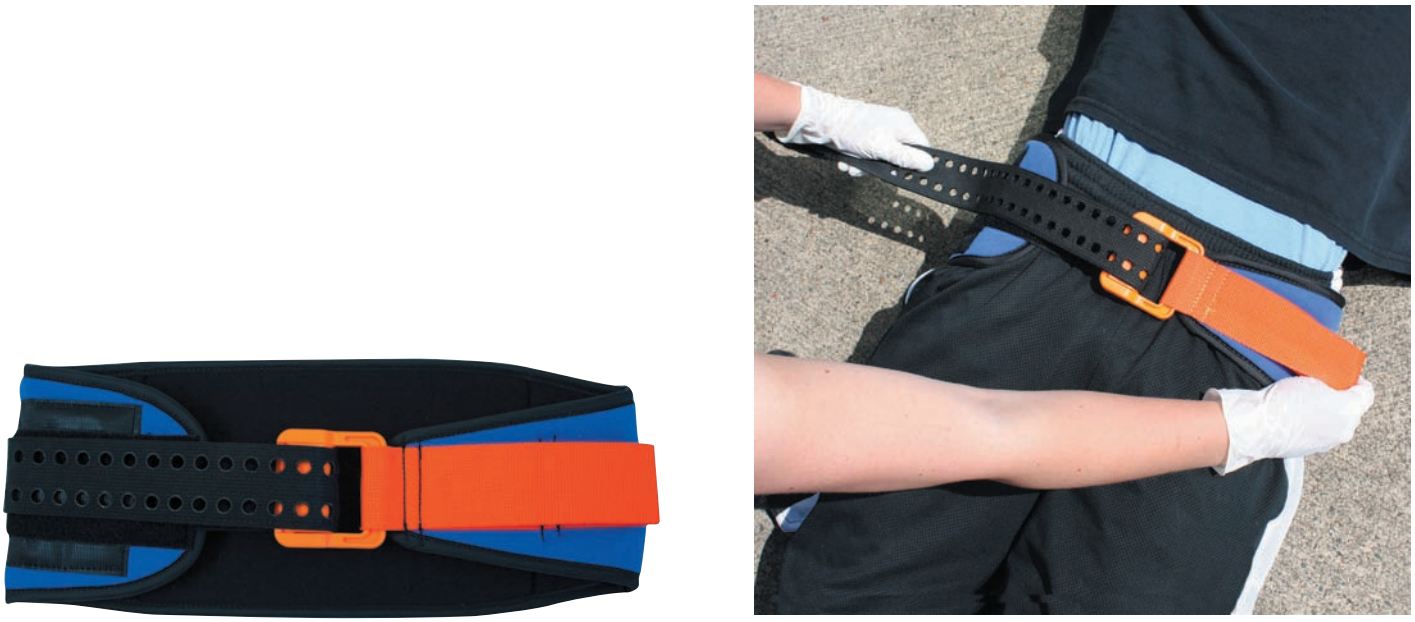
Spine injuries are covered in Chapters 10 and 11 and are also briefly included here to remind you that when there are findings to suggest an injury to the spinal cord, spinal motion restriction (SMR) must be used to prevent permanent disability or even death. In the most urgent cases, careful packaging of the patient on a long backboard can provide adequate splinting for a number of different extremity injuries. Remember that certain mechanisms of injury, such as a fall from a height in which the patient lands on both feet, can cause lumbar-spine fracture because forces are transmitted from the heels through the legs and pelvis, all the way up to the spine. Also remember that prolonged immobilization on a long backboard can have negative effects on the patient. The backboard is a transfer device, and the patient should be removed as soon as it is safe and practical to do so.

Pelvis Injuries

It is practical to include injuries to the pelvis with extremities because they are frequently associated. Pelvic injuries are usually caused by motor-vehicle collisions or by severe trauma such as falls from heights. They are identified by instability or pain in response to gentle pressure on the iliac crests, hips, and pubis during the ITLS Primary Survey. Once instability in the pelvis is identified in the exam there is no reason to repeat applying manual pressure to demonstrate instability. All this does is cause the patient more pain and can exacerbate bleeding.

There is always the potential for serious hemorrhage in pelvic fractures, so shock should be anticipated, and the patient must be rapidly transported (load and go). Presence of a pelvic fracture suggests that the patient has sustained a high-force injury. Internal bleeding from unstable pelvic fractures can be decreased by circumferential stabilization of the pelvis. Slings made from sheets have been used in the past for stabilization, but there are now several commercially available devices that provide more consistent stabilization (Figure 14-10). Pelvic stabilization is most beneficial in an **open-book pelvic fracture** (Figure 14-2) and decreases the need for blood transfusion.

open-book pelvic fracture: a severe pelvic fracture in which the symphysis is torn apart and the anterior pelvis is "opened" like a book. This is frequently associated with disruption of one or both sacroiliac joints; a high-force injury.



A B

Figure 14-10 A. Commercial pelvic sling device. B. Pelvic sling applied. *(Photos courtesy of SAM Splint)*



Figure 14-11 The scoop stretcher has been found to provide spinal stabilization equal to a backboard. *(Photo courtesy of Leon Charpentier, EMT-P and Ferno Washington, Inc.)*

Pelvic slings should be applied such that their compressive force is at the level of the greater trochanters and not the iliac crests. (Also see Chapter 13.) In the absence of sheets or pelvic binders, internal rotation of the feet, which are then secured together, will help close the pelvis. (Refer to Figure 15-1B in Chapter 15.)

Any patient with a pelvic injury should be evaluated for spinal injuries. If SMR is indicated, the vacuum mattress is useful in these patients because it is much more comfortable than the hard backboard. Log-rolling a patient with an unstable pelvic fracture can aggravate the injury. Adequate assistance and tools such as the scoop stretcher are useful to move patients to the ambulance stretcher, as it will limit motion of the fractured pelvis and associated pain (see Figure 14-11).

Femur Injuries

Femur fractures may have associated open wounds and, if so, they must be presumed to be open fractures. A lot of muscle tissue surrounds the femur, and when spasm develops after a femur fracture, it can cause the bone ends to override, causing more muscle damage, bleeding, potential nerve damage, and significant pain. Because of this, traction splints are used to stabilize midshaft femur fractures and limit additional injury and pain. As mentioned earlier, the large size of the thigh muscle can hide 1–2 liters of blood loss with each femur fracture. Bilateral femur fractures can be associated with a loss of up to 50% of the circulating blood volume.

Hip Injuries

Hip fractures are most often in the narrow "neck" of the femur, where strong ligaments occasionally allow this type of fracture to bear weight. The ligaments are very strong, and there is very little movement of the bone ends in the most frequent type of hip fracture. You must consider hip fractures in any older person who fell and now has pain in the knee, hip, or pelvic region. A geriatric patient who fell and cannot bear weight should be assumed to have a pelvic or hip fracture. The affected leg will often (but not always) be externally rotated and shortened. In the geriatric patient, fracture pain may be well tolerated and sometimes even ignored or denied. In general, the



Figure 14-12 Mechanism of posterior dislocation of the hip, "down and under."



Figure 14-13 Splinting posterior dislocation of the hip. *(Photo courtesy of Louis B. Mallory, MBA, REMT-P)*

tissues in the older patient are more delicate, and less force is required to disrupt a given structure. Remember that isolated knee pain may well be coming from damage to the hip. Do not use a traction splint for a hip fracture.

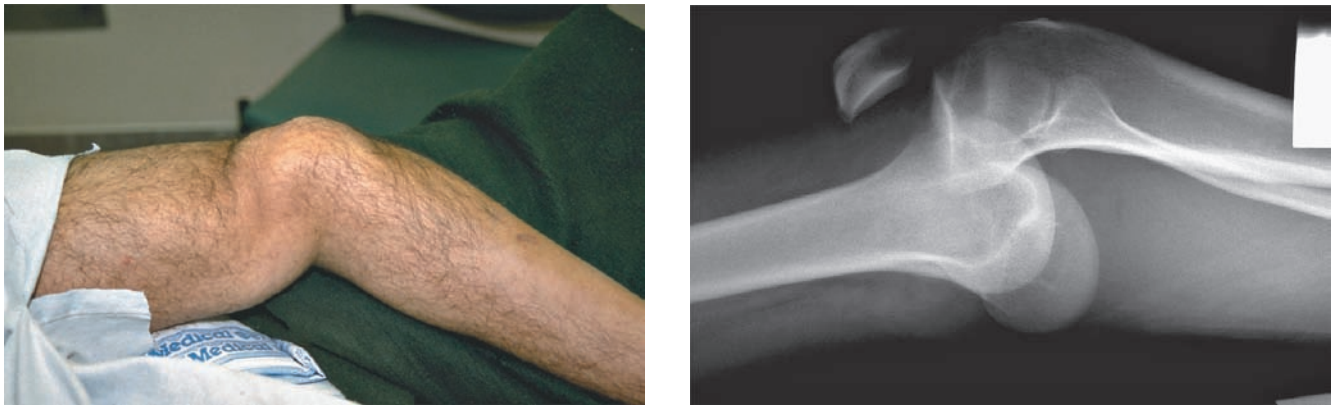
The hip may be dislocated either posteriorly or anteriorly. Posterior hip dislocations are most common and can result when the knee is struck by a dashboard, forcing the relatively loose, relaxed hip out of the posterior side of its cup (acetabulum) in the pelvis (Figure 14-12). Thus, any patient in a severe automobile crash with a knee injury must have the hip examined very carefully. All hip dislocations are orthopedic emergencies and require reduction as soon as possible to prevent sciatic nerve injury or necrosis of the femoral head due to interrupted blood supply. Patients with prosthetic hips can dislocate a hip without large forces being applied.

The posteriorly dislocated hip is usually flexed, and the patient will not be able to tolerate having the leg straightened. The leg will almost invariably be rotated toward the midline. A posterior hip dislocation should be supported in the most comfortable position by the use of pillows and by splinting to the uninjured leg (Figure 14-13).

An anterior hip dislocation is rare because of the complex mechanism required to produce it. The patient with an anterior hip dislocation will present with external rotation of the affected leg, much like a fractured hip, except you may not be able to bring the leg forward in line with the body. It may be very difficult to place this person in the supine position on a backboard or on a stretcher in the ambulance. Whereas the posterior hip dislocation puts pressure on the sciatic nerve, the anterior hip dislocation puts pressure on the femoral artery and vein. If the vein has collapsed, a clot can form distally, potentially leading to a pulmonary embolus when the hip is reduced.

Knee Injuries

Fractures or dislocations of the knee (Figure 14-14) are quite serious because the blood vessels and nerves that cross the knee joint are often injured if the joint is in an abnormal position. There is no way to know whether a fracture exists in an abnormally positioned knee and, in either case, the decision must be based on the circulation and neurologic function distally in the foot.



A B

Figure 14-14 Knee dislocation. A. Presentation of a knee dislocation. B. X-ray of the dislocation. *(Photos © Edward T. Dickinson, MD)*

A significant number of knee dislocations have associated artery and nerve injury. It is important to restore the circulation below the knee as quickly as possible and to transport the patient rapidly to definitive care to avoid devastating complications such as amputation. Because of this, prompt reduction of knee dislocation is very important. If there is loss of pulse or sensation, apply gentle traction by hand. Traction must be applied along the long axis of the leg. If there is resistance to straightening the knee, splint it in the most comfortable position and transport the patient rapidly. Knee dislocation is an orthopedic emergency.

Do not confuse knee joint dislocation with patellar dislocation. The patella can dislocate to the side, and the affected leg will be held slightly flexed at the knee. You can easily see that the patella is out of place. Although painful, this is not a serious injury and should simply be splinted with a pillow under the knee and the patient taken to the emergency department. Straightening the leg often reduces the patella dislocation, and the patient will sometimes spontaneously reduce this injury prior to your arrival.

Tibia and Fibula Injuries

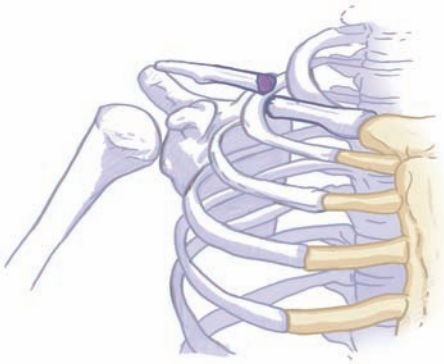
Fractures of the lower leg are a common injury. Over time, swelling and internal hemorrhage can cause compartment syndrome. It is rarely possible for patients to bear weight on fractures of the tibia, but fractures of the distal fibula can be mistaken for sprains. Fractures of the lower leg and ankle may be splinted with a rigid splint or a pillow. As with other fractures, it is important to dress any wound, pad any exposed bone ends under a splint, and manage the patient's pain. A dislocation of the ankle may require a gentle attempt at reduction if there is loss of circulation in the foot and you have a very long transport. Elevate the extremity to reduce risk of developing compartment syndrome and reassess distal pulses frequently.

Clavicle Injuries

The clavicle is the most frequently fractured bone in the body, with injury most common in the middle third of the bone. Clavicular injuries rarely cause major complications (Figure 14-15). Occasionally, there may be associated injuries to the subclavian blood vessels or to the nerves of the arm. You should carefully assess a patient with a clavicle fracture for other, more significant chest wall injuries. This injury is best immobilized with a sling and swathe.

Shoulder Injuries

Most shoulder injuries are not life-threatening, but because of the force required, they may be associated with severe injuries of the chest or neck. Many shoulder injuries are dislocations or separations of the shoulder from the clavicle and may



Signs and Symptoms

- Shoulder bent forward
- Elbow flexed and forearm held across chest
- Pain in shoulder area
- Swelling or lump



Applying a Sling and Swathe

- Fold arm of injured side across chest
- Place arm in sling and secure it to body with swathe

Figure 14-15 Fractured clavicle.

appear as a defect at the upper outer portion of the shoulder. The upper humerus is fractured with some degree of frequency, however. The radial nerve travels quite closely around the humerus and may be injured in humeral fractures. Injury to the radial nerve results in an inability of the patient to lift the hand (wrist drop).

Dislocated shoulders are very painful and quite often require a pillow between the arm and body to hold the upper arm in the most comfortable position. Shoulders that are held in abnormal positions should never be forced into a more anatomic alignment (Figure 14-16). Scapular fractures may refer pain to the shoulder joint itself. Because considerable force is required to fracture the scapula, anyone who is suspected of having this injury should be carefully evaluated for other chest injuries such as rib fractures, pulmonary contusion, or other blunt chest trauma.



Figure 14-16 Dislocated shoulder.

Elbow Injuries

In the prehospital setting, it is difficult to differentiate between an elbow fracture and a dislocation. Both can be serious because of the danger of damage to the vessels and nerves that run across the flexor surface of the elbow. The most common mechanism of injury is a fall onto an outstretched arm, fracturing the radial head. Elbow injuries should always be splinted in the most comfortable position and the distal function clearly evaluated (Figure 14-17). Never attempt to straighten or apply traction to an elbow injury due to the complexity of the anatomy. Transport these patients promptly.

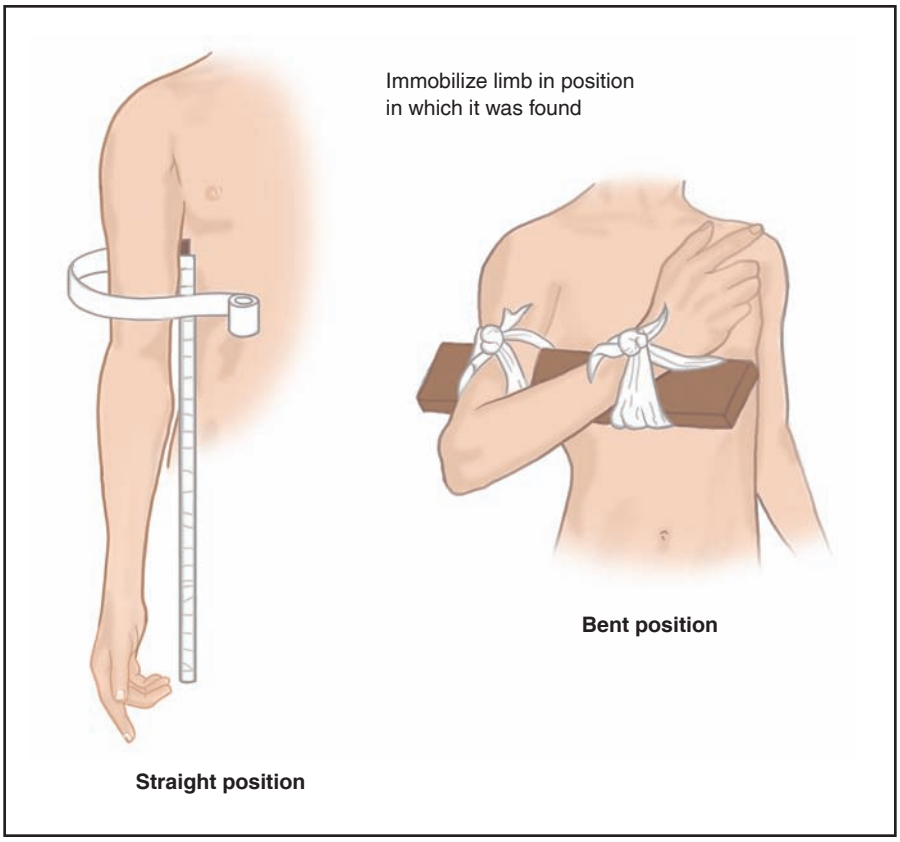
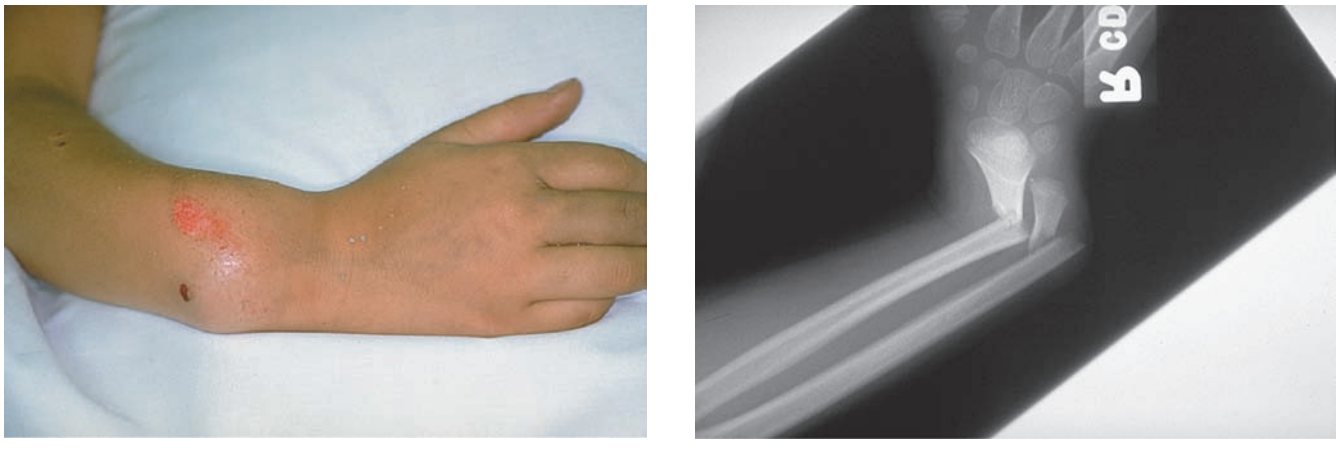


Figure 14-17 Fractures or dislocations of the elbow.



A B

Figure 14-18 Presentation of a forearm fracture. A. A fracture will often present with deformity. B. An x-ray of the fracture.

Forearm and Wrist Injuries

Fractures to the forearm and wrist are very common (Figure 14-18). Like elbow injuries, a common mechanism is a fall onto an outstretched arm. Usually, such a fracture is best immobilized with a rigid splint or an air splint (Figure 14-19). When splinting, a roll of gauze in the patient's hand will allow the hand and arm to be splinted in the position of function, which is often the most comfortable. Forearm fractures also put the patient at risk for compartment syndrome, so monitor closely.

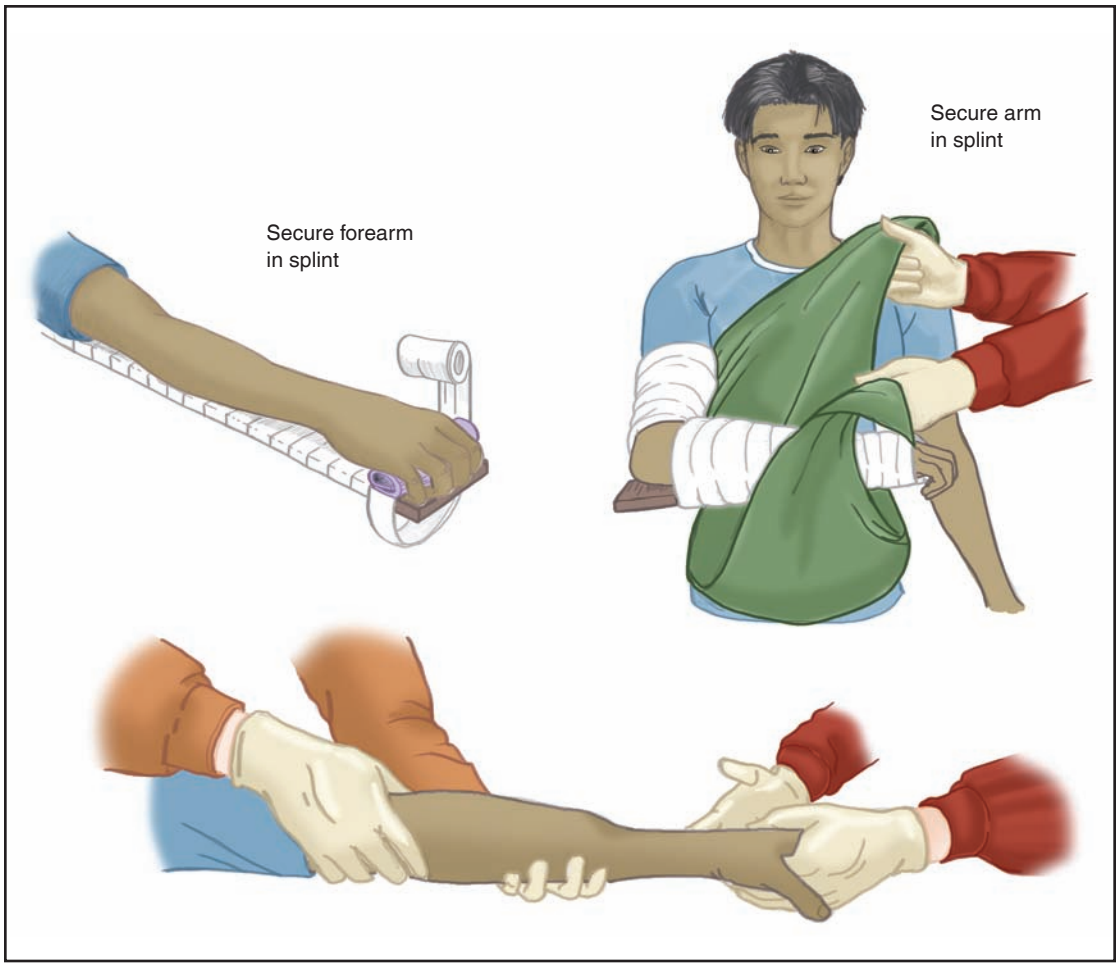


Figure 14-19 Fractures of the forearm and wrist.

Hand or Foot Injuries

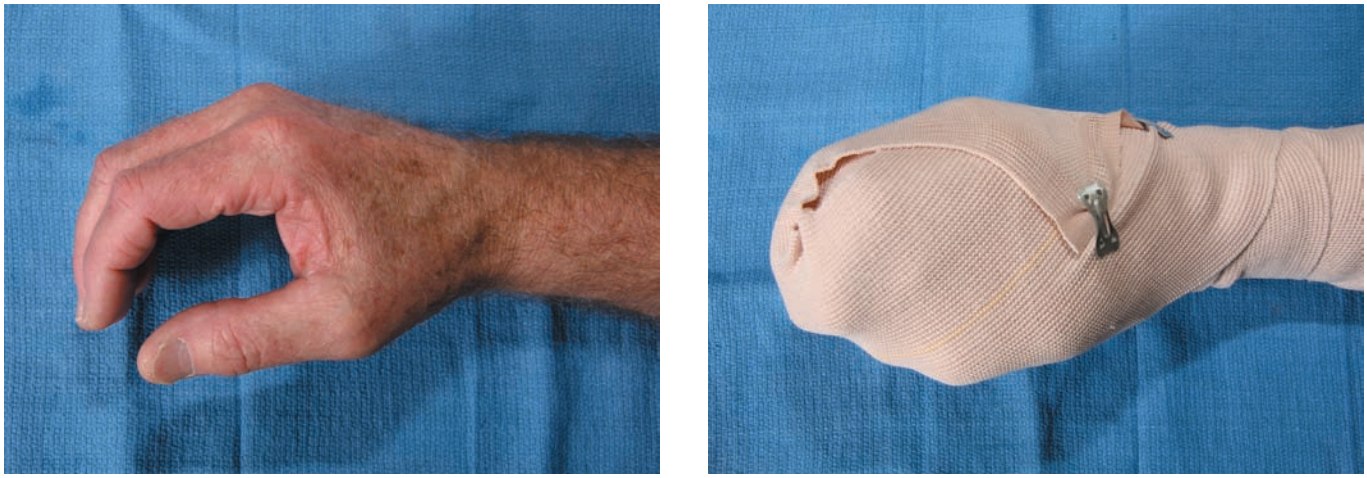
Many industrial accidents involving the hand or the foot produce multiple open fractures and avulsions. The injuries are often gruesome in appearance but are seldom associated with life-threatening bleeding. A pillow may be used very effectively to support them (Figure 14-20). An alternative method of dressing the hand is to insert a roll of gauze in the palm, then arrange the fingers and thumb in their position of function. The entire hand is then wrapped as though it were a ball inside a very large and bulky dressing (Figure 14-21).

Crush Injuries

Performing frequent ongoing assessments and close monitoring of vital signs is required for patients with a crush injury. To effectively address the toxins released and reduce the risk of developing crush syndrome, aggressive hydration with normal saline is required. In addition, alkalizing agents such as sodium bicarbonate and osmotic diuretics such as mannitol can increase urine flow through the kidneys and reduce the risk of renal failure. Initial administration of sodium bicarbonate should be at 1 mEq/kg bolus followed by an infusion of 0.25 mEq/kg body weight per hour of the solution described previously. The addition of sodium bicarbonate (3 × 50 mEq ampules) to a 1-liter bag of 5% dextrose (D_5W) will make a nearly isotonic solution for infusion.



Figure 14-20 Pillow-splinting an injured foot.



A B

Figure 14-21 A. Hand in position of function. B. Hand dressing. *(Photos courtesy of Stanley Cooper, EMT-P)*

If administration of fluids or medications prior to releasing the entrapped body area is not possible, consider application of a tourniquet proximal to the injury site on the extremity. Although application of the tourniquet will reduce systemic toxin release, crush syndrome will continue to develop. Early contact with medical direction or the receiving trauma facility is recommended for all patients who have experienced a crush injury.

Pain Control

Broken bones hurt. Adequate analgesia helps with patient movement and transport, and once injuries are stabilized it should be addressed. Judicious use of opiate or other analgesics (ketamine) will make caring for your patient easier. Please see Appendix B: Pain Control for more details regarding pain control.

Case Presentation *(continued)*

The emergency care provider performs an initial assessment on the driver, which reveals an alert young male who is anxious, but without respiratory distress and with a strong radial pulse of 96. His color is good, his head and neck are unremarkable, his chest is unmarked, and his breath sounds are clear and equal. His abdomen is soft and nontender and his pelvis appears stable on compression. His left ankle is swollen and rotated inward. The provider removes the shoes and finds pedal pulses are present in both feet. The patient's left wrist is swollen and his distal radius and ulna are tender to palpation. His left radial pulse is difficult to palpate but his capillary refill time (CRT) is less than 2 seconds and sensation is intact.

You decide that with no loss of consciousness, a normal neuro exam, and no neck pain that SMR is not needed. The emergency care provider splints the left arm from above the elbow to the hand, leaving only the fingers exposed, and adds a sling and swathe. She then pillow-splints the left ankle. After rechecking distal circulation and finding pedal pulses present and CRT in the fingers unchanged, the patient is placed on a stretcher to transfer to the ambulance, where he will be placed on the squad bench with his left foot elevated.

Summary

Although usually not life-threatening, extremity injuries can be disabling. These injuries can be more dramatic than more serious internal injuries, but do not let them distract you from following the usual steps of the ITLS Primary Survey. Keep in mind that unstable pelvic and femur fractures can be associated with life-threatening internal bleeding, so patients with these injuries are in the load-and-go category. Both of these injuries are considered high-force injuries.

Proper splinting is important to protect the injured extremity from further injury and help reduce pain. Dislocations of elbows, hips, and knees require careful splinting and rapid reduction to prevent severe disability. They are frequently load-and-go situations not because they are life-threatening, but because they are limb-threatening. Assessment of the neurovascular function distal to the injury should always be performed and the fracture or dislocation realigned if there is a loss of distal pulses. A high index of suspicion and early intervention for crush injuries are paramount to reducing the harmful effects of crush syndrome.

Resources

Abarbanell, N. R. 2001. "Prehospital Midthigh Trauma and Traction Splint Use: Recommendations for Treatment Protocols." *American Journal of Emergency Medicine* 19, no. 2 (March): 137–40.

Baek, S. M., and S. S. Kim. 1992. "Successful Digital Replantation After 42 Hours of Warm Ischemia." *Journal of Reconstructive Microsurgery* 8, no. 6 (November): 455–8.

Brown, D. M., and J. Worley. 2009. "Experience with Chitosan Dressings in a Civilian EMS System." *Journal of Emergency Medicine* 37, no. 1: 1–7.

Bledsoe, B., and D. Barnes. 2004. "Traction Splint: An EMS Relic?" *Journal of Emergency Medical Services* 29, no. 8 (August): 64–9.

Brodie, S., T. J. Hodgetts, J. Ollerton, J. McLeod, P. Lambert, and P. Mahoney. 2007. "Tourniquet Use in Combat Trauma: UK Military Experience." *Journal of the Royal Army Medical Corps* 153, no. 4 (December): 310–3.

Bledsoe, B. E., R. S. Porter, and R. A. Cherry. 2017. *Paramedic Care: Principles and Practice*, Vol. 5, 5th ed. Upper Saddle River, NJ: Pearson Education.

Centers for Disease Control and Prevention. 2013. "CDC Offers Primer on Blast Injury." *Journal of the American Medical Association* 309, no. 20: 208.

Committee on Trauma, American College of Surgeons. 2018. *Advanced Trauma Life Support*, 10th ed. Chicago: American College of Surgeons.

Cross, D. A., and J. Baskerville. "Comparison of Perceived Pain with Different Immobilization Techniques." *Prehospital Emergency Care* 5, no. 3 (July–September): 270–4.

Dayan, L., C. Zinmann, S. Stahl, and D. Norman. 2008. "Complications Associated with Prolonged Tourniquet Application on the Battlefield." *Military Medicine* 173, no. 1 (January): 63–6.

Demetriades, D., M. Karaiskakis, K. Toutouzas, K. Alo, G. Velmahos, and L. Chan. 2002. "Pelvic Fractures: Epidemiology and Predictors of Associated Abdominal Injuries and Outcomes." *Journal of the American College of Surgeons* 195, no. 1 (July): 1–10.

Dischinger, P. C., K. M. Read, J. A. Kufera, T. J. Kerns, C. A. Burch, N. Jawed, and S. M. Ho. 2004. "Consequences and Costs of Lower Extremity Injuries." *Annual Proceedings of the Association for the Advancement of Automotive Medicine* 48: 339–53.

Doyle, G. S., and P. P. Taillac. 2008. "Tourniquets: A Review of Current Use with Proposals for Expanded Prehospital Use." *Prehospital Emergency Care* 12, no. 2 (April–June): 241–56.

Friese, G., and G. LaMay. 2005. "Emergency Stabilization of Unstable Pelvic Fractures." *Emergency Medical Services* 34, no. 5 (May): 65, 67–71.

Granville-Chapman, J., and J. N. Midwinter. 2011. "Pre-hospital Haemostatic Dressings: A Systemic Review." *Injury* 42, no. 5 (May): 447–59.

Greaves, I., K. Porter, and J. E. Smith. 2003. "Consensus Statement on the Early Management of Crush Injury and Prevention of Crush Syndrome." *Journal of the Royal Army Medical Corps* 149, no. 4 (December): 255–9.

Klimke, A., M. Furin, and R. Overberger. 2019. "Prehospital Immobilization." In *Roberts and Hedges' Clinical Procedures in Emergency Medicine and Acute Care*, 7th ed., by J. R. Roberts, 917–36. Philadelphia: Saunders.

Krell, J. M., M. S. McCoy, P. J. Sparto, G. L. Fisher, W. A. Stoy, and D. P. Hostler. 2006. "Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization." *Prehospital Emergency Care* 10, no. 1 (January–March): 46–51.

Lee, C., and K. M. Porter. 2007. "The Prehospital Management of Pelvic Fractures." *Emergency Medical Journal* 24, no. 2 (February): 130–3. doi:10.1136/emj.2006.041384

Lee, C., K. M. Porter, and T. J. Hodgett. 2007. "Tourniquet Use in the Civilian Prehospital Setting." *Emergency Medicine Journal* 24, no. 8 (August): 584–7.

Sever, M. S., R. Vanholder, and N. Lameire. 2006. "Management of Crush-Related Injuries After Disasters." *New England Journal of Medicine* 354, no. 10 (March): 1052–63.

Walters, T. J., and R. I. Mabry. 2005. "Issues Related to the Use of Tourniquets on the Battlefield." *Military Medicine* 170, no. 9 (September): 770–5.

Wedmore, I., J. G. McManus, A. E. Pusateri, and J. E. Holcomb. 2006. "A Special Report on the Chitosan-Based Hemostatic Dressing: Experience in Current Combat Operations." *Journal of Trauma* 60, no. 3 (March): 655–8.

15



(Pawel Nawrot/Shutterstock)

Extremity Trauma Skills

S. Robert Seitz, MEd, RN, NRP
Darby L. Copeland, EdD, RN, NRP

Maßnahmen bei Extremitätentraumata
Habilidades para Trauma en Extremidades
Zbrinjavanje ozljeda ekstremiteta
Competências Práticas no Trauma das Extremidades
Травмы конечностей- практические навыки
Destrezas en el Trauma de Extremidades
Tecnicas de Abordagem do trauma das Extremidades

Skills presented in this chapter:

- Splint application
  - Thomas traction splint (half-ring splint)
  - Hare® traction splint
  - Sager® traction splint
- Pelvis stabilization
  - Using sheet or blanket
  - Using commercial device

Objectives

Upon successful completion of this chapter, you should be able to:

1. Explain when to use a traction splint.
2. Describe the complications of using a traction splint.
3. Apply a traction splint: Hare splint, Sager splint, and Thomas splint.
4. Demonstrate pelvic stabilization techniques.

Note: All students in this course are expected to be familiar with the technique of basic splint application using rigid splints and, as such, the technique is not covered here.

Traction Splints

Traction splints are designed to immobilize fractures of the femur. They are not useful for fractures of the hip, knee, or lower leg. Applying firm traction to a fractured or dislocated knee may tear the blood vessels behind the knee. If there is a suspected pelvic fracture, do not use a traction splint because it can cause further damage to the pelvis. Femur fractures below the midthigh that are not angulated or severely shortened may be immobilized with a rigid splint.

A traction splint works by applying linear forces along the bone to keep its ends immobilized. A padded device is first placed against the back of the pelvis (ischium) or to the groin and a hitching device is applied to the ankle. The splint then applies countertraction until the limb is straight and well immobilized. Apply the splint to the pelvis and groin very carefully to prevent excessive pressure on the genitalia. Also use care when attaching the hitching device to the foot and ankle so as not to interfere with circulation. Because you must always check distal pulses when you finish splinting, remember to remove the patient's shoe and sock before attaching the hitching device.

Application of a traction splint is a two-person job. One care provider must hold steady, gentle traction on the foot and leg while the other applies the splint. When dealing with load-and-go situations, do not apply the splint until critical life-saving interventions have been completed and the patient is in the ambulance en route to the hospital (unless the ambulance has not arrived).

Use caution when the patient is placed on a transport stretcher. If the splint extends beyond the end of the stretcher, be very careful when moving the patient and when closing the ambulance door so that you do not hit the splint and cause movement in the fracture site.

Multiple types and models of traction splints are available today. The application of three different types is described in the sections that follow. There are numerous other devices available that are effective. Advances in materials have led to new devices that are lighter and more compact. It is important to practice proper application of the device being used by your response agency.

Procedure

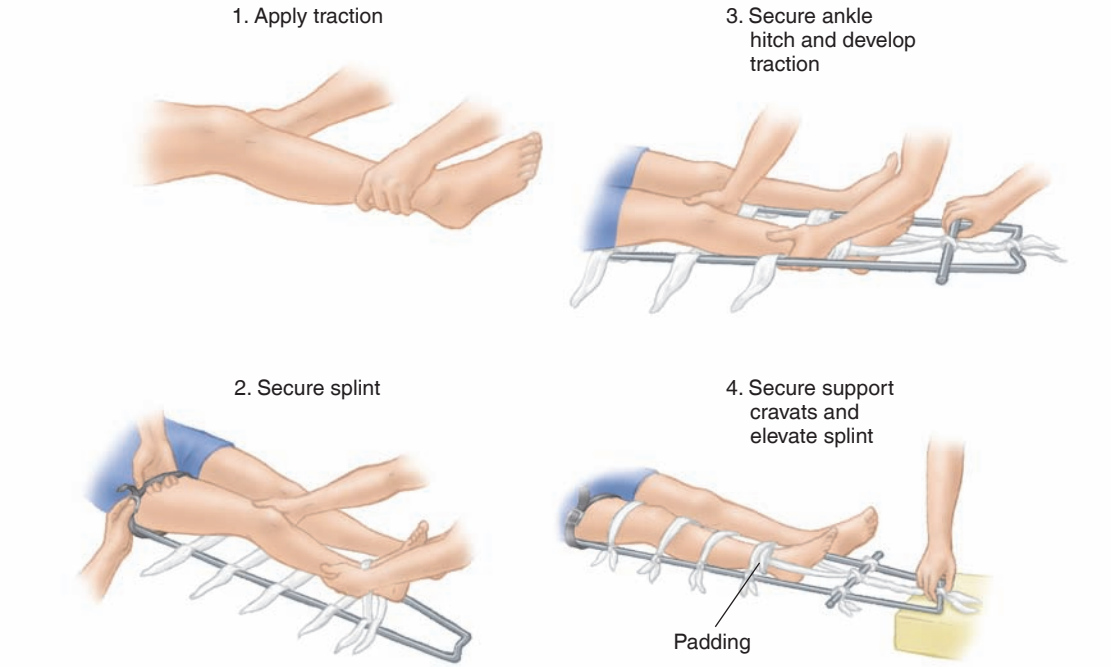
Applying a Thomas Traction Splint (Half-Ring Splint)

The Thomas splint was used exclusively prior to the advent of modern traction devices. During World War I, its use decreased the mortality rate for battlefield femur fractures from 80% to 40%. At that time it was considered one of the greatest advancements in medical care. It is still used in low-resource situations and is effective. Of note, gunshot wounds were the major cause of femur fractures during World War I and are by definition open fractures. The traction splint often caused bone ends to retract back under the skin and, in the pre-antibiotic era, infections were very common. Despite that, the mortality from femur fractures dropped significantly following the introduction of the Thomas splint.

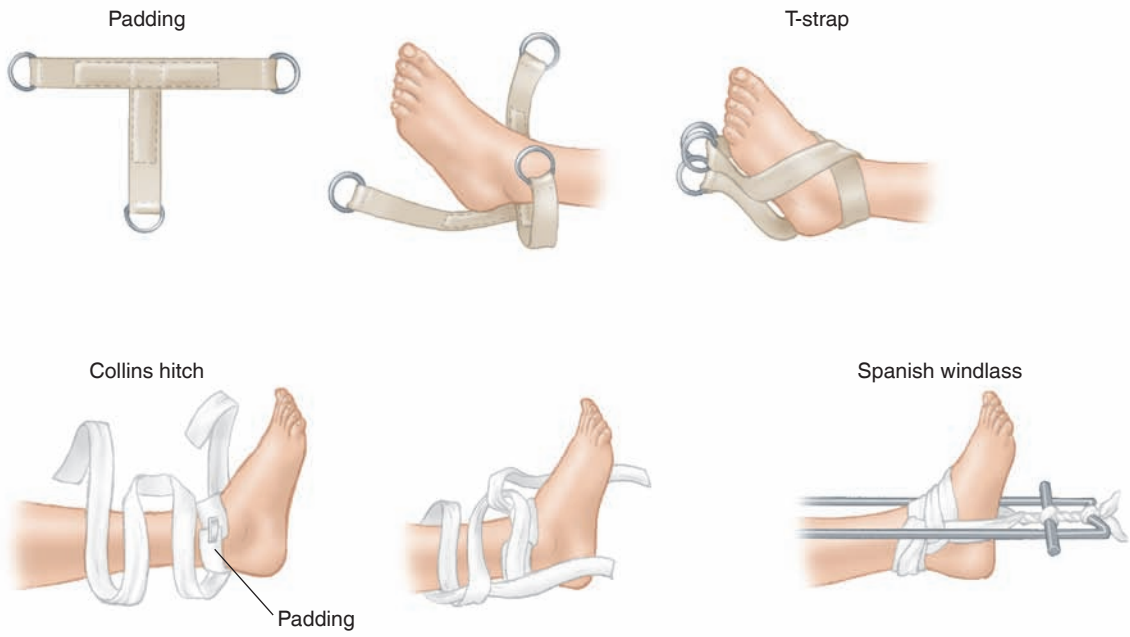
To apply a Thomas traction splint, follow these steps (Scan 15-1):

1. Have your partner support the leg and maintain gentle traction, while you cut away the clothing and remove the shoe and sock to check pulse, motor function, and sensation at the foot.
2. Position the splint under the injured leg. The ring goes down, and the short side of the splint goes to the inside of the leg. Slide the ring snugly up under the hip, where it will be pressed against the ischial tuberosity.
3. Attach the top ring strap.
4. Apply padding to the foot and ankle.
5. Apply the traction hitch around the foot and ankle.
6. Maintain gentle traction by hand.
7. Attach the traction hitch to the end of the splint.
8. Increase traction by Spanish windlass action, using a stick or several tongue depressors.
9. Position two support straps above the knee and two below the knee. Do not place straps over the fracture site.
10. Release manual traction and reassess pulse, motor function, and sensation.
11. Support the end of the splint so that there is no pressure on the heel.

SCAN 15-1 Applying a Thomas Traction Splint



15-1-1 Application of a Thomas traction splint.



15-1-2 Application of the traction hitch to the ankle.

Procedure

Applying a Hare® Traction Splint

The Hare traction splint is the modern version of the Thomas splint. To apply the Hare traction splint, follow these steps (Scan 15-2):

1. Position the patient on the backboard or stretcher.
2. Have your partner support the leg and maintain gentle traction, while you cut away the clothing and remove the shoe and sock to check pulse, motor function, and sensation at the foot.
3. Using the uninjured leg as a guide, pull the splint out to the correct length.
4. Position the splint under the injured leg. The ring goes down, and the short side goes to the inside of the leg. Slide the ring up snugly under the hip against the ischial tuberosity.
5. Attach the ischial strap.
6. Apply the padded traction hitch to the ankle and foot.
7. Attach the traction hitch to the windlass by way of the S-hook.
8. Turn the ratchet until the correct tension is applied.
9. Reassess pulse, motor function, and sensation of the leg.
10. Position and attach two support straps above the knee and two below the knee. Do not place over the fracture site.
11. Release manual traction and recheck pulse, motor function, and sensation.
12. To release mechanical traction (when too tight or when removing the splint), pull the ratchet knob outward and then slowly turn to loosen.

Procedure

Applying a Sager® Traction Splint

The Sager traction splint is different from the two splints already described in several ways. It works by providing countertraction against the pubic ramus and the ischial tuberosity medial to the shaft of the femur; thus, it does not go under the leg. The hip does not have to be slightly flexed, as with the Hare splint, because the Sager splint is lighter and more compact. You can also splint both legs with one splint, if needed.

The current Sager traction splints have been updated to make them simpler to apply. To apply one, follow these steps (Scan 15-3):

1. Position the patient on a long backboard or stretcher.
2. Have your partner support the leg and maintain gentle traction, while you cut away the clothing and remove the shoe and sock to check the pulse, motor function, and sensation at the foot.
3. Using the uninjured leg as a guide, pull the splint out to the correct length.
4. Position the splint to the inside of the injured leg with the padded bar fitted snugly against the pelvis in the groin. Attach the strap to the thigh. The splint can be used on the outside of the leg, using the strap to maintain traction against the pubic ramus. Be very careful not to catch the genitals of the male patient under the bar (or strap).
5. While your partner maintains gentle manual traction, attach the padded hitch to the foot and ankle.
6. Extend the splint until the correct tension is obtained.
7. Apply the elastic straps to secure the leg to the splint. Do not place them over the fracture site.
8. Release manual traction and recheck pulse, motor function, and sensation.

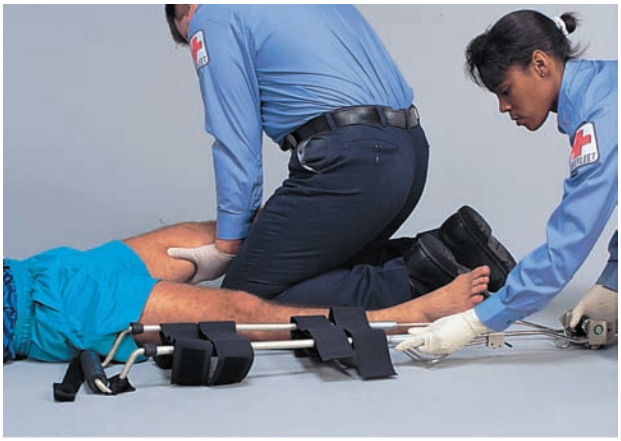
SCAN 15-2 Applying a Hare Traction Splint



15-2-1 Assess distal pulse, motor function, and sensation.



15-2-2 Stabilize the injured leg by applying manual traction.



15-2-3 Adjust the splint for proper length.



15-2-4 Position the splint under the injured leg until the ischial pad rests against the bony prominence of the buttocks. Once the splint is in position, raise the heel stand.



15-2-5 Attach the ischial strap over the groin and thigh.



15-2-6 Make sure the ischial strap is snug but not too tight as to reduce distal circulation.

(*continued*)

SCAN 15-2 Applying a Hare Traction Splint (*continued*)



15-2-7 With the patient's foot in an upright position, secure the ankle hitch.



15-2-8 Attach the S-hook to the D-ring and apply mechanical traction. Full traction is achieved when the mechanical traction is equal to the manual traction and the pain and muscle spasms are reduced. In an unresponsive patient, adjust the traction until the injured leg is the same length as the uninjured leg.



15-2-9 Fasten the leg support straps.



15-2-10 Reevaluate the ischial strap and ankle hitch to ensure that both are securely fastened.



15-2-11 Reassess distal pulse, motor function, and sensation.

SCAN 15-3 Applying a Sager Traction Splint



15-3-1 Place the splint along the medial aspect of the injured leg. Adjust it so that it extends about 4 inches beyond the heel.



15-3-2 Secure the strap to the thigh. *Caution*: The Sager splint should not be used if pelvic fracture is suspected.



15-3-3 Apply the ankle hitch and attach it to the splint.



15-3-4 Apply traction by extending the splint. Adjust the splint to 10% of the patient's body weight or up to 15 lb (7 kg) per extremity being immobilized.



15-3-5 Apply the straps to secure the leg to the splint. Reassess distal pulse, motor function, and sensation.

Pelvic Stabilization Techniques

Pelvic fractures involve either the iliac crest or the pelvic ring. Fractures to the iliac crest indicate that the patient was subjected to major force and is at risk for serious abdominal trauma. However, the fractures themselves are not as life-threatening as fractures of the pelvic ring, which have a much higher blood loss. In either case, the actual technique for stabilizing the fracture is the same and may be accomplished by either of the following two common approaches.

Procedure

Stabilizing the Pelvis with a Sheet or Blanket

1. Place a sheet or blanket horizontally on the lower half of the backboard or stretcher prior to moving the patient.
2. Use a scoop stretcher, if available, to move the patient onto the ambulance stretcher or backboard (if clinically indicated), placing the pelvis onto a sheet or blanket. Align the sheet so that the force applied by the sheet is at the greater trochanter. If a scoop stretcher is not available, log-roll the patient as gently and quickly as possible onto the sheet or blanket.
3. Tie two diagonal corners of the sheet or blanket together with a knot at the patient's hip on one side. Repeat with the remaining two corners, tying the knot on the opposite hip. In each case, gently and smoothly increase the tension until firm support is provided for the pelvis (Figure 15-1).



A



B

Figure 15-1 A. Manual stabilization of unstable pelvic fracture using a sheet. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)* B. Internal rotation of the feet to help close open book pelvic fracture. Remember to secure them together. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Procedure

Stabilizing the Pelvis with a Commercial Device

1. Open the device and place it horizontally on the lower half of the backboard prior to moving the patient.
2. Use a scoop stretcher, if available, to move the patient onto the ambulance stretcher or backboard (if clinically indicated), placing the pelvis onto a

Procedure *(continued)*

sheet or blanket. If a scoop stretcher is not available, log-roll the patient as gently and quickly as possible onto the pelvic binding device. A scoop stretcher is the preferred method to transfer a patient with a suspected pelvic fracture rather than log-rolling the patient.

3. Tighten the device as the manufacturer recommends. Gently and smoothly increase the tension until firm support is provided for the pelvis (Figure 15-2). It is important to remember that the compressive forces need to be applied at the level of the greater trochanters of the femur (hip level) and not at the iliac wings.
4. In the absence of a pelvic compression device or sheet, performing internal rotation of both feet and then securing them together can help to close the pelvic ring.



Figure 15-2 Stabilization of an unstable pelvic fracture using a commercial device. *(Courtesy of Sam Medical Products)*

References and Resources

Gardner, M. J., S. Parada, and M. L. Chip Routt Jr. 2009. "Internal Rotation and Taping of the Lower Extremities for Closed Pelvic Reduction." *Journal of Orthopedic Trauma* 23, no. 5 (May): 361–4.

Hsu, S. D., C. J. Chen, Y. C. Chou, S. H. Wang, and D. C. Chan. 2017. "Effect of Early Pelvic Binder Use in the Emergency Management of Suspected Pelvic Trauma: A Retrospective Cohort Study." *International Journal of Environmental Research and Public Health* 14, no. 10 (October): 1217. doi:10.3390/ijerph14101217

Scott, I., K. Porter, C. Laird, I. Greaces, and M. Bloch. 2013. "The Prehospital Management of Pelvic Fractures: Initial Consensus Statement." *Emergency Medicine Journal* 30, no. 12 (December): 1070–2.

16

Trauma Arrest

Ray Fowler, MD, FACEP, FAEMS
Ahamed Idris, MD
Jeremy Brywczynski, MD
A.J. Kirk, MD, FACEP



(Hypervision Creative/Shutterstock)

Herz-Kreislauf-Stillstand nach Trauma
Paro Cardiaco en Trauma
Kardiopulmonalni zastoj u traumi
Paragem Cardiorespiratória em Trauma
Henti Jantung Pada Pasien Trauma
Травматическая остановка сердца
Arrêt cardiaque traumatique

Καρδιακή Ανακοπή στο Τραύμα
A traumás eredetű keringés- és légzésmegállás
外傷性心肺停止
創傷脅持
Zastoj srca in dihanja pri poškodovancih

Key Terms

traumatic cardiopulmonary arrest (TCPA), *p. 315*

unsalvageable patient, *p. 315*

withholding or termination of resuscitation, *p. 316*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Identify treatable causes of traumatic cardiopulmonary arrest.
2. Describe the proper evaluation and management of the patient in traumatic cardiopulmonary arrest.
3. Identify patients in traumatic cardiac arrest for whom you should withhold resuscitation attempts.

Chapter Overview

You will encounter trauma patients who are found either pulseless or apneic on scene or who deteriorate rapidly and develop those signs while under your care. Although CPR in traumatic arrest is often considered futile, several causes of traumatic cardiac arrest are correctable, and prompt recognition and intervention could be lifesaving. This chapter discusses guidelines for when to attempt resuscitation and when it would be futile. It also reviews the causes of traumatic cardiac arrest and the best plan of action to rapidly identify the cause and match your response to that cause.

Case Presentation

A basic life support (BLS) ambulance arrives at the scene of a hiker who fell over a rock-faced cliff in a very rural area. The closest hospital is 15 miles away, and the closest level 2 trauma hospital is 45 miles away. In this emergency medical services (EMS) system, advanced life support (ALS) is only dispatched on request of the BLS ambulance on scene. The scene size-up reveals a safe scene with one patient (approximately 20 years old) in a litter that has just been raised from a canyon floor approximately 75 feet below by a wilderness rescue team. The patient was apparently hiking along the canyon edge and fell.

The patient is unresponsive, not breathing, and pulseless. There is an obvious deformity to the skull, multiple rib fractures by palpation, and deformity to the left femur. There were no witnesses to the fall, and it is difficult to determine when the fall occurred. An automated external defibrillator (AED) is applied, and it indicates, "No shock advised."

Before proceeding, consider these questions:

- Should CPR be initiated?
- Should the BLS ambulance request an ALS response?
- If ALS does respond, should they respond with "lights and sirens"?
- What are the likely causes of this cardiac arrest?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.



(Photo courtesy of International Trauma Life Support for Emergency Care Providers)

The Unsalvageable Patient

Attempting to resuscitate the patient in **traumatic cardiopulmonary arrest (TCPA)** can put you and the public in danger. Research has shown that emergency lights-and-sirens traffic can be hazardous to both prehospital providers and to the safety of the public. Do not attempt resuscitation unless there is some chance of the patient's survival. A review of 195 trauma patients who presented unconscious and without palpable pulse or spontaneous respiration found that patients with sinus rhythm and nondilated (<4 mm) reactive pupils had a good chance of survival. However, in those patients with asystole, agonal rhythm, ventricular fibrillation, or ventricular tachycardia (**unsalvageable patients**), there were no survivors. The National Association of EMS Physicians and the American College of Surgeons Committee on Trauma have jointly developed guidelines for **withholding or termination of resuscitation** in prehospital traumatic cardiopulmonary arrest (Table 16-1). You also should be familiar with your local protocols that relate to traumatic cardiac arrest.

traumatic cardiopulmonary arrest (TCPA): a grouping of conditions defined by the common precipitating factor of trauma as the origin for the cardiac arrest.

unsalvageable patient: one who does not have a reasonable expectation for resuscitation and survival based on defined clinical indicators and parameters. It is acceptable to withhold resuscitation under those conditions.

withholding or terminating resuscitation: based on research and published guidelines, attempting to resuscitate the patient in cardiac arrest may be withheld or terminated in certain instances.

Table 16-1: Guidelines for Withholding or Terminating Resuscitation of Prehospital Traumatic Cardiopulmonary Arrest*

1. Resuscitation should be withheld in cases of:
   a. Blunt trauma with no breathing, pulse, or organized rhythm on ECG on EMS arrival at the scene.
   b. Penetrating trauma with no breathing, pulse, pupillary reflexes, spontaneous movement, or organized ECG activity.
   c. Any trauma with injuries obviously incompatible with life (e.g., decapitation).
   d. Any trauma with evidence of significant time lapse since pulselessness, including dependent lividity, rigor mortis, etc.
2. Cardiopulmonary arrest patients in whom the mechanism of injury does not correlate with the clinical condition, suggesting a nontraumatic cause of the arrest, should have standard resuscitation initiated.
3. Termination of resuscitation efforts should be considered (consult medical direction):
   a. With EMS-witnessed cardiopulmonary arrest and 15 minutes of unsuccessful resuscitation.
   b. When transport time to the hospital emergency department is more than 15 minutes.
4. Special consideration should be given to victims of non-fatal drowning, lightning strike, and hypothermia.

*Joint Position Statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma (Revised 2012). *(National Association of EMS Physicians and American College of Surgeons Committee on Trauma. "Withholding of Resuscitation for Adult Traumatic Cardiopulmonary Arrest." Prehospital Emergency Care, Vol. 17, Issue 2 (April–June, 2013): p. 291.)*

Advanced cardiac life support (ACLS) has been principally directed toward dealing with a cardiac cause for the pulseless patient. In trauma cases, however, cardiopulmonary arrest is usually not due to primary cardiac disease, such as coronary atherosclerosis with acute myocardial infarction. In the trauma patient, you must direct your treatment toward identifying the underlying cause of the arrest, or you will not be successful in resuscitation. Use the ITLS Primary Survey to determine both the cause of the arrest and to identify those patients for whom you should attempt resuscitation.

PEARLS
Cardiac Arrest
Cardiac arrest following trauma is usually not due to cardiac disease.

Airway and Breathing Problems

Hypoxemia is a common cause of traumatic cardiopulmonary arrest. Acute airway obstruction or ineffective breathing will likely be clinically manifested as hypoxemia. Carbon dioxide accumulation from inadequate breathing contributes to the unsuccessful resuscitation of such patients. Airway problems such as those listed in Table 16-2 lead to hypoxemia by preventing the flow of oxygen to the lungs. Drugs and alcohol, often in conjunction with traumatic brain injury (TBI), can result in airway obstruction by the tongue as well as in respiratory depression.

Careful monitoring of the intoxicated patient may prevent respiratory or cardiac arrest. The same is true of the patient who is unconscious from TBI. The lax muscles in the pharynx allow the tongue to fall back and obstruct the airway. Obtaining and maintaining an open airway by use of the modified jaw-thrust maneuver along with an oro- or nasopharyngeal airway is paramount for patients with no gag reflex. You may use a supraglottic airway device (King Airway™, LMA™, i-gel™, etc.), if tolerated by the patient. The role of endotracheal intubation (ETI) in the major trauma patient is an area of wide debate and study. Theoretically, management of the airway should be simpler with ETI, but studies have questioned its benefit and any role in improving survival. In any case, the provider should use all efforts available to prevent aspiration, including having an effective suction device readily available.

Patients with TCPA caused by airway obstruction may respond if the anoxic period was not prolonged.

Table 16-2: Causes of Prehospital Traumatic Cardiopulmonary Arrest

1. Airway problems
   a. Foreign body
   b. Tongue prolapse
   c. Swelling
   d. Tracheal damage
   e. Hemorrhage into the airway
   f. Misplaced advanced airway
2. Breathing problems
   a. Tension pneumothorax
   b. Open pneumothorax (sucking chest wound)
   c. Flail chest
   d. Diaphragmatic injury
   e. High spinal cord injury
   f. Carbon monoxide inhalation
   g. Smoke inhalation
   h. Aspiration
   i. Non-fatal drowning
   j. Central nervous system depression from drugs/alcohol
   k. Apnea secondary to electric shock or lightning strike
3. Circulatory problems
   a. Hemorrhagic shock (empty heart syndrome) from any cause, including traumatic aortic dissection and other vascular injuries
   b. Tension pneumothorax
   c. Pericardial tamponade
   d. Myocardial contusion
   e. Acute myocardial infarction
   f. Cardiac arrest secondary to electric shock

Patients with hypoxia secondary to a breathing problem may have an adequate airway, but they are unable to oxygenate their blood because they cannot get oxygen and blood together at the alveolar-capillary membrane of the lungs. This could be from one or more of the following:

- Inability to ventilate, as in a tension pneumothorax, open pneumothorax, flail chest, pulmonary contusion, or a high spinal cord (C-3 or above) injury preventing motion of the diaphragm
- Lung tissue filled with fluid, as in the patient with aspiration of blood or vomit. Drowning patients rarely have fluid in their lungs acutely. They have hypoxemia early from lack of oxygen.
- A fire environment can produce toxic gases, such as carbon monoxide and cyanide. In addition, the fire will consume oxygen, leading to hypoxemia. Inhalation of the hot vapor can result in pulmonary edema, further preventing oxygenation by increasing the distance (by alveolar capillary membrane swelling) between the red blood cells and oxygen. (See Chapter 17.)
- Hypoventilation caused by TBI, lightning strike, and/or drugs and alcohol.

Patients with breathing problems should have aggressive appropriate airway management and assisted ventilation with high-flow oxygen. Many of these patients will respond quickly if they have not been anoxic for too long. It is important for you to remember that the patient in shock is very sensitive to positive-pressure ventilation (also known as "assisted" ventilation). Positive-pressure ventilation may diminish venous return to the heart. This lowers cardiac output, worsening the shock state. This is covered in more detail later in this chapter.

Circulatory Problems

PEARLS

ACLS Protocols

Do not rely on advanced cardiac life support (ACLS) protocols alone. TCPA protocols should include rapid and adequate volume replacement and chest decompression when indicated. Also, if the patient has had a chest seal applied to an open chest wound and experiences a TCPA, remove the seal to help decompress a possible tension pneumothorax.

The causes of TCPA due to circulatory failure are found in Table 16-2. Hypovolemic shock (shock due to blood loss) is the most common circulatory cause of TCPA. Blood loss may be external, internal, or both, and it may be classified as controlled or uncontrolled. Massive internal bleeding causing cardiac arrest is usually fatal and can display any of the cardiac-arrest ECG rhythms on the monitor, most commonly asystole or pulseless electrical activity.

Massive external bleeding causing TCPA can often be controlled in such conditions as amputations, and tourniquets can be lifesaving in such cases. Prompt intravenous (IV) fluid replacement—especially with blood and blood products—presents an opportunity for salvage of these patients.

Massive internal bleeding that produces cardiac arrest is due to a transected blood vessel, injury to an internal organ (such as liver and spleen), or both. TCPA in these patients is usually fatal. Arrival at a trauma center with some cardiac electrical activity presents a slight hope for successful resuscitation with prompt care by the trauma team.

Traumatic tension pneumothorax (a form of "mechanical or obstructive shock") reduces venous return due to increased intrathoracic pressure in the affected pleural space, accompanied by pressure against the mediastinum late in its course. Decreased venous return reduces cardiac output, and shock occurs. Jugular venous distention, tachycardia, and cyanosis occur, appearing similar to pericardial tamponade, and the patient's trachea may deviate away from the affected side with increasing pressure against the mediastinum late in the course of the condition.

It is vital to diagnose tension pneumothorax if it is present during TCPA. This is one potentially correctable cause of TCPA, and needle decompression or finger thoracostomy, if in your scope of practice, of the pleural space on the affected side may be lifesaving. (See Chapters 8 and 9.)

Traumatic pericardial tamponade (another form of "mechanical or obstructive shock") producing TCPA is quickly fatal. This condition is usually encountered in a patient with penetrating trauma to the chest wall. The heart is squeezed by blood and clots in the pericardial sac and cannot fill with blood during each beat. The pressure within the pericardial sac is transmitted to the chambers of the heart, preventing them from filling. That reduces venous return to the heart, and cardiac arrest and shock occur. Because of poor lung perfusion, cyanosis usually develops.

The patients with tamponade may show Beck's triad, which is a "quiet heart" (muffled heart tones because the heart is nearly empty and is surrounded by blood), evidence of blood not getting into the heart (jugular venous distention), and hypotension (due to low cardiac output) in the setting of equal bilateral breath sounds (unless a lung injury is also present).

Peripheral pulses diminish as hypotension worsens and, indeed, cardiac output may be so low that you cannot feel a pulse. Tachycardia is usually present on the monitor until cardiac arrest is imminent. The peripheral pulses may decrease or disappear with inspiration (termed *pulsus paradoxus*), which is an exaggeration of the slight (less than 10 mmHg) decrease in systolic blood pressure that occurs during normal inspiration.

Importantly, the multiple trauma victim may have massive hemorrhage in addition to cardiac tamponade or tension pneumothorax, reducing the distention of neck veins and making the tamponade or tension pneumothorax more difficult to detect.

Patients with pericardial tamponade are often in PEA and commonly will not respond to medications. The EKG monitor may show electrical alternans. Emergency care providers can try administering IV fluids (ideally while en route to a trauma center) to increase venous return. If allowed by protocol or by virtue of licensure and training, an emergency care provider may perform a pericardiocentesis. Removal of as little

as 10 mL of blood can result in return of spontaneous circulation (ROSC), though the provider should be aware that the hemorrhage in the pericardium may reaccumulate.

Acute myocardial infarction and myocardial contusion can produce inadequate blood flow (circulation) by either one or a combination of three mechanisms. Those mechanisms are dysrhythmia, acute pump failure, and pericardial tamponade. The patient with a myocardial contusion has usually been in a deceleration collision. There may be a chest wall or sternal contusion.

Ventricular fibrillation (VF) triggered by a blow to the anterior chest wall during cardiac repolarization is most commonly seen in teenage boys who are engaged in sporting activities or from compression of the chest against a steering wheel. This condition is known as *commotio cordis*. Prompt recognition that the VF may have been caused by a blow to the chest is critical, and rapid defibrillation is often lifesaving.

TCPA from an electrical shock, especially from alternating current, usually presents as ventricular fibrillation. It may respond to ACLS protocols if you are able to initiate resuscitation early enough following TCPA. Thus, standard ACLS, especially early defibrillation, can be lifesaving. The cardiac arrest seen following a lightning strike is frequently due to the prolonged apnea that may follow due to paralysis of the muscles of breathing. The victim of an electrical shock has suffered severe muscle spasm and may well have been thrown down or fallen a great distance. Thus, the same systematic approach to this patient as to any other is required to identify all associated injuries and to give the patient the best chance for a good outcome. However, it should be remembered that patients in TCPA after electrical or lightning injury have a higher rate of survival than arrest from other causes, and full resuscitation should always be attempted when they are encountered. Be sure the patient is no longer in contact with the electricity source so that you do not become a victim yourself!

It should be noted that in a lightning strike with multiple victims, emergency care providers should first begin resuscitating those victims who are pulseless and/or apneic. This is an exception to the classic mass-casualty triage rule of not resuscitating pulseless patients in a mass-casualty event. If a patient has a pulse after a lightning strike, he or she has a greater than 98% chance of surviving.

In summary, patients with traumatic cardiopulmonary arrest related to inadequate circulation have either one of the following:

- Inadequate return of blood to the heart because of:
  - —Hemorrhagic shock with inadequate circulating blood volume because of blood loss
  - —Increased pressure in the chest causing decreased venous return to the heart, as in tension pneumothorax or pericardial tamponade
- Inadequate pumping of the heart because of:
  - —Rhythm disturbances due to myocardial contusion, acute myocardial infarction, *commotio cordis*, or electrical shock
  - —Acute heart failure with pulmonary edema, as in large myocardial contusion or acute myocardial infarction

Approach to Trauma Patients in Cardiac Arrest

TCPA patients are a special group. Many are young and do not have preexisting cardiac conditions or coronary disease. Ensuring a complete scene size-up is important because many cases involve criminal activity (stabbings, shootings), so carefully record your observations of the scene after the EMS call is completed. Some TCPA patients may be resuscitated if you arrive soon enough and if you pay attention to the differences from the usual medical cardiac arrest.

PEARLS
Pregnant Patients

Traumatic cardiac arrest in the pregnant patient is treated the same as in other patients. If over 20 weeks' gestation, the uterus should be displaced to the left to improve venous return. Defibrillation settings and drug dosages are exactly the same. For hypovolemic arrest, the volume of fluid needed increases, and blood or crystalloid should be given as fast as possible during transport. Early notification to the hospital is needed to allow for preparation of emergent C-section.

PEARLS
Children in Cardiac Arrest

Because children who are in traumatic cardiac arrest are more likely to respond to resuscitation than adults, they are treated aggressively unless obviously unsalvageable.

PEARLS
Proper Response

An adequate number of emergency care providers are required to handle this situation well: one to drive the ambulance, one to ventilate, one to do chest compressions, and one to diagnose and treat the cause of the arrest.

The extremely poor resuscitation rate for TCPA patients is probably due to the fact that many of them have been hypoxic for a prolonged period of time before the arrest occurred. Prolonged hypoxia causes such severe acidosis that the patient may not respond to attempted resuscitation. One study concluded that of 138 trauma patients requiring prehospital CPR at the scene or during transport because of the absence of blood pressure, pulse, and respirations, none of the patients survived, whether the victim of blunt or penetrating trauma. In addition, there has been no survival benefit noted in traumatic cardiac-arrest patients transported by air over ground EMS.

Patients who suffer TCPA from isolated head injury usually do not survive. However, they should be aggressively resuscitated because the extent of injury cannot always be determined in the field and, therefore, you cannot predict the outcome for the individual patient. Such patients are also potential organ donors. With patients with a suspected traumatic brain injury, it is important to avoid hyperventilation because it decreases oxygen supply to the already injured brain tissue. Patients who are found in asystole after massive blunt trauma may be considered dead, especially if they do not respond to an initial resuscitation effort. The resuscitation of these patients may be terminated in the field if permitted by medical direction guidelines.

Children are a special case. Although some reports show the same dismal results for resuscitation of children in traumatic cardiac arrest in the field as for adults, one review of over 700 cases of children who received CPR in the field found that 25% survived to discharge. This may be in part because sometimes the pulse is difficult to find in a child. In any case, you should be especially aggressive in attempting to resuscitate children with no palpable pulse. Limit pulse checks to 10 seconds, and if no pulse has been found after 10 seconds, initiate or continue CPR.

General Plan of Action

Management of Traumatic Arrest

The field-correctable causes of TCA are often referred to as the H's and T's (Table 16-3). Your general approach is to identify these and correct them. As you approach the patient, note obvious injuries. The patient in cardiac arrest will have no active bleeding, but if he or she is in a pool of blood, you have strong evidence of an arrest from exsanguination. Control any exsanguinating hemorrhage with a tourniquet.

After determining unresponsiveness and breathlessness (or only gasping), provide SMR, if indicated. Open airway with SMR and clear any blood or vomitus. Attempt ventilation. Take no longer than 10 seconds to check for a pulse, and then begin good-quality chest compressions immediately. For emergency care providers the ratio of chest compressions to breaths is 30:2 with a compression rate of 100–110 per minute.

If no pulse is palpable, you must begin chest compressions immediately. Prepare for immediate transport, if you are not planning to terminate resuscitation. Allow two other emergency care providers to do the cardiopulmonary resuscitation while you

Table 16-3: Field-Correctable Causes of Traumatic Cardiac Arrest: The H's and T's

H	T
Hypoxia	Tension pneumothorax
Hypovolemia	Tamponade
Hydrogen ion (acidosis)	
Hypothermia	
Hyperkalemia	

get the monitor. Apply monitor-defibrillator. Perform at least 2 minutes of continuous chest compressions, and then check the cardiac rhythm. If either ventricular fibrillation or pulseless ventricular tachycardia (VF/pVT) is present, continue compressions while charging the defibrillator. Defibrillate with the energy recommended in your treatment guidelines. Evidence suggests that higher energy settings may have some benefit. Resume compressions for 2 minutes after defibrillation before reanalyzing the rhythm.

If asystole or PEA is present or if VF/pVT persists after the shock, you should evaluate the patient for the cause of the arrest, while continuing CPR. If the patient is a victim of blunt trauma and the patient is in asystole, consider termination of resuscitation. If the patient has penetrating trauma, quickly check the pupils. If the pupils are dilated and nonreactive, consider termination of resuscitation. As mentioned earlier, it may be beneficial to attempt bilateral needle decompression in the second intercostal space anteriorly (or fourth intercostal space laterally) because tension pneumothorax is one reversible cause of traumatic cardiac arrest. Resuscitation efforts should not be initiated for patients with either injuries incompatible with life or for those who have evidence of prolonged time since the arrest (see Table 16-1). If resuscitation attempts have already begun on these patients, it is appropriate to terminate resuscitation efforts as directed by your local medical direction.

For patients with an organized rhythm on ECG, you must quickly evaluate and treat for the cause of the arrest. This should be done in the ambulance during transport, if possible. Use the ITLS Primary Survey that you follow for every trauma patient to try to determine the cause of the TCPA.

PEARLS
Asystole

Patients found in asystole after massive blunt trauma are dead. There is no reasonable expectation of resuscitation.

PEARLS
Transport

Rapid transport to a surgical facility is necessary. Perform procedures in the ambulance during transport. Do not waste valuable time. It is important to recognize that it is very difficult to perform effective CPR in a moving ambulance, and automated compression devices may be beneficial.

Procedure

Initial Assessment and Critical Actions

1. Establish and control the airway using the appropriate airway adjunct according to your treatment guidelines. Ventilate with 100% oxygen. While the other emergency care providers are ventilating and performing chest compressions, you must systematically look for reversible causes of the arrest.
2. Look for breathing problems as a cause of the arrest. Answering the following questions may allow you to identify any breathing problems that may be the cause or a contributing factor:
   a. *Look at the neck.* Are the neck veins flat or distended? Is the trachea midline? Is there evidence of soft-tissue trauma to the neck?
   b. *Look at the chest.* Does the chest rise symmetrically each time you ventilate? Are there chest injuries (penetrations, bruising, flail segment)? If there is spontaneous respiration, is there any paradoxical motion noted?
   c. *Feel the chest.* Is there any instability or asymmetry? Is there any crepitation? Is there any subcutaneous emphysema?
   d. *Listen to the chest.* Are breath sounds present on both sides? Are the breath sounds equal?

If breath sounds are not equal, percuss each side of the chest. Is the side with the absent or decreased breath sounds hyperresonant or dull? If the patient has been intubated, is the endotracheal tube inserted too far?

If there are distended neck veins, decreased breath sounds on one side of the chest, with the trachea deviated away from the side of the injury, and hyperresonance to percussion of the chest on the affected side, then the patient may have a tension pneumothorax. An improperly positioned endotracheal tube can cause unequal breath sounds and may be harmful to the patient because only one lung is being ventilated.

You should always recheck the position of the endotracheal tube before you make a diagnosis of tension pneumothorax because it is much more common to have a poorly positioned endotracheal tube than to have a tension pneumothorax. A tension pneumothorax requires decompression (needle or finger thoracostomy) of the affected side of the chest, if you are trained in the procedure and your protocols allow for this. If required, call medical direction immediately for permission to decompress. Continue ventilation with 100% oxygen.

Do not discontinue chest compressions until either there is a palpable pulse or resuscitation is terminated. Even though you may have found one potential cause of the patient's arrest, there may be other causes as well. Other breathing problems (sucking chest wound, flail chest, simple pneumothorax) should be adequately managed by airway control and ventilation with high-flow oxygen. Once you have established an airway and are applying positive-pressure ventilation to the TCPA patient, you no longer have to seal sucking chest wounds or apply external stabilization to flails. Remember, though, that positive-pressure ventilation can convert a simple pneumothorax to a tension pneumothorax.

PEARLS

ITLS Primary Survey

The pulseless trauma patient requires attention in the ITLS Primary Survey to identify treatable problems in the proper priority.

Once the airway is adequately managed and the patient is being ventilated appropriately, you may concentrate on the circulatory system. As soon as IV access is obtained, rapidly give 2 liters of crystalloid solution (such as lactated Ringer's). Once again, do not delay on the scene if a determination is made to transport the patient. All treatment past initiating compressions, controlling external bleeding (see the following discussion), establishing the airway, and providing ventilations should be done during transport, if the decision has been made to continue resuscitation.

Hemorrhagic shock is the most common circulatory cause of traumatic cardiopulmonary arrest. If there is a large amount of blood on or around the patient, you should identify the source of the bleeding because this must be controlled if you resuscitate the patient. If there is no external bleeding, the patient must be carefully examined for evidence of internal bleeding. Reexamine the neck veins. Flat neck veins in the presence of sinus tachycardia on the monitor favor the presence of hypovolemic shock. If a decision is made to transport, attempt to start two large-bore IV lines while en route and initiate a bolus infusion (lactated Ringer's saline or blood, if available). Intraosseous (IO) lines are acceptable alternatives to IV lines, though the flow rate of the IO needle may not always approach that of large-bore IV catheters. A 10 cc flush of normal saline into the IO needle after placement into the bone often improves flow rate.

Decreased breath sounds on one side with percussion dullness on the same side suggests the presence of a significant hemothorax, though dullness to percussion may also be due to a ruptured diaphragm. Obvious bleeding, distended abdomen, multiple long bone fractures, or an unstable pelvis also suggest that hemorrhagic shock is a likely cause of the TCPA.

Penetrating wounds of the chest or upper abdomen, or contusions of the anterior chest, may cause pericardial tamponade and/or myocardial contusion. If the neck veins are distended, the trachea is midline, and breath sounds are equal, you should suspect pericardial tamponade as one of the causes of the TCPA. A fluid bolus may offer some resuscitation to this patient. Pericardiocentesis is indicated for tamponade, if in your scope of practice.

Electrical shock creates a special situation. It usually presents as ventricular fibrillation. Severe acidosis can develop rapidly during cardiac arrest, making resuscitation more difficult. TCPA secondary to electric shock may respond readily to ACLS protocols if you arrive before the acidosis is too severe. Do not forget to restrict the motion of the spine. A victim of high-voltage electrical shock may have fallen from a power line or have been thrown several feet by the violent muscle spasm associated with the shock. Be sure the patient is no longer in contact with the electrical source so that you do not become a victim yourself!

Considerations in Traumatic Cardiac Arrest Management

Research continues into how to optimize patient evaluation and management in TCPA patients. These patients present many challenges, requiring the ITLS provider to maintain current understanding in the care of these critically ill trauma victims.

Airway Management

It is unclear what the optimal airway is for the patient in TCPA. Prolonged periods of hypoxia have been demonstrated while the provider is attempting ETI in the prehospital phase of care. Excessive manipulation of the airway during ETI has been associated with increased risk of aspiration. A 2014 study revealed no difference in survival to hospital discharge in cardiac arrest patients when comparing the use of ETI to Combitube® placement in the prehospital phase of care (Tiah et al. 2014). Another study found a slight survival advantage from cardiac arrest in patients managed with a supraglottic airway as opposed to endotracheal intubation (Wang et al. 2018).

What is apparent is that the airway needed in managing a TCPA patient is the one that can adequately do the job. If a bag-valve mask (BVM) ventilation is adequate, then use that. Laryngeal fracture from blunt trauma or severe vocal cord edema due to inhaling burning gases may require cricothyrotomy. "One size fits all" does not apply in airway management of the patient in TCPA.

If the trauma patient had previously been intubated and then develops a cardiac arrest, assess the airway using the DOPE algorithm: D—displacement of the endotracheal tube, O–obstruction of the endotracheal tube, P–pneumothorax development, or E–equipment problems (ventilator failure, loss of oxygen supply). Then correct the problems identified.

Ventilation

Positive-pressure ventilations reduce venous return, whether via BVM, ETI, or supraglottic airways. You must attempt to provide adequate air exchange while avoiding overventilation. In the TCPA patient it is reasonable to begin with an assisted ventilation rate of one breath every 5–6 seconds with a tidal volume of about 5–8 mL/kg. This should provide good chest rise. The patient should be reassessed continuously during the resuscitation to determine if this rate of assisted ventilation is appropriate, too high, or too low.

Ultrasound

Over the last few years there has been an increasing use of portable ultrasound machines in the prehospital setting. While still expensive and most often used by physicians and/or critical care transport programs, an ultrasound can help identify the presence of cardiac tamponade, pneumothorax, cardiac activity, and abdominal hemorrhage as potential causes of arrest. Ultrasound may be employed by providers with appropriate training to document absent cardiac motion in the setting of pulseless electrical activity if prehospital termination of resuscitation is being considered.

Capnography

Oxygen (O_2) is supplied to cells by the lungs and vascular system. The oxygen is transported via the red blood cells in the vascular system to the cells of the body, where energy substrate (such as carbohydrate) is enzymatically burned in the cells, producing energy, water, and carbon dioxide (CO_2). The amount of CO_2 produced by the cells is directly related to the amount of O_2 delivered to the cells. The CO_2 that is produced is returned to the lungs to be exhaled.

CO_2 can be measured at the airway through a technique called *waveform capnography* (literally, graphing the wave of exhaled CO_2). Thus, waveform capnography provides a glimpse into the actual metabolism of the body, and the normal level measured at the airway is approximately 40 mmHg during exhalation.

The measuring of CO_2 at the airway has three considerations: Is CO_2 appearing at the airway, what is the "shape" of the curve, and what is the measurement of CO_2 being exhaled at the top of the curve? If no CO_2 is being found during ventilation, then the provider should first be concerned that the airway may be obstructed in some manner. For example, if an endotracheal tube is in place, then a zero level of CO_2 may mean that the endotracheal tube has become displaced. The shape of the curve should be relatively "square," and such conditions as bronchoconstriction can alter the shape of the CO_2 curve.

The "top of the curve" of CO_2 excretion should normally be about 40 mmHg. A low measured level of CO_2 at the airway in TCPA patients is an indication that O_2 supply to the cells may be low. Rising CO_2 levels during resuscitation of TCPA patients is an indication of improving circulation.

Overventilation of the TCPA patient can reduce cardiac output. This lowers O_2 delivery to the tissues, reducing CO_2 production and measured capnography at the airway. Thus, measuring capnography at the airway is a useful guide to establishing the correct ventilation rate and tidal volume (literally, minute ventilation) in the TCPA patient, adjusting the ventilation rates downward (while maintaining good deep compressions) if capnography measures under 10 mmHg. Refer to your medical direction guidelines for ventilation management during traumatic cardiac arrest.

Case Presentation *(continued)*

A BLS ambulance is on the scene of a hiker who fell 75 feet into a canyon. The fall was, unwitnessed and time of impact undetermined. Another hiker saw the patient laying on the canyon floor and called 911. The closest hospital is 15 miles away; level 2 trauma hospital, 45 miles away. The scene is safe, and one patient (approximately 20 years old) is found. The patient is unresponsive, apneic, and pulseless. There is an obvious deformity to the skull, multiple rib fractures, and deformity to the left femur. An AED is applied, and it indicates, "No shock advised."

Because the cardiac rhythm could not be determined by the AED, CPR is initiated, and an ALS unit is requested to respond. ALS arrives within 5 minutes of being summoned. The ALS team assesses the patient and finds him unresponsive, with no spontaneous respirations and no pulses (with or without CPR). The heart monitor is applied, and the ECG reveals asystole in two leads. The ALS team contacts medical direction to request stopping resuscitative efforts. Medical direction approves the request, and resuscitative efforts are stopped. Responders notify law enforcement so that the accident can be investigated.

The autopsy revealed massive cerebral trauma, rib fractures, pulmonary contusion, a lacerated liver, and pelvic and left femur fractures. Cause of death was cited as accidental traumatic brain injury and exsanguination.

Summary

The trauma patient in cardiopulmonary arrest is most often suffering from a breathing or circulatory problem. If you are to have a chance to save this patient, you must identify the cause of the arrest with the ITLS Primary Survey and then rapidly transport the patient while performing those procedures that specifically address the cause of the arrest. Although it is very rare to successfully resuscitate a patient suffering from a trauma arrest secondary to hemorrhagic shock, attention to detail will allow you the best opportunity to "bring one back from the dead," which is the greatest challenge and greatest satisfaction in EMS.

References and Resources

American Heart Association. 2015. "Guidelines for Cardiopulmonary Care Resuscitation (CPR) and Emergency Cardiovascular Care Science." *Circulation* 132: S313–4. Accessed October 1, 2018. https://eccguidelines.heart.org/index.php/circulation/cpr-ecc-guidelines-2/.

Cera, S. M., G. Mostafa, R. F. Sing, J. L Sarafin, B. D. Matthews, and B. T. Heniford. 2003. "Physiologic Predictors of Survival in Post-Traumatic Arrest." *The American Surgeon* 69, no. 2 (February): 140–4.

Chinn, M., and R. Colella. "An Evidence-Based Review of Prehospital Traumatic Cardiac Arrest." *Journal of Emergency Medical Services* 42, no. 4 (April): 26–32.

Davis, D. P., D. Hoyt, M. Ochs, D. Fortlage, T. Holbrook, L. K. Marshall, and P. Rosen. 2003. "The Effect of Paramedic Rapid Sequence Intubation on Outcome in Patients with Severe Traumatic Brain Injury." *Journal of Trauma, Injury, Infection, and Critical Care* 54, no. 3 (March): 444–53.

Di Bartolomeo, S., G. Sanson, G. Nardi, V. Michelutto, and F. Scian. 2005. "HEMS vs. Ground-BLS Care in Traumatic Cardiac Arrest." *Prehospital Emergency Care* 9, no. 1 (January–March): 79–84.

Fontanarosa, P. B. 1993. "Electric Shock and Lightning Strike." *Annals of Emergency Medicine* 22, no. 2, pt. 2 (February): 378–87.

Hopson, L. R., E. Hirsh, J. Delgado, R. M. Domeier, N. E. McSwain, and J. Krohmer. 2003. "Guidelines for Withholding or Termination of Resuscitation in Prehospital Traumatic Cardiopulmonary Arrest: Joint Position Statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma." *Journal of the American College of Surgeons* 196, no. 1 (January): 106–12.

National Association of EMS Physicians and American College of Surgeons Committee on Trauma. 2013. "Withholding of Resuscitation for Adult Traumatic Cardiopulmonary Arrest." *Prehospital Emergency Care* 17, no. 2 (April–June): 291.

Perron, A. D., R. F. Sing, C. C. Branas, and T. Huynh. 2001. "Predicting Survival in Pediatric Trauma Patients Receiving Cardiopulmonary Resuscitation in the Prehospital Setting." *Prehospital Emergency Care* 5, no. 1 (January–March): 6–9.

Rosemurgy, A. S., P. Norris, S. M. Olson, J. M. Hurst, and M. H. Albrink. 1993. "Prehospital Traumatic Cardiac Arrest: The Cost of Futility." *Journal of Trauma* 35, no. 3 (September): 468–74.

Saeedi, M., H. Hajisevediavadi, J. Seyedhosseini, V. Eslami, and H. Sheikhmotaharvahedi. 2014. "Comparison of Endotracheal Intubation, Combitube, and Laryngeal Mask Airway Between Inexperienced and Experienced Emergency Medical Staff: A Manikin Study." *International Journal of Critical Illness and Injury Science*. 4(4) (October–December): 303–8. doi: 10.4103/2229-5151.147533.

Saunders, C. E., and C. Heye. 1994. "Ambulance Collisions in an Urban Environment." *Prehospital and Disaster Medicine* 9, no. 2 (April–June): 118–24.

Tiah, L., K. Kajino, O. Alsakaf, D.C. Bautista, M.E. Ong, D. Lie, G.Y. Naroo, N.E. Doctor, M.Y. Chia, and H.N. Gan. 2014. "Does Pre-hospital Endotracheal Intubation Improve Survival in Adults with Non-traumatic Out-of-hospital Cardiac Arrest? A Systematic Review." *Western Journal of Emergency Medicine*. Nov; 15(7): 749–757.

Truhlář, A., C. D. Deakin, J. Soar, G. E. Khalifa, A. Alfonzo, J. J. Bierens, G. Brattebø, H. Brugger, J. Dunning, S. Hunyadi-Antičević, et al. 2015. "European Resuscitation Council Guidelines for Resuscitation 2015: Section 4. Cardiac Arrest in Special Circumstances." *Resuscitation* 133 (October): 148–201.

Wang, H.E, R.H. Schmicker, M.R. Daya, S.W. Stephens, A.H. Idris, J.N. Carlson, M.R. Colella, H. Herren, M. Hansen, N.J. Richmond, J.C.J. Puyana, T.P. Aufderheide, R.E. Gray, P.C. Gray, M. Verkest, P.C.Owens, A.M. Brienza, K.J. Sternig, S.J. May, G.R. Sopko, M.L. Weisfeldt, and G. Nichol. 2018 "Effect of a Strategy of Initial Laryngeal Tube Insertion vs Endotracheal Intubation on 72-Hour Survival in Adults With Out-of-Hospital Cardiac Arrest: A Randomized Clinical Trial." *Journal of the American Medical Association*. 320(8) (August): 769-778.

Wang, H. E., and D. M. Yealy. 2006. "How Many Attempts Are Required to Accomplish Out-of-Hospital Endotracheal Intubation?" *Academic Emergency Medicine* 13, no. 4 (April): 372–7.

Warner, K. J., J. Cuschieri, M. Copass, G. J. Jurkovich, and E. M. Bulger. 2007. "The Impact of Prehospital Ventilation on Outcome After Severe Traumatic Brain Injury." *Journal of Trauma* 62, no. 6 (June): 1330–8.

17

Burns



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

Lisa Hrutkay, DO, FACEP
Roy Alson, PhD, MD, FAEMS

Verbrennungen
Quemaduras
Opekline
Queimaduras
Trauma Termal
Ожоги
Brûlures

Εγκαύματα
Égések
熱傷
燒傷
Opekline

Key Terms

burn depth, *p. 330*
carbon-monoxide poisoning, *p. 337*
chemical injury, *p. 340*
electrical injury, *p. 342*
heat-inhalation injury, *p. 337*
lightning injury, *p. 344*
Parkland formula, *p. 346*
radiation injury, *p. 345*
rhabdomyolysis, *p. 344*
rule of nines, *p. 331*
smoke-inhalation injury, *p. 339*
thermal injury, *p. 338*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Identify the basic anatomy of the skin, including:
   a. Epidermal and dermal layers
   b. Structures found within
2. List the basic functions of the skin.
3. Describe types of burns as a function of burn depth.
4. Estimate depth of burn based on skin appearance.
5. Estimate extent of burn using the rule of nines.
6. Describe the initial management of:
   a. Thermal burns
   b. Chemical burns
   c. Electrical burns
7. List situations and physical signs that:
   a. Indicate inhalation injury
   b. Suggest carbon-monoxide poisoning
8. Discuss how carbon monoxide causes hypoxia.
9. Describe the initial treatment for carbon-monoxide poisoning.
10. Identify which patients may require transport to a burn center.

Chapter Overview

According to the American Burn Association, there are over 1 million burn injuries per year in the United States, resulting in more than 4,500 deaths. The World Health Organization reports that there are over a quarter of a million deaths worldwide from burns, many of them in developing countries. Burns are a major public health problem worldwide. Many who survive their burns are left severely disabled and/or disfigured. Although the number of those killed or injured has decreased in the last 40 years, primarily due to the use of smoke detectors and the improvements in burn care, burn injury is still a major problem. Applying the basic principles taught in this text can help decrease death, disability, and disfigurement from burn injuries. Because the rescue of burn patients can be extremely dangerous, following the rules of scene safety is extremely important. Multiple agents (Table 17-1) can cause burn injuries, but in general, pathologic damage to the skin is similar no matter what the cause. Specific differences among the types of burns are discussed in later sections.



Case Presentation

You are the senior emergency care provider on an ambulance dispatched along with the fire department to a reported tire fire with injuries. On arrival, the fire officer informs you that there is one injured patient. The fire has been extinguished. The officer reports that the patient threw a cup of petrol onto the fire to get it to burn faster, spilling some on his shirt. There was a large flash of flame. The patient sustained burns to his arms, chest, and face.

Before proceeding, consider these questions:

- What critical signs are you looking for?
- What are your treatment priorities?
- How would you triage this patient?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

Anatomy and Pathophysiology

The Skin

The largest organ of the body, the skin, is made up of two layers. The outer, or surface, layer is called the *epidermis*. It serves as a barrier between the environment and the body. Underneath the thin epidermis is a thick layer of collagen connective tissue called the *dermis*. This layer contains the important sensory nerves and also the support structures such as the hair follicles, sweat glands, and oil glands (Figure 17-1).

Table 17-1: Types of Burn Injuries

- Thermal: flame, scald, steam
- Electrical
- Chemical
- Radiation

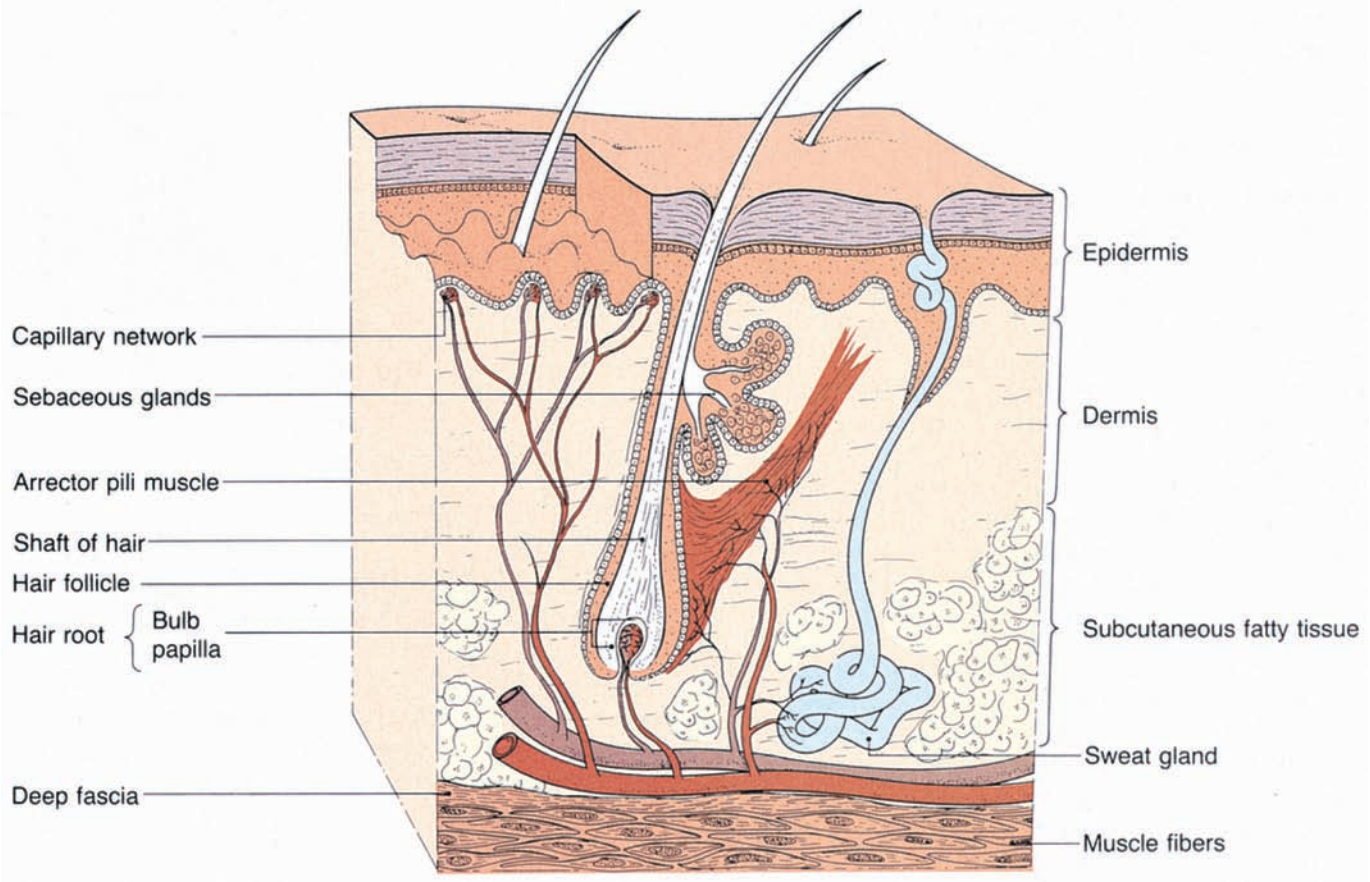


Figure 17-1 The skin.

The skin has many important functions, which include acting as a mechanical and protective barrier between the body and the outside world, sealing fluids inside, and preventing bacteria and other microorganisms from readily entering the body.

The skin is also a vital sensory organ that provides input to the brain on general and specific environmental data and serves a primary role in temperature regulation. Damage to the skin renders it unable to carry out these functions and puts the body at risk for serious problems.

Burn damage occurs when heat or caustic chemicals come in contact with the skin and damage its chemical and cellular components. In addition to actual tissue injury, the body's inflammatory response can cause additional injury or increase the severity of a burn. The portions of the skin that are necrosed by the thermal insult are referred to as the *zone of coagulation* and have suffered irreversible injury. Surrounding this area is a *zone of stasis*, where blood flow is compromised and tissues will die if blood flow is not restored. This condition is seen in the deeper areas of partial-thickness burns and is helped by good burn care and fluid resuscitation. Surrounding the zone of stasis is the *zone of hyperemia*, where there is increased blood flow to the tissues as a result of the actions of inflammatory mediators released by damaged skin.

Table 17-2: Characteristics of Various Depths of Burns

	Superficial (First Degree)	Partial Thickness (Second Degree)	Full Thickness (Third Degree)
Cause	Sun or minor flash	Hot liquids, flashes, or flame	Chemicals, electricity, flame, hot metals
Skin color	Red	Mottled red	Pearly white and/or charred, translucent and parchment-like
Skin surface	Dry with no blisters	Blisters with weeping	Dry with thrombosed blood vessels
Sensation	Painful	Painful	Anesthetic with peripheral pain
Healing	3–6 days	2–4 weeks, depending on depth	Requires skin grafting

Classifying Burns by Depth

burn depth: a classification of severity of burns by how deep the skin is burned. In order of worsening injury: superficial burns (first degree), partial-thickness burns (second degree), and full-thickness burns (third degree).

Burns are characterized, based on the depth of tissue damage and skin response, as superficial (first degree), partial thickness (second degree), or full thickness (third degree). Superficial burns result in minor tissue damage to the outer epidermal layer only, but do cause an intense and painful inflammatory response. The most common injury of this type is "sunburn." Although no medical treatment is usually required for superficial burns, various medications can be prescribed that significantly speed healing and reduce the painful inflammatory response.

Partial-thickness burns cause damage through the epidermis and into a variable depth of the dermis. Such injuries will heal (often without scarring) because the cells lining the deeper portions of the hair follicles and sweat glands will multiply and grow new skin for healing. Antibiotic creams or various specialized types of dressings are routinely used to treat these burns, and therefore, appropriate medical evaluation and care should be provided for patients with these injuries. Emergency care of partial-thickness burns involves cooling the burn and covering it with a clean, dry dressing.



Figure 17-2 Superficial (first-degree) burn.

Full-thickness burns cause damage to all layers of the epidermis and dermis. No more skin cell layers are left, so healing by regrowth of epidermal cells is impossible. All full-thickness burns leave scars that later may contract and limit motion of the burned extremity (or restrict movement of the chest wall if the thorax is involved). Deeper full-thickness burns usually result in skin protein becoming denatured and hard, forming a firm, leather-like covering that is referred to as *eschar*.

Characteristics of burns are listed in Table 17-2. Depth levels and examples are shown in Figures 17-2, 17-3, and 17-4.

Determining the Severity of Burns

The body's normal inflammatory response to a burn injury can result in progressive tissue damage for a day or two following the injury, which may well result in an increase in **burn depth**. Any condition that either reduces circulation (shock) to this damaged tissue or by itself causes further tissue damage will lead to burn progression with increasing burn depth. Because of this process of burn progression, it is not essential to determine exactly the burn



Figure 17-3 Partial-thickness (second-degree) burn. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 17-4 Full-thickness (third-degree) burn to the lower extremities. Note that these burns are circumferential and will require escharotomies. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

depth in the field. You should, however, be able to clearly discern between superficial and deep burns. Because the decision to transport to a burn center is based on both depth and extent of the burn, you should also be able to estimate the amount of body surface involved in the burn.

Burn size is best estimated in the field using the **rule of nines** (Figure 17-5). Utilizing the rule of nines, the body is divided into areas that are either 9% or 18% of the total body surface, and by roughly drawing in the burned areas, the extent can be estimated.

rule of nines: a method of estimating the body surface area burned by a division of the body into regions, each of which represents approximately 9% of the total surface area, plus 1% for the genital area.

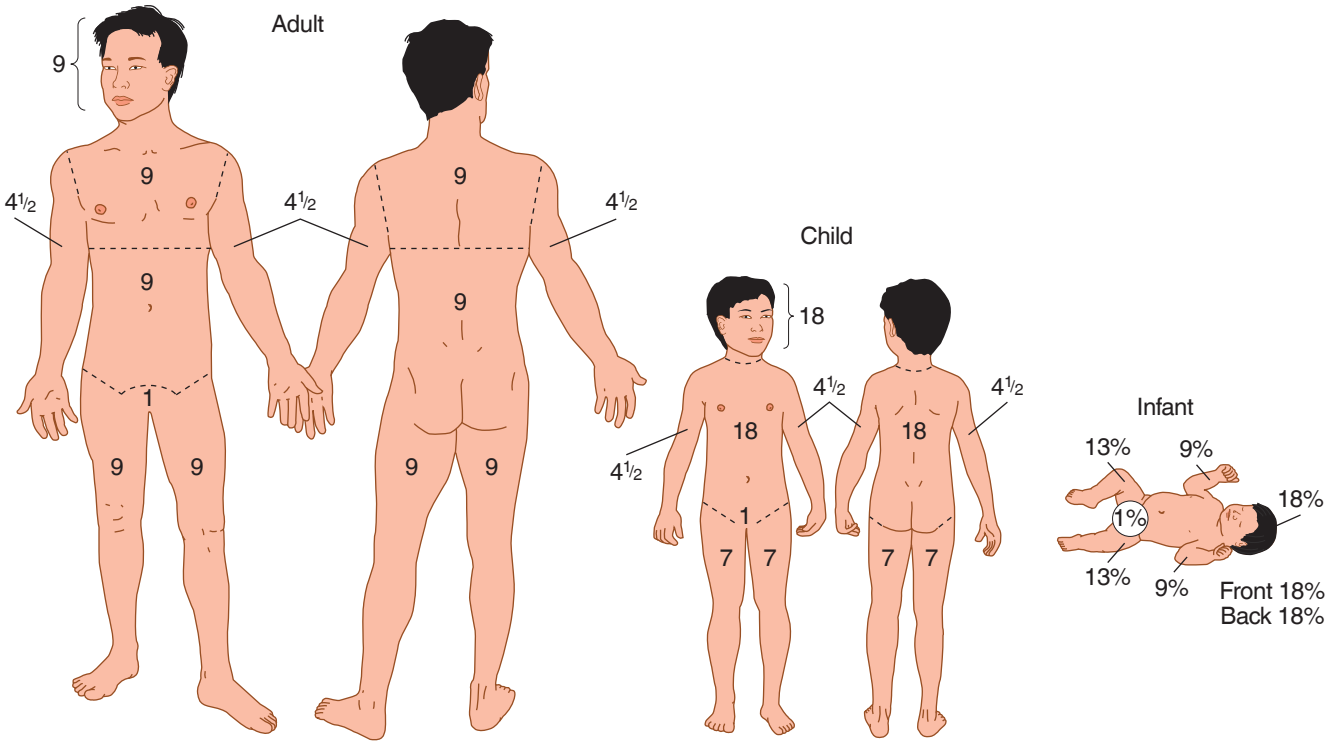


Figure 17-5 The rule of nines.

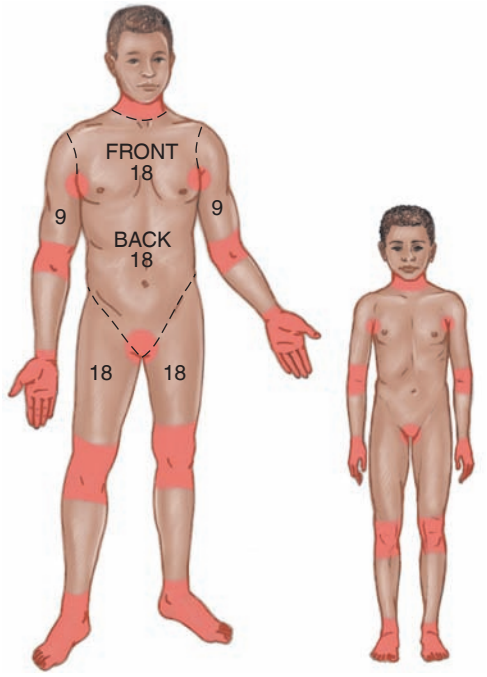


Figure 17-6 Areas in which small burns are more serious: Partial- or full-degree burns in these areas (shaded portions) should be treated in the hospital.

Only partial-thickness and full-thickness burns are used for this calculation. In small children there are some differences in body size proportions, so a *Lund and Browder chart* is helpful (Table 17-3).

For smaller or irregular burns, the size can be estimated using the entire palmar surface (including the fingers) of the patient's hand, which is very close to 1% of the total body surface area. Even small burns can be serious if they involve certain parts of the body that affect function or appearance (Figure 17-6).

Initial care that is directed specifically toward the burn should concentrate on limiting any progression of the burn depth and extent by removing from the burn source and cooling the burn.

Patient Assessment and Management

Evaluation of the burn patient is often complicated by the dramatic nature of the injuries. Prehospital care providers can easily be overwhelmed by the extent of such injuries. You must remember that even patients with major burns rarely expire in the initial postburn period from the burn injury. Death in the immediate postburn period is usually a consequence of associated trauma or conditions such as airway compromise or smoke inhalation. A careful, systematic approach using the ITLS Primary Survey will allow you to identify and manage critical life-threatening problems and to improve patient outcome. The ITLS Primary and Secondary Surveys should follow the standard format described in Chapter 2.

Table 17-3: Lund and Browder Chart

Age (Years)						%	%	%
Area	**0–1**	**1–4**	**5–9**	**10–15**	**Adults**	**2°**	**3°**	**Total**
Head	19	17	13	10	7			
Neck	2	2	2	2	2			
Ant. Trunk	13	17	13	13	13			
Post. Trunk	13	13	13	13	13			
R. Buttock	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$			
L. Buttock	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$			
Genitalia	1	1	1	1	1			
R.U. Arm	4	4	4	4	4			
L.U. Arm	4	4	4	4	4			
R.L. Arm	3	3	3	3	3			
L.L. Arm	3	3	3	3	3			
R. Hand	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$			
L. Hand	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$			
R. Thigh	$5\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{2}$	$9\frac{1}{2}$			
L. Thigh	$5\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{2}$	$9\frac{1}{2}$			
R. Leg	5	5	$5\frac{1}{2}$	6	7			
L. Leg	5	5	$5\frac{1}{2}$	6	7			
R. Foot	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$			
L. Foot	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$			
					Total			

Weight _____

Height _____

Adapted from Lund and Browder 1944.

ITLS Primary Survey

Scene Size-up

The steps for assessing a major burn patient are the same as for any other major trauma patient. Begin by performing a scene size-up as outlined in Chapter 1, with an emphasis on your own safety. After the size-up is completed, your next priority is to remove the patient to a safe area away from the source of the burn.

There are specific and significant dangers in removing the burn source in all types of burn injuries. As a structure fire progresses, there is a point at which flashover occurs. Flashover is the sudden explosion into flame of everything in the room, with the temperature rising instantaneously to over 3,600°F (2,000°C). There is often little warning before this happens. Thus, rescue of patients from burning buildings takes priority over all other treatment.

Remember also that fire consumes oxygen and produces large quantities of toxic products and smoke. Personnel making entry to carry out rescue should wear self-contained breathing apparatus (SCBA) or risk becoming victims themselves. Extrication of the patient from the burn source should be performed by personnel trained to work in

PEARLS

Assessment

Treat burn patients as trauma patients: ITLS Primary Survey, critical interventions, transport decision, ITLS Secondary Survey, and ITLS Ongoing Exam.

PEARLS

Safety

- Maintain appropriate safety when removing patients from the source of a burn injury.
- Remember that dealing with hazardous materials requires proper training and equipment. You must always use the appropriate personal protective equipment.

the fire environment. As an emergency care provider, your responsibility should begin when the patient is delivered to you in a safe place, unless you are a trained firefighter.

Chemicals are not always easy to detect, either on the patient's body or on objects in the environment. Rescuers have suffered severe chemical burns because of the failure to note contamination by toxic and caustic chemicals and to use the appropriate personal protective equipment (PPE). Special training in hazardous materials management is recommended for all rescuers so that they can recognize such dangers.

Electricity, even at household voltages, is exceptionally dangerous, as is the handling of high-voltage wires. Specialized training, knowledge, and equipment are required to appropriately deal with these situations, and you should not attempt to remove wires unless specifically trained and equipped to do so. Even objects commonly believed to be safe, such as wooden sticks, manila rope, and firefighter's gloves, may not be protective and may result in electrocution. If at all possible, the source of electricity should be turned off before any attempt at rescue is made.

Initial Assessment

Burn patients differ from other trauma patients in that the burning process must be halted immediately upon removal of the patient from the source of the burn. This is best done with a quick irrigation of the burn with room-temperature tap water. Any source of clean water can be used, but do not use cold water. Irrigate for only 5–10 minutes so the patient does not become hypothermic. This can be done by another emergency care provider while the team leader begins the ITLS Primary Survey.

PEARLS
Airway Compromise

Early deaths from burns are rarely due to burn injury, but are due to airway compromise. Perform frequent exams of the airway, and be prepared to secure it with an endotracheal tube or other method.

People do not actually die rapidly from burn injuries. Early burn deaths are usually the result of airway compromise, smoke inhalation, or associated trauma. Death from shock due to fluid loss from the burn will not be seen for many hours (or days), and sepsis usually takes days to develop. Burn victims may also sustain multiple trauma from falls or other mechanisms. Hemorrhagic shock will develop rapidly compared to burn shock, so that management of the patient's blunt or penetrating trauma using ITLS guidelines is very important. Even though the burn is highly visible and makes an intense impression at the scene, other than stopping the burn process, care of the burn itself has a lower priority than control of major hemorrhage and airway management. You should perform an initial assessment as soon as the patient is in a safe area.

Begin by quickly assessing for any source of major hemorrhage and control it as quickly as possible. If you are the sole prehospital provider, this would be your first priority. If there are two trained providers available, hemorrhage control can be performed simultaneously with assessment of the level of consciousness and securing the cervical spine, if indicated. The next priority is to assess the airway. If the patient is hoarse or exhibits stridor, protecting the airway is an immediate concern. Assessment of breathing and circulation is then carried out.

Rapid Trauma Survey

PEARLS
Inhalation Injury

- Any type of burn can have some degree of inhalation injury.
- Remember that a history of smoke exposure in a closed space is the best predictor of smoke inhalation or other airway injuries.

Based on findings from the scene size-up and the initial assessment, a rapid trauma survey or focused exam is then performed, a baseline set of vital signs is obtained, and, if possible, a SAMPLE history is obtained. At this point a determination is made on the need for immediate transport and critical interventions. Critical problems in the burn patient that require immediate intervention include airway compromise, altered level of consciousness, or the presence of major injuries in addition to the burn. Clues from the mechanism of injury that point to critical problems include a history of being confined in a closed space with the fire or smoke, electrical burns, chemical exposure, falls from a height, or other major blunt-force trauma. Oxygen at 12–15 L/minute by nonrebreather mask (or endotracheal tube, if indicated) should be initiated as soon as possible for all patients with major burns.

The rapid trauma survey of the burn patient is directed toward identification of causes of breathing and circulatory compromise after controlling any possible major hemorrhage. In addition to clues from the mechanism of injury, findings that should alert

the responder to potential airway problems are the presence of facial and scalp burns, sooty sputum, and singed nasal hair and eyebrows. Examine the oral cavity to look for soot, swelling, or erythema (redness). Ask the patient to speak. Hoarseness, stridor, or persistent cough suggest involvement of deeper airway structures and indicate the need for aggressive airway management. Auscultate the chest. Wheezing or rales should alert you to the presence of lower-airway injury from inhalation. Examine burned areas and check for distal pulses. Based on the initial assessment and the mechanism of injury, a search for associated injuries should be the focus of the remainder of the rapid trauma survey.

In your assessment of the burn patient, note and record the type of burn mechanism and the circumstances of the event, such as entrapment, explosion, smoke exposure, chemical/electrical details, and other possible mechanisms of injury. An appropriate past medical history should also be documented in writing. If the patient is unable to speak, ask other witnesses and/or fire personnel about the circumstances of the injury.

ITLS Secondary Survey

Perform a standard ITLS Secondary Survey on stable patients. This survey should include an evaluation of the burn, estimating the depth based on appearance and also estimating the burn size. Those findings are important in determining the level of medical care that is appropriate for the burn patient.

Patient Management

Attend to the burn wound itself once the immediate life threats have been addressed. As mentioned earlier, try to limit burn wound progression as much as possible. Rapid cooling early in the course of a surface burn injury can help limit this progression. Following removal from the source of the burn, the skin and clothing are still hot, and this heat continues to injure the tissues, causing an increase in burn depth and seriousness of the injury. Cooling halts this process and, if done appropriately, is beneficial. Cooling should be done with tap water or any source of clean room-temperature water, but it should be undertaken for no more than 5–10 minutes. Cooling for longer periods of time can induce hypothermia and subsequent shock. Do not use ice or ice water because this may induce hypothermia.

PEARLS
Cooling

Early after the burn event, properly cool the surface thermal injury with room-temperature water, but do not cause hypothermia.

Following the brief period of cooling, manage the burn by covering the patient with clean, dry sheets and blankets to keep the patient warm and to prevent hypothermia. It is not necessary to have sterile sheets. Usually, nothing other than a clean sheet should be put on the burn, but antimicrobial sheets (Acticoat™ or Silverlon®) can be used if you have prolonged transport times. The patient should be covered even when the environment is not cold because damaged skin loses temperature-regulation capacity. Water-Jel® is another dressing that can be used to cover the burns in the field.

The important thing to remember is that patients should never be transported on wet sheets, wet towels, or wet clothing, and ice is absolutely contraindicated. Ice will worsen the injury because it causes vasoconstriction and thus reduces the blood supply to already damaged tissue. Cooling the burn wound improperly can cause hypothermia and additional tissue damage and could be worse than not cooling the burn at all. Initial management of chemical and electrical burn injuries is described later in this chapter in the sections addressing those injuries.

PEARLS
Fluid Resuscitation

Initiation of fluid resuscitation on scene is not as important as management of other potential life threats. Most burn injuries do not require large fluid volumes in the prehospital phase unless there is a long transport time.

During the evaluation of the extent of the burn injury, you should remove the patient's loose clothing and jewelry. Cut around burned clothing that is adherent, but do not try to pull the clothing off the skin. Intravenous (IV) line insertion is rarely needed on scene during initial care unless delay in transport to a hospital is unavoidable. It takes hours for burn shock to develop. Therefore, the only reason to initiate IV therapy on scene is if other factors indicate a need for fluid volume or medication administration. Attempting to start IV therapy on scene in major burn patients is often difficult and routinely delays initial transport and arrival at the hospital. IV or intraosseous (IO) access should be established during transport.

Table 17-4: Injuries That Benefit from Care at a Burn Center

- Partial-thickness burns greater than 10% total body surface area (TBSA)
- Burns that involve the face, hands, feet, genitalia, perineum, or major joints
- Third-degree burns in any age group
- Electrical burns, including lightning injury
- Chemical burns
- Inhalation injury
- Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
- Any patients with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit. Physician judgment will be necessary in such situations and should be in concert with the regional medical direction plan and triage protocols.
- Burned children in hospitals without qualified personnel or equipment for the care of children
- Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention

Source: Committee on Trauma, American College of Surgeons 2006.

Normal saline in large volumes can lead to hyperchloremia. If available, lactated Ringer's solution is preferred for fluid resuscitation in major burns. Colloid-containing fluids are generally not used in the prehospital setting.

Burn wounds are very painful. This is obvious to anyone who has sustained even a minor burn. Administration of pain medication, in the field setting, is an important part of patient care. The risk of analgesics masking associated trauma and central nervous system or cardiovascular depression associated with the use of pain medications is minimal. In the major burn patient, with or without coexisting trauma and especially with long transport times, administration of analgesics in appropriate dosages will improve patient comfort. Therefore, control of the patient's pain using pain control protocols or after consultation with medical direction is an essential component of burn care. Remember that the dose of morphine is 0.1 mg/kg (up to 10 mg) for both pediatric and adult patients. We often underdose analgesics in major burns. While opiates can depress blood pressure and respirations, close monitoring of the patient will allow you to correct these issues should they arise. See Appendix B for discussion of analgesia.

All but the most minor of burn injuries should be evaluated at the hospital. Specialized forms of therapy are now available that offer specific advantages in the treatment of superficial, partial-thickness, and full-thickness burns. Partial-thickness burns can become infected and progress to full-thickness burns because of poor care. The sooner specialized burn therapy can be initiated, the more rapid and satisfactory the results will be.

Table 17-4 lists conditions that would benefit from care at a burn center. Based on available local resources and protocols, it may be appropriate to bypass a local facility and transport these patients directly to the burn center.

Special Problems in Burn Management

The following sections review management of specific types of burns based on the injury mechanism. Be aware that more than one type of burn can be present in a patient. For example, a high-voltage electrical burn injury may also produce flame burns due to ignition of the patient's clothing.

Circumferential Burns

Full-thickness burns result in the formation of an eschar that is tough and unyielding. If the full-thickness burn is circumferential to an extremity (see Figure 17-4) as the burn edema develops in the extremity, the eschar can act like a tourniquet and

result in loss of circulation to that extremity. Thus, all extremity burns should undergo regular pulse checks. Though not a prehospital procedure, consideration should be given to the performance of an escharotomy at the hospital prior to transfer to a burn center. If the chest is the site of the circumferential burn, the eschar may limit chest excursion during respiration and lead to hypoxia. Intubation and escharotomy can prevent hypoventilation in this situation.

Flash Burns

Flash burns are virtually always superficial or partial-thickness burns. A flash burn occurs when there is some type of explosion, but no sustained fire. The single heat wave traveling out from the explosion results in such short patient–heat contact that full-thickness burns almost never occur. Only areas directly exposed to the true heat wave will be injured. Typically, face and hands are involved. An example of this type of burn is seen when someone pours gasoline on a charcoal fire to get it to heat up faster. In situations of possible flash explosion risk, you should always wear proper protective clothing and avoid entry into explosive environments. Other injuries (fractures, internal injuries, blast chest injuries, etc.) may occur as a result of an explosion.

Inhalation Injuries

Inhalation injuries account for more than half of the 4,500-plus burn-related deaths in the United States each year. Inhalation injuries are classified as carbon-monoxide poisoning, **heat-inhalation injury**, or smoke (toxic) inhalation injury. Most frequently, inhalation injuries occur when a patient is injured in a confined space or is trapped; however, even victims of fires in open spaces may have inhalation injuries. Flash explosions (no fire) practically never cause inhalation injuries.

heat-inhalation injury: thermal burns of the upper airway caused by inhaling flame or hot gases. The lower airways are usually not affected because of efficient cooling by moist mucous membranes.

Carbon-Monoxide Poisoning

Carbon-monoxide poisoning and asphyxiation are by far the most common causes of early death associated with burn injury. When any material burns, oxygen in the air is consumed, and the fire environment should be considered to be an oxygen-deprived environment. Carbon monoxide is a by-product of combustion and is one of the numerous chemicals in common smoke. It is present in high concentrations in auto exhaust fumes and fumes from some types of home space heaters. Because it is colorless, odorless, and tasteless, its presence is virtually impossible to detect without special instruments.

carbon-monoxide poisoning: a type of inhalation injury from inhalation of the colorless, odorless, and tasteless gas carbon monoxide. Carbon monoxide binds to the hemoglobin molecule and prevents oxygenation of the cells of the body.

Carbon monoxide binds to hemoglobin (257 times stronger than oxygen), resulting in the hemoglobin being unable to transport oxygen. Patients quickly become hypoxic even in the presence of low concentrations of carbon monoxide. An alteration in level of consciousness is the predominant sign of this hypoxia (Table 17-5). A cherry-red skin color or cyanosis is rarely present as a result of carbon-monoxide poisoning and, therefore, cannot be used in the assessment of patients for this condition.

Table 17-5: Symptoms Associated with Increasing Levels of Carboxyhemoglobin Binding

Carboxyhemoglobin Level	Symptoms
20%	Headache common, throbbing in nature; shortness of breath on exertion
30%	Headache present; altered central nervous system function with disturbed judgment; irritability, dizziness, decreased vision
40–50%	Marked central nervous system alteration with confusion, collapse; also fainting with exertion
60–70%	Convulsions; unconsciousness; apnea with prolonged exposure
80%	Rapidly fatal



Figure 17-7 Example of a transcutaneous carbon monoxide (CO) monitor. *(© Dr. Bryan E. Bledsoe)*

Pulse oximetry will remain normal to high in the presence of carbon monoxide and cannot be used to assess patients for carbon-monoxide poisoning. Some newer-model pulse oximeters (Figure 17-7) can specifically measure carboxyhemoglobin levels and, if available, should be used on all those who have the possibility of exposure to carbon monoxide. Death usually occurs because of either cerebral or myocardial ischemia or myocardial infarction due to progressive cardiac hypoxia.

Treat patients suspected of having carbon-monoxide poisoning with high-flow oxygen by mask. If such a patient loses consciousness, begin advanced life support with intubation and ventilation using 100% oxygen. If a patient is simply removed from the source of the carbon monoxide and allowed to breathe fresh air, it takes up to 7 hours to reduce the carbon monoxide/hemoglobin complex to a safe level. Having the patient breathe 100% oxygen decreases this time to about 90–120 minutes and use of hyperbaric oxygen (100% oxygen at 2.5 atmospheres) will decrease this time to about 30 minutes (Figure 17-8).

All suspected cases of carbon-monoxide poisoning or toxic inhalation should be transported to an appropriate hospital. The decision to transport the patient to a hyperbaric chamber should be made in consultation with medical direction.

Cyanide and Smoke Inhalation In the modern world, many items in homes and businesses are made of plastics. When combusted, many of them give off toxic gases, which can cause significant pulmonary injury. Among the toxic components in smoke is hydrogen cyanide. It is highly toxic and causes cellular hypoxia by preventing the cell from using oxygen to generate energy to function. Studies of smoke inhalation victims have shown elevated levels of cyanide in some cases.

Opinions regarding empirical treatment of smoke inhalation victims for cyanide poisoning still vary. Several studies suggest that patients who do not respond rapidly to treatment for hypoxia and carbon-monoxide poisoning should be treated for cyanide exposure. The current recommended agent for such treatment is IV hydroxocobalamin (Cyanokit®), which combines with cyanide to form nontoxic cyanocobalamin (vitamin B_{12}). Hydroxocobalamin is easier and safer to use in the prehospital setting than the previous "Lilly" or "Pasadena" cyanide antidote kits. This is an area of burn management that is continuing to evolve as more research is conducted.

thermal injury: injury to the tissues caused by heat from flame, hot liquids, hot gases, or hot solids.

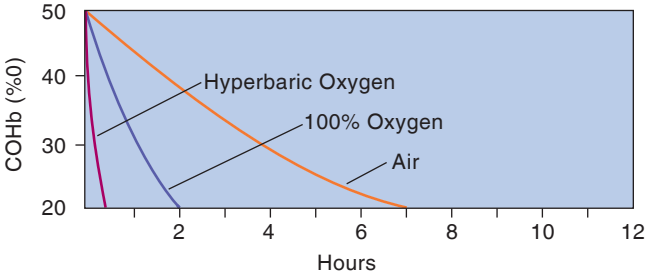


Figure 17-8 Decay curve for disappearance of carboxyhemoglobin from 50% lethal level to 20% acceptable level in air, 1 atm. O_2 (100% oxygen) and 2.5 atm. O_2 (hyperbaric oxygen—100% at 2.5 atmospheres).

Heat-Inhalation Injuries Heat-inhalation injuries are confined to the upper airway because breathing in flame and hot gases does not result in heat transport down to the lung tissue itself. The water vapor in the air in the tracheal–bronchial tree effectively absorbs this heat. Steam inhalation is the exception to this rule because steam is superheated water vapor. A second exception to this rule is if the patient has inhaled a flammable gas that then ignites and causes **thermal injury** to the level of the alveoli (e.g., a painter in a closed space where the paint fumes are ignited by a spark).

As a result of the heat injury, tissue swelling occurs just as it does with surface burns. The vocal cords themselves do not swell because they are dense fibrous bands of connective tissue. However, the loose mucosa in the supraglottic area (the hypopharynx) is where the swelling occurs, and it can easily progress to complete airway obstruction and death (Figure 17-9).

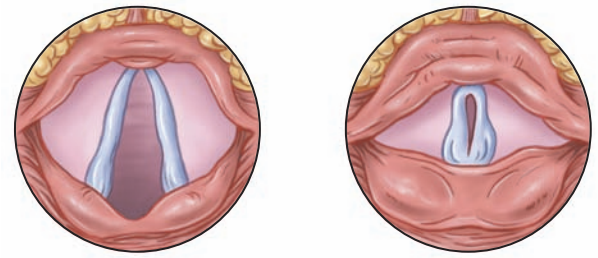
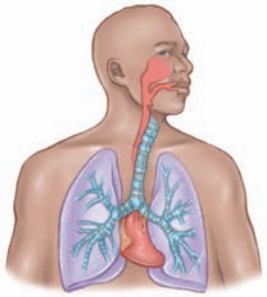


Figure 17-9 Heat inhalation can cause complete airway obstruction by swelling of the hypopharynx: left side—normal anatomy; right side—swelling proximal to cords.



- Burns of the face
- Singed eyebrows or nasal hair
- Burns in the mouth
- Carbonaceous (sooty) sputum
- History of being confined in a closed space while being burned
- Exposure to steam

Figure 17-10 Danger signs of upper airway burns.

There is usually some time between the injury and the development of airway edema, so loss of airway due to direct thermal injury is rare in the initial prehospital phase. However, be aware that once the swelling begins, the airway can obstruct rapidly. Development of a hoarse voice or stridor is an indication for immediate protection of the airway by endotracheal intubation. If possible, the oxygen being administered should be humidified. Aggressive fluid resuscitation can hasten swelling of the airway. Some systems will use aerosolized epinephrine when upper-airway edema develops in an effort to delay swelling while preparing for a definitive airway.

During secondary transport to a burn center, the risk of airway swelling can become significant and can cause airway obstruction as volume-resuscitation IV fluids are being administered. For this reason, patients with airway burns should be sedated and intubated before a transfer. It is much easier to electively intubate a patient in the emergency department than do a crash intubation in the back of an ambulance.

Figure 17-10 lists signs that should alert you to the danger of your patient having upper-airway burns. Swollen lips (indicating the presence of thermal injury at the airway entrance) and hoarseness (indicating altered air flow through the larynx area) are warning signs of early airway swelling. Stridor (high-pitched inspiratory breathing and/or a seal-bark cough) indicates severe airway swelling with pending airway obstruction and represents an immediate emergency. The only appropriate treatment is airway stabilization, preferably oral endotracheal intubation. This procedure may be far more difficult than under other routine circumstances because of significant anatomic alterations due to swelling. Video laryngoscopy may help.

In addition, because of irritation of inflamed damaged tissue, lethal laryngospasm may occur when the endotracheal tube first touches the laryngeal area. Therefore, this procedure is best undertaken in a hospital emergency department and should be done in the field only when absolutely necessary. Consider contacting medical direction. You should be prepared to perform a surgical airway in these patients if you are unable to intubate.

PEARLS

Chemical Burns

Chemical injuries, in general, require prolonged and copious irrigation.

Smoke-Inhalation Injuries **Smoke-inhalation injury** (Figure 17-11) is the result of inhaled toxic chemicals that cause structural damage to lung cells. Smoke may contain hundreds of toxic chemicals that damage the delicate alveolar cells. Smoke from plastic and synthetic products is the most damaging. Tissue destruction in the bronchi and alveoli may take hours to days. However, because the toxic products in the smoke are very irritating, they can precipitate bronchospasm or coronary artery spasm in susceptible individuals. Treat bronchospasm with inhaled beta agonists (albuterol) and oxygen.

smoke-inhalation injury: injury to the lungs or other body organs from inhalation of toxic gases found in smoke.



- Patients exposed to smoke in an enclosed place
- Patients who were unconscious while exposed to smoke or fire
- Patients with a cough after being exposed to smoke or fire
- Patients short of breath after being exposed to smoke or fire
- Patients with chest pain after being exposed to smoke or fire

Figure 17-11 Patients in whom you should suspect smoke inhalation. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Chemical Burns

Thousands of different types of chemicals can cause burn injuries. Chemicals may not only injure the skin, but can also be absorbed into the body and cause internal organ failure (especially liver and kidney damage). Volatile forms of chemicals may be inhaled and cause lung tissue damage with subsequent severe life-threatening respiratory failure. The effects of the chemical agents on the other organ systems, such as the lung or liver, may not be immediately apparent after exposure.

chemical injury: injury to the skin or other body organs from exposure to caustic or toxic chemicals.

A **chemical injury** is frequently deceiving in that initial skin changes may be minimal even when the injury is severe. This could lead to secondary contamination of rescuers. Minimal burns on the patient may not be obvious. As a result, you can get the chemicals on your own skin unless appropriate precautions are taken.

Factors that lead to tissue damage include chemical concentration; amount, manner, and duration of skin contact; and the mechanism of action of the chemical agent. The pathological process causing the tissue damage continues until the chemical is either consumed in the damage process, detoxified by the body, or physically removed. Attempts at inactivation with specific neutralizing chemicals are dangerous because the process of neutralization may generate other chemical reactions (heat) that may worsen the injury. Therefore, you should focus your treatment on chemical removal by following these four steps.

Procedure

Removing the Source of Chemical Burns

1. Wear appropriate protective gloves, eyewear, and respiratory protection, if needed. In some situations, you will need to wear a chemical protective suit as well.
2. Remove all the patient's clothing. Place in plastic bags to limit further contact.
3. Flush chemicals off the body by irrigating copiously with any source of available clean water. If dry chemicals are on the skin, they should first be thoroughly brushed off before performing copious irrigation. Remember: *The solution to pollution is dilution!*
4. Remove any retained agent adhering to the skin by any appropriate physical means such as wiping or gentle scraping. Follow this with further irrigation (Figures 17-12 and 17-13).



A



B

Figure 17-12 For a chemical burn, A. brush away dry powders, and then B. flood the area with water.

Procedure *(continued)*



Figure 17-13 Acid burn of the ankle being irrigated. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



A



B

Figure 17-14 A. Chemical burns to the eyes; B. emergency care of chemical burns to the eye; C. nasal cannula for eye irrigation. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

Figure 17-14 (continued)



C

Ideally, all contaminated patients should be decontaminated prior to transport to limit skin damage and prevent contamination of the ambulance or hospital. Remember, removing the patient from the dangerous environment or removing the dangerous environment from the patient is your first priority for patient care. Critical interventions including airway management can be initiated prior to and during the decontamination process. If the patient has not been fully decontaminated prior to transport, notify the receiving hospital as soon as possible, so that they can be prepared to manage the patient.

Irrigation of caustic chemicals in the eye is especially important because irreversible damage will occur in a very short period of time (less than the transport time to the hospital). Irrigation of injured eyes may be difficult because of the pain associated with eye opening. However, you must begin irrigation to prevent severe and permanent damage to the corneas (Figure 17-14). Check for contact lenses or foreign bodies and, if present, remove them early during irrigation. A nasal cannula hooked to an IV bag of normal saline and placed over the bridge of the nose makes an excellent bilateral eyewash system during transport. Tap water can be used to irrigate the eyes if saline is not available.

PEARLS

Electrical Burns

Immediately check the cardiac status of victims of electrical injury.

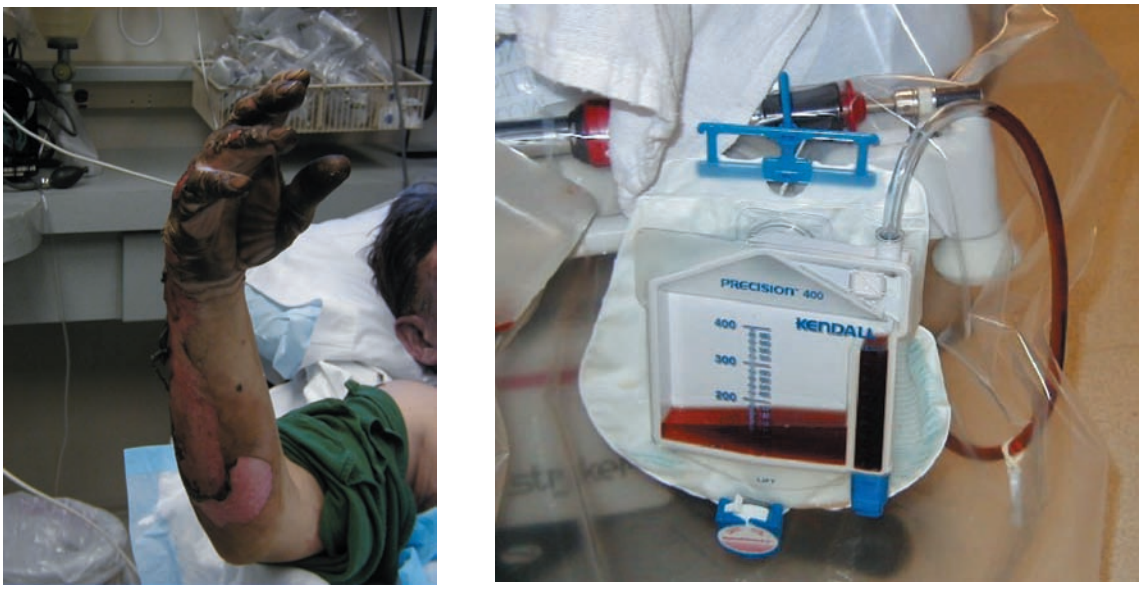
Electrical Burns

In cases of electrical burns, damage is caused by electricity entering the body and traveling through the tissues. Injury results from the effects of the electricity on the function of the body organs and from the heat generated by the passage of the current. Extremities are at risk for more significant tissue damage, versus the torso, because their small size results in higher local current density (Figure 17-15). The factors that determine severity of **electrical injury** include the following:

- Type and amount of current (alternating versus direct current and also the voltage)
- Path of the current through the body
- Duration of contact with the current source

electrical injury: injury from the passage of electrical current through the body; can be from heat generated in tissue from electrical current passing through the body, cardiac dysrhythmias from current passing through the heart, and thermal burns from ignition of clothing.

The most serious and immediate injury that results from electrical contact is cardiac arrhythmia. Any patient who receives an electric current injury, regardless of how stable he or she looks, should have a careful immediate evaluation of his or her cardiac status and continuous monitoring of cardiac activity. The most commonly seen



A B

Figure 17-15 A. Electrical burn to arm. Note entrance at the hand. B. Dark-colored urine as a result of rhabdomyolysis from high-voltage electrical injury. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

life-threatening arrhythmias are premature ventricular contractions, ventricular tachycardia, and ventricular fibrillation.

Aggressive cardiac life support in accordance with AHA/ILCOR guidelines for the management of arrhythmias should be undertaken because these patients are often younger and have normal, healthy hearts. Most of the victims do not have preexisting cardiovascular disease, and their heart muscle tissue is usually not damaged as a result of the electricity. With good CPR, the chances for successful resuscitation are excellent. Even under circumstances of prolonged CPR, resuscitation is often possible. Once those efforts at managing cardiac status are complete, provide field care as previously described for thermal burns.

Electrical injuries cause skin burns at the entrance and exit sites because of high temperatures generated by the electric arc (4,500°F [2,500°C]) at the skin surface. Additional surface-flame burns may result if the patient's clothing is ignited. Fractures and dislocations may be present due to the violent muscle contractions that electrical injuries cause. Often patients are involved in construction and may sustain fractures or other injuries due to falls after an electric shock. Internal injuries usually involve muscle damage, nerve damage, and possible intravascular blood coagulation due to electrical current passage. Internal chest or abdominal organ damage due to electrical current is exceedingly rare.

At the scene of an electrical injury, your first priority is scene safety. Determine if the patient is still in contact with the electrical current. If so, you must remove the patient from contact without becoming a victim yourself (Figure 17-16). Handling high-voltage electrical wires is extremely hazardous. Special training and special equipment are needed to deal with downed wires. Never attempt to move wires with makeshift equipment. Tree limbs, pieces of wood, and even



Figure 17-16 Removal of high-voltage electrical wires. Do not try to remove wires with safety equipment (or sticks) unless specially trained. Turn off the electricity at the source or call the power company to remove the wires. *(Photo © Mark C. Ide)*

manila rope may conduct high-voltage electricity. Even firefighter gloves and boots do not offer adequate protection in this situation. If possible, leave the handling of downed wires to power company personnel or develop a special training program with your local power company to learn how to use the special equipment designed to handle high-voltage lines. If power company personnel are turning off the electricity, be sure they test it to confirm the current is off before you approach the patient.

In the field setting, it is impossible to determine the extent of the damage in electrical burns because much of the burn injury is deep within the muscle. Therefore, all patients with electrical burns should be transported for hospital evaluation. Due to the potential for arrhythmia development, routine IV access should be initiated in the ambulance, along with continuous cardiac monitoring. IV fluid resuscitation should be started during transport in this situation. Because of extensive tissue destruction, the fluid needs during interfacility transport of an electrical burn patient are often higher than for patients with thermal burns. The rule of nines may underestimate fluid needs.

rhabdomyolysis: disintegration (lysis) or dissolution of muscle. This releases large amounts of myoglobin into the blood, which can precipitate in the kidneys, causing renal failure.

Patients with electrical burns are at risk for developing **rhabdomyolysis**, which is the breakdown of muscle with the release of myoglobin into the circulation and renal failure, as the myoglobin crystals block the kidney tubules. In those cases, the rule of nines is not applicable, and formulae such as the Parkland formula do not adequately estimate the fluid needs of these patients. Resuscitation is guided by the response to fluid therapy with the target being to maintain a urine output of 0.5–1 cc/kg body weight per hour. This level of urine flow also helps to reduce the risk of renal failure from rhabdomyolysis. Also with breakdown of muscle cells, potassium is released into the circulation and can lead to hyperkalemia, which can result in cardiac arrhythmias and death. Tall peaked T-waves on the ECG may be a sign of hyperkalemia. Intravenous calcium (gluconate or chloride) along with intravenous sodium bicarbonate, 50% dextrose, and insulin can temporarily reduce the effects of hyperkalemia on the heart.

Lightning Injuries

lightning injury: injury by the multiple effects of very short duration and very high-voltage direct current on the body. The most serious effect is cardiac and respiratory arrest.

Lightning is a significant cause of weather-related deaths in North America each year. A **lightning injury** is very different from other electrical injuries in that lightning produces extremely high voltages (>10,000,000 volts) and currents (>2,000 amps), but has a very short duration (<100 msec) of contact.

Lightning produces a flashover phenomenon, in which the current flows around the outside of the victim's body. Consequently, the internal damage from current flow seen with generated electricity is not seen in a lightning strike. Most of the effects from a lightning strike are the result of the massive direct current (DC) shock that is received. Classic lightning-strike burns produce a fernlike or splatter pattern across the skin (Figure 17-17).

The victim does not need to be struck directly to sustain an injury. Lightning can strike an adjacent object or the nearby ground and still produce an injury to a victim. Often, prior to the injury, the victim's skin is wet, from either sweat or rain. This water, when heated by the lightning current, is quickly vaporized to steam, producing superficial and partial-thickness burns, and may literally explode the clothing off the victim. Because these burns are superficial, aggressive fluid resuscitation is not required.

The most serious effect of a lightning strike is cardiorespiratory arrest, with the massive current acting like a defibrillator to briefly stop the heart. Cardiac activity often spontaneously resumes within minutes. However, the respiratory drive centers of the brain are depressed by the current discharge and take longer to recover and resume the normal respiratory drive. Consequently, the patient remains in respiratory arrest, which is followed by a second cardiac arrest from hypoxia.

The essential component of the management of the lightning-strike patient is restoration of cardiorespiratory function, while protecting the cervical spine. Follow standard guidelines for CPR and advanced cardiac life support (ACLS). Because lightning



Figure 17-17 Flashover pattern of burns on the skin of a victim of a lightning strike. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

strikes can occur at sporting events and other outdoor gatherings, strikes often become multiple-casualty events. It must be stressed that in a multiple-casualty lightning strike, the conventional triage approach of a pulseless or nonbreathing patient equaling a dead patient should not be followed. If a patient is awake or breathing after a lightning strike, they will most likely survive without further intervention. Resuscitative efforts should concentrate on those patients who are in respiratory or cardiac arrest because prompt CPR and ACLS increase the chance that they will survive.

Long-term problems have been seen in lightning-strike patients, such as the development of cataracts or neurologic and/or psychologic difficulties. Perforation of the eardrum is quite common and, rarely, long bone or scapular fractures may be seen in the victims of generated high-voltage electrical injuries. These fractures are managed as described in Chapter 15.

Radiation Burns

Ionizing radiation damages cells by breaking molecular bonds. Skin burns from radiation look exactly like thermal burns and cannot be differentiated by their appearance alone. However, radiation burns develop slowly over days and so generally do not present as an emergency. Because of the damage to the skin cells, **radiation injury** heals very slowly. The burns can cause fluid loss just as thermal burns do and are even more prone to infection.

radiation injury: injury to the skin and tissues from the effect of ionizing radiation. The injury is caused by the radiation breaking molecular bonds within the cell and cannot be differentiated from thermal burns by appearance alone.

Patients with radiation burns are not radioactive unless they are contaminated with radioactive material. If there is any danger that they might be contaminated, you should call for the hazardous materials team to scan them for radiation and perform decontamination, if needed. Noncontaminated radiation-burn patients are initially treated the same as any burn patient. Decontamination of patients contaminated by radioactive material is beyond the scope of this course. More information on radiation injury is available from the Radiation Emergency Assistance Training Site (REACTS) at *https://orise.orau.gov/reacts/*.

Circumferential Burns

As mentioned earlier in patient management, circumferential full-thickness burns can lead to neurovascular compromise. Although that is rarely a problem on the fire scene, it may become significant during an interfacility transfer. Full-thickness burns that are circumferential on an extremity can act as a tourniquet as edema progresses. Early on, the patient may complain of loss of sensation and tingling and eventually develop ischemic pain with loss of pulses. Circumferential full-thickness burns on the extremities will require an escharotomy by the physician, especially if long transport times are involved. Circumferential burns of the chest can interfere with chest expansion and thus compromise respirations. Again, escharotomy in this setting can improve ventilatory status.

Be sure to alert the receiving facility if you are transporting a patient with full-thickness circumferential burns.

Secondary Transport

PEARLS

Secondary Transport

- Plan all secondary transports to burn centers and effectively continue resuscitation during such transports.
- Do not begin a secondary transport of a patient with a possible airway burn without the patient being intubated before transport.

Major burns often do not occur in locations where immediate transport to a burn center is possible. As a result, transport from a primary hospital to a burn center is commonly necessary. After the initial stabilization, prompt transfer to a burn center can improve patient outcome. During this transport, it is important for the emergency care providers to continue resuscitation initiated at the referring facility.

Prior to secondary transport, the transferring physician should have completed the following:

- Stabilization of respiratory and hemodynamic function, which may include intubation and IV access for fluid administration
- Assessment and management of associated injuries
- Review of appropriate lab data (specifically, blood gas analysis)
- Insertion of nasogastric tube in patients having burns covering more than 20% of the body surface area
- Placement of a Foley (urinary) catheter to allow measurement of urine output, which can assist in determining the adequacy of ongoing fluid resuscitation
- Assessment of peripheral circulation and appropriate wound management including escharotomy, if indicated
- Burn patients will need appropriate and adequate IV or IM analgesics during transport.
- Proper arrangements with the receiving hospital and physician

Specifically discuss the transport with either the referring or the receiving physician to determine what special functions may need monitoring and to determine the appropriate range for fluid administration because burns often require extremely large hourly IV rates for appropriate cardiovascular support. Initial resuscitative fluid needs in a burn patient are calculated using the **Parkland formula**:

Parkland formula: a formula to calculate initial fluid resuscitation of the burn patient. The formula is: fluid needs for first 24 hours = 4 cc of Ringer's lactate or normal saline × % of burn area × body weight in kilograms.

$$4\text{ cc} \times \%\text{ Burn area} \times \text{Body weight (kg)} = \text{Amount of Ringer's lactate (LR) needed in the first 24 hours}$$

Half of this fluid is given in the first 8 hours and the remainder over the next 16 hours. If large amounts of fluids are to be given, Ringer's lactate is preferred. Normal saline in large amounts can cause hyperchloremic acidosis and should be avoided.

The Advanced Burn Life Support Course recommends 2–4 mL/kg of LR and that additional fluid administration be adjusted to maintain a mean arterial pressure (MAP) of 60 mmHg and a urine output of 0.5–1.0 mL/kg/hr (Billington and Arnoldo 2016).

The U.S. military has been using the "Rule of 10s" to guide initial fluid resuscitation in the field:

1. Estimate burn size to the nearest 10%.
2. Multiply % TBSA × 10 = Initial fluid rate in mL/hr (for adult patients weighing 40–80 kg).
3. For every 10 kg above 80 kg, increase the rate by 100 mL/hr.

This formula provides less total volume than the Parkland formula and should be guided by the patient's clinical response.

It is important for you to maintain careful records indicating patient condition and treatment during transport. You should also make an in-depth report to the receiving facility.

Minor Burns

There may be times when an emergency care provider is asked to care for minor burns, such as when providing medical support at a major fire to first responders. Burn wounds should be cooled with tepid water, not ice. After drying the area, assess for burn depth. Full-thickness burns should be evaluated by a physician, preferably a burn specialist. Partial-thickness burns without blisters can be covered with a sterile dressing. Topical burn agents such as silver sulfadiazine or bacitracin may be applied.

If the patient is going to be seen soon at a medical facility, then do not apply the topical agent because emergency department personnel will remove it upon arrival. Do not use silver-containing antibiotic creams on exposed places, such as the face, because they can be photoreactive and darken the skin. Partial-thickness burns with blisters can be debrided, based on local protocol and scope of practice of the emergency care provider. Because they are likely to rupture on their own, large, flimsy blisters (>2 in. or>6 cm) can be debrided. Smaller blisters that affect joint movement can also be debrided. Apply dressings along with a topical burn agent or one of the newer membrane dressings.

All of these patients should be seen by a burn specialist or surgeon in follow-up. Do not forget that burns are painful and the patient will need appropriate analgesics.

Pediatric Burns

Children represent nearly one-half of all patients who seek treatment for burns. Because of their thinner skin, they are at greater risk for severe injury following a burn. Postburn problems, such as hypothermia, are more likely to occur in children because of their larger surface area to body mass ratio. Because of differences in anatomy, the rule of nines must be modified because in small children the head represents a larger portion of the body surface. The Lund and Browder chart is better for estimating burn size in children (Table 17-3). The patient's palmar surface (1%) rule applies to children as well as adults.

Sadly, burns in children may be the result of intentional injury and, in fact, 10–16% of all nonaccidental trauma cases involve burns (Hobbs 1989). You should be alert for signs of abuse. They include burns that match shapes of objects such as curling irons, household irons, or cigarette burns. Also suspicious for abuse are multiple stories of how



Figure 17-18 Scald burns on a child. This is a typical pattern of burns due to nonaccidental trauma. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*

the injury occurred or stories of the burn being caused by activities by the child that are inconsistent with the child's development. Burns to the genitalia, perineum, or in a stocking or glove distribution should raise suspicion (Figure 17-18). If there is a suspicion of abuse, this must be reported to child protective services or law enforcement. Follow your local laws and protocols.

Fire and EMS personnel can help reduce burns in children through community education. Programs to teach parents about limiting the temperature on household water heaters to 120°F (49°C) and programs to teach children about fire safety can make a significant impact on the incidence of pediatric burns in your community. You should be aware that older adults may also be victims of abuse by burns. (See Chapter 18.)

Case Presentation *(continued)*

On arrival the fire officer informs you the fire is out, and all hazards are controlled. When you ask what happened, you are told the patient sustained burns to his face, chest, and right arm after throwing a cup of petrol onto the fire to get it to burn faster.

You direct your partner to check on the patient. Your initial assessment reveals the patient has a normal speaking voice and respiration and a strong radial pulse that is slightly fast. Some wheezes are heard. A focused exam reveals singed head hair, eyebrows, and nasal hairs. The right forearm shows blisters along with charred skin, with burns that appear to be circumferential. There is redness in his nose, mouth, and pharynx.

Your patient walks to the ambulance and is placed on the cot. At this time it is noted that his voice is becoming hoarse and he is complaining of feeling difficulty in breathing and pain to the burn areas. An ITLS Ongoing Exam reveals bilateral wheezes, but the pulse oximeter reading is 90% without oxygen and 95% on 15 liters of oxygen by nonrebreather mask. The presence of airway signs should lead you to consider presence of upper-airway burns and possibly loss of the airway.

Normally, flash burns outdoors do not pose risk of inhalation injury, but given that his clothes ignited, he has sustained more than a flash burn. The patient has an active gag reflex and will not tolerate intubation, so you do not attempt to intubate at this time. You do notify the burn center of the potential airway problem and, just in case, remind yourself where the needle cricothyrotomy equipment is located. Your patient is given an albuterol nebulizer treatment and taken to the nearest burn center due to both airway involvement and circumferential arm burns.

The patient is admitted to the burn ICU, where he develops acute respiratory distress syndrome (ARDS) and has a protracted course. However, because of his youth and general good health, he survives. His upper-airway burns resulted from inhalation of the vapor, and the ARDS resulted from probable aspiration.

Summary

The mechanisms of burn injuries are potentially deadly for both you and your patient. Remember scene safety! All burns are serious and should be evaluated at the hospital. Do not forget the basics: Half of all burn deaths are from inhalation injuries. Aggressive airway management may be needed. Stop the burning process by quickly irrigating the burn with room-temperature water. A clean sheet is all you need to put out the burn, other than a blanket to cover the patient to prevent hypothermia. Instead of being a load-and-go situation, patients with chemical burns must be decontaminated immediately or the burn damage will continue to progress during transport. Electrical burns and lightning injuries are commonly associated with cardiac arrest, but rapid evaluation and management are usually lifesaving. High-voltage electricity is extremely dangerous, so have trained personnel turn off the current before approaching the patient. Do not begin secondary transfer of a burn patient until the patient has been properly stabilized and the airway protected. As research continues, burn management will undergo changes. Providers should continue to educate themselves so that they can provide their patients with the best possible care.

References and Resources

Billington, M., and B. D. Arnoldo. 2016. "Modern-Day Burn Resuscitation: Moving Beyond the Parkland Formula." Accessed January 18, 2019. http://www.emdocs.net/modern-day-burn-resuscitation-moving-beyond-parkland-formula/

Borron, S. W., F. J. Baud, P. Barriot, M. Imbert, and C. Bismuth. 2007. "Prospective Study of Hydroxocobalamin for Acute Cyanide Poisoning in Smoke Inhalation." *Annals of Emergency Medicine* 49, no. 6 (June): 794–801.

Chung, K. K., J. Salinas, E. M. Renz, R. A. Alvarado, B. T. King, D. J. Barillo, L. C. Cancio, S. E. Wolf, and L. H. Blackbourne. 2010. "Simple Derivation of the Initial Fluid Rate for the Resuscitation of Severely Burned Adult Combat Casualties: In Silico Validation of the Rule of 10." *Journal of Trauma* 69 (Suppl. 1) (July): S49–54. doi:10.1097/TA.0b013e3181e425f1.

Committee on Trauma, American College of Surgeons. 2006. *Guidelines for the Operations of Burn Units: Resources for Optimal Care of the Injured Patient*. Chicago: American College of Surgeons.

Committee on Trauma, American College of Surgeons. 2017. "Injuries Due to Burns and Cold." In *Advanced Trauma Life Support*, 10th ed., 230–44. Chicago: American College of Surgeons.

Danks, R. R. 2003. "Burn Management: A Comprehensive Review of the Epidemiology and Treatment of Burn Victims." *Journal of Emergency Medical Services* 28, no. 5 (May): 118–41.

Fortin, J. L., J. P. Giocanti, M. Ruttimann, and J. J. Kowalski. 2006. "Prehospital Administration of Hydroxocobalamin for Smoke Inhalation-Associated Cyanide Poisoning: Eight Years of Experience in the Paris Fire Brigade." *Clinical Toxicology* 44 (Suppl. 1): 37–44.

Gausche-Hill, M., K. M. Brown, Z. J. Oliver, C. Sasson, P.S. Dayan, N. M. Eschmann, T. S. Weik, B. J. Lawner, R. Sahni, Y. Falck-Ytter, et al. 2014. "An Evidence-Based Guideline for Prehospital Analgesia in Trauma." *Prehospital Emergency Care* 18 (Suppl. 1): 25–34.

Hettiaratchy, S., and R. Papini. 2004. "Initial Management of a Major Burn: Overview." *British Medical Journal* 328, no. 7455: 1555–7.

Hobbs, C. J. 1989. "ABCs of Child Abuse: Burns and Scalds." *British Medical Journal* 298, no. 13: 1305.

Jenkins, J. A. 2014. "Emergent Management of Thermal Burns." Accessed March 2, 2015. http://emedicine.medscape.com/article/769193-overview

Leybell, I. 2014. "Cyanide Toxicity." Accessed January 1, 2015. http://emedicine.medscape.com/article/814287-overview

Lloyd, E. C., B. C. Rodgers, M. Michener, and M. S. Williams. 2012. "Outpatient Burns: Prevention and Care." *American Family Physician* 85, no. 1 (January): 25–32.

Lund, C. C., and N. C. Browder. 1944. "The Estimation of Areas of Burns." *Surgery, Gynaecology, Obstetrics* 79: 352–8.

Miller, K., and A. Chang. 2003. "Acute Inhalation Injury." *Emergency Medicine Clinics of North America* 21, no. 2 (May): 533–7.

Miller, S., and C. Menckhoff. "Optimizing Outcome in the Adult and Pediatric Burn Patient." *Trauma Reports* 10, no. 2 (March): 1.

Nagel, T. R., and J. E. Schunk. 1997. "Using the Hand to Estimate the Surface Area of a Burn in Children." *Pediatric Emergency Care* 13, no. 4 (August): 254–5.

Office of Juvenile Justice and Delinquency Prevention, Office of Justice Programs, U.S. Department of Justice. 1997. "Burn Injuries in Child Abuse." Accessed May 4, 2009. https://www.ncjrs.gov/pdffiles/91190-6.pdf

18



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Pediatric Trauma

Patrick Maloney, MD, FACEP
Ashley Larrimore, MD (Diplomate ABEM in EM and EMS)
Ann M. Dietrich, MD, FAAP, FACEP

Traumata bei Kindern
Trauma Pediátrico
Ozljede u dječjoj dobi
Trauma Pediatrik
Травмы у детей
Traumatismes en pédiatrie
Παιδιατρικό Τραύμα
Gyermekkori trauma
小児の外傷
兒童創傷
Poškodbe otrok

Key Terms

child restraint seat, *p. 371*
consent, *p. 354*
fluid resuscitation, *p. 368*
length-based tape, *p. 355*
nonaccidental trauma (NAT), *p. 358*
SCIWORA, *p. 371*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe effective techniques for gaining the confidence of children and their parents.
2. Predict the most likely pediatric injuries based on common mechanisms of injury.
3. Describe and clinically apply the ITLS Primary and Secondary Surveys in the pediatric patient.
4. Demonstrate understanding of the need for immediate medical intervention and transport in potentially life-threatening circumstances, regardless of the availability of immediate parental consent.
5. Differentiate the equipment needs of pediatric patients from those of adults.
6. Describe the various ways to perform spinal motion restriction on a child and how this differs from an adult.

Objectives (continued)

7. Discuss the need for involvement of EMS personnel in injury prevention programs for parents and children.

Note: Because of increasing demand for further training in management of the injured child, ITLS has developed a one-day course (Pediatric ITLS) that covers this subject in greater detail. You may get more information about this course by calling ITLS International at 888-495-4875 (outside the United States, call 630-495-6442).

Chapter Overview

Providing appropriate and efficient prehospital care for pediatric patients is challenging. The goal of all prehospital care is to minimize further injury, ensure patient safety, and manage life-threatening conditions. When applying these principles to the pediatric population, you must remember that children are not just little adults. They differ from adults in a number of ways:

1. Unique patterns of injuries
2. Different physical and psychosocial responses to those injuries
3. Require special equipment for assessment and treatment
4. Often more challenging to assess and with whom to communicate
5. Often treating both the child and the accompanying parent and must address their concerns and fears

Doctors as well as emergency care providers are frequently less confident treating children because of these differences as well as the fact that children sustain severe injuries less frequently than adults. As a result, many providers do not develop as much expertise as they would like. Those with children of their own may be further hampered by the intense emotions felt when treating a child with a serious injury.

For these reasons you should study this chapter carefully. It offers a review of the ITLS Primary Survey, stresses the differences between children and adults, and describes how to manage critical injuries. In addition, the U.S. Emergency Medical Services for Children (EMSC) program promotes pediatric prehospital care and may assist both individual prehospital providers as well as medical directors.



(Photo courtesy of Herjua/Shutterstock)

Case Presentation

Your ambulance has responded to the scene of a motor vehicle collision in which a car has struck a tree. Fire service has controlled the hazards on scene. Your attention is directed to the 10-month-old infant still secured in a car seat that was found on the floor between the rear and front seats of the car. The driver (grandfather) states the child has been awake but periodically crying since the collision. You perform an initial assessment of the little girl and find her to be alert, with normal skin color and unlabored respirations.

Case Presentation *(continued)*

Before proceeding, consider these questions:

- Pending arrival of the mother, what steps should you take to reassess and treat the child?
- How should the infant be readied for transport?
- Given the mechanism of injury, should she be removed from her car seat?
- What form, if any, of spinal motion restriction should be considered, and will her age affect this decision?
- How does the evaluation of an infant differ from that of an adult?
- Would awaiting the arrival of the mother facilitate such an evaluation?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient's care.

Communication with the Child and Family

Children are typically part of a family unit or have caregivers whom they are dependent upon. Therefore, family-centered care of an injured child is ideal. (Remember that the caregiver of a child is not always a biological parent, but for simplicity the generic term "parent" is used in this chapter when referring to the guardian/caregiver of a child.) After an injury to their child, parents should be encouraged to provide physical and emotional support. Parents who receive careful instructions and guidance may be helpful to the emergency provider. Explain to them what you are doing and why you are doing it, and then use their trust relationship with the child to enhance your history gathering, physical examination, and care of the patient. Inclusion and respect of the family will improve the performance of all aspects of the stabilization of an injured child.

The best way to gain parental confidence is to demonstrate your competence and compassion in managing their child. Parents are more likely to be cooperative if they see that you are confident, organized, and using equipment that is designed for children. Show the parents you understand their importance by involving them in the support of their child. Whenever possible, keep parents in physical and verbal contact with the child. They can perform simple tasks such as holding the child's hand and providing verbal reassurance. Parents can explain to the child what is happening or sing their favorite songs.

Occasionally, the emotional stress of an ill or injured child may be overwhelming for a parent. When that happens, parents may become visibly anxious, agitated, or even quiet, withdrawn, and "frozen." As the emergency care provider, it is important to recognize the emotional response of the parent. Remember, most children will look to their parents for clues on how to act. If their parent is calm and cooperative, the child will more likely also be composed, but if a parent is panicking and unable to remain calm, the child will more likely also be anxious and uncooperative. In situations where the parent is unable to follow your instructions and remain calm, it is sometimes best to ask the parent to step back. Ask the family which caregiver is the best source of support for the child, explicitly outlining what would be the ideal support person: calm, supportive, and able to provide support to the child. It is important to use your best judgment of what is best for the child in these difficult situations. Make sure that the parents receive appropriate care if they were also injured or if they need help coping with the situation.

When evaluating an injured child, emergency care providers must remember that children of different ages have different cognitive skills and interact with the world in different ways. By making a child-friendly environment and using child-friendly

language and gestures, your patient will feel more comfortable and will be more cooperative with your evaluation and treatment.

Remember to speak and act in a way that is understandable and calming to the child and parents. This will not only help console the scared and hurt child, but it also will help you accurately assess the child's condition. A child who can be consoled and interacts normally with a parent likely has a normal mental status. In contrast, a child who cannot be consoled or cannot interact in the usual way may have a head injury, may be in shock, may be hypoxic, or may have severe pain. Because they are familiar with a child's baseline mental status, the parents are your best resource for detecting subtle changes in the child's behavior. They will notice when the child is "not acting right" before you will. This is especially helpful in dealing with children who have "special needs" who may not respond in a manner typical for a child their age. Record and report your observations just as you would report changes in level of consciousness of an adult.

Children younger than 9 months like to hear "cooing" sounds or the jingle and sight of keys. Children younger than 1 year of age know many "ah" sounds, like "mama" and "papa." Try to use them. Older children are very literal in their understanding of language. Therefore, always choose your words carefully and explain exactly what you mean in simple terms. For example, when placing an IV in a child, instead of using the word "flush," which will likely make the child think of a toilet, you may describe the saline as "clear water that makes the medicine and blood move."

Whenever possible, try to give a child and parent reasonable options. This will not only give them a sense of participation and control but also will avoid the trap of asking a 2-year-old for permission. Rather than ask, "May I listen to your heart and lungs?", which will usually be answered with an emphatic "No!" by a toddler, ask the child if he or she would like you to listen to his or her heart or look in his or her mouth first. When there are no options, such as when placing a cervical collar or transporting a child in an ambulance, clearly tell the child what you are doing in a calm tone and with a smile on your face. When possible, show it does not hurt, perhaps by doing it to a parent or yourself. Never lie to a child.

Always try to tell the child and parents what you are going to do before you do it. Most children do not like surprises, especially when they are scared or uncomfortable. For example, say, "We are going to hold your head still. Mom, this is important in case he has hurt his neck." Speak simply, slowly, and clearly. Be gentle and firm.

Distraction is a great tool. Infants and children younger than 1 year of age can often be easily distracted with a simple flashlight. The toddler and young child can benefit from holding a toy or doll. Ask the parent to get one favorite belonging, if easily available, for the ride to the hospital. It will make the trip to and through the hospital easier.

Before you leave the scene, be sure to ask the parent about other children. Sometimes parents are so concerned about one that they forget other small children who may be in a high-risk situation, such as alone in the house. If you are at an accident scene, ask any injured adults, if able to communicate, if there are any other occupants in the car. If they are unable to communicate, look for signs of children in the car and be sure to search the area if unsure, as children do not know to stay in the car and, if frightened, may run and hide, especially in children with autism or other developmental issues.

Parental Consent

consent: the granting of permission to treat a child. It is usually given by the parents or legal guardians but is not required in an emergency situation if neither are present.

Many jurisdictions have **consent** laws that exist to protect children. Although consent to treat is necessary for children who are stable and desirable for all injured children, any child with a critical injury should not have care delayed while attempting to obtain consent. Prehospital care providers must assess the situation quickly and decide whether delaying emergency care to obtain parental consent could possibly harm the child. In a situation in which a child needs emergency care (such as a child in a bicycle/motor-vehicle collision with no parent present), you must treat that

child immediately. When in doubt, always err on the side of treating and transporting any seriously injured child, regardless of the ability to obtain appropriate consent. Remember to document why you are transporting without parental permission, and always notify medical direction of this action. As soon as safe and feasible, you should attempt to notify a parent or other caretaker.

If the parents or legal guardians do not want you to transport or treat a child, and you believe that your care is in the child's best interest, try to persuade the parents. If available, utilize online medical direction for assistance in talking to the parents. Often, if parents are told by a doctor on the phone or radio that their child is potentially very ill or injured, the parents will agree to treatment and transport. If you cannot convince them, document your actions and your conversation with the parents about potential injuries and risks of nontreatment and transport on the written report and ask the parent or guardian to sign a refusal of care form. If the child has a critical injury and the parents refuse transport, notify law enforcement and the appropriate social authorities immediately and try to continue care of the child until they arrive. If you suspect child abuse, notify authorities at the appropriate time. You should not confront the possible abuser but act in the best interests of the child.

PEARLS
Abuse

You are the emergency medical responder at the scene of the injury. Be alert to signs of nonaccidental trauma.

Assessment and Care

Pediatric Equipment

Table 18-1 contains a list of suggested pediatric equipment for the prehospital provider. A more detailed list can be downloaded from the American Academy of Pediatrics website (AAP and NAEMSP 2014). Keep pediatric equipment separate from your adult equipment so you do not have to search for it when needed urgently. It would be ideal to keep equipment in different child sizes in separate compartments. However, lack of storage space and high expense make multiple containers and duplicate equipment impractical.

PEARLS
Equipment

Children require special equipment. Without this equipment, you cannot provide the pediatric patient with adequate care.

Using a **length-based tape** makes it much simpler to determine the appropriate equipment and medication doses for a child.

length-based tape: a method of estimating the appropriate-size equipment and doses of medications for children. The method is based on the fact that a child's weight is proportional to his or her length.

A length-based tape helps you measure the length of a child, estimate the child's weight, appropriately choose equipment of the correct size, and administer precalculated doses of fluid and medications (Figures 18-1 and 18-2, pp. 357–358). The device allows you to focus on the patient instead of trying to remember the correct equipment size and drug dose. The length-based tape estimates weight and equipment size better than medical professionals. Although there is some controversy about the accuracy of length-based medication dosages because of the increased incidence of childhood obesity, length-based resuscitation systems continue to be recommended as safe, rapid, and accurate tools. In addition to length-based tape systems, numerous apps exist for smartphones (e.g., First 5 Minutes, the Handtevy System, and the Pedi-Wheel). Studies comparing the various systems now available show a variance in accuracy of weight estimation for the systems (Lowe et al. 2016; Wells et al. 2017).

Common Mechanisms of Injury

Trauma is the number one cause of death in children age 1–18. Children are most commonly injured from falls (either from standing height or higher), motor-vehicle collisions, automobile–pedestrian or bicycle crashes, burns, submersion injuries (drownings), and child abuse. Blunt trauma is much more common than penetrating injuries in children. Young children who fall from higher than a few feet often land on their heads because the head is disproportionately large and heavy compared to the body of an older child or adult. Fortunately, when children fall from a height of less than 3 feet, they rarely sustain serious head injuries. One exception to this rule is infants younger than 3 months of age, who may be seriously injured from seemingly minor falls.

Table 18-1: Prehospital Pediatric Equipment and Supplies

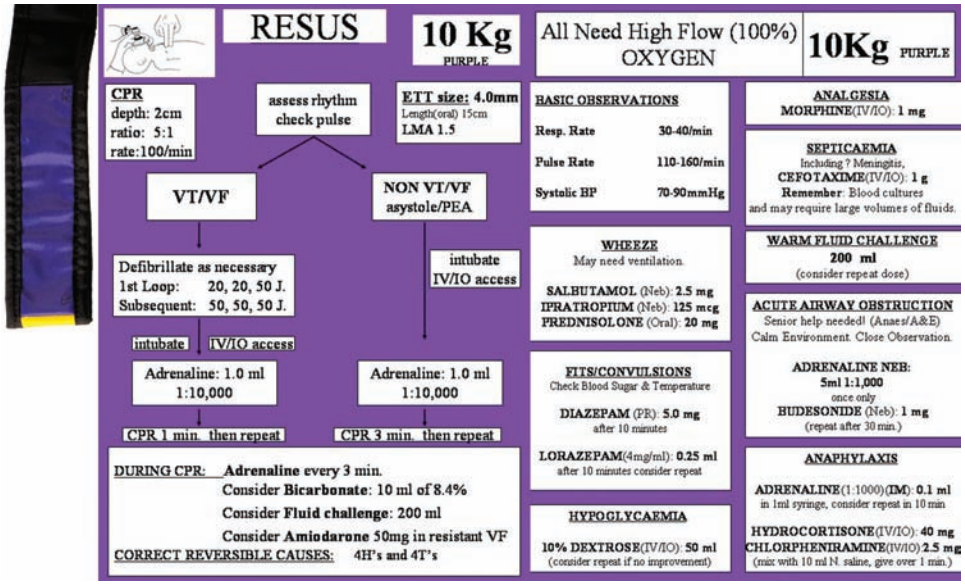
BLS Equipment and Supplies	
Essential	**Desirable**
• Infant car seat • Oropharyngeal airways: infant, child, and adult sizes (sizes 00–5) with tongue blades for insertion • Self-inflating resuscitation bag: child and adult sizes • Masks for bag-valve mask device: neonatal, infant, child, and adult sizes • Oxygen masks: infant, child, and adult sizes • Nonrebreathing mask: pediatric and adult sizes • Stethoscope • Pediatric femur traction splint • Pediatric backboard with head immobilizer • Pediatric cervical collars (rigid) • Blood pressure cuff, infant and child • Portable suction unit with a regulator • Suction catheter: tonsil-tip and 6F–14F • Extremity splints: pediatric size • Bulb syringe • Obstetric pack • Thermal blanket • Water-soluble lubricant	• Nasopharyngeal airways: sizes 18F–34F or 4.5–8.5 mm • Glasgow Coma Score reference • Small stuffed toy • Fingerstick blood glucose device • Pulse oximeter
ALS Equipment and Supplies	
ALS units should carry everything on the BLS list, plus the following items:	
Essential	**Desirable**
• Transport monitor • Transport monitor • Blood glucose analysis system • Defibrillator with adult and pediatric paddles • Monitoring electrodes: pediatric sizes • Endotracheal tubes: uncuffed, sizes 2.5–6 mm; cuffed, sizes 6–8 mm • Endotracheal tube stylets: pediatric and adult sizes • Infant and child laryngoscope: straight blades, sizes 0–3; curved blades, sizes 2–4 • Nasogastric tubes: sizes 8F–16F • KID (immobilization device) • Magill forceps: pediatric and adult • IO needles: sizes 16, 18, 20 • Butterfly cannulae, #23 and #25 gauge • Over-the-needle catheters, #16–24 gauge • Pediatric armboards • Broselow© (or other length-based) tape • Nebulizer	• Disposable CO_2 detection device • End-tidal CO_2 monitors



Figure 18-1 Use of length-based tape.



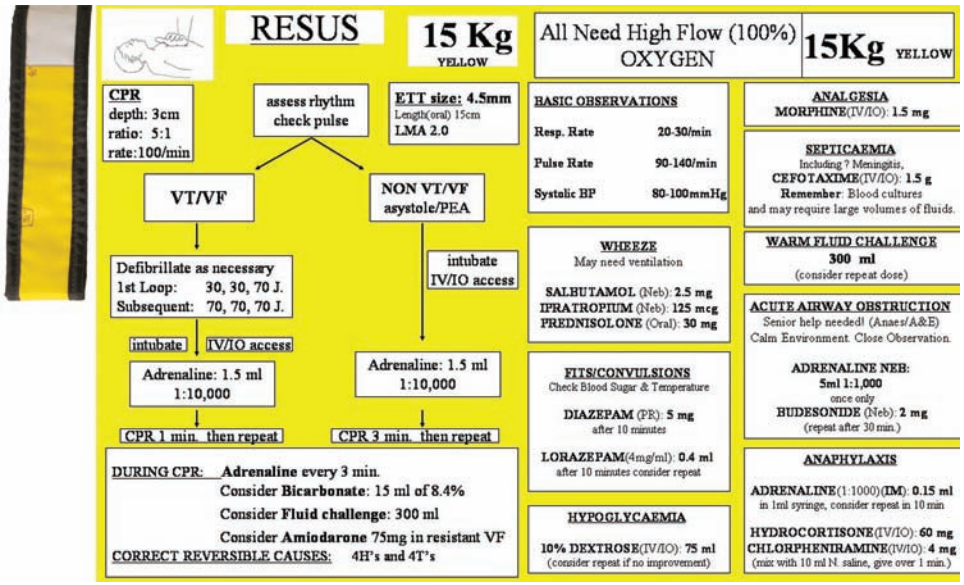
A



B

Figure 18-2 Standard Pediatric Aid to Resuscitation Card system has color-coded tape and a booklet of precalculated doses of fluids, medications, and equipment. *(Photos courtesy of Kyee Han, MD)*

Figure 18-2 (continued)



C

Injuries sustained by children riding bicycles, motorcycles, and dirt bikes, especially if they are not wearing a helmet, are often severe. Motor-vehicle collisions—especially if car seats, booster seats, and lap-belt restraints are improperly used—may result in seat-belt syndrome, which can include life-threatening injuries to the liver, spleen, intestines, and/or lumbar spine.

nonaccidental trauma (NAT): injury that is deliberately inflicted upon an individual; previously referred to as "child abuse." Also called *nonaccidental injury (NAI)*.

Whenever a patient's injury pattern is not consistent with the mechanism, child abuse, also called **nonaccidental trauma (NAT)** or *nonaccidental injury (NAI)*, should be considered. Suspect abuse if the history does not match the injury or if the mechanism of injury is not consistent with the child's developmental status (e.g., a 2-month-old infant cannot walk and therefore cannot break his or her leg running across the floor). Other warning flags for NAT include a delay in seeking care, inconsistent and/or changing details provided by caretaker during assessment, variation of stories between parents or caregivers, or if you have any other concerns. Remember to report any of these findings to the emergency department team and/or appropriate local authorities. Be familiar with the reporting requirements for your agency.

General Assessment

When arriving at the scene of an accident, it is very important to quickly assess the situation and the injured child. After ensuring your own safety, your next step is to develop a general impression of the injured child. As you approach the child, try to decide, based on appearance, work of breathing, and circulation (Pediatric Assessment Triangle, an objective tool developed by the American Academy of Pediatrics see Figure 18-3), whether he or she appears to be severely injured or in distress with an abnormal appearance, increased work of breathing, and altered circulation (sick) or not in any distress with a normal appearance, no increased work of breathing, and normal circulation (not sick).

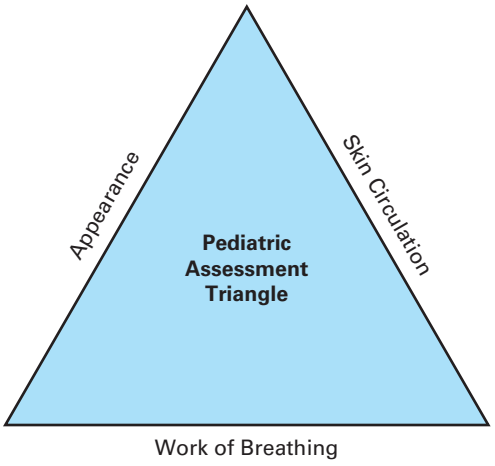


Figure 18-3 Pediatric Assessment Triangle, an objective tool developed by the American Academy of Pediatrics.

Although a preschool child may appear to be sleeping rather than unconscious from an injury, remember that most children will not sleep through the arrival of emergency vehicles. Following a traumatic event, a decreased level of consciousness may suggest hypoxia, shock, head trauma, or seizure.

Assessment of the Airway

As you begin your assessment, stabilize the neck in a neutral position with your hands. Do not take time to apply a cervical collar until you have finished the ITLS Primary Survey (Figure 18-4).

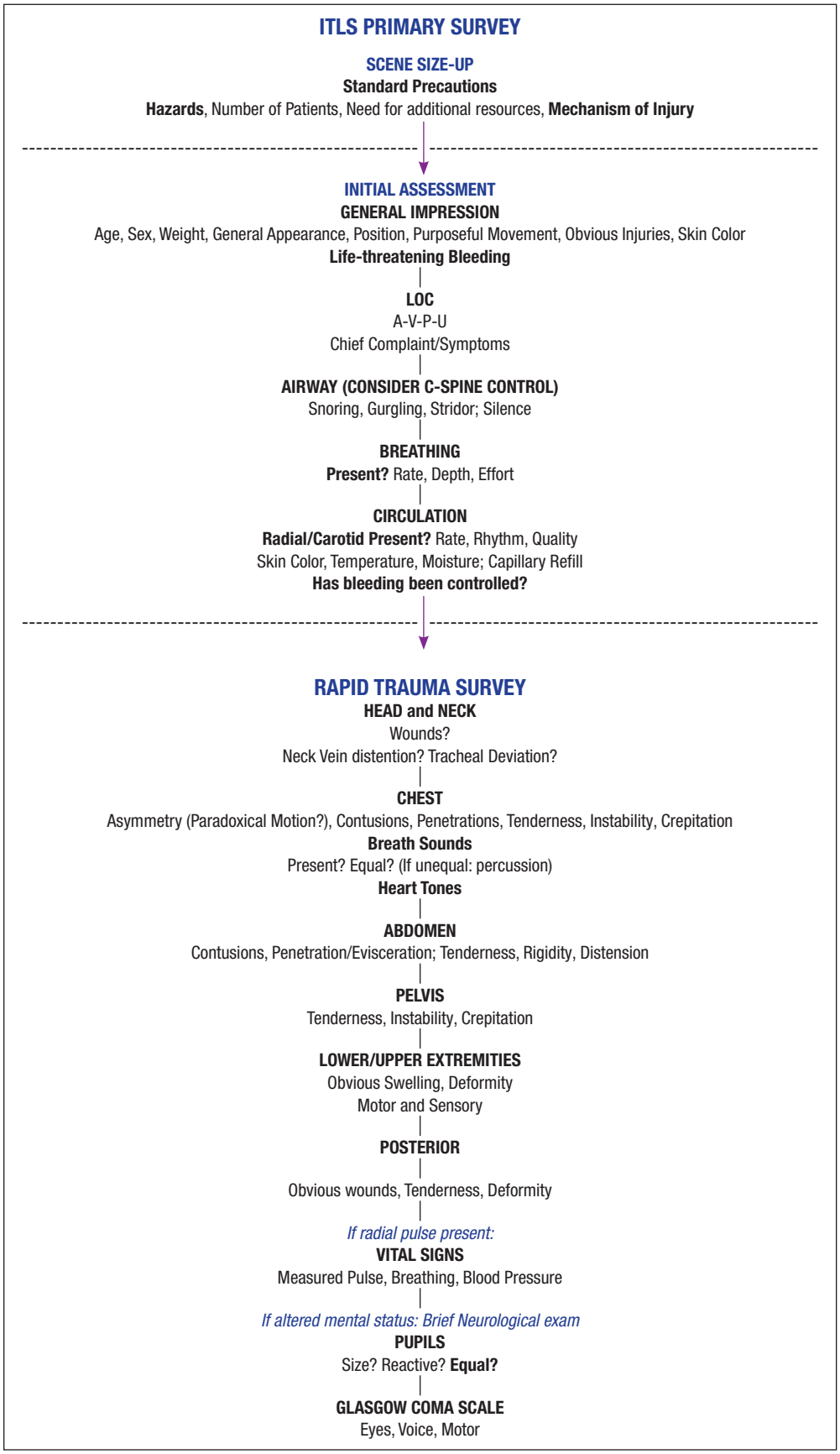


Figure 18-4 Steps in the assessment and management of the trauma patient are the same for both children and adults.



Figure 18-5 Most children require padding under their back and shoulders to keep the C-spine in a neutral position. *(Photo courtesy of Bob Page, MEd, NRP, CCP, NCEE)*

Inspecting the airway is easier in the child than in the adult. It is true that the child's tongue is large, the tissue is soft, and the airway obstructs easily, but other characteristics make it easier to manage the child's airway. For example, neonates are obligatory nose-breathers, so clearing the nose with a bulb syringe can be lifesaving. To use the bulb syringe, first collapse the bulb end of the syringe, and then put the point end in the nose of the child and release the bulb. When you remove the syringe from the nose, squeeze the bulb to empty the mucus, blood, or vomit, and repeat. The bulb syringe can be used to remove secretions from the posterior pharynx of infants as well. For more extensive bleeding and secretions, a powered suction device may be needed.

Look for signs of airway obstruction in the child, including apnea, stridor, and "gurgling" respirations. If identified, perform a jaw-thrust maneuver without moving the neck. That will help lift the relatively large tongue out of the airway. Suctioning oral secretions and any vomit from the posterior pharynx also can help. Inserting an oropharyngeal airway may help keep the obstructed airway patent in an unconscious child. (See Chapter 7.) If a tooth is so loose that you are worried it may fall out and pose an aspiration risk, you may preemptively gently remove it using a piece of gauze and your fingers. Also, remember that in small children, the occiput is rather large compared to the torso. When positioned flat on a spinal immobilization board or stretcher, the occiput will often flex the neck and the floppy upper airway. This can result in compression and occlusion of the airway. To prevent this from happening, place a pad underneath the torso of children younger than 8 years old to keep the neck in a neutral position. (See Figure 18-5 and Chapter 11.) Hyperextension of the neck may also cause airway occlusion.

Assessment of Breathing

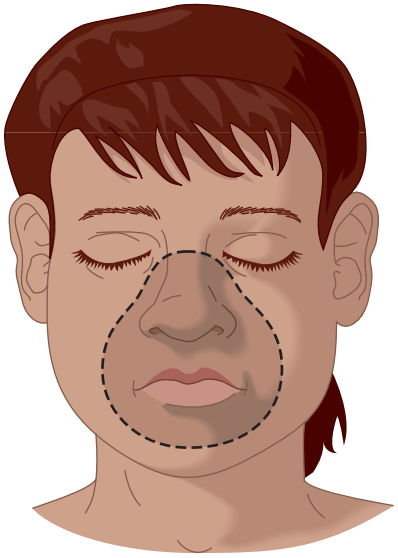
Assess the child for breathing difficulty. Start by counting the child's rate of breathing. Children less than 8 years of age breathe faster than adults normally do. However, children usually breathe even faster when they are having difficulty; and then, when they can no longer compensate, they will have periods of apnea or a very slow respiratory rate. Note whether the child is "working hard" to breathe, demonstrated by subcostal or suprasternal retractions, abdominal accessory muscle use, nasal flaring, or grunting. Look at the chest rise, listen for air going in and out, and feel the air coming out of the nose. If there is no movement, reposition the jaw. Assess for airway obstruction (AHA/ILCOR). If you still do not sense any air exchange, you must breathe for the child. If you have any doubt that the child is breathing adequately on his or her

own, immediately assist the child's breathing. Provide supplemental oxygen to any child with respiratory difficulty, circulatory compromise, or an altered mental status.

Artificial Ventilation

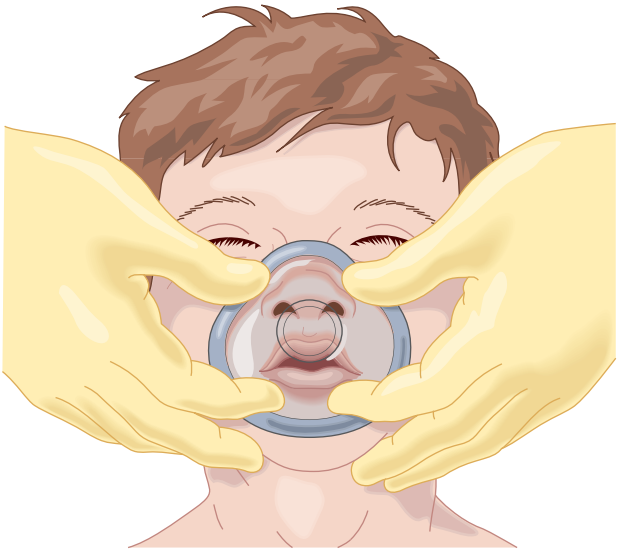
The most common cause of cardiac arrest in children, including trauma patients, is hypoxia and respiratory failure. Therefore, the most important skill you must master is artificial ventilation with a bag-valve mask (BVM) resuscitation device. Remember, if you can mechanically oxygenate and ventilate a child, you may be able to save that child's life.

It is crucial that your BVM device has a good seal around the face. If the face mask does not fit well, try a different-size face mask or try turning the mask upside down. Pay attention to your hand placement as well (Figure 18-6). Large adult hands can easily obstruct the airway or injure a child's eyes. Give each breath slowly over 1 second.



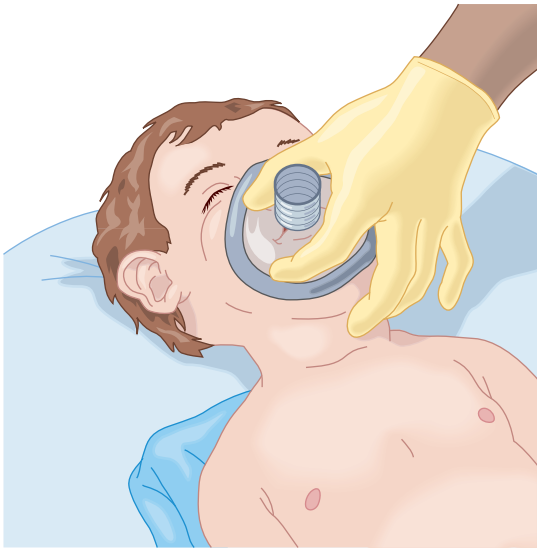
A

Figure 18-6a The mask should fit on the nose and the cleft above the chin.



B

Figure 18-6b Two-handed face mask seal.



C

Figure 18-6c One-handed face mask seal.

Try to use the lowest pressure necessary to see good chest rise with each breath. If the chest is rising, air is getting into the lungs. If you do not see good chest rise, too little air is entering the lungs. Check air entry on both sides of the chest with your stethoscope. If the child is not getting good chest rise with each breath, make sure you have a good mask seal and air entry is not obstructed. If still unsuccessful, you may need to provide more pressure with each rescue breath. Be careful not to provide too much pressure because that can cause a pneumothorax or overinflate the stomach and cause vomiting. Remember that most pediatric resuscitation bags have a pop-off valve. In the prehospital setting, it is usually best to ensure that this valve is turned off.

When providing artificial ventilation, typical rates are 20 per minute for a child younger than 1 year of age, 15 per minute for older than 1 year of age, and 10 per minute for an adolescent. Studies have found that rescuers tend to hyperventilate even when consciously trying not to. Always make sure that your bag is connected to oxygen and that it is flowing (usually 10–15 lpm). Cricoid pressure (Sellick maneuver; see Chapter 4) is not currently recommended in a child because excessive cricoid pressure can easily obstruct a child's airway and the maneuver has not been shown to prevent aspiration.

Endotracheal Intubation If BVM ventilation of the child is effective, then endotracheal intubation (ETI) is an elective procedure. Studies have not shown that prehospital intubation improves the outcome of children. In one study, use of a BVM was associated with higher survival to hospital discharge compared to ETI and supraglottic airway (Hansen et al. 2017).

It is usually better not to intubate the child in the field if you can ventilate successfully with a BVM. Rapid and safe transportation to a trauma center, where definitive care is readily available, is one of the most important prognostic factors for survival in trauma patients. Therefore, any unnecessary time spent at the scene should be avoided.

Intubation is extremely difficult to perform even in an emergency department, so if you must intubate in the field, be prepared. While you set up your equipment, your partner should preoxygenate the child by applying a nonrebreather mask if the child is breathing on his or her own adequately. If the child is not breathing adequately, preoxygenate (not hyperventilate) with five to seven breaths of high-flow oxygen via a BVM at the normal rate for the age of the child; 3 minutes of tidal volume breathing using an O_2 flow of 9 lpm is the most efficient preoxygenation technique to reach $FetO_2 > \text{or} = 90\%$ (Chiron et al. 2007).

Unlike with adult patients, there is no literature to show that high-flow oxygen via nasal cannula prolongs apneic time in pediatric patients. However, a study (Wing et al. 2012) did show high-flow oxygen via pediatric nasal cannula did reduce the need for intubation in acute respiratory insufficiency.

Orotracheal, rather than nasotracheal, intubation should be used on all children. There are several ways to choose the right-size endotracheal tube. The simplest is to refer to your length-based tape system. Other techniques include choosing a tube that is about the same diameter as the tip of the child's little finger, or using the following equation:

$$4 + \frac{\text{Age in years}}{4} = \text{Size of tube (mm)}$$

In small children the smallest part of the airway is just below the vocal cords. As a result, traditional practice is to use an uncuffed tube in children younger than 8 years old. However, most experts now recommend using cuffed endotracheal tubes in all patients. If using a cuffed tube, choose a tube that is 0.5 mm smaller than the recommended uncuffed tube size unless using a 3.0 mm tube (in which case you should not downsize at all). In general, you should not inflate the cuff unless directed to do so by your medical direction because a cuff that is overinflated may damage the child's airway.

There is a significant risk of neck movement with any tracheal intubation, so have someone manually stabilize the patient's neck during intubation. Using a straight blade (Miller blade), enter the mouth on the right and gently sweep the tongue to the left. Then use the blade to lift the epiglottis and visualize the larynx. Compared to adults, the small child's larynx is closer to the mouth as well as more anterior (higher up). If you cannot see the cords because of the relatively large and floppy epiglottis, advance the laryngoscope blade to the epiglottis and lift again. The cords should be seen easily.

A common scenario is one in which the laryngoscope is initially advanced beyond the glottis and into the esophagus. If you encounter this clinical situation, gently and slowly withdraw your laryngoscope while visualizing the anatomy. You will likely see the vocal cords "drop down" into your visual field, at which point you may insert your endotracheal tube.

Supraglottic airways (SGA) such as the laryngeal mask (LMA), i-gel, King LT airways and others are available in pediatric sizes and can be used as rescue airways. They should not be used for airway burns or airway swelling from allergic reactions because they are supraglottic and so do not keep the glottis open.

Pulse oximetry should be used during every intubation. It is a good tool for knowing when you need to stop your intubation attempt to oxygenate the patient again prior to another attempt (usually when the SpO_2 drops below about 90%). Remember, in general, children will desaturate faster than adults. Other ways to make sure that you remember to ventilate include holding your breath when no one is breathing for the child. As soon as you get an urge to breathe, but after no more than 15 seconds, stop trying to intubate, bag the child to reoxygenate, and try again in a few minutes. An alternative effective method is to have the team member who is manually stabilizing the neck count aloud to 15 slowly.

Confirm the endotracheal tube is in the correct place by following the confirmation protocol. (See Chapter 7.) Although a disposable, qualitative end-tidal carbon dioxide detection device can be used to confirm that it is correctly positioned within the airway, capnography is the best way to both confirm the tube is in place and continually monitor its position. If using the colorimetric device, please be sure to use one specific for the pediatric patient. Be sure to secure the tube in place. Apply benzoin to the cheek and lip. Firmly tape (or tie with linen tape or plastic oxygen tubing) the tube to the corner of the mouth. Alternatively, a commercial endotracheal tube holder may be used, if available.

Beware that simple flexion of the neck can push the tube into the right mainstem bronchus, and extension of the neck can pull the tube out of the trachea. Fortunately, a rigid cervical collar or towel rolls applied to the sides of the neck are easy and practical adjuncts to limit any unnecessary head and neck movement in children and not only protect the trauma patient's cervical spine from potential further injury but also help reduce the likelihood of endotracheal tube movement and dislodgement in both trauma and nontrauma patients (Becker and Langhan 2017).

Normal ventilation is difficult to maintain among providers delivering BVM ventilation to pediatric patients without objective feedback. Incorporation of capnography monitoring may improve BVM ventilation in children.

Supplemental Oxygen Preparing a child for transport often calls for some improvisation with tape and straps. However, both can restrict chest movement, so assess the child's ventilation frequently en route. Any child with a significant injury should receive supplemental oxygen (as close to 100% oxygen as possible), even if there seems to be no difficulty breathing. Injury, fear, and crying all increase oxygen demands. Children with any type of injury are likely to vomit, so be prepared by having your suction apparatus set up and readily available. Remember to give ventilation instructions to your teammate before moving to assessment of circulation.

PEARLS

Shock

Because of strong compensatory mechanisms, children can look surprisingly well in early shock. When they deteriorate, however, they often "crash." If you have a long transport time and the mechanism of injury or the assessment suggests the possibility of hemorrhagic shock, be prepared. When you give fluid resuscitation to a child, give 20 mL/kg in each bolus, then reassess. Make sure the total amount of fluid you give is reported to the hospital.

Assessment of Circulation

In a young child, the brachial and femoral pulses (central pulses) are usually easy to feel as are the radial and dorsalis pedis pulse (peripheral pulses). The carotid pulse is not easily palpated in children because they typically have short necks. Because tachycardia also occurs with fear and anxiety, the child should then be assessed for signs of poor perfusion, including weak peripheral pulses compared to central pulses, cool distant extremities, and delayed capillary refill time. A weak rapid pulse with a rate over 150 is usually a sign of shock in children of all ages except neonates (Table 18-2).

Prolonged capillary refill, cool extremities, and skin mottling may indicate decreased tissue perfusion. Capillary refill may be used along with other methods to assess circulation, but do not depend on it alone to diagnose shock because refill time is prolonged by anything that causes vasoconstriction of the skin, such as cold environment or fear. To test capillary refill time, compress the nail bed, the entire foot, or the skin over the sternum for 2 seconds. Then release to see how quickly the blood returns and the skin color normalizes. Skin color should return to the precompressed state within 2 seconds. If it does not, the child has vasoconstriction, which may be a sign of shock.

Control of Bleeding Obvious bleeding sources must be controlled to maintain adequate blood volume and circulation. Remember, a child's blood volume is about 80–90 mL/kg, so a 10-kg child has less than 1 liter of blood. Even relatively minor injuries can cause significant blood loss (as little as 200 mL of blood loss represents approximately 20% of the child's total volume). Therefore, pay closer attention to blood loss in a child than you do in an adult. Remember that bleeding may not be immediately evident if the child is fully clothed or lying on an absorbent surface such as carpet or grass. Be sure to expose the child's body and look for bleeding. Posterior scalp lacerations are especially notorious for causing unnoticed bleeding. Use pressure firm enough to control arterial bleeding, if necessary. If you ask the parent or a bystander to help hold pressure, monitor them to be sure they are applying enough pressure to stop the bleeding.

One mistake emergency medical personnel commonly make is using a large bulky dressing, towel, or piece of clothing to attempt to stop bleeding. Unfortunately, bulky dressings often do not provide enough direct pressure to stop the bleeding. Instead, they simply absorb large amounts of blood and disguise potentially serious bleeding. Your gloved hand and fingers in combination with a gauze dressing is usually your best tool for applying constant firm pressure to the site of bleeding. Once the bleeding is under control, you may attempt to apply a more secure dressing. Be sure to recheck the dressing and wound often to ensure that the bleeding has not recurred.

Exsanguinating hemorrhage should be addressed in the primary survey with control by direct pressure or a tourniquet, if necessary. Tourniquets are recommended for life-threatening bleeding that cannot be controlled by other means. Their lifesaving benefits outweigh the small potential risk of further limb injury and loss. (See Chapter 4.) Be aware that conventional tourniquets may not fit small children.

Table 18-2: Ranges for Vital Signs

Age	Weight (kg)	Respiration (per minute)	Pulse (per minute)	Systolic Blood Pressure (mmHg)
Newborn	3–4	30–50	120–160	>60
6 mo–1 yr	8–10	30–40	120–140	70–80
2–4 yr	12–16	20–30	100–110	80–95
5–8 yr	18–26	14–20	90–100	90–100
8–12 yr	26–50	12–20	80–100	100–110
>12 yr	>50	12–16	80–100	100–120

Rapid Trauma Survey or Focused Exam

Perform a rapid head-to-toe exam (rapid trauma survey) for children who have been injured by a generalized mechanism or when you do not know the mechanism of injury. Also consider in children less than 2 years of age with a sudden unexplained alteration in mental status. Children who have a focused (isolated) injury or an insignificant injury may have a focused exam of the injured part only. Children with insignificant mechanisms of injury may not require an ITLS Secondary Survey.

Rapid Trauma Survey

The rapid trauma survey is a quick examination of the head, neck, chest, abdomen, pelvis, and extremities, and a brief neurological exam is used if there is altered level of consciousness. Look for life-threatening injuries. By this time, the child should be adequately exposed to assess all the injuries. Parents may be able to assist with this because most children are taught not to allow strangers to disrobe them. You cannot assess what you cannot see. Examine head to toe and front to back, following the sequence of the rapid trauma survey. This will reduce the likelihood that you will miss a critical injury.

Rapidly check the head and neck for signs of injury, such as bruises, abrasions, lacerations, and puncture wounds. Also look for distended neck veins and tracheal deviation. What appears to be minor trauma to the neck can be life-threatening because any bleeding or swelling within the neck can compress and obstruct a child's airway very quickly.

Look at, listen to, and feel the chest. Look for deformities, contusions, abrasions, perforations, burns, tenderness, lacerations, and swelling (DCAP-BTLS). Listen to breath sounds on each side and note any abnormalities. Feel for tenderness, instability, and crepitus (TIC). If not already done, have one of your partners stabilize flail segments, seal open wounds, or decompress a tension pneumothorax.

Gently palpate the abdomen and note any contusions, abrasions, penetrations, or distention. Children with significant abdominal injury may not breathe deeply due to pain, just as a child with appendicitis will not jump or walk due to pain. If there is no complaint of pain in the pelvic area, gently palpate the pelvis, noting any TIC. Quickly evaluate the extremities for obvious injury.

As soon as you finish the rapid trauma survey, transfer the child to a spinal motion restriction (SMR) device. Remember to log-roll the child the same way you would an adult. (See Chapter 10.) Children who are up and moving at the scene prior to your arrival, who have minor mechanisms of injury with no mental status change or any concerning physical exam findings, or who have only penetrating injuries and no neurologic deficits do not require SMR. Since the evidence is weak in this area, SMR is still recommended for any child with altered mental status, multisystem injury, neurologic deficits, or major distracting injuries. This is the time to check the child's back carefully for any injuries. If an appropriate-size cervical collar is available, place it on the child, securing the body first and then the head to the SMR device. If a rigid cervical collar is unavailable, you may use bulky towel rolls to help immobilize the child's head and neck.

Critical Trauma Situation

If you have found a critical trauma situation, the child needs rapid transport. Once you have the child packaged, you should leave the scene as quickly as possible. Remember to use a pad under the upper torso to align the neck in a neutral position. Pediatric-size rigid cervical collars are useful, especially in children older than 1 year of age, and can help remind the patient and providers not to move the head. Do not depend on the cervical collar alone, however. Restrict motion of the head with tape and a head motion-restriction device or bulky towel rolls. There are very few procedures that should be done in the field. Minutes count, especially in children. On-scene times of less than 5 minutes are desirable.

Table 18-3: Suggested Criteria for Transfer to an Emergency Department Approved for Pediatrics or a Pediatric Trauma Center

Criteria
• Obstructed airway
• Need for an airway intervention
• Respiratory distress
• Shock
• Altered mental status
• Dilated pupil
• Glasgow Coma Scale score <13
• Pediatric Trauma Score <8
• Mechanism of injury (less-reliable indicators) associated with severe injuries:
◦ Fall from a height of 10 feet or more
◦ Motor-vehicle collision (MVC) with fatalities
◦ Ejection from an automobile in an MVC
◦ In an MVC, significant intrusion into the passenger compartment
◦ Hit by a car as a pedestrian or bicyclist
◦ Fractures in more than one extremity
◦ Significant injury to more than one organ system

Administer 100% oxygen to all pediatric patients who have potentially serious injuries. Strong evidence supports the policy that BVM ventilation of the critical child is preferable to placing an endotracheal tube, if the transport time to an appropriate emergency department is relatively short.

When considering transportation options, providers should be aware of local and regional resources and policies. This includes deciding on the appropriate destination for a particular patient (the nearest emergency department vs. a regional pediatric trauma center) as well as choosing the best transportation mode (BLS vs. ALS vs. air ambulance). As a general rule, any child with life-threatening injuries or hemodynamic instability should be transported to the nearest facility with the capabilities to stabilize the patient further. See Table 18-3 for a partial list of mechanisms of injury that are criteria for transport to an emergency department approved for pediatrics or a pediatric trauma center.

If a pediatric patient needs a procedure, you must decide whether it is worth the time and attention in the field. You should consider how long it will take to perform, how urgent the procedure is, how difficult it will be at the scene versus in the back of the ambulance or at the hospital, and how much it will delay reaching definitive care. Issues found during the ITLS Primary Survey must be corrected. However, if you can adequately mask-ventilate the pediatric patient, then immediate intubation in the field is not necessary. If you have a 3-minute procedure (an IV) and a 30-minute transport, the intravenous (IV) line probably should be started en route. If you are awaiting the arrival of a helicopter, you may attempt the procedure, but be sure to have the child packaged and ready when transportation arrives. Some procedures may be best performed in the ambulance while en route to the hospital. Always call ahead so that the emergency department can have the necessary equipment and personnel ready. Perform the ITLS Ongoing Exam and ITLS Secondary Survey en route if there is time.

If, after completing the ITLS Primary Survey, you find no critical trauma situation, place the child on a backboard and do a methodical ITLS Secondary Survey.

ITLS Secondary Survey

To perform an ITLS Secondary Survey for pediatric patients, record accurate vital signs, take a SAMPLE history, and perform a complete head-to-toe exam, including a more detailed neurologic exam as you would for an adult. During your neurologic

Table 18-4: Pediatric Glasgow Coma Scale

		>1 year	<1 year	
Eyes Opening	4	Spontaneously	Spontaneously	
	3	To verbal command	To shout	
	2	To pain	To pain	
	1	No response	No response	
		>1 year	**<1 year**	
Best Motor Response	6	Obeys	Spontaneous	
	5	Localizes pain	Localizes pain	
	4	Flexion—withdrawal	Flexion—normal	
	3	Flexion—abnormal (decorticate rigidity)	Flexion—abnormal (decorticate rigidity)	
	2	Extension (decerebrate rigidity)	Extension (decerebrate rigidity)	
	1	No response	No response	
		>5 year	**2–5 years**	**0–23 months**
Best Verbal Response	5	Oriented and converses	Appropriate words and phrases	Smiles, coos, cries appropriately
	4	Disoriented and converses	Inappropriate words	Cries
	3	Inappropriate words	Cries and/or screams	Inappropriate crying and/or screaming
	2	Incomprehensible sounds	Grunts	Grunts
	1	No response	No response	No response

exam make a notation of the child's behavior and response to the environment (alert and reaching for mom, and so on) and calculate the Glasgow Coma Scale (GCS) score or, if less than 5 years old, the GCS for Infants and Children (Table 18-4). Finish bandaging and splinting, and transport the child while continuously monitoring. Notify medical direction.

Potentially Life-Threatening Injuries

Hemorrhagic Shock

All exsanguinating hemorrhage should be addressed in the primary survey with direct pressure and/or tourniquets. Internal bleeding can be a much more subtle problem. The most common sites of severe internal bleeding in children are the chest, abdomen, pelvis, and long bones (femur fractures). Intracranial blood loss rarely causes hemorrhagic shock. Early shock (often referred to as *compensated shock*) is far more difficult to diagnose in a child than in an adult because of a child's ability to hemodynamically compensate and maintain a normal blood pressure despite life-threatening bleeding. *Persistent tachycardia is the most reliable early indicator of shock in a child.*

Individual variances and environmental factors can make some of the signs of shock subtle, making recognizing early signs of shock challenging. Tachycardia can occur because of fear or fever, and mottling can be normal in an infant younger than 6 months of age, especially when exposed to cool environmental temperatures. Extremities can be cold because of cold exposure, and capillary refill can be prolonged in a child who is cold. Though all of that is true, a child with compromised circulation

will have more than one of the following signs: tachycardia, mottling, cool extremities, and prolonged capillary refill time. In general, a child should be carefully evaluated and assumed to have signs of shock if there is persistent tachycardia or signs of poor peripheral perfusion (prolonged capillary refill time, weak peripheral pulses, or cool or mottled extremities).

Low blood pressure is a late sign of shock in children (also called *decompensated shock*). Do not be falsely reassured by a normal blood pressure. A child may still have a serious injury and be compensating to maintain a normal blood pressure. When measuring a children's blood pressure, the rule of thumb for cuff size is to use the largest one that will fit snugly on the patient's upper arm. If there is too much noise, you can perform a blood pressure by palpation. Find the radial pulse, pump up the blood pressure cuff until you no longer feel the pulse, and allow air to leak slowly while observing the dial on the blood pressure cuff. Record the pressure at which you first feel the pulse and label it "p," for palpation. This will be a systolic blood pressure only and will be slightly lower than a blood pressure that can be auscultated. As a general estimate, the lower limit of normal (fifth percentile) for systolic blood pressure is approximately 60 mmHg in neonates (<30 days old), 70 mm Hg in infants (1 month to 1 year old), and (70 + [2 × age in years]) mmHg in children 1 year and older. (Remember that these are not "normal" parameters, but rather low values that should prompt you to be very concerned.) A systolic blood pressure below those values should be treated as decompensated shock, which means the child has lost a very significant amount of blood.

It is useful to routinely measure blood pressures in all children to enhance your comfort and skill with this procedure so you are able to obtain a blood pressure quickly and efficiently in a frightened or significantly injured child. With repeated practice in healthy children you will be more prepared for the difficult situations.

fluid resuscitation: the replacement of intravascular volume in a hypovolemic child by infusing a crystalloid solution.

Fluid Resuscitation

If shock is suspected (compensated with a normal blood pressure or decompensated with a low blood pressure), the child requires **fluid resuscitation**. You should establish vascular access quickly and give a fluid bolus. The initial bolus should be 20 mL/kg of normal saline given as rapidly as possible. If there is no response, another 20 mL/kg may be given. Data suggests that blood products will be indicated in patients with evidence of shock following two fluid boluses (Polites et al. 2018).

When considering a peripheral IV, try to insert the largest practical catheter available to give the fluid bolus quickly. If the child is in shock, it may be difficult to see or feel a peripheral vein. In an unstable, critical patient, you will need to insert an intraosseous (IO) needle. (See Figure 18-7 and Chapter 5 for technique.) At this time, no scientific data are available to suggest that any child in hemorrhagic shock should not be given IV fluids. Remember that cardiac output equals stroke volume multiplied by heart rate. Children cannot increase their stroke volume significantly compared to adults, so when hypovolemic and returning less blood to the heart, they can only maintain perfusion by vasoconstriction and increasing their heart rate. Sometimes children in severe shock develop bradycardia, and this can cause a severe and frequently fatal decrease in perfusion. Treat hypovolemia early.



Figure 18-7 An IO needle in a child's proximal tibia being used for venous access. *(Photo courtesy of Bob Page, MEd, NRP, CCP, NCEE)*

Head Trauma

Traumatic brain injury (TBI) is the most common cause of death in pediatric patients. The head is the primary focus of injury because a child's head is proportionately larger than that of an adult. The goal

of managing TBI is twofold. First, it is important to quickly recognize life-threatening intracranial emergencies. Second, you should focus on preventing any secondary injury to the brain. Although some of the injury to the brain occurs from the initial impact, further injury results from preventable causes (secondary brain injury) such as hypoxia and poor perfusion (shock). To minimize those risks, you should prioritize three simple principles:

- *Give oxygen.* Head injury increases brain cell metabolic rate and decreases blood flow in at least part of the brain. All pediatric patients with a head injury should receive 100% oxygen. Similar to adults, children with brain injuries should not be hyperventilated unless they have evidence of cerebral herniation syndrome. (See Chapter 12.) Remember to monitor ventilation with capnography, if available.
- *Ensure adequate cerebral perfusion.* Blood must get to the brain to carry oxygen. It is therefore critical to recognize early signs of shock (tachycardia and poor perfusion) and aggressively correct hypovolemia. Remember, a systolic blood pressure less than 60 mmHg in a young infant (<1 month of age), 70 mmHg in a child 1 month to 1 year old, and [70 + (2 × age in years)] in children older than 1 year should be considered hypotension. Hypotension has been shown to be a predictor of poor outcome in TBI patients.
- *Be prepared to prevent aspiration.* TBI patients frequently vomit. Suction should be readily accessible for any child with a head injury.

A change in level of consciousness is the best indicator of TBI. A child entering the emergency department with a GCS of 10 that has deteriorated from a GCS of 13 in the field will be approached very differently than a child who has a GCS score of 10 that has improved from a GCS of 7 in the field. Assessments using vague words like "semi-conscious" are not helpful. Instead, note specific points such as whether the child is alert and interactive, asking for parent/crying, reaching for the parent, reacting to pain or voice, and so on.

Assessment of pupils is as important in a child with altered level of consciousness as in an adult. Note also whether the eyes are moving both left and right or whether they remain in one position. Do *not* move the head to determine this.

A child who is following simple commands has an intact central nervous system and is adequately perfusing the brain. Overall, it may be difficult at the scene to assess the extent of a child's head injury. So, always assume an injured child might have a serious head injury. Priorities should be focused on prevention of secondary brain injury and rapid transport to a trauma center equipped to provide definitive care.

Chest Injury

Children with chest injuries generally give visible signs of respiratory distress, such as tachypnea, grunting, nasal flaring, and retractions. Any injured child with any respiratory distress will benefit from supplemental oxygen. Be aware that children's normal respiratory rates are higher than those of adults (Table 18-2, p. 364). As a general rule, a child breathing faster than 40 breaths per minute, or an infant faster than 60, usually has respiratory distress.

Other signs of respiratory distress include nasal flaring (the nose moves like a rabbit's nose) and retractions, which are the caving-in of the suprasternal, intercostal, or subcostal areas upon inspiration. Grunting is usually abnormal and indicates significant respiratory distress and indicates a need for ventilatory assistance. Observe the child's breathing pattern as well. Shallow breathing, apneic spells (10–20 seconds of no breathing), or agonal respirations are all signs of respiratory failure and mandate ventilatory assistance.

Children with blunt chest injury are at risk for pneumothorax. A sudden deterioration in oxygenation, increased respiratory distress, and asymmetric breath sounds are classic findings for a pneumothorax. Any child with a sudden deterioration following

BVM ventilation or intubation should also have this in their differential. However, because the chest is small, a difference in breath sounds from side to side may be more subtle than in the adult and may be difficult to appreciate on auscultation. It is also difficult to diagnose tension pneumothorax in young children, who usually have short, fat necks that mask both neck vein distention and tracheal deviation. If a tension pneumothorax develops, the trachea usually eventually shifts away from the side of the pneumothorax, although this is a very late finding. Needle thoracostomy can be lifesaving, in children as well as adults. Decompression in the second intercostal space midclavicular or fourth to fifth midaxillary line should be effective. (See Chapter 7.)

Children in the preadolescent age group have highly elastic chest walls. Therefore, rib fractures, flail chest, pericardial tamponade, and aortic rupture are less common than in older children and adults. However, pulmonary contusion is more common. If a child does have rib fractures or a flail chest, he or she has sustained a significant force to the chest and should be assumed to have serious internal injuries.

Abdominal Injury

The second leading cause of pediatric traumatic death is blunt abdominal trauma, resulting in solid organ injury and bleeding. Common mechanisms include motor-vehicle collisions, bicycle crashes, sports-related injuries, and child abuse. In children, the liver and spleen are relatively large and both protrude below the ribs, exposing these organs to blunt external forces.

Abdominal injuries are difficult to diagnose in the field and are frequently missed because the presentation can be subtle. Children may have a difficult time communicating that they have abdominal pain, or the history may be limited secondary to the age of the child or other injuries the child has sustained. Any injured child who complains of abdominal pain should be assumed to have an intra-abdominal injury. The physical exam may also be challenging because of fear, pain, and the age of the child. A child can have a severe abdominal injury with minimal signs of trauma. Findings on examination that suggest significant abdominal injury include tenderness, bruising, and signs of shock. Seat-belt marks and bicycle handlebar marks are also worrisome. Presence of bruising or seat-belt marks on the abdomen should increase suspicion for abdominal injury.

Your assessment should be quick but thorough. If a child with blunt trauma is in shock with no obvious source of bleeding, assume that the patient is bleeding internally and your decision should be to load and go as quickly as possible. Remember, however, that normal vital signs (heart rate and systolic blood pressure) do not rule out serious intra-abdominal injury.

If a child has signs of shock (tachycardia, poor perfusion), initiate intravenous access and administer a fluid bolus. If the child does not have tachycardia or poor perfusion, intravenous access may be delayed for short transports. If the child has an altered mental status, tachycardia, and poor perfusion, consider IO access. Any child who has been crying or is suffering an abdominal injury may develop gastric distention and a tendency to vomit, so be prepared.

Spine Injury

Children have short necks, big heads, and loose ligaments. Fortunately, cervical spine injuries are uncommon before adolescence. When they do occur, children younger than 9 years of age usually have upper cervical spine injuries (C1–C3) in contrast to older children and adults, who usually have lower cervical spine injuries (C5–C7). Children with significant head injuries, altered mental status, or focal neurologic deficits are very concerning for a possible spine injury. There is no proven protocol for "clearing" the spine of a child in the field. A cervical collar is not necessary if the head is properly restricted in a padded device. In alert, conscious children with a significant mechanism of injury or distracting injuries, try to make a game of packaging the child. You can promise you will give him or her a ride in the ambulance as a reward

after you get him or her all wrapped up and ready. Have a parent or other familiar person assist, if possible. Be sure your packaging does not restrict chest movement. As mentioned before, children up to about 8 years of age will need a pad under the torso to keep the neck in a neutral position.

Any child with transient neurologic deficits by history or physical exam should have SMR initiated and carefully maintained. Although, not a field diagnosis spinal cord injury without radiographic abnormality (**SCIWORA**) refers to a child with a history of transient neurologic deficits (paresthesias) or abnormal neurologic findings or exam who has normal radiographs and CT scan at the hospital. MRI may reveal spinal cord trauma in some of these patients.

SCIWORA: refers to spine injuries that are not identified on plain x-rays or a CAT scan. The letters stand for spinal cord injury without radiographic abnormality.

Child Restraint Seats

If properly restrained in a **child restraint seat**, a child in a motor-vehicle collision is much less likely to have a serious injury than an unrestrained passenger. Unfortunately, many children are not properly restrained in the car seat or the car seat itself is not correctly anchored to the vehicle. Appropriate use of car seats is an area of injury prevention in which EMS can play a significant role through public education.

child restraint seat: a piece of safety equipment in which a child sits and that is designed to protect a child in case of a motor-vehicle collision. It must fit the child, and the child must be properly strapped into the seat for it to be effective.

Children should be transported in the ambulance using a size- and age-appropriate restraint system, properly secured to the ambulance cot or stretcher.

If the child is *uninjured* and there is no other appropriate restraint system available, the child's car seat can be used, as long as it is undamaged and properly secured in the ambulance. Place padding around the child's head and tape the head directly to the car seat (Scan 18-1). This method of transportation should be used only after a complete assessment has revealed no injury to the child. Consult local guidelines and protocols for definitive guidance.. If the child has evidence of any serious injuries, then remove the child from the car seat and package appropriately.

SCAN 18-1 Stabilizing an Apparently Uninjured Child in a Car Seat



18-1-1 One emergency care provider stabilizes the car seat in an upright position and applies and maintains manual in-line stabilization throughout the SMR process.



18-1-2 A second emergency care provider applies an appropriate-size cervical collar. If one is not available, improvise using a rolled hand towel.

(*continued*)

SCAN 18-1 Stabilizing an Apparently Uninjured Child in a Car Seat (*continued*)



18-1-3 The second emergency care provider places a small blanket or towel on the child's lap, then uses straps or wide tape to secure the chest and pelvic areas to the seat.



18-1-4 The second emergency care provider places towel rolls on both sides of the child's head to fill the voids between the head and seat. He tapes the head into place, taping across the forehead and the collar, but avoiding taping over the chin, which would put pressure on the neck. The patient and seat can be carried to the ambulance and secured to the stretcher, with the stretcher head raised.

Case Presentation *(continued)*

You are assessing a 22-pound (10 kg) infant who is in a car seat that was thrown to the floor during a collision and ended up in front of the rear seat. The infant has been crying periodically since the accident. The initial assessment (using the Pediatric Assessment Triangle) is normal. The emergency care provider approaches the infant for a more detailed evaluation. Keeping in mind that the child was restrained in the child seat but that the seat was not properly secured in the car and fell forward onto the rear floor, you are concerned about multisystem trauma.

While the infant remains in the car seat, you begin quietly talking to the child and playing with her feet. The child smiles when tickled. The responder gently palpates the legs and hips while the child is distracted by a flashlight. Gently palpating the child's abdomen produces more giggling but no distress. You now unzip the child's jump suit and note that the torso is unmarked. The child's chest and abdomen move easily with breathing and show no signs of injury. The respiratory rate is about 32. As you attempt to auscultate her chest, she starts grabbing the stethoscope. You note that the child's head moves freely forward and to both sides. Her head is unmarked and reveals no sign of trauma, tenderness, or swelling. The arms move freely and the distal pulse is about 124 and strong.

Case Presentation *(continued)*

You determine that, absent any sign of injury or distress, and with the child seat having potential for damage as it was not secured in the car, you will transport the child using a pediatric restraint system in your ambulance. You communicate to the child's grandfather that there are no major injuries found and that the child will be transported to the hospital.

Summary

To provide good trauma care for children, you must have the proper equipment, know how to interact with frightened parents, know the normal vital signs for various ages (or have them posted in your trauma box), and be familiar with the injuries that are more common in children. Fortunately, the assessment sequence is the same for children as for adults. If you perform your assessment well, you will obtain the information needed to make the right decisions in management. Focusing on assessment and management of the child's airway (with cervical spine control), breathing, and circulation will result in the best possible outcome.

Although assessment and management of the injured child are lifesaving skills, all responders involved in the care of the seriously injured child should also be concerned about prevention. Car seats, bicycle helmets, seat belts, all-terrain vehicle injuries, water safety, scald-burn injuries, firearm safety, and active-shooter drills are within the EMS area of concern. Donate your time to teaching safety (Figure 18-8), and speak out for laws (infant seat restraints, seat belts, drunk driving) that save lives.



Figure 18-8 It is important to organize or participate in programs that educate children about injury prevention and health care. *(Photo © ZUMA Press, Inc./Alamy)*

References and Resources

American Academy of Pediatrics, American College of Emergency Physicians, American College of Surgeons Committee on Trauma, Emergency Medical Services for Children, Emergency Nurses Association, National Association of EMS Physicians & National Association of State EMS Officials. 2014. "Equipment for Ground Ambulances." *Prehospital Emergency Care*, 18:1: 92–7.

American College of Surgeons Committee on Trauma, American College of Emergency Physicians, National Association of EMS Physicians, Pediatric Equipment Guidelines Committee of the EMS for Children Partnership for Children Stakeholder Group, and American Academy of Pediatrics. 2009. "Policy Statement—Equipment for Ambulances." *Pediatrics* 124, no. 1 (July): 166–71.

American Heart Association. 2015. *Web-based Integrated Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Part 12: Pediatric Advanced Life Support*. Dallas, TX: Author.

Becker, H. J., and M. L. Langhan. 2017. "Can Providers Use Clinical Skills to Assess the Adequacy of Ventilation in Children During Bag-Valve Mask Ventilation?" *Pediatric Emergency Care*. doi:10.1097/PEC.0000000000001314 [Epub ahead of print].

Bliss, D., and M. Silen. "Pediatric Thoracic Trauma." *Critical Care Medicine* 20 (Suppl. 11) (November): S409–15.

Chiron, B., C. Mas, M. Ferrandière, C. Bonnard, C. J. Fusciardi, C. Mercier, and M. Laffon. 2007. "Standard Preoxygenation vs. Two Techniques in Children." *Paediatric Anaesthesia* 17, no. 10 (October): 963–7.

Dietrich, A., S. Shaner, and J. Campbell. 2009. *Pediatric International Trauma Life Support*. 3rd ed. Oakbrook Terrace, IL: International Trauma Life Support.

DiRusso, S. M., T. Sullivan, D. Risucci, P. Nealson, and M. Slim. 2005. "Intubation of Pediatric Trauma Patients in the Field: Prediction of Negative Outcome Despite Risk Stratification." *Journal of Trauma* 59, no. 1 (July): 84–91.

Emergency Medical Services for Children (EMSC) National Resource Center. n.d. Accessed January 9, 2014. http://childrensnational.org/emsc

Fleicher, G. R., S. Ludwig, and M. Henretig. 2010. *Textbook of Pediatric Emergency Medicine*. 6th ed. Philadelphia: Lippincott Williams and Wilkins.

Gausche, M., R. J. Lewis, S. J. Stratton, B. E. Haynes, C. S. Gunter, S. M. Goodrich, P. D. Poore, M. D. McCollough, D. P. Henderson, F. D. Pratt, et al. 2000. "Effect of Out-of-Hospital Pediatric Endotracheal Intubation on Survival and Neurological Outcome: A Controlled Clinical Trial." *Journal of the American Medical Association* 283, no. 6 (February): 783–90.

Hansen, M. L., A. Lin, C. Eriksson, M. Daya, B. McNally, R. D. Yanez, D. Zive, C. Newgard, and CARES Surveillance Group. 2017. "A Comparison of Pediatric Airway Management Techniques During Out-of-Hospital Cardiac Arrest Using the CARES Database." *Resuscitation* 120 (November): 51–6. doi:10.1016/j.resuscitation.2017.08.015.

Hernandez, B. S. n.d. Child Abuse (Non-accidental Trauma). Accessed May 5, 2019. https://saem.org/cdem/education/online-education/peds-em-curriculum/gu-ob/child-abuse-(non-accidental-trauma).

Holmes, J. F., P. E. Sokolove, W. E. Brant, and N. Kuppermann. 2002. "A Clinical Decision Rule for Identifying Children with Thoracic Injuries After Blunt Torso Trauma." *Annals of Emergency Medicine* 39, no. 5 (May): 492–9.

Holmes, J. F., P. E. Sokolove, W. E. Brant, M. J. Palchak, C. W. Vance, J. T. Owings, and N. Kuppermann. 2002. "Identification of Children with Intra-abdominal Injuries After Blunt Trauma." *Annals of Emergency Medicine* 39, no. 5 (May): 500–9.

Kokoska, E. R., M. S. Keller, M. C. Rallo, and T. R. Weber. 2001. "Characteristics of Pediatric Cervical-Spine Injuries." *Journal of Pediatric Surgery* 36, no. 1 (January): 100–5.

Kuppermann, N., J. F. Holmes, P. S. Dayan, J. D. Hoyle Jr., S. M. Atabaki, R. Holubkov, F. M. Nadel, D. Monroe, R. M. Stanley, D. A. Borgialli, et al. 2009. "Identification of Children at Very Low Risk of Clinically-Important Brain Injuries After Head Trauma: A Prospective Cohort Study." *Lancet* 374, no. 9696 (October): 1160–70.

Lowe, C. G., R. T. Campwala, N. Ziv, and V. J. Wang. 2016. "The Broselow and Handtevy Resuscitation Tapes: A Comparison of the Performance of Pediatric Weight Prediction." *Prehospital Disaster Medicine* 31, no. 4 (August): 364–75.

Murray, B. L., and R. J. Cordie. 2014. "Pediatric Trauma." In *Rosen's Emergency Medicine*. 8th ed., edited by J. A. Marx, R. S. Hockberger, and R. M. Walls, 305–23. Philadelphia: Mosby/Elsevier.

Polites, S. F., R. M. Nygaard, P. N. Reddy, M. D. Zielinski, C. J. Richardson, T. A. Elsbernd, B. M. Petrun, S. L. Weinberg, S. Murphy, D. D. Potter, D. B. Klinkner, and C. R. Moir. 2018. "Multicenter Study of Crystalloid Boluses and Transfusion in Pediatric Trauma-When to Go to Blood?" *Journal of Trauma and Acute Care Surgery*. 85(1) (July): 108–112.

Olufolabi, A. J., G. A. Charlton, and P. M. Spargo. 2004. "Effect of Head Posture on Tracheal Tube Position in Children." *Anaesthesia* 59, no. 11 (November): 1069–72.

Pang, D. 2006. "Spinal Cord Injury Without Radiographic Abnormality in Children, 2 Decades Later." *Neurosurgery* 55, no. 6 (December): 1325–42.

Rozzelle, C. J., B. Aarabi, S. S. Dhall, D. E. Gelb, R. J. Hurlbert, T. C. Ryken, N. Theodore, B. C. Walters, and M. N. Hadley. 2013. "Management of Pediatric Cervical Spine and Spinal Cord Injuries." *Neurosurgery* 72 (Suppl. 2) (March): 205–26.

Viccellio, P., H. Simon, B. D. Pressman, M. N. Sha, W. R. Mower, J. R. Hoffman, and NEXUS Group. 2001. "A Prospective Multicenter Study of Cervical-Spine Injury in Children." *Pediatrics* 108, no. 2 (August): E20.

Vitale, M. G., J. M. Goss, H. Matsumoto, and D. P. Roye Jr. 2006. "Epidemiology of Pediatric Spinal Cord Injury in the United States: Years 1997 and 2000." *Journal of Pediatric Orthopedics* 26, no. 6 (November–December): 745–9.

Walls, R. M., and M. F. Murphy. 2017. *Manual of Emergency Airway Management*. 5th ed. Philadelphia: Lippincott Williams and Wilkins.

Wells, M., L. N. Goldstein, A. Bentley, S. Basnett, and I. Monteith. 2017. "The Accuracy of the Broselow Tape as a Weight Estimation Tool and a Drug-Dosing Guide–A Systematic Review and Meta-Analysis." *Resuscitation* 121 (December): 9–33.

Wing, R., C. James, L. S. Maranda, and C. C. Armsby. 2012. "Use of High-Flow Nasal Cannula Support in the Emergency Department Reduces the Need for Intubation in Pediatric Acute Respiratory Insufficiency." *Pediatric Emergency Care* 27, no. 11 (November): 1117–23.

19

Geriatric Trauma

Leah J. Heimbach, JD, RN, EMT-P
Jonathan G. Newman, MD, MMM, EMT-P, FACEP
Jere F. Baldwin, MD, FACEP, FAAFP



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

Traumata im Alter
Trauma Geriátrico
Ozljede u starijoj životnoj dobi
Trauma Geriatrik
Травмы у лиц пожилого возраста
Traumatismes chez la personne âgée
Γηριατρικό Τραύμα
Trauma időskorban
高齢者の外傷
老年創傷
Poškodbe starostnikov

Key Terms

altered mental status, *p. 379*
anticoagulant, *p. 381*
chronic disease, *p. 382*
compensate, *p. 379*
kyphosis, *p. 379*
osteoporosis, *p. 379*
pathophysiology of aging, *p. 378*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Describe the changes that occur with aging.
2. Explain how these changes can affect your assessment and management of the geriatric trauma patient.
3. Describe how the assessment and management of the geriatric trauma patient are impacted by the aging process.
4. Explain how aging affects the ability of a geriatric patient to compensate for injury and shock.

Chapter Overview

Worldwide, there are more than 600 million people over the age of 65, per the United Nations. Citizens of the United States over age 65 comprise over 14% of the U.S. population, and that number is expected to double in the next 25–30 years. The 85-and-older age group is the fastest-growing segment of the U.S. population. The geriatric population also comprises a significant number of patients being transported by ambulance. In the United States, over 30% of all patients transported by ambulance are over the age of 65.

"Elderly" is often understood as being 65 years or older in the United States because retirement benefits are usually initiated at about this point in life. However, chronological age is not the most reliable definition of "elderly." It is more appropriate to consider the physiologic processes that change with time, such as fewer numbers of neurons, decreased functioning of the kidneys, and decreased elasticity of the skin and tissues.

As a group, older adult (also referred to as geriatric) patients tend to respond to injury poorly compared to younger adults. Geriatric patients who are injured have a higher mortality for a given injury, compared to the population at large. The American College of Surgeons and the Eastern Association for the Surgery of Trauma have issued guidelines that trauma patients over age 55 years should be transported to a trauma center (ACS TQIP).

According to the U.S. National Safety Council, falls, thermal injury, and motor-vehicle collisions have been identified as common causes of traumatic death in the geriatric population. This is an even greater concern given that, as a whole, the older adult population continues to assume more active lifestyles, making them more prone to injury.

Falls account for the bulk of major injuries in the geriatric population, with hip and femur fractures, traumatic brain injuries (TBIs), and wrist fractures being commonly seen as a result. Often these falls are at ground level, which are not high-energy injuries. However, because of physiologic changes, such falls may result in significant injury. Motor-vehicle collisions account for approximately 25% of geriatric deaths, even though older adults drive fewer miles. The geriatric population has a higher incidence of collision than any other age group, second only to those under the age of 25. Eight percent of geriatric deaths are attributable to thermal injuries, which include inhalation, contact with a heat source resulting in scalding and flame burns, and electrical injury.

Older patients have a worse outcome from trauma compared to similarly injured younger patients, including increased mortality. By understanding the normal physiologic changes involved in the aging process, you will be prepared to identify subtle and occult injuries, provide optimum care, and select the most appropriate receiving facility for the geriatric trauma victim.

This patient population is one in which EMS can have a significant impact through prevention programs. Unlike many other health care providers, EMS routinely enters the homes of patients and has the ability to observe the presence of hazards and other issues that put the patient at risk. As EMS systems develop and expand community paramedic programs, older patients can benefit very much from home safety assessments and medication audits. The goal is to prevent injuries and thus improve outcomes. Referrals to the appropriate agencies to arrange for support for the patient or mitigation of risk should be part of the care that EMS provides.

This chapter reviews aging processes, highlights illnesses to which the geriatric patient is susceptible, and shows how those processes and illnesses make the assessment and management of the geriatric patient more challenging.



Case Presentation

Your ambulance has been dispatched to the scene of a motor-vehicle collision. As you arrive on scene, you are directed to a van to take care of a woman sitting in the passenger seat. You note a crack in the windshield on her side of the vehicle. The patient is an elderly woman covered in white powder (cornstarch from the airbag), with her seatbelt in place. She is responsive to voice, seems confused, and asks repeatedly, "What happened?" As you approach her, you notice bleeding from her nose.

Before proceeding, consider these questions:

- What kind of assessment should you perform?
- Is this patient at increased risk for having occult injuries, more so than a younger person?
- Should this patient be managed without spinal motion restriction (SMR)?
- Does this patient require immediate transport?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

pathophysiology of aging: the process of aging that consists of the gradual decline in the normal function of many body systems, which may in part be responsible for greater risk of injury in the elderly population.

Pathophysiology of Aging

The **pathophysiology of aging** is a gradual process whereby changes in bodily functions occur. The changes are in part responsible for the greater risk of injury in the geriatric population.

The Aging Body

Airway

Changes in airway structures of the geriatric patient may include tooth decay, gum disease, and use of a dental prosthesis. Caps, bridges, dentures, and fillings all present potential airway obstructions in the geriatric trauma patient. In addition, arthritic changes may make airway management more challenging, due to decreased movement of the mandible and decreased neck mobility.

Respiratory System

Changes in the respiratory system begin to appear in the early adult years and increase markedly after the age of 60. Circulation to the pulmonary system decreases 30%, reducing the amount of carbon dioxide and oxygen exchanged at the alveolar level. There is a decrease in chest wall movement and in the flexibility of the muscles of the chest wall. The changes cause decreased inhalation time, resulting in rapid breathing. There is a decrease in vital capacity (the amount of air exchanged per breath) because of an increased residual volume (volume of air remaining in the lungs after deep exhalation). Overall breathing capacity and maximal work rate may decrease. If there is a history of cigarette smoking or a history of working in an area with pollutants, the changes in breathing are even more significant. Rib fractures can result in increased mortality for patients admitted to trauma centers. They may be associated with underlying organ injuries, such as heart, great vessels, liver, spleen, and lungs. Difficulty swallowing increases risk of aspiration.

Cardiovascular System

Circulation is reduced in older adults due to changes in the heart and the blood vessels. Cardiac output and stroke volume may decrease, and the conduction system may degenerate. The ability of the heart valves to operate efficiently may decline.

Those changes can predispose the patient to congestive heart failure and pulmonary edema. Arteriosclerosis increases frequently in the course of the aging process, resulting in an increased peripheral vascular resistance (and perhaps systolic hypertension). Older patients may routinely have higher blood pressures and a significant change in tissue perfusion may occur in a patient when a baseline blood pressure of 160 drops to 120 as a result of trauma. All of these changes can contribute to older patients having a reduced cardiac output as compared to younger patients.

Neurologic and Sensory Function

Several changes occur in the brain with age. The brain shrinks, while the outermost meningeal layer, the dura mater, remains tightly adherent to the skull. This creates a space or an increased distance between the brain and the skull. Veins that cross this space may be stretched and may bleed with even minor trauma, increasing risk of a subdural hematoma. Also many older patients are on some type of antiplatelet or antithrombotic therapy and have delayed blood clotting, further increasing risk of intracerebral hemorrhage. A hardening, narrowing, and loss of elasticity also occurs in some arteries in the brain. A deceleration injury may cause blood vessel rupture and potential bleeding inside the skull.

With aging, a decline occurs in both visual and auditory function. As a result, older patients may not see potential hazards or hear warnings and thus are more likely to sustain an injury. Because of diminished balance and reflexes, older patients are at an increased risk for falls. Because of osteoporosis and other aging processes, even a fall from standing can produce significant injury in an older patient.

There is decreased blood flow to the brain. The patient may experience a slowing of sensory responses such as pain perception and decreases in hearing, eyesight, or other sensory perceptions. Many older patients may have a higher pain tolerance from living with conditions such as arthritis or from being on analgesic medications chronically. This can result in their failure to identify areas in which they have been injured. Other signs of decreased cerebral circulation due to the aging process may include confusion, irritability, forgetfulness, altered sleep patterns, and mental dysfunctions such as loss of memory and regressive behavior. There may be a decrease, even an absence, of the ability to **compensate** for shock.

Some older patients will develop dementia or a psychiatric illness that can make assessment of their mental status challenging. It is helpful to check with family or a caregiver about whether the patient's mental status is altered from his or her baseline.

compensate: the body's natural ability to adapt to a range of conditions. In the elderly patient there may be a decrease, or even an absence, in the ability to compensate for shock or other conditions.

PEARLS

Altered Mental Status

Older patients with **altered mental status** should always be checked for hypoglycemia, shock, and head trauma, rather than assuming that they are senile.

altered mental status: a diminished level of awareness or consciousness. It has more significance in the elderly trauma patient as a benchmark for other health care providers who will assess the patient.

Thermoregulation

Mechanisms to maintain normal body temperature may not function properly in older adults. The patient may not be able to respond to an infection with a fever or may not be able to maintain a normal temperature in the face of injury. The geriatric patient with a broken hip who has been lying on the floor in a room where the temperature is 64°F (18°C) can experience hypothermia.

Renal System

A decrease in the number of functioning nephrons in the kidneys of the geriatric patient can result in a decrease in filtration and a reduced ability to excrete urine and drugs. Older patients may therefore be more sensitive to drugs that cause sedation. It has been recommended that the dosages of these medications be reduced by 20–40% to reduce the risk of oversedation.

Musculoskeletal System

The geriatric patient may exhibit signs of changes in posture. There may be a decrease in total height due to the narrowing of the vertebral discs, slight flexion of the knees and hips, and decreased muscle strength. This can result in a **kyphosis** of the spine, resulting in an "S" curvature often seen in stooped older adults. The geriatric patient may also have advanced **osteoporosis**—a thinning of the bones resulting in a decrease in bone density. This renders the bones more susceptible to fractures. Patients who

kyphosis: a condition caused by narrowing of the vertebral discs and gradual collapse of the osteoporotic thoracic vertebral bodies often seen in older adults who present in a stooped posture with an "S" shape to the spine.

osteoporosis: a condition frequently seen in older adults in which there is gradual loss of calcium in the bones with a decrease in bone mass and density, making the bones more easily fractured.

are older than age 65 have an increased risk for cervical spine fractures after injury. Furthermore, mechanisms of injury alone may be an insufficient predictor of potential for injury because older adults are at greater risk from lower-intensity trauma than the general population.

Frequently in this population, diminished subcutaneous tissue decreases protection from falls and blunt trauma. This lack can decrease the person's ability to respond to temperature changes. Also, as skin loses elasticity as well as its natural padding, there is an increased risk of developing pressure sores. Appropriate padding and appropriate removal from hard surfaces, such as a long spineboard, can decrease this risk. Finally, a decrease in physical activity may cause a weakening in the strength of the muscle and bone. This will also render the geriatric person more susceptible to fractures, even from only a slight fall.

Gastrointestinal System

Saliva production, esophageal motility, and gastric secretion may decrease as a person ages. This can result in decreased ability to absorb nutrients. Constipation and fecal impactions are common. The liver may be enlarged because of disease processes or may be failing due to disease or malnutrition. This can result in a decreased ability to metabolize medications. Associated poor intake, especially of fluids, can leave older patients dehydrated and thus at increased risk for shock following injury.

Immune System

As the aging process continues, the geriatric patient may be less able to fight off infection. The patient who is in a poor nutritional state will be more susceptible to infection from open wounds, IV access sites, and lung and kidney infections. The geriatric trauma patient who is not otherwise severely injured may die from sepsis due to an impaired immune system.

Other Changes

The total body water and total number of body cells may be decreased in older adults. An increase in the proportion of body weight as fat may exist as well. There also may be a loss in the capacity of the body's systems to adjust to illness or injury.

Table 19-1 summarizes some of the common age-related changes that affect trauma in older adult patients.

Table 19-1: Some Age-Related Changes Affecting Trauma in Older Patients

Body System	Change
Airway	• Dental prosthesis may obstruct airway • Spine immobility makes intubation more challenging
Cardiovascular	• Baseline blood pressures may be higher; patient may be hypotensive at "normal pressures" for younger patient • Medications may blunt cardiovascular response to trauma
Respiratory	• Decreased vital capacity
CNS	• Brain atrophy increases risk of intracranial bleeding • Use of anticoagulants increases risk of intracranial bleeding • Cognitive impairment • Balance declines, increasing risk of falls
Vision	• Visual impairment increases risk of falls
Skeletal	• Osteoporosis increases risks of fractures with minor trauma

Medications

Many medications taken by geriatric patients can interfere with the ability to compensate after sustaining trauma. **Anticoagulants** may increase bleeding time. Antihypertensives and peripheral vasodilators can interfere with the body's ability to constrict blood vessels in response to hypovolemia. Beta-blockers can inhibit the heart's ability to increase the rate of contraction, even in hypovolemic shock. Pain medications and those taken for behavioral problems may depress the level of consciousness, making assessment of head injury challenging. As these medications may alter the response of the geriatric patient to traumatic injury, knowledge of the medications the patient is taking can alert you to the fact that the patient's condition may be more unstable than indicated by current signs and symptoms.

anticoagulant: medication that inhibits blood clotting

Aging and Injury

A number of the aging processes contribute to the increased risk of injury to the geriatric patient. The changes that may increase susceptibility to injury include the following:

- Slower reflexes
- Failing eyesight
- Hearing loss
- Arthritis
- Fragile skin and blood vessels
- Fragile bones
- Cognitive decline

Causative factors related to the aging process have been linked with specific injuries such as tripping over furniture and falling down stairs. Further investigation reveals that those falls are often related as much to a decrease in the function of special senses, such as loss in peripheral vision, as they are to syncope, postural instability, transient impairment of cerebrovascular perfusion, alcohol ingestion, or medication usage. Alterations in perception and delayed response to stressors may contribute to injury in the geriatric patient. When treating the geriatric trauma patient, remember that the priorities are the same as for all trauma patients. However, you must consider four important issues:

- General organ systems may not function as effectively as those in the younger adult, especially the cardiovascular, pulmonary, and renal systems.
- The geriatric patient may have a chronic illness that may complicate the effectiveness of trauma care.
- Bones may fracture more easily with less force. Fractures of major bones such as hips or femurs can be life-threatening even with proper care.
- Underlying medical problems such as cardiovascular disease or diabetes may be responsible for the patient having an event that leads to trauma.

Assessment and Management

Geriatric patient assessment, as any assessment, must take into account priorities, interventions, and life-threatening conditions. However, you must be acutely aware that geriatric patients can die from less-severe injuries than younger patients. In addition, it is often difficult to separate the effects of the aging process or of a chronic illness from the consequences of an injury. The chief complaint may seem trivial because the patient may not report truly important symptoms. You must search for important signs or symptoms. In the geriatric patient, it is not uncommon for him or her to suffer from more than one illness or injury at the same time. Remember, the older patient may not have the same response to pain, hypoxia, or hypovolemia as a younger person. Do not underestimate the severity of the patient's condition.

You may have difficulty communicating with the patient. This could result from the patient's diminished senses, hearing or sight impairment, or depression. The geriatric patient nonetheless should not be approached in a condescending manner. Do not allow others to take over the reporting of events from a patient who is able and willing to communicate reliable information. Unfortunately, the patient may minimize or even deny symptoms out of fear of becoming dependent, bedridden, institutionalized, or of losing a sense of self-sufficiency. It is important that you explain any actions, including removing any clothing, before initiating the physical assessment.

There are other considerations in assessing the geriatric trauma patient. Peripheral pulses may be difficult to evaluate. Older patients often wear many layers of clothing, which can impede physical assessment. You also must distinguish between signs and symptoms of a **chronic disease** and an acute problem. For instance, a geriatric patient may have nonpathologic rales, or the loss of skin elasticity and the presence of mouth breathing may not necessarily represent dehydration, or dependent edema may be secondary to venous insufficiency with varicose veins or inactivity rather than congestive heart failure.

chronic disease: a long-lasting or recurrent illness that may be underlying the acute problem that prompted need for emergency care. Signs and symptoms between the chronic disease and trauma may need to be distinguished.

Pay attention to deviation from expected ranges in vital signs and other physical assessment findings in the geriatric patient. An injury that is isolated and uncomplicated in the young adult may be debilitating in the older adult. This may be due to the patient's overall condition, lowered defenses, or inability to keep the effects of an injury localized.

When obtaining the patient's past medical history, it is important to note what medications the patient may be taking. As noted earlier, medications can mask or inhibit responses to injury.

ITLS Primary Survey

Scene Size-up

Size up the scene to decide if it is safe, to determine the number of patients, and to identify the mechanism of injury. Observe the surrounding area for indications that the patient is able to provide his or her own care; for signs of alcohol abuse or ingestion of multiple medications; and for signs of violence, abuse, or neglect. Unfortunately, abuse and neglect of this population are common. When your assessment of the patient and surroundings is suspicious for abuse or neglect, the emergency care provider should notify the proper authorities. Be sure to gather the patient's medications and bring them to the hospital.

Initial Assessment

As with any trauma patient, you should begin with your general impression and look for life-threatening bleeding. As you evaluate the airway, you should you maintain spinal motion restriction (SMR) while assessing the initial level of consciousness. It has more significance with older patients than with younger patients because subsequent health care providers may attribute a decreased level of consciousness to a preexisting condition rather than to the trauma. This is more likely to occur if you have not clearly indicated that the patient was clear, lucid, and cooperative at the scene.

If a patient responds appropriately to initial verbal statements, he or she has an open airway and is conscious. If the patient does not respond, gently open the airway with a modified jaw-thrust maneuver while maintaining the neck in a neutral position. This position may be difficult to determine with certainty because of arthritis and kyphosis (excessive outward curving of the spine, bending the head forward). It is important to recognize this and not to forcibly place the occiput flat on the ambulance stretcher, backboard, or ground, but instead add padding to the stretcher or backboard to maintain the patient's usual spinal position. The vacuum backboard is very helpful here. Lordosis (excessive curvature of the lower spine) may also make positioning the patient on the ambulance stretcher (or backboard or scoop stretcher)

more difficult. Padding of the voids is important to maintain spinal alignment and patient comfort.

There is increased potential for the airway to be partially obstructed. Clear the airway, being alert to possible tooth fragments due to decay and gum disease and dental devices such as caps, bridges, dentures, and fillings. Look in the mouth for partially eaten food or regurgitated stomach contents.

Look, listen, and feel for movement of air. Ensure that the rate and volume of air exchange is adequate. The geriatric patient with unresolved airway difficulty or a decreased level of consciousness should be transported immediately. In such a case, frequently monitor the respiratory effort and level of consciousness (remember to check blood glucose). Consider intubation. If drug-assisted intubation is being performed, remember that you might not need as much sedation.

Place your face over the patient's mouth to look at the chest rise, to listen to the quality of the breath sounds from the mouth, and to feel the patient's breath against your ear. If the breathing is so fast that there is inadequate air exchange (more than 20 breaths per minute), if it is too slow (fewer than 10 breaths per minute), or if the volume of air being exchanged is inadequate, provide assisted ventilation with 100% supplemental oxygen. Capnography is an effective way to monitor the patient's ventilation objectively.

Check the rate and quality of the pulse at the wrist (check at the neck if there is no pulse at the wrist). Evaluate skin color and condition. Scan the patient for bleeding, and control any bleeding with pressure.

Rapid Trauma Survey or Focused Exam

The choice between the rapid trauma survey and the focused exam depends on the mechanism of injury and/or the results of the initial assessment. If there is a dangerous generalized mechanism of injury (e.g., auto crash or fall from a height) or if the patient is unconscious, you should perform a rapid trauma survey. If there is a dangerous focused mechanism of injury suggesting an isolated injury (e.g., bullet wound to the thigh or stab wound to the chest), you may perform the focused exam, which is limited to the area of injury.

If there is no significant mechanism of injury and the initial assessment is normal (the patient is alert with no history of loss of consciousness, breathing normally, and a radial pulse less than 100, not complaining of dyspnea or chest, abdominal, or pelvic pain), you may move directly to the focused exam based on the patient's chief complaint. Be aware that older patients may not become tachycardic after trauma due to aging processes or medications.

To perform a rapid trauma survey, examine the head, neck, chest, abdomen, pelvis, and extremities. That is, briefly assess the head and neck for injuries and to see if the neck veins are flat or distended and if the trachea is midline. You may apply a cervical collar or other cervical SMR at this time, if there is tenderness. Then look, feel, and listen to the chest. Look for both asymmetrical and paradoxical movement. Note if the ribs rise with respiration or if there is only diaphragmatic breathing. Look for signs of blunt trauma or open wounds. Feel for tenderness, instability, or crepitation (TIC). Listen to see if breath sounds are present and equal bilaterally.

Make appropriate interventions for chest injuries. Remember that chest injuries are more likely to cause serious problems in older people with poor pulmonary reserve. Be especially alert to problems in patients with chronic lung disease. Those patients usually have borderline hypoxia even when they are not injured. Briefly notice heart sounds so you will have a baseline for changes such as development of muffled heart sounds. Rapidly expose and look at the abdomen (distention, contusions, penetrating wounds), and gently palpate the abdomen for tenderness, guarding, and rigidity. Check the pelvis and extremities for wounds, deformity, and TIC. Note whether the patient can move fingers and toes before transferring to a backboard.

Critical Transport Decisions

A few procedures may be initiated on scene, but do not delay transport. Examples of critical interventions that may be initiated at the scene are the following:

- Control major bleeding.
- Provide airway management.
- Assist ventilation.
- Begin CPR.
- Seal sucking chest wounds.
- Decompress a tension pneumothorax.
- Stabilize impaled objects.

Consider whether the time delay in initiating those procedures outweighs the risks of delaying transportation. The chance of survival decreases with a corresponding increase in the length of scene time. The same indications for immediate transport apply for older patients as for younger patients. (See Chapter 2.) Remember, you may not have as dramatic a response to injury in older patients, so you should ensure early transport. If one of the critical conditions is present, immediately transfer the patient to an ambulance stretcher with appropriate padding; apply oxygen, if needed; load the patient into the ambulance; and transport rapidly to the nearest appropriate trauma facility.

PEARLS

Chronic Illnesses

Chronic illnesses such as congestive heart failure and chronic obstructive pulmonary disease should be taken into account as you make judgments about interventions needed to care for the older trauma patient.

Packaging and Transport

Package or prepare the older patient for transport as quickly and gently as possible. If clinically indicated, take extra care when performing SMR on the geriatric trauma patient. Collars may not fit older patients, and emergency care providers may have to improvise with soft collars, towel rolls, and head blocks. SMR includes padding void areas that may be exaggerated due to the aging process. The older patient with kyphosis will require padding under the shoulders and head to maintain the neck in its usual alignment (Figure 19-1). Do not force the neck into a neutral position if it causes pain to do so or if the neck is obviously fused in a forward position. In addition, the supine position may increase respiratory difficulty for the geriatric patient. It is possible to maintain SMR while having the head of the ambulance stretcher angled upward. Remember to treat and transport the geriatric trauma patient, as you do all trauma patients, gently and quickly (Figure 19-2).

PEARLS

SMR

- When performing SMR on an older adult patient, steps should be taken to remove him or her from the backboard as soon as is practical. While the patient is on the long spine board, padding should be used to minimize injury to bony prominences. The vacuum backboard produces less pressure on the back.
- Extra padding may also be required under the head and shoulders to maintain the cervical spine in its normal alignment.



Figure 19-1 Older adult patients with kyphosis require padding under the head and shoulders to maintain the spine in its usual alignment.



Figure 19-2 Elevated head of stretcher to improve breathing. Spinal alignment still maintained (line).

Reassessment Exams

Perform an ITLS Secondary Survey on scene if the patient is stable. If there is any question about the patient's condition, you should transport and perform the ITLS Secondary Survey en route. Perform frequent ITLS Reassessment Exams. If IV therapy is to be started, it should be done en route to the hospital. If you start large-bore IV lines en route, monitor the patient's response to IV fluid infusion very closely. Volume infusion may precipitate congestive heart failure in patients with underlying cardiovascular disease. However, do not withhold IV fluids in a patient who is showing signs of hypovolemic shock. You may wish to give smaller fluid boluses and repeat, if needed. Frequently assess the patient's pulmonary status, including lung sounds and cardiac rhythm. All older patients should have cardiac monitoring, pulse oximetry, and capnography, if available.

Case Presentation *(continued)*

You are on the scene of a motor vehicle collision. You have been assigned to assess and care for an older woman who is in the front passenger seat. The vehicle she was in collided with a parked car. Her husband is in the driver's seat and is being assessed by another crew. As you approach your patient, you note she is responding but seems dazed and somewhat confused. You also observe a hematoma on the right side of her head and bleeding from her nose. You find that her airway is open, she is breathing at about 15–20 times per minute, and she keeps asking what happened, over and over. You explain that someone will keep her head from moving too much as an EMT takes manual control of her C-spine. You then check her pulse at the wrist and find it strong, though irregular, with a rate of about 90. In doing so, you note bruising of her right forearm. Otherwise, her skin color and temperature are cool and dry, without pallor or cyanosis.

In response to questioning, the patient says she thinks she may have blacked out. She admits to pain in her face and forearm but says she does not think she hurts anywhere

Case Presentation *(continued)*

else. A rapid palpation of the neck, chest, abdomen, pelvis, and extremities reveals no tenderness or pain. To allow for better access and extrication of the patient in the rear seat, you decide to rapidly extricate her to a long backboard. Placing a C-collar, you proceed to extricate her onto the stretcher and to transfer her to the ambulance.

Once in the ambulance, you carefully remove the backboard from under her by pulling the board from her feet while holding her on the stretcher. You then explain you will perform a rapid head-to-toe examination to discover if she has any other injuries. She agrees. Carefully cutting away her clothes, you note mildly elevated neck veins. She answers that she is treated for high blood pressure, mild congestive heart failure, an irregular heartbeat, and high blood sugar. Her medications are in her purse and include a calcium channel blocker for hypertension and Coumadin, which she takes for her "irregular heartbeat." While you continue with a rapid trauma survey, noting some bruising at the sternum and anterior iliac crest (seat belt?), your partner prepares to take vital signs. It is at that moment that the patient becomes suddenly unresponsive and has a brief tonic-clonic seizure.

You repeat the initial assessment and find the patient is now unresponsive, airway clear, respirations rapid, pulse about 50, and blood pressure 162/90. You check her pupils and find the right pupil larger than the left. A GCS check reveals that she has no eye opening or verbal response to pain and withdraws her right arm and leg only. (No movement on the left.) Suspecting a cerebral bleed (possibly an epidural hematoma, in light of the history of possible initial loss of consciousness, lucid interval, and sudden loss of consciousness), you determine the need to transport immediately to the trauma center.

En route you contact the trauma center to report the situation, place the patient on 12 liters per minute oxygen, and prepare to assist ventilation, which has become irregular. Due to short transport time you decide to support the airway with a bag-valve mask. Upon arrival at the hospital, you give a report to the trauma team. A CT scan of her head reveals an epidural hematoma. She undergoes an evacuation of the hematoma and after a long hospitalization is discharged to a rehabilitation facility.

Summary

You will be called on to treat and transport an increasing number of geriatric trauma patients. Although the mechanisms of injury may be different from those of younger adults, the prioritized evaluation and treatment is the same. As a general rule, older patients have more serious injuries and more complications than younger patients. Some suggest that an age greater than 60 years is sufficient reason to take an injured patient to a level 1 trauma center. The physiologic processes of aging and frequent concurrent illnesses make evaluation and treatment more difficult. You must be aware of the differences to provide optimal care to the patient.

References and Resources

American College of Surgeons Committee on Trauma. n.d. *ACS TQIP Geriatric Trauma Management Guidelines*. Accessed May 5, 2019. https://www.facs.org/~/media/files/quality%20programs/trauma/tqip/geriatric%20guide%20tqip.ashx.

Bergeron, E., A. Lavoie, D. Clas, L. Moore, S. Ratte, S. Tetreault, J. Lemaire, and M. Martin. 2003. "Elderly Trauma Patients with Rib Fractures Are at Greater Risk of Death and Pneumonia." *Journal of Trauma* 54, no. 3 (March): 478–85.

Bledsoe, B. E., R. S. Porter, and R. A. Cherry. 2017. *Paramedic Care: Principles and Practice*. 5th ed., Vol. 6. Upper Saddle River, NJ: Pearson Education.

Centers for Disease Control and Prevention. 2017. "Falls Among Older Adults: An Overview." Accessed August 2017. http://www.cdc.gov/HomeandRecreationalSafety/Falls/adultfalls.html.

Chu, I., F. Vaca, S. Stratton, B. Chakravarthy, W. Hoonpongsimanont, and S. Lotfipour. 2007. "Special Topic: Injury Prevention Geriatric Trauma Care: Challenges Facing Emergency Medical Services" *California Journal of Emergency Medicine* 8, no. 2 (May): 51–5.

Dalton, T., M. R. Rushing, M. E. A. Escott, and B. J. Monroe. 2015. "Complexities of Geriatric Trauma Patients." *Journal of Emergency Medical Services* 40, no. 11 (November). Accessed May 5, 2019. https://www.jems.com/articles/print/volume-40/issue-11/features/complexities-of-geriatric-trauma-patients.html.

Davidson, G. H., C. A. Hamlat, F. P. Rivara, T. D. Koepsell, G. J. Jurkovich, and S. Arbabi. 2011. "Long-term Survival of Adult Trauma Patients." *Journal of the American Medical Association* 305, no. 10 (March): 1001–7.

Diku, M., and K. Newton. 1998. "Geriatric Trauma." *Emergency Medicine Clinics of North America* 16, no. 1 (February): 257–74.

Greenbaum, J., N. Walters, and P. D. Levy. 2009. "An Evidence-Based Approach to Radiographic Assessment of Cervical Spine Injuries in the Emergency Department." *Journal of Emergency Medicine* 36, no. 1 (January 2009): 64–71.

Jacobs, D. G. "Special Considerations in Geriatric Injury." *Current Opinions in Critical Care* 9, no. 6 (December 2003): 535–9.

Patel, V. I., H. Thadepalli, P. V. Patel, and A. K. Mandal. 2004. "Thoracoabdominal Injuries in the Elderly: 25 Years of Experience." *Journal of the National Medical Association* 96, no. 12 (December): 1553–7.

Pudelek, B. 2002. "Geriatric Trauma: Special Needs for a Special Population." *AACN Clinical Issues* 13, no. 1 (February): 61–72.

Sasser, S., R. C. Hunt, M. Faul, D. Sugerman, W. S. Pearson, T. Dulski, M. M. Wald, G. J. Jurkovich, C. D. Newgard, E. B. Lerner, et al. 2012. "Guidelines for Field Triage of Injured Patients: Recommendations of the National Expert Panel on Field Triage, 2011." *Morbidity and Mortality Weekly Report* 61, no. RR01 (January): 1–20.

Shifflette, V. K., M. Lorenzo, A. J. Mangram, M. S. Truitt, J. D. Amos, and E. L. Dunn. 2010. "Should Age Be a Factor to Change from a Level II to a Level I Trauma Activation?" *Journal of Trauma* 69, no. 1 (July): 88–92.

Staudenmayer, K. L., R. Y. Hsia, N. C. Mann, D. A. Spain, and C. D. Newgard. 2013. "Triage of Elderly Trauma Patients: A Population-Based Perspective." *Journal of the American College of Surgeons* 217, no. 4 (October): 569–76.

Stevenson, J. 2004. "When the Trauma Patient Is Elderly." *Journal of Perianesthesia Nursing* 19, no. 6 (December): 392–400.

Zarzaur, B. L., M. A. Croce, L. J. Magnotti, and T. C. Fabian. 2010. "Identifying Life-Threatening Shock in the Older Injured Patient: An Analysis of the National Trauma Data Bank." *Journal of Trauma* 68, no. 5 (May): 1134–8.

20

Trauma in Pregnancy

Walter J. Bradley, MD, MBA, FACEP



(Courtesy of Roy Alson, PhD, MD, FACEP, FAEMS)

Traumata während der Schwangerschaft
Trauma en el Embarazo
Ozljede u trudnoći
Trauma na Grávida
Trauma Pada Kehamilan
Травма во время беременности
Traumatismes chez la femme enceinte
Τραύμα στην Εγκυμοσύνη
Trauma a terhesség alatt
妊婦の外傷
妊娠創傷
Poškodbe v nosečnosti

Key Terms

abruptio placenta, *p. 395*

domestic violence, *p. 396*

physiological changes, *p. 391*

supine hypotension syndrome, *p. 393*

Objectives

Upon successful completion of this chapter, you should be able to:

1. Understand the dual goals in managing the pregnant trauma patient.
2. Describe the physiological changes associated with pregnancy.
3. Understand the pregnant trauma patient's response to hypovolemia.
4. List the types of injuries most commonly encountered in the pregnant trauma patient.
5. Describe the initial assessment and management of the pregnant trauma patient.
6. Discuss trauma prevention in pregnancy.

Chapter Overview

When the crossroads of pregnancy and trauma meet, there are unique challenges. The vulnerability of the pregnant trauma patient and potential injuries to the unborn child serve as reminders of the dual roles of providing care to both mother and fetus. In addition, the pregnant patient is often at risk for a higher incidence of accidental trauma. The increase in syncope, hyperventilation, and excess fatigue commonly associated with early pregnancy, as well as physiologic changes that accompany it, can affect balance and coordination and add to risks.

Trauma is a leading cause of morbidity and mortality in pregnancy. Although maternal mortality due to other causes (such as infection, hemorrhage, hypertension, and thromboembolism) has declined over the years, the number of maternal deaths due to penetrating trauma, suicide, homicide, and motor-vehicle collisions has risen steadily. In the United States, between 6 and 20% of pregnant women experience some degree of trauma, not all of which is accidental. Significant injuries occur in approximately 1 in 12 patients who are trauma victims. Injuries requiring hospital ICU admission occur in three to four pregnancies per 100 deliveries. Motor-vehicle collisions account for two-thirds of trauma in pregnant patients. Falls, abuse, domestic violence, penetrating injuries, and burns are also common. Because minor injuries rarely present problems for emergency medical services (EMS) providers, the following discussion focuses on the more severe traumatic injuries to the pregnant patient. Several factors impact trauma in pregnancy and affect fetal morbidity and mortality. They include hypoxia, infection, drug effects, and preterm delivery.

Case Presentation



You respond to a single vehicle collision with a tree. The driver of the car, a female, lost control of the vehicle at a speed of 30 miles (48 km) per hour. She was restrained and the airbag deployed from the steering wheel. The scene is safe and police are willing to assist you with the female driver, who is seven months pregnant. She denies loss of consciousness and head, neck, or back pain. Her only complaint is a tender abdomen. Upon inspection there is a superficial abrasion running horizontally across her abdomen.

Before proceeding, consider these questions:

- What is likely to have caused this abrasion?
- Should this patient be transported and evaluated at the emergency department or in the birthing center at the hospital?
- Might the incident induce premature labor?
- If she goes into labor, is the fetus old enough to be viable?
- Could this patient be managed without spinal motion restriction (SMR)? If SMR is indicated for a pregnant patient, are there special precautions to consider?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

Pregnancy

Fetal Development

The effect of trauma on pregnancy is influenced by the gestational age of the fetus, the type and severity of the trauma, and the extent of disruption of normal uterine and fetal physiology. The fetus develops in the first 3 months of pregnancy. Beyond the third month of gestation, the fully formed fetus and uterus grow rapidly, with the uterine fundus reaching the umbilicus by the fifth month and the epigastrium by the seventh month (see Figure 20-1 and Table 20-1). In countries with well-developed health care systems, the fetus is considered viable at 20 weeks, with over 50% survival reported following preterm delivery. (*Full term* is defined by the American College of Obstetrics and Gynecology as 40 weeks +/−1 week.)

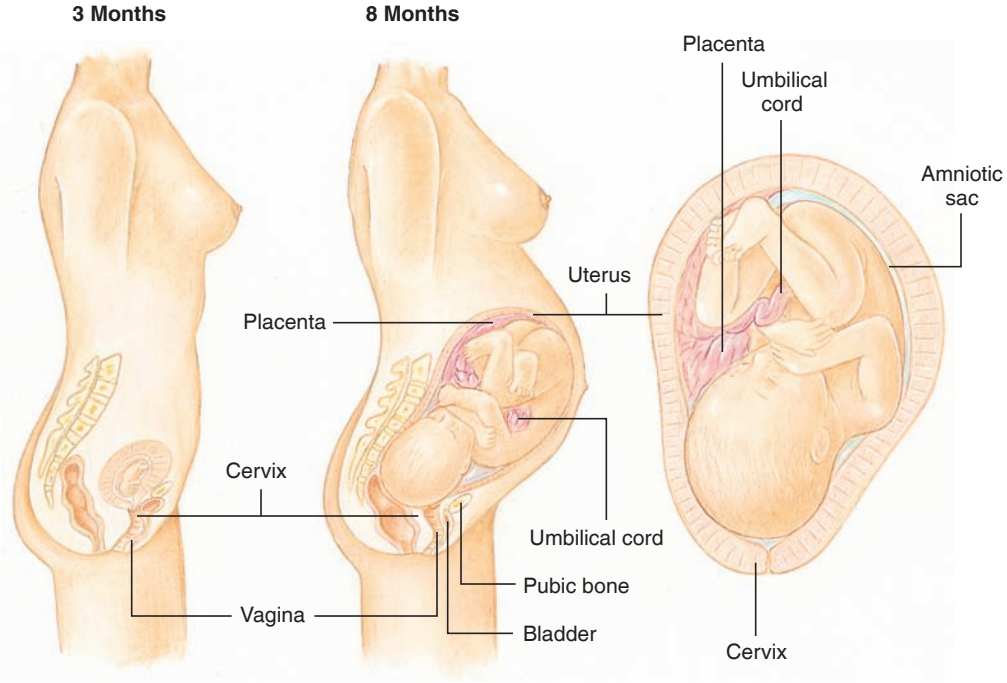


Figure 20-1 Anatomy of pregnancy: uterus at 3 months and at 8 months gestation.

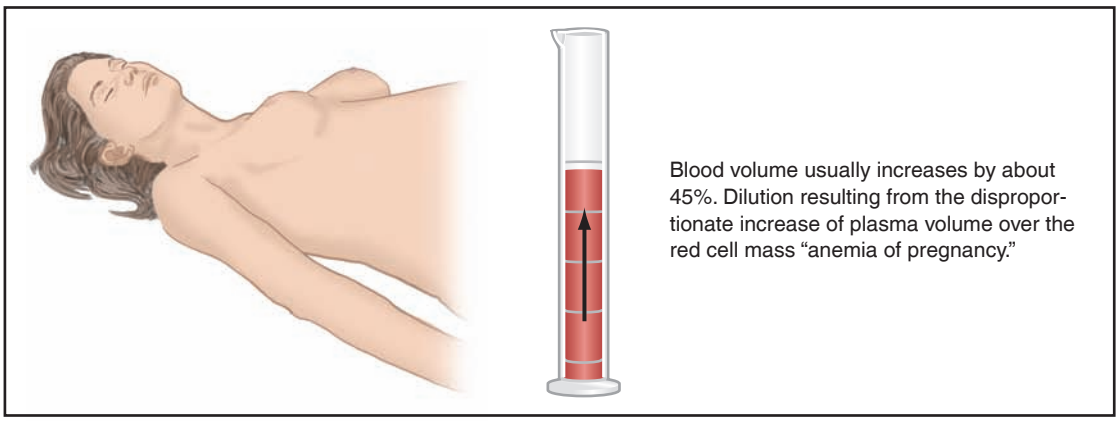
Table 20-1: Assessment of a Pregnancy

	First Trimester (1–12 weeks)	Second Trimester (13–24 weeks)	Third Trimester (25–40 weeks)
Viability	Fetus not viable	Potential viability	Fetus viable
Vaginal bleeding	Potential miscarriage	Potential miscarriage	Potential preterm birth
Fetal heart tones	Not obtainable consistently	120–170 beats per minute	120–160 beats per minute
Height of fundus above symphysis pubis	Difficult to measure	Halfway to umbilicus equals 16 weeks; to the umbilicus equals 20 weeks	1 cm equals 1 week until 37 weeks, then uterus height decreases as the fetus settles into the pelvis

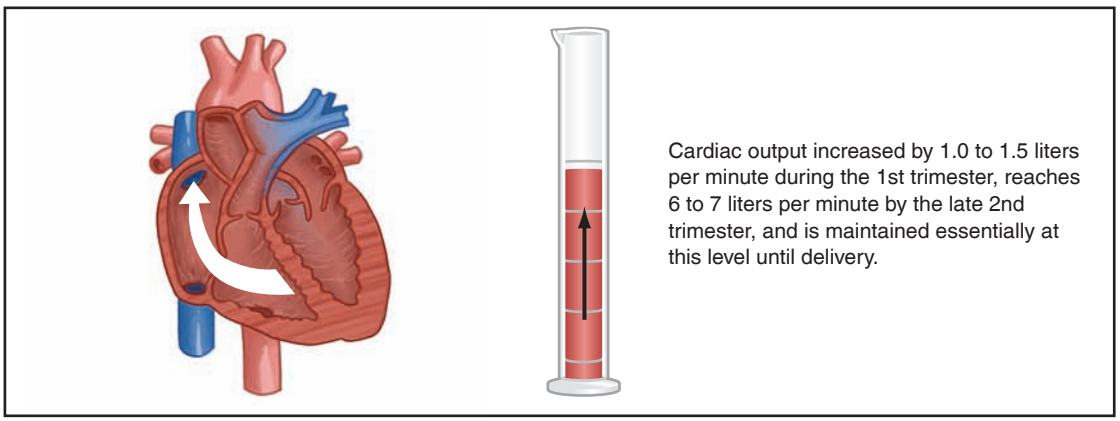
Physiologic Changes During Pregnancy

During pregnancy, significant **physiological changes** occur. These changes, affect and sometimes alter the physiologic response by both the mother and fetus. Changes include blood volume (increases), cardiac output (increases), and blood pressure (decreases) (Figure 20-2). The respiratory system also changes significantly due to an enlarging uterus that will elevate the diaphragm and decrease the volume of the thoracic cavity. To maintain minute ventilation, the mother's respiratory rates

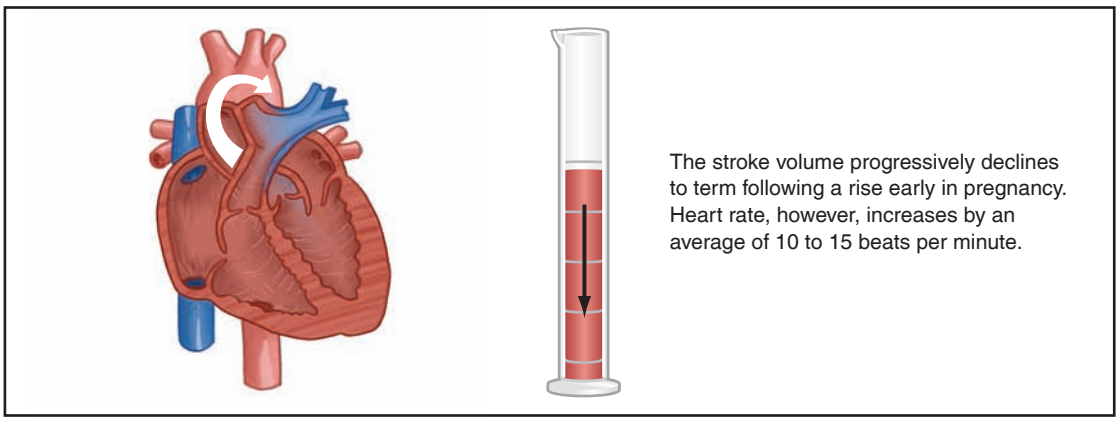
physiological changes: the normal changes that occur to the body of a woman as she progresses through her pregnancy. These affect blood volume, vital signs, and even response to hypovolemia.



A



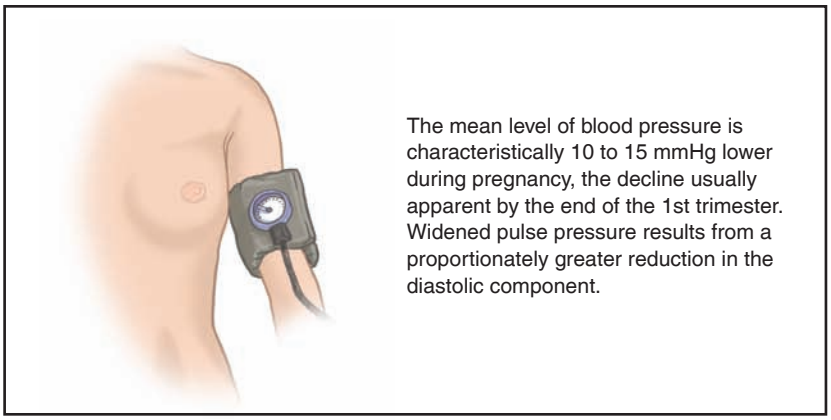
B



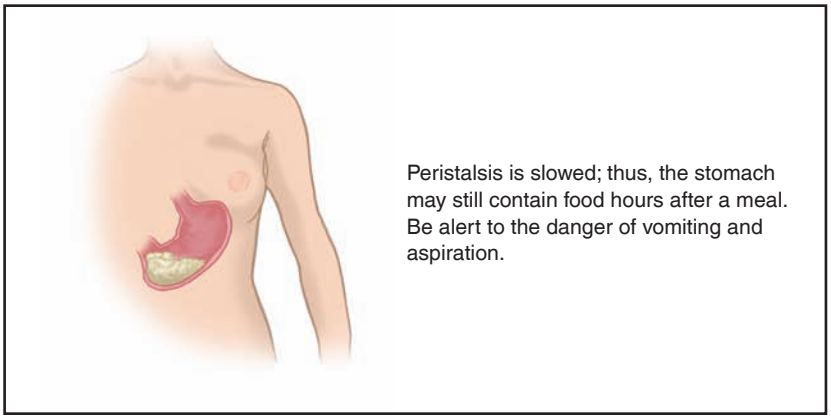
C

(*continued*)

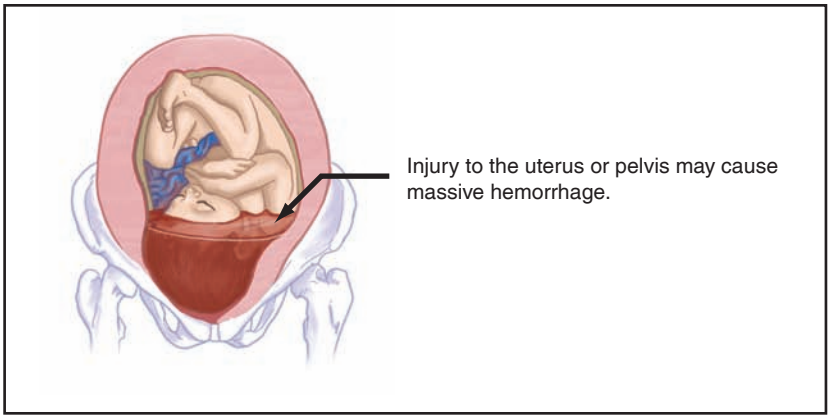
Figure 20-2 Physiologic changes during pregnancy.



D



E



F

Figure 20-2 (*continued*)

will increase, leading to a relative alkalosis, and predisposes the patient to hyperventilation. There is, in addition, an increase in both total number of red blood cells and plasma volume. As plasma volume is greater than red blood cell volume, the patient develops a physiologic anemia of pregnancy. However, many patients have poor nutritional intake during pregnancy and because the fetus draws iron from the mother, the patient may also develop an absolute anemia. Gastric motility is also decreased; thus, always assume the stomach of a pregnant patient is full. Always guard against vomiting and aspiration. Table 20-2 illustrates these changes during pregnancy.

Table 20-2: Physiological Changes During Pregnancy

Parameter Monitored	Normal Female	Change
Blood volume	4,000 mL	Increased 40–50%
Heart rate	70	Increased 10–15%
Blood pressure	110/70	Decreased 5–15 mmHg
Cardiac output	4–5 lpm	Increased 20–30%
Hematocrit/hemoglobin	13/40	Decreased
PCO_2	38	Decreased
Gastric motility	Normal	Decreased

Responses to Hypovolemia

Acute blood loss results in a decrease in circulating blood volume. The cardiac output decreases as the venous return falls. This hypovolemia causes the arterial blood pressure to fall, resulting in an inhibition of vagal tone and the release of catecholamines. The effect of this response is to produce vasoconstriction and tachycardia.

Blood flow to the uterus is heavily dependent on perfusion pressure. Anything that decreases systemic perfusion such as shock can seriously impact blood delivery to the fetus. Uterine vasoconstriction leads to reduction in uterine blood flow by 20–30%. Because of the increased blood volume, the pregnant patient may lose up to 1,500 mL of blood before any detectable change is noted in the blood pressure. The fetus reacts to this hypoperfusion by a drop in the arterial blood pressure and a decrease in heart rate. The fetus in turn experiences a reduced oxygen delivery from the maternal circulation. Therefore, it is important to give 100% oxygen to the mother to provide sufficient oxygen to the fetus. A shock state in the mother is associated with an 80% fetal mortality rate.

PEARLS

Hypovolemia

- Do not mistake normal vital signs in pregnant patients as signs of shock. The pregnant patient has a normal resting pulse that is 10–15 beats faster than usual, and the blood pressure is 10–15 mmHg lower than usual. However, it is also important to realize that a blood loss of 30–35% can occur in these patients before there is a significant change in blood pressure. Therefore, be especially alert to all signs of shock, and monitor the vital signs with frequent ITLS Ongoing Exams.
- Cardiac arrest in the pregnant patient is treated the same as for other patients. Defibrillation settings and drug dosages are the same. For hypovolemic arrest, the volume of required fluid increases, and 4 liters of normal saline should be given as fast as possible during transport.

Assessment and Management

Special Considerations

Major goals in caring for the pregnant trauma patient are evaluation and stabilization. The ITLS Primary Survey is the same for the pregnant patient as for other patients. (See Chapter 2.) All prehospital interventions are directed toward optimizing both fetal and maternal outcome. If the patient is pregnant, there are actually two patients being treated. *Optimal care for the fetus is appropriate treatment of the mother.* Oxygen administration (100% by nonrebreather mask or by endotracheal intubation) should be rapid. Promptly obtain venous access and begin administration of IV fluids. Monitoring of this patient should be immediate and constant because the anatomic and physiologic changes of pregnancy make the trauma assessment more difficult.

As the uterus enlarges, it displaces the internal contents. In addition to the effects on respiration already mentioned, the displacement of organs by the uterus may alter where the patient feels pain on palpation, as organs are not in their "usual positions."

In pregnant trauma patients, especially after the first trimester, it is important during the rapid trauma survey to examine the perineum to look for hemorrhage or leakage of fluid or even a presenting part. These findings could suggest impending delivery, rupture of membranes, placenta previa, or uterine rupture. During the abdominal exam, the uterus should be palpated to assess if there are uterine contractions, though this may be difficult in a moving ambulance. In the event that the patient is in active labor, follow your obstetric/delivery protocol.

Called **supine hypotension syndrome**, acute hypotension in the pregnant patient due to decreased venous return requires special mention. It usually occurs when the patient is

supine hypotension syndrome: the drop in blood pressure seen when a woman who is greater than 20 weeks pregnant is in the supine position. The hypotension is caused by the weight of the pregnant uterus pressing on the inferior vena cava and decreasing the return of blood to the heart by up to 30%.

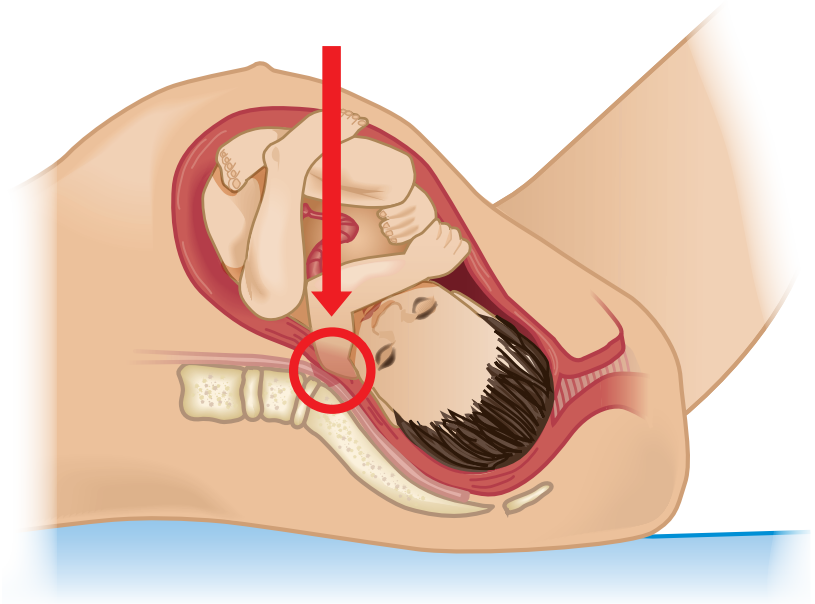


Figure 20-3 Venous return to the maternal heart may be decreased up to 30% because of vena cava compression by the fetus. Transport the patient tilted left side down or manually displace uterus to the left.

in a supine position with a 20-week or larger uterus (uterus up to umbilicus) (Figure 20-3). The enlarged uterus compresses the inferior vena cava, leading to decreased venous return and resulting in decreased cardiac output. This leads to maternal hypotension, syncope, and ultimately fetal bradycardia. Left uterine displacement can increase maternal cardiac output by 30% and restores circulation. Uterine displacement must be maintained at all times during resuscitation, transport, and perioperatively for nonobstetric surgery. Therefore, the transport of all pregnant trauma patients, if no contraindication exists, should be by one of the following methods to alleviate vena cava compression:

- Elevate the right hip 4–6 inches (10–15 cm) with a towel and manually displace the uterus to the left (Figure 20-4).
- Tilt or rotate the backboard 15–30 degrees to the patient's left. Patients should not be left on the backboard longer than necessary.

You must be very careful when strapping a third-trimester pregnant patient onto the ambulance stretcher. Many patients will roll right over onto the ambulance floor if not secured to the stretcher. The vacuum backboard is more comfortable and makes it easier to maintain SMR of the pregnant patient. Table 20-3 illustrates evaluation of uterine size and its effect on management of the pregnant patient.

PEARLS

Treatment

- You are treating two patients. However, the mortality of the fetus is directly related to the treatment provided to the mother. The goal of prehospital intervention is to maximize the chances of maternal survival, which will provide the fetus with the best chance for survival.
- If the mother dies, continue CPR and notify the hospital to be prepared for immediate cesarean section. Have them bring a sonogram machine to the emergency department for immediate evaluation of the fetus.
- Hypoxemia of the fetus may go unnoticed in the injured pregnant patient. Treatment should include high-flow oxygen.



Figure 20-4 Manual displacement of the patient's gravid uterus to the left.

Table 20-3: ITLS Primary Survey Brief Evaluation of Uterine Size

Uterine Size <20 Weeks	Uterine Size >20 Weeks
Uterus not to umbilicus	Uterus to umbilicus or higher
↓	↓
Pregnancy management unchanged	Lateral displacement of uterus
↓	↓
Maternal stabilization	Brief confirmation of fetal heart activity, if possible
	↓
	Maternal stabilization
	Secondary fetal stabilization

PEARLS

Abdominal Trauma

Trauma to the abdominal compartment can cause occult bleeding in either the intrauterine or retroperitoneal area. Keep in mind that gradual stretching of the abdominal wall during pregnancy, along with hormonal changes within the body, make the peritoneal surface less sensitive to irritable stimuli. Therefore, bleeding can occur intraperitoneally, and the signs of rebound, guarding, and rigidity may not be present.

Types of Trauma

Motor-Vehicle Collisions

Though relatively minor abdominal trauma can cause fetal death, the most common cause of fetal death in trauma is maternal death. Motor-vehicle collisions (MVCs) account for 65–75% of pregnancy-related trauma in North America. Fetal distress, fetal death, **abruptio placenta**, uterine rupture (Figure 20-5), and preterm labor are often seen in pregnant patients who have been in MVCs. A review of the literature indicates that less than 1% of pregnant patients will sustain injury when there is only minor damage to the vehicle.

abruptio placenta: the separation of the placenta from the wall of the uterus.

Head injury is the most common cause of death in pregnant patients involved in MVCs. This is closely followed by uncontrolled hemorrhage. Pregnant victims of MVCs have associated injuries, such as pelvic fractures, that often result in concealed hemorrhage within the retroperitoneal space. The retroperitoneal area, because of its low-pressure venous system, can accommodate the loss of 4 or more liters (eight or more units) of blood into that area with few clinical signs. Seat-belt use with both a shoulder restraint and lap belt can significantly decrease patient mortality and has not shown any increase in uterine injuries. In late-term pregnancy some women will either not wear seat belts or wear them improperly, due to discomfort caused by the belt over the gravid abdomen. They are at increased risk for injury as a result.

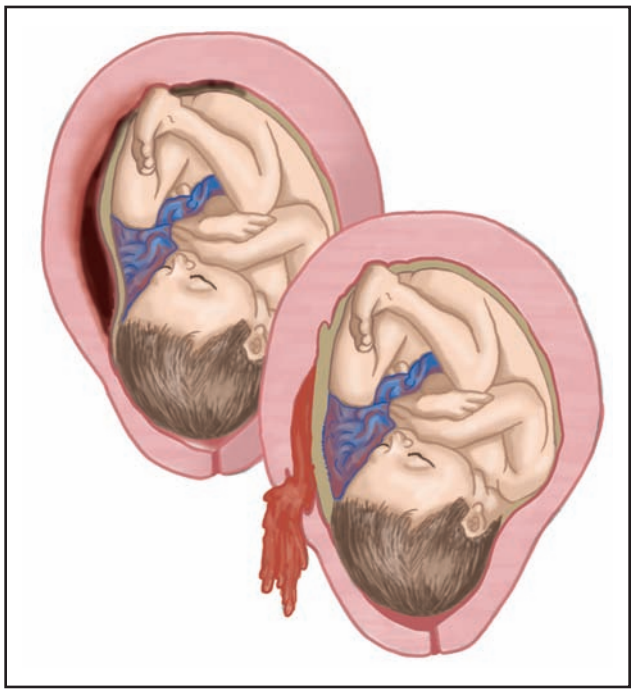


Figure 20-5 Blunt trauma to the uterus may cause separation of the placenta (abruptio placenta) or rupture of the uterus. Massive bleeding may occur, *but there may not be visible vaginal bleeding early.*

Penetrating Injuries

Penetrating injuries (gunshot wounds and stabbings) can be devastating to the pregnant patient. If the path of entry is below the uterine fundus, the uterus often offers protection to the mother, absorbing the force of the bullet or knife. Upper abdominal wounds often injure the bowel due to its displacement upward by the uterus. Studies have shown that gunshot wounds to the pregnant abdomen carry a high mortality rate for the fetus (40–70%). Mortality rate is lower for the mother (4–10%) because the large uterus usually protects vital organs. Stab wounds follow much the same pattern of outcome, with fetal mortality rates of about 40%. Definitive care will depend on several factors, involving degree of shock, associated organ injury, and time of gestation.

domestic violence: physical abuse in the home usually from spouse or partner. During the second and third trimester, it is estimated that 1 in 10 pregnant women experiences physical abuse.

Domestic Violence

A large number of pregnant women experience **domestic violence**. The frequency appears to worsen as pregnancy progresses. Through the second and third trimesters, it is estimated that 1 in 10 women experiences abuse during pregnancy. Physical abuse is more likely to result in proximal and midline injuries than the distal injuries of accidental trauma. The face and neck are most common. Domestic abuse has also been associated with low birth weight, which leads to problems for the child. The pregnant patient who is under great stress produces hormones (e.g., high circulating adrenaline levels) that negatively affect the pregnancy. The folklore that pregnant patients should be shielded from frightening or disturbing situations may be true. Spouses and partners are the perpetrators of the violence in 70–85% of cases. Emergency care providers should work with law enforcement to ensure that victims of domestic violence have a safe place to go.

Falls

The incidence of falls increases with the progression of pregnancy. This is in part due to an alteration in the patient's center of gravity. The incidence of significant injury is proportionate to the force of impact and the specific body part that sustains the impact. Pelvic injuries may result in fetal injury and *abruptio placentae* (separation of the placenta from the uterine wall causing placental hemorrhage leading to fetal hypoxia and often fetal death). Placental abruption is characterized by severe abdominal pain with little or no vaginal bleeding. Emergency department evaluation and fetal monitoring is recommended for even minor abdominal trauma during pregnancy.

Burns

Of the 2.2 million patients who suffer burn injuries in the United States annually, less than 4% are pregnant. The overall mortality and morbidity resulting from thermal injuries to the pregnant patient is not markedly different from the nonpregnant patient. However, it is important to remember that the fluid requirement for the pregnant burn victim is greater than that of the nonpregnant woman. Fetal mortality increases when the maternal surface burn exceeds 20%. The pregnant patient and the fetus are at significant risk when exposed to carbon monoxide (CO), especially as CO binds preferentially to fetal hemoglobin. Any pregnant woman with CO exposure should receive 100% oxygen by mask and emergency medical providers should consider transport to a center with hyperbaric oxygen capability.

FAST Exam

The use of ultrasound in the assessment and treatment of trauma patients is rapidly becoming a mainstay in the prehospital and hospital settings.

The focused assessment with sonography in trauma, abbreviated "FAST," is a rapid bedside ultrasound examination performed by surgeons, emergency physicians, and trained paramedics as a screening test for blood surrounding the chest and abdominal organs.

The FAST exam assesses four classic areas for free fluid, often due to the presence of blood. The areas are:

- Perihepatic space
- Perisplenic space
- Pericardium
- Pelvis

This noninvasive exam involves no exposure to radiation, is less costly than a CT scan, can be performed at the bedside or in the field, and offers a rapid assessment in the hemodynamically unstable patient. Its use in the care of trauma in pregnancy has been well established. FAST offers an effective means of addressing

the double-jeopardy concept of two patients, mom and fetus, in the traumatized pregnancy patient.

The extended FAST exam, or "E-FAST," allows for additional evaluation of both the lungs by adding bilateral anterior thoracic ultrasonography. Although an additional adjunct in the assessment of trauma care, it is important for caregivers to recognize the appropriate applications, pitfalls, and technical limitation of its use in pregnancy, especially with the displacement of intra-abdominal organs. The utility of the exam remains very dependent on the experience of the examiner.

Additionally, ultrasound allows the emergency care provider to assess fetal heart rate, which can be difficult to hear in the noisy environment of the ambulance. Normal fetal heart rate is between 120 and 160 beats per minute. Fetal heart rates that are low suggest insufficient blood flow or oxygen delivery to the fetus. Provide supplemental oxygen to the mother if not already started. Maintain adequate perfusion with fluid resuscitation and notify the receiving facility of the findings.

Cardiopulmonary Resuscitation

Cardiac arrest due to trauma has a poor outcome (see Chapter 16). In the pregnant trauma patient, CPR may be less effective due to displacement of contents by the expanding uterus and less venous return due to caval compression, as previously discussed. Resuscitation of the mother is the best way to resuscitate the fetus. Early notification of the receiving hospital is important so that they can prepare to perform a perimortem caesarian section, if indicated.

Trauma Prevention in Pregnancy

Upon reviewing major causes of trauma in pregnancy, it is clear that specific recommendations such as proper seat-belt use in motor vehicles, reporting and counseling for domestic violence, and education of the multiple physiologic, anatomic, and emotional changes associated with pregnancy will all serve to reduce trauma. Some patients get very little, if any, prenatal care, and even less prenatal education. If the situation is not critical, you should not hesitate to educate your pregnant patients when you are called to see them.

Case Presentation *(continued)*

An ALS ambulance is on scene of a car–tree collision at 30 miles (48 km) per hour. After assessing the scene for hazards and mechanism, the emergency care providers find that the driver, who is seven months pregnant, was restrained and the airbag deployed from the steering wheel. The patient denies loss of consciousness and head, neck, or back pain. Her only complaint is tenderness beneath a superficial abrasion running horizontally across her abdomen.

Because of the mechanism of injury, the team performs a rapid trauma survey that is normal with the exception of generalized tenderness of the abdomen but no rebound. The fundus of the uterus is at the xyphoid. The vital signs are normal. It appears the patient had her lap belt across her abdomen instead of her pelvis, and it could have caused uterine or intrauterine injury, so the patient is placed on an ambulance stretcher in the semireclining position, with no SMR, and transported nonemergency to the hospital where her obstetrician practices. A sonogram was done in the emergency department, and no abnormality was seen, so a fetal monitor was applied and the patient was observed overnight. She developed premature labor during the night and delivered a healthy 5-pound, 6-ounce (2.4 kg) girl. She had a normal postpartum course, and she and the baby did well.

Summary

Management of the pregnant trauma patient requires knowledge of the physiologic changes that occur during pregnancy. Pregnant patients require rapid evaluation and also rapid interventions for stabilization, including aggressive oxygen administration and fluid resuscitation. They require special techniques in packaging and transport to prevent vena cava compression syndrome. Because of the difficulty in early diagnosis, you should have a low threshold for load and go, if there is any danger of the development of hemorrhagic shock. Pregnant patients with serious injuries should be directly transported to a facility (trauma center) capable of managing these complex patients. Optional fetal care is dependent on optimal care of the mother.

References and Resources

Chang, J., C. J. Berg, L. E. Saltzman, and J. Herndon. 2005. "Homicide: A Leading Cause of Injury Deaths Among Pregnant and Postpartum Women in the United States, 1991–1999." *American Journal of Public Health* 95, no. 3 (March): 471–7.

Coker, A. L., M. Sanderson, and B. Dong. 2004. "Partner Violence During Pregnancy and Risk of Adverse Pregnancy Outcomes." *Paediatric and Perinatal Epidemiology* 18, no. 4 (July): 260–9.

El-Kady, D., W. M. Gilbert, J. Anderson, B. Danielsen, D. Towner, and L. H. Smith. 2004. "Trauma During Pregnancy: An Analysis of Maternal and Fetal Outcomes in a Large Population." *American Journal of Obstetrics and Gynecology* 190, no. 6 (June): 1661–8.

Esposito, T. J. 1994. "Trauma During Pregnancy." *Emergency Medicine Clinics of North America* 12, no. 1 (February): 167–99.

Fildes, J., L. Reed, N. Jones, M. Martin, and J. Barrett. 1992. "Trauma: The Leading Cause of Maternal Death." *Journal of Trauma* 32, no. 5 (March): 643–5.

Hill, D. A., and J. J. Lense. 1996. "Abdominal Trauma in the Pregnant Patient." *American Family Physician* 53, no. 4 (March): 1269–74.

Kilpatrick, S. J. 2019. "Initial Evaluation and Management of Pregnant Women with Major Trauma." Accessed May 5, 2019. https://www.uptodate.com/contents/initial-evaluation-and-management-of-pregnant-women-with-major-trauma.

Lewiss, R. E., T. Saul, and M. Del Rios. 2009. "EFAST—Extended Focused Assessment with Sonography for Trauma." Accessed May 21, 2019. https://www.acepnow.com/article/efast-extended-focused-assessment-sonography-trauma/?singlepage=1.

Maghsoudi, H., R. Samnia, A. Garadaghi, and H. Kianvar. 2006. "Burns in Pregnancy." *Burns: Journal of the International Society for Burn Injuries* 32, no. 2 (March): 246–50.

Mendez-Fiqueroa, H., J. D. Dahlke, R. A. Vrees, and D. J. Rouse. 2013. "Trauma in Pregnancy: An Updated Systematic Review." *American Journal of Obstetrics and Gynecology* 209, no. 1 (July): 1–10.

Pons, P. T. 1994. "Prehospital Considerations in the Pregnant Patient." *Emergency Medical Clinics of North America* 12, no. 1 (February): 1–7.

Vaizey, C. J., M. J. Jacobson, and F. W. Cross. 1994. "Trauma in Pregnancy." *British Journal of Surgery* 81, no. 10 (October): 1406–15.

Weiss, H. B., T. Songer, and A. Fabio. 2001. "Fetal Deaths Related to Maternal Injury." *Journal of the American Medical Association* 286, no. 15 (October): 1863–8.

21

The Impaired Patient



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Jonathan G. Newman, MD, MMM, FACEP, EMT-P

Patienten unter Einfluss von Alkohol und Drogen
El Paciente con Abuso de Drogas y Alcohol
Pacijent s posebnim potrebama
Trauma no Doente Inabilitado
Pasien Dengan Gangguan Kesadaran (dibawah pengaruh zat berbahaya)
Пациент под влиянием алкоголя и наркотиков
Le patient aux facultés altérées par l'alcool ou la drogues
Άτομα Με Ειδικές Ανάγκες
A fogyatékos sérült
アルコールや薬物の影響下にある傷病者
受損病人
Poškodovanec pod vplivom opojnih substanc

Key Terms

capacity, *p. 405*
close-ended questions, *p. 403*
excited delirium (EXD), *p. 404*
interactive style, *p. 403*
patient restraint, *p. 404*
uncooperative patient, *p. 404*

Objectives

Upon successful completion of this chapter, you should be able to:

1. List signs and symptoms of patients under the influence of alcohol and/or drugs.
2. Describe some strategies you would use to help ensure cooperation during assessment and management of a patient under the influence of alcohol and/or drugs.
3. Define excited delirium.
4. List the special considerations for assessment and management of patients in whom substance abuse is suspected.
5. Describe what steps you need to take to protect yourself from exposure to possible drugs of abuse on the scene.

Chapter Overview

The relationship between alcohol and trauma is well documented. The World Health Organization states that 1.35 million persons are killed in road traffic accidents each year. The young are most affected by this. About one-third of these events involve alcohol or other substances of abuse. Studies of individuals who are substance abusers note that these persons are at greater risk of suffering an injury than the general population and they are more likely to have repeated injuries.

Abuse of drugs and alcohol is a worldwide problem. Substance abuse includes abuse of alcohol, drugs, or both. It has been associated with a number of traumatic events, often resulting from accidents, car crashes, suicides, and homicides and other violent crimes. Furthermore, a study reported in the *Journal of the American College of Surgeons* found a high rate of alcohol and illicit drug use in patients who die from trauma (Demetriades et al. 2004). Therefore, it would not be surprising to find that a number of seriously injured trauma patients are under the influence of alcohol or some other substance. This group of trauma patients often presents with unique challenges that require some special patient management techniques along with good ITLS care. The industrialized world has seen a recent increase in drug abuse, both prescription and illicit. This "epidemic" of drug abuse is actually responsible for more deaths than motor-vehicle collisions in the United States (National Institutes of Health 2017). The use of these drugs has contributed to increased traumatic injury, either directly from impairment or from the violence associated with drug trafficking.



Case Presentation

You are on an ambulance dispatched to a motor-vehicle collision in which a car has crashed into a utility pole. The airbag has deployed. The pole appears intact and no wires are dislodged. The vehicle has been turned off by the police. The patient appears unresponsive as you approach the vehicle. A police officer pulls a nasal naloxone injector from his pocket and administers it to the patient as you reach the vehicle. You hear snoring respirations and see an uncapped needle on the passenger seat and a bag of white powder that has spilled.

Before proceeding, consider these questions:

- How would you approach this patient?
- What critical signs are you looking for?
- Could some effects of alcohol or drug intoxication mimic trauma-related signs and symptoms? Is this a load-and-go patient?
- Could the scene dynamics change and become unsafe?

Keep these questions in mind as you read through the chapter. Then, at the end of the chapter, find out how the emergency care providers managed this patient.

Substance Abuse

A high index of suspicion combined with the results of the physical exam, the history obtained from the patient or bystanders, and evidence at the scene can clue you in to whether your patient is under the influence of alcohol or drugs. Table 21-1 includes commonly abused drugs, along with signs and symptoms of their use.

Table 21-1: Commonly Abused Drugs with Their Associated Signs and Symptoms

Drug Category	Common Names	Signs and Symptoms of Use or Abuse
Alcohol	Beer, whiskey, wine, mouthwash	Altered mental function, confusion, polyuria, slurred speech, coma, hypertension, hyperthermia
Amphetamines, methamphetamines	Bennies, ice, speed, uppers, dexies, Ecstasy, MDMA, Adderall, bath salts, crystal	Excitement, hyperactivity, dilated pupils, hypertension, tachycardia, tremors, seizures, fever, paranoia, psychosis
Cocaine	Coke, crack, blow, rock	Same as amphetamines plus chest pain, lethal dysrhythmias
Hallucinogens	Acid, LSD, PCP, peyote, mushrooms	Hallucinations, dizziness, dilated pupils, nausea, rambling speech, psychosis, anxiety, panic
Marijuana	Grass, hash, pot, tea, weed, K2 and Spice (contain synthetic marijuana compounds)	Euphoria, sleepiness, dilated pupils, dry mouth, increased appetite
Narcotics/opiates	Heroin, horse, big H, Darvon, codeine, stuff, morphine, smack, fentanyl, Percocet, opana	Altered mental status, constricted pupils, bradycardia, hypotension, respiratory depression, hypothermia
Sedatives and psychoactive medications	GHB; barbiturates; benzodiazepines (e.g., Librium, Valium, Xanax, Ativan, Rohypnol) Antidepressants: Elavil, Prozac, Sinequan, Effexor Antipsychotics: Thorazine, Zyprexa, Abilify	Altered mental status, dilated pupils, cardiac dysrhythmias, hypotension, respiratory depression, hypothermia

While prescription medications are carefully formulated to contain the drug in the amount listed on the label, street drugs are not. They are often mixed or "cut" with other active drugs or inactive fillers. The drugs that are used to cut the main substance will change the drug's effect and may alter the signs and symptoms the patient experiences. The fillers used change the amount of the primary drug contained in each dose. Therefore, the patient's report of how much drug was used is helpful, but not a 100% reliable indication of what symptoms to expect.

One example is that methamphetamines are sometimes mixed with "bath salts" (synthetic stimulant drugs), resulting in an increase in the variety of signs and symptoms seen. Heroin is often cut with inactive and sometimes active materials, such as fentanyl (a powerful synthetic opiate). Occasionally it is cut less than usual. When patients use their usual amount of such drugs, more extreme signs and symptoms are experienced and an increased number of deaths occur. The recent increase in opiate overdoses and deaths is attributable to the availability of inexpensive fentanyl, which is mixed with or substituted for heroin, resulting in the user overdosing, often fatally.

New or emerging drugs, such as "Krokodil," which is desomorphine, has been seen. Desomorphine has been used in Russia since the early 2000s. Its use in the United States was first reported in 2013. It has an effect similar to heroin but lasts for a shorter period of time. Its use is associated with tissue damage and can result in skin ulcers and gangrene. Amputations are sometimes necessary.

"N-bomb" includes a group of designer drugs called 25B-NBOMe, 25C-NBOMe, and 25I-NBOMe. These drugs target the serotonin receptor and cause hallucinations. Patients using these drugs will have signs and symptoms similar to the hallucinogens listed in Table 21-1. However, small amounts of these drugs have caused seizures, cardiac and respiratory arrest, and death.

Found in southern Mexico, salvia is an herbal hallucinogen that can produce an altered perception of the external reality that results in a patient becoming unable to interact properly in his or her surroundings. Users may have dizziness, trouble walking, and slurred speech.

Synthetic cannabinoids have become popular and are often consumed by vaping. They can produce hallucinations. In 2018 the Centers for Disease Control and Prevention reported that, when mixed with Brodifacoum, a rodenticide related to warfarin that is thought to prolong the effects of synthetic marijuana, users have developed coagulopathy, which can be dangerous in trauma.

Assessment and Management

Your ITLS Primary and Secondary Surveys should follow the ITLS guidelines already described in this text. (See Chapter 2.) As you approach the patient, focus on scene safety. Uncapped needles may transmit disease if the provider is stuck. Powdered drugs, such as fentanyl, can produce symptoms in responders if inhaled or accidently ingested. Use PPE to protect yourself.

Emergency care providers must be aware of certain things when conducting an exam on a patient who is suspected of substance abuse. Pay particular attention to mental status, pupils, speech, and respiration, and note any needle marks. An altered mental status can be seen in every form of substance abuse. However, remember that an altered level of consciousness in a trauma patient should be assumed to be due to a head injury, shock, or hypoglycemia until proven otherwise. Also remember that all patients have an emergency medical condition until proven otherwise.

Pupils are often constricted in patients who have abused opiates. Dilated pupils are common in patients exposed to amphetamines, cocaine, hallucinogens, and marijuana. Patients who use barbiturates will have pupils that are constricted early on. However, if high doses have been consumed, the pupils can eventually become fixed and dilated. Speech can be slurred when patients use alcohol or sedatives, and patients who are under the influence of hallucinogens may seem to ramble when they talk. Respiration can be significantly depressed with opiates and sedatives. Stimulant agents such as cocaine can produce agitation, tachycardia, and hypertension, which may make identifying occult blood loss more difficult. Additionally, many drugs of abuse lessen the patient's perception of and response to pain, making your assessment more challenging.

Patients with altered mental status should be assessed for hypoglycemia and the possibility of opiate or other drug intoxication such as sedatives. In the presence of decreased level of consciousness, decreased respirations, and pinpoint pupils, consider opiate intoxication and administer naloxone. Naloxone can be given intravenously, intramuscularly, or intranasally. Remember that the effects of naloxone are fairly short and many opiates have longer duration, so that patients may begin to again show the effects of the opiate as the naloxone wears off. Repeat dosing may be necessary in this situation.

If naloxone is given too rapidly, it may precipitate acute withdrawal, leading to an agitated and combative patient. Emergency care providers may wish to titrate the naloxone dose to achieve improved respirations. Remember that with some of the newer synthetic opioids, higher doses of naloxone may be needed. American Heart Association/International Liaison Committee on Resuscitation (2015) guidelines

PEARLS
Under the Influence

It is extremely difficult to differentiate between patients under the influence and those experiencing a medical and/or trauma emergency. You may have to alter your usual management techniques. Many patients will initially refuse treatment. You may have to consult local protocol, medical direction, and appropriate law enforcement personnel for assistance.

PEARLS
Attitude

The standard ITLS approach to patient care, as outlined in Chapter 2, will work well, even with patients under the influence. Your attitude can help determine if your patient approach will be accepted or not. Be positive and nonjudgmental.

support use of naloxone in cardiac-arrest patients in whom opiate overdose is suspected.

The history supplied by the patient or bystanders can help to establish whether substance abuse is involved. Try to find out what was used, when it was taken, and how much was taken. It is also important to determine if the event was an intentional overdose. If you know the name of the drug taken, you may need to check with your local poison control center because the number of prescription medications that are abused is in the hundreds, and many have serious toxic effects.

However, be aware that patients often deny that they have used or abused any substances. If possible, inspect the patient's surroundings for clues that drugs or alcohol may have been used. Note any alcoholic beverage bottles, pill containers, injection equipment, smoking or snorting paraphernalia, or unusual odors. This may be your only clues to a possible intoxication/overdose in an unresponsive patient.

Trauma patients under the influence of alcohol or drugs can challenge the provider not only by their traumatic injuries but also by their attitudes. The way in which you interact with patients who have abused substances can determine if the patient will be cooperative or uncooperative. Your interactive style or how you speak to the patient can be as important as what you are doing for them. If you appear to be confrontational or offensive, it may make patients uncooperative and force you both to lose precious minutes of the Golden Period. If your **interactive style** is positive and nonjudgmental, the patient is more likely to be cooperative and allow all the appropriate medical interventions, thus decreasing on-scene time. As noted before, all the substances that are abused can cause an altered mental state. When interacting with patients, you must be prepared to deal with euphoria, psychosis, paranoia, or confusion and disorientation.

interactive style: your speech and body language as you interact with a patient. A positive, nonjudgmental interactive style facilitates assessment and interventions while decreasing scene time.

Some interaction strategies that can help you gain your patient's cooperation are as follows:

- *Identify yourself to patients and orient them to the surroundings.* Tell them your name and your title (e.g., "Paramedic"). Ask for their names and how they would like to be addressed. Avoid using generic names like "Bub" or "Honey." With this patient population, it may be necessary to orient patients to place, date, and what is going on multiple times. Keep in mind that repetitive questions by the patient may be a sign of a head injury rather than intoxication.
- *Treat patients in a respectful manner and avoid being judgmental.* Often a lack of respect can be heard in the tone of your voice or how you say things, not just in what you say. Never forget that you are there to save lives. This includes all patients. You are not a police officer, and you are not there to pass judgment on a patient's worth to society. Also take care not to destroy evidence.
- *Acknowledge the concerns and feelings of patients.* Those who are scared or confused may be more comfortable with what is taking place if you recognize and address those feelings. Be gentle but firm. Explain all treatment interventions before they are performed. Be honest; backboards and extrication collars can be uncomfortable and IV lines can hurt.
- *Let patients know what will be required of them.* For instance, they may be confused and not realize that they need to hold still while responders are trying to stabilize them.
- *Ask* **close-ended questions** *when getting a history from patients.* Close-ended questions can be answered with a yes or a no. Patients may only be able to concentrate for short periods of time, and they may ramble when asked open-ended questions that require a full answer. Consider getting as much of the history as you can from relatives, friends, or bystanders. This might help improve the reliability of what you discover. Get as much relevant history as you can, but do not delay transport.

close-ended questions: questions that can be answered with a yes or a no. This is often the best approach with patients under the influence of alcohol or drugs due to their limited ability to concentrate.

The Uncooperative Patient

patient restraint: methods of limiting the motion and mobility of patients to prevent them from becoming a danger to themselves or others.

uncooperative patients: patients who behave inappropriately and do not respond to reasonable requests and limits placed on them for their own safety and that of caregivers. Based on jurisdiction, a range of options are available for restraining patients against their will when warranted for patient safety, assessment, and care. A variety of physical and chemical restraints can be implemented.

A small percentage of your patients may be uncooperative. You must be firm with them. Set limits to their behavior, and let them know when their behavior is inappropriate. Consider physical **patient restraint** or *chemical restraint* only if you are not able to secure enough cooperation to provide adequate care. Often being direct without being confrontational may be enough to convince an **uncooperative patient** to allow medical care to be provided. Respond to aggressive statements without adopting aggressive speech or posture yourself. Do not argue as this can increase the tension. With intoxicated patients you often have to repeatedly redirect them back toward what you want them to do.

Other things EMS can do to prevent escalation is not yell at the patient, respect the patient's personal space, and do not talk to the patient in a condescending manner. Acknowledge his or her concerns and try to maintain eye contact.

You should watch for clues regarding physical violence, such as verbal threats, aggressive posture by the patient, rapidly shifting eye movements, and fist-clenching. If the situation becomes physical, you should back out to safety and allow law enforcement to perform their job. Given that many traumatic events involve motor-vehicle collisions or violent acts such as assault, it is a good policy to have law enforcement on the scene. The actual dispatch of law enforcement is governed by local protocol, but do not hesitate to request their support if you feel it is needed.

Appropriate training on how to deal with patients who have behavioral issues or substance abuse problems will help emergency care responders provide effective care to such patients. Crisis intervention training programs have been established in many jurisdictions to help law enforcement and other responders deal with these challenging situations.

Excited Delirium

excited delirium (EXD): a syndrome characterized by sympathetic nervous system excitation with tachycardia, hyperthermia, and hypertension. These patients often hallucinate and are very agitated. They are at risk for cardiac dysrhythmias and death.

Excited delirium (EXD) is a syndrome characterized by agitation and aggressive behavior. The syndrome often results in death of patients, especially when restrained. The patient exhibits tachycardia, hyperthermia, and hyperactivity and often hallucinates. These patients are often difficult to handle, as they can display incredible strength. Deaths have been attributed to the patient being placed into prone restraint with hands behind the back and legs bent forward ("hog-tie position"), resulting in "positional asphyxia." However, it is now believed that the effects of the stimulants (cocaine, methamphetamine, etc.) leads to cardiac dysrhythmias and their signs reflect sympathetic nervous system overstimulation. To safely subdue these patients, law enforcement will often use less than lethal weapons, such as pepper spray or a Taser. Decontaminate patients if they have been pepper-sprayed. Cardiac monitoring should be applied due to tachycardia, although diaphoresis may make it hard for pads to stick. Taser probes can be removed with direct traction in most cases (Figure 21-1).

Management of these patients can be challenging. Preventing injury to yourself and other responders is important, along with protecting the patient from further injury. Rapidly sedating the patient is the most effective way to control the situation. IM benzodiazepines and haloperidol have been used effectively. Recent studies have shown good results with IM ketamine. Local protocol will determine which agents can be used. Take care to avoid a needlestick injury when dealing with the struggling patient.

Plan for these type of patient encounters. First, check with your local jurisdiction to determine what protocol you must use when restraining patients against their will. Many jurisdictions allow police officers to place people in protective custody if they are a threat to themselves or others. Severely injured trauma patients who refuse or will not cooperate with care may be considered a threat to themselves.



Figure 21-1 Taser probe removal. *(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)*



Figure 21-2 Reeves sleeve.

The decision whether a patient can refuse care is based on a patient's **capacity**. This varies with jurisdictions. For emergency care providers to treat a patient, the patient must consent to care. In many places unresponsive patients are able to be treated based on the concept of implied consent. These are situations in which it is assumed a reasonable person would want care and not receiving care carries significant risk to the patient. For the patient to refuse, they must display the capacity to do so. This means patients have no alteration of mental status, such as a head injury, intoxication, hypoxia, or hypoglycemia, and that they understand the risks and possible detrimental outcomes (up to and including death) if they refuse care.

This is a very difficult situation for emergency care providers because they are there to help. The decision as to whether the patient has the capacity should be documented in the patient care report.

Once the decision has been made to restrain the patient, it must be carried out with care. The actual process of physically restraining the patient is beyond the scope of this course, and the emergency care providers should receive this training from the agency for which they work. At the simplest level, securely strapping a patient to an ambulance stretcher or backboard with use of a cervical collar and head motion-restriction device can serve to restrain most patients. Caution must be taken not to worsen any current injuries or to inflict any new ones. There is often no good solution to this predicament. Restrained patients could struggle so hard that spinal motion restriction (SMR) is rendered ineffective. The Reeves sleeve is one piece of equipment that is very effective in providing both restraint and motion restriction (Figure 21-2).

Restrained patients must always have a provider who can manage the airway, should the patient vomit. Even if SMR is needed, the patient can be restrained on the ambulance stretcher with the head elevated. Be sure to check extremities distal to restraints for pulse and motor and sensory function as part of your ongoing assessment.

capacity: the ability of the patient to understand his or her situation and to make an informed decision about his or her care.

PEARLS

Management

- Check fingerstick glucose and provide ECG monitoring on every patient with altered mental status.
- In this population, hypothermia, hypotension, and respiratory depression are common and must be treated aggressively. Involve the poison control center early if the person has taken a drug with which you are not familiar.

Crews should plan and practice procedures for restraining patients, ideally in cooperation with local law enforcement. The trauma scene is not the place to learn new skills. Reassess restrained patients often. Restrained patients must have an emergency care provider with them during the entire time they are under EMS care and be attached to the appropriate monitor. Intoxicated patients, especially those on stimulants, are at risk for death during transport.

The standard ITLS approach to patient care will work well, even with patients under the influence of alcohol or drugs. Ensure that the scene is safe, determine the number of injured, and discover the mechanism of injury. Use standard precautions. Many patients who are dependent on drugs and/or alcohol are at increased risk for infection with hepatitis B, hepatitis C, and HIV. Follow the ITLS Primary and Secondary Surveys as recorded in Chapter 2. Remember to note any mental status changes that might be associated with substance abuse.

When performing the ITLS Secondary Survey, be sure to include the specific areas that can provide clues to substance abuse. As with all trauma patients, treatment includes the consideration of oxygen, an IV line, cardiac monitoring, and oxygen saturation or expired carbon dioxide monitoring. Check blood sugar in all patients with altered mental status.

Table 21-2 lists drug categories and associated specific treatments or areas requiring close attention when substance abuse is suspected. A survey of American teenagers by the National Institute on Drug Abuse (NIDA; 2015) shows that overall drug use continues to decline in that age group. However, they reported that the perception of 3, 4-methylenedioxymethamphetamine (MDMA or Ecstasy) as harmful is declining, and this might be a precursor to an increase in the use of this drug. The NIDA notes an increase in the nonmedical use of the narcotics Vicodin (hydrocodone) and OxyContin (oxycodone).

Table 21-2: Drug Categories and Specific Treatments to Consider or Areas to Assess Closely

Drug Category	Specific Treatments and Areas to Assess
Alcohol	Administer IV thiamine and glucose; use D50W if indicated; watch for hypothermia.
Amphetamines/ methamphetamine	Monitor for seizures and dysrhythmias; treat seizures with diazepam or lorazepam.
Cocaine	Monitor for seizures and dysrhythmia; treat rhythm disorders. Avoid betablockers, as these may increase myocardial ischemia. Benzodiazepines may be helpful for agitation.
Hallucinogens	Provide reassurance. Benzodiazepines may be helpful for agitation.
Marijuana	Provide reassurance. Benzodiazepines may be helpful for agitation.
Narcotics/opiates	Try naloxone*, watch for hypothermia, hypotension, and respiratory depression (CO_2 monitor).
Sedatives	Try naloxone* and consider flumazenil**, watch for hypothermia, hypotension, and respiratory depression (CO_2 monitor).

*Naloxone should be titrated to the patient's respirations. Repeated doses may be indicated because the narcotic may last longer than the effects of the naloxone.

**Flumazenil use is controversial. It can precipitate seizures in patients dependent on benzodiazepines and may cause seizures in those who have been using benzodiazepines to prevent seizures and in those patients who have overdosed on tricyclic antidepressants. Flumazenil should be given only on direct order of medical direction.

Case Presentation *(continued)*

The ITLS Primary Survey shows an unresponsive patient with an airway at risk. The presence of drugs and paraphernalia is noted and you are wearing gloves and a mask in case the powder is disturbed. The second emergency care provider opens the airway while supporting the cervical spine.

The patient begins to awaken from the naloxone given by law enforcement. He begins talking and though confused pushes the second emergency care provider away. He is still not oriented to person or place but states that he is fine and he wants to drive home. He becomes loud and abusive toward EMS personnel and the police when told he cannot drive home. You attempt to convince him in a firm manner of the need to be assessed. Despite your calm demeanor, he remains agitated. A police officer now tells the patient he can go with the ambulance or he can go in the police car, but he is too confused to refuse care. The patient reluctantly agrees to be evaluated and transported. The ITLS Secondary Survey shows only superficial lacerations and no major injury, likely due to use of a seat belt and the presence of airbags. The patient does try to get off the stretcher several times during transport, but each time sits down when politely but firmly told to do so.

He is evaluated in the hospital emergency department and treated for his superficial wounds. A urine drug screen also shows presence of cannabis, but no other drugs. The emergency department staff gives him information about alcohol and substance abuse and treatment options because this is not his first visit to the hospital due to substance abuse. The patient is discharged in the care of his father, who is unhappy about having to pick him up in the middle of the night.

Summary

Knowing the signs and symptoms of alcohol and drug abuse will allow you to recognize the patient who may be impaired. Assessing the patient for signs and symptoms outlined in this chapter can help you confirm your suspicions. Determining that your patient has abused some substance will allow you to pay attention to specific areas for critical changes as well as provide lifesaving interventions that may be indicated for individual substances. The five interaction strategies for improving patient cooperation are very important when dealing with the patient under the influence of alcohol or drugs, but those strategies should also be used with all patients. Remember that the patient's safety is a primary concern. If you must restrain a patient for his or her safety, do so in a planned manner that is most sensitive to your patient's needs.

References and Resources

American Academy of Orthopedic Surgeons, Elling, B., and K. M. Elling. 2009. "Toxicology and Behavioral Emergencies." In *Paramedic: Pharmacology Applications*, 274–278. Sudbury, MA: Jones and Bartlett Learning.

American Heart Association. 2015. "Web-based Integrated Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care—Part 10: Special Circumstances of Resuscitation." ECCguidelines.heart.org.

Bledsoe, B., R. Porter, and R. Cherry. 2017. *Paramedic Care: Principles and Practice*. 5th ed., Vols. 3 and 5. Upper Saddle River, NJ: Prentice Hall.

Demetriades, D., G. Gkiokas, G. C. Velmahos, C. Brown, J. Murray, and T. Noguchi. 2004. "Alcohol and Illicit Drugs in Traumatic Deaths: Prevalence and Association with Type and Severity of Injuries." *Journal of the American College of Surgeons* 199, no. 5 (November): 687–92.

Drug Enforcement Administration. 2013. "251-NBOMe, 25C-NBOMe, and 25B-NBOMe." Accessed January 3, 2015. http://www.deadiversion.usdoj.gov/drug_chem_info/nbome.pdf.

Drug Enforcement Administration. 2013. "Salvia Divinorum and Salvinorin A." Accessed January 3, 2015. http://www.deadiversion.usdoj.gov/drug_chem_info/salvia_d.pdf.

Miller, T. R., D. C. Lestina, and G. S. Smith. 2001. "Injury Risk Among Medically Identified Alcohol and Drug Abusers." *Alcoholism, Clinical and Experimental Research* 25, no. 1 (January): 54–9.

National Institute on Drug Abuse. 2011. "Commonly Abused Drugs Chart." Accessed January 3, 2015. http://www.drugabuse.gov/drugs-abuse/commonly-abused-drugs-charts/commonly-abused-drugs-chart.

National Institute on Drug Abuse. 2011. "Commonly Abused Prescription Drugs Chart." Accessed January 3, 2015. http://www.drugabuse.gov/drugs-abuse/commonly-abused-drugs-charts/commonly-abused-prescription-drugs-chart.

National Institute on Drug Abuse. 2014. "Emerging Trends: Krokodil." Accessed January 3, 2015. http://www.drugabuse.gov/drugs-abuse/emerging-trends.

National Institute on Drug Abuse. 2015. "Drug Facts: Nationwide Trends." Accessed January 3, 2015. http://www.drugabuse.gov/infofacts/nationtrends.html.

National Institutes of Health. 2017. "Trends and Statistics: Overdose Death Rates." Accessed January 2019. https://www.drugabuse.gov/related-topics/trends-statistics/overdose-death-rates.

Office of National Drug Control Policy. n.d. "Fentanyl Safety Recommendations for First Responders." Accessed September 2018. https://www.whitehouse.gov/ondcp/key-issues/fentanyl/.

Pajonk, F. G., P. Schmitt, A. Biedler, J. C. Richter, W. Meyer, T. Luiz, and C. Madler. 2008. "Psychiatric Emergencies in Prehospital Emergency Medical Systems: A Prospective Comparison of Two Urban Settings." *General Hospital Psychiatry* 30, no. 4 (July–August): 360–6.

Su, H. K., M. Baker, and L. J. Baraff. 2014. "Design Drug 25B-NBOMe Use Likely to Land Overdose Cases in Your Emergency Department." Accessed January 3, 2015. http://www.acepnow.com/article/designer-drug-25b-nbome-use-likely-land-overdose-cases-emergency-department/.

Takeuchi, A., T. L. Ahern, and S. O. Henderson, 2012. "Excited Delirium." *Western Journal of Emergency Medicine* 12, no. 1 (January): 77–83.

Vike, G. M., M. L. DeBard, T. C. Chan, J. D. Ho, D. M. Dawes, C. Hall, M. D. Curtis, M. W. Costello, D. C. Mash, S. R. Coffman, et al., "Excited Delirium Syndrome (ExDS): Defining Based on a Review of the Literature." *Journal of Emergency Medicine* 47, no. 5 (November): 897–905.

Glossary

abruptio placenta the separation of the placenta from the wall of the uterus.

airborne precautions steps HCWs can take to protect themselves and patients from contracting diseases transmitted through inhalation, including use of an N-95 respirator.

altered mental status a diminished level of awareness or consciousness.

alveolar shunt any process that obstructs the alveoli and prevents oxygen from reaching the alveoli and adequate gas exchange, resulting in persistent hypoxemia refractory to increasing levels of supplemental.

amputation an open injury caused by the cutting or tearing-away of a limb, body part, or organ.

anticoagulant medication that inhibits blood clotting

AVPU an abbreviated description of the patient's level of consciousness. AVPU stands for alert, responds to verbal stimuli, responds to pain, and unresponsive.

bacille de Calmette et Guérin (BCG) vaccine against tuberculosis prepared from a strain of bovine tuberculosis that has been weakened; not commonly used in the United States.

Beck's triad the three clinical signs of cardiac tamponade (distended neck veins, muffled heart sounds, and hypotension).

blast injuries injuries commonly produced by the different mechanisms associated with an explosion (air blast, shrapnel, burns, etc.).

blood and OPIM blood or other body fluids or tissues that can carry infectious organisms.

blunt trauma injury produced by application of force to the body.

burn depth a classification of severity of burns by how deep the skin is burned. In order of worsening injury: superficial burns (first degree), partial-thickness burns (second degree), and full-thickness burns (third degree).

capacity the ability of the patient to understand his or her situation and to make an informed decision about his or her care.

capnography a noninvasive device that detects or measures the amount of carbon dioxide in the expired breath of a patient.

carbon-monoxide poisoning a type of inhalation injury from inhalation of the colorless, odorless, and tasteless gas carbon monoxide. Carbon monoxide binds to the hemoglobin molecule and prevents oxygenation of the cells of the body.

cerebral herniation syndrome a critical syndrome in which swelling of the brain forces portions of the brain tissue down through the opening at the base of the skull, squeezing the brainstem and causing coma, dilatation of pupils, contralateral paralysis, elevated blood pressure, and bradycardia.

cerebral perfusion pressure (CPP) the net pressure gradient causing blood flow through the brain.

chemical injury injury to the skin or other body organs from exposure to caustic or toxic chemicals.

child restraint seat a piece of safety equipment in which a child sits and that is designed to protect a child in case of a motor-vehicle collision. It must fit the child, and the child must be properly strapped into the seat for it to be effective.

chronic disease a long-lasting or recurrent illness that may be underlying the acute problem that prompted need for emergency care. Signs and symptoms between the chronic disease and trauma may need to be distinguished.

closed fracture a break in a bone in which there is no break in the continuity of the overlying skin.

close-ended questions questions that can be answered with a yes or a no. This is often the best approach with patients under the influence of alcohol or drugs due to their limited ability to concentrate.

committee for tactical emergency casualty care (C-TECC) adaptation of the principles of TCCC to the civilian high threat environment.

compartment syndrome a condition in which increased tissue pressure in a muscle compartment results in decreased blood flow, leading to tissue hypoxia and possible muscle, nerve, and vessel impairment; can be permanent if the cells die.

compensate the body's natural ability to adapt to a range of conditions. In the elderly patient there may be a decrease, or even an absence, in the ability to compensate for shock or other conditions.

consent the granting of permission to treat. In a child it is usually given by the parents or legal guardians but is not required in an emergency situation if neither are present.

contact precautions steps health care workers can take to protect themselves and patients from contracting diseases transmitted through direct contact with infected patients or materials.

contracoup an injury to the brain on the opposite side of the original impact.

coup an injury to the brain in the area of original impact.

crepitation the sound or feel of broken fragments of bone grinding against each other.

crush syndrome a systemic condition that results from crushing injury to muscles with cell death. The release of toxic products, including myoglobin, results in development of shock and acute renal failure and eventual death. The associated renal failure is known as traumatic rhabdomyolysis.

Cushing's reflex a reflex in which the body responds to markedly elevated ICP by raising both the diastolic and systolic blood pressure, reduction of heart rate, and irregular respiration. Also called *Cushing's response*, this happens late in the course of the head injury.

DCAP-BLS short for Deformities, Contusions, Abrasions, Penetrations, Burns, Lacerations, Swelling.

disaster an emergency that disrupts the normal community function and causes concern for the safety and property and lives of its citizens but cannot be managed with routine resources and procedures (U.S. Federal Emergency Management Agency). Disasters are best defined by available resources; when demand exceeds resources, one is then operating in a disaster mode.

disease A dysfunction in the body usually due to an identifiable cause, producing specific signs and symptoms.

dissociative anesthetic anesthetic agent that separates brain perception of stimuli such that the user feels detached from self and the environment.

domestic violence physical abuse in the home usually from spouse or partner. During the second and third trimester, it is estimated that 1 in 10 pregnant women experiences physical abuse.

droplet precautions steps health care workers can take to protect themselves and patients from contracting diseases transmitted through droplets of fluid, such as nasal or respiratory secretions; includes use of mask, gown, and goggles.

drowning respiratory impairment as a result of submersion/immersion in a liquid

drug-assisted intubation (DAI) the administration of a sedative and paralytic agent to improve the ability to intubate a patient. This was previously called *rapid sequence intubation (RSI)*.

ECMO extracorporeal membrane oxygenation; procedure in which blood is circulated by a pump through an "artificial lung" and then returned to the body

electrical injury injury from the passage of electrical current through the body; can be from heat generated in tissue from electrical current passing through the body, cardiac dysrhythmias from current passing through the heart, and thermal burns from ignition of clothing.

emergency rescue the immediate removal, without use of SMR, of a patient from an immediately life-threatening situation.

endorphins hormones secreted in the brain that activate the body's opiate receptors and induce analgesic.

essential equipment equipment that is worn or carried when the team approaches the trauma patient. It includes personal protective equipment; long backboard and strapping; rigid cervical extrication collar; oxygen and airway equipment; and trauma box.

evisceration the protruding of intestinal organs through a wound.

excited delirium (EXD) a syndrome characterized by sympathetic nervous system excitation with tachycardia, hyperthermia, and hypertension. These patients often hallucinate and are very agitated. They are at risk for cardiac dysrhythmias and death.

external laryngeal manipulation (ELM) a maneuver to improve visualization of the vocal cords during endotracheal intubation. Also called BURP (back-up-right pressure).

flail chest the fracture of two or more adjacent ribs in two or more places, causing instability of the chest wall and paradoxical movement of the "flail segment" in a spontaneously breathing patient.

fluid resuscitation the replacement of intravascular volume in a hypovolemic child by infusing a crystalloid solution.

focused exam an exam used when there is a focused (localized) mechanism of injury or an isolated injury. The exam is limited to the area of injury.

frostbite freezing of tissue that is intracellular or extracellular, depending or the speed of freezing; tissue damage depends on the degree and depth of freezing; in the field, classified as superficial (first and second degree) or deep (third and fourth degree)

frostnip vasoconstriction on exposed skin, without actual freezing or tissue damage; frost may be seen over this exposed area; the area can be rewarmed easily in the field with a warm hand or armpit; may precede frostbite

general impression a brief note of the patient's age/sex/weight, position, and any obvious injuries, including life-threatening external bleeding.

Hartford Consensus a consensus-based guideline dealing with the medical approach to mass shooting incidents

heat exhaustion mild elevation of body temperature associated with fluid loss in hot environment

heat-inhalation injury thermal burns of the upper airway caused by inhaling flame or hot gases. The lower airways are usually not affected because of efficient cooling by moist mucous membranes.

heat stroke life-threatening rise in body temperature due to excessive heat production or inability to lose heat, characterized by marked elevation of body temperature and altered mental status

hemorrhagic shock shock caused by insufficient blood within the vascular system.

hemostatic agents chemical or physical agents that help stop hemorrhage by facilitating clotting of the blood at the bleeding site.

hepatitis B virus (HBV) virus responsible for hepatitis B, transmitted through contact with blood or body fluids.

hepatitis C virus (HCV) virus that causes hepatitis C.

high-energy event a mechanism of injury in which it is likely that there was a large release of uncontrolled kinetic energy transmitted to the patient, thus increasing the chance for serious injury.

human immunodeficiency virus (HIV) a virus that weakens the immune system, predisposing a patient to a wide range of unusual infections.

hypoventilation the movement of air into and out of the lungs is unable to maintain the carbon dioxide level below 45 mmHg.

hypovolemic shock shock caused by insufficient volume (blood or fluid) within the vascular system.

impaled object an injury in which an object is embedded in the body tissue.

incident command system (ICS) the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in the management of resources during emergency incidents. It is used for all kinds of emergencies and is applicable to small as well as large and complex incidents.

index of suspicion the medical provider's estimate of a disease or injury being present in a patient. A high index of suspicion means there is a high probability the injury is present. A low index of suspicion means there is a low risk of the injury.

initial assessment includes a general impression of the patient on approach, his or her level of responsiveness, airway status, breathing, and circulation to prioritize the patient and identify immediately life-threatening conditions; part of the primary survey.

interactive style your speech and body language as you interact with a patient. A positive, nonjudgmental interactive style facilitates assessment and interventions while decreasing scene time.

intracranial pressure (ICP) the pressure of the brain and contents within the skull.

intrathoracic abdomen the part of the abdomen located under a thin sheet of muscle, called the *diaphragm*, and enclosed by the lower ribs; contains the liver, gallbladder, spleen, stomach, and transverse colon.

ITLS Patient Assessment the process by which the emergency care provider evaluates a trauma patient to determine injuries sustained and the patient's physiologic status; made up of the ITLS Primary Survey, ITLS Reassessment Exam, and ITLS Secondary Survey.

ITLS Primary Survey an evaluation to assess scene safety and to find immediate life-threatening injuries; made up of the scene size-up, initial assessment, and either the rapid trauma survey or the focused exam.

ITLS Reassessment Exam an abbreviated exam to determine changes in the patient's condition.

ITLS Secondary Survey a comprehensive head-to-toe exam to find additional injuries that may have been missed in the ITLS Primary Survey.

joint dislocation a complete disruption of a joint with total loss of contact between the joint's articular surfaces.

kinetic energy (KE) the energy that an object has as a result of being in motion.

kyphosis a condition caused by narrowing of the vertebral discs and gradual collapse of the osteoporotic thoracic vertebral bodies often seen in older adults who present in a stooped posture with an "S" shape to the spine.

length-based tape a method of estimating the appropriate-size equipment and doses of medications for children. The method is based on the fact that a child's weight is proportional to his or her length.

LEON technique for predicting when a patient will be difficult to intubate. LEON means Look for abnormal anatomy, Evaluate 3-3-2 rule, check for Obstructions, and Neck mobility.

lightning injury injury by the multiple effects of very short duration and very high-voltage direct current on the body. The most serious effect is cardiac and respiratory arrest.

load-and-go situation refers to a critical patient who needs to be transported as soon as possible after the primary survey is completed.

lung compliance the "give" or elasticity of the lungs

massive hemothorax the presence of at least 1,000 mL of blood loss into the pleural space of the thoracic cavity.

mean arterial pressure (MAP) the sum of the diastolic blood pressure plus one-third (systolic blood pressure minus diastolic blood pressure).

mechanical and cardiogenic shock shock produced by conditions that affect the ability of the heart to pump blood; caused by a damaged heart (myocardial contusion) or by conditions preventing the filling of the heart (pericardial tamponade, tension pneumothorax).

mechanism of injury (MOI) the means by which the patient was injured, such as a fall, motor vehicle collision, or explosion.

mediastinum the anatomic region within the thorax, located between the lungs, that contains the heart and great vessels, trachea, major bronchi, and esophagus.

minute volume the volume of air breathed in and out in 1 minute. This varies from 5 to 12 liters per minute.

MIST Report U.S. and NATO militaries have adopted this format to keep the report brief. The letters stand for Mechanism of injury/Medical problems identified; Injuries found; Signs/Symptoms/Significant injuries; and Treatment rendered.

Monro-Kellie Doctrine states that the contents of the skull—brain, blood, and CSF—are at a fixed volume and a change in volume of one is compensated by a decrease in the other two.

multicasualty incident (MCI) an incident involving a large number of persons injured in which the EMS system is unable to manage the situation utilizing day-to-day procedures. An MCI may be classified as a disaster, but not all disasters are MCIs nor are all MCIs disasters. Also referred to as a mass casualty incident.

narcotic a drug that reduces consciousness and relieves pain derived from opium.

neurogenic shock shock caused by spinal injury in which the spinal connections to the adrenal glands and to the blood vessels are interrupted and the vasoconstrictors, epinephrine and norepinephrine, are not produced. Without the vasoconstrictors the blood vessels dilate and redistribute blood flow to a larger vascular volume, causing relative hypovolemia, and the heart muscle cannot be stimulated to contract harder and faster.

neurovascular injury an injury that involves nerves and blood vessels. Also called *neurovascular compromise*.

neutral alignment aligning the patient according to the baseline physiologic spinal position.

nonaccidental trauma (NAT) injury that is deliberately inflicted upon an individual; previously referred to as "child abuse." Also called *nonaccidental injury (NAI)*.

nonfatal drowning a drowning in which the person survives.

no-reflow phenomenon the inability of restoring oxygenation and blood pressure to restore perfusion to the cortex after an anoxic episode of 4–6 minutes or more.

normal ventilation the movement of air into and out of the lungs is able to maintain the carbon dioxide level between 35 and 45 mmHg.

occupant restraint systems systems built into a vehicle to prevent the driver and passengers from being thrown about the interior of the vehicle or from being ejected from the vehicle in the event of a collision, such as seat belts and airbags.

open-book pelvic fracture a severe pelvic fracture in which the symphysis is torn apart and the anterior pelvis is "opened" like a book. This is frequently associated with disruption of one or both sacroiliac joints; a high-force injury.

open fracture a broken bone in which a piece of the bone is protruding through the overlying skin.

open pneumothorax accumulation of air in the pleural space secondary to penetrating injury presenting as an open or sucking chest wound (>3 cm in diameter).

opiate a drug derived from opium, which has analgesic effects.

OPIM short for *other potentially infectious material* to which an emergency care provider may be exposed (other than blood).

osteoporosis a condition frequently seen in older adults in which there is gradual loss of calcium in the bones with a decrease in bone mass and density, making the bones more easily fractured.

paradoxical pulse a clinical sign of cardiac tamponade. It is an exaggeration of the normal variation of the strength of the pulse during the inspiratory phase of respiration, in which the blood pressure decreases as one inhales and increases as one exhales. The paradox is that, in the case of a pericardial tamponade with decreased cardiac output, the palpated radial pulse disappears during inspiration. Also called *pulsus paradoxus*.

paresthesia abnormal sensation; a "tingling" or "burning" sensation.

Parkland formula a formula to calculate initial fluid resuscitation of the burn patient. The formula is: fluid needs for first of Ringer's lactate or normal of burn weight in kilograms.

patent airway an open airway.

pathophysiology of aging the process of aging that consists of the gradual decline in the normal function of many body systems, which may in part be responsible for greater risk of injury in the elderly population.

patient restraint methods of limiting the motion and mobility of patients to prevent them from becoming a danger to themselves or others.

penetrating trauma an injury produced when an object penetrates the skin, creating an open wound, and possibly damaging deeper structures.

pericardial tamponade the rapid collection of blood between the heart and pericardium from a cardiac injury. The accumulating blood compresses the ventricles of the heart, preventing the ventricles from filling between contractions and causing cardiac output to fall.

peritoneum a thin serous membrane that lines the abdominal cavity and covers the organs of the abdomen.

personal protective equipment (PPE) equipment that an emergency care provider dons for protection from various dangers that may be present at a trauma scene. At a minimum, PPE entails wearing protective gloves. At a maximum, PPE is a chemical suit and self-contained breathing apparatus.

PFD personal flotation device.

physiological changes the normal changes that occur to the body of a woman as she progresses through her pregnancy. These affect blood volume, vital signs, and even response to hypovolemia.

pleural space the potential space between the visceral and parietal pleura within the thorax. In disease or injury states this space can fill with air, fluid, or blood.

PMS stands for pulses, motor function, and sensation.

postexposure prophylaxis (PEP) the administration of medications to prevent infection from the agent to which the person was exposed.

preventable death those conditions that will result in patient death prior to arrival at definitive care if they are not addressed.

primary brain injury the immediate damage to the brain tissue that is the direct result of an injury force.

primary hypothermia a condition in which the core body temperature is less than 35°C or 95°F following exposure to cold.

primary spinal cord injury injury to the spinal cord that occurs at the time of the trauma itself. This injury results from the cord being cut, torn, or crushed or by its blood supply being cut off.

pulse oximeter a noninvasive device for measuring the oxygen saturation of the blood.

pulse pressure the pressure driving blood through the vascular system. It is calculated by subtracting the diastolic from the systolic blood pressures (SBP – DBP = PP).

radiation injury injury to the skin and tissues from the effect of ionizing radiation. The injury is caused by the radiation breaking molecular bonds within the cell and cannot be differentiated from thermal burns by appearance alone.

rapid extrication the rapid removal of a patient from a dangerous position or situation using modified SMR.

rapid sequence intubation (RSI) a process in which endotracheal intubation is performed on a patient at high risk for aspiration, by providing sedation, paralysis, and limiting manual ventilation after paralysis until intubation is completed.

rapid trauma survey a brief exam from head to toe and back, performed to identify life-threatening injuries.

reassessment exam an exam performed repeatedly on an ongoing basis. Its purpose is to find any changes in the patient's condition.

rehabilitation process by which response personnel on a scene are provided with rest, fluid replenishment, and medical assessment.

remote assessment medicine (RAM) assessing an injured subject or team member without making physical contact.

Rescue Task Force (RTF) Concept A team composed of EMS and law enforcement personnel working together to provide evacuation and immediate care to victims in an active shooter event.

retroperitoneal abdomen the part of the abdomen behind the thoracic and true portions of the abdomen, separated from the other abdominal regions by a thin retroperitoneal membrane; includes the kidneys, ureters, pancreas, posterior duodenum, ascending and descending colon, abdominal aorta, and the inferior vena cava.

rhabdomyolysis disintegration (lysis) or dissolution of muscle. This releases large amounts of myoglobin into the blood, which can precipitate in the kidneys, causing renal failure.

rule of nines a method of estimating the body surface area burned by a division of the body into regions, each of which represents approximately 9% of the total surface area, plus 1% for the genital area.

SAMPLE history the minimum amount of information needed for a trauma patient; the letters in SAMPLE stand for symptoms, allergies, medications, past medical history, last oral intake, and events preceding the incident.

scene size-up observations made and actions taken at a trauma scene before actually approaching the patient. It is the initial step in the ITLS Primary Survey.

SCIWORA refers to spine injuries that are not identified on plain x-rays or a CAT scan. The letters stand for spinal cord injury without radiographic abnormality.

seat-belt sign a bruise or abrasion across the abdomen from an improperly positioned lap belt. It can be a clue to blunt intra-abdominal injury.

secondary brain injury an injury to the brain that is the result of hypoxia and/or decreased perfusion of brain tissue after a primary injury.

secondary collision when an unsecured object continues to move after the vehicle collides with something (primary collision), and the object strikes an occupant (or unsecured occupant strikes vehicle interior).

secondary hypothermia Low body temperature resulting from previous illness or as a result of medical treatment.

secondary insult damage that is not the direct result of the trauma but due to trauma-induced changes in body systems; for example, hypoxia worsening traumatic brain injury.

secondary spinal cord injury injury to the spinal cord that occurs from hypotension, generalized hypoxia, injury to blood vessels, swelling, compression of the cord from surrounding hemorrhage, or injury to the cord from movement of a damaged and unstable spinal column.

simple pneumothorax the presence of air in the pleural space that causes the lung to separate from the chest wall and can compromise the mechanics of breathing.

smoke-inhalation injury injury to the lungs or other body organs from inhalation of toxic gases found in smoke.

span of control the number of individuals a supervisor is responsible for, usually expressed as the ratio of supervisors to individuals. (Under the U.S. National Incident Management System, an appropriate span of control is between 1:3 and 1:7.)

special weapons and tactics (SWAT) A designated law enforcement team whose members are recruited, selected, trained, equipped and assigned to resolve critical incidents involving a threat to public safety which would otherwise exceed the capabilities of traditional law enforcement first responders and/or investigative units.

spinal column the 33 vertebrae that house and protect the spinal cord.

spinal cord an electrical conduit composed of specific bundles of nerve tracts. It connects the brain to the muscles and organs of the body.

spinal motion restriction (SMR) techniques and equipment primarily used in the field that help to minimize movement of the spine in cases where the patient's spine cannot be completely immobilized.

sprain a sudden twist of a joint with stretching or tearing of ligaments.

standard precautions steps each health care worker takes to protect him- or herself and the patient from exposure to infectious agents; includes treating each patient and him- or herself as if they were infectious.

standard precautions steps each health care worker takes to protect themselves and their patient from exposure to infectious agents; includes treating each patient and him- or herself as if infectious. At a minimum this entails wearing gloves, frequently requires a face shield, and occasionally requires a protective gown.

strain a stretching or partial tearing of a muscle or musculotendinous unit.

supine hypotension syndrome the drop in blood pressure seen when a woman who is greater than 20 weeks pregnant is in the supine position. The hypotension is caused by the weight of the pregnant uterus pressing on the inferior vena cava and decreasing the return of blood to the heart by up to 30%.

supraglottic airway (SGA) an airway that can be inserted without having to visualize the larynx. Previously called blind insertion airway device (BIAD).

tactical combat casualty care Also called TCCC; guidelines for the care of combat casualties developed by the Committee on Tactical Combat Casualty Care (CoTCCC).

tactical EMS (TEMS) provision of emergency medical services in a tactical environment, usually with high threats and resource constrained.

temporary cavity the maximum temporary displacement of tissue due to the hydrostatic shock from a bullet's passage.

tension pneumothorax a condition in which air continuously leaks out of the lung into the pleural space. The air continues to accumulate without means of exit, resulting in increasing intrathoracic pressure on the affected side and eventual collapse of the superior and inferior vena cava as well as the lung.

thermal injury injury to the tissues caused by heat from flame, hot liquids, hot gases, or hot solids.

TIC short for Tenderness, Instability, Crepitus.

tidal volume the amount of air that is inspired and expired during one respiratory cycle.

tranexamic acid (TXA) a synthetic analog of the amino acid lysine. An antithrombolytic agent, it works by blocking the activation of plasminogen to plasmin, which normally breaks down clots in the body. It has been used in surgery to reduce blood loss, particularly in obstetric, gynecologic, and orthopedic procedures. It has been shown to be effective in care of hemorrhage from trauma.

traumatic cardiopulmonary arrest (TCPA) a grouping of conditions defined by the common precipitating factor of trauma as the origin for the cardiac arrest.

triad of death a lethal combination of hypothermia, coagulopathy, and metabolic acidosis.

triage to prioritize or sort injuries or the injured, usually into four categories: Priority 0, 1, 2, and 3 (Black, Red, Yellow, Green).

true abdomen the part of the abdomen from the lower ribs and including the pelvis but anterior to the retroperitoneum; contains the large and small intestines, a portion of the liver, and the bladder. In a female, the uterus, fallopian tubes, and ovaries are also part of the true abdomen.

uncooperative patients patients who behave inappropriately and do not respond to reasonable requests and limits placed on them for their own safety and that of caregivers. Based on jurisdiction, a range of options are available for restraining patients against their will when warranted for patient safety, assessment, and care. A variety of physical and chemical restraints can be implemented.

unsalvageable patient one who does not have a reasonable expectation for resuscitation and survival based on defined clinical indicators and parameters. It is acceptable to withhold resuscitation under those conditions.

vasoconstriction the constriction (narrowing) of the small arteries (arterioles) to maintain the blood pressure and perfusion of vital organs.

ventilation the movement of air or gases into and out of the lungs.

viscus internal body organ; plural: viscera.

withholding or terminating resuscitation based on research and published guidelines, attempting to resuscitate the patient in cardiac arrest may be withheld or terminated in certain instances.

wound ballistics the study of the behavior of the projectile when it strikes the target and transfers energy to the target.

wound track the path through the tissue made by a projectile.

This page intentionally left blank

Index

A

Abdominal trauma
  anatomy of abdomen, 271
  assessment of, 273–274
  in children, 370
  evisceration, caring for, 273, 275
  injuries, types of, 271–272
  new trends in managing, 275–276
  pregnant patients and, 395
  scene size-up, 272–273
  sonography, 59
  stabilization, 274–275
Abruption placenta, 396
Absolute hypovolemia, 82–83
Abuse, child, 256, 347, 355
Active shooter events, scene size-up, 26
Acute epidural hematoma, 258
Acute subdural hematoma, 259
Adam's apple, 119
Adult respiratory distress syndrome (ARDS), 254
Advanced cardiac life support (ACLS), 318
Advanced Life Support (ALS) ambulance, 23
Aging pathophysiology, 378–380
Airbags, 30–32
Airway management
  adjuncts, 124–127
  anatomy, 118–121
  assessment, 50
  bag masks, using, 131–132, 140–141
  basic procedures, 137–141
  blind insertion airway devices, 125–126
  burns and, 334
  capnography, 121, 160–163
  capnometry, 160–163
  in children, 358, 360
  drug-assisted intubation, 126, 165–169
  in elderly, 378
  endotracheal tubes, anchoring, 164
  endotracheal tubes, description of, 126–127
  endotracheal tubes, placement of, 158–160
  equipment/kit, 133, 151–152
  face-to-face (tomahawk method) intubation, 156, 158
  fiberoptic and video intubation, 169–170
  intubation, 151–170
  laryngeal mask airway, 148–151
  laryngoscopic orotracheal intubation, 153–157
  nasopharyngeal airways, 124, 138–139
  oropharyngeal airways, 124–125, 139–140
  oxygen, supplemental, 128
  patent/open airway, 121–123
  placement of tubes, 158–160
  pocket mask with supplemental oxygen, using, 140
  pulse oximeters, 129, 141–142
  spinal trauma and, 213, 219, 230
  suctioning, 123–124, 138
  supraglottic airways, 125–126, 143–151
  thoracic trauma and, 177
  traumatic cardiopulmonary arrest and, 316–317, 323
  troubleshooting while monitoring, 163–164
  ventilation, 117, 128–132
Alcohol abuse. *See* Impaired patients
All-terrain vehicles (ATV), accidents, 27
Altered mental status, 379
Alveolocapillary membrane, 118, 129
Amputations, 285–286
Anatomy
  abdomen, 271
  airway, 118–121
  fetal development, 390
  head, 251
  skin, 328–329
  spinal column and cord, 206–208
  thorax, 173–175
Anoxic brain injury, 258
Aortic rupture/tear, 187–188
Arachnoid, 251
Artificial ventilation, 129–130
  in children, 361–363
Assessment. *See also* Patient assessment
  of abdominal trauma, 273–274
  of burns, 331–335
  of extremity trauma, 288
  of head trauma, 260–265
  of spinal trauma, 205–206, 211–212, 216, 234
  of thoracic trauma, 175–177
  of traumatic cardiopulmonary arrest, 319–322
Asystole, 321
AVPU, 49, 50

B

Backboards
  long, 215, 238–241
  purpose of, 219
  removing patient from, 231–232
  securing patients onto, 243–245
  short, 218
Bag-valve-masks (BVM), using, 131–132, 140–141
Battle's sign, 262
Beck's triad, 88, 185, 318
Benzodiazepines, 165, 168
Blast injuries, 35–36, 189
Blast scenes, assessment of, 25–26
Bleeding, controlling. *See also* Hemostatic agents; Tourniquets
  in children, 364
Blind insertion airway devices (BIADs), 125–126, 143
Blunt cardiac injuries (BCIs), myocardial contusion, 186–187
Blunt trauma
  body collision, 29
  defined, 27
  machine collision, 28
  organ collision, 29, 30
Body collision, 29
BOOTS mnemonic, 132
Brain
  anoxic brain injury, 258
  cerebral contusion, 257
  cerebral herniation syndrome, 254–255
  concussions, 256–257
  diffuse axonal injury, 257
  in elderly, 379
  injuries, in children, 368–369
  injuries, primary and secondary, 252–253
  injuries, types of, 252–253, 256–260
  intracranial hemorrhage, 258–259
  intracranial pressure, 253–254
  pathophysiology of, 252–255
  subarachnoid hemorrhage, 259–260
Breathing assessment, 50–51
  in children, 360–361
Bronchi, 121
Bronchial tree injury, 188
Broselow tape, 106
Bullets, tissue injury, 34
Burn centers, 336
Burn depth, 330, 331
Burns
  airway compromise, 334
  assessment of, 331–335
  characteristics of various depths of, 330
  chemical, 340–342
  children and, 332, 333, 347–348
  circumferential, 336–337, 346
  cooling, 335
  depth classification of, 330, 331
  determining severity of, 330–332
  electrical, 342–344
  flash, 337
  fluid resuscitation, 335, 346
  inhalation injuries, 337–339
  lightning injuries, 344–345
  Lund and Browder chart, 332, 333
  management of, 335–348
  minor, 347
  pain medication administration, 335–336
  pregnant patients and, 396
  radiation, 345
  rapid trauma survey, 334–335
  rule of nines, 331, 332

Burns (*continued*)
scene size-up, 333–334
secondary transport, 346–347
types of, 328
BURP maneuver, 120
Bystanders, assessment of, 25

C

Cannulation of external jugular vein, 98
Capacity, 405
Capillary refil, 80
Capnography, 91–92, 121, 160–163, 323–324
Capnometry, 160–163
Carbon monoxide poisoning, 337–338
Carboxyhemoglobin binding, 337
Cardiac arrest. *See* Traumatic cardiopulmonary arrest (TCPA)
Cardiac tamponade, 87–88, 184–186
Cardiogenic shock, 80, 82, 88–90
Cardiopulmonary resuscitation, 397
Carina, 121
Car seats, 371–372
Cavitation, 272
Celox, 84
Central neurogenic hyperventilation, 264
Cerebral contusion, 257
Cerebral herniation syndrome, 53, 254–255
Cerebral perfusion pressure (CPP), 253
Cerebrospinal fluid (CSF), 207, 251
Cervical collars, 205, 213, 230, 235
Cervical spine stabilization, 49–50
Chemical burns/injury, 340–342
Chest decompression
anterior approach, 195–197
indications for performing, 194
lateral approach, 197–199
open pneumothorax, 199–200
Chest injuries. *See* Thoracic trauma
Child abuse, 256, 355
Children
abdominal trauma, 370
airway assessment, 358, 360
artificial ventilation, 361–363
assessment of, 355–364
bleeding, controlling, 364
breathing, assessment of, 360–361
burns, 332, 333, 347–348
cardiac arrest, 320
chest trauma, 369–370
circulation, assessment of, 364
communicating with, 353–354
endotracheal intubation, 362–363
equipment needed to treat, 356
fluid resuscitation, 368
Glasgow Coma Scale, 367
head/brain injuries, 368–369
intraosseous infusion, manual, 103–104
length-based resuscitation tapes to estimate weight of children, 106, 107, 355
mechanisms of injury, common, 355, 358
oxygen, supplemental, 363
parental consent, 354–355
rapid trauma survey, 365–367
shock in, 364, 367–368
spinal trauma and, 206, 210, 219, 222, 370–371
stabilizing uninjured, in car seat, 371–372
vital signs, 364
Child restraint seats, 371–373
Chronic disease, 382
Circulation assessment
in children, 364
in elderly, 378–379
Circulatory problems, traumatic cardiopulmonary arrest and, 318–319
Circumferential burns, 336–337, 346
Civilian tactical emergency casualty care (C-TECC), 26
Clavicle injuries, 298
Closed-ended questions, 403
Closed fractures, 282
Colorimetric CO_{22} detectors, 161
Combat Application Tourniquet (CAT), 110, 285
Combitube, esophageal tracheal, 125
Commotio cordis, 319
Communication
with family and children, 353–354
with receiving hospital, 284, 342, 346
Compartment syndrome, 287
Compensate, 379
Compensated shock, 81, 367
Compliance, 130–131
Compression syndrome, 398
Concussions, 256–257
Consent, parental, 354–355
Contracoup, 252
Coup, 252
Crash/rescue scenes, assessment of, 24–25
Crepitation, 288
Cricoid, 120
Cricoid cartilage, 120, 121
Cricothyroid membrane, 120, 121
Crime scenes, assessment of, 25
Crush injuries, 287–288, 301–302
Crush syndrome, 287–288
Cullen's sign, 273
Cushing's reflex/response, 253
Cyanide inhalation, 338

D

DCAP-BLS, 57, 58
"Decade of Action for Road Safety (2,031–2,040)", 39
Decompensated shock, 81, 368
Dermis, 328, 330
Diaphragm, 92, 174, 175, 199, 271
Diaphragmatic rupture/tear, 188
Diffuse axonal injury, 257
Direct-vision orotracheal intubation, 127
Disease, 27
Dislocations, 284
Distributive (relative hypovolemia) shock, 82, 85–86
Domestic violence, 396
Drug-assisted intubation (DAI), 126, 165–169, 262
Drugs/drug abuse. *See also* Impaired patients
categories and specific treatments and assessment, 406
commonly abused, with signs and symptoms, 401
effects on the elderly, 380
Dura mater, 251

E

Early shock, 80
Elbow injuries, 299–300
Elderly. *See* Geriatric trauma
Electrical burns/injury, 342–344
Emergency and Military Tourniquet® (EMT), 111
Emergency medical services (EMS), 26, 37, 39
Emergency Rescue
defined, 212
spinal trauma and, 212, 236–238
Endotracheal intubation, in children, 362–363
Endotracheal tubes (ETTs)
anchoring, 164
description of, 118, 121, 126–127
placement of, 159–160
Epidermis, 328, 330
Epiglottis, 118, 119
Equipment
airway, 133
essential, 26–27
intubation, 151–152
needed for trauma patients, 46
needed for treating children, 356
personal protective, 24
Eschar, 330, 336–337
Esophageal detector device (EDD), 159
Esophageal tracheal Combitube, 125
Esophagus, 120
Essential equipment, 26–27
$ETCO_{22}$ detection, 160–161
Etomidate, 168
Evisceration
caring for, 275
defined, 273
Excited delirium (EXD), 404–407
Explosions, 25–26, 35–36
External hemorrhage, 84
External jugular vein, cannulation of, 98
External laryngeal manipulation (ELM), 120
Extremities, head trauma and, 263
Extremity trauma
amputations, 285–286
assessment of, 288
clavicle injuries, 298
compartment syndrome, 287
crush injuries, 287–288, 301–302
dislocations, 284
elbow injuries, 299–300
femur injuries, 296
forearm and wrist injuries, 300–301
fractures, 282–284
hand or foot injuries, 301
hemostatic agents, 287, 295
hip injuries, 296–297
impaled objects, 287
knee injuries, 297–298
management of, 288–289
neurovascular injuries, 282, 286
open wounds, 284–285
pelvis injuries, 295–296, 312–313
scene size-up, 288
shoulder injuries, 298–299
spinal injuries, 288, 295
splinting, 289, 295, 297, 306–311
sprains and strains, 286
tibia and fibula injuries, 298
tourniquets, 284–285, 294–295
EZ-IO device, 99–102

F

Face-to-face (tomahawk method) intubation, 156, 158
Facial injuries, 255–260
Falls, 32–33
  elderly and, 377
  pregnant patients and, 396
Family, communicating with, 353–354
Farms
  scene size-up, 25
  tractor accidents, 27, 29
FAST (focused assessment with sonography in trauma), 59, 276, 396–397
FAST Responder intraosseous device, 104–105
Fédération Internationale de Football Association (FIFA), 257
Femur injuries, 296
Fetal development, 390
Fiberoptic intubation, 169–170
Fibula injuries, 298
Flail chest, 177–179
Flash burns, 337
Flashover, 333, 344, 345
Fluid resuscitation
  burn patients and, 335, 346
  cannulation of external jugular vein, 98
  in children, 368
  defined, 368
  intraosseous infusion, 98–99
  intraosseous infusion using EZ-IO device, 99–102
  length-based resuscitation tapes to estimate weight of children, 106, 107
Focused exam, 23, 44, 45, 51–52
Foot injuries, 301
Forearm injuries, 300–301
Fractures
  closed, 282
  extremities and, 282–284
  open, 282, 284
  rib, 177, 190
  skull, 256
  sternal, 190
Frontal impact, 27, 29

G

Gagging, 124
Gastrointestinal system, in elderly, 380
General impressions, 49
Geriatric trauma
  aging pathophysiology, 378–380
  altered mental status, 379
  assessment of, 381–385
  defined, 377
  falls, 377
  injury, risk of, 381
  medications, effects of, 381
  spinal trauma and, 222–224
  transporting, 384–385
Glasgow Coma Scale (GCS), 53, 56, 85, 264, 367
Glottic opening, 119, 121
Glottis, 121
Golden Period, 289, 403

H

Hand injuries, 301
Hare traction splint, 294, 308–310
Hazmat incidents, assessment of, 25
Head motion-restriction device, 230
Head trauma
  anatomy of head, 251
  assessment of, 260–265
  brain injuries, primary and secondary, 252–253
  brain injuries, types of, 252–253, 256–260
  cerebral herniation syndrome, 254–255
  in children, 368–369
  facial injuries, 255–260
  intracranial pressure, 253–254
  management of, 265
  seizures, 265
  shock and, 85
  skull injuries, 256
  vital signs, 264–265
  vomiting, 262
Heat-inhalation injury, 337–339
Helmets, spinal trauma and removing, 222–224, 246–248
HemCon Dressing, 84
Hemorrhage
  control of life-threatening, 107–108
  external, 84
  internal, 84
  intracranial, 258–259
  posttraumatic, 82
  subarachnoid, 259–260
Hemorrhagic shock, 79, 291, 322, 364, 367–368
Hemostatic agents, 51
  defined, 84
  extremity trauma and use of, 287, 295
  use of, 112, 113
Hemothorax, massive, 181–182
High-energy event, 28
High-space (relative hypovolemia, vasodilatory) shock, 82, 85–86, 210, 393
Hip injuries, 296–297
Hyoid bone, 118
Hyperventilation, 128, 265
Hyperventilation rates, 255
Hypopharynx, 119
Hypotension, 81, 82, 252–254
Hypothermia, 258, 335, 379, 406
Hypovolemic shock, 80, 82–83, 85–86, 393
Hypoxemia, 316, 317, 394
Hypoxia, 253

I

i-gel supraglottic airway, 146–148
Immune system in elderly, 380
Impaired patients. *See also* Drugs/drug abuse
  assessment of, 402–403
  excited delirium, 404–407
  handling uncooperative patients, 404
  how to obtain patient's cooperation, 403
  substance abuse, 400–402
Impaled objects, 190, 287
Index of suspicion, 28
Inhalation injuries, 337–339, 349
Initial assessment, 44, 45, 49–51
Injury
  blast/explosion, 35–36
  bullets, tissue injury, 34
  patterns, mechanism of injury and, 27, 29
Interactive style, 403
Intermittent positive pressure ventilation (IPPV), 129–130
Internal hemorrhage, 84
Intracerebral hemorrhage, 260
Intracranial hemorrhage, 258–259
Intracranial pressure (ICP), 53, 253–254
Intraosseous infusion (IO)
  complications, 99
  FAST Responder device, 104–105
  indications and contraindications, 99
  recommended sites, 99
  role of, 98
  using EZ-IO device, 99–102
Intrathoracic abdomen, 174, 271
Intubation. *See also* Airway management
  drug-assisted, 126, 165–169
  endotracheal, in children, 362–363
  face-to-face, 156, 158
  fiberoptic and video, 169–170
  laryngoscopic orotracheal intubation, 153–157
  preparation for, 151–152
  rapid sequence, 127
  wrap, 152
ITLS Primary Survey. *See also* Assessment; Patient assessment
  description of, 23, 44–51
  procedure, 64–69
ITLS Reassessment Exam
  description of, 23, 44, 45, 55, 56
  procedure, 71–73
ITLS Secondary Survey
  description of, 23, 44, 45, 56–59
  procedure, 74–76

J

Joint dislocations, 284
Junctional tourniquets, 112

K

Kehr's sign, 273
Kendrick extrication device, 218, 236–237, 294
Ketamine, 168
Kinetic energy (KE), 27
King LT-D airway, 125, 143–146
Knee injuries, 297–298
Knife wound, 33
Kyphosis, 379

L

Lactate levels, 59, 276
Laryngeal mask airway (LMA), 125, 126, 148–151
Laryngeal prominence, 119, 120
Laryngoscopic orotracheal intubation, 153–157
Laryngospasm, 120
Larynx, 119–121
Lateral impact, 27, 29
Late shock, 80–81
Length-based resuscitation tapes to estimate weight of children, 106, 107, 355
Level of consciousness (LOC)/mental status, 49–50
Lift-and-slide technique, 231
Lightning injuries, 344–345
Loadand-go situation, 54
Log roll, 215, 217, 231, 239–241, 296
Low-volume (absolute) shock, 82

Lund and Browder chart, 332, 333
Lung compliance, 123
Lungs, 121

M

Machine collision, 28
Mass casualty incident (MCI), 23
Massive hemothorax, 181–182
Mass shooting events, scene size-up, 26
Mean arterial blood pressure (MAP), 253
Mechanical (cardiogenic or obstructive) shock, 81, 82, 86–88
Mechanism of injury (MOI)
  blunt trauma, 27–33
  defined, 27
  penetrating trauma, 33–36
Mediastinum, 174
Medical direction, contacting, 54–55
Medically assisted airway management (MAAM). *See* Drug-assisted intubation
Medications, elderly and effects of, 381
Mental status
  altered, 81, 379
  level of consciousness (LOC)/mental status, 49–50
Miller body splint, 218, 243, 245
Minute volume, 128
MIST Report, 59, 60
Monro-Kellie Doctrine, 251
Motorcycle helmets
  spinal trauma and removing, 222–224, 246–248
Motor-vehicle collisions (MVCs)
  body collision, 29
  features, 27
  high-energy event, 28
  index of suspicion, 28
  injuries, patterns of, 27, 29
  machine collision, 28
  occupant restraint systems, 30–32
  organ collision, 29, 30
  pregnant patients in, 395
  secondary collisions, 30
  vehicle safety mechanisms, 30
Mouth-to-mask ventilation, 131
Mouth-to-mouth ventilation, 131
Multiple-casualty incidents (MCIs), 23, 26
Musculoskeletal system, in elderly, 379–380
Myocardial contusion, 88, 89, 186–187
Myocardial infarction (MI), 89

N

Nasal cavity, 118
Nasopharyngeal airways (NPAs)
  description of, 124
  inserting, 138–139
Nasopharynx, 118
Neck wounds, spinal trauma and, 225
Neurogenic shock, 85, 210–211
Neurologic function, in the elderly, 379–380
Neurovascular injuries/compromise, 281, 286
Neutral alignment, 213
Newton's first law of motion, 27, 28
Nonaccidental injury (NAI), 358
Nonaccidental trauma (NAT), 358
No-reflow phenomenon, 258
Normal ventilation, 128

O

Obese patients, spinal trauma and, 219, 224
Obstructive shock, 80, 82, 86–88
Occupant restraint systems, 30
Open-book pelvic fractures, 295
Open fractures, 282, 284
Open pneumothorax, 179–181, 199–200
Open wounds, to extremities, 284–285
OPIM (other potentially infectious material), 24
Organ collision, 29
Orlowski, James, 98
Oropharyngeal airway (OPA)
  description of, 124–125
  inserting, 139–140
Oropharynx, 118–119
Osteoporosis, 379–380
Other potentially infectious material (OPIM), 24
Oxygen, supplemental, 140
  for children, 363

P

Paradoxical pulse, 185
Paralytics, 167, 168
Parents
  communicating with, 353–354
  consent from, 354–355
Paresthesia, 210
Parkland formula, 346
Patellar dislocation, 298
Patent/open airway, 121–123
Pathophysiology
  of head trauma, 252–255
  of shock, 80–81
  of spinal-cord injury, 210
  of thoracic trauma, 175
Patient assessment. *See also* Assessment
  adjuncts for, 59
  airway, 50
  breathing, 50–51
  of children, 355–364
  circulation, 51
  components of, 45, 65
  defined, 44
  of elderly, 381–385
  focused exam, 23, 44, 45, 51–52
  general impressions, 49
  ground rules for teaching and evaluating, 77
  of impaired patients, 402–403
  initial, 44, 49–51
  ITLS Primary Survey, 23, 44–51, 64–69
  ITLS Reassessment Exam, 23, 44, 45, 55, 56, 71–73
  ITLS Secondary Survey, 23, 44, 45, 56–59, 74–76
  level of consciousness (LOC)/mental status, 49–50
  of pregnant patients, 393–394
  rapid trauma survey, 23, 44, 45, 51–53, 69–71
  SAMPLE history, 53–54
  scene size-up and, 45–49
  transport decisions, 54
Patient restraints, 404
Patients, scene size-up and determining number of, 26
Pedestrian *versus* car, 27, 29
Pediatric Assessment Triangle, 358
Pediatric trauma. *See* Children
Pelvis injuries, 282, 295–296
  stabilization techniques, 295–296, 312–313
Penetrating injuries, 174, 395
Penetrating trauma
  blast/explosion, 35–36
  defined, 33
  wound ballistics, 33–34
Pericardial tamponade, 87–88, 184, 318
Peritoneum, 273
Personal protective equipment (PPE), 24
Pharmacologically assisted laryngeal mask (PALM), 151
Physiologic changes during pregnancy, 391–393
Pleural space, 174
Pneumatic antishock garment (PASG), 270
Pneumothorax
  open, 179–181, 199–200
  simple, 190
  tension, 86–87, 182–184
Pocket mask with supplemental oxygen, using, 140
Positive pressure ventilation, 129–130
Posttraumatic hemorrhage, 82
potentially life-threatening injury, 27
Pregnancy/pregnant patients
  abdominal trauma, 395
  abruption placenta, 396
  assessment of, 393–394
  burns, 396
  cardiac arrest, 320, 393
  cardiopulmonary resuscitation, 397
  domestic violence, 396
  falls, 396
  FAST exam, 396–397
  fetal development, 390
  hypovolemia, 393
  motor-vehicle collisions, 395
  penetrating injuries, 395
  physiologic changes during, 391–393
  supine hypotension syndrome, 393
  transporting, 215, 394
  uterine size, assessment of, 395
Preventable death, 36
Primary brain injury, 252–253
Primary spinal cord injury, 210
Priorities of trauma care
  airway, 36, 37
  breathing, 36, 37
  circulation, 36, 37
  prevention and public education, 37, 39
  secondary insults, 36
  trauma triage decisions, 37, 38
  XABC, 36, 37
Procedures
  airway management, basic, 137–141
  bag masks, using, 140–141
  blast injuries, management of, 189
  cannulation of external jugular vein, 98
  capnography, 162–163
  cardiac tamponade, management of, 186
  chemical burns, removing source of, 340–341
  chest decompression, anterior approach, 195–197

chest decompression, lateral approach, 198–199
chest seal for penetrating chest wound, placement of, 200
diaphragmatic tears, management of, 188
face-to-face intubation, 156, 158
flail chest, management of, 179
Hare traction splint, 308–310
head trauma, management of, 266–267
hemostatic agents, 113
i-gel supraglottic airway, inserting, 147–148
intraosseous infusion on a child, manual, 103–104
intraosseous infusion using EZ-IO device, 99–102
ITLS Secondary Survey, 74–76
King LT-D airway, inserting, 144–146
laryngeal mask airway, inserting, 148–151
laryngoscopic orotracheal intubation, 155–156
length-based resuscitation tapes to estimate weight of children, 106, 107
log roll, 242
massive hemothorax, management of, 182
myocardial contusion, management of, 187
nasopharyngeal airways, inserting, 138–139
open pneumothorax, management of, 180–181
oropharyngeal airway, inserting, 139–140
patient positioning, 137
pelvic stabilization techniques, 295, 312–313
pocket mask with supplemental oxygen, using, 140
potential aortic tears, management of, 188
primary survey, performing, 64–69
reassessment exams, performing, 72–73
Sager traction splint, 308, 311
shock, internal hemorrhage, 85
shock, when bleeding has been controlled, 83
splinting, 290–291
suctioning airway, 138
tension pneumothorax, management of, 184
Thomas (half-ring) traction splint, 306
tourniquet, 111
traumatic cardiopulmonary arrest, management of, 321
tube placement, confirmation of, 158–159, 162–163
wound packing, 108
Protective gear, spinal trauma and removing, 222–224
Pulmonary contusion, 189
Pulse
distal to injury, 289
oximeters, 129, 141–142
paradoxical, 185
pressure, 80
thready, 83
Pulse, motor function, sensation (PMS), 55, 289
Pulse oximeters, 129
Pulsus paradoxus, 88, 185, 318
Pupils
head trauma and, 262–263
impaired patients and, 402
Pyriform fossa, 119

Q

Qualitative capnometry, 160, 161
Quantitative capnometry, 160, 161
Quantitative waveform capnography, 160, 161
QuikClot® Combat Gauze, 84

R

Raccoon eyes, 138, 262–263
Radiation burns/injury, 345
Rapid extrication
defined, 212
spinal trauma and, 212, 236–238, 239
Rapid sequence airway (RSA), 127
Rapid sequence intubation/induction (RSI), 127. *See also* Drug-assisted intubation
Rapid trauma survey, 23, 44, 51–53, 69–71
Rear impact, 27, 29
Reeves sleeve, 218, 243, 245, 246, 405
Relative hypovolemia, 82, 85–86
Renal system, in elderly, 379
Respiration, 72, 74, 128
in elderly, 378
Respiratory rates, normal *versus* abnormal, 53
Restraints, 404
Resuscitation tapes, length-based, 106, 107
Resuscitation, withholding or termination of, 315–316
Resuscitative endovascular balloon occlusion of the aorta (REBOA), 92
Retroperitoneal abdomen, 271
Rhabdomyolysis, 344
Ribs
flail chest, 177–179
fractures, 177, 190
Rocuronium, 168
Rule of nines, 331, 332

S

Safety. *See also* Standard precautions
scene, 24–26
spinal motion restriction and patient, 204
Sager traction splint, 294, 308, 311
SAMPLE history, 53–54
Scalp, 251
scalp wounds, 255–256
shock and, 255
wounds, 255–256
Scene size-up
defined, 23
mechanism of injury (MOI), 27–36
patient assessment, 45–49
patients, number of, 26
scene safety, 24–26
standard precautions, 24
steps of, 24
SCIWORA, 371
Scoop stretchers, 243–245, 296
Seat-belt sign, 273
Secondary brain injury, 252–253
Secondary collisions, 30
Secondary insults, 36
Secondary spinal cord injury, 210
Secondary transport, 346–347
Seizures, head trauma and, 265
Sellick maneuver, 120
Sensory function, in the elderly, 379
Septum, 118, 125, 138, 139
Shock
cardiogenic, 80, 82, 88–90
in children, 364, 367–368
compensated, 81, 367
decompensated, 81, 368
defined, 79
distributive (relative hypovolemia) shock, 82, 85–86
early, 80
head injuries and, 85, 255
hemorrhagic, 79, 291, 322, 364, 367–368
high-space (relative hypovolemia, vasodilatory) shock, 82, 85–86, 210
hypovolemic, 80, 393
late, 80–81
low-volume (absolute) shock, 82
management, 83–85
mechanical (obstructive), 81, 82, 86–88
neurogenic, 85, 210–211
pathophysiology, basic, 80–81
in pregnant patients, 393
signs and symptoms, 81
spinal, 85–86, 210–211
syndromes, 82–83
tachycardia, evaluation of, 81–82
treatment, 90–92
vital signs, 264
Shockwave, 34
Shoulder injuries, 298–299
Silos, 25
Simple pneumothorax, 190
Simple rib fracture, 190
Situational awareness
additional resources, 27
essential equipment, 26–27
patients, number of, 26
scene safety, 24–26
scene size-up, 23–24
standard precautions, 22–23, 24
Skin, anatomy of, 328–329
Skull, 251, 252
fractures, 256
Small-vehicle crashes, 27, 29
Smoke inhalation, 338
SPARC system, 106
Spinal column, 206–208
Spinal cord, 207–208
Spinal-cord injury without radiographic abnormality (SCIWORA), 210
Spinal fluid, 207, 251
Spinal immobilization, 206, 215
Spinal injuries, 208–211, 295
Spinal motion restriction (SMR)
backboards, long, 215, 238–241
backboards, removing patient from, 231–232
backboards, securing patients onto, 243–245
backboards, short, 218
cervical collar, placing, 236
children and, 206, 210, 219, 222
in closed-space rescues, 219
complications of, 219
components of, 230
defined, 203
devices, 205, 217, 218
emergency rescue and, 212, 236–238
evolution of, 204–206
goals of, 230

Spinal motion restriction (SMR) (*continued*)
head and neck situations, 245
indications for, 204–206, 215, 230, 235
Kendrick extrication device, 218, 236–237
log roll, 215, 217, 231, 239–241
neck wounds and, 225
obese patients and, 219, 224
older adult patients, 222
patient safety and, 204
pediatric patients, 220
principles of, 230–233
prone, seated, and standing patients, 220
protective gear, removing, 222–224
rapid extrication and, 212, 236–238, 239
short extrication device, 236
water rescues, 219–221
Spinal shock, 86, 208
Spinal trauma. *See also* Spinal motion restriction (SMR)
airway intervention, 213, 219, 230
anatomy of spinal column and cord, 206–208
assessment of, 205–206, 211–212, 216
in children, 206, 210, 219, 222, 370–371
incidence of, 203
initial assessment and level of consciousness and, 49
log roll, 215, 217, 231, 239–241, 296
mechanisms of blunt, 208–210
movement, minimizing, 212–215
protective gear, removing, 222–224
restrictions, complications of, 219
restrictions, indications for, 204–206, 215
shock, 85–86, 210–211
splinting, 289, 295, 297
Splinting
procedure, 290–291
purpose of, 289
Splints
traction, 291, 292, 306–311
types of, 291–294
when to use, 289
Sport Concussion Assessment Tool, 257
Sprains, 286
Standard precautions
defined, 22–24
scene size-up and, 24
Steering wheel injuries, 30–32
Sternal fractures, 190
Sternal notch, 120, 121
"Stop the Bleed" public awareness campaign, 39
Straddle slide, 231
Strains, 286
Strapping systems, 230
Subarachnoid hemorrhage, 259–260
Substance abuse. *See* Impaired patients
Succinylcholine, 168
Sucking chest wound, 179–181
Suctioning airway, 123–124, 138
Supine hypotension syndrome, 393
Supplemental oxygen, 128
for children, 363
Supraglottic airways (SGA), 143–151, 363

T

Tachycardia, evaluation of, 81–82
Tactical combat casualty care (TCCC), 36
Tactical medicine (XABC), 36, 37
Temporary cavity, 34
Tenderness, instability, and crepitus (TIC), 57, 58
Tension pneumothorax, 86–87, 182–184
Thermal injury, 338
Thermoregulation, 379
Thomas (half-ring) traction splint, 306
Thoracic trauma
airway obstruction, 177
anatomy of thorax, 173–175
aortic rupture/tear, 187–188
assessment of, 175–177
blast injuries, 189
cardiac tamponade, 184–186
chest decompression, 194–200
in children, 369–370
diaphragmatic rupture/tear, 188
emergency care of chest injuries, 175–177
flail chest, 177–179
impaled objects, 190
massive hemothorax, 181–182
myocardial contusion, 186–187
open pneumothorax, 179–181
pathophysiology, 175
pulmonary contusion, 189
rib fractures, 177
simple pneumothorax, 190
simple rib fracture, 190
sternal fractures, 190
tension pneumothorax, 182–184
tracheal or bronchial tree injury, 188
traumatic asphyxia, 190
treatment goals, 191
Thorax, anatomy of, 173–175
Thready pulse, 83
Thyroid cartilage, 120
Tibia and fibula injuries, 298
Tibia injuries, 298
Tidal volume, 123, 128, 129
Tomahawk method, 156
Tourniquets, 51, 90, 93, 110–112
extremity trauma and use of, 284–285, 294–295
Trachea, 121
Tracheal/bronchial tree injury, 188
Tracheal rings, 121
Traction, 213
Hare, 294, 308–310
Kendrick, 236–237, 294
Sager, 294, 308, 311
Thomas (half-ring), 306
Traction splints, 291, 292
Tractor accidents, 27, 29
Tranexamic acid (TXA), 91, 276
Transport decisions, 54
children and, 371–372
elderly and, 384
pregnant patients and, 394
secondary, 339, 346–347
traumatic cardiopulmonary arrest and, 321
Trauma assessment. *See also* Assessment; Patient assessment
treatment decision tree, 64, 67–69
Traumatic aortic rupture, 187–188
Traumatic asphyxia, 190
Traumatic brain injury (TBI). *See* Brain; Head trauma
Traumatic cardiopulmonary arrest (TCPA)
airway and breathing problems, 316–317, 323
assessment of, 319–322
causes of, 317
in children, 320
circulatory problems, 318–319
defined, 315
guidelines for withholding or terminating resuscitation, 315–316
management of, 323–324
in pregnant patients, 320
transport, 321
True abdomen, 271
Turbinates, 118

U

Ultrasound, portable, 59, 323
Uncooperative patients, 404
Unsalvageable patient, 315–316
Uterine size, assessment of, 395

V

Vacuum mattress, 243
Vasoconstriction, 81
Vecuronium, 168
Vehicle collisions. *See* Motor-vehicle collisions (MVCs)
Ventilation
artificial, in children, 361–363
artificial/positive pressure, 129–130
compliance, 130–131
defined, 117
normal, 128–129, 255
rates, 255
techniques, 131–132
traumatic cardiopulmonary arrest and, 316–317, 323
Video intubation, 169–170
Viscus, 272
Vital signs
for children, 364
head trauma and, 264–265
shock and, 264
Vomiting, head trauma and, 262

W

Water, spinal trauma in, 219–221
Watercraft accidents, 27, 29
Windshield survey, 24, 39
Withholding/termination of resuscitation, 315–316
Wound ballistics, 33–34
Wound packing, 107–109
Wound track, 34
Wrist injuries, 300–301

Z

Zone of coagulation, 329
Zone of hyperemia, 329
Zone of stasis, 329

Appendix

A



(CandyBox Images/Shutterstock)

Standard Precautions

Katherine West, BSN, MSEd, CIC
Howard Werman, MD, FACEP
Richard N. Nelson, MD, FACEP

Editors' Note: *This appendix is divided into two parts. The printed text includes a review of bloodborne pathogens and the basic principles of standard precautions. Other infectious diseases and precautions are covered in the online version of this appendix at www.pearsonhighered.com/bradyresources. In many EMS systems, education regarding prevention of exposure is mandated by rule or regulation. Note that this appendix does not address precautions against biological weapons. The reader should consult guidelines published by his or her public health agency. References are included in the online version of this appendix (Appendix A-2).*

Key Terms

bacille de Calmette et Guérin (BCG), *p. A-7*

blood and OPIM, *p. A-6*

contact precautions, *p. A-6 (online)*

droplet precautions, *p. A-7 (online)*

hepatitis B virus (HBV), *p. A-3*

hepatitis C virus (HCV), *p. A-4*

human immunodeficiency virus (HIV), *p. A-5*

postexposure prophylaxis (PEP), *p. A-6*

standard precautions, *p. A-6*

Objectives

Upon successful completion of this appendix and the online portion, you should be able to:

1. Identify the three most common bloodborne viral illnesses to which emergency care providers are likely to be exposed in the provision of patient care.
2. Describe precautions emergency care providers can take to prevent exposure to blood and other potentially infectious materials (cerebrospinal fluid, synovial fluid, amniotic fluid, pericardial fluid, pleural fluid, or any fluid with gross visible blood).
3. Describe procedures for emergency care providers to follow if they are accidentally exposed.
4. Identify those situations in which a higher level of personal protective equipment is needed, beyond the basic equipment used in daily patient care.
5. List vaccines and immunizations recommended for EMS personnel.

Objectives (continued)

6. Discuss the signs and symptoms of airborne and droplet-transmitted diseases, and describe protective measures to reduce possible exposure to them. (*online version only*)
7. Discuss multidrug-resistant organisms, and describe precautions for care of patients with multidrug-resistant illnesses and airborne/droplet diseases. (*online version only*)

Overview

All occupations carry some risk. For EMS, risks have included highway hazards, fires, downed electrical wires, toxic substances, and scene security problems. The provision of patient care may pose the additional possibility of exposure to bloodborne diseases. Fortunately, precautions can be taken to markedly reduce those risks. In addition, if despite the use of personal protective equipment an exposure occurs, medical postexposure treatment is available to reduce the chances of acquiring the disease. In addition, there are vaccines and immunizations that protect personnel from many diseases to which they may be exposed. If protected by vaccine, the risk from exposure is lessened. Exposure does not mean infection. Exposure can be treated or prevented.

A discussion of the entire spectrum of diseases to which you are potentially exposed is beyond the scope of this appendix. However, the three most common types of viral bloodborne infections are appropriate to discuss in conjunction with trauma management because their modes of spread are primarily by contaminated blood and other potentially infectious materials (OPIM). They are hepatitis B (HBV), hepatitis C (HBC), and human immunodeficiency virus (HIV) infection.

It is a common misconception that all body fluids are potentially infectious. Body fluids that do not pose a risk for HBV, HCV, and HIV are tears, sweat, saliva, urine, stool, vomitus, nasal secretions, and sputum unless they *contain visible blood contamination*. It is also important to note that vaginal secretions and semen are only a risk of transmission through sexual contact. Saliva offers protection from some diseases as well, such as HIV.

This appendix offers a review of the three most common types of viral bloodborne infections plus a brief review (online) of the airborne- and droplet-transmitted diseases that can pose a risk to emergency care providers. These airborne and droplet diseases include tuberculosis, measles, mumps, rubella, chickenpox, and influenza. Recently, there has been an increase in cases of these diseases due to waning of protection over time and the movement to not vaccinate children. This rise is attributed to a decline in vaccination rates. Last, a brief overview of infections caused by multidrug-resistant organisms is available online to increase emergency care provider awareness of the risk such infections present.

Diseases of Concern

Table A-1 lists common infectious diseases and their routes of transmission.

Bloodborne Diseases

Hepatitis B

The term *viral hepatitis* is used to describe a group of viral infections involving the liver. At least five types of hepatitis virus have been described: hepatitis A, B, C, D, and E. Hepatitis A and E are spread primarily through contact with contaminated fecal material and are not bloodborne. They are most prevalent in the developing world. Hepatitis D is transmitted through blood and body-fluid exposure to patients already infected with hepatitis B. Because of their frequent contact with blood and needles, health care workers (HCWs) are considered at risk of becoming infected with the **hepatitis B virus**. Fortunately, hepatitis B is the one form of hepatitis for which there is an effective preventive vaccine. Today in the United States, there is universal vaccination. Similar programs exist in many other countries. Health care providers have been receiving vaccine since 1982, all newborns since 1990, and all middle school, high school, and college students since 2000. As a result, there has been a 95% reduction in occupationally acquired hepatitis B infection and a decrease in all cases in the United States.

Hepatitis B virus is an infectious virus usually spread by exposure to infected blood and is also sexually transmitted. It is the major cause of acute and chronic hepatitis, cirrhosis, and liver cancer. There are three effective vaccines available to prevent infection: Recombivax-B, Engerix-B, and a new low-dose series vaccine, Heplisav-B. Following an acute infection, 3–5% of hepatitis B patients become chronic carriers of the virus and remain potentially infectious.

In 2011, the Centers for Disease Control and Prevention (CDC) reported that hepatitis B infection in HCWs acquired through occupational exposure has become a rare event. HBV is spread by contact with contaminated blood or OPIM, sexual transmission, and direct contact with a contaminated item and nonintact skin. Infection usually occurs from contaminated needlesticks or through sexual contact. The risk for acquiring HBV infection by occupational exposure is only an issue for personnel who have not been vaccinated and who do not report an exposure. In those situations, there is an estimated 6–30% risk for contracting HBV infection, if the source patient is positive for active disease.

PEARLS

An EMS Standard

All patients are potential carriers of infectious disease. That is why standard precautions are the EMS standard for practice.

hepatitis B virus (HBV): virus responsible for hepatitis B, transmitted through contact with blood or body fluids.

Table A-1: Infectious Diseases and Route of Transmission

Bloodborne ***(includes body fluids)***	**Airborne**	**Droplet**
HIV	Chickenpox	Influenza
Hepatitis B	Measles	Pertussis
Hepatitis C	Tuberculosis	Rubella
Rabies		Mumps
Cutaneous anthrax		*Neisseria meningitidis* (bacterial meningitis)
Viral hemorrhagic fevers (Ebola)		Severe acute respiratory syndrome (SARS)
		Ebola
		Diphtheria
		Novel influenza virus (H1N1)

If the nonvaccinated EMS provider reports the exposure, he or she can be treated. There is also a special treatment protocol for those who did not previously mount an antibody response to the vaccine and have an exposure.

Besides vaccination, emergency care providers can take other steps to decrease risk. Use of devices to minimize needlestick as mandated by the Needlestick Safety and Prevention Act of 2000 requires the use of needle-safe or needleless devices (Figure A-1). The use of devices designed to comply with this legislation has cut the number of sharps injuries by more than half since its implementation. Infection can also occur by contact of bloody secretions with open skin lesions or mucosal surfaces, so use of standard precautions is key to prevent exposure. Routine testing of donor blood for HBV makes transmission from blood transfusions very rare.

Another form of protection is hepatitis B immunoglobulin (HBIG). This preparation contains antibodies to HBV and provides temporary, passive protection against it. HBIG is only 70% effective and, when effective, provides protection for only 4–6 months. HBIG is used only when there has been a significant exposure to HBV in an unimmunized person and should be given in conjunction with vaccine to offer full coverage post exposure.

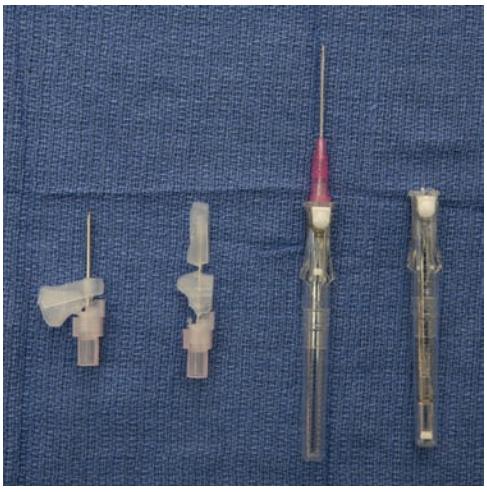
Hepatitis C

hepatitis C virus (HCV): virus that causes hepatitis C.

The **hepatitis C virus (HCV)** is an infectious virus primarily spread by exposure to infected blood. HCV was identified in 1988–1989 and was previously called non-A, non-B hepatitis. The incubation period is 6–9 weeks. HCV infection tends to be less severe than HBV during the initial infection. However, there appears to be a greater likelihood of becoming a chronic carrier of HCV following infection. Liver failure and cirrhosis occur in 20–80% of chronic HCV carriers.

The incidence rate for occupational transmission is low and usually related to a contaminated needlestick injury. HCWs can acquire infection through hollow-bore needlesticks with contaminated needles if the patient has a high amount of virus circulating in his or her blood. Fortunately, the use of needle-safe devices has led to a significant decrease in contaminated sharps injuries. The risk rate for developing HCV after a needlestick is about 1.3%, if the source is positive for HCV with viral load.

In 2017, there were over 2,000 new cases of HCV reported in the United States. Note that a number of those cases were patients who were infected by HCWs who had the disease but who did not follow infection control protocols properly or at all.



A



B

Figure A-1 A. Safety needles and B. Needleless medication administration system. *(Photos courtesy of Stanley Cooper, EMT-P)*

Prior to 1992, HCV was the leading cause of hepatitis resulting from blood transfusions. Today, as a result of better testing of donated blood, HCV is no longer transmitted via this route. The virus also appears to be spread by sharing of intravenous needles, sexual contact, tattooing, and body piercing, much like HBV.

Currently, no vaccine is available to protect against HCV infection. Evidence suggests that there is no protective effect provided by administering immune globulin following exposure to HCV. However, now rapid HCV testing can be performed on the source patient. If the source is positive, the exposed provider will undergo baseline testing and repeat testing for the virus 3 weeks after the exposure event. The Occupational Safety and Health Administration (OSHA) is enforcing the CDC postexposure guidelines: Rapid HCV testing is to be performed on the source patient following exposure to HCV.

If a patient is found to have contracted HCV from an exposure event, he or she will be offered 8–12 weeks of drug treatment, which has resulted in a cure in most of those who receive treatment. Several drugs are available to treat HCV.

Human Immunodeficiency Virus Infection

HIV infection is caused by the **human immunodeficiency virus (HIV)**. Patients with HIV infection have difficulty fighting certain infections due to a compromised immune system. This predisposes the HIV-infected patient to a variety of unusual infections not generally seen in healthy patients of similar age. They are called "opportunistic infections" and pose a risk to the patient but not to the care provider. An example is *Pneumocystis jirovecii* (formerly known as *P. carinii*) pneumonia (PCP). Most individuals have this yeastlike fungus in their lungs, but it does not cause illness because a healthy immune system prevents it from causing infection. PCP is not transmissible from an infected patient to care providers with intact immune systems. Other examples of opportunistic infections in HIV patients are those caused by atypical mycobacteria. This is a medical issue for the patient but does not pose a risk to the healthy HCW.

human immunodeficiency virus (HIV): a virus that weakens the immune system, predisposing a patient to a wide range of unusual infections.

Patients infected with HIV can present with a wide spectrum of clinical manifestations. Early symptoms, like many viral illnesses, resemble the flu. Many patients with HIV infection are asymptomatic. Other patients will test positive for HIV because they had an exposure at some time but did not develop the disease and thus cannot transmit the disease to others. HIV patients being treated with current drugs may be free of virus circulating in their blood and, as such, are not able to transmit the infection. This means that there is prevention by treatment. Generally, after 48 weeks of treatment, the patient is free of circulating virus. About 96% of those treated HIV patients have no circulating virus in their blood. In October 2017, the medical community agreed with this research. Knowing that a patient is HIV positive may not be enough information to assess risk for infection. Testing the source patient's blood for viral load may be needed to determine risk for transmission following an exposure.

HIV appears to be transmitted in a manner similar to HBV. Although the virus has been cultured from a variety of body fluids, only blood has been implicated in the transmission of the virus in the workplace. This is because other body fluids do not carry enough virus particles to transmit the disease. Semen and vaginal secretions have been shown to transmit the virus during sexual activity only. There is no evidence to suggest that HIV is transmitted by casual contact or by blood on intact skin.

Transmission to HCWs has been documented only after accidental parenteral exposure (needlestick) or exposure of mucous membranes and open wounds to large amounts of infected blood. Measurable risk data for occupational exposure is 0.23% for needlestick injuries and 0.09% for mucous membrane exposure. There is one documented case of transmission from infected blood on nonintact skin and involved an HCW with extensive dermatitis who did not always use appropriate universal precautions.

HIV appears to be different from the hepatitis B virus in two ways. First, it does not survive outside the body. Routine germicidal cleaning agents are effective. Second, it is transmitted far less efficiently than HBV.

Several groups have been identified as having a high risk of HIV infection. They include men who have sex with men (MSM), intravenous drug abusers, patients who have received blood transfusions or pooled-plasma products prior to 1992 (such as hemophiliacs), and heterosexual contacts of HIV-positive persons. However, because of the difficulty in identifying HIV-infected patients, all contacts with **blood and OPIM** should be considered a potential HIV exposure. This concept (all patient blood/OPIM except sweat is potentially infective) is why **standard precautions** are "universally" applied.

blood and OPIM: blood or other body fluids or tissues that can carry infectious organisms.

standard precautions: steps each health care worker takes to protect him- or herself and the patient from exposure to infectious agents; includes treating each patient and him- or herself as if they were infectious.

Currently, no vaccine is available to protect against HIV infection. Antiretroviral drug regimens, though not a cure, have been shown to prolong the lives of HIV/AIDS patients for up to 50 years after diagnosis. This would make HIV infection today a chronic disease. Some studies have suggested that antiretroviral agents may reduce the risk of HIV transmission in HCWs if administered *within 72 hours* following an exposure to HIV-infected blood and OPIM that meets the CDC criteria. The decision to administer such agents should be based on the nature of the exposure, the likelihood that the patient is infected with HIV, the duration of time following exposure, and consultation with the exposed HCW. In general, a large-gauge hollow needle that had been in the patient's vein or artery exposures are more significant than solid instruments (such as a scalpel).

postexposure prophylaxis (PEP): the administration of medications to prevent infection from the agent to which the person was exposed.

If the exposure meets the CDC criteria for **postexposure prophylaxis (PEP)**, PEP should be administered within 72 hours of the exposure. This time frame allows for proper counseling. Exposed personnel need to be counseled about the side effects and other issues involving the use of the drugs for PEP before they are started. Baseline lab work also needs to be drawn. By performing rapid HIV testing on the source patient, an emergency care provider may be able to avoid being placed on medications unnecessarily while awaiting results of additional bloodwork on the source.

Rapid HIV testing is required as part of the postexposure workup. The cost is low, and testing takes about 10–20 minutes. There is often co-infection with syphilis, so testing is to include syphilis if the source is HIV positive. If PEP drugs are to be offered, the treating physician (in North America) should call the toll-free PEP Hotline at 1-888-448-4911 for a second opinion. In other areas of the world, treating physicians should follow facility protocols before the drugs are prescribed. Remember, all postexposure medical follow-up begins with testing the source patient, not the exposed emergency care provider. A baseline blood test is only needed if the source patient tests positive.

contact precautions: steps health care workers can take to protect themselves and patients from contracting diseases transmitted through direct contact with infected patients or materials.

Airborne Transmissible Diseases

Tuberculosis

Tuberculosis (TB) is a bacterial infection caused by a bacteria, *Mycobacterium tuberculosis*, which is spread from an infected person to susceptible people through the air, especially by coughing or sneezing. This is not a highly communicable disease. Contracting tuberculosis requires prolonged direct contact, as in a family living situation. Only persons with active infection of the lung or throat spread tuberculosis.

From 1985 to 1993, the incidence of active tuberculosis increased significantly to over 25,000 cases in the United States. It was the result of an increase in cases among people infected with HIV and an increase in immigration of people from areas where tuberculosis infection is endemic (Asia, Latin America, the Caribbean, and Africa). Because of better public health measures, tuberculosis has been declining in the past several years. Cases decreased by over 84% from 1997 to 2009 and another 2.9% between 2016 and 2017. In fact, the number of cases in 2017 was the lowest ever reported in the United States.

Risk factors for tuberculosis include homelessness, certain immigrant populations (Asia, Africa), patients at risk for HIV infection, and people who live in congregate settings (correction facilities, nursing homes, homeless shelters). On a global perspective, there was an effort to eliminate the disease by 2015. However, this goal was not met due to wars in countries where the disease is most prevalent, drug shortages, and testing solution shortages. This is the responsibility of U.S. Immigration and Customs Enforcement (ICE).

PEARLS

Tuberculosis

If your patient has a persistent cough plus other symptoms suggestive of TB, place a surgical mask on the patient, not on yourself. You should also wear a mask, especially if the patient requires oxygen and cannot wear a mask. The appropriate mask for emergency care providers is an N-95 respirator.

Only patients with active disease can transmit TB. Classic symptoms include a productive cough that lasts longer than 3 weeks in conjunction with two or more of the following: pain in the chest, coughing up bloody sputum, weakness or fatigue, unexplained weight loss, loss of appetite, fever, chills, night sweats, or hoarseness.

Since 1995, the CDC has recommended placing a surgical mask on any patient suspected of having TB. The CDC recommends that when treating patients with active TB or suspected TB, emergency care providers should wear a surgical mask if the patient cannot wear one and to use the exhaust fan in the back of the vehicle. (Note that U.S. OHSA guidelines still recommend a N-95 mask.) HCWs should receive tuberculin skin testing prior to employment and periodically based on the department's risk assessment.

Treatment of tuberculosis includes antibiotic agents. A positive TB skin test (TST) means the person has been exposed/infected with TB (TB infection), but it does not necessarily indicate active disease. *TB disease* is the term for the active disease. If there is a positive skin test but no indication of active TB, isoniazid (INH) or rifampin may be given for a short course of treatment, usually once a week for 12 weeks. More extensive and prolonged antibiotic therapy is necessary if active TB is confirmed. There is now blood testing for TB that is more accurate than the skin test. The CDC advises this form of testing for health care workers.

Multidrug-resistant TB is a more serious form of the disease and means that the organism has become resistant to two of the first-line antibiotics. Additional drugs are available to treat both conventional and multidrug-resistant TB.

Outside the United States, **bacille de Calmette et Guérin (BCG)** is a vaccine used to prevent TB. In portions of Europe and Asia, universal vaccination with BCG is the standard. The protection offered by the vaccine is not lifelong, and the reported efficacy in preventing TB infection has varied. It should be noted that if vaccinated with BCG, a person will always test positive if given a purified protein derivative (PPD) test. Even if vaccinated with BCG, an emergency care provider should utilize appropriate PPE (surgical mask), exhaust fan or setting the heat or air conditioning on the nonrecirculating position, and standard precautions when caring for a suspected TB patient.

droplet precautions: steps health care workers can take to protect themselves and patients from contracting diseases transmitted through droplets of fluid, such as nasal or respiratory secretions; includes use of mask, gown, and goggles.

bacille de Calmette et Guérin (BCG): vaccine against tuberculosis prepared from a strain of bovine tuberculosis that has been weakened; not commonly used in the United States.

PEARLS

Notification of Exposed Emergency Care Providers

The Ryan White Comprehensive AIDS Resources Emergency Act, U.S. Public Law 101-381, requires inclusion of all emergency response employees—firefighters, emergency medical technicians, paramedics, law enforcement officers, and volunteers—in the postexposure medical notification process in the event of an exposure to a bloodborne or airborne transmissible disease.

Procedure

General Considerations

1. Be knowledgeable about infection from hepatitis B, hepatitis C, and HIV. Understand their etiologies, signs and symptoms, routes of transmission, and epidemiology (relationships of the various factors determining the frequency and distribution of a disease).
2. If you have on your own body open or weeping lesions, take special precautions to prevent exposure of those areas to blood and OPIM (see Table A-2). Lesions should be covered with a bandage. This also applies to new tattoos. If the lesions cannot be adequately protected, get placed on work restriction. Avoid invasive procedures, other direct patient care activities, and handling of equipment used for patient care.
3. *Perform routine handwashing before and after all patient contact*. Wash hands as soon as possible following exposure to blood or OPIM. Wash hands after glove removal. Alcohol-based foam or gel is best for in-field use. Emergency care providers should not have artificial nails or extensions because they can be hard to clean and can trap potentially infectious materials. Fungal infections are often associated with these nails and can be transmitted to a patient.
4. Become immunized against the hepatitis B virus, chickenpox, measles, mumps, and rubella if you are not protected by acquired immunity. Get your Tdap booster.
5. Report any exposure event to your designated infection control officer (DICO).

(*continued*)

Procedure *(continued)*

Table A-2: Recommended Personal Protective Equipment for Worker Protection Against HIV and HBV Transmission in Prehospital Settings*

Task or Activity	Disposable Gloves	Gown	Mask	Protective Eyewear
Bleeding control with spurting blood	Yes	Yes	Yes	Yes
Bleeding control with minimal bleeding	Yes	No	No	No
Emergency childbirth	Yes	Yes	Yes	Yes
Blood drawing	Yes	No	No	No
Starting IV line	Yes	No	No	No
ET intubation or use of BIAD	Yes	No	No, unless splashing is likely	No, unless splashing is likely
Oral/nasal suctioning, manually cleaning airway	Yes	No	No, unless splashing is likely	No, unless splashing is likely
Handling and cleaning instruments with microbial contamination	Yes	No, unless soiling is likely	No	No
Measuring blood pressure	No	No	No	No
Measuring temperature	No	No	No	No
Giving an injection	No	No	No	No

** From CDC Guidelines for Public Safety Personnel and OSHA Guidelines.*

Appendix

B



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Analgesia and Pain Control for the Trauma Patient

Roy L. Alson, PhD, MD, FAEMS

Editors' Note: *This appendix is based on a lecture developed by the Germany chapter of the ITLS.*

Key Terms

dissociative anesthetic, *p. B-5*

endorphins, *p. B-2*

narcotic, *p. B-2*

opiate, *p. B-4*

Objectives

Upon successful completion of this appendix, you should be able to:

1. Describe the benefits to the patient from controlling pain in the field.
2. Discuss indications, contraindications, and possible complications for use of analgesics.
3. List when to use specific agents for pain control.

Note: Doses given in this chapter are guidelines only and current at the time of publication. Providers should consult local medical control for definitive dosing and guidelines for administration.

Overview

Traumatic injuries hurt. Relief from pain is one of the things that injured patients want and providing that relief is part of good trauma care. For many years, EMS operated under the false assumption that by administering analgesics, emergency care providers would "mask" injuries, making it difficult to identify injuries and thus harming patients. Fortunately, that dogma has been shown to be wrong. In addition, with the rise of opiate addiction in many countries, many health care providers have been reluctant to use pain medications out of the false concern of addicting patients.

Controlling pain increases patient comfort, reduces anxiety, and makes it easier for the emergency care provider to provide quality patient care. This appendix briefly reviews the physiology of pain and the techniques and medications that emergency care providers can use to control it. This discussion is limited to the control of major pain following trauma, not pain control for minor injuries. Thus, oral and over-the-counter medications are not covered. Providers should always consult local medical control and protocols prior to initiating any therapy.

Physiology of Pain

The body's response to painful stimuli is complex. Pain perception is mediated by nerve cells (neurons) and signals transmitted to the brain. Local anesthetics such as lidocaine work at this level to block the perception of pain and the transmission of nerve impulses. We can also control pain by altering its perception in the brain.

endorphins: hormones secreted in the brain that activate the body's opiate receptors and induce analgesic.

narcotic: a drug that reduces consciousness and relieves pain derived from opium.

In response to pain, the body releases **endorphins**, a group of hormones that act to block the body's perception of pain by binding to opiate receptors in the brain. Opiate **narcotics** also bind to these same opiate receptors and therefore decrease pain perception. Pain signals are carried to the brain by two types of nerve fibers. Fast fibers carry signals from the skin and extremities and allow the body to reflexively move body parts when there is a noxious stimulus. Slow fibers, which tend to innervate the internal organs, yield a more diffuse and achy pain. An example of these two types of fibers is seen with appendicitis. Early on as the appendix becomes inflamed, patients tend to complain of a dull, achy abdominal pain. Once the inflamed appendix touches the parietal peritoneum, the pain becomes very localized, classically to the right lower quadrant.

Pharmacology of Pain Control for the Prehospital Setting

The ideal pain medication for use by emergency care providers should be rapid in onset and easy to administer, with few side effects and a short-to-moderate duration of action. No such perfect agent exists, although several available medications do have many of these desirable characteristics. Our discussions will be limited to parenteral medications, as many oral medications have a duration of onset that is too long to be of use in most EMS situations. Be aware that many military and disaster medical teams, which usually have much longer patient transport times, utilize oral medications for pain, due to ease of administration.

The following discussion considers both opiate and nonopiate analgesics as well as nonpharmacologic interventions that can assist with pain control in the field setting.

Assessment of Pain

Pain severity is very subjective. Remember that a patient's response to pain can be strongly influenced by prior experiences, cultural factors, presence of intoxicating substances, and your demeanor. One should inquire about the nature of the pain using the OPQRST mnemonic (see Table B-1).

Assess pain severity by asking the patient to quantify the pain on a 0 to 10 scale, with 0 being "no pain" and 10 being "the worst pain you can imagine" (see Figure B-1). The patient's reported pain level should be recorded in the ambulance call record.

Table B-1: OPQRST Mnemonic

O	Onset of the pain, fast or slow?
P	Factors that provoke or palliate the pain
Q	Quality of the pain
R	Radiation of the pain
S	Severity of the pain
T	Timing of the pain

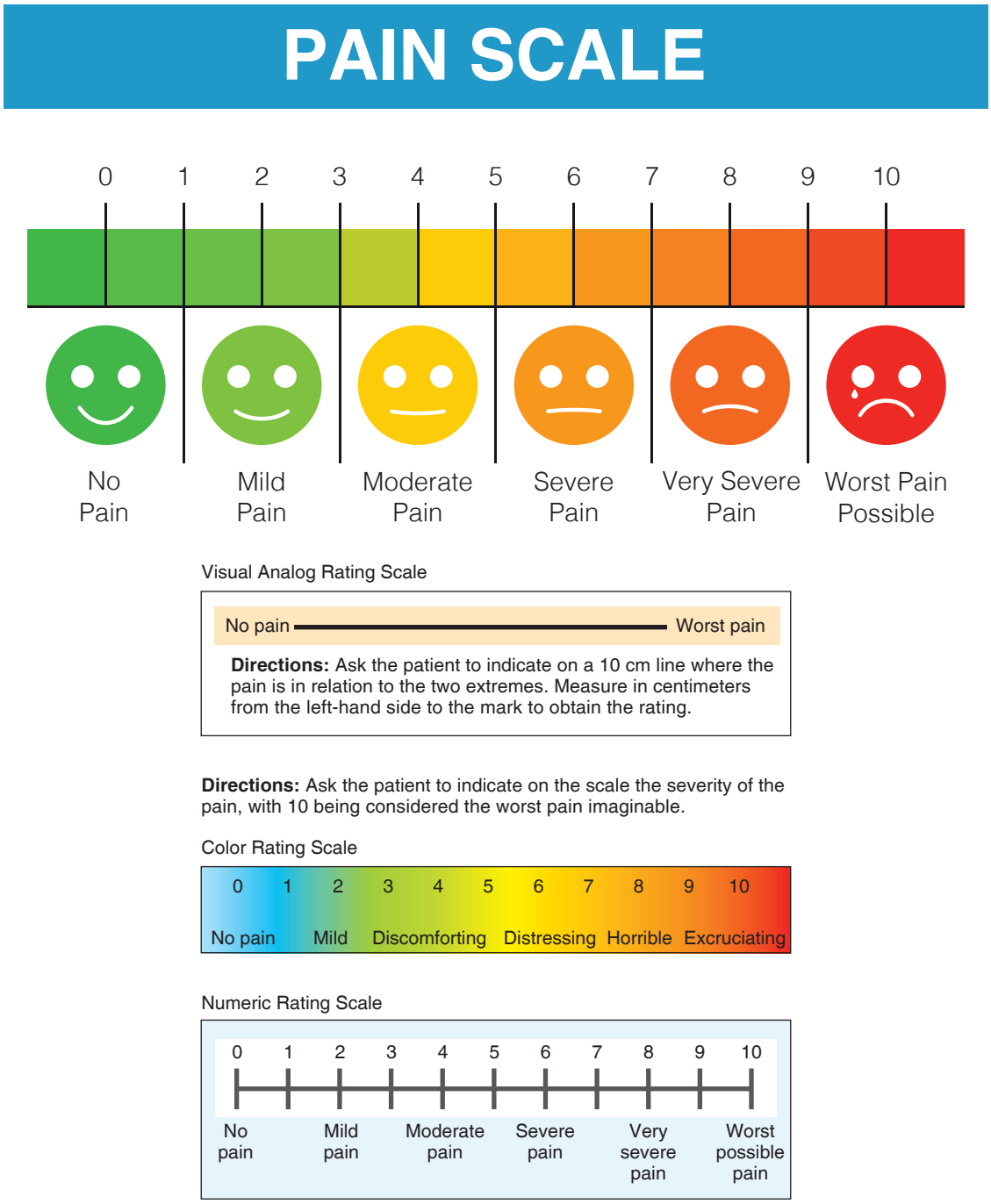


Figure B-1 Examples of visual and analog pain scales that can help quantify the level of pain the patient reports. *(Top: EgudinKa/Shutterstock)*

Table B-2: Nonpharmacologic Methods for Pain Control

Supportive actions include—

- ***Empathy*** can also reduce a patient's anxiety
- ***Distraction*** may help the patient focus on something else instead of the pain
- ***Placing patient in position of comfort*** may reduce a patient's pain; for example, helping a patient with abdominal pain bend his or her knees
- ***Splinting fractures*** reduces the painful movement of bone ends
- ***Application of ice*** to extremity injuries
- ***Avoid hypothermia*** by keeping the patient warm and dry
- ***Remove*** the source of the pain

Nonpharmacologic Methods for Pain Control

Nonpharmacologic methods can be given by any level of care provider and can be initiated rapidly. They should be used for all patients, regardless of their pain level, and will work in tandem with any pharmacologic treatment provided. All are good basic patient care skills. Even if your patient is not alert, talk to him or her and advise them of what you are doing. This is especially important if you are getting ready to perform a procedure that can cause pain, such as starting an intravenous (IV) or intraosseous (IO) line or moving a fractured limb. For patients with extremity injuries, ice is an effective therapy. Table B-2 lists some nonpharmacologic methods of pain control.

Pharmacologic Management of Pain

Multiple options for the pharmacologic management of pain are available. Choice is guided by the patient's condition and what provider skills are permitted under local protocols.

Inhaled Analgesics

Nitrous oxide (N_2O) is an organic gas that has been used as an anesthetic since the early 19th century. Commonly known as "laughing gas," most people are aware of N_2O due to its use by dentists. It has a rapid onset and emergence. Because N_2O can fill gas-containing spaces (intestines, etc.), it should not be used in situations such as a pneumothorax or bowel obstruction. Hypoxia is the major complication with its use, and it may also have teratogenic effects. Thus, used in a confined space, such as an ambulance, without a scavenger system to remove N_2O that has leaked, should be avoided.

Delivery systems for EMS use are self-administered by the patient. The system is set to deliver a 50/50 mix of N_2O and oxygen. If the oxygen flow drops, the system shuts down. The adjustment is not operator adjustable. The patient holds the mask over his or her face and uses the medication until they achieve pain relief or they fall asleep, dropping the mask from their face. This type of system has been used by many EMS systems successfully over the last 25 years.

Narcotic Analgesics

opiate: a drug derived from opium, which has analgesic effects.

Opiates, which are derived from opium poppy (Papaver somniferum), have been used to control pain for thousands of years. They are effective in blocking pain perception in the brain as well as inducing euphoria and CNS depression. Modern opioids are semi-synthetic derivations of the base opiate alkaloid.

As a class, opiates and opioids can cause the release of histamine, but the impact can be variable (Baldo and Pham 2012). Opiates are also known to cause hypotension

after administration, so their use in trauma patients who are hypotensive may be problematic. Too much opiate administration can result in respiratory depression, but this can be reversed with Naloxone.

Opiates can be given by multiple routes—PO, PR, IN, IM, SQ, and IV—and have a rapid onset of action. Morphine and fentanyl are two of the more commonly used medications in EMS.

Morphine

- Onset of action: < 5 minutes IV, 10–20 minutes IM
- Peak effects: 20 minutes
- Duration: 6 hours
- Typical IV dose: 2.5–10.0 mg (0.1 mg/kg up to adult dose for pediatrics)

Fentanyl

- Onset of action: Immediate IV, 5–10 minutes IM
- Peak effects: 3–5 minutes
- Duration: 30–60 minutes
- Typical IV dose: 25–100 mcg Adult or 1 mcg/kg up to adult dosing for pediatrics

Non-Narcotic Analgesics

Ketorolac is a nonsteroidal anti-inflammatory drug (NSAID) that is used for the short-term relief of pain. Like all NSAIDS, it can cause platelet inhibition so it is not an ideal agent for use with trauma patients. It is, however, very useful for pain control in patients with ureteral colic.

- Onset of action: < 30 minutes IV, 30 minutes IM
- Peak effects: 45–60 minutes
- Duration: 4–6 hours
- Typical IV dose: 30 mg

Acetaminophen injection is an analgesic and antipyretic that is also used to relieve mild to moderate pain or reduce fever. It is also used in conjunction with opioids for patients with more severe pain. However, higher costs of this drug limit use for many agencies.

Ketamine is a **dissociative anesthetic**, related to phencyclidine (PCP), an illegal street drug that causes hallucinations and agitation. In low doses ketamine has analgesic effects without causing dissociation. In higher doses it causes anesthesia without depressing respirations, making it useful for induction during drug-assisted intubation. Ketamine is also useful for sedation of patients who are agitated, including those with excited delirium, a condition that may be caused by stimulant drug use. Emergence reactions (agitation and combativeness) can occur after use of ketamine; benzodiazepines can help with this. The long-reported rise in intracranial pressure following administration of ketamine has not proven to be clinically significant in comparison to the impact of hypoxia on traumatic brain injury (see Chapter 12).

dissociative anesthetic: anesthetic agent that separates brain perception of stimuli such that the user feels detached from self and the environment.

Ketamine can be given IM, IN, IO, or IV; usual doses include:

- Pain control, adult: 0.2 mg/kg IV or IO adult or 0.5 mg/kg IN; maximum dose 25 mg; may repeat at 10 minutes to maximum dose of 50 mg
- Pain control, pediatric: same dosing as adult, with maximum dose of 25 mg; may repeat at 10 minutes with maximum dosing of 0.4 mg/kg
- Sedation, adult: 4 mg/kg IM for excited delirium; may repeat at 5 minutes

Figure B-2 shows a sample EMS pain management protocol.

COUNTY OF SAN DIEGO
HEALTH & HUMAN SERVICES AGENCY
EMERGENCY MEDICAL SERVICES

LIVE WELL SAN DIEGO

COUNTY OF SAN DIEGO EMERGENCY MEDICAL SERVICES
POLICY/PROCEDURE/PROTOCOL

No. S-173
Page: 1 of 1

SUBJECT: PEDIATRIC TREATMENT PROTOCOL - PAIN MANAGEMENT

Date: 05/18/2018

BLS	ALS
• Assess level of pain • Ice, immobilize and splint when indicated • Elevation of extremity trauma when indicated	• Continue to monitor and reassess pain as appropriate. **For treatment of pain as needed with signs of adequate perfusion:** • Morphine IV per drug chart SO MR per drug chart **BHO** **OR** • Morphine IM per drug chart SO MR per drug chart **BHO** **OR** <10 kg: • Fentanyl IV/IN per drug chart **BHO** MR per drug chart **BHO** ≥10 kg: • Fentanyl IV/IN per drug chart SO MR per drug chart **BHO** max 75mcg **OR** <2 years of age: • IV Acetaminophen contraindicated ≥ 2 years of age: • IV Acetaminophen per drug chart SO x1 infuse over 15 minutes **Special Considerations:** 1. When changing route of administration requires **BHO** (e.g., IV to IM or IN to IV) 2. A change in analgesic while treating a patient requires **BHO** (e.g., changing from morphine to fentanyl) *BHPO* for: • Chronic pain states • Isolated head injury • Acute onset severe headache • Drug/ETOH intoxication • Multiple trauma with GCS <15 • Suspected active labor

*Note: IV acetaminophen should be drawn from the vial using a syringe and diluted in a 50 mL or 100 mL normal saline bag and administered over 15 minutes using the pediatric drug chart indicated doses.

Figure B-2 Sample EMS Pain Management Protocol, San Diego County, California.

References and Resources

Baldo, B. A., and N. H. Pham. 2012. "Histamine-releasing and allergenic properties of opioid analgesic drugs: Resolving the two." *Anaesthesia and Intensive Care* 40, no. 2: 216–35.

Heightman, A. J. 2018. "Examining when to provide pain management for patients." Accessed February 15, 2019.

http://www.jems.com/articles/print/volume-41/issue-11/departments-columns/from-the-editor/examining-when-to-provide-pain-management-for-patients.html.

Persson, J. 2013. 2013. "Ketamine in pain management." *CNS Neuroscience and Therapeutics* 19: 396–402.

Phrampus, P., and P. Paris. 2016. "A guide to prehospital pain management." Access February 15, 2019. http://www.jems.com/articles/print/volume-41/issue-11/features/a-guide-to-prehospital-pain-management.html?c=1.

This page intentionally left blank

Appendix

C



(Courtesy Roy Alson, PhD, MD, FACEP, FAEMS)

Multicasualty Incidents and Triage

Roy Alson, PhD, MD, FAEMS
David Maatman, NRP
John T. Stevens, NRP
Jere F. Baldwin, MD, FACEP, FAAFP

Key Terms

disaster, *p. C-3*

incident command system (ICS), *p. C-2*

multicasualty incident (MCI), *p. C-2*

span of control, *p. C-3*

triage, *p. C-3*

Objectives

Upon successful completion of this appendix, you should be able to:

1. Compare and contrast the definitions of the terms *disaster* and *multicasualty incident*.
2. Define the term *span of control*.
3. Describe the SALT triage scheme.
4. Classify patients based on priority need for treatment.

The Role Of EMS

It is not uncommon for EMS to have more than one patient at a trauma scene. However, most day-to-day operational procedures are designed for the single-patient incident. Safety, organization, and communication are paramount in all EMS activities. When faced with multiple patients, this need is even greater. It is essential that the components (safety, organization, and communication) be effective and that all entities of the emergency system work from the same plan.

An effective and efficient way to obtain this unity is to have EMS operate as a branch of the **incident command system (ICS)**. Primary functional components of the medical branch include the medical director, triage, treatment, transport, and staging. (Even with a single-patient incident, those five components exist, but one person is usually responsible for the functions of all components.) A medical director may be in charge of the patient care (team leader), injuries are triaged (prioritized assessment), treatment is provided for the patient, a transport decision that includes destination and mode of transport is made, and deployment of on-scene vehicles is determined from a point of safety, ingress, and egress (staging).

Having the medical branch function as part of the ICS provides EMS with dependable, reproducible results when faced with **multicasualty incidents (MCIs)**. As with the other components of an ICS, the medical branch must be simple enough for new users, but expandable enough to provide the necessary structure to manage large incidents.

incident command system (ICS): the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in the management of resources during emergency incidents. It is used for all kinds of emergencies and is applicable to small as well as large and complex incidents.

multicasualty incident (MCI): an incident involving a large number of persons injured in which the EMS system is unable to manage the situation utilizing day-to-day procedures. An MCI may be classified as a disaster, but not all disasters are MCIs nor are all MCIs disasters.

Incident Command System

Though originally developed to assist in the response to wildland fires, ICS was quickly recognized as a system that could help public safety responders provide effective and coordinated incident management for a wide range of situations. In the United States, it has evolved into the National Incident Management System's Incident Command System (NIMS ICS). The NIMS ICS was developed, under the Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA). Additional information about NIMS can be found online at *www.fema.gov/NIMS*. Similar systems are used elsewhere in the world; for example, the United Kingdom has the Major Incident Management System (MIMS) (Hodgetts and Porter 2013). It is essential that emergency care providers be familiar with and practice using the command and control system used by their agency.

Basic Incident Command Structure with Major Functions Identified

The five major functions that are central to the incident command system are Command, Operations, Planning, Logistics, and Administration/Finance. On any operation, regardless of size, these functions must be addressed in order to successfully manage the event.

The typical on-scene components of the operations section of an ICS are Command, Fire Suppression, Rescue/Extrication, Law Enforcement, and Medical (Figure C-1). The structured flexibility of ICS and related systems enables the systems to adapt to all types of emergency incidents: fire, rescue, law enforcement, and multicasualty incidents. Because of the modular design, the structure of such systems can be expanded or compressed, depending on the changing conditions of an incident. It must be staffed and operated by qualified personnel from an emergency service agency.

If an on-scene incident command system is not immediately established, rescuers will take independent actions, which will frequently be in conflict with each other. Those independent actions (freelancing) may be dangerous and disruptive in an environment that requires organization and accountability. Without organization and accountability, chaos will occur, and too many people will attempt to command the incident. If you do not control the situation, the situation will control you.

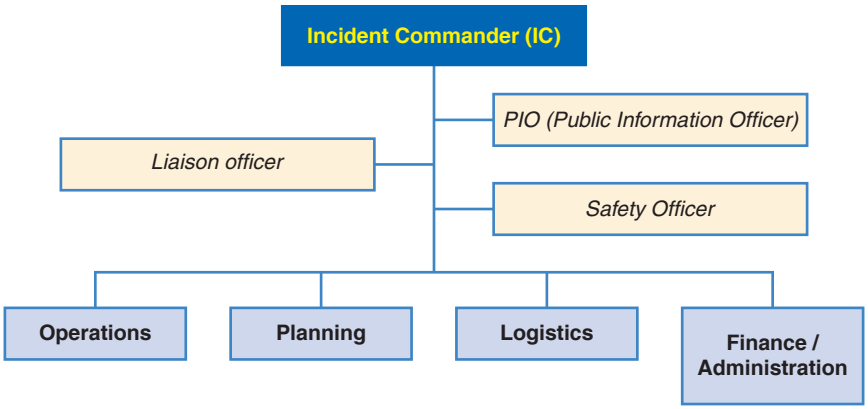


Figure C-1 Basic incident command structure with major functions identified. *(Based on Los Angeles Fire Department – Disaster Preparedness Section, 2005. https://from chemm.nlm.nih.gov/)*

Note that the incident commander (IC) is directly supervising only four section chiefs. This reflects the principle of **span of control**. Other key components of ICS include:

- *Unity of Command*—personnel report to only one supervisor.
- *Management by Objective*—Objectives for the incident are established by the IC.
- *Modular and Flexible*—System can expand and contract as needed and adapts to all types of events.
- *Common terminology*—All responders and agencies are using the same terms, which eliminates confusion.

span of control: the number of individuals a supervisor is responsible for, usually expressed as the ratio of supervisors to individuals. (Under the U.S. National Incident Management System, an appropriate span of control is between 1:3 and 1:7.)

Triage

Triage is the process of sorting patients to optimize care. This is something that EMS does every day. We identify the most critical patient and direct our resources toward doing all that we can for that patient. When the demands on the system exceed available resources, providers must shift their focus to a "**disaster**" mode. An example is a multiple casualty incident (MCI) where there are more casualties than there are resources to provide care. As opposed to doing everything we can for the individual patient, the focus shifts to the "group." The objective is to do the:

Greatest Good for the Greatest Number

Providers must now take into account not only the severity of the injury or illness but also survivability based on the available resources. As an example, in a patient who has 90% body surface area burns, fluid resuscitating him or her per the Parkland Formula could use up all the available fluids at the scene. As a result, another patient who is in mild shock could end up in moderate to severe shock due to not having resuscitative fluids available. This patient, during an MCI, would be classified as expectant.

Remember that triage is a dynamic process. As more resources arrive on the scene or more patients are found, the allocation of patients to triage classes will change. The provider in the role of triage officer should be experienced and able to perform the assessment rapidly. In addition, triage performed on the scene can be very different from the triage performed at the hospital, due again to changing resources and the effects of interventions performed.

Numerous triage schemes and tagging systems have been developed and used—with varying degrees of success. One of the challenges is that different EMS agencies may use different tags or systems, which can lead to confusion when providing mutual aid.

All the schemes use similar principles of determining the priority of a patient. The primary principles used are assessment of respirations, perfusion, and level of

PEARLS

Scientific Basis for Triage

There are no studies showing superiority of any one triage system.

triage: to prioritize or sort injuries or the injured, usually into four categories: Priority 0, 1, 2, and 3 (Black, Red, Yellow, Green).

disaster: an emergency that disrupts the normal community function and causes concern for the safety and property and lives of its citizens but cannot be managed with routine resources and procedures (U.S. Federal Emergency Management Agency). Disasters are best defined by available resources; when demand exceeds resources, one is then operating in a disaster mode.

consciousness (obeys commands). The START (Simple Triage and Rapid Treatment), JumpSTART (pediatric version of START), Triage Sieve (UK), and SMART Triage (UK) all look at these basic functions and provide quantitative limits for determining classification. SALT (Sort, Assess, Lifesaving interventions and Treatment/transport) uses a more qualitative approach.

Patients are classified based on severity of injuries:

- *Priority 0—Deceased.* Black tagged; dead; all vital signs absent.
- *Priority 1—Immediate.* Red tagged; critical condition, unstable but salvageable (load and go).
- *Priority 2—Delayed.* Yellow tagged; serious condition, potentially unstable.
- *Priority 3—Minimal.* Green tagged; stable condition, minor injuries, "walking wounded."

Some systems add an additional category:

- *Priority 4—Expectant.* Gray tagged; critical condition, unstable but unlikely to survive with existing resources. The patients categorized as Expectant have vital signs but are likely to die without consuming vast resources for care. The expectant category is intended to be flexible and dynamic, depending on the resources available, access to patients, time to treatment, and the provider's level of training.

PEARLS

Knowledge and Practice with Triage Improves Performance

Providers should be familiar with the system used by their agency and practice use of the triage system regularly.

SALT Triage

Developed as a consensus document by the Centers for Disease Control and Prevention, SALT is designed to allow providers to rapidly identify who needs immediate treatment (Figures C-2 and C-3). It is based on the concept that triage on the scene is different from that performed at a casualty collection point or receiving facility.

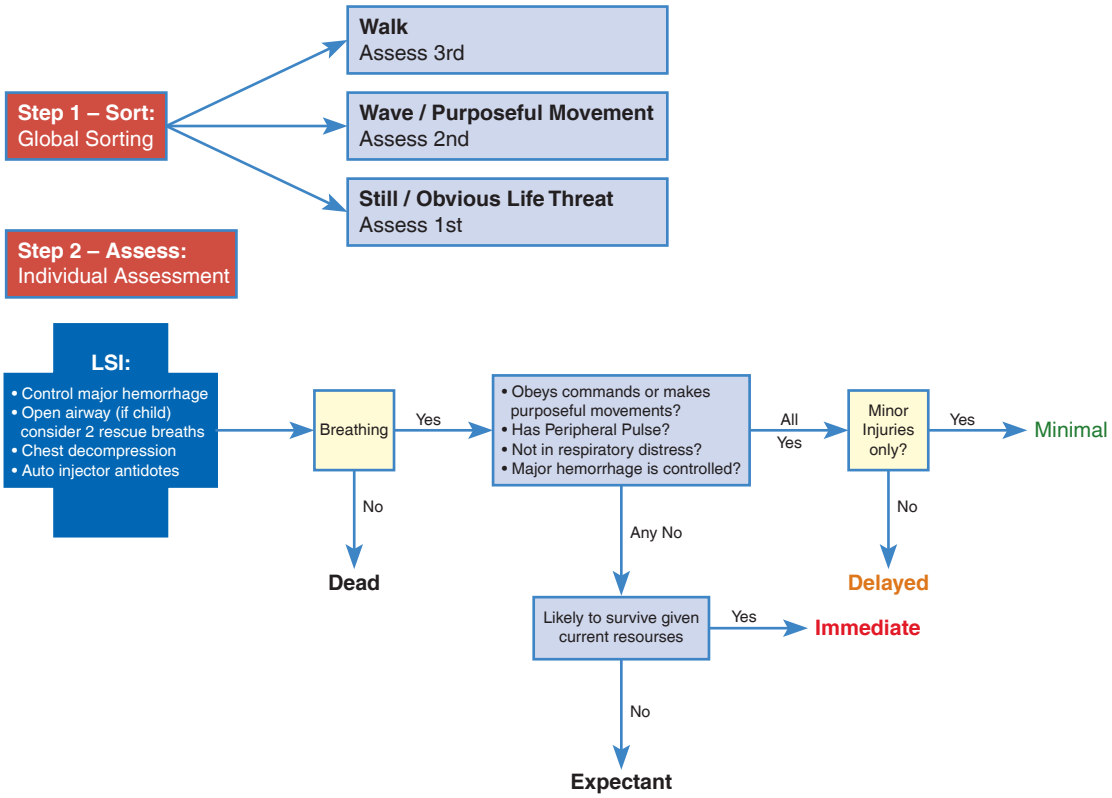


Figure C-2 Model Uniform Core Criteria: SALT Triage. *(Based on FICEMS, 2014. National Implementation Of the Model Uniform Core Criteria for Mass Casualty Incident Triage from www.ems.gov)*

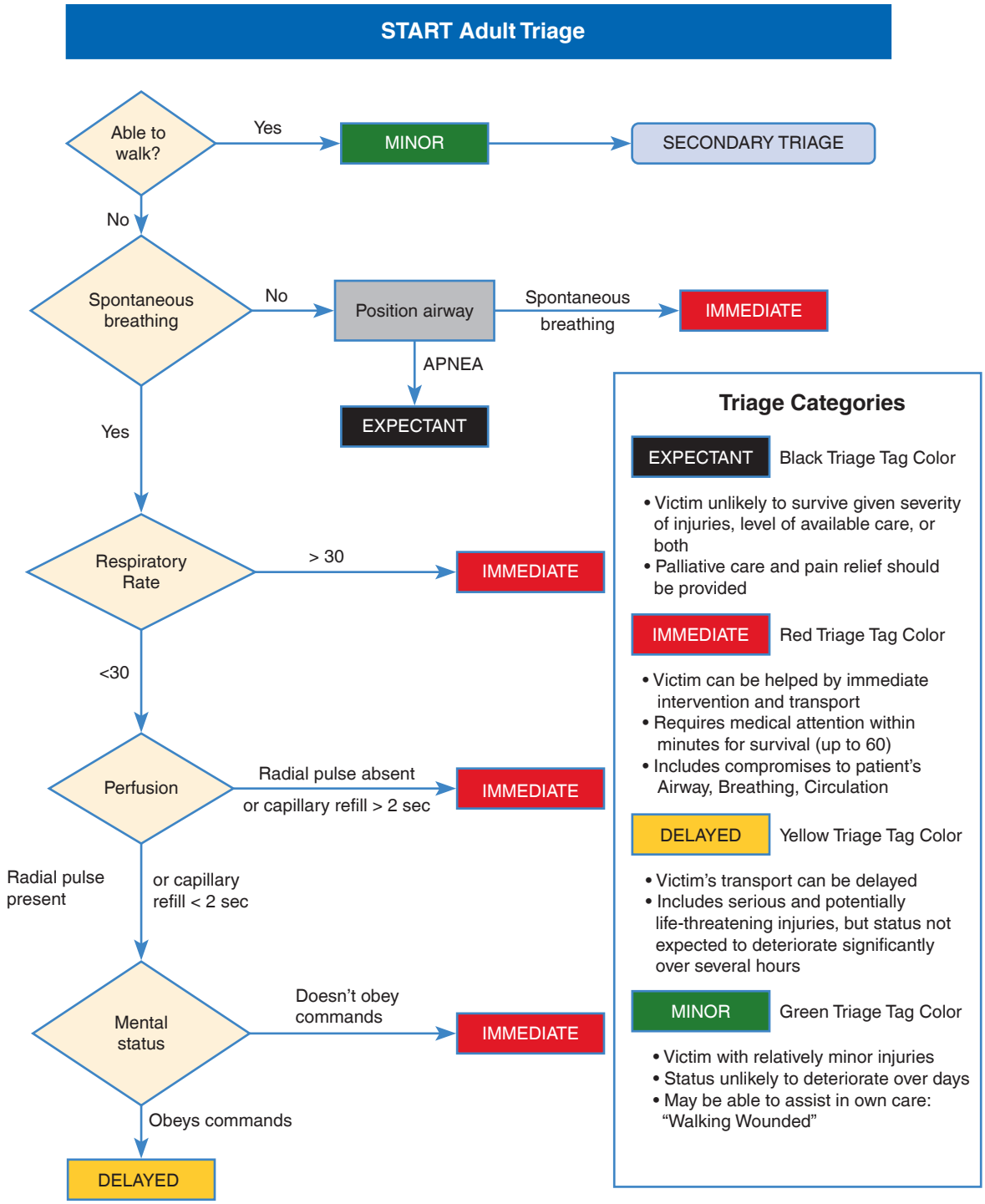


Figure C-3 Model Uniform Core Criteria: SALT Triage.

Field triage, also called *primary triage*, focuses on identifying patients who are critical (have immediate life threats) and who need intervention right away.

SALT begins with the first-arriving responders, one of whom must assume the role of triage officer (TO). To rapidly determine who is not sick, the TO uses a loudspeaker to instruct anyone who can hear the instructions to walk to a location identified by the responders. Anyone able to walk to the location requires intact perfusion and CNS and is not critical. With this first step the TO has removed all stable, or Green, patients.

As some patients many have injuries that prevent them from walking, the TO now asks those remaining who can hear the command to hold up their hands. Again, to perform this task these patients must have intact perfusion. The TO now begins to assess those who did not respond to either commands.

The second step is the individual assessment, which is immediately followed by lifesaving interventions. This assessment is really based on the primary survey. Control exsanguinating bleeding with tourniquets. Open the airway. If not breathing, the patient is deceased, except in pediatric patients, where the provider may give two rescue breaths (JumpSTART).

Please refer to Figure C-2 for the steps to sort out the triage classes in SALT. Remember that survival based on the available resources enters into the picture. Some agencies utilize START or similar triage algorithms at this point. The final step is to prioritize patients for transport, again based on resources available.

There are numerous tagging systems on the market, each with advantages and disadvantages (Figure C-4). Providers should be familiar with the system used by their agency. A good way to develop familiarity and maintain comfort with the use of tags is to use them one day a month on patients who are transported. This also allows the receiving facilities to maintain comfort with their use.

The priorities of any incident, no matter how small or large, should be safety, organization, and patient care. To provide the most effective and efficient patient care, one must approach it in a safe and organized fashion. Regular practice improves efficiency and reduces both overtriage and undertriage.



Figure C-4 Examples of triage tagging systems.

References and Resources

Cone, D. C., J. Serra, K. Burns, D. S. MacMillan, L. Kurland, and C. Van Gelder. 2009. "Pilot test of the SALT mass casualty triage system." *Prehospital Emergency Care* 13, no. 4: 536–40.

Hodgetts, T., and C. Porter. 2013. *Major incident management system*. Hoboken, NJ: Wiley.

Introduction to ICS. Accessed July 22, 2010. http://training.fema.gov/EMIWeb/IS/IS100A.asp.

Kahn, C., C. H. Schultz, K. T. Miller, and C. L. Anderson. 2009. "Does START triage work?: An outcomes assessment after a disaster." *Annals of Emergency Medicine* 54, no. 3: 424–31.

Lerner, E. B., D. Cone, E. S. Weinstein, R. B. Schwartz, P. L. Coule, M. Cronin, I. S. Wedmore, E. M. Bulger, D. A. Mulligan, R. E. Swienton, et al. 2011. "Mass casualty triage: An evaluation of the data and refinement of a national guideline." *Disaster Medicine and Public Health Preparedness* 5: 129–37.

Romig, L. E. *The JumpSTART Pediatric MCI triage tool and other pediatric disaster and emergency medicine resources*. Accessed July 22, 2010. http://www.jumpstarttriage.com.

Sasser S. M., R. C. Hunt, M. Faul, D. Sugerman, W. S. Pearson, T. Dulski, M. M. Wald, G. J. Jurkovich, C. D. Newgard, E. B. Lerner, et al. 2012. "Guidelines for field triage of injured patients: Recommendations of the National Expert Panel on Field Triage, 2011." *Morbidity and Mortality Weekly Report: Recommendations and Reports* 61, no. RR01 (January): 1–20.

START Support Services. *START triage: The race against time*. Accessed July 22, 2010. http://www.start-triage.com.