Emergency War Surgery
Previous page:
Hero’s Highway shuts down. Airmen from the 332nd Expeditionary Medical Group carry a stretcher under the Hero’s Highway flag during an aeromedical evacuation training exercise. The historical flag was recently cased in a ceremony on September 1, 2011.
Photograph: US Air Force photo no. 110707-F-GU448-007.
Photographer: Senior Airman Jeffrey Schultze.
Emergency War Surgery

Fourth United States Revision

2013

Borden Institute
US Army Medical Department Center and School
Fort Sam Houston, Texas

Office of The Surgeon General
United States Army
Falls Church, Virginia
“All the circumstances of war surgery thus do violence to civilian concepts of traumatic surgery. The equality of organizational and professional management is the first basic difference. The second is the time lag introduced by the military necessity of evacuation. The third is the necessity for constant movement of the wounded man, and the fourth—treatment by a number of different surgeons at different places instead of by a single surgeon in one place—is inherent in the third. These are all undesirable factors, and on the surface they seem to militate against good surgical care. Indeed, when the overall circumstances of warfare are added to them, they appear to make more ideal surgical treatment impossible. Yet this was not true in the war we have just finished fighting, nor need it ever be true. Short cuts and measures of expediency are frequently necessary in military surgery, but compromises with surgical adequacy are not.”

—Michael E. DeBakey, MD
Presented at Massachusetts General Hospital
Boston, October 1946
THE FOURTH UNITED STATES REVISION

of

EMERGENCY WAR SURGERY

IS DEDICATED TO THE

COMBAT PHYSICIAN
Dosage Selection:

The authors and publisher have made every effort to ensure the accuracy of dosages cited herein. However, it is the responsibility of every practitioner to consult appropriate information sources to ascertain correct dosages for each clinical situation, especially for new or unfamiliar drugs and procedures. The authors, editors, publisher, and the Department of Defense cannot be held responsible for any errors found in this book.

Use of Trade or Brand Names:

Use of trade or brand names in this publication is for illustrative purposes only and does not imply endorsement by the Department of Defense.

Neutral Language:

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

The opinions or assertions contained herein are the personal views of the authors and are not to be construed as doctrine of the Department of the Army or the Department of Defense. For comments or suggestions on additional contents in forthcoming editions, please contact the publisher (www.cs.amedd.army.mil/borden).

CERTAIN PARTS OF THIS PUBLICATION PERTAIN TO COPYRIGHT RESTRICTIONS. ALL RIGHTS RESERVED.

NO COPYRIGHTED PARTS OF THIS PUBLICATION MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL (INCLUDING PHOTOCOPY, RECORDING, OR ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM), WITHOUT PERMISSION IN WRITING FROM THE PUBLISHER OR COPYRIGHT OWNER.
Contents

EDITORIAL BOARD xi
CONTRIBUTORS xii
ACKNOWLEDGMENTS xvii
FOREWORD xix
PREFACE xxi
PROLOGUE xxiii

Chapter 1: Weapons Effects and War Wounds 1
Chapter 2: Roles of Medical Care (United States) 17
Chapter 3: Mass Casualty and Triage 29
Chapter 4: Aeromedical Evacuation 47
Chapter 5: Airway/Breathing 61
Chapter 6: Hemorrhage Control 69
Chapter 7: Shock, Resuscitation, and Vascular Access 77
Chapter 8: Anesthesia 89
Chapter 9: Soft-Tissue and Open Joint Injuries 101
Chapter 10: Infections 113
Chapter 11: Critical Care 131
Chapter 12: Damage Control Surgery 175
Chapter 13: Face and Neck Injuries 183
Chapter 14: Ocular Injuries 205
Chapter 15: Head Injuries 219
Chapter 16: Thoracic Injuries 241
Chapter 17: Abdominal Injuries 257
Chapter 18: Genitourinary Tract Injuries 277
Chapter 19: Gynecological Trauma and Emergencies 291
Chapter 20: Wounds and Injuries of the Spinal Column and Cord 307
Chapter 21: Pelvic Injuries 317
Chapter 22: Extremity Fractures 327
Chapter 23: Amputations 341
Chapter 24: Injuries to the Hands and Feet 349
Chapter 25: Vascular Injuries 357
Chapter 26: Burns 377
Chapter 27: Environmental Injuries 393
Chapter 28: Radiological Injuries 427
Chapter 29: Biological Warfare Agents 435
Chapter 30: Chemical Injuries 443
Chapter 31: Pediatric Care 451
Chapter 32: Care of Enemy Prisoners of War/Internees 461
Chapter 33: Battlefield Transfusions 467
Chapter 34: Compartment Syndrome 489
Chapter 35: Battlefield Trauma Systems 497
Chapter 36: Emergency Whole Blood Collection 503
Envoi 513
Appendix 1: Principles of Medical Ethics 515
Appendix 2: Glasgow Coma Scale 519
Appendix 3: Department of Defense Trauma Registry 521
Abbreviations and Acronyms 529
Significant Military Medical Terms 541
Product Manufacturers 543
Index 545
Editorial Board

Chair/Senior Medical Editor
Miguel A. Cubano, MD, FACS
CAPT, MC, US Navy
Deputy Commander
Defense Medical Readiness Training Institute
Fort Sam Houston, Texas

Executive Medical Editor
Martha K. Lenhart, MD, PhD, FAAOS
COL, MC, US Army

Medical Co-Editors
Jeffrey A. Bailey, COL, MC, US Air Force
George P. Costanzo, COL, MC, US Air Force
Brian J. Eastridge, COL, MC, US Army
James R. Ficke, COL, MC, US Army
Christopher M. Hults, CDR, MC, US Navy
Zsolt T. Stockinger, CAPT, MC, US Navy

Borden Institute Editorial Staff
Daniel E. Banks, MD, MS, MACP
LTC, MC, US Army
Director and Editor in Chief

Timothy K. Jones, DDS
COL (Ret), DC, US Army
Assistant Director

Vivian Mason
Volume Editor

Douglas Wise
Layout Editor

Bruce Maston
Illustrator
Contributors

Romney Anderson, COL, MC, US Army
Jayson Aydelotte, MAJ, MC, US Army
Martin Baechler, COL, MC, US Army
Jeffrey A. Bailey, COL, MC, US Air Force
Linda Beltra, CAPT, MC, US Navy
John R. Benjamin, CDR, MC, US Navy
Terence G. Benson, MAJ, BSc, US Air Force
Alan Berg, COL, MC, US Air Force
Ian H. Black, MAJ, MC, US Army Reserves
Sharon Blondeau, CAPT, NC, US Navy
Harold R. Bohman, CAPT (Ret), MC, US Navy
Mark E. Boston, COL, MC, US Air Force
Mark W. Bowyer, COL (Ret), MC, US Air Force
Chester Buckenmaier III, COL, MC, US Army
Frank Butler, CAPT, MC, US Army
Ramon F. Cestero, CDR, MC, US Navy
Michael Charlton, LT COL, MC, US Air Force
George P. Costanzo, COL, MC, US Air Force
Tracy Cotner-Pouncy, RN
James E. Cox, COL (Ret), MC, US Air Force
Miguel A. Cubano, CAPT, MC, US Navy
Virgil Deal, COL, MC, US Army
Sherrilee A. Demmer, RN, BSN
David Dromsky, CDR, MC, US Navy
James Dunne, CAPT, MC, US Navy
Brian J. Eastridge, COL, MC, US Army
Mary Edwards, LTC, MC, US Army
James R. Ficke, COL, MC, US Army
Stephen Flaherty, COL, MC, US Army
Richard Gonzales, COL, MSC, US Army
Kurt Grathwohl, COL, MC, US Army
Steven Hadley, COL, MC, US Air Force
Dan R. Hansen, COL, MC, US Army
Kenneth C. Harris, COL, MC, US Army
Scott Helmers, CAPT, MC, US Navy
Linda Hill, LCDR (Ret), MSC, US Navy
Christopher M. Hulits, CDR, MC, US Navy
Joel Jenne, LT COL, MC, US Air Force
Jefferson Jex, MAJ, MC, US Army
Jason Johnson, MAJ, MC, US Army
Timothy K. Jones, COL (Ret), DC, US Army
John Keeling, CDR, MC, US Navy
James Keeney, LT COL, MC, US Air Force
Jess Kirby, MAJ, MC, US Army
Kevin Kirk, LTC, MC, US Army
Eric Kuncir, CAPT, MC, US Navy
Julio Lairret, MAJ, MC, US Air Force
Ronald A. Lehman, LTC, MC, US Army
Martha K. Lenhart, COL, MC, US Army
Henry Lin, CDR, MC, US Navy
Mark A. MacDougall, LTC, AN, US Army
Patricia McKay, CAPT, MC, US Navy
Alan Murdock, LT COL, MC, US Air Force
Shawn Passons, LCDR, NC, US Navy
Jeremy Perkins, LTC, MC, US Army
Benjamin Potter, MAJ, MC, US Army
Joseph Rappold, CAPT, MC, US Navy
Todd Rasmussen, LT COL, MC, US Air Force
Francisco Rentas, COL, MC, US Army
Evan Renz, COL, MC, US Army
Mark Richardson, COL, MC, US Air Force
Keyan Riley, MAJ, MC, US Air Force
John R. Rotruck, CDR, MC, US Navy
Zsolt T. Stockinger, CAPT, MC, US Navy
Joseph Strauss, CDR, MC, US Navy
Daniel Unger, CAPT, MC, US Navy
Teun van Egmond, COL, MC, Royal Netherlands Army
Glenn Wortmann, COL (Ret), MC, US Army
Illustration Contributors
E. Weissbial
Joint Trauma System
SonoSite, Inc

Illustrators
Bruce Maston
Jessica Shull
Douglas Wise

2004 Contributors

We also pay tribute to the contributors of the 2004 Edition of Emergency War Surgery:

Editors
Ronald F. Bellamy, COL (Ret), MC, US Army
Matthew Brengman, MAJ, MC, US Army
David G. Burris, COL, MC, US Army
Paul J. Dougherty, LTC, MC, US Army
David C. Elliot, COL, MC, US Army
Joseph B. FitzHarris, COL, MC, US Army
Stephen P. Hetz, COL, MC, US Army
John B. Holcomb, COL, MC, US Army
Donald H. Jenkins, LTC, MC, US Air Force
Christoph Kaufmann, LTC, MC, US Army
Dave Ed. Lounsbury, COL, MC, US Army
Peter Muskat, COL, MC, US Air Force
Lawrence H. Roberts, CAPT, MC, US Navy

Contributors
Keith Albertson, COL, MC, US Army
Rocco A. Armonda, LTC, MC, US Army
Kenneth S. Azarow, LTC, MC, US Army
Ronald F. Bellamy, COL (Ret), MC, US Army
Matthew Brengman, MAJ, MC, US Army
David G. Burris, COL, MC, US Army
Frank Butler, CAPT, US Navy
Mark D. Calkins, MAJ, MC, US Army
Leopoldo C. Cancio, LTC, MC, US Army
David B. Carmacke, MAJ, MC, FS, US Air Force
Maren Chan, CPT, US Army
Contributors

David J. Cohen, COL, MC, US Army
Jan A. Combs, MAJ, MC, US Army
Paul R. Cordts, COL, MC, US Army
Nicholas J. Cusolito, MAJ, NC, US Air Force
Daniel J. Donovan, LTC, MC, US Army
Paul J. Dougherty, LTC, MC, US Army
David C. Elliot, COL, MC, US Army
Martin L. Fackler, COL (Ret), MC, US Army
John J. Faillace, MAJ, MC, US Army
Gerald L. Farber, LTC, MC, US Army
Joseph B. FitzHarris, COL, MC, US Army
Stephen F. Flaherty, LTC, MC, US Army
Roman A. Hayda, LTC, MC, US Army
John B. Holcomb, COL, MC, US Army
Michael R. Holtel, CAPT, MC, US Navy
Stephen P. Hetz, COL, MC, US Army
Jeffrey Hrutkay, COL, MC, US Army
Annesley Jaffin, COL, MC, US Army
Donald H. Jenkins, LTC, MC, US Air Force
James Jeziorski, LTC, MC, US Army
Christoph Kaufmann, LTC, MC, US Army
Kimberly L. Kesling, LTC, MC, US Army
Thomas E. Knuth, COL, MC, US Army
Wilma I. Larsen, LTC, MC, US Army
George S. Lavenson, Jr, COL (Ret), MC, US Army
James J. Leech, COL, MC, US Army
Dave Ed. Lounsbury, COL, MC, US Army
Christian Macedonia, LTC, MC, US Army
Craig Manifold, MAJ, MC, US Air Force
Patrick Melder, MAJ, MC, US Army
Alan L. Moloff, COL, MC, US Army
Allen F. Morey, LTC, MC, US Army
Peter Muskat, COL, MC, US Air Force
Mary F. Parker, LTC, MC, US Army
George Peoples, LTC, MC, US Army
Karen M. Phillips, LTC, DC, US Army
Ronald J. Place, LTC, MC, US Army
Paul Reynolds, COL, MC, US Army
Lawrence H. Roberts, CAPT, MC, US Navy
David Salas, MSGT (Ret), US Air Force
Joseph C. Sniezek, MAJ, MC, US Army
Scott R. Steele, CPT, MC, US Army
Allen B. Thach, COL, MC, US Army Reserve
Johnny S. Tilman, COL, MC, US Army
John M. Uhochak, COL, MC, US Army
Steven Venticinque, MAJ, MC, US Air Force
Ian Wedmore, LTC, MC, US Army
Emergency War Surgery

Additional Contributors
Chester Buckenmaier, LTC, MC, US Army
Eskil Dalerius, COL, Swedish Armed Forces
Michael Deaton, COL, MC, US Army
William Dickerson, COL, US Air Force
Peter Rhee, LTC, MC, US Army
Glenn Wortmann, LTC, MC, US Army

Illustrators
Bruce Maston
Jessica Shull
Acknowledgments

Special acknowledgment to CAPT W. R. Dalton, Commander of the Defense Medical Readiness Training Institute, for his leadership and oversight during this revision of Emergency War Surgery.

The information contained in this book reflects a generous collaborative effort. Thank you to all of the contributors and content reviewers for their valuable time and contributions.

Thanks to Donalda (Dee) Smith whose efforts and selfless service were unprecedented. Dee deserves special recognition for persevering and committing more than 3 years to getting this book organized, connecting doctors with chapters, and providing untiring service to see it to its completion. She was the driving force behind this book and spent countless hours making phone calls, sending multitudinous e-mails, and communicating with doctors all over the country and OCONUS. Without her, this book would not have been possible.

Tremendous gratitude to Colonel Martha Lenhart of the Borden Institute who was instrumental in ensuring that this book was a priority, and who selflessly provided guidance and encouragement during all stages of its production. We would also like to express our sincere thanks to Vivian Mason, Volume Editor, Borden Institute, for her dedication and technical support.


Miguel A. Cubano, MD, FACS
Captain, MC, US Navy
Deputy Commander
Defense Medical Readiness Training Institute
Foreword

It is an honor for me to acknowledge the time, efforts, and experience collected in this fourth revision of Emergency War Surgery. Once again, a team of volunteers representing the Military Health System and numerous clinical specialties has committed itself to compiling state-of-the-art principles and practices of forward trauma surgery.

War surgery and treatment of combat casualties at far-forward locations, frequently under austere conditions, continue to save lives. Military medical personnel provide outstanding health support to those who serve in harm’s way. As war has evolved, so has our medical support to those who fight. Today, American service members face a new terrain of mobile urban conflict. Despite advances in personal and force protection, our forces remain vulnerable to blast wounds, burns, and multiple penetrating injuries not usually encountered in civilian settings. This publication expertly addresses the appropriate medical management of these and other battle and nonbattle injuries.

I congratulate contributors to this edition for drawing on the experiences of colleagues who recently returned from tours of duty in Southwest Asia to provide the most current handbook. I wish to publicly extend my gratitude, and that of the American people, to the courageous men and women who serve in the medical departments of our armed services. I commend your dedicated service and acknowledge your sacrifices, and those of your families, to provide the best healthcare to those who protect our nation. All Americans are indebted to your service.

Jonathan Woodson, MD
Assistant Secretary of Defense for Health Affairs
Director of TRICARE Management Activity

May 2012
Washington, DC
Preface

The moral test of a nation’s character is how its citizens care for those who are ill or injured as a consequence of war. This edition of the *Emergency War Surgery* manual (the 4th revision) exemplifies the continuing commitment of military healthcare providers to Soldier well-being across the continuum of care from remote battlefields to stateside evacuation. This resource epitomizes shared knowledge from healthcare providers dedicated to the delivery of lifesaving care, which underpins our honored legacy of military medicine. The authors have documented our providers’ intellectual commitment and unwavering ability to advance the practice of medicine under arduous combat conditions. The battlefield experience has always informed medicine. The increased experience of combat and innovation resulting from the last decade of war will forever be etched within the pages of this manual, not as a monument for posterity, but as a practical handbook to enhance the working medical knowledge and skills of our fighting force.

It is said that the Greek god of medicine, Asclepius, was born as a result of an emergency medical intervention. Heroic acts of courage by Soldiers, Sailors, Airmen, and Marines are a testament to our nation’s ability to overcome adversity even in the face of mortal challenge. As enemy tactics in Iraq and Afghanistan evolved, with increased application of improvised and vehicle-borne explosive devices, medical leaders at all levels questioned existing paradigms and conventional wisdom. They developed evidence-based Clinical Practice Guidelines, changed or augmented existing treatment modalities, and spearheaded progressive alterations to ballistic survival gear. From the application of tourniquets at the point of injury to the design and development of prosthetics during the rehabilitative phase of treatment, our medical teams continue to conduct new research and challenge medical dogma to solve current problems.

*Emergency War Surgery* is a testament to the courage exhibited by our military men and women in these difficult times. This manual represents the collective efforts of numerous military scholars and
Emergency War Surgery pays homage to those who willingly paid the ultimate price of freedom. Each word should be read in their honor.

With honor, humility, and profound admiration, we present the 4th edition of the Emergency War Surgery manual with the express hope that we will not forget the lessons we have learned.

Patricia D. Horoho
Lieutenant General, US Army
Surgeon General
Commanding General US Army Medical Command

Matthew L. Nathan
Vice Admiral, US Navy
Surgeon General

Thomas W. Travis
Lieutenant General, US Air Force
Surgeon General

April 2013
Washington, DC
Prologue

“War is the only proper school for the surgeon.”
— Hippocrates

Within the last century, our wars have traveled from the hedgerows of Europe and beaches in the Pacific, to the jungles of Vietnam, and now to the deserts and mountains of Southwest Asia. The common denominator of these conflicts is intense human suffering and death as a result of injury on the battlefield. Most recently, after a decade of war, what is recent past is prologue for this work: more than 5,000 dead and tens of thousands of combat casualties with significant injury in the decade from 2001 to 2011. Per the philosophy of Hippocrates, “What have we learned?” and, more importantly, how can we pass that knowledge along to those who will follow? As the concept of modern warfare has changed, so, too, has medical care evolved on the battlefield. The current contingency operations have produced medical advances that will be our legacy and the new foundations for the military surgeons of the future.

War surgery today is about using evidence and best practice to optimize care of our wounded warriors. Although grounded in the fundamental training of the general surgeon and surgical specialist, it must be adaptive to the challenges of extremely high injury acuity, the burden of overwhelming casualty numbers, long and unforgiving hours, environmental extremes, logistical austerity, and the reality that mission accomplishment may precede medical necessity. It is a concept built on realistic experience and lessons learned over a decade of continuous conflict. War has predictably proliferated innovations in medicine and surgery. Modern technology and communication have yielded substantial impact on the battlefield, in that we are better able to use contemporary lessons learned to disseminate, educate, and change practice to mitigate casualty outcomes in relatively “real time.”

Advances in combat casualty care are associated with the lowest case fatality rate in the history of warfare, a fact rendered even more remarkable by the complexity of injury and expedited
transcontinental evacuation of casualties across the globe. Within
this realm of medical innovation, one of the most important
contemporary advances to military medicine on the battlefield has
been the development and implementation of the Joint Trauma
System, a system whose singular vision is that every soldier,
Marine, sailor, or airman injured on the battlefield or in the theater
of operations has the optimal chance for survival and maximal
potential for functional recovery. The motto of the system is
“Right Patient, Right Time, Right Place, Right Care.” The trauma
system is built on the infrastructure of the Department of Defense
Trauma Registry (DoDTR), in that data improve medical care; that
data drive doctrine, policy, and decision-making; and that data
create new knowledge to further the evolution of battlefield care.
Pertinent to the casualty and the surgeon, the mission of the Joint
Trauma System is to improve trauma care delivery and patient
outcomes across the continuum of care, utilizing continuous
performance improvement and evidence-based medicine. Value
of the trauma system is evidenced by development of more
than 36 evidence-based battlefield relevant Clinical Practice
Guidelines (CPGs) that have decreased morbidity and mortality
from combat injury. Relevant CPGs are cited extensively in this
version of Emergency War Surgery.

Furthermore, the antiquated system of prehospital care espoused
by Pre-Hospital Trauma Life Support (PHTLS) has been
ubiquitously supplanted by the paradigm of Tactical Combat
Casualty Care (TCCC), divided into phases depending on the
tactical scenario. In each phase, the greatest potential threat to life
is managed as a priority in the context of mission capability and
mission completion. Embedded within the overarching concept
of TCCC are hemorrhage control and airway management.
Tourniquet utilization has become a fundamental pillar of
hemostasis in TCCC and has been shown to be associated with
an attributable survival advantage.

Developers of the technique of balanced resuscitation coined
the term “damage control resuscitation.” It was conceptualized
on this battlefield and has reduced the mortality rate of massive
transfusion casualties from 40% to less than 20%. Further
refinements of this resuscitation paradigm include the use of
novel hemostatic agents, coagulopathy testing modalities, and even mobile resuscitative team strategies.

Even with all of the advances that have taken place on the battlefield in the last decade, several challenges loom on the horizon. Despite the lowest case fatality rate in history, the “died of wounds rate” remains largely unchanged. The vast majority of combat casualties die on the battlefield before ever reaching a medical treatment facility. Therefore, the greatest chance to impact combat casualty care occurs long before the surgeon ever has the opportunity to stop the bleeding. The charge to the generation of surgeons reading this text is to make this situation better.

It is the earnest hope of the authors of this Emergency War Surgery handbook that it will gather dust on the shelves of tomorrow’s military surgeon, knowing all too well that with predictable certainty that far too soon the “balloon will go up” and military surgeons will once again heed the call.

There is no greater calling, nor greater responsibility, nor greater sense of worth than to care for a wounded brother-in-arms.

Brian J. Eastridge, MD, FACS
Colonel, MC, US Army
Trauma Consultant, US Army Surgeon General

Miguel A. Cubano, MD, FACS
Captain, MC, US Navy
Deputy Commander
Defense Medical Readiness Training Institute

Jeffrey A. Bailey, MD, FACS
Colonel, MC, FS, US Air Force
Director, Joint Trauma System

May 2012
San Antonio, Texas