War Surgery *in* Afghanistan and Iraq

A SERIES OF CASES, 2003–2007


Baghdad
بغداد
مبنى المسافرين
Passenger Terminals

It is impossible to convey to you
the picture of human misery continually before my eye. . . .
While I amputate one man's thigh, there lay at one time thirteen,
all beseeching to be taken next. . . .
It was a strange thing to feel my clothes stiff with blood,
and my arms powerless with the exertion of using the knife! . . .
The view of the field, the gallant sorties, the charges,
the individual instances of enterprise and valour
recalled to me the sense the world has of victory and Waterloo.
But this is transient. A gloomy uncomfortable view of
human nature is the inevitable consequence of
looking upon the whole as I did—as I was forced to do.

—Sir Charles Bell (1774–1842)

War Surgery in Afghanistan and Iraq

A SERIES OF CASES, 2003–2007

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The Nation today needs men who think in terms of service to their country and not in terms of their country's debt to them.

—General Omar N. Bradley, 1948

And so, my fellow Americans: ask not what your country can do for you—ask what you can do for your country.

—John F. Kennedy, 1961

★ ★ ★ ★ ★

TO SERVICE

To the Soldiers, Marines, Airmen, and Sailors

who have sacrificed so much

for their country

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The purpose of this textbook is to provide concise supplemental material for military surgeons deploying or preparing to deploy to a combat theater. The information contained herein will foster discussion that may form the basis of policy and doctrine. Every effort has been made to ensure that information provided is consistent with official OTSG/MEDCOM policy and doctrine. This is not, however, an official Department of the Army publication. The views expressed are those of the editors and should not be construed necessarily to reflect the views of the Department of Defense, the Department of the Army, or the Army Medical Department.

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FOREWORD

On January 29, 2006, I was riding on top of an Iraqi APC (armored personal carrier), heading down a road in Taji, Iraq, that was supposed to represent a success story of the war: a collaboration between US and Iraqi forces against the insurgents. As the newly named co-anchor of ABC World News Tonight, I was in Iraq to cover President Bush's State of the Union address and to report on the positive stories of the war—the hard work of the military to train and empower local forces on the ground.

In an instant, an improvised explosive device (IED) exploded about 20 yards from the vehicle, and my life was changed forever, as well as that of my cameraman, Doug Vogt. The force of the blast, a 155-mm shell, shattered my skull over the left temporal lobe. Hundreds of rocks, packed around the IED, were blasted into the side of my face. One rock, the size of a child's marble, sheared my helmet chinstrap in half and traveled through the left side of my neck, coming to rest on the carotid artery on the other side of my head.

For the next 36 days, I would remain in a medically induced coma; but the quick actions and amazing skills of the medics, military doctors, nurses, and assistants would not only save my life, but also save my brain function following this life-threatening injury. Their experiences with such large numbers of those wounded by IEDs, most of whom would not have survived in previous wars, gave them the confidence to make split-second decisions. In the medical barracks of Balad, the doctors did not hesitate, giving me the chance for the best possible outcome.

One of the most amazing stories I heard later, which speaks to me of the dedication of our men and women in uniform, is a story about the MEDEVAC pilots. After the IED exploded, a gunfight ensued and the helicopter pilots were instructed not to land. Unaware of who was on the ground and only knowing that someone needed help, these pilots turned down the radio, ignored the order, and landed. I was then taken to Baghdad, assessed, and then sent to Balad, where—within the hour—my skull flap was removed and my brain began swelling. From Balad, I was sent to Landstuhl Regional Medical Center in Germany, a major way station for wounded soldiers en route to the United States. Just 60 hours after my family arrived there, I was ready to be transported again to neurosurgical care at the National Naval Medical Center (also known as Bethesda Naval Hospital) outside of Washington, DC.

"The willingness with which our young people are likely to serve in any war, no matter how justified, shall be directly proportional to how they perceive the Veterans of earlier wars were treated and appreciated by their nation."

It was there that I received top-notch medical care from an expert team of dedicated military specialists. It was their skill, perseverance, team approach, and kindness that created a platform from which to heal. In writing this foreword, I want to applaud the efforts, bravery, and dedication of the American military. It is well known that much of cutting edge medicine in civilian life comes from the valiant efforts, ingenuity, and pure guts of the battlefield physicians in an effort to save lives under extreme conditions. I am not a hero. I leave that to the men and women serving their country in uniform who put their lives on the line every day for our freedoms. After their wounds, their lives (like mine) are changed forever. What do we owe these men and women? How do we measure our debt to them and their families? What will be our legacy of how we treat those with long-term injuries—such as traumatic brain injury, posttraumatic stress disorder, depression, and other mental illnesses—that can require years of appropriate therapy as the brain heals and the body regenerates?

George Washington, our nation's first Commander in Chief, said, "The willingness with which our young people are likely to serve in any war, no matter how justified, shall be directly proportional to how they perceive the Veterans of earlier wars were treated and appreciated by their nation." Today, in the face of so many injured returning from the wars in Iraq and Afghanistan, we are faced with a wave of wounded, many of them young, all of them returning to a life vastly different than what they left, and families who must learn to deal with a new reality. Are we adequately meeting that charge from our founding father?

Once I passed through the acute stage of my injury, the real work began with my long journey to heal during rehabilitation. Time, energy, commitment, and dedicated professionals supplied the framework to help my brain heal. The love and encouragement of family and friends provided my personal motivation to "get my brain back."

I hope that this book instructs deployed physicians in aspects of the care of initial injuries. But may it also serve as a stepping-off point to focus on continuing that quality of care in the long road to rehabilitation following the injury. My family and I are so appreciative and forever grateful for the medical care that I received from the military. It is our dream that the attention to the wounded remains as focused in the long journey to heal as it is in those white-hot moments in the surgical theater when nothing is spared to save a life.

Bob Woodruff
July 2007

PREFACE

It is not uncommon for editors of multiauthored textbooks, and for reviewers of these books, to comment apologetically—or critically—on the inherent bumpiness of such works. We make no such apology here. Indeed, we maintain that the individual nuance and variation among this series of cases are a testament to the collective dedication of the many surgeons, deployed in Southwest Asia, who volunteered their experiences to the effort that produced this textbook.

The photographs were taken mostly in the field by handheld digital cameras. The surgical accounts were typed into e-mails dispatched to the Borden Institute from overseas Forward Surgical Teams (FSTs), combat support hospitals (CSHs), and their equivalent sister Service deployable surgical facilities, or collected from surgeons on their return from these deployments. End-of-chapter peer review commentary has been provided, but the editors have been careful to maintain the individual character of each case as it was presented, as it evolved, as it was managed, and as it was concluded . . . not in every case successfully.

The result of this extraordinary frankness, included in such a broad spectrum of acute trauma surgical presentations, is a textbook unlike any other in the surgical literature. Paired, as it is intended to be, with the 2004 edition of *Emergency War Surgery, Third United States Revision*, this text provides the deploying surgeon, as well as surgical housestaff, with the fundamental principles and priorities critical in managing the trauma of modern warfare; and all medical professionals with insights into the extraordinary technical, clinical, and ethical challenges of their colleagues.

The US Army Medical Department applauds the diligent work of the editors in collecting these cases and providing the necessary instruction and discussion in order to provide optimal forward surgical care—care that is the duty of a great nation to those who serve.

ERIC B. SCHOOMAKER, MD, PhD, FACP
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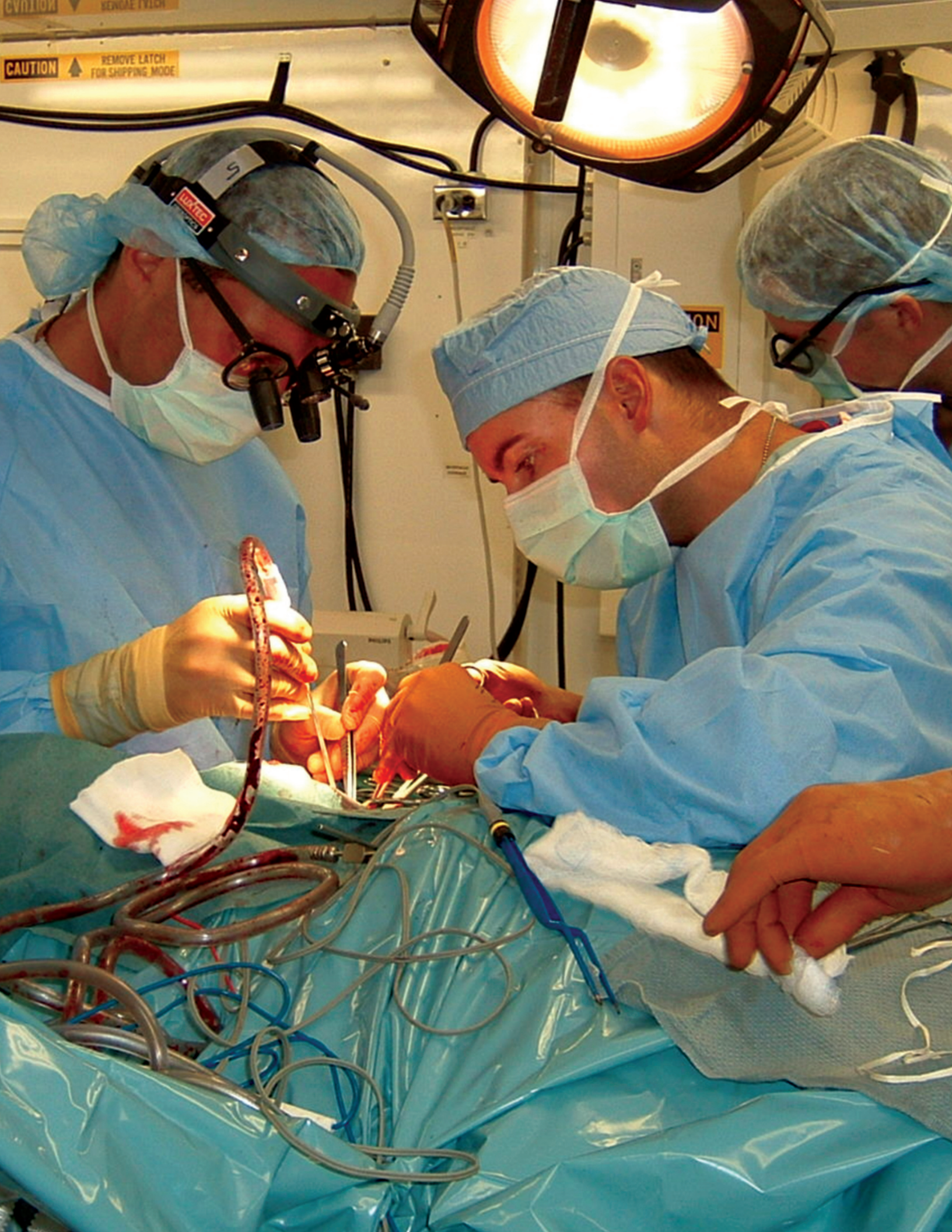
The Surgeon General

Washington, DC, December 2007


CAUTION
REMOVE LATCH
FOR SHIPPING MODE

INTRODUCTION

. . . he who would become a surgeon,
therefore, should join the army and follow it.
—HIPPOCRATES

Following terrorist attacks of September 11, 2001 on the United States, US military forces were mobilized and deployed to Afghanistan (Operation Enduring Freedom [OEF]) in 2001 and to Iraq (Operation Iraqi Freedom [OIF]) in 2003. Deployed forces were accompanied by Army field medical assets (eg, the Mobile Army Surgical Hospital [MASH], the Combat Support Hospital [CSH], and the Forward Surgical Team [FST]), as well as their Air Force and Navy equivalents. Almost immediately, these medical units were presented with the casualties, both military and civilian, of insurgent guerilla warfare.

When *Emergency War Surgery, Third United States Revision* (EWS) was published in 2004, it was the intention of the Borden Institute to present this handbook in an electronic version, as well as in a printed format. Although EWS is widely available today, including on the World Wide Web (http://bordeninstitute.army.mil) and as a CD-ROM, plans to incorporate instructional video links proved technically infeasible. Nonetheless, the Borden Institute continued to solicit case reports related to the resuscitation and management of acute trauma in the field. These requests were extended in an ad hoc fashion predominantly to US Army medical units as they rotated in and out of operations in Iraq and Afghanistan.

Today, it is common for deployed physicians to have ready access to personal digital cameras, and to use these to capture presentations and operative stages of their surgical cases. We are grateful for the generous response to our requests. In 2005, with almost 50 cases on file, we decided to collect these into a single series for publication and distribution to surgeons deploying to overseas theaters of war. Our goal was to select cases such that, when paired with the pertinent section of EWS, they would provide important insight and guidance on one or more aspects of the management of acute combat trauma. We believe we have succeeded in this endeavor. Over 80 cases are now captured and presented in identical format with "Teaching Points" describing key aspects that the attending surgeon took away from his or her case. "Clinical Implications" follow. Largely developed by the editors, these points are intended to address the broader issues of all cases similar to the one presented. Due to multiple considerations, the editors decided not to identify contributors at the case level, a reluctant decision not intended to diminish the debt due these dedicated individuals. A single photo without legend

at the opening of each case is a deployment scene from Iraq or Afghanistan and is usually unrelated to the case. Nearly all subsequent clinical photos, however, were taken by staff attending the case presented.

It is important to clarify what this book is not. It is not a comprehensive textbook of surgery. Nor does it substitute for a preparation grounded in the principles of surgery, patient management, or the experience that comes with years at the bedside. We do believe, however, that we have captured the comprehensive spectrum of trauma that characterizes war today, as well as the military medical interventions that have evolved to deliver the wounded from the ferocious destruction of modern warfare. As the history of mankind has been regrettably punctuated in its largest part by the history of war, so have numerous leaps in the advancement of medicine been attributed to lessons learned in war. The present conflicts in Iraq and Afghanistan have proved no exception.

Indeed, the pace of clinical adjustment and improvement in this war is startling and unprecedented. Due to the present availability of high-speed communication, practiced command and control, rapid air evacuation, routine teleconferencing between in-theater level III medical assets and level IV and V facilities (in Germany and the United States, respectively), and (increasingly) computer-based patient tracking, refinement of medical-surgical practice is ongoing rather than gleaned decades after the conflict ends, as was the case in previous wars. A change in the technique for field decompression of suspected pneumothorax and revised thresholds for suspicion of extremity compartment syndromes are two examples of midcourse theater medical corrections.

"... refinement of medical-surgical practice is ongoing rather than gleaned decades after the conflict ends, ..."

Broader changes in treatment are also evident. These often began when anecdotal notice was extended to wider practice if not controlled trials. To be sure, emergency surgical resuscitation in combat does not readily lend itself to placebo-controlled or blinded trials. However, an improving computerized database does permit intratheater outcomes comparisons, as well as theater comparisons to civilian and/or historical norms. As a result, hemorrhage control—the most preventable cause of death on the battlefield—has significantly improved in OIF and OEF, given the introduction of field-applied topical hemostatics (QuikClot and the HemCon Bandage), improved use of prefashioned tourniquets, low-volume and hypertonic resuscitation, newer ratios of packed red cell-to-plasma transfusions, recent (limited) theater availability of apheresis platelets, early resort to fresh whole blood, and perhaps the timely use of human recombinant Factor VIIa.

As important as these interventions, however, has been a wider understanding of the need to recognize early, treat prophylactically, and thereby avoid what has been familiarly called a "triad," but which is, in fact, a relentless vortex of hypothermia, metabolic acidosis, and (hypo)coagulopathy in the severely injured. This approach, known as damage control resuscitation, is transforming the priorities and mechanics of forward acute trauma management fraught with wide practitioner variation to an applied science based on sound physiological principles and with measurable goals and outcomes.

The major precepts of damage control resuscitation are to stop bleeding, minimize contamination, and restore blood flow in order to establish near-normal physiology prior to embarking on definitive repair of injuries. Damage control surgery does not connote haste. Careful attention to a full examination; frequent checks of the patient's evolving physical and mental status; and constant scrutiny for missed sources of bleeding, infection, and compartment syndrome require time and tedium. But explicit in battlefield care is the requirement for resuscitation to be undertaken in the context of timely evacuation to higher echelons of capability.

These then are some of the recurring themes in this book:

- Frequent reference to EWS.
- Setting priorities; emphasis on early consideration of damage control resuscitation.
- Appropriate incorporation of damage control principles into a moving scheme of aeromedical evacuation.
- Defining state-of-the-art combat trauma surgery as practiced in the conflicts in Iraq and Afghanistan.

Another recurring theme is evident in these cases. Battlefield casualties immediately include noncombatant civilians, including women and children, along with host national allies and enemy combatants. All of these individuals are entitled to medical and surgical care. Although all combat casualties are initially resuscitated and stabilized in the immediately available deployed medical facilities, if further definitive care is necessary, US military casualties are evacuated out of theater and rapidly moved along a chain of ever-escalating levels of medical capability. In contrast, host nationals and enemy combatants remain in the combat theater for all of their care, eventually returning to the host country's indigenous medical system (except for enemy combatants who remain in designated US military medical facilities). Since CSHs are designed to provide resuscitation, stabilization, and rapid evacuation for injuries requiring more definitive care, the initially deployed CSHs were neither equipped nor staffed to provide the protracted, resource intensive care necessary for long-term definitive care or rehabilitation. Ad hoc accommodations had to be made for complex orthopaedic, oral-maxillofacial, neurosurgical, and burn care, among many other difficult-to-manage combat wounds. US military physicians would often embark on heroic salvage efforts for severely injured extremities. They understood that in the depleted, underresourced, and overstretched host nation hospitals, amputation of the involved limb was, by far, the most likely outcome. Military general surgeons, in particular, have had to broaden their expertise in order to attend patients whose injuries in a stateside setting would often place them under the care of subspecialty trained colleagues.

"Battlefield casualties immediately include noncombatant civilians, including women and children, along with host national allies and enemy combatants."

These shortcomings of deployed military medical facilities were especially poignant for pediatric casualties. Both experience and equipment were wanting in the care of these injured children. As deployed medical assets have matured in theater, many shortfalls have been corrected. Nonetheless, the dichotomy of different pathways of care for American versus host nation casualties remains an ongoing challenge.

. . . to care for him who shall have borne the battle,
and for his widow, and his orphan, ...

—Abraham Lincoln
Second Inaugural Address, 1864

"attention to the wounded remains as focused in the long journey to heal as it is in those white-hot moments . . . when nothing is spared to save a life."

This textbook is not intended to represent an historical account of the US Army Medical Department in the ongoing conflicts in Afghanistan and Iraq. That history waits to be written by others. Nonetheless, we recognize that what is presented here as a clinical-technical work of applied medicine, with time, necessarily becomes an historical reflection of the state-of-the-art and capability of military medicine at the opening of the 21st century.

The editors profoundly share the hope, expressed herein by Mr. Woodruff, that "attention to the wounded remains as focused in the long journey to heal as it is in those white-hot moments . . . when nothing is spared to save a life."

The focus of this book is immediate trauma care. But the wounds attended, as well as the experiences that accompany them, are too often lifelong. Recovery is incomplete. Management becomes rehabilitation. Life is interrupted—forever demarcated in terms of "before" and "after" a split second in war.

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Washington, DC
October 2007

PROLOGUE
Trauma System Development and Medical Evacuation in the Combat Theater

Introduction

Throughout history, care of the wounded soldier has been the essence of military medicine. The first trauma centers were, by their very nature, military facilities. Many medical advancements have been made during warfare—from the use of a makeshift "ambulance" by Baron Dominique Jean Larré to move casualties off Napoleon's battlefields quickly and back to surgical units in the rear to the advent of blood transfusions during World War I. Lessons learned by military physicians during times of conflict eventually made their way into peacetime practice. In Korea and Vietnam, Mobile Army Surgical Hospitals (MASHs) were deployed to decrease the transit time from the site of injury to definitive surgical treatment. One of the great advances that made the transition from the Vietnam battlefield to the present urban landscape has been the development of similar urban trauma centers and systems.

The helicopter, the advanced training of field medics, and the concentration of surgical resources in a single center all expedited the development of centers for trauma care. The late 1960s to the late 1970s saw the evolution of our modern civilian emergency medical system (EMS) and trauma center capabilities. Few

young people learning to be paramedics today could imagine a time when the local undertaker's hearse also doubled as the community ambulance. Over the past few decades, the American College of Surgeons/Committee on Trauma (ACS/COT) has established guidelines to facilitate the development of civilian trauma centers and systems. The US military deployed its medical assets in Iraq and Afghanistan to support its troop dispositions. With these assets in place, the US Army Medical Department then spearheaded joint efforts to connect and operate these separate facilities as much as possible in accord with ACS/COT standards. This latter effort included establishing subspecialty care centers (eg, neurosurgery), on-site wounding and outcomes data collection, and theaterwide Clinical Practice Guidelines (CPGs). The result has been the development and deployment of the world's largest and most complex trauma system.

Trauma System

ACS/COT emphasizes "optimal care given available resources." This reflects the important and abiding principle that the needs of all injured patients are addressed in as timely a fashion as possible and at the highest standard of care reasonably available. A trauma system is an arrangement of available resources coordinated for the effective delivery of emergency healthcare services in a geographical region. The goal is to "Get the Right Patient to the Right Hospital in the Right Amount of Time"—the motto of the US Central Command Joint Theater Trauma System (JTTS) team.

"A trauma system is an arrangement of available resources coordinated for the effective delivery of emergency healthcare services in a geographical region."

Military Health System Echelons of Care

Current routes of patient evacuation, from site of injury to definitive care, include four echelons of care for US forces (Fig. 1):

1. **Level I Echelon of Care**—This unit level, the Battalion Aid Station/Combat Medic, is initiated at the Self-Aid/Buddy Care level, and consists of immediate first aid and transport. It includes care by combat lifesavers, nonmedical soldiers who receive additional training in wound care. Both the medic and the casualty patient may still be under fire, and there is limited medical equipment available. The combat medic has increasingly assumed the responsibility—and capability—of recognizing and treating potentially preventable causes of death: exsanguinating hemorrhage (early tourniquet application topical hemostatics), pneumothorax (needle angiocatheter), and airway control (oral intubation, cricothyroidotomy). Triage outcome at level I is either return to duty with minimal treatment or evacuate from the battle zone. Casualty evacuation is ideally less than 1 hour to the level II echelon of care.

2. **Level II Echelon of Care**—This level often includes a Forward Surgical Team (FST). Each service provides this level, staffed with from 5 to 20 personnel. The Army FST is typically composed of a 20-person team, with 1 orthopaedic surgeon, 3 general surgeons, 2 nurse anesthetists, 1 critical care nurse, and technicians. The team is able to perform lifesaving resuscitative surgery. This team, when used in its doctrinal configuration, is capable of at least 10 operating room (OR) cases per day and a total of 30 operations within 72 hours. In present operations in Iraq and Afghanistan, it is not uncommon for an FST to be split into two geographically separate facilities. When split, however, its capabilities are degraded. Evacuation to level III care typically occurs as soon as possible after treatment.

"The combat medic has increasingly assumed the responsibility . . . of recognizing and treating potentially preventable causes of death. . . ."

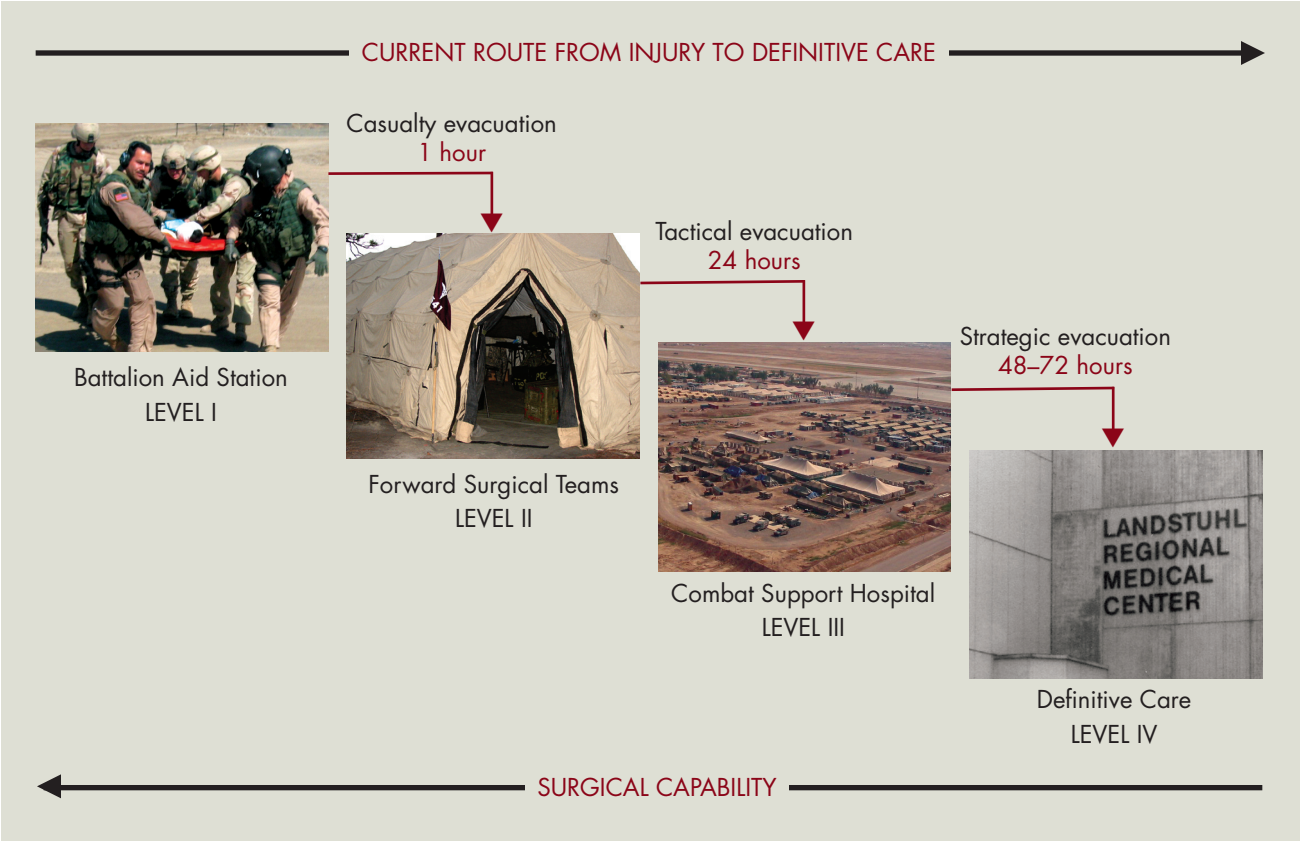


FIGURE 1. *Military system echelons of care.*

3. **Level III Echelon of Care**—Army combat support hospitals (CSHs), but also Navy ships and Air Force theater hospitals, are all capable of further definitive care, and are often located within the combat zone. Level III provides triage, resuscitation, transfusion, initial surgery, definitive and reconstructive surgery, postoperative care, intensive care, and patient holding capacity. Patients are either returned to duty in theater or stabilized for further evacuation. Such facilities are modular and allow for a 44-bed to a full 248-bed configuration as required. In full complement (248 beds), the CSH has six OR tables, allowing 96 operating hours per day. Professional capability routinely includes general, orthopaedic, thoracic, and oral and maxillofacial surgeons; anesthesia providers (as anesthesiologists and certified registered nurse anesthetists [CRNAs]); and internists, emergency medicine physicians, a radiologist, and a psychiatrist. Within 48 to 72 hours, a strategic evacuation can be underway to the next level of care and (in Operation Iraqi Freedom/Operation Enduring Freedom [OIF/OEF]) out of the combat theater. In the shortest timeframes today in Iraq, this can begin less than 12 hours from the time of wounding. Patients who are host nationals, however, are not evacuated out of area and may require definitive surgeries and prolonged hospitalization at a sustained level of care not originally envisioned for the CSH (see Introduction).

TABLE 1. *Echelons of Military Medical Care*

MILITARY DESIGNATION	DESCRIPTION OF US CIVILIAN COUNTERPART	US CIVILIAN DESIGNATION
I. Battalion Aid Station	EMS/corpsman/medic ambulance team	—
IIA. Area medical support facility	Outpatient clinic	—
IIB. FSTs	Community hospital with limited emergency surgery capability	IV
III. Theater hospital in Iraq—eg, Army CSH and (formerly) MASHs	Regional trauma center, limited capability, 30-day ICU holding capability	III
IV. LRMC	Major trauma center	II
V. For example, WRAMC, BAMC, NNMC, WHMC	Major trauma center with teaching and research	I

BAMC: Brooke Army Medical Center (Fort Sam Houston, Texas); CSHs: Combat Support Hospitals; EMS: emergency medical system; FSTs: Forward Surgical Teams; ICU: intensive care unit; LRMC: Landstuhl Regional Medical Center (Landstuhl, Germany); MASHs: Mobile Army Surgical Hospitals; NNMC: National Naval Medical Center (Bethesda, Maryland); WHMC: Wilford Hall Medical Center (Lackland Air Force Base, Texas); WRAMC: Walter Reed Army Medical Center (Washington, DC).

4. **Level IV Echelon of Care**—This definitive care stop is the general hospital that is en route back to the continental United States (CONUS). During the current conflicts in Southwest Asia, this is Landstuhl Regional Medical Center (LRMC) in Germany. (Some would describe LRMC as a level V facility given its location outside of the theater of war. By this criterion, level IV is a definitive surgical capability within the actual theater of war, but outside of the combat zone.) This level IV echelon of care reevaluates and treats all en route patients. The LRMC is staffed and equipped for general and specialized medical and surgical care. Patients not expected to return to duty are stabilized and evacuated to CONUS. Reconditioning and rehabilitating services are provided for those patients who will be returned to duty within theater. LRMC finds itself in a unique position because it is the common pathway node between theater operations in Southwest Asia (OIF/OEF) and CONUS medical facilities. Virtually 100% of US troops evacuated from those two theaters of operations pass through LRMC for additional care. LRMC provides multidisciplinary trauma surgical management to those who have sustained catastrophic injury and is where the first step in the process of rehabilitating the wounded begins. The average length of stay is less than 4 days. Then, the patient is transferred to the **Level V** Echelon of Care in CONUS military medical centers. These levels of care should not be confused with the civilian ACS/COT levels of trauma center designation, which uses these ordinals in reverse order (Table 1).

Aeromedical Evacuation

The aeromedical evacuation system is capable of moving more than 1,000 casualties per month from theater operations in Southwest Asia. Critical Care Air Transport Teams (CCATTs) are flying intensive care units with a staff of three (typically, a physician trained in critical care, a critical care nurse, and a respiratory therapist) capable of not only transporting a ventilated critically ill casualty, but also able to continue resuscitation and advance the care of the casualty patient en route to the next echelon of care. From September 2001 through September 2007, there have been more than 44,000 air evacuation/CCATT patients transported by the US Air Force aeromedical evacuation system from OIF/OEF. This capability, which did not exist more than 10 years ago, undergoes continual scrutiny and refinement.

"Critical Care Air Transport Teams . . . are flying intensive care units with a staff of three . . . capable of not only transporting a ventilated critically ill casualty, but also able to continue resuscitation and advance the care of the casualty patient en route to the next echelon of care."

Movement of severely injured patients is always a critical event that requires appropriate timing and careful attention to minute details. Determining the optimal time of transfer in the continuum of military medical care requires balancing the benefit of resources available at the next echelon against the risks inherent in moving a critical patient with all the necessary tubes, lines, monitors, and equipment in a ground and/or air ambulance. Many patients are initially too unstable to be placed in a system in which the present air evacuation component (from Southwest Asia) often exceeds 10 hours of flight time. The system, however, is evolving. Traditional air evacuation moved *stable* patients who required little intervention outside preflight orders. CCATT enables the safe transport of *stabilized* patients—stability that depends on ongoing intervention, such as ventilator management, sedation, pressors, etc.

Ideally, each of these parameters should be met prior to transfer of any patient:

- Heart rate < 120.
- Systolic blood pressure > 90.

- Hematocrit > 27%.
- Platelet count > 50,000.
- INR < 2.0.
- pH > 7.30.
- Base deficit < 5.
- Temperature > 35°C.

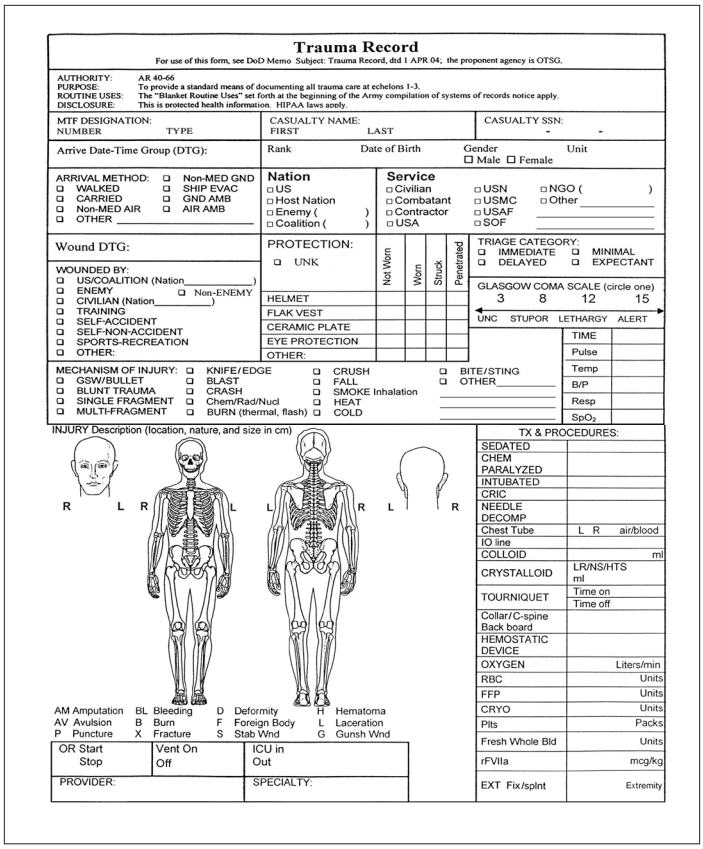
When any one or more of these criteria is not met, the responsible physician should hold the patient and continue treatment or document the limitations at the current facility that compel urgent, high-risk transfer.

Combat Trauma System Implementation

Organizing and appointing working groups to implement an ACS/COT-like trauma system within the US Army Medical Department doctrine were pivotal to the successful development and implementation of a modern combat trauma system. In addition to providing a rapidly deployable, mobile, modular, and sustainable infrastructure, such a system would need to constantly improve coordination of care, provide data to address and answer operational questions, predict manpower needs, and provide medical situational awareness (ie, injury patterns and evaluate protection/prevention maneuvers). Such data could be collected to evaluate outcomes, assess training, improve continuity of care, and facilitate system-wide, data-driven, and real-time improvements.

The goal was to develop and implement a trauma system modeled after recent successes of stateside civilian systems (which, in turn, were modeled on experiences from the Vietnam War), but leavened by the realities of combat. A trauma system director and a team of trauma nurse coordinators have been utilized for just this purpose. One tenet used to guide trauma care algorithms and the location and

"A modern combat trauma system provides a rapidly deployable, mobile, modular, and sustainable infrastructure that coordinates care, provides data to address and answer operational questions, predicts manpower needs, and provides medical situational awareness."



Trauma Record

For use of this form, see DoD Memo Subject: Trauma Record, dtd 1 APR 04; the proponent agency is OTSG.

AUTHORITY: AR 40-66
PURPOSE: To provide a standard means of documenting all trauma care at echelons 1-3.
ROUTINE USES: The "Blanket Routine Uses" set forth at the beginning of the Army compilation of systems of records notice apply.
DISCLOSURE: This is protected health information. HIPAA laws apply.

MTF DESIGNATION: NUMBER TYPE
CASUALTY NAME: FIRST LAST
CASUALTY SSN: - -
Arrive Date-Time Group (DTG):
Rank Date of Birth Gender ☐ Male ☐ Female Unit

ARRIVAL METHOD: ☐ WALKED ☐ CARRIED ☐ Non-MED AIR ☐ OTHER ☐ Non-MED GND ☐ SHIP EVAC ☐ GND AMB ☐ AIR AMB

Nation: ☐ US ☐ Host Nation ☐ Enemy ( ) ☐ Coalition ( )

Service: ☐ Civilian ☐ Combatant ☐ Contractor ☐ USA ☐ USN ☐ USMC ☐ USAF ☐ SOF ☐ NGO ( ) ☐ Other

Wound DTG:

PROTECTION: ☐ UNK

	Not Worn	Worn	Struck	Penetrated
HELMET				
FLAK VEST				
CERAMIC PLATE				
EYE PROTECTION				
OTHER:				

TRIAGE CATEGORY: ☐ IMMEDIATE ☐ MINIMAL ☐ DELAYED ☐ EXPECTANT

GLASGOW COMA SCALE (circle one): 3 8 12 15
UNC STUPOR LETHARGY ALERT

WOUNDED BY: ☐ US/COALITION (Nation) ☐ ENEMY ☐ Non-ENEMY ☐ CIVILIAN (Nation) ☐ TRAINING ☐ SELF-ACCIDENT ☐ SELF-NON-ACCIDENT ☐ SPORTS-RECREATION ☐ OTHER:

TIME	
Pulse	
Temp	
B/P	
Resp	
SpO_2	

MECHANISM OF INJURY: ☐ GSW/BULLET ☐ BLUNT TRAUMA ☐ SINGLE FRAGMENT ☐ MULTI-FRAGMENT ☐ KNIFE/EDGE ☐ BLAST ☐ CRASH ☐ Chem/Rad/Nucl ☐ BURN (thermal, flash) ☐ CRUSH ☐ FALL ☐ SMOKE Inhalation ☐ HEAT ☐ COLD ☐ BITE/STING ☐ OTHER

INJURY Description (location, nature, and size in cm)

AM Amputation BL Bleeding D Deformity H Hematoma
AV Avulsion B Burn F Foreign Body L Laceration
P Puncture X Fracture S Stab Wnd G Gunsh Wnd

TX & PROCEDURES:

SEDATED	
CHEM PARALYZED	
INTUBATED	
CRIC	
NEEDLE DECOMP	
Chest Tube	L R air/blood
IO line	
COLLOID	ml
CRYSTALLOID	LR/NS/HTS ml
TOURNIQUET	Time on / Time off
Collar/C-spine Back board	
HEMOSTATIC DEVICE	
OXYGEN	Liters/min
RBC	Units
FFP	Units
CRYO	Units
Plts	Packs
Fresh Whole Bld	Units
rFVIIa	mcg/kg
EXT Fix/splnt	Extremity

OR Start / Stop	Vent On / Off	ICU in / Out
PROVIDER:		SPECIALTY:

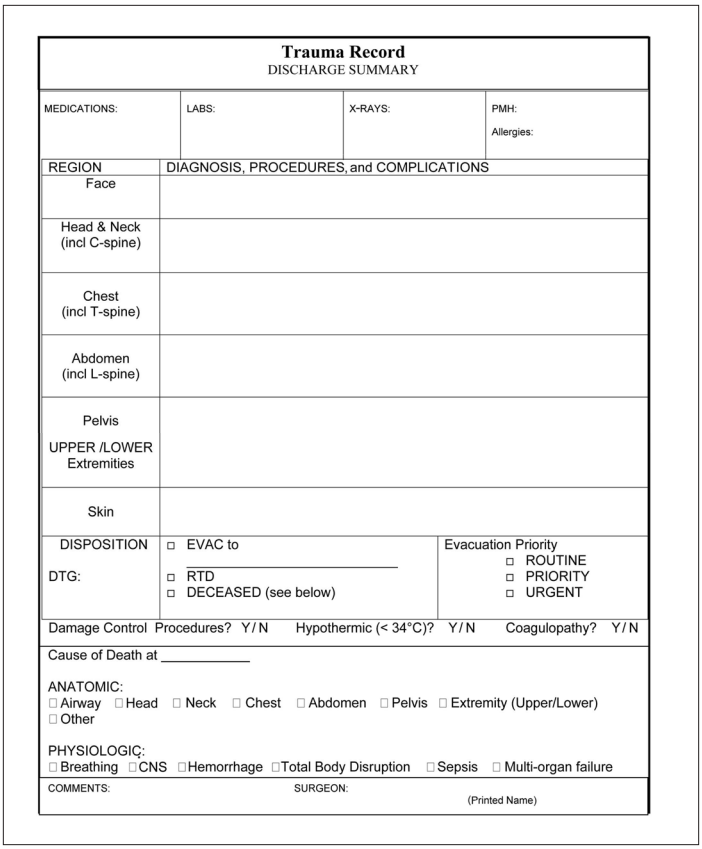
FIGURE 2.
(Front) *Theater trauma registry.*

capability of resources equates to the following: elapsed time from injury to lifesaving surgery is to be as short as possible; but, in every case, less than 2 hours (ie, "deliver the right casualty to the right care at the right place and in the right time").

Care for injured soldiers in current theater operations has been the focus of the JTTS. Additionally, the JTTS continues to work on performance improvement issues. Some of the responsibilities of the trauma system director include the following:

- Recommending optimal placement of surgical assets within theater.
- Developing triage criteria for casualty evacuation to the appropriate level of care.
- Ensuring adequate communication at/between military treatment facilities at every level of care.
- Standardizing approaches to common battle injury patterns across theater.

JTTS also has the responsibility to review and maintain a Joint Theater Trauma Registry (Fig. 2), conduct and collate morbidity and mortality reporting and operative case reporting, and develop a Performance Improvement Program and initiatives for the entire trauma system. This includes evaluating the Casualty Evacuation/Air Evacuation System (evacuation times and casualty outcomes) and assisting with development of the clinical information management scheme for theater.



Trauma Record
DISCHARGE SUMMARY

MEDICATIONS:	LABS:	X-RAYS:	PMH: Allergies:

REGION	DIAGNOSIS, PROCEDURES, and COMPLICATIONS
Face	
Head & Neck (incl C-spine)	
Chest (incl T-spine)	
Abdomen (incl L-spine)	
Pelvis UPPER /LOWER Extremities	
Skin	

DISPOSITION DTG:	☐ EVAC to _____ ☐ RTD ☐ DECEASED (see below)	Evacuation Priority ☐ ROUTINE ☐ PRIORITY ☐ URGENT

Damage Control Procedures? Y / N Hypothermic (< 34°C)? Y / N Coagulopathy? Y / N

Cause of Death at _____

ANATOMIC:
☐ Airway ☐ Head ☐ Neck ☐ Chest ☐ Abdomen ☐ Pelvis ☐ Extremity (Upper/Lower)
☐ Other

PHYSIOLOGIC:
☐ Breathing ☐ CNS ☐ Hemorrhage ☐ Total Body Disruption ☐ Sepsis ☐ Multi-organ failure

COMMENTS: SURGEON: (Printed Name)

FIGURE 2.
(Back) *Theater trauma registry.*

Areas for system improvement have been identified in the need for smoother transmission of healthcare information along the multiple and physically distant echelons of care and a smoother transition between healthcare teams when units rotate into and out of theater (ie, retention of operational memory). The requirement is to educate all healthcare providers in the importance of information flow, standardize documentation of health forms, and have a central electronic patient data repository. This patient data repository is intended to have all available medical records scanned at the level III echelon of care and then placed on a secure Web site, thus giving providers access to critical healthcare information at all echelons of care.

Stateside, where civilian casualties typically present one at a time, we are challenged with documenting patient encounters adequately. It is difficult to imagine how daunting a task it is for a field medic—under fire, with multiple injured comrades, as well as numerous enemy casualties—to document even the simplest of clinical findings or events on the battlefield. Recordkeeping is much more difficult at aid stations or FST locations, where military healthcare is conducted under the most austere conditions. Documentation there is often, necessarily, an afterthought.

"Areas for system improvement have been identified in the need for smoother transmission of healthcare information along the multiple and physically distant echelons of care and a smoother transition between healthcare teams when units rotate into and out of theater. . . ."

Trauma Registry

"To . . . capture documentation and evaluate injury patterns, as well as the care provided, the US Army Institute of Surgical Research has developed the Joint Theater Trauma Registry."

To optimally capture documentation and evaluate injury patterns, as well as the care provided, the US Army Institute of Surgical Research has developed the Joint Theater Trauma Registry. This repository is collected on forms developed exclusively for use by the deployed military while, at the same time, designed to facilitate completion of nurse and physician examinations and treatment records. (See Fig. 2 for an early version of this form.)

This field clinical information—collated, tabulated, dissected, analyzed, and thoughtfully reviewed—will become the database of battlefield casualty management in Iraq and Afghanistan.

SUGGESTED READING

Appendix 3: Theater Joint Trauma Record. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Chapter 2: Levels of medical care. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Chapter 4: Aeromedical evacuation. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

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ARE WE DOING BETTER?
Assessing Combat Casualty Data

Combat casualty data are readily available during the present war in Afghanistan and Iraq, with some newspapers even publishing summaries of the numbers of Americans killed and wounded on a daily basis. It is common to read analyses of these data in which they are interpreted to show remarkable improvement in the outcome of the management of combat injury compared with historical norms. However, caution is needed when coming to such a conclusion because deaths in combat are determined by a multitude of factors, of which the effectiveness of the deployed medical system is only one. Certainly, the total number of combat casualties has little to do with medical care, but has everything to do with the number of warriors at risk and the casualty-generating potential of the battlefield (ie, the weapons used and the war-fighting tactics). One might think that the ratio of the killed in action (KIA) to wounded is closer to telling us the effect of medical care, but this proportional mortality more likely reflects the lethality of the weapons. The unprecedented use and effectiveness of today's protective equipment (all other factors being equal) should make for a less lethal battlefield because armor decreases the lethality of weapons. When a blunt index of injury severity is used (the number of wounded divided into those who returned to duty quickly and those who did not), we are closer to assessing the effect of medical care. Because combat casualty care is unlikely to affect casualties with only minor injuries, the ratio of KIA to those surviving with wounds of severity preventing rapid return to duty is likely to be more affected by the excellence of combat casualty care.

The unprecedented use and effectiveness of today's protective equipment (all other factors being equal) should make for a less lethal battlefield because armor decreases the lethality of weapons.

Combat casualty care can and does prevent deaths. However, the lethality of the weapon and the anatomical location of wounds remain dominant. Most of those who are killed in combat die quickly and before lifesaving surgery is possible. Perhaps the index most sensitive to the quality of combat casualty care is the fraction of those with potentially fatal wounds who are evacuated from the battlefield alive, but who then die in the hospital (ie, died of wounds [DOW]). But even this measure will be affected by the lethality of weapons and the speed of the evacuation from the battlefield. Indeed, fast evacuation of the very severely injured—those likely to die despite aggressive care—may even increase the number of casualties who are ultimately categorized as DOW.

With these factors in mind, it is interesting to calculate some indicators of mortality outcome in the present conflict in Iraq. Data on DOW in Iraq (US Army and Marines) from March 2003 through the end of June 2007 are as follows:

- total DOW for all services—663; and
- total wounded not returned to duty within 3 days—11,831.[1,2]

DOW mortality is calculated to be 5.3%. Data for the conflict in Vietnam are as follows:

- total DOW for all services—5,289; and
- total wounded not returned to duty within 1 day—153,303.[3]

DOW mortality is calculated to be 3.3%. It appears that medical treatment facility mortality outcome was better in the Vietnam War; however, this conclusion seems implausible. It may be that, in the present war, better treatment of the gravely wounded is vitiated by more lethal injuries and more rapid evacuation of the mortally wounded. Or, it may be that the difference is a statistical artifact because the same time periods are not used for data collection (ie, return to duty in 1 day for Vietnam, 3 days for the present war).

The second index mentioned previously (ratio of KIA to casualties with wounds of such severity that rapid return to duty is prohibited) also needs to be considered, even though it is less likely to reflect the influence of medical treatment. Data of American KIA as of June 2007 are as follows:

- total KIA for all services—2,265; and
- total wounded not returned to duty within 3 days—11,831.[1,2]

KIA mortality is calculated to be 16.1%. Data for the conflict in Vietnam are as follows:

- total KIA for all services—40,934; and
- total wounded not returned to duty within 1 day—153,303.[3]

The military has made enormous efforts to improve battlefield first-aid training and equipment. It is likely that at least some of the decrease in the number of KIA reflects this effort.

KIA mortality is calculated to be 21.1%. Clearly, casualties in the present war are less likely to die before reaching a medical treatment facility than in the Vietnam War. Why? It cannot be due to better medical care in a medical treatment facility, but it could and probably is at least partially due to better battlefield first aid at the site of wounding. The military has made enormous efforts to improve battlefield first-aid training and equipment. It is likely that at least some of the decrease in the number of KIA reflects this effort. A second explanation involves battlefield lethality. The explosive devices used by terrorists have a fearsome reputation, and therein lays a paradox. If the weapons are more lethal, the proportion of those injured who are KIA should increase. The fact that the proportion is actually less clearly points to the excellent protection afforded by the military's wide use of individual body armor. Historical data indicate that penetrating missile wounds of the trunk were responsible for about one third of combat deaths.[4] Defeating even one half of such threats might well be expected to decrease mortality and therefore accord with the observed percent KIA.

However, until more data are made available, it will remain difficult to separate conclusively the effect of medical care on mortality from battlefield factors, such as weapons lethality.

The widespread belief that mortality has been reduced in the present war—compared with historical norms—appears, then, to be well founded. However, until more data are made available, it will remain difficult to separate conclusively the effect of medical care on mortality from battlefield factors, such as weapons lethality. It is certainly possible that evacuation in the present war is so fast that many more casualties with potentially fatal wounds reach hospital-level care and are saved by modern surgery than in past wars. But only data on evacuation time and, ideally, quantitative injury severity assessment will allow this question to be addressed.

—Ronald F. Bellamy, MD, FACS, COL, MC, US Army (Ret.)

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War Surgery *in* Afghanistan and Iraq

A SERIES OF CASES, 2003–2007

This four-litter ambulance was struck by an RPG en route to the 28th CSH in Iraq. The medic on board placed himself across his casualty and was killed in the attack.