Surgical Legacies of Modern Combat: Translating Battlefield Medical Practices into Civilian Trauma Care

Achieving Zero Preventable Deaths Conference

April 18-19, 2017

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American College of Surgeons
Inspiring Quality: Highest Standards, Better Outcomes
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The Committee on Trauma

NHTSA
National Highway Traffic Safety Administration

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Disclosures

None

Disclaimer

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

War's Role as a Teacher For Antiquity

"He who would become a surgeon should join an army and follow it for war is the only proper school for a surgeon'.."

History of Battlefield Medical Lessons

Desert Shield/Storm
- Burn team augmentation of evacuation hospitals to provide theater-wide burn care
- Intercontinental aeromedical transport of burn patients

Vietnam
- Improved use of helicopters
- Improved laboratory support
- Portable radiology equipment
- Mechanical ventilators in theater

Korean Conflict
- Improved fluid resuscitation
- Forward availability of definitive surgery
- Helicopters for patient evac/transport
- Primary repair/grafts for vascular injury

World War II
- Whole blood/plasma available
- Specialty-specific surgical groups
- Antibiotics
- Fixed wing aero-medical evacuation

World War I
- IV fluids
- Blood transfusions
- Motorized ambulances
- Topical antisepsis

Contemporary Battlefield Lessons Learned
Joint Trauma System

- Focused empiricism / timely dissemination of knowledge
- Performance Improvement / generation of best practices
- Epidemiology of injury death
- Tactical Combat Casualty Care
- Acute surgical care
    - Damage control resuscitation
    - Forward surgical elements
    - Serial damage control surgery

Genesis of the Military Trauma System Effort
Review of Battlefield Medical Care
Army Trauma Consultant 2003

- **Unorganized delivery of trauma care on the battlefield**
  - **Casualties going to the wrong location**
  - **Suboptimal staffing and placement of surgical assets**
- **Medical records are not reliably being delivered with casualties at each level (<40%)**
  - **Impact on clinical care**
  - **Documentation directive**
- **No trauma registry driven by medical input that allows accurate description of injuries or deaths**
  - **Unable to reliably answer questions and improve outcomes**
    - **Survivable Injuries and/or deaths**
    - **Lack of performance improvement measures / research**

Battlefield Lesson

Learning Healthcare System

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Joint Trauma System Operational Cycle

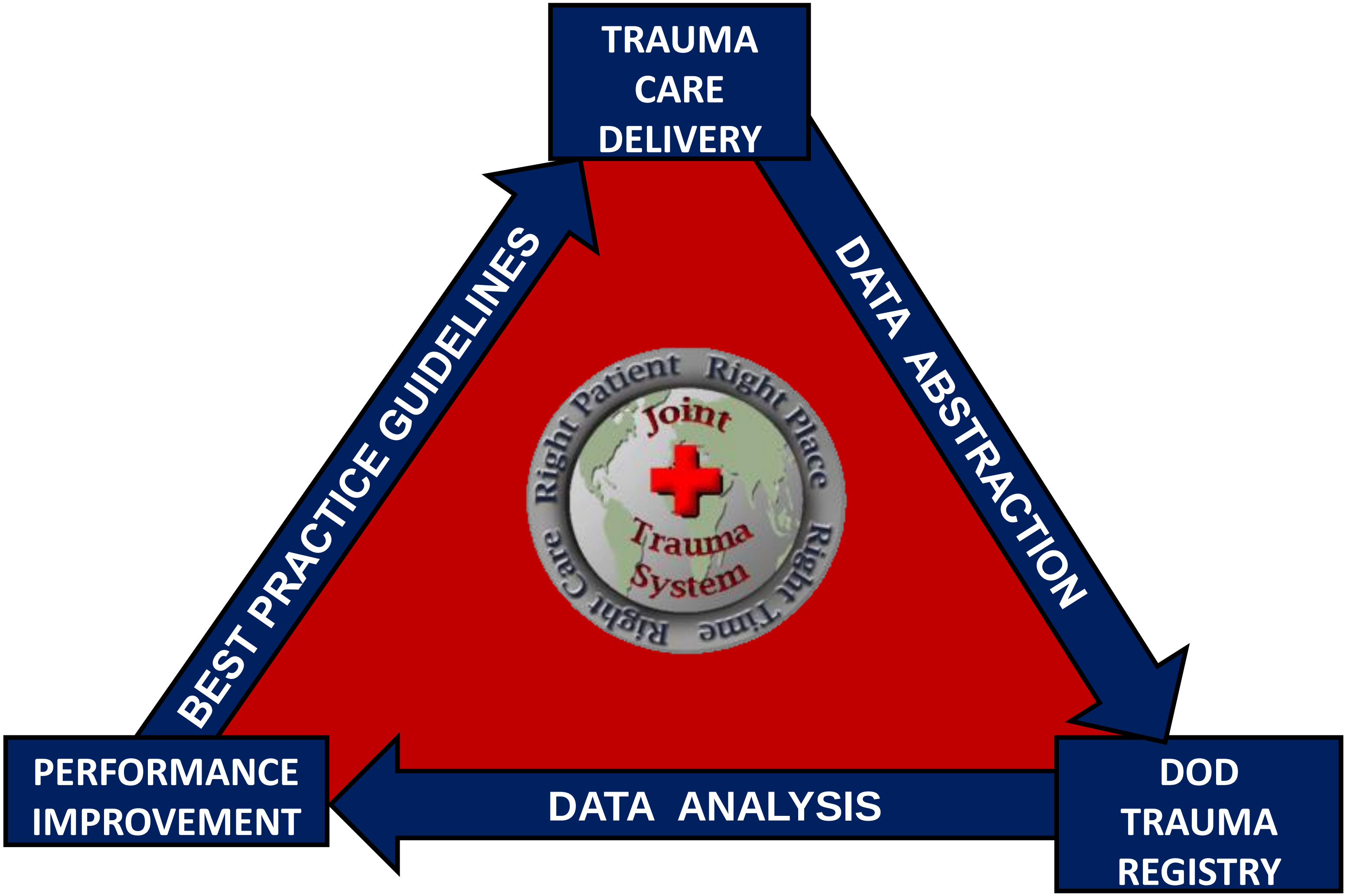


FIGURE 4-3 Joint Trauma System operational cycle and links to the U.S. Department of Defense's Combat Casualty Care Research Program. NOTE: DoD = U.S. Department of Defense; PI = performance improvement. SOURCE: Haut et al., 2016.

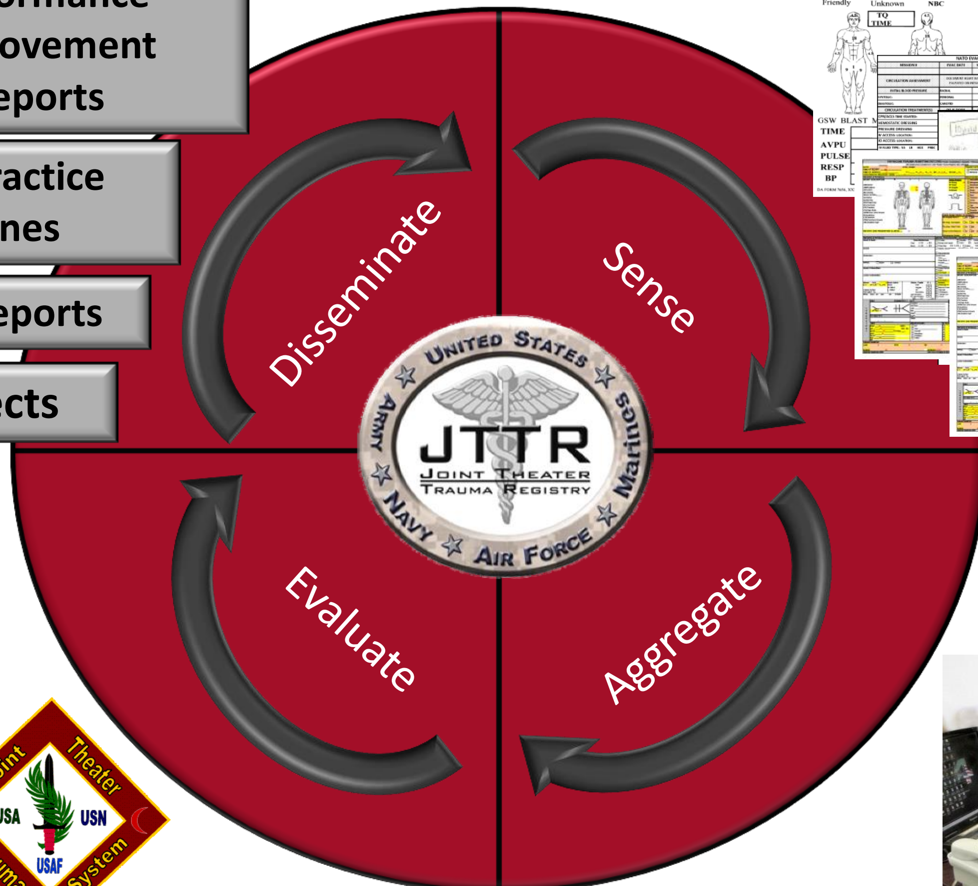
JTS Directorate
Functions and Services

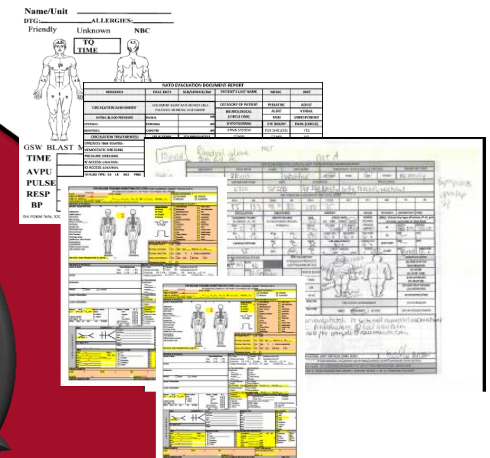
Performance Improvement Reports

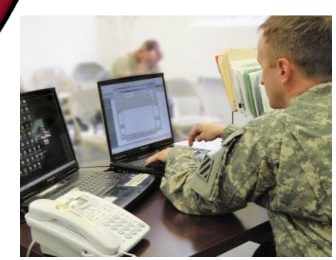
Clinical Practice Guidelines

Concurrent Reports

Special Projects







Right Patient Right Place Right Time Right Care
Joint Trauma System

Joint Theater Trauma System
USA USN USAF

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Clinical Practice Guidelines

JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE (JTS CPG)

Damage Control Resuscitation (CPG ID: 18)
This CPG provides evidence–based guidance to minimize variation in resuscitation practices and improve the care of massively hemorrhaging, severely injured casualties.

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Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Services or DoD.

TABLE OF CONTENTS

- Evidence-based
- Best clinical practice
- Tailored to operational battlefield environment
- Open access
- Resource for deploying surgeons and medical providers

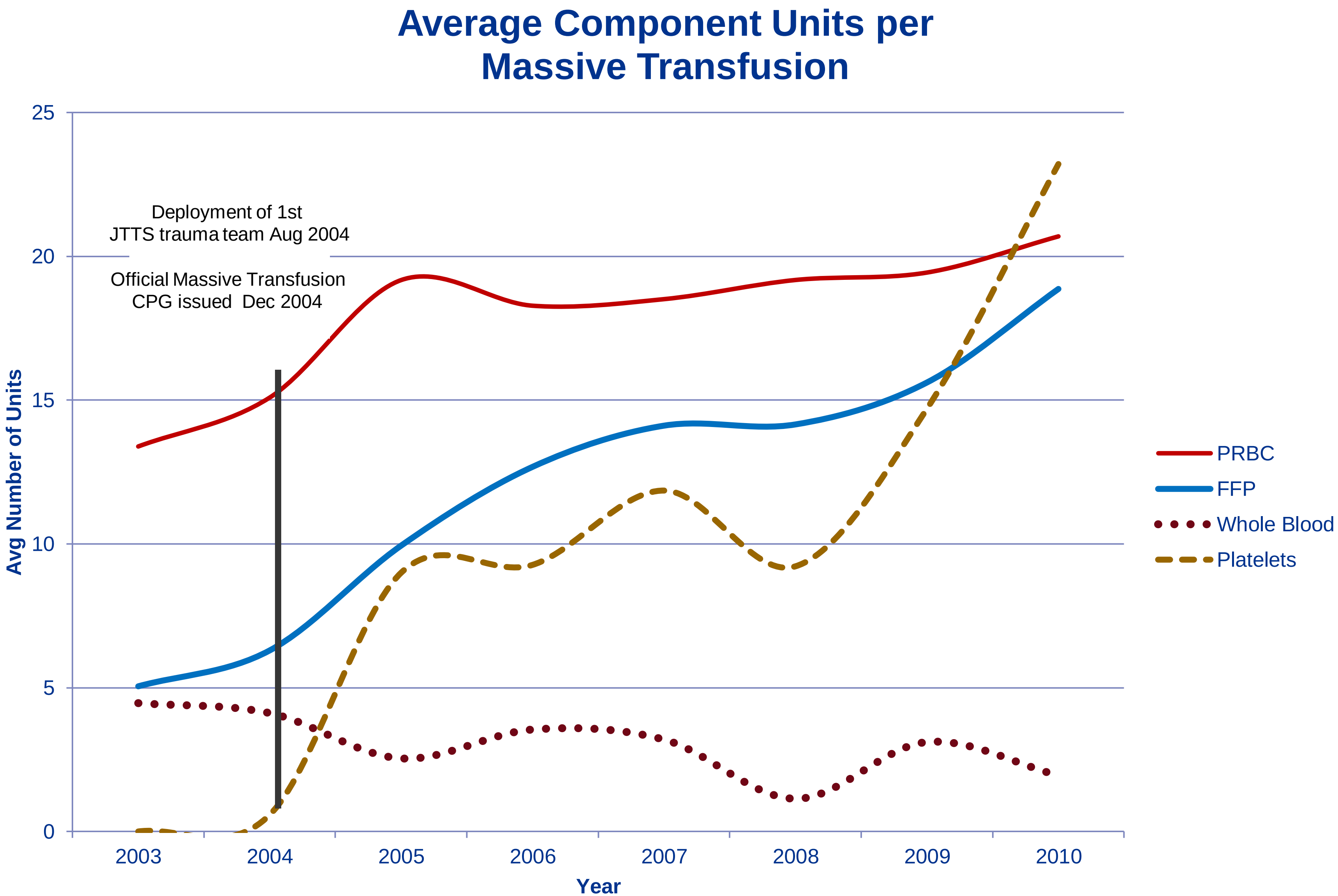
Focused Epiricism

Pragmatic approach to process improvement

- Urgency to improve outcomes because of high morbidity and mortality rates
- High-quality data are not available to inform clinical practice changes
- Data collection is possible.

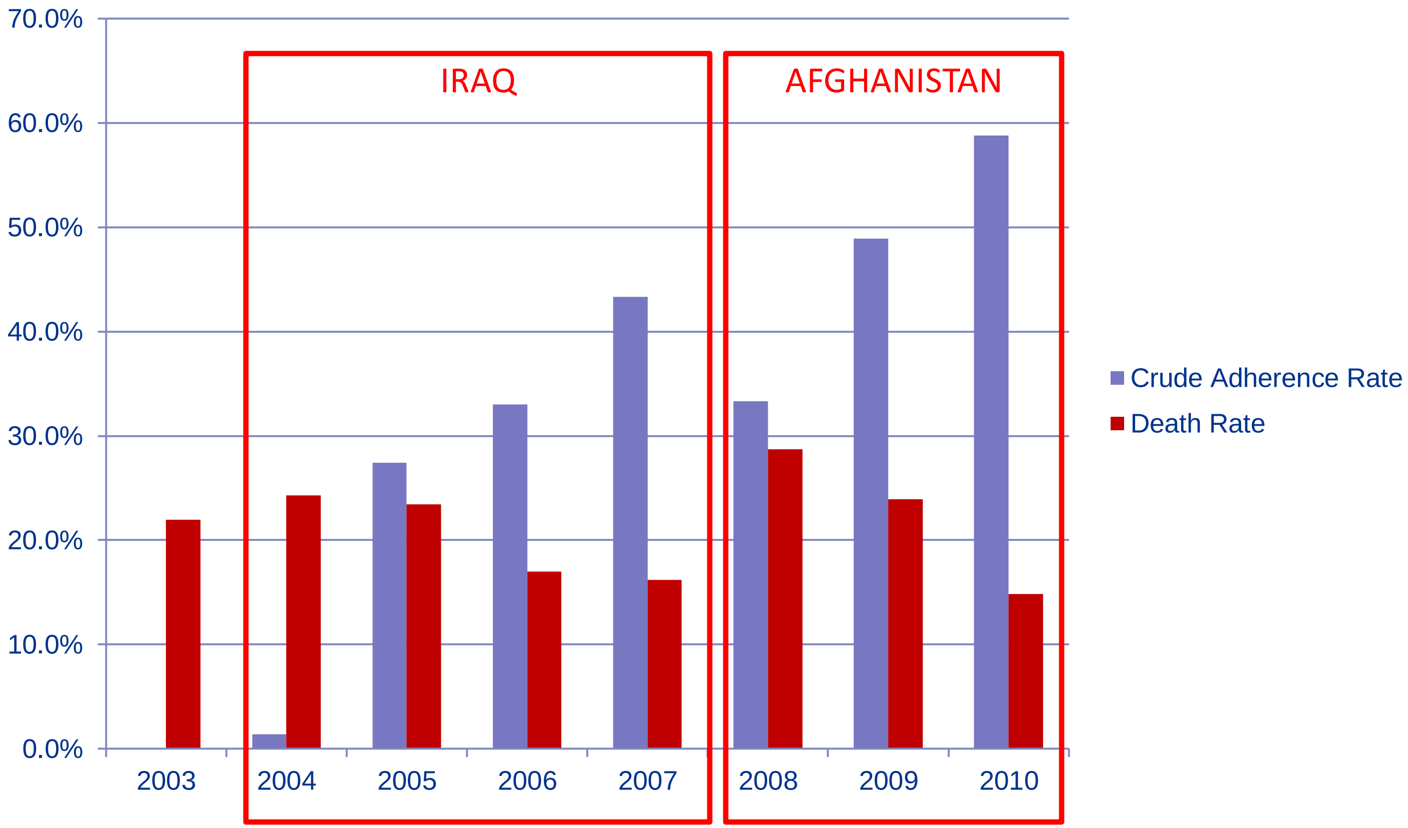
- Principle of focused empiricism is using the best data available in combination with clinical experience to develop clinical practice guidelines through an iterative process

- Successes
  - Damage control resuscitation
  - Whole blood for massive transfusion
  - Tranexamic acid
- Failures
  - Factor VIIa



Average Component Units per
Massive Transfusion
Deployment of 1st
JTTS trauma team Aug 2004
Official Massive Transfusion
CPG issued Dec 2004
Avg Number of Units
25
20
15
10
5
0
2003
2004
2005
2006
2007
2008
2009
2010
Year
PRBC
FFP
Whole Blood
Platelets

Damage Control Resuscitation Compliance



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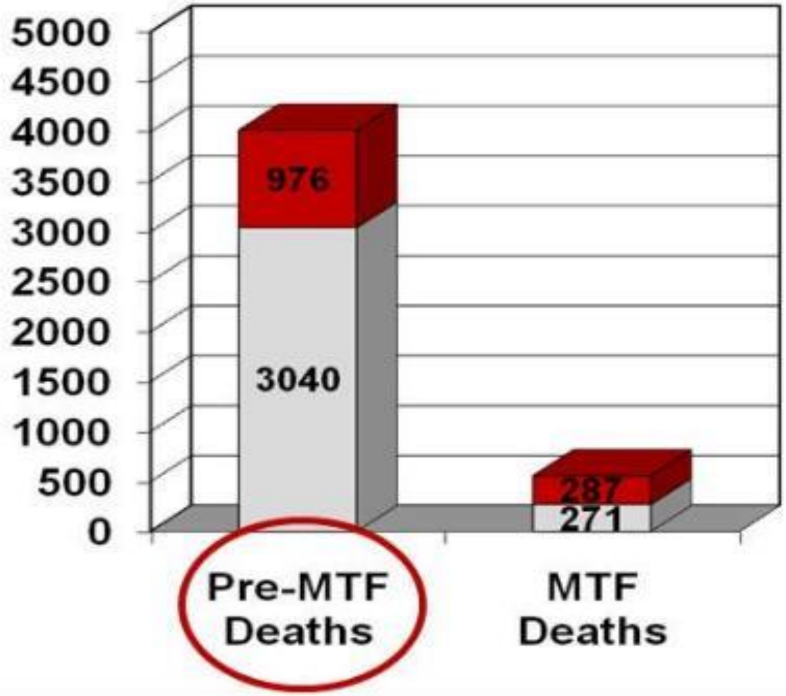
Epidemiology
of
Prehospital Trauma Mortality

Where Can We Save the Most Lives?



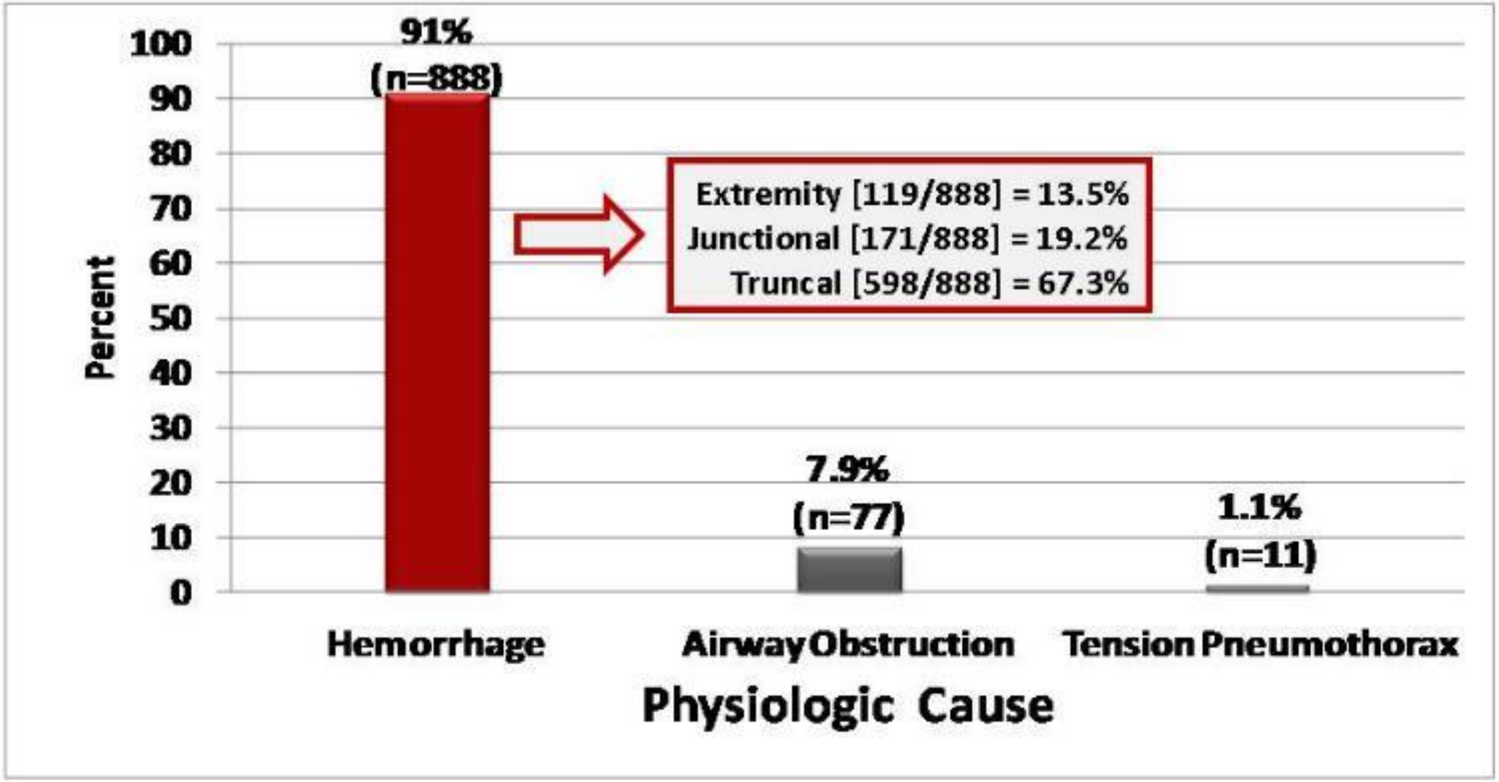
■ Potentially Survivable

□ Non-Survivable

Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma 2012, 73(6) Suppl 5: 431-7.

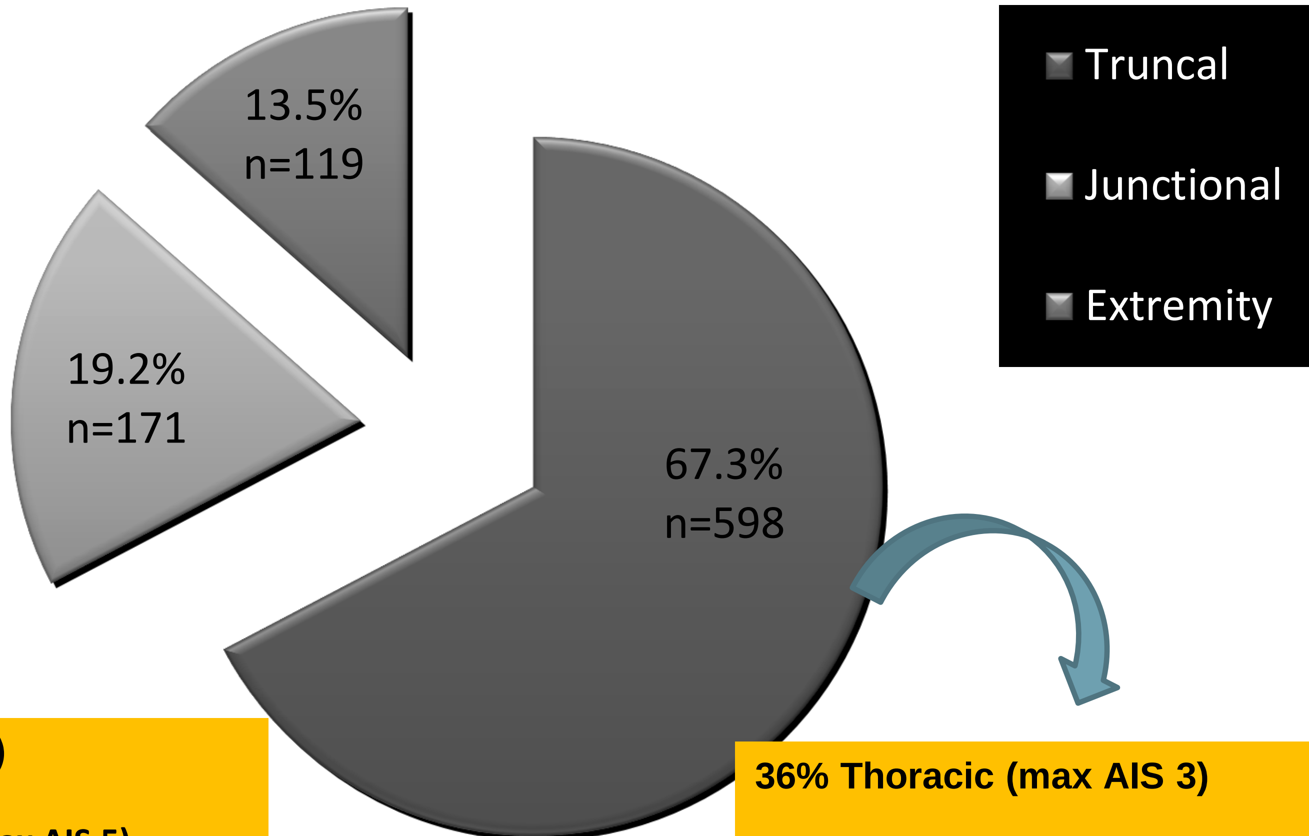
Eastridge BJ, Hardin M, Cantrell J, et al. Died of wounds on the battlefield: causation and implications for improving combat casualty care. Journal of Trauma 2011. 71(Suppl 1):4-8.

What were the Causes of Preventable Death?



Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma 2012, 73(6) Suppl 5: 431-7.

Hemorrhage Focus (n=888)



39% Cervical (max AIS 1)

61% Axilla and Groin (max AIS 5)

36% Thoracic (max AIS 3)

64% Abdominopelvic (max AIS 4/5)

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Eliminating Preventable Death on the Battlefield

- US Military
  - Preventable Prehospital Deaths = **25%**
- US Rangers
  - Preventable Deaths = **3%**

- Ranger success attribution:
  - Leadership
    - Command-directed casualty response program
  - Training
    - All Rangers and Docs trained in TCCC

Kotwal RS, Montgomery HR, Kotwal BM, et al. Eliminating preventable death on the battlefield. Arch Surg 2011.

Multi-Disciplinary Multi-Institutional Mortality Investigation in the Civilian Prehospital Environment (MIMIC)

CNTR
Coalition for National Trauma Research

- Develop a methodology for evaluating the causes and pathophysiology of pre-hospital deaths (optimal & in context)
- Network of experts to apply the methodology to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.
  - Trauma surgery
  - Neurosurgery
  - Orthopedic surgery
  - Forensic pathology
  - Emergency medicine
  - Emergency medical services

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Multi-Disciplinary Multi-Institutional Mortality Investigation in the Civilian Prehospital Environment (MIMIC)

CNTR
Coalition for National Trauma Research

- Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths occurring in six regions of the country representative of the population.
- Describe the epidemiology of pre-hospital mortality in the context of trauma system development and estimate human and fiscal impact on society.
- Develop a blueprint for a sustained public health / injury mitigation strategies in the pre-hospital environment, identifying high priority areas for trauma systems performance improvement

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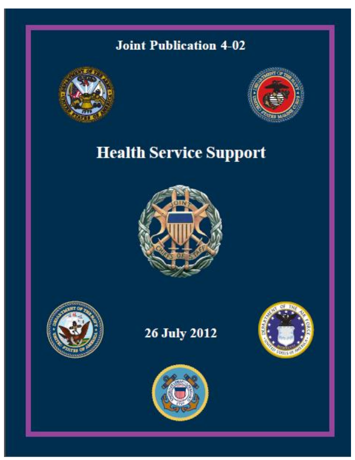
Pre-Hospital Care

Tactical Combat Casualty Care


Joint Publication 4-02

Health Service Support

26 July 2012

Tactical Combat Casualty Care

Set of trauma management guidelines customized for the battlefield that focus on the most common causes of preventable deaths on the battlefield:

- **Hemorrhage**
  - **Noncompressible**
  - **Junctional**
  - **Peripheral**
- **Airway obstruction**
- **Tension pneumothorax**

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Butler FK, Hagmann J, Butler EG. Tactical combat casualty care in special operations. Military Medicine 1996;161(Suppl.):3-16.

Pre-Hospital
Translation of Lessons Learned

Tactical Combat Casualty Care


Joint Trauma System Review of Pre-Hospital Trauma Care
in Combined Joint Operating Area – Afghanistan (CJOA-A)

Date: 1 December 2012 [Updated 30 January 2013] Classification: Unclassified

CENTCOM Commander Brief:

Saving Lives on the Battlefield

U.S. Central Command Pre-Hospital Trauma Care Assessment Team:

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Col Stacy A. Shackelford USAF – CAPT Donald R. Bennett USN – Col Jeffrey A. Bailey USAF

TACTICAL COMBAT CASUALTY CARE:
FROM THE BATTLEFIELDS OF AFGHANISTAN AND IRAQ TO THE STREETS OF AMERICA

Hartford Consensus

Threat suppression

Hemorrhage control

Rapid **E**xtrication to safety

Assessment by medical providers

Transport to definitive care

- Need integrated response Fire, EMS, Law Enforcement, Medical

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The Hartford Consensus

- American College of Surgeons
- FBI
- White House – Medical Policy
- White House Medical
- Asst Secretary of Defense - Health Affairs
- Asst Secretary of Homeland Security – Health Affairs
- Medical Section – Major Chiefs of Police
- ACS Committee on Trauma
- DoD Committee on TCCC

Improving Survival from Active Shooter Events: The Hartford Consensus

Active Shooter and Intentional Mass-Casualty Events: The Hartford Consensus II

The Hartford Consensus III: Implementation of Bleeding Control

The Hartford Consensus IV: A Call for Increased National Resilience

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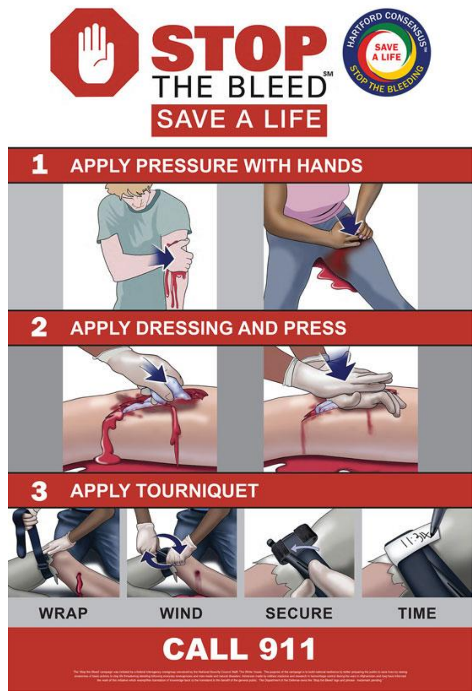
Pre-Hospital Translation Initiatives



LEFR-TCC

Law Enforcement
First Responder
Tactical Casualty Care

NAEMT

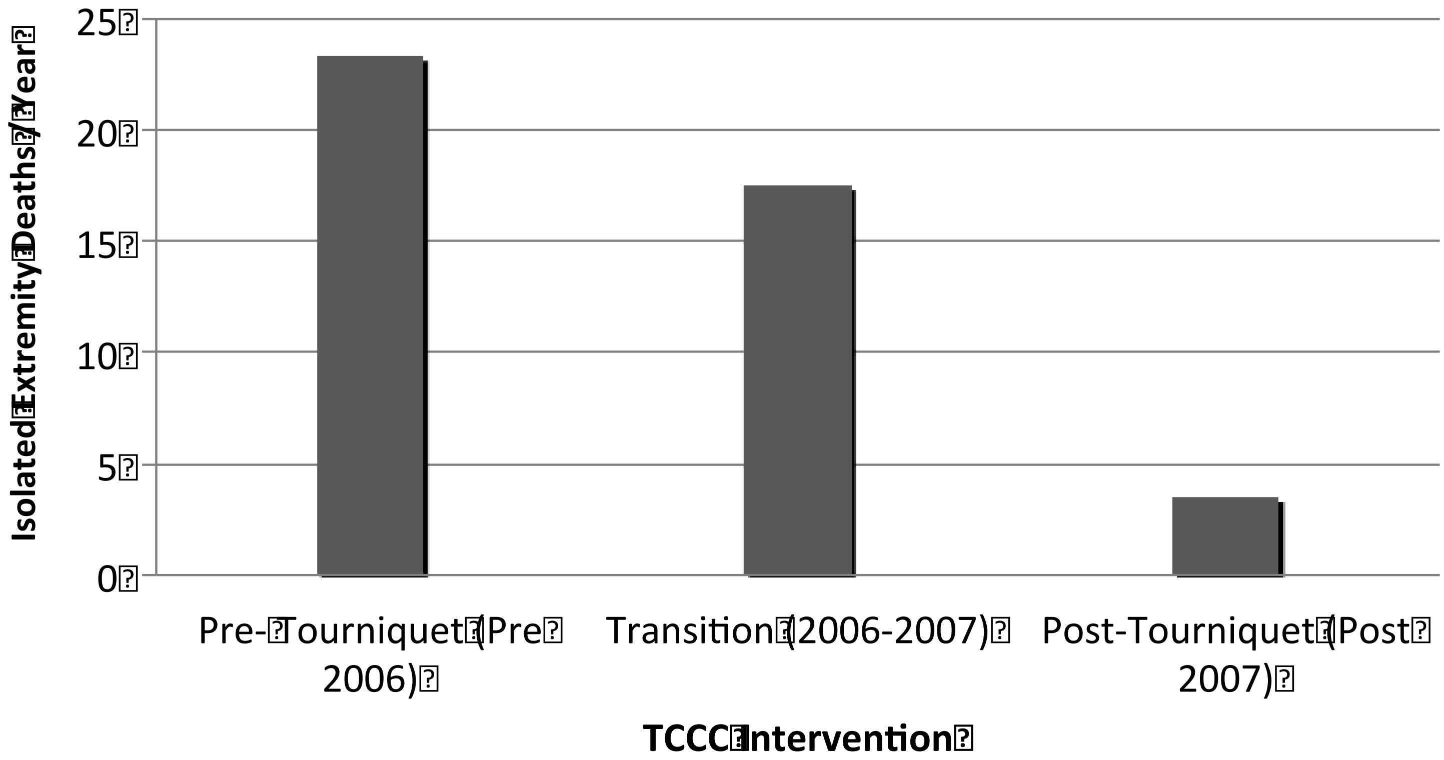
Hemorrhage Control: Tourniquets

Kragh, et al – Tourniquet Study

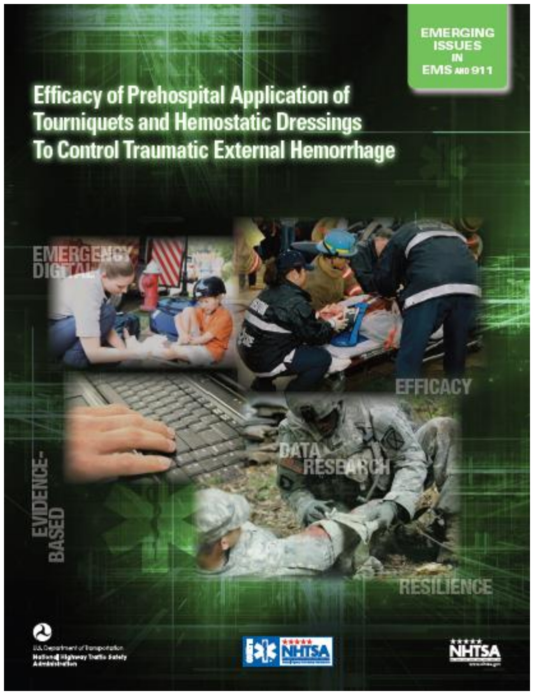
- **Ibn Sina Hospital, Baghdad, 2006**
- **Tourniquets are saving lives on the battlefield**
- **31 lives saved in 6 months by use of prehospital tourniquets**

> "The fate of the wounded lays with those who apply the first dressing."
>
> - Col. Nicholas Senn, 1844-1908

Impact of Tourniquets on the Battlefield



Civilian Tourniquet Consensus



PHTLS
Prehospital Trauma Life Support

- Data strongly suggests that tourniquet use saves lives.

- Adverse side effects associated with tourniquets appear to be manageable and do not appear to outweigh the benefits of tourniquet use.

Battlefield Lesson

Resuscitation

Hemostatic Resuscitation

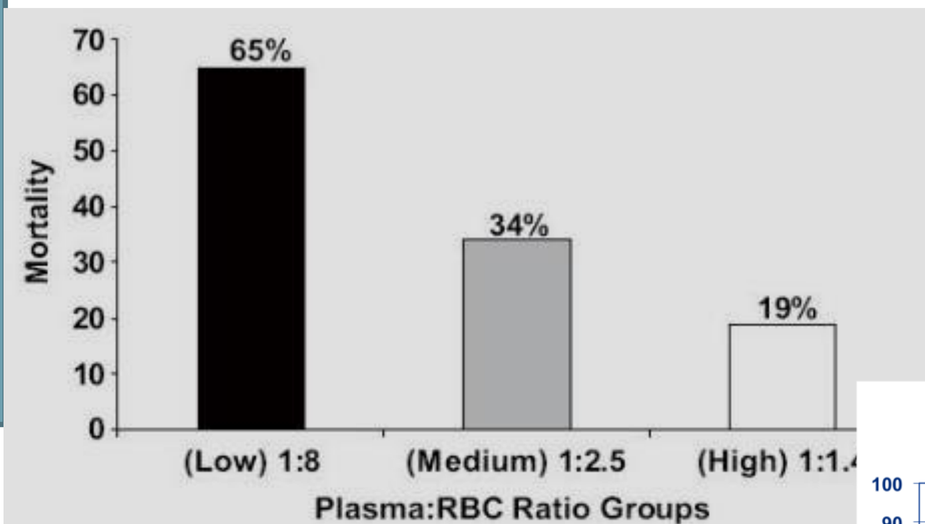
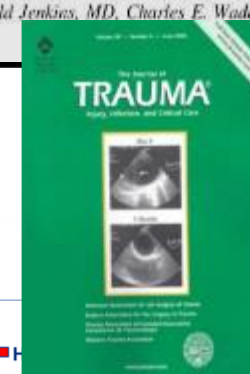


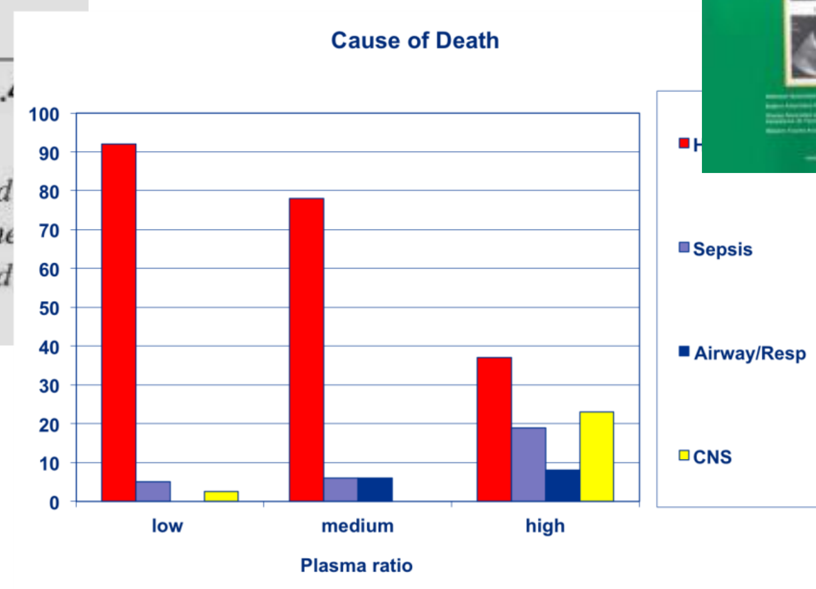
Fig. 1. *Percentage mortality associated with low, medium, and plasma to RBC ratios transfused at admission. Ratios are me ratios per group and include units of fresh whole blood counted as plasma and RBCs.*

The Journal of TRAUMA® Injury, Infection, and Critical Care

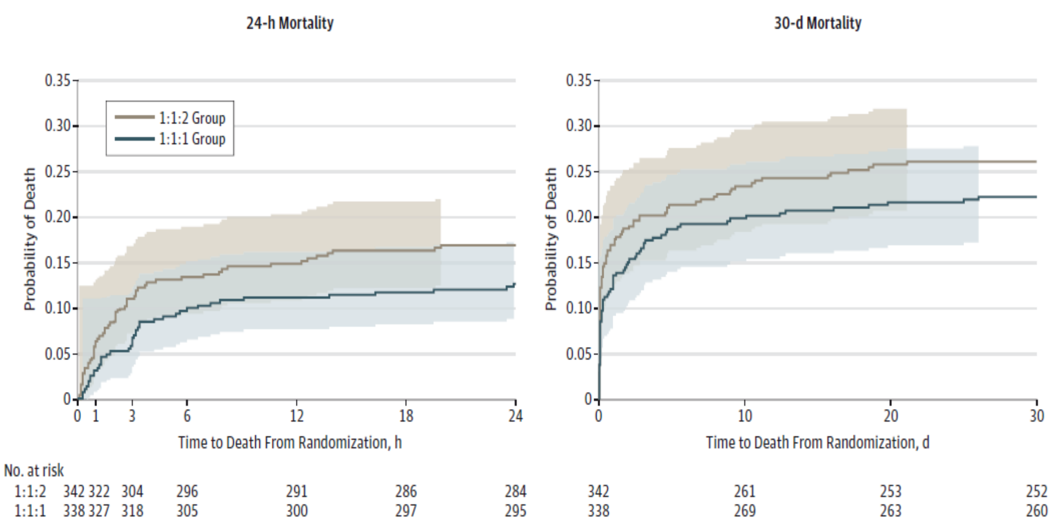
The Ratio of Blood Products Transfused Affects Mortality in Patients Receiving Massive Transfusions at a Combat Support Hospital

Matthew A. Borgman, MD, Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Thomas Repine, MD, Alec C. Beekley, MD, James Sebesta, MD, Donald Jenkins, MD, Charles E. Wade, PhD, and John B. Holcomb, MD





Civilian Trial
Pragmatic Randomized Optimal Platelet and Plasma Ratio Trial (PROPPR)



	First 24 Hours			30 Days		
	No. (%)			No. (%)		
	1:1:1 Group (n = 338)	1:1:2 Group (n = 342)	Difference (95% CI),%[a]	1:1:1 Group (n = 335)	1:1:2 Group (n = 341)	Difference (95% CI), %[a]
Total No. of deaths	43	58		75	89	
Cause of death[b]						
Exsanguination	31 (9.2)	50 (14.6)	−5.4 (−10.4 to −0.5)	36 (10.7)	50 (14.7)	−3.9 (−9.1 to 1.2)
Traumatic brain injury	11 (3.3)	12 (3.5)	−0.3 (−3.2 to 2.7)	27 (8.1)	35 (10.3)	−2.2 (−6.7 to 2.2)
Respiratory, pulmonary contusion, or tension pneumothorax	3 (0.9)	1 (0.3)	0.6 (−0.9 to 2.4)	5 (1.5)	2 (0.6)	0.9 (−0.8 to 3.0)
Sepsis	0	0	0 (−1.1 to 1.1)	1 (0.3)	2 (0.6)	−0.3 (−1.9 to 1.2)
Multiple organ failure	0	0	0 (−1.1 to 1.1)	10 (3.0)	8 (2.3)	0.6 (−2.0 to 3.4)
Type of cardiovascular event						
Stroke	0	1 (0.3)	−0.3 (−1.7 to 0.9)	2 (0.6)	1 (0.3)	0.3 (−1.1 to 1.9)
Myocardial infarction	1 (0.3)	1 (0.3)	0 (−1.4 to 1.4)	1 (0.3)	2 (0.6)	−0.3 (−1.9 to 1.2)
Pulmonary embolism	0	1 (0.3)	−0.3 (−1.7 to 0.9)	0	1 (0.3)	−0.3 (−1.7 to 0.9)
Transfusion-related fatality	0	0	0 (−1.1 to 1.1)	1 (0.3)	0	0.3 (−0.8 to 1.7)

Holcomb et al *JAMA* 2015;313:471 – 482

Whole Blood Resuscitation in Combat

The Journal of TRAUMA® Injury, Infection, and Critical Care

Warm Fresh Whole Blood Is Independently Associated With Improved Survival for Patients With Combat-Related Traumatic Injuries

Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Alec C. Beekley, MD, and John B. Holcomb, MD

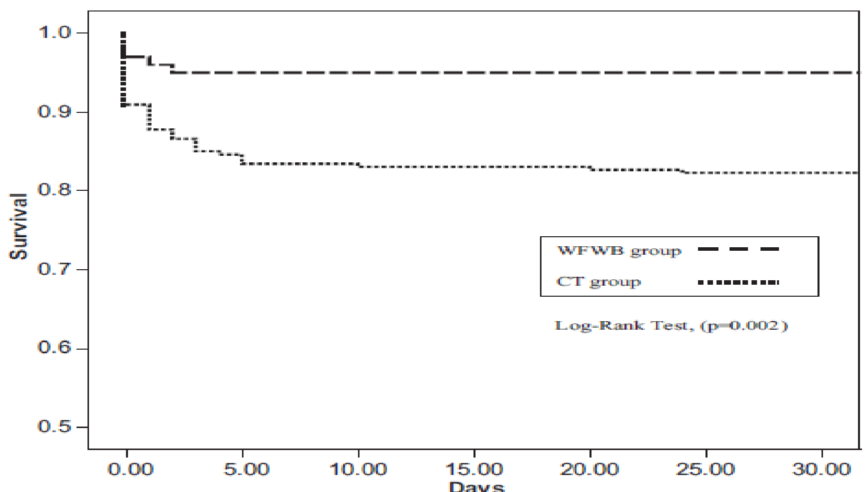


Fig. 1. *Kaplan-Meier curve of 30-day survival according to study group.*

Fresh whole blood use by forward surgical teams in Afghanistan is associated with improved survival compared to component therapy without platelets
Transfusion 2013

Shawn C. Nessen, Brian J. Eastridge, Daniel Cronk, Robert M. Craig, Olle Berséus, Richard Ellison, Kyle Remick, Jason Seery, Avani Shah, and Philip C. Spinella

FWB in austere combat environments safe and independently associated with improved survival when compared with resuscitation with RBCs and FFP alone.

Whole Blood: Back to the Future

- **Whole blood historically primary resuscitative solution for hemorrhagic shock.**
- **Transition to using component therapy occurred without evidence superior efficacy or safety.**
- **Misconceptions**
  - **Whole blood must be ABO specific (O low titer 1:256)**
  - **Whole blood cannot be leukoreduced**
  - **Cold storage causes loss of platelet function**
- **Cold whole blood stored for up to 21 days has greater hemostatic capacity than blood components transfused in a 1 : 1 : 1 (in vitro)**

Spinella, Cap: Curr Opin Hematol 2016, 23

Battlefield Lesson

Forward Transitioning
Damage Control Philosophy

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

Pre-Hospital DCR Concepts

- Stop obvious hemorrhage
  - Hemostatic adjuncts
- Correction of coagulopathy
- Judicious fluid management (permissive hypotension)
- Thermoregulation
- Minimize pre-hospital time ("Golden Hour" is relative)

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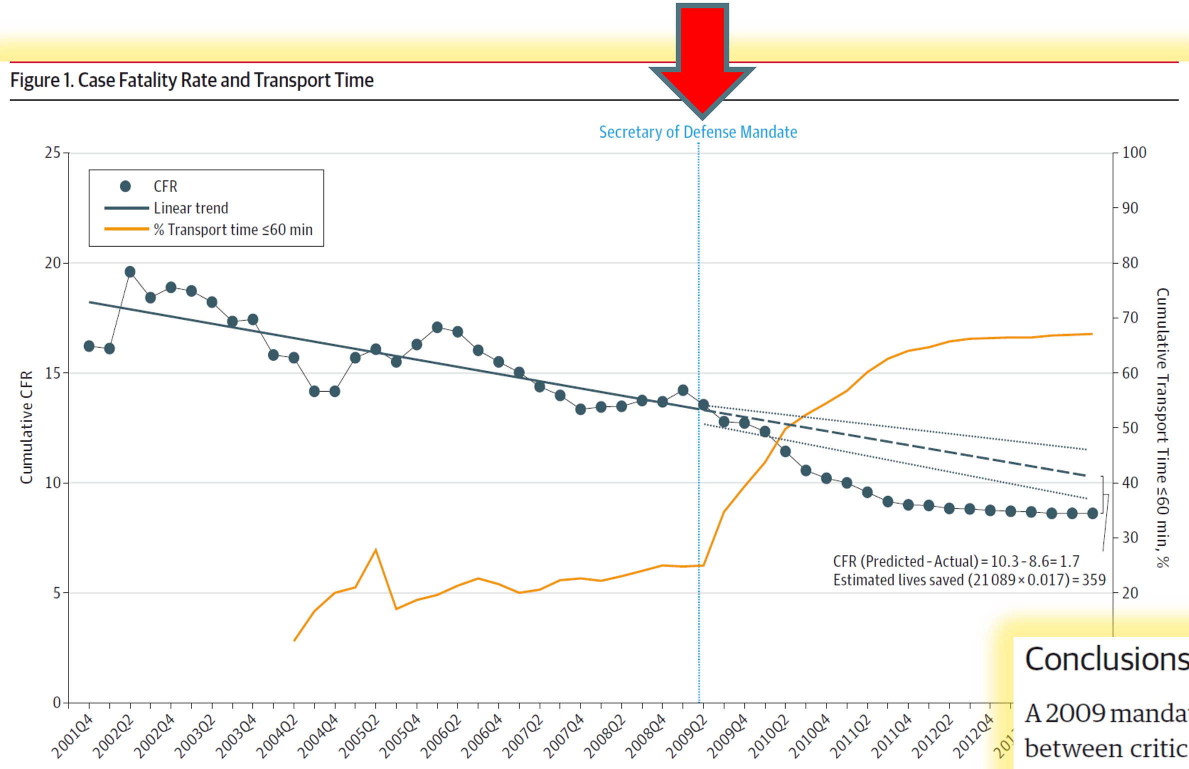
Golden Hour and the Gates Effect

Figure 1. Case Fatality Rate and Transport Time



Conclusions

A 2009 mandate by Secretary of Defense Gates reduced the time between critical injury and definitive care for combat casualties in Afghanistan. Despite evidence of increased severity and complexity of wounds from explosive devices, the combination of reduced prehospital transport time and increased treatment capability are likely contributors of casualty survival.

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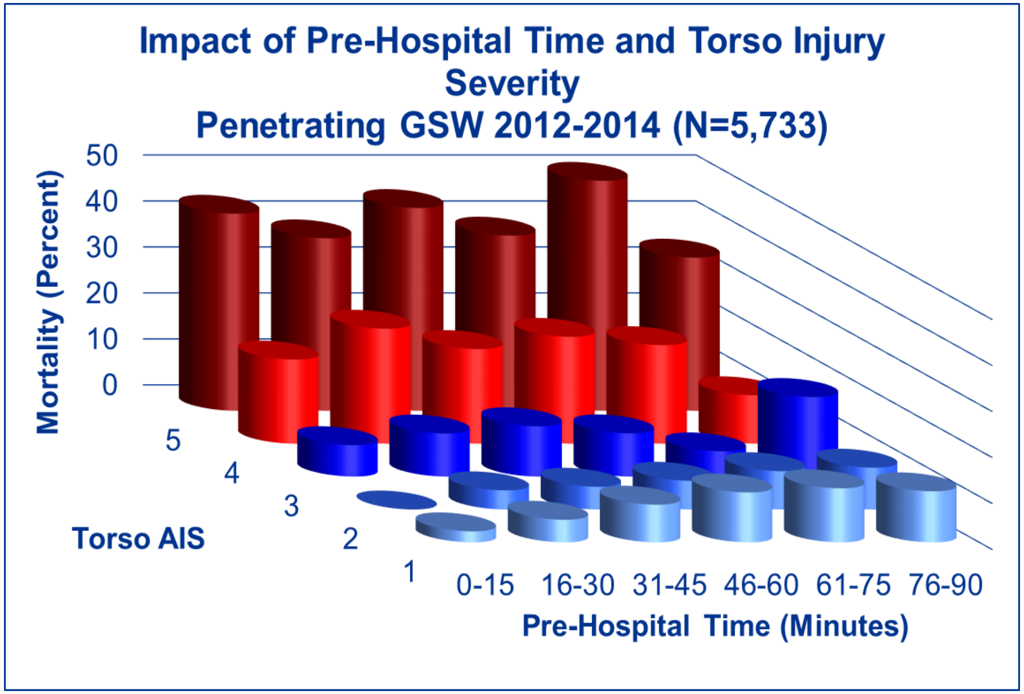
Prehospital Time
Noncompressible Torso Hemorrhage (GSW)



Critical nature of prehospital time in patients with non-compressible torso hemorrhage.

Evacuation times < 30 minutes not realistic, particularly in rural or austere environments.

Emphasizes need to develop therapies to increase the window of survival in the prehospital environment.

Alarhayem, Eastridge: Time is the Enemy. Am J Surg 2016

Military Tactical DCR Forward

- **FWB is the best prehospital resuscitation fluid**
- **75th Ranger Regiment program**
  - **Type O – Low Titer Anti-A, Anti-B abs**
  - **Donors pre-screened for typing, titers, and infectious diseases**
  - **Use donor pool to transfuse casualties in shock**

REVIEW ARTICLES

MILITARY MEDICINE, 180, 8:869, 2015

Tactical Damage Control Resuscitation

MAJ Andrew D. Fisher, SP USA; MAJ Ethan A. Miles, MC USA*; LTC Andrew P. Cap, MC USA†; CDR Geir Strandenes, MC‡; COL Shawn F. Kane, MC USA§*

ABSTRACT Recently the Committee on Tactical Combat Casualty Care changed the guidelines on fluid use in hemorrhagic shock. The current strategy for treating hemorrhagic shock is based on early use of components: Packed Red Blood Cells (PRBCs), Fresh Frozen Plasma (FFP) and platelets in a 1:1:1 ratio. We suggest that lack of components to mimic whole blood functionality favors the use of Fresh Whole Blood in managing hemorrhagic shock on the battlefield. We present a safe and practical approach for its use at the point of injury in the combat environment called Tactical Damage Control Resuscitation. We describe pre-deployment preparation, assessment of hemorrhagic shock, and collection and transfusion of fresh whole blood at the point of injury. By approaching shock with goal-directed therapy, it is possible to extend the period of survivability in combat casualties.

Civilian DCR Forward

SHOCK, Vol. 41, Supplement 1, pp. 84–89, 2014

IMPLEMENTATION AND EXECUTION OF CIVILIAN REMOTE DAMAGE CONTROL RESUSCITATION PROGRAMS

Donald Jenkins,[*] James Stubbs,[†] Steve Williams,[‡] Kathleen Berns,[§] Martin Zielinski,[*] Geir Strandenes,[‖¶] and Scott Zietlow[*]

[*]Division of Trauma, Critical Care and Emergency General Surgery, Department of Surgery, Mayo Clinic; and [†]Mayo Clinic Transfusion Medicine, Rochester, Minnesota; [‡]Medical Operations Royal Caribbean Cruises Ltd, Miami, Florida; [§]Mayo Clinic Medical Transport, Rochester, Minnesota; and [‖]Norwegian Naval Special Operation Commando and [¶]Department of Immunology and Transfusion Medicine, Haukeland University Hospital, and Institute of Clinical Science, University of Bergen, Bergen, Norway

Received 5 Nov 2013; first review completed 2 Dec 2013; accepted in final form 3 Jan 2014

ABSTRACT—Remote damage control resuscitation is a recently defined term used to describe techniques and strategies to provide hemostatic resuscitation to injured patients in the prehospital setting. In the civilian setting, unlike the typical military setting, patients who require treatment for hemorrhage come in all ages with all types of comorbidities and have bleeding that may be non–trauma related. Thus, in the austere setting, addressing the needs of the patient is no less challenging than in the military environment, albeit the caregivers are typically not putting their lives at risk to provide such care. Two organizations have pioneered remote damage control resuscitation in the civilian environment: Mayo Clinic and Royal Caribbean Cruises Ltd. The limitations in rural Minnesota and shipboard are daunting. Patients who have hemorrhage requiring transfusion are often hundreds of miles from hospitals able to provide damage control resuscitation. This article details the development and implementation of novel programs specifically designed to address the varied needs of patients in such circumstances. The Mayo Clinic program essentially takes a standard-of-care treatment algorithm, by which the patient would be treated in the emergency department or trauma bay, and projects that forward into the rural environment with specially trained prehospital personnel and special resources. Royal Caribbean Cruises Ltd has adapted a traditional military field practice of transfusing warm fresh whole blood, adding significant safety measures not yet reported on the battlefield (see within this Supplement the article entitled "Emergency Whole Blood Use in the Field: A Simplified Protocol for Collection and Transfusion"). The details of development, implementation, and preliminary results of these two civilian programs are described herein.

KEYWORDS—Shock, prehospital, trauma, shipboard, helicopter, whole blood, TXA

INTRODUCTION

Remote damage control resuscitation (RDCR) is essentially defined as the concept of damage control resuscitation applied in prehospital care, likely most important in austere situations in which, traditionally, blood products and robust resuscitative capability have not existed. This article describes the development and implementation of two such RDCR programs in civilian environments: one at Mayo Clinic Trauma Center (inclusive of Mayo Clinic Medical Transport) and the other aboard Royal Caribbean Cruises Ltd (RCCL) cruise ships.

Identification of the need for a civilian RDCR program

Early and aggressive use of blood components has become the standard of practice for the management of traumatic hemorrhagic shock and the deleterious effects of primary and secondary coagulopathy that develops in the majority of severely injured trauma victims. The prehospital resuscitation of the exsanguinating patient with trauma is time and resource dependent. Rural and maritime hemorrhage care (medical and injury causes combined) magnifies these factors because transportation time to definitive care is increased. The combination of damage control resuscitation with emphasis on early plasma delivery and the location of definitive care centers remote from initial resuscitation in the rural environment or aboard ship have led to the development of RDCR programs in those settings. Austere environment applies just as well in civilian settings as it does in military settings, as in contrast to the short prehospital transit time in most civilian urban trauma centers, the geographic expanse of the rural landscape or the maritime environment leads to inherent delay in the care of the hemorrhaging patient. Even in the presence of a mature regional rural trauma system and robust ship-to-shore evacuation, the care of a patient in shock is limited by the timing and effectiveness of resuscitation in those remote areas.

Aggressive replacement of coagulation factors with plasma is a crucial hemostatic resuscitation component of effective massive transfusion protocols (MTPs). Because of the necessity to transfuse plasma early and often in the severely injured, the lag time associated with the thawing and provision of fresh frozen plasma (FFP) hampers such efforts. Massive transfusion protocols have evolved to rely on the rapid availability of thawed plasma (TP) for use in hemostatic resuscitations (1).

The rural trauma center and helicopter emergency medical services experience in Minnesota

To address the early resuscitation needs and trauma-induced coagulopathy in the exsanguinating patient with trauma, an RDCR strategy was developed that involves prehospital TP-first transfusion protocol, and the use of tranexamic acid (TXA) was

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TRAUMA HEMOSTASIS AND OXYGENATION RESEARCH POSITION PAPER ON REMOTE DAMAGE CONTROL RESUSCITATION: DEFINITIONS, CURRENT PRACTICE, AND KNOWLEDGE GAPS

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Prehospital Plasma PAMPer Trial

ORIGINAL CONTRIBUTIONS

TAKING THE BLOOD BANK TO THE FIELD: THE DESIGN AND RATIONALE OF THE PREHOSPITAL AIR MEDICAL PLASMA (PAMPER) TRIAL

Joshua B. Brown, MD, Francis X. Guyette, MD, MPH, Matthew D. Neal, MD, Jeffrey A. Claridge, MD, Brian J. Daley, MD, Brian G. Harbrecht, MD, Richard S. Miller, MD, Herb A. Phelan, MD, Peter W. Adams, BS, Barbara J. Early, BSN, Andrew B. Peitzman, MD, Timothy R. Billiar, MD, Jason L. Sperry, MD, MPH

TABLE 1. Specific aims of the PAMPer trial

Primary aim	Determine whether prehospital transfusion of 2 units of AB plasma compared to standard air medical care reduces 30-day mortality in trauma patients at risk for hemorrhagic shock
Secondary aim 1	Determine whether prehospital transfusion of 2 units of AB plasma compared to standard air medical care results in lower 24-hour RBC transfusion requirement, incidence of MOF, NI, ALI, and TRALI[a]
Secondary aim 2	Determine whether transfusion of 2 units of AB plasma compared to standard air medical care results in a lower 24-hour plasma, platelet, crystalloid, colloid, and vasopressor requirement
Secondary aim 3	Determine whether transfusion of 2 units of AB plasma compared to standard air medical care results in improved INR, PT/PTT, and TEG measures of coagulopathy[b]
Secondary aim 4	Determine whether transfusion of 2 units of AB plasma compared to standard air medical care modulates the early immune response[c]

Prehospital Blood Outcomes

ORIGINAL SCIENTIFIC ARTICLES

Pre-Trauma Center Red Blood Cell Transfusion Is Associated with Improved Early Outcomes in Air Medical Trauma Patients

Joshua B Brown, MD, Jason L Sperry, MD, MPH, FACS, Anisleidy Fombona, BS, Timothy R Billiar, MD, FACS, Andrew B Peitzman, MD, FACS, Francis X Guyette, MD, MPH

	AOR for PTC RBC	95% CI	p Value
All HEMS			
24-h survival	4.91	1.51–16.04	0.01
Shock on admission	0.28	0.09–0.85	0.03
TIC	1.39	0.87–2.24	0.17
In-hospital survival	1.06	0.42–2.61	0.90
Scene HEMS			
24-h survival	6.31	1.88–21.14	<0.01
Shock on admission	0.24	0.07–0.80	0.02
TIC	2.02	0.53–7.71	0.30
In-hospital survival	4.32	0.76–24.72	0.10

AOR, adjusted odds ratio; HEMS, helicopter emergency medical services; PTC, pre-trauma center; TIC, trauma-induced coagulopathy.

Prehospital blood transfusion in the en route management of severe combat trauma: A matched cohort study

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		Recipients	Nonrecipients	*p*
n		97	97	
Prehospital interventions	Intraosseous access	14 (14.4)	16 (16.5)	0.824*
	Advanced airway	19 (19.6)	9 (9.3)	**0.041***
	Chest decompression	19 (19.6)	22 (22.6)	0.629*
Prehospital time, min		68 (50–100)	109.5 (70–171)	**0.008****
Admission observations	Cardiac arrest	7 (7.2)	9 (9.3)	1*
	Systolic blood pressure	132 (111–145)	131 (114–150)	0.145**
	Respiratory rate	19 (15–24)	20 (16–26)	0.173**
	Heart rate	92 (74–115)	105 (82–128)	**0.041****
Tranexamic acid		22 (22.6)	0 (0)	U/T
Recombinant activated factor VII		2 (2)	10 (10.3)	**0.033***
Prehospital transfusion	PRBC	1 (1–2) [0–4]	N/A	
	FFP	2 (1–2) [0–4]	N/A	
In-hospital transfusion	PRBC	2 (1–8.5) [0–49]	0 (0–3.5) [0–26]	**<0.001****
	FFP	2 (0–7.5) [0–44]	0 (0–1) [0–20]	**<0.001****
	Cryoprecipitate	0 (0–0) [0–4]	0 (0–0) [0–3]	0.068**
	Platelets	0 (0–0) [0–7]	0 (0–0) [0–6]	**<0.007****
Total PRBC		4 (2–10) [0–53]	0 (0–3.5) [0–26]	**<0.001****
Total FFP		2 (2–9) [1–44]	0 (0–1) [0–20]	**<0.001****
Any in-hospital PRBC transfusion		75 (77)	38 (39)	**<0.001****
Massive transfusion		12 (12)	8 (8)	0.388*
FFP/PRBC ratio		1 (0.83–1.23)	0.46 (0–0.72)	**<0.001****
Mortality		8 (8.2)	19 (19.6)	**0.013****

*Categorical data are shown as n (%) and compared using McNemar test.
**Ordinal and scale data are shown as median (IQR) with [range] added where relevant and compared using the Wilcoxon signed-rank test.
Significant results shown in **bold**.
U/T, untestable because of the limitations of McNemar test (because of zero value). N/A, not applicable; U/T untestable due to zero value.

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The Committee on Trauma

NHTSA

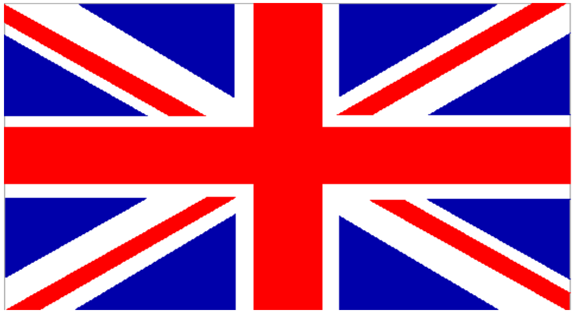
NIH

Prehospital Whole Blood

- Program development /proof of concept in process at several institutions
  - Mayo Clinic
  - University of Pittsburgh
  - University of Texas Health San Antonio / San Antonio Military Medical Center

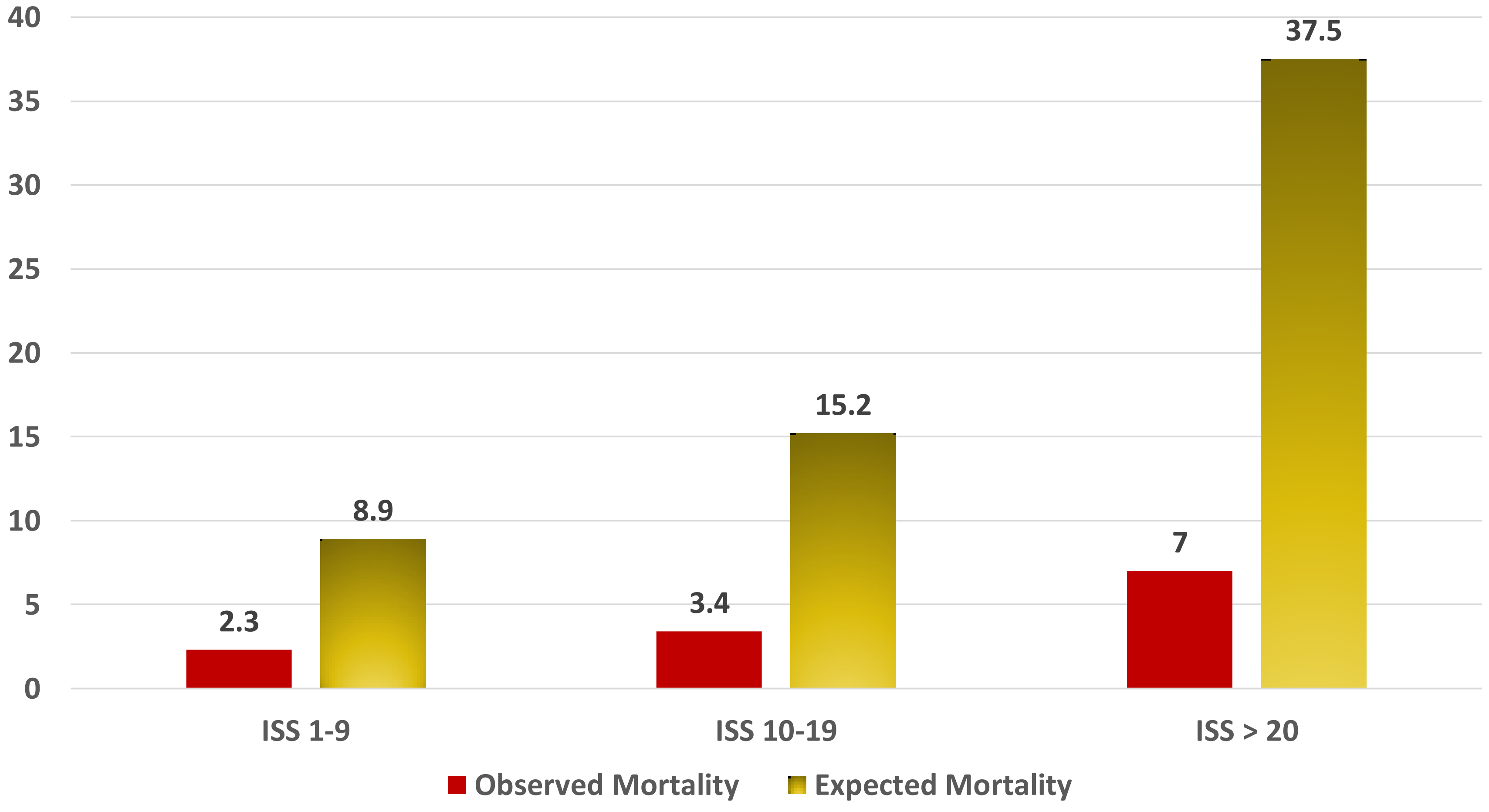
DCR Forward

Versus



- Scoop and Run or Stay and Play?
- Advanced providers?
- Critical care capabilities
- Blood products
- Surgical capability enroute

UK MERT


40
35
30
25
20
15
10
5
0
37.5
15.2
8.9
7
3.4
2.3
ISS 1-9
ISS 10-19
ISS > 20
Observed Mortality
Expected Mortality

Battlefield Continuum of Care
Proof of Concept Forward Surgery

Route from Injury to Definitive Care

CASEVAC
1 Hour

TACTICAL EVAC
24 Hours

STRATEGIC EVAC
48-72 Hours

BAS
Level 1

Forward Surgical teams
Level 2

Combat Support Hospital, EMEDS, Fleet Hospital
Level 3

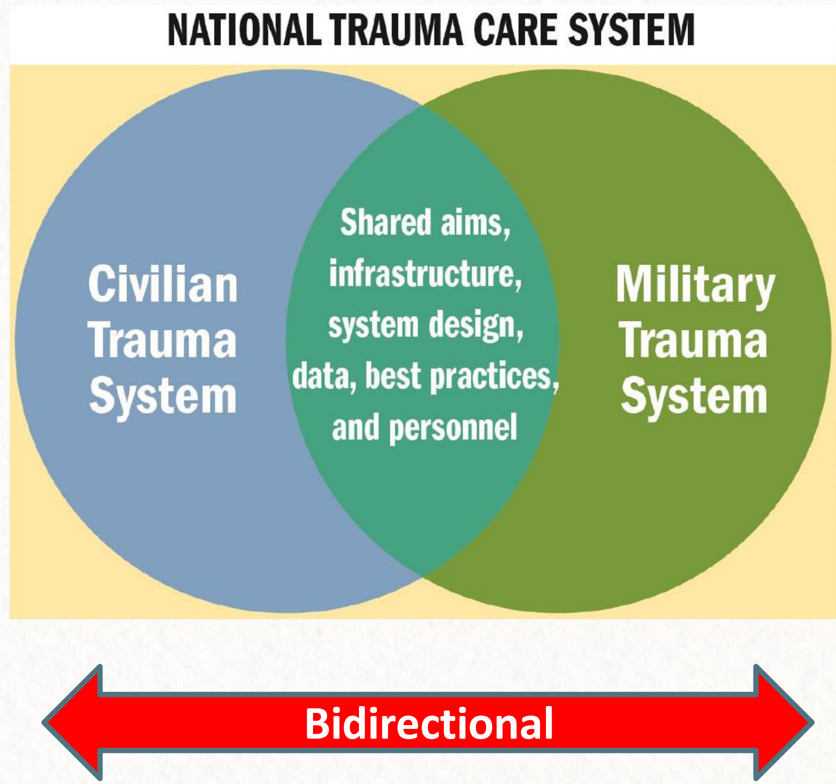
Definitive Care
Level 4

Surgical Capability

The Vision: A National Trauma Care System

A national strategy and joint military–civilian approach for improving trauma care is lacking. **A unified effort is needed** to ensure the delivery of optimal trauma care **to save the lives of Americans** injured within the United States and on the battlefield.

A national learning trauma care system would **ensure continuous improvement of trauma care best practices** in military and civilian sectors.



"Military and civilian trauma care will be optimized together, or not at all."