Trauma Resuscitation: Translating Military Lessons Learned into the Civilian Sector

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The only one who benefits from war is medicine

It's not about the war, it's about the warriors
Lessons Learned from Previous Conflicts

“From our earliest records of Western societies sending their citizens into harm’s way, those societies have usually made some provision for their citizens’ care”

- Paré and ligature
- Larrey and forward surgical care-flying ambulance
- Letterman and medically controlled evacuation
- Esmarch and first aid
- Pirogoff’s observation that “war is an epidemic of trauma”
- Nightingale's focus on sanitation, nutrition

Combat casualty care and lessons learned from the past 100 years of war: John Oh, MD et al
The First World War acted as a catalyst for the rapid development of blood banks and transfusion techniques. Canadian Lieutenant Lawrence Bruce Robertson was instrumental in persuading the Royal Army Medical Corps to adopt the use of blood transfusion at the Casualty Clearing Stations for the wounded. In October 1915, Robertson performed his first wartime transfusion with a syringe to a patient suffering from multiple shrapnel wounds.
Lessons Learned from Previous Conflicts

- Burn
- Shock
- Laboratory
- Antibiotics
- Evacuation
- Vascular Surgery
- Plastic Surgery
- Wound Management

  - Similar work regarding invasive fungal infections from blast injuries is ongoing at America’s leading military medical center, and carries direct relevance to the conflicts of today

- Blood Transfusion:
  - WWI blood bank-saving lives through transfusion-50-100 pints a day
Lessons Learned from Previous Conflicts

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

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

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

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

Desert Shield/Storm
- Burn team augmentation of evacuation hospitals to provide theater-wide burn care
- Intercontinental aeromedical transport of burn patients
Florence Nightingale 1850

Just 150 years ago, nursing was not regarded as a profession
Development of a nursing profession met with opposition
Changed the image of nursing
Rules of cleanliness
Introduced special diets
Improved water supply
Consistent proper nursing care
Used data to change outcome

*Mortality 40% to 2% in 1 years*
Florence Nightingale: Using Data

Crimean War
Soldiers dying from dysentery, wound infections, lack of sanitation, lack of nutrition and sunlight
Data shared with British Military leaders

Implemented
• Infection control measures
• Improved nutrition
• Separated infected from non infected
• Used outside solariums for sunshine
Princess Vera Gedroitz
• Surgeon
• Poet
• Author
• Refused to operate on abdominal injuries older than 3 hours. (80% mortality)
• To access more soldiers inside that critical window, Gedroitz outfitted a rail car as a mobile operating suite, moving treatment toward the fight
• 183 operations on abdominal wounds
• Reversed the policy re: abdominal surgery during war changed
Lessons Learned from Previous Conflicts

• Military advances in WW II associated with improved triage
• Military advances in Korea and Vietnam associated with expeditious evacuation and early mobility
• IOM defines injury as major U.S. healthcare issue needing:
  – Urban systems development
  – Governmental funding and oversight
  – ACS COT leadership role
  – "Optimal Resources for Care of the Seriously Injured"
Lessons Learned from Previous Conflicts

Korean Conflict 1950

MASH units followed the front
Increased patient acuity
Evacuation by helicopter brought more seriously wounded soldiers to definitive treatment
Hemorrhagic fever
Hemodialysis
Intensive care
Lessons Learned from Previous Conflicts (Post Vietnam)

- No codification of lessons learned from Vietnam or Gulf War
- No protracted military conflict / Lack of major combat experience
- Failure to maintain emphasis on combat casualty care training and sustainment
- Lack major developments in medical infrastructure
- Command and control issues (line versus medical)
- Forward surgical elements
- Air evacuation assets
Historical Route From Injury to Definitive Care

CASUALTY EVAC
- Evac Policy - 1 Day

Field Hospital
“Level 2”

Battalion Aid Station
“Level 1”

TACTICAL EVAC
- Evac Policy - 7 Days

In Theater Hospital
“Level 3”

STRATEGIC EVAC
- Evac Policy - 15 Days

Definitive Care
“Level 4”

Vietnam 45 days

Iraq and Afghanistan 1-3 days
HISTORY OF WARTIME PREHOSPITAL/ER SHOCK RESUSCITATION

<table>
<thead>
<tr>
<th>WW I/WW II</th>
<th>Vietnam</th>
<th>Korea</th>
<th>OIF/OEF</th>
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</thead>
<tbody>
<tr>
<td>50 years of Plasma, Albumin and Whole Blood</td>
<td>40 years of Crystalloid/Clear Fluids &amp; WB:</td>
<td>1. 3rd space resuscitation</td>
<td>Forward to the past (DCR):</td>
</tr>
<tr>
<td>50 years of Plasma, Albumin and Whole Blood</td>
<td>40 years of Crystalloid/Clear Fluids &amp; WB:</td>
<td>2. Fractionation of WB</td>
<td>1. Early plasma</td>
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<tr>
<td>50 years of Plasma, Albumin and Whole Blood</td>
<td>40 years of Crystalloid/Clear Fluids &amp; WB:</td>
<td></td>
<td>2. ”WB” equivalent</td>
</tr>
<tr>
<td>50 years of Plasma, Albumin and Whole Blood</td>
<td>40 years of Crystalloid/Clear Fluids &amp; WB:</td>
<td></td>
<td>3. FWWB</td>
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</table>
CONSEQUENCE

Military had fallen far behind the construct of the experience gained and lessons learned from civilian trauma systems.
History of Civilian Trauma Systems

- Military advances in WW II associated with improved triage
- Military advances in Korea and Vietnam associated with expeditious evacuation
- IOM defines injury as major U.S. healthcare issue
- Urban systems development
- Governmental funding and oversight
- ACS COT leadership role
- "Optimal Resources for Care of the Seriously Injured"
Public Hospitals Defacto Trauma Centers

- Cook County
- SFCH
- Bellevue
- Detroit Receiving
- Jackson Memorial
- The Med
- Ben Taub General
- Harborview
- Grady Memorial
- Philadelphia General
- St. Louis City
- DC General
- Kings County
- Baltimore City
- Cincinnati General
- LA County
- Charity Hospital
Joint Trauma Systems Operational Cycle
JTTS Concept of Operation

Components Across the Continuum of Care

Leadership
- Recognized lead facility and consulting assets
- Director/ Coordinators

Communication
- Intra theater
- Inter theater

Clinical Practice Guidelines
- Adopt CPGs
- Communicate, train

Research
- AOR research mechanism
- Deployed clinicians to conduct research
- Process for validating joint data/research requirements

QA/PI
- Feedback mechanism for all providers
- Uniform M&M process for MTFs, C2, including Level IV and V

Information Systems
- Support for all other components
- Primarily=longitudinal health record
- Joint Theater Trauma Registry (JTTR)
- Joint Patient Tracking Application (JPTA)

Prevention
- Linkage with Material developers
- CHPPM and Safety Center

Integrated Pre-Hospital and Hospital Care
- Integrated approach for MTFs and divisional medical units
- Coordinated divisional EVAC SOPs

Integrated Pre-Hospital and Hospital Care
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Landstuhll Regional Medical Center

For over 25 years, Landstuhl Regional Medical Center (LRMC) has served as a model of “selfless service” stepping up to the demand of a suddenly increased rate of traumatically injured service members arriving from the battlefield.

From Operation Desert Storm/Desert Shield; through the attacks in Somalia, and the USS Cole; to the recent conflicts in Afghanistan, Iraq and Benghazi.

From a community hospital providing routine care LRMC transitioned into an ACS Verified Level 1, tri-service, integrated trauma center serving tens of thousands of evacuated service members.
The Landstuhl “Prism”

**Input:** Chaotic, complex compilation of nationalities, diagnoses, medical records and damage control care processes from combat theaters.

**Output:** Stable patients following a consistent CPG-guided evaluation and with a complete and organized medical record who are evacuated to facilities throughout the world.
Landstuhl Regional Medical Center


- ONLY military Level 4 MTF supporting US Central Command

- Referral center for US European, US African and Special Operations Commands
Joint Trauma System Performance Improvement

Practice Guidelines, Consistent Documentation Tools

Assessment, Communication and Data Collection/Analysis

Monitor, Educate and Improve Outcomes

Level IIb
Injury
Salvage Surgery
1st hour

Level III
2nd
Salvage Surgery or Definitive surgery

Level IV
Landstuhl
Germany
Definitive Surgery & Optimize for air evacuation

Level V
USA – Landstuhl
Definitive Care, reconstruction, short and long term rehab
Pivotal Experiences: Continuous Communication
Pivotal Experiences:
VTC System Wide Military Trauma PI

Weekly Clinical VTC
(video and audio teleconference)
- JTTS Trauma Director and Program Manager
- Iraq and Afghanistan Level IIb and III, CCATT and Medevac
- NATO Level III, CCATT and Medevac
- 6 trauma coordinators embedded at each Level III
- Level V facilities at WRAMC, BAMC, NNMC
- VA Polytrauma Centers

JTTS San Antonio, JTTS Theater and LRMC
Teleconference for operational issues (weekly)

JTTS Trauma Directors Leadership Teleconference (quarterly)

System Wide VTC (monthly)
Pivotal Experiences: Importance of a Military Trauma System and Trauma Center Verification

Trauma System

Trauma Service

Trauma Center

Trauma Program
Performance Improvement

Data driven process
Involved multidisciplinary staff
Inclusive of entire continuum of care
Evaluate system response
Improve patient outcomes
Ensure competent & current providers
Pivotal Experience: LRMC Trauma Performance Improvement ("Exemplar"-ACS)

- Primary Review
- Secondary Review
- Tertiary Review

Issue Identification
- Complication/Audit Filter Review
- Downrange/Resuscitation
- CCATT
- ICU/Acute Care
- Continuum CONUS

TMD, TND, TPIC, TNC

Actions
- Education Session
- Discussion/Counseling
- Track/Trend
- Guideline/Policy Development
- PI Team Project

Issues Elevated to Hospital PIC Monthly
Trauma Morning PI Report and ICU Rounds

Flights in 1-2 times/day/7 day/week
• (plane full of patients)
Flights out only Sun-Tue-Fri
Forum for issue identification
Primary Review of PI issues
55 Audit Filters, 60 Complications
Track compliance with CPGs
Plan of care discussed
Issues are captured
• TNCs use tablet computers for direct entry into Joint Theater Trauma Registry (JTTR->DoDTR)

Summary of discussions
System issues tackled immediately
Pivotal Experiences:
Trauma Registry Across the Continuum
Pivotal Experience: Remote Damage Control Resuscitation

Austere/rural environment patients
- Modified transfusion strategy
- Different than those with scene/pre-hospital time < 30 minutes
- Limited resources available
- Lack of plasma availability
- 40% of the population, 60% of the trauma mortality

Current treatment options for uncontrolled hemorrhage in this environment are very limited

>75% of combat fatalities occur in the field
Damage Control Resuscitation
“5 H’s”

- Hemorrhage control
  - OR timely fashion
    - Definitive solution to bleeding is in the OR/IR
- Hypotensive resuscitation
  - Systolic BP=80-90 torr
    - “Tolerate” shock vs. Popping clots
- Hemostatic resuscitation
  - Blood products early and often: Plasma
    - Prevention of coagulopathy
      - Dilution
      - ACoTS
  - Minimize crystalloid administration
- Homeostasis
  - Hypothermia
  - Acidosis
- Hypnosis: having our cake and eating it too
  - DCA
    - Vasoconstriction → Vasorelaxed
Where Are Soldiers Dying? Where Can We Save the Most Lives?

But most are from truncal hemorrhage
Pivotal Experiences: 1:1:1 Transfusion

Need for Massive Transfusion
• 2% civilian
• 8-16% in combat casualties

IV Hemostasis
• INR > 1.5 on arrival predictive of need for massive transfusion (MT)
• Fresh thawed plasma best resuscitation fluid in MT
  - Optimum ratio of plasma to crystalloid 1:1 to avoid clotting factor dilution

IV Hemostasis
• Use of fresh whole blood
• Early use of cryoprecipitate
• Recombinant Factor Via (rFVIII)
Is the MTP (1:1:1) the Modern Day Whole Blood Equivalent:

- Crystalloid fluid
  - Poor volume expander
  - Carries no oxygen, coagulation factors
- What if we administer the fractionated parts of WB as a 1:1(1) ratio?
  - Volume
  - Oxygen delivery
  - Coagulation factors
Whole Blood in Combat

- **US Vietnam** > 230,000 units transfused (mostly cold)
- **US OIF/OEF** > 10,000 units transfused (almost all fresh): first transfusion October 2001
  - 1st six WFWB to one casualty prior to invasion
  - First troops in contact flew from remote location
  - 50 cold whole blood by preponderance of blood types taken with invasion force
  - 40 additional cold whole blood at MTF all type O
  - 2 casualties transfused cold whole blood, one with 6 units the other with 4 units
Civilian Use of Whole Blood is Limited

- Military: *(Fresh Warm)* Whole Blood
  - Warm: 20-24 °C*
  - Fresh if < 24 hours old
  - Walking blood bank
    - Pre-tested

- Civilian: Whole Blood
  - Cold: 1-4°C*
  - Formal testing for transmissible disease.
    - 72 hours
  - Licensed for 21 days
  - Difficult to obtain from blood centers
    - Fractionation of WB
      - Efficient use of blood product
      - Financial
Cold-Storage Platelets for Treatment of Hemorrhage
Better, Safer, Cheaper, Available Now
US Army Institute of Surgical Research

LTC Andrew P. Cap, MD, PhD, FACP
Dr. Heather F. Pidcocke, MD, PhD
Dr. Philip C. Spinella, MD, FCCM

Coagulation and Blood Research Program
October 23, 2013
COLD PLATELETS ARE:

**BETTER**

- Better hemostatic function:
  - *in vitro* and clinical data demonstrate better:
    - Clot strength
    - TEG
    - Aggregation
    - Metabolics
How Much Difference Does Additional Cryoprecipitate and Platelets Make?

2003 Iraq
- Mortality: >20%
  - No platelets and cryoprecipitate available in theater

2012 Afghanistan
- Mortality: <10%
  - Greater cryoprecipitate and platelets availability.
    - *ISS scores higher* in casualties in 2012 than those in 2003.

Evolving MTP
1:1:1:1
Protocol – Helicopter Phase

Indications for PRBC and Plasma administration in adult trauma patients

Plasma + RBC
1. Hypotension (single reading of systolic blood pressure < 90mmHg)
2. Tachycardia (single reading of heart rate ≥ 120)
3. Penetrating mechanism
4. Point of care lactate ≥ 5.0 mg/dl
5. Point of care INR ≥ 1.5
6. StO2 < 65

Plasma Alone
1. Point of care INR ≥ 1.5
2. Stable Hemodynamics
Pivotal Experiences: Fasciotomies

Fasciotomies
• Fallujah review

Data analysis
• Delayed Fasciotomy associated with poor outcomes
• Weekly VTC PI
• AL/AR/ACT

1. Incomplete or delayed fasciotomy for compartment syndrome is associated with poor outcomes. A review of 337 combat casualties (685 fasciotomies) showed that fasciotomy requiring revision at Level IV was associated with more muscle necrosis (35% vs. 9%, p < 0.01) and higher mortality (20% vs. 4%, p < 0.01) than those not requiring revision. Casualties who underwent first fasciotomy at Level IV had more muscle necrosis (23% vs. 10%, p < 0.01), higher mortality (19% vs. 5%, p < 0.01) and higher amputation rates (31% vs. 15%, p < 0.01) than those with first fasciotomy in theater.
Pivotal Experiences: Tourniquets

Whereas civilian blunt trauma victims may have a "golden hour," casualties with penetrating battlefield trauma often have only a "platinum 5 minutes."

Mil Med. 2004 Dec;169(12 Suppl):8-10, 4
Pivotal Experiences: Translated from military to civilian sector
Lessons Learned: Wound Hemostasis

Hemostatic Dressings:

- Key to avoiding coagulopathy: control bleeding early
- Primarily used for non-extremity hemorrhage, but also useful in severely mangled limbs
- Applied with pressure < 5 minutes, patient “wrapped” and then transported
Choices for Topical Hemostatic Agents

HemCon (chitosan)
• Originally as bandage
• Now in roll that can be stuffed into wound

QuikClot (initially available as a powder; subsequently marketed in a adherent package)
• Very exothermic (up to 147°F)
• Difficult to debride from wound due to adherence

New Advanced Clotting Sponge (ACS)
• Gauze sack: is easily removed from wound
Pivotal Experiences: Negative Pressure Therapy

Closed negative pressure dressing
V.A.C. adjunct after exploration

VAC negated need for dressing changes and allowed the use of a closed, more sterile, and tolerable wound management strategy

This technique accelerated wound contraction and granulation

War wounds from Iraqi soldiers 4.2 days to wound closed

War wounds from American soldiers 42 days to wound closed

Air Evacuation would not allow wound vacs on airplanes
Pivotal Experiences: Burn Flowsheet

Burn Care
• Revised Guidelines - Combat related
• Single standard
• Burn flow sheet
• Emergency War Surgery course
• Weekly VTC - PI

Post implementation of burn flow sheet
• Incidence of abdominal compartment syndrome: 30% to 13%
• Mortality 41% to 18%
Pivotal Experiences: mild Traumatic Brain Injury

Traumatic Brain Injury
- Inpatient Screening
- Outpatient Screening
- Global Algorithm
- 100% Capture
- Initial screening
- Military Assessment of Concussion Evaluation score (MACE)
- Neurology evaluation
- Exertion testing if asymptomatic at rest
- Referral to TBI sites in United States
Pivotal Experiences:
Critical Care Air Transport Teams
Pivotal Experiences: Acute Lung Team Transports from Combat Zone

Devastating Lung Injury Team
- CENTCOM Acute Lung Team (CCATT)
- VDR-4
- LTV 1000
- CCO/SVO2 monitor
- Portable ECMO
Challenge: Moving ICU to C17 PLANE
Pivotal Experiences: Pumpless Extracorporeal Lung Assist

PECLA in partnership w/ Regensburg Hospital, Germany

Interventional lung assist (ILA) system in use since 2000 in Europe and Canada in more than 1200 patients

Surgical lung assist (SLA) system FDA approved but not yet commercially available

No electrical requirement for use

Device allows separation of oxygenation and ventilation functions of respiration

• Mechanical ventilator oxygenates utilizing lung protective strategies
• Carbon dioxide elimination via the device through an extracorporeal circuit
PIVOTAL EXPERIENCES:
PUMPLESS EXTRACORPOREAL LUNG ASSIST
AAST Senior Visiting Surgeon Program at Landstuhl
4th Collaboration between Civilian and Military In Theater Trauma System Evaluation: 3 Continents

Vision of the Joint Trauma System

That every soldier, marine, sailor, or airman injured on ANY battlefield or in ANY theater of operations has the optimal chance for survival and maximal potential for functional recovery.

Objective

At the invitation of US Central Command (CENTCOM) Surgeon and sponsored by the Air Force Central Command, a group of nationally recognized trauma experts visited US and NATO military medical facilities in Germany and Afghanistan.
Evaluation Team

Michael Rotondo, MD, FACS
• Professor/Chair, Department of Surgery, East Carolina University; Director, Center of Excellence for Trauma and Surgical Critical Care, Pitt County Memorial Hospital, Greenville, NC. Chairman, ACS Committee on Trauma

Thomas Scalea, MD, FACS
• Francis X. Kelley, Professor of Trauma, University of Maryland School of Medicine, and Physician and Chief, R. Adams Cowley Shock Trauma Center, Baltimore, MD

Kathleen Martin, MSN, RN
• Trauma Nurse Director, Landstuhl Regional Medical Center, Germany, Past President of the Society of Trauma Nurses and for Chair of the TOPIC Committee

Col Jeffrey Bailey, MD, FACS
• Director, Joint Trauma System, Institute of Surgical Research, and former Director, USAF Center for Sustainment of Trauma and Readiness Skills, St. Louis, MO

LtCol Anne Rizzo, MD, FACS, USAFR
• Associate Professor of Surgery, Virginia Commonwealth University, Vice Chair, Department of Surgery and Associate Surgical Residency Program Director
Trauma Resuscitation Bagram: ATLS Principles
OR, Craig Hospital, Bagram Role 3
C17 Return Bagram to Ramstein
• Evidence Based Practice
• Decrease Variation
• Clinical Practice Guidelines

• Data Driven (JTI)
• Outcome Driven

• Leadership and Communication

• Trauma Specific Education
• Pre-deployment Training

• Performance Improvement/Patient Safety

• Commitment
• Support
• Sustainment JTS
• Team Dynamics Role 1-V

• Education and Training

• Evidence Based Practice
• Decrease Variation
• Clinical Practice Guidelines

• Clinical Excellence and Investigation

• Commitment
• Support
• Sustainment JTS
• Team Dynamics Role 1-V
A NATIONAL TRAUMA CARESYSTEM

Integrating Military and Civilian Trauma Care Systems to Achieve Zero Preventable Deaths After Injury
Study Sponsors

- American College of Emergency Physicians
- American College of Surgeons
- National Association of Emergency Medical Technicians
- National Association of EMS Physicians
- Trauma Center Association of America
- U.S. Department of Defense’s U.S. Army Medical Research and Materiel Command
- U.S. Department of Homeland Security’s Office of Health Affairs
- U.S. Department of Transportation’s National Highway Traffic Safety Administration
Identify and describe the key components of a learning health system necessary to optimize care of individuals who have sustained traumatic injuries in military and civilian settings.

Characterize the military’s Joint Trauma System (JTS) and Defense Health Program research investment and their integrated role as a continuous learning and evidence-based process improvement model.

Examine opportunities to ensure that advances in trauma care are sustained and built on for future combat operations.

Consider strategies necessary to more effectively translate, sustain, and build upon elements of knowledge and practice from the military’s learning health system into the civilian health sector and lessons learned from the civilian sector into the military sector.
Framework for a Learning Trauma Care System

Committee built upon the components of a continuously learning health system articulated by IOM (2013) report *Best Care at Lower Cost*.

Components of a **continuously learning trauma care system:**
- Digital capture of the patient care experience
- Coordinated performance improvement and research to generate evidence-based best trauma care practices
- Processes and tools for timely dissemination of trauma knowledge
- Systems for ensuring an expert trauma care workforce
- Patient-centered trauma care
- Leadership-instilled culture of learning
- Transparency and incentives aligned for quality trauma care
- Aligned authority and accountability for trauma system leadership

Patient centeredness is the core of a learning trauma care system.
Context

• The Imperative
  – The U.S. service members the nation sends into harm’s way and every American should have the best possible chance for survival and functional recovery after injury.

• The Urgency
  – Military burden: ≈6,850 service member deaths in Iraq and Afghanistan. Nearly 1,000 from potentially survivable injuries.
  – Civilian burden: 147,790 U.S. trauma deaths in 2014 - as many as 30,000 may have been preventable with optimal trauma care.
  – Threats from active shooter and other mass casualty incidents.
  – As wars end and service members leave the military, the knowledge, experience and advances in trauma care gained over past decade are being lost.

• The Opportunity
  – Existence of a military trauma system built on a learning system framework that has achieved unprecedented survival rates for casualties.
  – Organized civilian trauma system that is well positioned to assimilate recent wartime trauma lessons learned and serve as a repository and incubator for innovation during the interwar period.

Traumatic injury accounts for nearly half of all deaths for Americans under 46 years of age and cost the nation $670B in 2013.
Thank you for your time today.

Any Questions?

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