Inside this Issue:

- Case Report: A Herpes Zoster Outbreak on the Sinai Peninsula
- Case Report: Activation of Walking Blood Bank Based on Mechanism of Injury
- Case Report: Anthrax Case Report Relevant to Special Operations Medicine
- In Brief: Measures of Instructor Learning
- In Brief: Tourniquet Effectiveness When Placed Over JSLIST
- Comparison of Pneumatic Tourniquet Models
- Single, Wider, and Paired Tourniquet Pressures
- Field Sterilization in the Austere Environment
- Simulation Versus Live Tissue for Training Trauma Procedures
- Inner Ear Barotrauma
- Effect of Cooling Shirt on Core Body Temperature
- Integration of TECC Into the National TEMS Competency Domains
- Letters to the Editor: A AJT Design and Testing and Field Electronic Medical Records
- Ongoing Series: Clinical Corner, Human Performance Optimization, Infectious Diseases, Injury Prevention, Picture This, Prolonged Field Care, Special Talk, World of Special Operations Medicine, TCCC Updates, TacMed Updates, and more!

Dedicated to the Indomitable Spirit and Sacrifices of the SOF Medic

A Peer-Reviewed Journal That Brings Together the Global Interests of Special Operations’ First Responders
Tactical Combat Casualty Care: Top Lessons for Civilian EMS Systems from 14 Years of War

Dr. Frank Butler
16 May 2016

Disclaimers
“...construed as official or as reflecting the views of the Departments of the Army, Air Force, Navy or the Department of Defense.”

Disclaimers
- I will include reference to commercial devices but I have no financial relationships or conflicts related to this talk.
- Several of the medications discussed (tranexamic acid, fentanyl lozenges, low-dose ketamine) are recommended for off-label uses.
TCCC Updates

DoD Joint Trauma System

Coalition forces at the end of the Afghanistan conflict had the best definitive care and evacuation system in history.

- TCCC’s job is to make sure that the casualties get to the hospital alive so that they can benefit from it - 87% of combat fatalities die in the prehospital phase.

Tactical Combat Casualty Care

The Prehospital Arm of the US Military’s Joint Trauma System

- Medics, Corpsmen, PJs
- Combat Lifesavers
- All Combatant Self/Buddy Care
- Includes Tactical Evacuation Care

Photo - MSG Harold Montgomery

Tactical Trauma Care at 8000 ft in the Hindu Kush

Battlefield Trauma Care: 1970

“All seem uncertain regarding the best method to implement factual knowledge to the man most in need, the front line trooper... citing our ineptness in the field of self-help and first aid....”

CAPT J. S. Maughon
MIL Med 1970

Battlefield Trauma Care: 1995

- Based on trauma courses NOT developed for combat
- Medics taught NOT to use tourniquets
- No hemostatic dressings
- Large volume crystalloid fluid resuscitation for shock
- 2 large bore IVs on all casualties with significant trauma
- Civil War-vintage technology for battlefield analgesia (IM morphine)
- No focus on prevention of trauma-related coagulopathy
- No tactical context for care rendered
- Special Ops Medics - venous cutdowns if trouble starting an IV
- Heavy emphasis on endotracheal intubation for prehospital airway management
Tourniquets Reconsidered: 1992
• ATLS 1992: NO tourniquets
• Fear of ischemic damage to limbs
  But
• Exsanguination from extremity hemorrhage was the #1 cause of preventable death among US casualties in Vietnam (estimated 3,421 deaths)
• Tourniquets can control extremity hemorrhage
• Tourniquets are used routinely during orthopedic surgery
• Limbs are not lost as a result
• Also - if you had to choose between death and losing a leg...
  • "No TQ" rule: NOT evidence-based; NOT logic based

Tactical Combat Casualty Care (TCCC): A Different Approach
• Battlefield trauma care research effort - Special Operations and USUHS: 1993-1996
• Combat environment and mission considered
• Combat medic training and equipment considered
• Project included input from combat medics, corpsmen, and pararescuemen (PJs)
• Evidence-Based - INCLUDING requiring evidence for prevailing practice at that time
• Goal - To Prevent Preventable Deaths

Combat Fatalities: Two Types
• Non-Preventable:
  • Helicopter hit by a rocket and explodes in mid-air
• Potentially Preventable:
  • Special Forces Soldier
  • Shot in the knee
  • No other major wounds
  • Bled to death - 2003

The acceptable number of preventable deaths is - ZERO.

What is the Cause of Death?

Tactical Combat Casualty Care in Special Operations

Military Medicine Supplement August 1996

Evidence-based trauma care guidelines customized for use on the battlefield
Tourniquets in TCCC
Mil Med 1996

“It is very important, however, to stop major bleeding as quickly as possible since injury to a major vessel may result in the very rapid onset of hypovolemic shock... Ischemic damage to the limb is rare if the tourniquet is left in place less than an hour and tourniquets are often left in place for several hours during surgical procedures. In the face of massive extremity hemorrhage, in any event, it is better to accept the small risk of ischemic damage to the limb than to lose a casualty to exsanguination......

Committee on Tactical Combat Casualty Care (CoTCCC)

- First funded by USSOCOM in 2001-2002 at the Naval Operational Medicine Institute (NOMI)
- Later sponsored by Navy and Army Surgeons General and the U.S. Army Institute of Surgical Research
- 42 members - all services
- Trauma Surgeons, EM and Critical Care physicians, operational physicians and PAs; medical educators; combat medics, corpsmen, and PJs
- 100% deployed experience in 2015
- Relocated to the Defense Health Board in 2007 at the direction of ASD/HA
- Moved to the Joint Trauma System in 2013

Battlefield Trauma Care: Now

- Phased care in TCCC
- Aggressive use of tourniquets initially
- Combat Gauze as hemostatic agent
- Aggressive needle thoracostomy
- Sit up and lean forward airway positioning
- Surgical airways for maxillofacial trauma
- Hypotensive resuscitation with blood products
- IVs only when needed; IO access if required
- PO meds, fentanyl lozenges, ketamine as “Triple Option” for battlefield analgesia
- Hypothermia prevention; avoid NSAIDs
- Battlefield antibiotics
- Tranexamic acid (TXA)
- Junctional Tourniquets; X-Stat

TCCC: How Do We Know That it’s Working?

- Paper published 1996 in Mil Med
- First used by Navy SEALs, 75th Ranger Regiment, Army Special Missions Unit, and Air Force Pararescue in 1997
- PHTLS, ACS COT and NAEMT endorsement 1999
- All of Special Ops adopted in 2005
- Now used throughout U.S. military
- Allied nations and civilian sector as well
Eliminating Preventable Death on the Battlefield

Kotwal et al – Archives of Surgery 2011
• All Rangers and docs trained in TCCC
• U.S. military preventable deaths: 24%
• Ranger preventable death incidence: 3%

TCCC: Success in Combat
3rd Infantry Division

“The adoption and implementation of the principles of TCCC by the medical platoon of TF 1-15 IN in OIF 1 resulted in overwhelming success. Over 25 days of continuous combat with 32 friendly casualties, many of them serious, we had 0 KIAs and 0 Died From Wounds, while simultaneously caring for a significant number of Iraqi civilian and military casualties.”

CPT Michael Tarpey
Battalion Surgeon 1-15 IN
AMEDD Journal 2005

TCCC in Canadian Forces

CONCLUSION

For the first time in decades, the CF has been involved in a war in which its members have participated in sustained combat operations and have suffered increasingly severe injuries. Despite this, the CF experienced the highest casualty survival rate in history. Though this success is multifactorial, the determination and resolve of CF leadership to develop and deliver comprehensive, multileveled TCCC packages to soldiers and medics is a significant reason for that and has unquestionably saved the lives of Canadian, Coalition and Afghan Security Forces. Further-

ASDHA TCCC Letter
14 February 2014

“What Can TCCC Offer to My Civilian EMS System?

• Tourniquets
• Hemostatic dressings
• Trauma airway approach
• TCCC Needle Decompression Plan
• Tranexamic Acid (TXA)
• Hypotensive resuscitation - with blood products where possible
• Intraosseous vascular access
• Triple-Option Analgesia

What Can TCCC Offer to My Civilian EMS System?
Lest we forget - most of the U.S. military went to war in Afghanistan and Iraq without tourniquets.

Tourniquet Outcomes in TCCC Transition Initiative Report

- Sixty-seven successful tourniquet applications identified
- No avoidable loss of limbs due to tourniquet use identified

Butler, Greydanus, Holcomb
2006 USAISR Report
“TCCC: Combat Evaluation 2005”

Preventable Combat Deaths from Not Using Tourniquets

  - 193 of 2,600 fatalities
  - 7.4% of total combat fatalities
  - 77 of 982 (in both cohorts of fatalities)
  - 7.8% of total fatalities - no better than Vietnam
- Tourniquets became widely used in 2005-2006
- Eastridge - J Trauma 2012: OEF + OIF (to Jun 2011)
  - 119 of 4,596 fatalities
  - 2.6% of total fatalities - a 67% decrease

Tourniquets - Kragh et al
Annals of Surgery 2009

- Ibn Sina Hospital, Baghdad, 2006
- Prehospital tourniquets are saving lives on the battlefield
- 31 lives saved in 6 months period
- 232 patients with tourniquets on 309 limbs
- No limbs lost to tourniquet ischemia
- This paper turned the tide on tourniquets in the military

Tourniquets in the U.S. Military - 2003

“Tourniquets have been the signature success in battlefield trauma care in Afghanistan and Iraq. Based on the work of Army COL John Kragh and colleagues, the number of lives saved from this intervention has been estimated to be between 1,000 and 2,000.”

Davis et al
Journal of Trauma Acute Care Surg
2014

- And the “1,000-2,000 lives saved” estimate was made in 2008 - six years before the end of the conflicts.
Tourniquet Phobia

- "But - I learned that tourniquets are dangerous and should only be used only as a last resort!"
- This is a medical "Urban Myth" that has cost the lives of thousands of casualties and trauma victims.
- Many thousands of tourniquets were used in the US Military in Iraq and Afghanistan.
- ZERO limbs were lost from tourniquet use in those two conflicts.
- 2 hours of tourniquet time is very safe.

Use and Success Rate

77 tourniquets were used for 73 patients
- Only 1 was used on the same extremity due to incorrect application of the first CAT at outside ED. All others were used for different extremity injuries
- All CAT were successful except for one listed above (98.7%)
- Improvised tourniquets used prior to our arrival were universally unsuccessful

What Can TCCC Offer to My Civilian EMS System?

- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia

When You Can’t Use a Tourniquet

- Groin, axilla
- Neck

Use a hemostatic dressing!

CoTCCC-Recommended Hemostatic Dressings

- Combat Gauze
- Celox Gauze
- ChitoGauze

*Always apply with 3 minutes of firm direct pressure!
TCCC Updates

Combat Gauze When You Can’t Use a Tourniquet

Prehospital use of hemostatic dressings by the Israel Defense Forces Medical Corps: A case series of 122 patients

Dr. Avi Shina et al
Journal of Trauma 2015

“The 88.6% self-reported success rate in junctional hemorrhage control is encouraging, as junctional hemorrhage is increasingly looked at as the currently most common cause of preventable death in the battlefield.”

External Hemorrhage Control Practice Guidelines

- The American College of Surgeons Committee on Trauma now endorses the use of both tourniquets and hemostatic dressings
- So does the American College of Emergency Physicians
- So does the National Association of EMTs

Use and Success Rate

- 77 tourniquets were used for 73 patients
- Only 1 was used on the same extremity due to incorrect application of the first CAT at outside ED. All others were used for different extremity injuries
- All CAT were successful except for one listed above (98.7%)
- Improvised tourniquets used prior to our arrival were universally unsuccessful

Use and Success Rate

- 62 total Quick Clot Combat Gauze rolls were used for 52 patients
- 8 (15%) patients required more than 1, but only 1 was needed per wound location
- 59 (95%) were successful
  - 1 required CAT
  - 1 Head
  - 1 Face
- All were used per protocol, after unsuccessful use of standard compression bandages

Hemostatic Agent Comparison

<table>
<thead>
<tr>
<th>Hemostatic Source</th>
<th>QC Act</th>
<th>Hemostar</th>
<th>CoTCCC</th>
<th>Winnetka</th>
<th>Combat Gauze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemostatic efficacy</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Side effect</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ready to use</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Training requirement</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Lightweight and durable</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>2 yrs Shelf life</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Stable in extreme condition</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>FDA approved</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Biodegradable</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>~$30</td>
<td>~$25</td>
<td>~$25</td>
<td>~$25</td>
<td>~$25</td>
</tr>
</tbody>
</table>

Prehospital use of hemostatic Bandages and Tourniquets; Translation from Military Experience to Implementation in Civilian Trauma Care

Scott P. Zietlow, MD
Associate Professor of Surgery
College of Medicine, Mayo Clinic
Division of Trauma, Critical Care & General Surgery
Chair, Medical Director, Mayo Clinic Medical Transport

CotCCC Meeting – Feb 2014

External Hemorrhage Control Policy Statement

American College of Emergency Physicians
Prehospital Emergency Care 2014

- The American College of Surgeons Committee on Trauma now endorses the use of both tourniquets and hemostatic dressings
- So does the American College of Emergency Physicians
- So does the National Association of EMTs

All articles published in the Journal of Special Operations Medicine are protected by United States copyright law and may not be reproduced, distributed, transmitted, displayed, or otherwise published without the prior written permission of Breakaway Media, LLC. Contact Editor@JSOMonline.org.
Individual First Aid Kits (IFAKs)

At this point in time, the US Military has more experience with tourniquets and hemostatic dressings than any other organization in history. (14 years of war and 50,000 + casualties)

- In 2001 - very few American combatants had tourniquets - no one had hemostatic dressings
- In 2015 - no American combatant goes onto the battlefield without an IFAK that contains both

Cost: $128

Translating Military Advances in External Hemorrhage Control to Law Enforcement

Dr. Frank Butler
International Association of Chiefs of Police
26 October 2015

Ft. Hood Shootings 2009
Officer Kim Munley

- 12 dead; 31 wounded on 5 Nov 09
- Officer Munley got the shooter
- She was in turn shot in both thighs
- Direct pressure and improvised tourniquets used by several physicians unsuccessful at controlling hemorrhage - went into shock
- Saved by Army 68W medic with a CAT tourniquet on left thigh

No mention of tourniquet use in the story

TCCC in the Civilian Sector

Injured transit police officer went into cardiac arrest following Watertown gunfire

MBTA Transit Police Officer Richard Donahue remains in critical condition at Mt. Auburn hospital

CAMBRIDGE, Mass. — Richard Donahue, the MBTA transit police officer critically wounded in a gun battle with the bombing suspects, had lost nearly all his blood and his heart had stopped from a single gunshot wound that severed three major blood vessels in his right thigh.

The Hartford Consensus: ACS Response to Sandy Hook

- 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

Hartford Consensus III

- Recommended tourniquets and hemostatic dressings for EMS/Fire and Rescue/Law Enforcement Officers.
- “All hemostatic dressings and tourniquets must be clinically effective as documented by valid scientific data. The Tactical Combat Casualty Care guidelines for the U.S. military contain objective evidence to support the safety and efficacy of the various options for tourniquets and hemostatic dressings.”

Dr. Lenworth Jacobs - ACS

“When discussing tourniquets and hemostatic dressings in 2015, one can be either evidence-based or brand neutral - but not both.”

FKB - CoTCCC
Implementing the Hartford Consensus: 6 Saves in 2 Years

“Three of the cases in our paper were police officers who were ambushed and sustained arterial injuries (Lakewood, Colorado July 2014 and Aurora, Colorado December 2014). There is no doubt that they would have exsanguinated without application of a TQ, in one case self applied and in the other two, buddy care.”

Dr. Peter Pons et al
Journal of Emergency Medicine 2015

What Can TCCC Offer to My Civilian EMS System?
- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia

Airway Management in Maxillofacial Trauma
- Most airway fatalities in combat are from direct trauma to the airway
- Casualties with severe facial injuries can often protect their own airway by sitting up and leaning forward.
- Let them do it if they can!

Evolution of Needle Decompression (NDC) in TCCC
- Revised indications - 1996
- Chest tubes usually not needed for initial management - 1996
- 3.25-inch, 14-gauge catheter - 2008
- Bilateral NDC for loss of VS - 2011
- External anatomy landmark - 2012
- Lateral site as alternative - 2012
**Needle Decompression Works!**

Video courtesy Dr. Oleksandr Linchevskyy
Medical Director, Patriot Defence
Ukraine

**Tension Pneumothorax**

*Military Medicine 2008*

- Several NDC failures seen at autopsy with 5 cm catheters - then performed 100 virtual autopsies
- Mean chest wall thickness was 4.86 cm
- Predicted success rate for 5 cm catheter - 50%
- 8 cm catheter would have reached the pleural space in 99% of subjects - other papers confirm

**NDC – Mayo Clinic**

*February 2016*

- Mayo Clinic: 91 NDC procedures on 71 patients
- Pre-March 2011: 5 cm NDC catheters
- Post-March 2011: 8 cm NDC catheters
- Success rates: 5 cm - 41%; 8 cm 83%
- No complications with either length

**Old Army Ranger Saying**

Lessons learned aren’t really lessons learned - unless you actually learn them.

What length NDC needle is your EMS using?

**JTTS VTC 10 Mar 11**

TBI and Tension Pneumo

- Mounted IED attack
- LOC from closed head trauma
- Lost vital signs prehospital
- CPR on arrival at hospital
- Bilateral NDC done in ER
- Rush of air from left-sided tension pneumo
- Return of VS
- Significant DAI at WRAMC
- TCCC Guidelines changed: Don’t pronounce a casualty with torso trauma until bilateral NDC has been performed

**Needle Decompression Site**

*J Am Coll Surg 2008*

- 134 consecutive trauma patients at Afghanistan MTF
- Seven needle decompression performed
- All seven decompressions performed at least 2 cm medial to MCL - no major complications noted
- Recommended using nipple line as landmark - don’t enter the chest medial to this line
- Later recommended 4-5 ICS at AAL as alternate site
What Can TCCC Offer to My Civilian EMS System?

- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia


- Subgroup analysis of 20,211 trauma patients based on time of administration of TXA
- Timing; only deaths due to bleeding
- 3076 overall deaths; 1063 due to bleeding
- Risk of death due to bleeding was significantly reduced (5.3% vs 7.7%) if TXA was given within 1 hour of injury. At 1-3 hrs after injury, also significant (4.8 vs 6.1%) At times > 3 hrs, mortality increased.

MATTERS Paper Summary
Morrison - Arch Surg - 2011

- 896 consecutive combat casualties: TXA or no-TXA
- First report of TXA use in combat casualties
- TXA group had lower mortality (17.4% vs 23.9%; P=0.03) despite TXA group being more severely injured (ISS 25.2 vs 22.5)
- Benefit was greatest in casualties who received a MT: mortality with TXA was 14.4% vs 28.1% in the no-TXA group (p=0.004)
- Both DVT and PE were increased in the TXA group, (PE in TXA MT group 3.2% vs 0% in no-TXA MT group); no PE fatalities in the study

Beyond CRASH-2 and MATTERS

Karam - TXA in BTKA
J Arthroplasty 2013

- Simultaneous, bilateral total knee replacements
- Retrospective review; historical controls
- TXA group n= 37; control group n = 50
- IV TXA 20 mg/kg - given BEFORE incision or at time of tourniquet release
- Transfusion needed post-op:  Control 50% ; TXA 11%
- No thromboembolic events in either group

Huang - TXA Meta-Analysis
J Surg Res 2013

- Results: “A total of 46 randomized controlled trials involving 2925 patients were included. The use of TXA reduced total blood loss by a mean of 408.33 mL...”
- Conclusion: TXA significantly reduced blood loss and blood transfusion requirements in patients undergoing orthopedic surgery, and did not appear to increase the risk of DVT.
Question 1

- For a trauma patient with ongoing life-threatening extremity hemorrhage - what is the best time to apply a tourniquet?
  - Within 1 hour?
  - Within 3 hours?
  - RIGHT NOW?

Question 2

- For a trauma patient with ongoing major noncompressible blood loss - what is the best time to reduce the bleeding?
  - Within 1 hour?
  - Within 3 hours?
  - RIGHT NOW?

TXA Take-Homes

- There is Level A evidence that TXA reduces mortality in trauma patients.
- There is Level A evidence that TXA reduces blood loss in elective surgery patients.
- There is Level A evidence that TXA does not increase the risk of thromboembolic complications in elective surgery patients.
  - (NOTED - that elective surgery is not trauma.)
- The best way to prevent death from hemorrhage is to PREVENT blood loss.
- Likely more benefit if TXA is given as soon as possible after injury
- 2016 - TXA added to USA Medical Equipment Set - COL Lance Cordoni

Harvey - TXA Annals Emerg Med 2014

- Does the Use of Tranexamic Acid Improve Trauma Mortality?

Bottom Line: According to the available evidence, tranexamic acid has been shown to significantly decrease mortality in bleeding trauma patients, with no significant increase in thromboembolic complications if administered within 3 hours of injury. However, no evidence of better outcomes with anesthetic brain injury. As such, we recommend early treatment with tranexamic acid in trauma patients without isolated brain injuries who have or are at risk for significant hemorrhage and in patients who receive reanimation with blood products, particularly if they require massive transfusion or have a high risk of death at baseline.

ASDHA Letter on TXA 9 October 2013

- Response to CENTCOM Surgeon request
- TXA use no longer restricted to SOF and MTFs
- Need to accumulate data; monitor outcomes

What Can TCCC Offer to My Civilian EMS System?

- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia
**Ideal Resuscitation Fluid**

<table>
<thead>
<tr>
<th>Volume</th>
<th>Hemostatic</th>
<th>O2 Carrying Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalloid</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Colloid</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Plasma</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>1:1:1</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Whole Blood</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

"The historic role of crystalloid and colloid solutions in trauma resuscitation represents the triumph of hope and wishful thinking over physiology and experience."

LTC Andre Cap
J Trauma, 2015

There is an increasing awareness that fluid resuscitation for casualties in hemorrhagic shock is best accomplished with fluid that is identical to that lost by the casualty - whole blood.

**TCCC Fluid Resuscitation fm Hemorrhagic Shock: 2014**

Order of precedence for fluid resuscitation of casualties in hemorrhagic shock:

1. Whole blood
2. 1:1:1 plasma:RBC:platelets
3. 1:1 plasma and RBCs
4. (tie) Plasma (liquid, thawed, dried) or RBCs alone
5. Hextend
6. (tie) Lactated Ringers or Plasma-LyteA

**Damage Control Resuscitation**

- 246 combat casualties with massive transfusions
- Mortality at hospital D/C by plasma to RBC ratio
  - Low ratio (1:8) - Mortality was 65%
  - Medium ratio (1:2.5) - Mortality was 34%
  - High ratio (1:1.4) - Mortality was 19%
  - P < 0.001

**Forrest Gump on Fluid Resuscitation**

**Titrating Fluid Resuscitation: A Look Back: 1993**

- Prehospital fluid resuscitation in 1993 per ATLS - 2 liters of crystalloid (NS or LR)
- TCCC recommendation: Titrate to improved level of consciousness or palpable radial pulse
- Systolic BP of 80-90 mmHg; 90 or more in TBI
**Blood Pressure and Rebleeding - J Trauma 2003**

- 70 swine with 1.5, 2.0, or 2.8 mm aortic punch
- Resuscitation was with LR after 5-30 min delay
- 5 animals died before fluid resuscitation
- 3 died at onset of fluid resuscitation
- For remaining 62 animals, rebleeding occurred at mean SBP of 94; MAP of 64

**Crystalloids in Trauma Patients - J Trauma 2011**

- Prospective RCT; community consent obtained
- Aggressive early crystalloid resuscitation vs resuscitation delayed until after repair of vascular injury
- Penetrating torso trauma; systolic BP < 90 mmHg
- Early n = 309; Delayed n = 289
- Volume: Early = 2,476 mL; Delayed = 375 mL
- Survival: Early = 62%; Delayed = 70% (p=0.04)

**Restrictive Fluid Resuscitation Duke - J Trauma - 2012**

- 307 trauma patients - retrospective study
- Penetrating torso injury; SBP < 90
- RFR = Less than 150 mL of crystalloid prior to damage control surgery (DCS) (n=132)
- SFR = 150 mL or more prior to DCS (n=175)

**28 January 2016 Somewhere in Theater**

- 2 GSW to the chest - entered above the chest plates
- 2+ liters of blood from chest tube
- Resuscitated with thawed FFP, freeze-dried plasma, and PRBCs
- “Not a drop of crystalloid”
- Ketamine for pain - no opioids
- Found at surgery to have a right pulmonary vein injury
- Arrested on the table - revived successfully
- Survived and doing well
What Can TCCC Offer to My Civilian EMS System?

- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia

Intraosseous Vascular Access

- Studied at US Army Institute of Surgical Research in 2000
- Pioneered in prehospital trauma by TCCC in 2002
- First recommended for TCCC by a CoTCCC Ranger Medic (SFC Rob Miller)
- Special Ops medics previously taught to do battlefield venous cutdowns when peripheral IV access was difficult to obtain
- PYNG FAST-1 and EZ-IO are the most commonly used devices
- IO techniques are used universally in the military

IO Vascular Access Save Houston - 27 March 2016

- Memorial Hermann Hospital
- Multiple stab wound victim - including left popliteal artery and intercostal artery injuries
- BP reported as 90 systolic at scene; no pulse in ED
- Multiple peripheral IV attempts failed
- Central line attempt failed
- IO started and 2 units RBCs/2 units plasma infused
- ED thoracotomy
- pH 6.83; lactate 26; BD 24
- Survived and doing well
- Trauma surgeon: “Would have died without IO”

What Can TCCC Offer to My Civilian EMS System?

- Tourniquets
- Hemostatic dressings
- Trauma airway approach
- TCCC Needle Decompression Plan
- Tranexamic Acid (TXA)
- Hypotensive resuscitation - with blood products where possible
- Intraosseous vascular access
- Triple-Option Analgesia

150 Years of Evolution: Civil War vs US Mil 2001

Battlefield analgesia: Intramuscular morphine

Triple-Option Analgesia in TCCC

The simplified “Triple-Option” approach to battlefield analgesia has three primary goals:
1. Preserve the fighting force
2. Provide rapid and maximal relief of pain from combat wounds
3. Minimize the likelihood of adverse effects on the casualty from the analgesic medication used
### Triple-Option Analgesia

#### Tactical Field and TACEVAC Care

- Analgesia on the battlefield should generally be achieved using one of three options depending on the level of the casualty's pain and the nature of his or her injuries.

#### Option 1

1. **Mild to Moderate Pain**
   - Casualty is still able to fight
   - **TCCC Combat pill pack:**
     - Tylenol - 650-mg bilayer caplet, 2 PO
     - Meloxicam - 15 mg PO

#### Option 2

2. **Moderate to Severe Pain**
   - Casualty IS NOT in shock or respiratory distress
   - Casualty IS NOT at significant risk of developing either condition
   - Oral transmucosal fentanyl citrate (OTFC) 800 ug
   - Place lozenge between the cheek and the gum
   - Do not chew the lozenge

#### Option 3

3. **Moderate to Severe Pain**
   - Casualty IS in hemorrhagic shock or respiratory distress
   - Casualty IS at significant risk of developing either condition
   - Ketamine 50 mg IM or IN
   - Ketamine 20 mg slow IV or IO
   - Repeat doses q30min prn for IM or IN
   - Repeat doses q20min prn for IV or IO
   - End points: Control of pain or development of nystagmus (rhythmic back-and-forth movement of the eyes)

### Warning: Morphine and Fentanyl Contraindications

- Hypovolemic shock
- Respiratory distress
- Unconsciousness
- Severe head injury
- **DO NOT** give morphine or fentanyl to casualties with these contraindications.

### Ketamine - Safety

- Very favorable safety profile
- Few, if any, deaths attributed to ketamine as a single agent
- FDA Insert:
  - "Ketamine has a wide margin of safety; several instances of unintentional administration of overdoses of ketamine (up to ten times that usually required) have been followed by prolonged but complete recovery."
ACEP and Triple Option Analgesia

- American College of Emergency Physicians
- Leaders in prehospital trauma care
- 2015 Policy statement mirrors the TCCC Triple-Option Analgesia Plan

Questions?