

Tactical Combat Casualty Care: Lessons from 14 Years of War



Dr. Frank Butler
University of Kentucky Medical Center
8 April 2016



Disclaimers

“The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Departments of the Army, Air Force, Navy or the Department of Defense.”



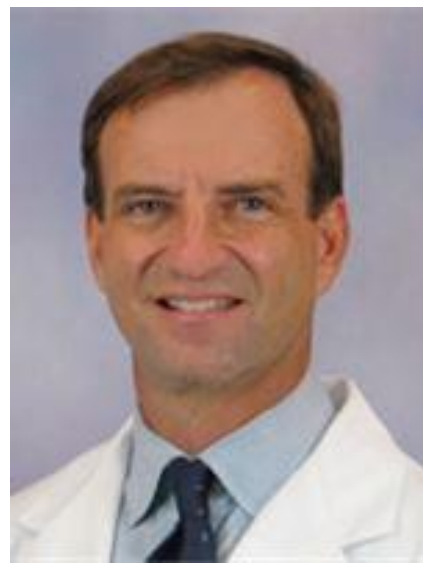
Disclaimers

- *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.*

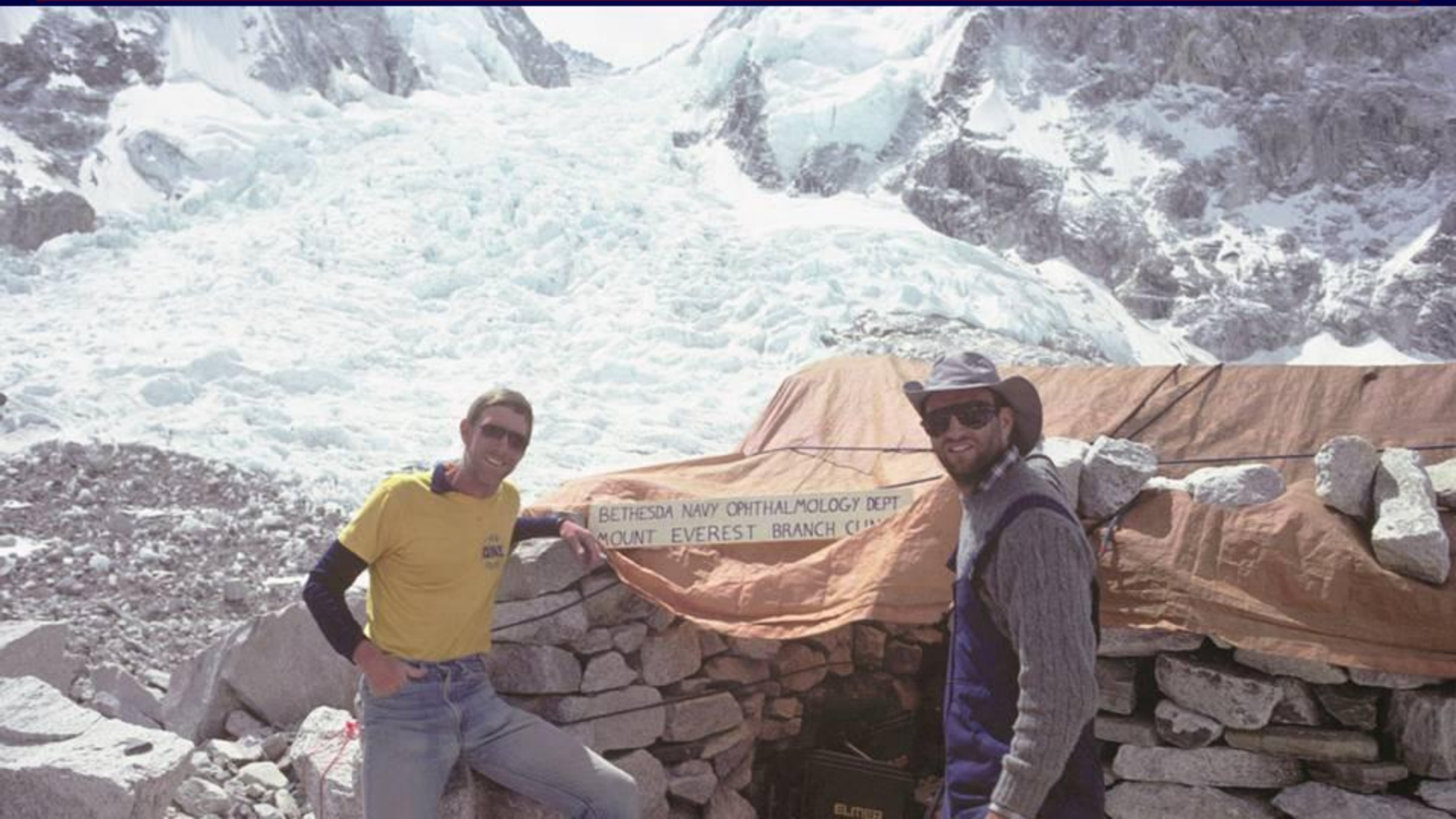


Thanks!

- **Committee on TCCC**
- **Joint Trauma System**
- **USA Institute of Surgical Research**
- **Dr. John Holcomb**
- **Dr. Norman McSwain**
- **Dr. Lenworth Jacobs**
- **LTC (P) Bob Mabry**
- **COL (Ret) Russ Kotwal**
- **COL Brian Eastridge**
- **MSG (Ret) Harold Montgomery**
- **Drs. David and Jennifer Harris**



Mount Everest Base Camp Eye Clinic





Tactical Combat Casualty Care

*The Prehospital Arm of the US Military's
Joint Trauma System*



TCCC

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



TCCC Overview

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 Trauma Care at 8000 ft in the Hindu Kush





A Look Back: Battlefield Trauma Care: 1970

“The striking feature was to see healthy young Americans with a **single injury of the distal extremity** arrive at the magnificently equipped field hospital, usually within hours, but **dead on arrival**. In fact there were **193 deaths** due to wounds of the upper and lower extremities, of the 2600.”

*CAPT J.S. Maughon
Mil Med 1970*

* Extremity hemorrhage math in Vietnam:

193 of 2600 = 7.4% x 46, 233 fatalities = 3,421

preventable US deaths from extremity hemorrhage



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**”little if any improvement has been made in this phase of treatment of combat wounds in the past 100 years.”

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 Course 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 there 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**



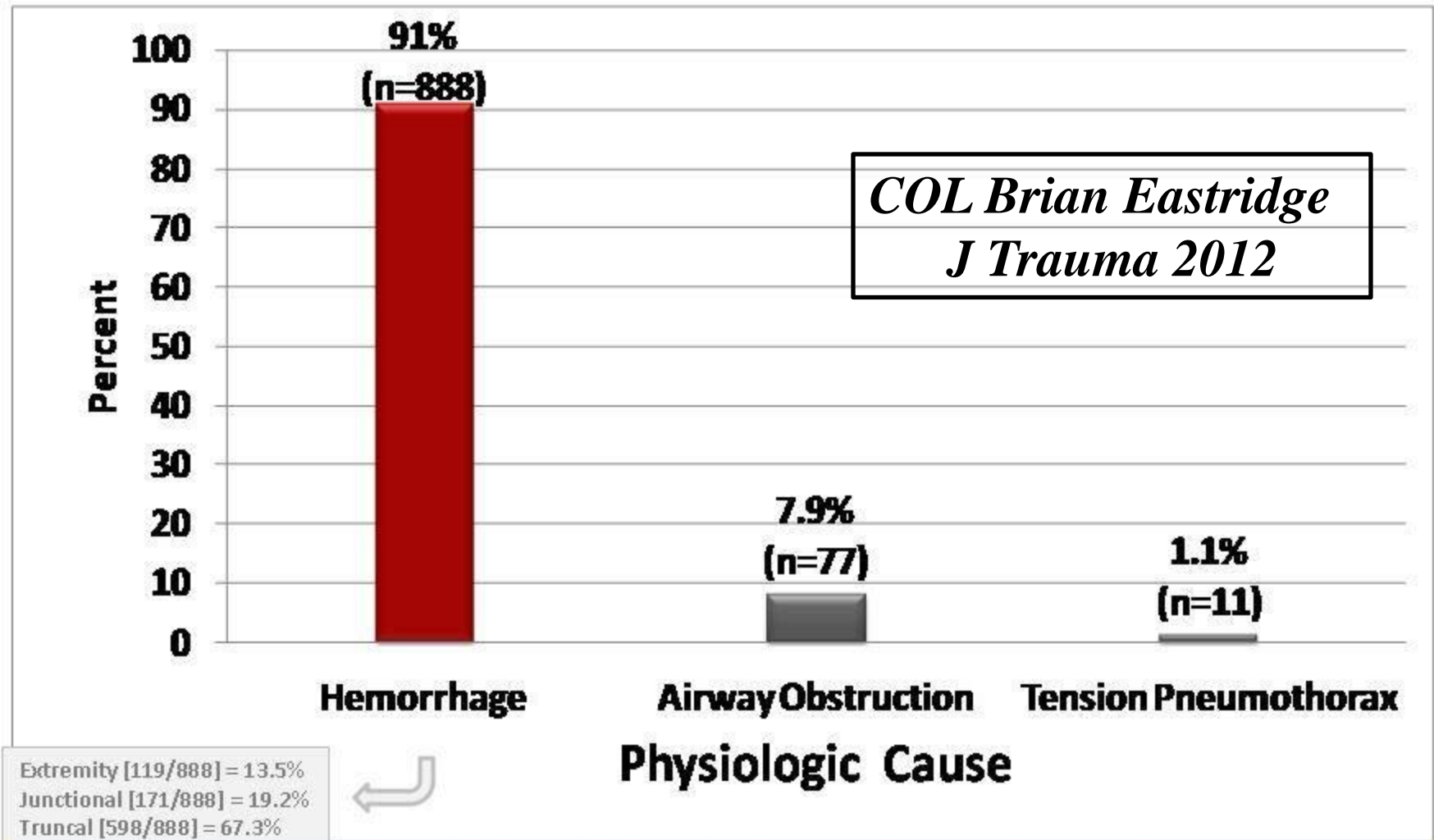


The acceptable number of preventable deaths is – ZERO.



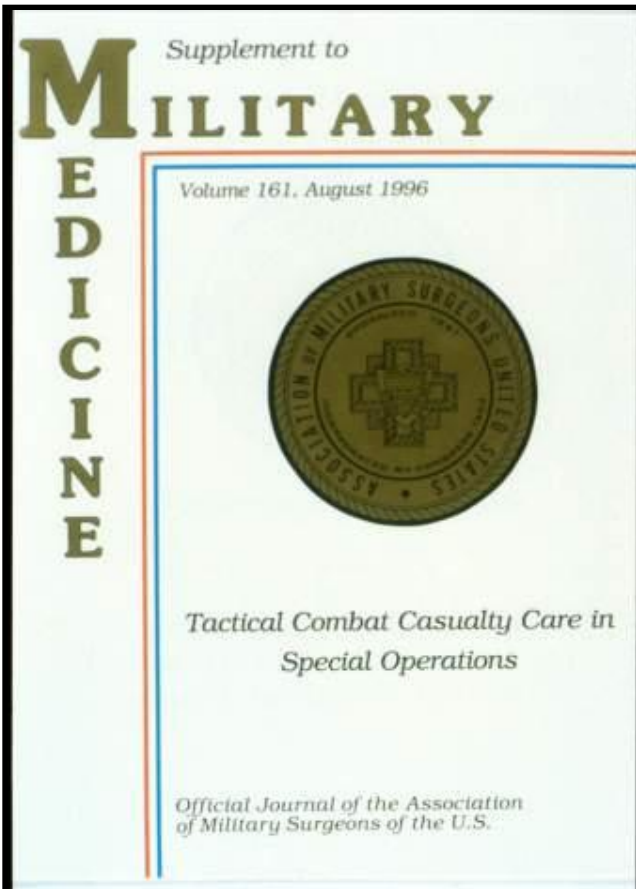
Christian Golczynski, 8, receives the flag that covered the coffin of his father, U.S. Marine Staff Sgt. Marcus Golczynski from Lt. Col. Ric Thompson during a graveside service in Wheeler, Tenn.

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....The need for immediate access to a tourniquet in such situations makes it clear that all SOF operators on combat missions should have a suitable tourniquet readily available at a standard location on their battle gear and be trained in its use.”

How Is TCCC Updated?

*The Committee
on TCCC*





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; XStat**





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





Tactical Combat Casualty Care (TCCC)

- 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





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



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 in Canadian Forces

Savage et al: Can J Surg 2011

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



HEALTH AFFAIRS

THE ASSISTANT SECRETARY OF DEFENSE

1200 DEFENSE PENTAGON
WASHINGTON, DC 20301-1200

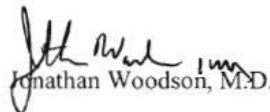
FEB 14 2014

MEMORANDUM FOR DIRECTOR, DEFENSE HEALTH BOARD

SUBJECT: Tactical Combat Casualty Care Training for Deploying Personnel, 2011-02

Please accept my appreciation for your continued efforts to provide the Department of Defense with constructive recommendations to help maximize the health, safety, and effectiveness of the U.S. Armed Forces. As we continue to seek opportunities to improve and standardize medical training, we have reviewed and will accept your recommendations related to "Tactical Combat Casualty Care (TCCC) Training for Deploying Personnel." We will incorporate training guidance as described in your recommendation to facilitate uniform TCCC training throughout the Department.

The point of contact for questions regarding this action is Ms. Elizabeth Fudge. Ms. Fudge may be reached at (703) 681-8295, or Elizabeth.Fudge@dha.mil.


Jonathan Woodson, M.D.

“...uniform TCCC training throughout the Department.”



What Can TCCC Offer to My Civilian EMS System?





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**



**Lest we forget – most of the U.S. military
went to war in Afghanistan and Iraq
without tourniquets**

Tourniquets in the U.S. Military - 2003





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”



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**



Preventable Combat Deaths from Not Using Tourniquets

- **Maughon – *Mil Med 1970*: Vietnam**
 - 193 of 2,600 fatalities
 - 7.4% of total combat fatalities
- **Kelly – *J Trauma 2008*: OEF + OIF (2003/4 and 2006)**
 - 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 in the US Military

“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.





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

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



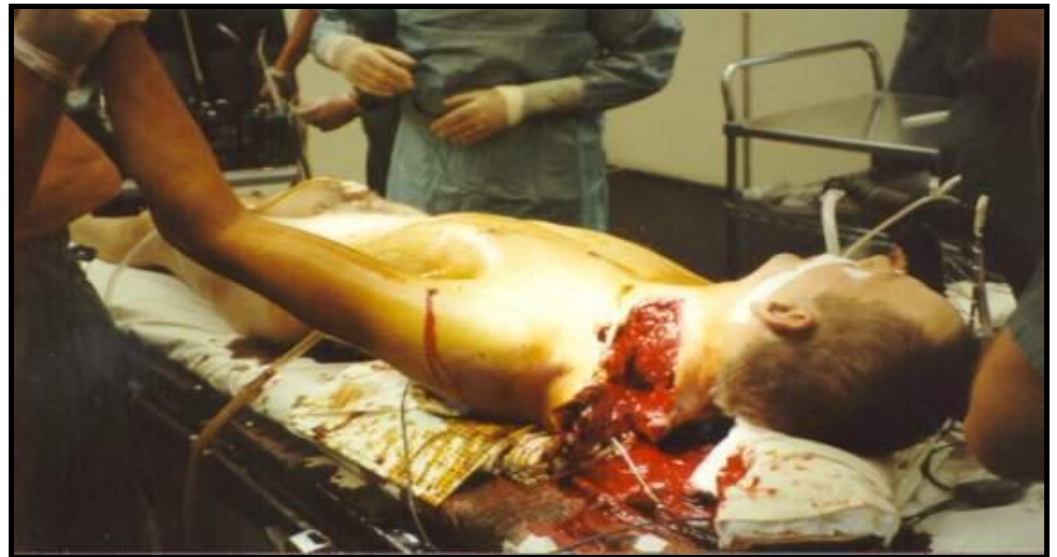
What Can TCCC Offer to My Civilian EMS System?

- 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
First Choice



Celox Gauze



ChitoGauze

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

Hemostatic Agent Comparison

	QC ACS	HemCon	Celox	WoundStat	Combat Gauze
Hemostatic efficacy	+	+	+++	++++	++++
Side effect	None	None	---	---	None
Ready to use	√	√	√	√	√
Training requirement	+	+	+	+++	++
Lightweight and durable	++	+++	+++	++	+++
2 yrs Shelf life	√	√	√	√	√
Stable in extreme condition	√	√	√	√	√
FDA approved	√	√	√	√	√
Biodegradable	No	No	Yes	No	No
Cost (\$)	~30	~75	~ 25	30- 35	~25



Combat Gauze When You Can't Use a Tourniquet

ORIGINAL ARTICLE

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

Avi Shina, MD, MHA, Ari M. Lipsky, MD, PhD, Roy Nadler, MD, Moran Levi, Avi Benov, MD, MHA, Yuval Ran, MD, MHA, Avraham Yitzhak, MD, and Elon Glassberg, MD, MHA, *Tel Hashomer, Israel*

“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.”

Dr. Avi Shina et al

Journal of Trauma 2015



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

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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

Use and Success Rate

- 62 total Quik 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

Summary

- Use of tourniquets and hemostatic bandages in pre-hospital civilian care are highly effective
- Training and subsequent proficiency of skills are maintained despite infrequent use
- Inpatient follow-up from statewide trauma system data is ongoing
- Our experience suggests 2 tourniquets and 2 topical hemostatic agents per transport vehicle would be adequate without adding excessive expense
- This single system experience should be easily applied to other pre-hospital care programs



External Hemorrhage Control Practice Guidelines

SPECIAL CONTRIBUTION

AN EVIDENCE-BASED PREHOSPITAL GUIDELINE FOR EXTERNAL HEMORRHAGE
CONTROL: AMERICAN COLLEGE OF SURGEONS COMMITTEE ON TRAUMA

Eileen M. Bulger, MD, FACS, David Snyder, PhD, Karen Schoelles, MD, FACP,
Cathy Gotschall, ScD, Drew Dawson, BA, Eddy Lang, MD, CM CCFP (EM) CSPQ, Nels
D. Sanddal, PhD, NREMT, Frank K. Butler, MD, FAAO, FUHM, Mary Fallat, MD, FACS,
Peter Taillac, MD, Lynn White, MS, CCRP, Jeffrey P. Salomone, MD, FACS, NREMT-P,
William Seifarth, MS, NREMT-P, Michael J. Betzner, MD, FRCPC, Jay Johannigman, MD,
FACS, Norman McSwain, Jr., MD, FACS, NREMT-P

American College of Emergency Physicians
External Hemorrhage Control
Policy Statement
October 2014

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**



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)



Cost: \$128

- **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**

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**





TCCC in the Civilian Sector

Injured transit police officer went into cardiac arrest following Watertown gunfight

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

CAMBRIDGE, Mass. — Richard Donohue, 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.

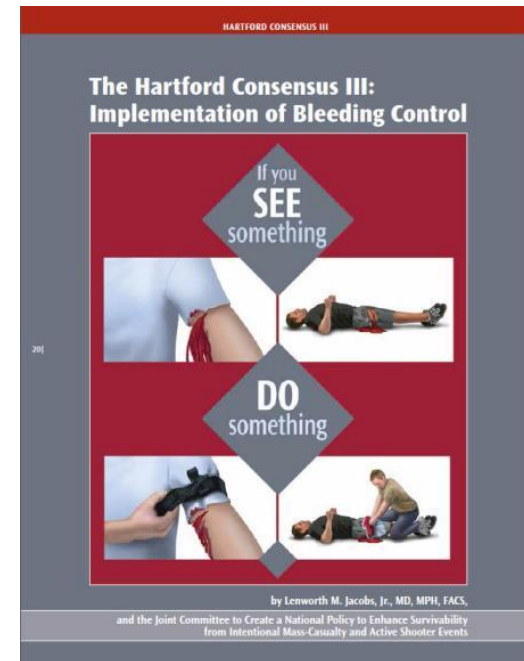
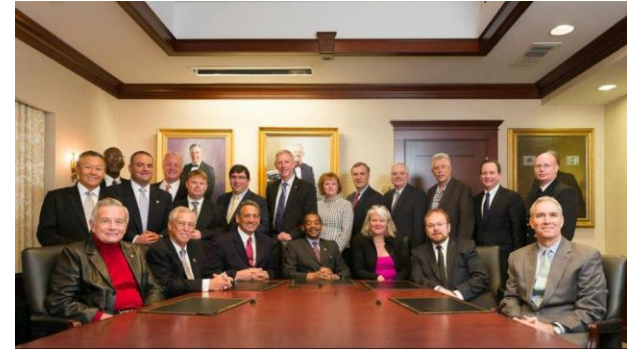
** No mention of tourniquet use in the story*





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

THE HARTFORD CONSENSUS ON ACTIVE SHOOTERS: IMPLEMENTING THE CONTINUUM OF PREHOSPITAL TRAUMA RESPONSE

Peter T. Pons, MD,*† Jesse Jerome, EMT-P,† Jeffrey McMullen, EMT-P,† James Manson, EMT-P,†
James Robinson, EMT-P,‡ and Will Chapleau, EMT-P, RN, TNS*§

*PreHospital Trauma Life Support, National Association of Emergency Medical Technicians, Clinton, Mississippi, †Denver Paramedic Division, EMS Education Department, Denver Health and Hospital Authority, Denver, Colorado, ‡Denver Paramedic Division, Denver Health and Hospital Authority, Denver, Colorado, and §American College of Surgeons, Chicago, Illinois
Reprint Address: Peter T. Pons, MD, 16430 Leyden Street, Brighton, CO 80602-6087

“ 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



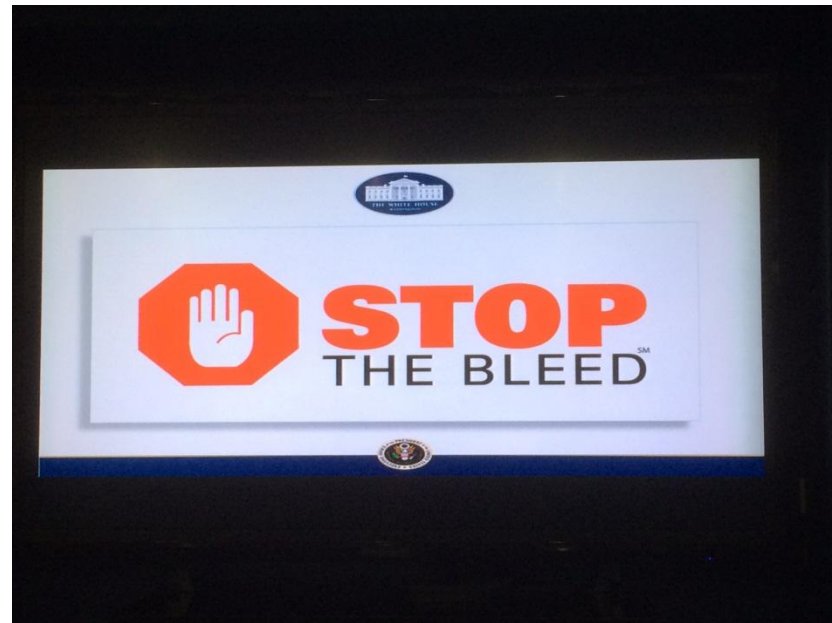
White House

“**Bystander** – Stop the Bleed”



Bystander “Stop the Bleed” Forum

October 6, 2015



- **White House meeting on this topic 6 October 2015**
- **Emphasis was on BYSTANDERS – now renamed “Immediate Responders” being able to use tourniquets and hemostatic dressings**



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!**



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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

MILITARY MEDICINE, 172, 12:000, 2007

Chest Wall Thickness in Military Personnel: Implications for Needle Thoracentesis in Tension Pneumothorax

Guarantor: COL H. Theodore Harcke, MC USA

Contributors: COL H. Theodore Harcke, MC USA*†§; LCDR Lisa A. Pearse, MC USN‡; COL Angela D. Levy, MC USA§; John M. Getz, BS‡; CAPT Stephen R. Robinson, MC USN‡

- **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

ORIGINAL ARTICLE

Needle thoracostomy: Clinical effectiveness is improved
using a longer angiocatheter

Johnathon M. Aho, MD, Cornelius A. Thiels, DO, Moustafa M. El Khatib, MBBCh, Daniel S. Ubl,
Danuel V. Laan, MD, Kathleen S. Berns, APRN, Elizabeth B. Habermann, PhD,
Scott P. Zietlow, MD, and Martin D. Zielinski, MD, Rochester, Minnesota

- **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.



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

An Evaluation of Tactical Combat Casualty Care Interventions in a Combat Environment

Maj Homer C Tien, MD, MSc, FRCSC, Vincent Jung, Sandro B Rizoli, MD, PhD, FRCSC, FACS,
Maj Sanjay V Acharya, MD, FRCPC, LCdr John C MacDonald, MD, FRCPC

- **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**



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- **Triple-Option Analgesia**



CRASH-2: Timing of TXA Dosing – Lancet 2011

Ⓜ The importance of early treatment with tranexamic acid in bleeding trauma patients: an exploratory analysis of the CRASH-2 randomised controlled trial

*The CRASH-2 collaborators**

- **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**



TXA



Beyond CRASH-2 and MATTERS



Karam – TXA in BTKA J Arthroplasty 2013

Evaluation of the Efficacy and Safety of Tranexamic Acid for Reducing Blood Loss in Bilateral Total Knee Arthroplasty

Joseph A. Karam, MD ^a, Michael R. Bloomfield, MD ^a, Timothy M. Dilorio, MD ^a, Andrea M. Irizarry, MD ^a, Peter F. Sharkey, MD ^b

^a The Rothman Institute at Thomas Jefferson University, The Sheridan, Philadelphia, Pennsylvania

^b The Rothman Institute at Riddle Memorial Hospital, Health Center 4, Media, Pennsylvania

- **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**
- **Transfusion needed post-op: Control 50%; TXA 11%**
- **No thromboembolic events in either group**



Huang – TXA Meta-Analysis J Surg Res 2013

The use of tranexamic acid to reduce blood loss and transfusion in major orthopedic surgery: a meta-analysis

Fei Huang, MD,^{a,1} Dan Wu, PhD,^{b,1} Guangwen Ma, MD,^a Zongsheng Yin, MD,^{c,*} and Qing Wang, MD^a

^aDepartment of Orthopaedics, The Fourth Affiliated Hospital of Anhui Medical University, Hefei, Anhui, People's Republic of China

^bDepartment of Scientific Research and Medical Education, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, People's Republic of China

^cDepartment of Orthopaedics, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, People's Republic of China

- **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....**”

Conclusions: TXA significantly reduced blood loss and blood transfusion requirements in patients undergoing orthopedic surgery, and did not appear to increase the risk of DVT.



Harvey – TXA

Annals Emerg Med 2014

TRAUMA/BEST AVAILABLE EVIDENCE

Does the Use of Tranexamic Acid Improve Trauma Mortality?

Virginia Harvey, MD; JeanMarie Perrone, MD; Patrick Kim, MD

0196-0644/\$-see front matter

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<http://dx.doi.org/10.1016/j.annemergmed.2013.08.028>

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 serious prothrombotic complications if administered within 3 hours of injury. There is, however, no evidence of benefit in patients with traumatic 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 resuscitation with blood products, particularly if they require massive transfusion or have a high risk of death at baseline.



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***



ASDHA Letter on TXA

9 October 2013



HEALTH AFFAIRS

THE ASSISTANT SECRETARY OF DEFENSE

1200 DEFENSE PENTAGON
WASHINGTON, DC 20301-1200

OCT 09 2013

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (MANPOWER AND
RESERVE AFFAIRS)
ASSISTANT SECRETARY OF THE NAVY (MANPOWER AND
RESERVE AFFAIRS)
ASSISTANT SECRETARY OF THE AIR FORCE (MANPOWER
AND RESERVE AFFAIRS)
DIRECTOR, JOINT STAFF

SUBJECT: Use of TXA in Combat Casualty Care

- 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**
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- **Intraosseous vascular access**
- **Triple-Option Analgesia**



Fluid Resuscitation from Hemorrhagic Shock

“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.



Ideal Resuscitation Fluid

	Volume	Hemostatic	O2 Carrying Capacity
Crystalloid	Y	N	N
Colloid	Y	N	N
Plasma	Y	Y	N
1:1:1	Y	Y	Y
Whole Blood	Y	Y	Y



TCCC Fluid Resuscitation for Hemorrhagic Shock: 2014

Updated Fluid Resuscitation Plan

Order of precedence for fluid resuscitation of casualties
in hemorrhagic shock

- 1. Whole blood**
- 2. 1:1:1 plasma:RBCs:platelets**
- 3. 1:1 plasma and RBCs**
- 4. (tie) Plasma (liquid, thawed, dried) or RBCs
alone**
- 8. Hextend**
- 9. (tie) Lactated Ringers or Plasma-Lyte A**



Damage Control Resuscitation

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

- 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**



Prehospital Plasma

- **Liquid or thawed plasma is not an option for most ground troops**
- **Dried plasma (freeze-dried or spray-dried) is currently the best option for units not able to utilize liquid plasma**
- **Dried plasma contain approximately the same levels of clotting proteins as liquid plasma**
- **Most coalition partners are using freeze-dried plasma at present**
- **Outcomes data pending**
- **No FDA-approved dried plasma product at present**



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**

The New England Journal of Medicine

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Volume 331

OCTOBER 27, 1994

Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

WILLIAM H. BICKELL, M.D., MATTHEW J. WALL, JR., M.D., PAUL E. PEPE, M.D.,
R. RUSSELL MARTIN, M.D., VICTORIA F. GINGER, M.S.N., MARY K. ALLEN, B.A.,
AND KENNETH L. MATTOX, M.D.

- **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 = 2,478 mL; Delayed = 375 mL**
- **Survival: Early = 62%; Delayed = 70% (p=0.04)**



Blood Pressure and Rebleeding – J Trauma 2003

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

Blood Pressure at which Rebleeding Occurs after Resuscitation in Swine with Aortic Injury

Jill L. Sondeen, PhD, Valerie G. Coppes, BS, and John B. Holcomb MD,

- **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

Emergency Department Crystalloid Resuscitation of 1.5 L or More is Associated With Increased Mortality in Elderly and Nonelderly Trauma Patients

Eric J. Ley, MD, Morgan A. Clond, PhD, Marissa K. Srouf, BS, Moshe Barnajian, MD, James Mirocha, MS, Dan R. Margulies, MD, and Ali Salim, MD

- **Retrospective study – 3,137 patients**
- **Subgroups: 1, 1.5, 2, and 3 liters**
- **Overall mortality 5.2%; elderly 17.3%; non 4%**
- **Did not specify which crystalloid**
- **“ED volume replacement of 1.5 L or more was an independent risk factor for mortality.”**



Restrictive Fluid Resuscitation Duke – J Trauma - 2012

ORIGINAL ARTICLE

Restrictive fluid resuscitation in combination with
damage control resuscitation: Time for adaptation

Marquinn D. Duke, MD, Chrissy Guidry, DO, Jordan Guice, Lance Stuke, MD, MPH, Alan B. Marr, MD,
John P. Hunt, MD, MPH, Peter Meade, MD, MPH, Norman E. McSwain, Jr., MD,
and Juan Carlos Duchesne, MD, New Orleans, Louisiana

- 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)



Restrictive Fluid Resuscitation Duke – J Trauma - 2012

METHODS:	This is a retrospective analysis from January 2007 to May 2011 at a Level I trauma center. Inclusion criteria included penetrating torso injuries, systolic blood pressure less than or equal to 90 mm Hg, and managed with DCR and damage control surgery (DCS). There were two groups according to the quantity of fluid before DCS: (1) standard fluid resuscitation (SFR) greater than or equal to 150 mL of crystalloid; (2) RFR less than 150 mL of crystalloid. Demographics and outcomes were analyzed.
RESULTS:	Three hundred seven patients were included. Before DCS, 132 (43%) received less than 150 mL of crystalloids, grouped under RFR; and 175 (57%) received greater than or equal to 150 mL of crystalloids, grouped under SFR. Demographics and initial clinical characteristics were similar between the study groups. Compared with the SFR group, RFR patients received less fluid preoperatively (129 mL vs. 2,757 mL; $p < 0.001$), exhibited a lower intraoperative mortality (9% vs. 32%; $p < 0.001$), and had a shorter hospital length of stay (13 vs. 18 days; $p = 0.02$). Patients in the SFR group had a lower trauma intensive care unit mortality (5 vs. 12%; $p = 0.03$) but exhibited a higher overall mortality. Patients receiving RFR demonstrated a survival benefit, with an odds ratio for mortality of 0.69 (95% confidence interval, 0.37–0.91).
CONCLUSION:	To the best of our knowledge, this is the first civilian study that analyzes the impact of RFR in patients managed with DCR. Its use in conjunction with DCR for hypotensive trauma patients with penetrating injuries to the torso conveys an overall and early intraoperative survival benefit. (<i>J Trauma Acute Care Surg.</i> 2012;73: 674–678. Copyright © 2012 by Lippincott Williams & Wilkins)

- **Pre-op crystalloid: RFR mean = 129 mL**
- **Pre-op crystalloid: SFR mean = 2757 mL**
- **RFR intra-op mortality 9%; SFR mortality 32%**
- **P = 0.001**



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**



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- **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”

Courtesy Dr. John Holcomb

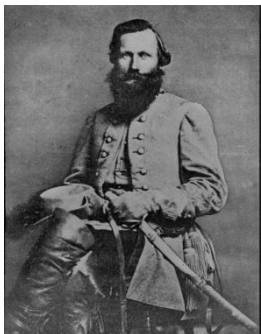


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150 Years of Evolution: Civil War vs US Mil 2001



Civil War Soldier



British 1853 Enfield Musket



**Battlefield analgesia:
Intramuscular morphine**



Modern Soldier



M4A1 Carbine



**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.**



Triple-Option Analgesia

Option 1

Tactical Field and TACEVAC Care:

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**





Triple-Option Analgesia Option 2

2) Moderate to Severe Pain

Casualty IS NOT in shock or respiratory distress

AND

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





Triple-Option Analgesia

Option 3

3. Moderate to Severe Pain

Casualty IS in hemorrhagic shock or respiratory distress

OR

Casualty IS at significant risk of developing either condition

- Ketamine 50 mg IM or IN

Or

- 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

POLICY STATEMENT

Policy Statement

Policy statements and clinical policies are the official policies of the American College of Emergency Physicians and, as such, are not subject to the same peer review process as articles appearing in the journal. Policy statements and clinical policies of ACEP do not necessarily reflect the policies and beliefs of *Annals of Emergency Medicine* and its editors.

Out-of-Hospital Use of Analgesia and Sedation

Approved by the ACEP Board of Directors June 2015

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



Questions?

