
“Those who cannot remember the past are condemned to repeat it.”
-George Santayana
U.S. NAVAL HOSPITAL SHIP
MERCY

Disclosure

- Financial Disclosure
  - Abbott Laboratories (stock holder)
  - AbbVie (stock holder)
  - Fecobionics (consultant)
  - Springer (editor)

- Research
  - ARTEMIS - DOD Grant. No financial disclosure.
  - RCHSD – Health Care Disparity Trauma Research Award
  - REBOA – No financial disclosure

- No financial disclosures related the topic of this lecture or any supporting materials in relation to this discussion.

Romeo C. Ignacio, Jr
CAPT (Ret.) MC USN

Surgical Support for UNITAS Exercise at Lima, Peru

FMF training at Camp Lejuene, NC

- 24 years in the U.S. Navy
- Deployed to various parts of the world: Japan, South Korea, Philippines, Cambodia, Italy, Peru
- Serve as a staff pediatric surgeon at Naval Medical Center San Diego (NMCSD) 2009-2018.
- Program Director, General Surgery at Naval Medical Center San Diego

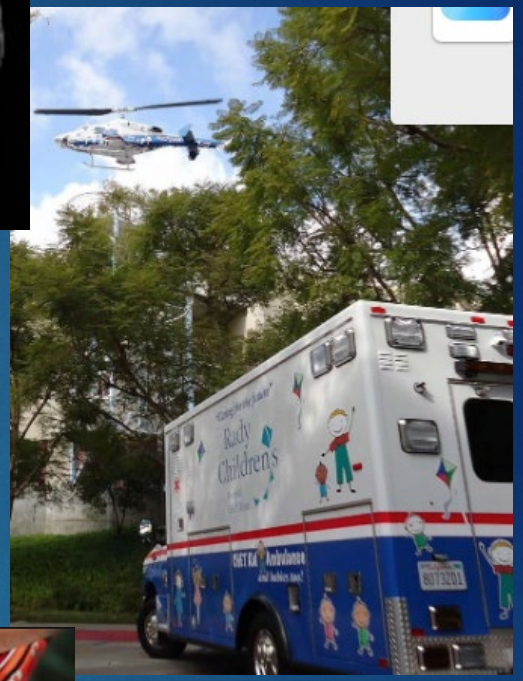
- Involvement with trauma and combat training;
  - ADVON (Advance Echelon) Surgeon/DIO for Pacific Partnership
  - Fleet Surgical Team 3 – USS SOMERSET 2017. Surgical Support for UNITAS Exercise at Lima, Peru
  - OPERATION SHARP SPIKE. Subject Matter Expert/Surgical evaluator for EMF (Expeditionary Medical Facility 2017.
  - Trauma Director for ATLS/PHTLS in Far East
  - Defense Medical Readiness Training Institute, United States Army. Fort Sam Houston, TX. Instructor for Combat Casualty Care Course. (2003-2017)

USNS MERCY Hospital ship established in San Diego, CA

US ambassador visits Cambodian Military Hospital in Phnom Penh
to commend joint US/Cambodia medical operations

THANK YOU FOR THOSE
WHO HAVE SERVED
(AND THOSE ACTIVE DUTY/RESERVES
WHO CONTINUE TO SERVE)

Pediatric War Zones: Lessons Learned from the Battlefield



Romeo C. Ignacio, Jr. MD, MS, Mpath, FACS, FAAP, MAMSE
Trauma Medical Director
Surgical Director of the Pediatric Intensive Care Unit
Staff Pediatric Surgeon
Rady Children's Hospital San Diego

UC San Diego
SCHOOL OF MEDICINE

Goals

- NOT to discuss war injuries in children
- Discuss the affect of war and armed conflicts to the regional pediatric population
- Describe the military experience in relation to pediatric combat injuries
- Discuss how military medicine has influenced civilian pediatric trauma.

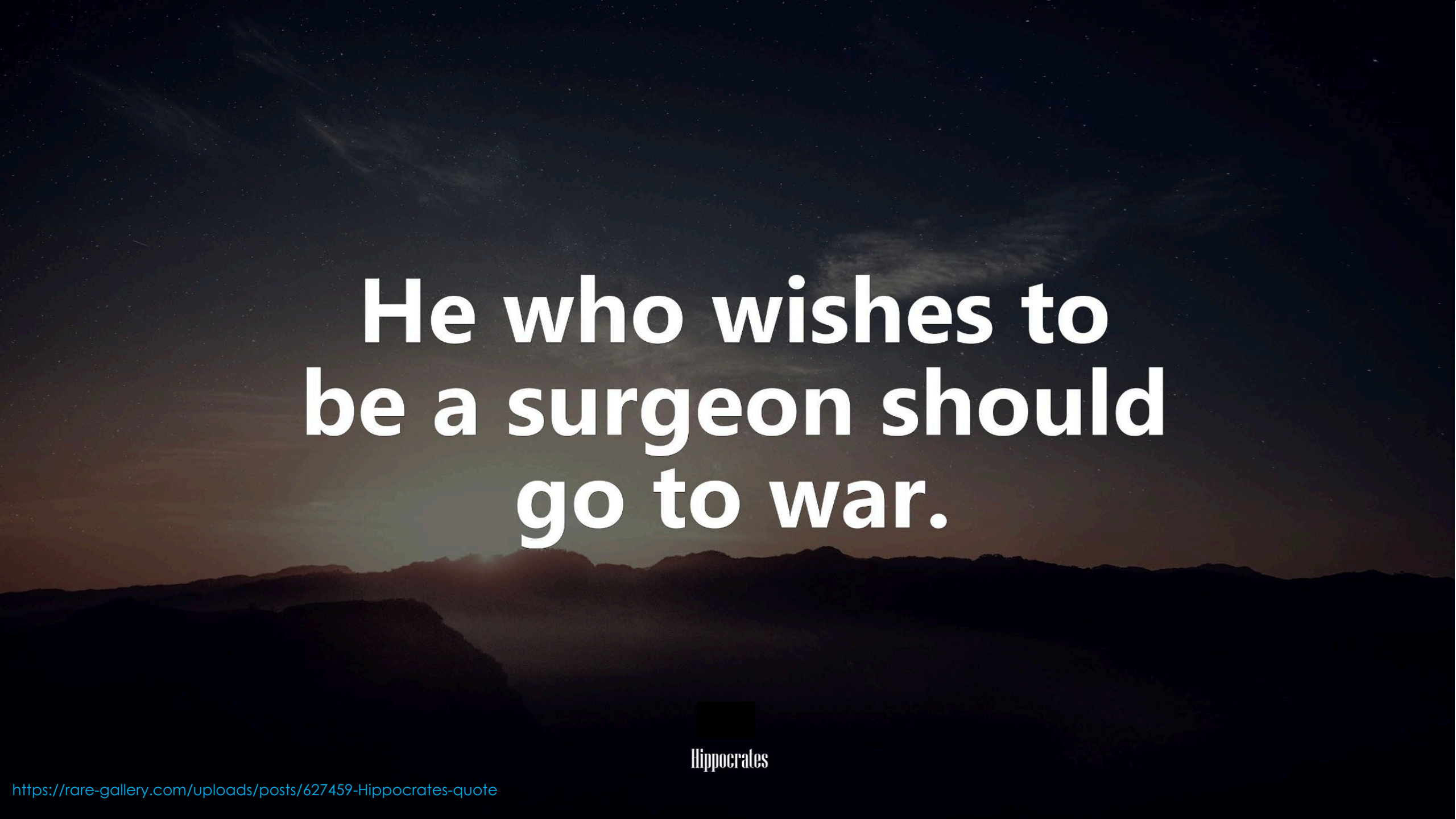
Outline

- Describe the incidence of pediatric casualties during various conflicts
- Discuss the lessons learned and published literature from the military who have been involved in various combat missions
  - Transportation
  - Resuscitation
  - Hemorrhage Control
  - Simulation and Education

Pediatric Trauma and War

- First surgeons deployed to Afghanistan in Operation Enduring Freedom (2001)
  - Not prepared for pediatric trauma
  - No equipment (ETT, chest tubes, etc.) for children
  - Minimal experience in managing pediatric trauma

April 3, 2003

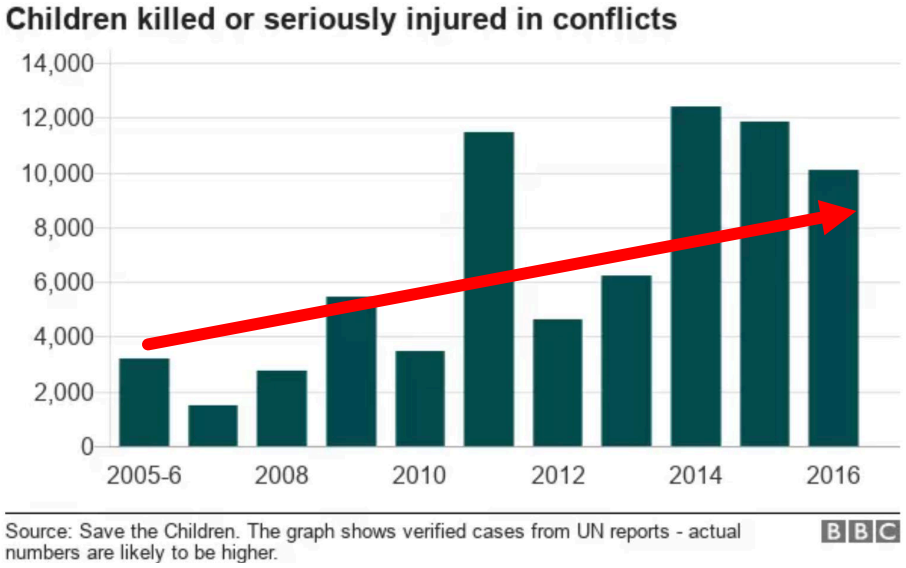


https://rare-gallery.com/uploads/posts/627459-Hippocrates-quote


Yes, this is me
unfortunately

Children in War Zones

- As of 2020, children are more risk from armed conflict than the last 30 years
- In 2018, it is estimated that > 350 million children were living in a conflict zone
- There is still a 300% increase in the number of children killed or maimed since 2010

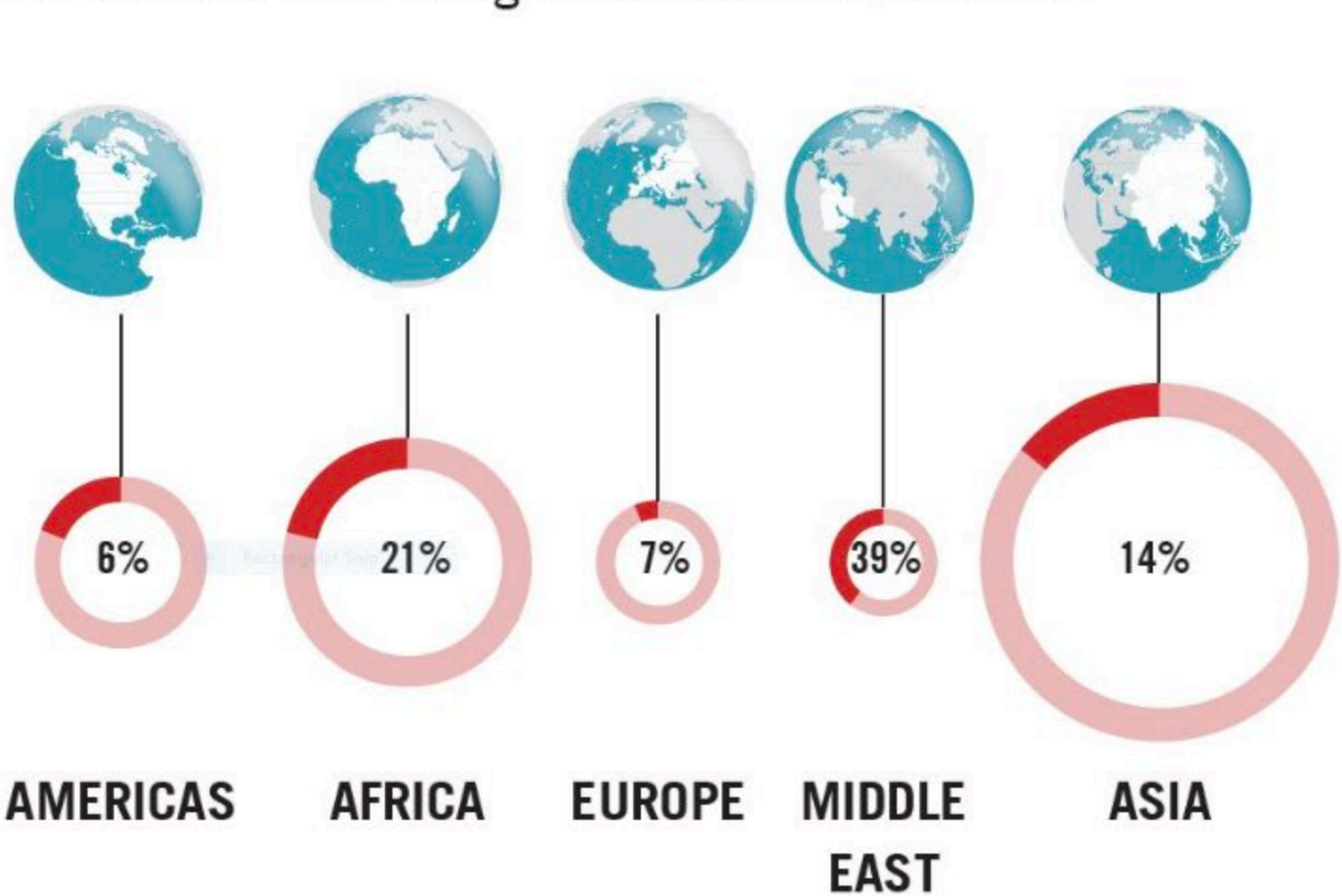


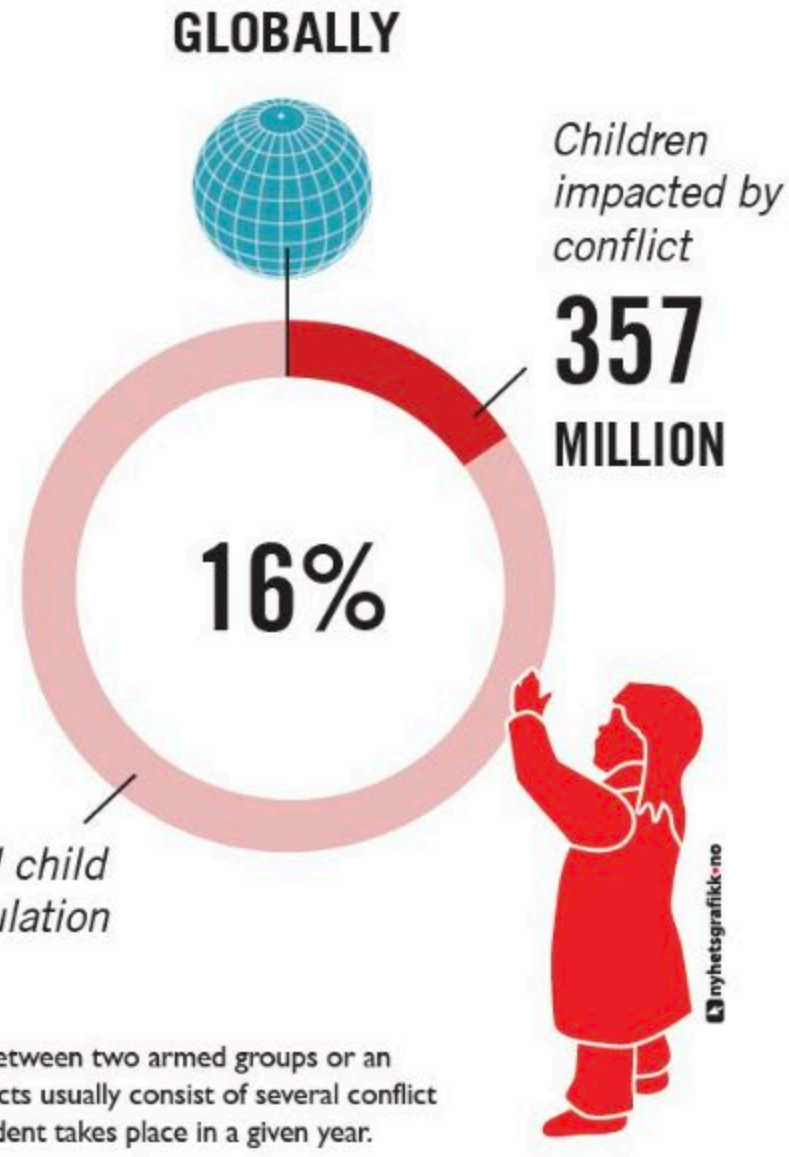
Children in War Zones

- In Ukraine, in Feb 2022
  - More than 400 children have been killed and >800 injured
- The effects of war have other long-lasting effects on children:
  - Education disruption
  - Access to care
  - Mental health
  - Access to food

Children affected by conflict

1 in 6 children were living in conflict areas in 2016





PRIO

Save the Children

A conflict event is defined as a lethal incident, either a violent clash between two armed groups or an attack on civilians by a group/groups, at a given time and place. Conflicts usually consist of several conflict events. Conflict area: an area 50km or less from where a conflict incident takes place in a given year.

Data source: PRIO/UCDP. For more information: www.savethehildren.net/waronchildren

Not prepared for pediatric trauma ….

Pediatric Wartime Injuries in Afghanistan and Iraq: What Have We Learned?

Xiaoming Shi, M. Edwards • Published 1 April 2016 • Medicine • U.S. Army Medical Department journal

The majority of the documented experience in pediatric trauma care during the past decade of conflict is from the inpatient Role 3 mission. Pediatric patients (defined as 14 years of age or less) accounted for 5% to 10% of combat admissions. Care for these patients was resource intensive and mortality rates significantly higher than those seen in pediatric hospitals in the United States. The largest documented experience to date with explosive injuries and massive transfusions in children were reported from this conflict. Improvements in logistic and personnel support was seen throughout the decade of conflict, however long-term outcomes and clinical practice guidelines to direct future care for these children are lacking. Collapse

COL(Ret.) Mary Edwards, MC, USA

- For Operation Enduring Freedom, many surgeons were no prepared for pediatric trauma
- Pediatric patients accounted for 5 - 10% of combat admissions
- Largest documented experience with pediatric explosive injuries and the need for MTP

Need for pediatric-specific resources and training

- Gale et al, reviewed the DOD Trauma Registry over a 10 year period
  - 1955 pediatric patients that required ICU care
  - Median composite ISS was 14
  - 90% survived
  - Significant higher mortality than seen in the U.S. pediatric hospitals
  - Most common mechanism of injury
    - Explosives (45.2%)
    - Gunshot wounds (20.8)

Pediatric Trauma Patient Intensive Care Resource Utilization in U.S. Military Operations in Iraq and Afghanistan

Hannah L. Gale, MD[1]; Matthew A. Borgman, MD[1]; Michael D. April, MD, PhD[2,3]; Steven G. Schauer, DO, MS[2,4,5,6]

Objectives: Children represent a unique patient population treated by military personnel during wartime, as seen in the recent conflicts in Iraq and Afghanistan. We sought to describe ICU resource utilization by U.S. military personnel treating pediatric trauma patients in Iraq and Afghanistan.
Design: This is a retrospective review of prospectively collected data within Department of Defense Trauma Registry.
Setting: We studied pediatric casualties treated in U.S. and coalition military hospitals in Iraq and Afghanistan between January 2007 and January 2016.
Patients: We queried the Department of Defense Trauma Registry for patients less than 18 years with one documented day within an ICU.
Interventions: We used descriptive statistics to analyze injuries patterns and interventions. We defined prolonged length of stay as ICU stay four days or greater. Regression methodology was utilized to identify factors associated with prolonged length of stay.
Measurements and Main Results: There were 1955 (56.8%) pediatric patients that met our inclusion criteria. The most common mechanism of injury was explosive (45.2%) followed by gunshot wounds (20.8%). The median composite ISS was 14. The median length of stay was 3 days with 90.2% surviving to hospital discharge. Mechanical ventilation was the most frequent intervention (67.6%) followed by arterial access (21.8%). Prolonged length of stay was associated with all serious injuries, ventilator management, blood product administration, wound dressing, bronchoscopy, imaging, and central venous access.
Conclusions: Pediatric casualties accounted for nearly one in 10 admissions with the majority requiring intensive care. The most commonly performed interventions were mechanical ventilation, vascular access, and imaging, each of which requires a specialized skill set to provide optimal patient management. All serious injuries by body region except facial were associated with a prolonged length of ICU stay, as well as blood product administration, ventilator management, intracranial pressure monitoring, wound care, bronchoscopy, imaging, and central venous access. The epidemiology of this unique population may be useful in planning future pre-deployment training and resource management in ICUs in deployed environments.
Key Words: armed conflicts; critical care; health resources; military medicine; pediatrics; wounds and injuries

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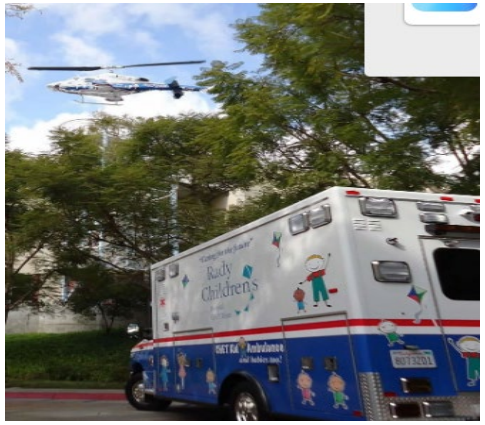
[3]2nd Infantry Brigade Combat Team, 4th Infantry Division, Fort Carson, CO.
[4]U.S. Army Institute of Surgical Research, JBSA Fort Sam Houston, TX.
[5]59th Medical Wing, JBSA Fort Sam Houston, TX.
[6]Uniformed Services University of the Health Sciences, Bethesda, MD.
This work was performed at Brooke Army Medical Center, JBSA Fort Sam Houston, San Antonio, TX.

Contributions to Trauma by Military Medicine

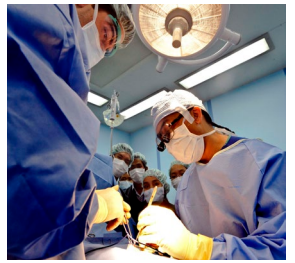
- Civilian & Military Collaboration
- Joint Trauma Registry/Research
- Resuscitation
- Blood Transfusion
- Hemorrhage Control
- Simulation & Education
- Traumatic Brain Injury
- Prevention/Protection
- Logistics &Transportation
- Advances in Technology
- Rehabilitation
- Mental Health/Well-Being

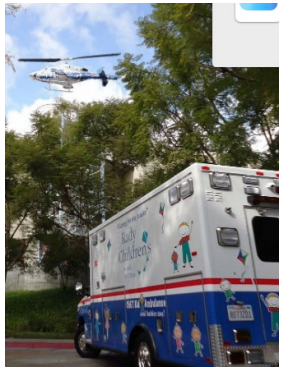
Civilian and Military Trauma also differ….



Advances in Trauma in the Military

- Civilian & Military Collaboration
- Joint Trauma Registry/Research
- Transportation
- Blood Transfusion
- Hemorrhage Control
- Simulation & Education
- Traumatic Brain Injury
- Prevention/Protection
- Logistics &Transportation
- Advances in Technology
- Rehabilitation
- Mental Health/Well-Being





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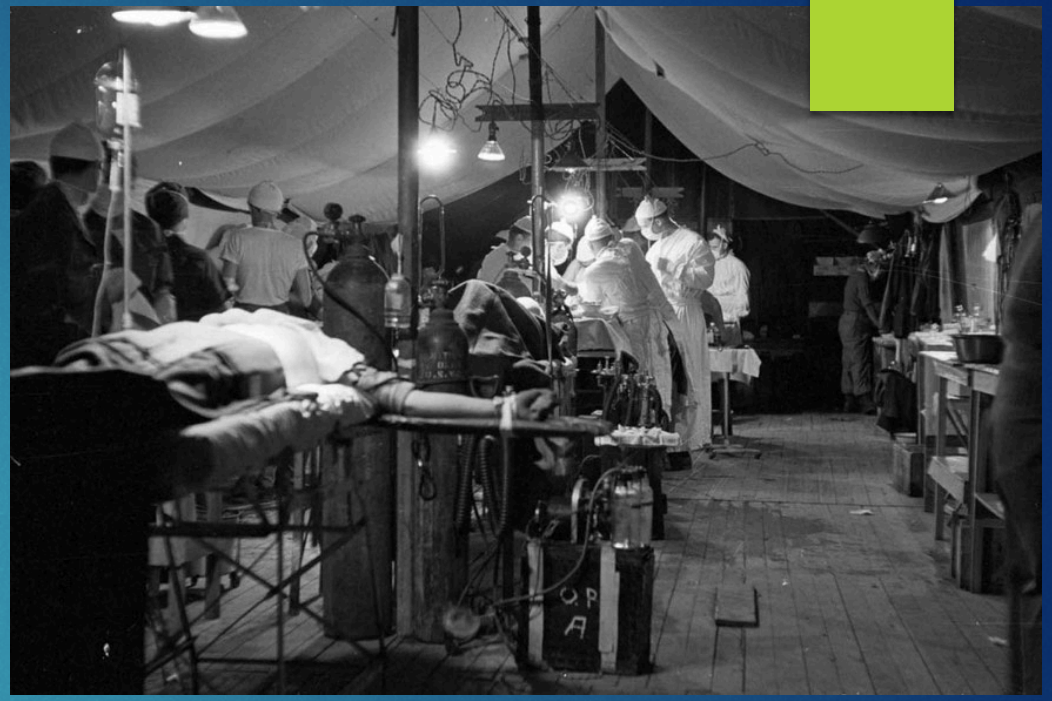
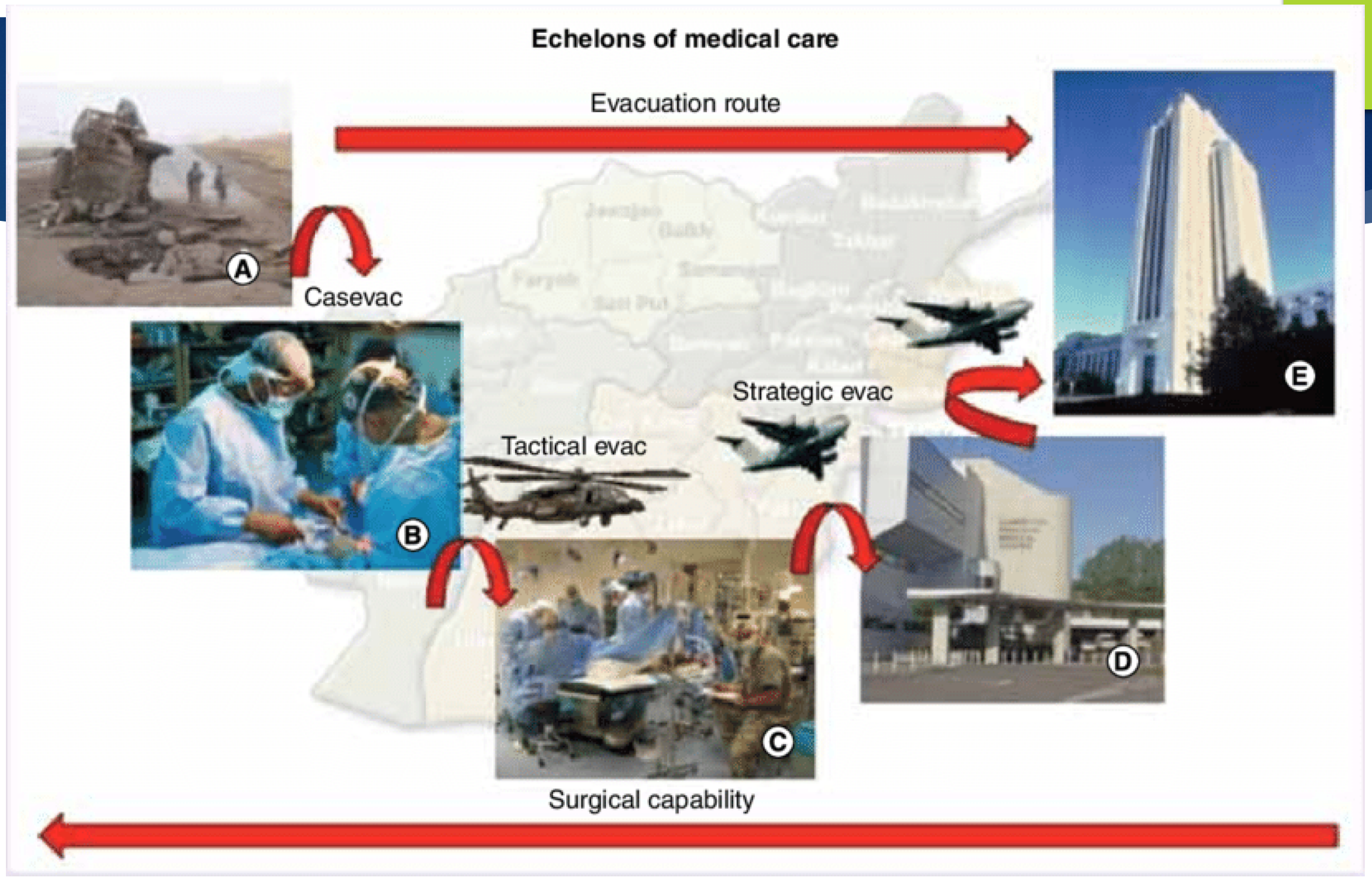
Medical Evacuation and Air Transportation

- At the end of World War I, soldier treated within 6 hours and transported by stretchers to a medical facility had an increase of survival of 600%. Mortality was 25%
- During WWII, the first ever helicopter MEDEVAC was performed which was the start of Army Medical Transport at the front lines.
- In the Korea War, 17,000 patients were MEDEVAC'ed to safer locations
- In the Vietnam era, MEDEVAC teams aka "Dust Off" Crews in Bell UH-1 "Huey" further reduced delay in medical treatment with survival rates of 75-80%.

MASH units and Today's MEDEVAC

- M.A.S.H. (**Mobile Army Surgical Hospitals**) units were hospital resources brought closer to the front, sometimes within range of enemy artillery.
- Soldiers were initially treated by a medic, then sent to a **Battalion Aid Station** for emergency or stabilizing treatment, and then transported to a MASH unit for more extensive treatment.
- Development of Echelons of care from first aid -→ initial resuscitation and hemorrhage control -→ definitive surgery -→ definitive care and rehab. This led to 98% survival.




Echelons of medical care
Evacuation route
A
Casevac
B
Tactical evac
C
Strategic evac
D
E
Surgical capability

"Golden Hour"

98% Survival

Prehospital Care

Combat Medics

Echelon I and II

CCATT

Echelon III (Level 3 MTF)

Specialized Rehab Centers

CCATT

Echelon IV (ie LRMC)

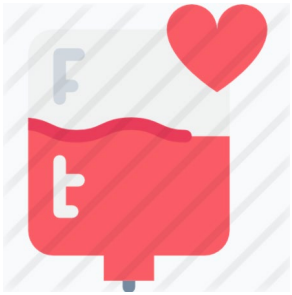
CCATT

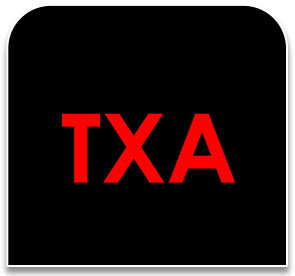
Echelon V US Facility

The medical facility at each echelon of care is referred to as the respective level of care medical treatment facility. For instance, an echelon III medical facility like the hospital at Bagram Air Base, is referred to as a level 3 facility.

CCATT performs both tactical intra-theatre(ie level 2 to level 3) and strategic inter-theatre (level 3 to level 4) transports

Resuscitation & Blood Transfusion

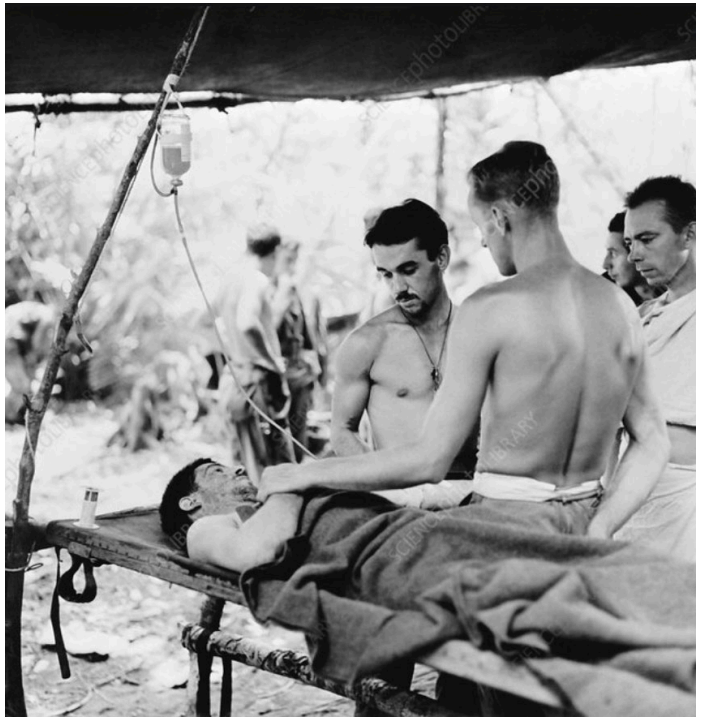




- Avoidance of excessive crystalloids
- Use of 1:1:1 PRBC:FFP: Platelets ”balanced” transfusion
- Protocol of Massive Transfusion Protocol in Trauma
- Use of Whole Blood transfusion
- Use of TXA (Tranexemic Acid)

History of Blood Transfusions in the Military

- At the outset of World War 1 (WW1), the British military thought that blood transfusions have a mortality of more than 50%.
- During WWI, there were several advancements in transfusion medicine (blood typing, anticoagulation, and storage).
- As a result, by the end of WW1, many casualties were being resuscitated with whole blood and this quickly became the standard of care in several military hospitals.
- Knowledge of whole blood–based resuscitation continued to evolve during both World War II (WWII) and the Korean War.



Blood plasma transfusion, World War II. US soldiers and medics attending a wounded soldier who is being given a blood plasma transfusion.

History of Blood Transfusions in the Military

- During Vietnam era, component separation became more popular because of:
  - minimized the waste of whole blood
  - allowed extended useful lifespan of RBC (4→6 weeks), FFP (extend to 1 year if in cold storage)
  - selected therapies outside of trauma (thrombocytopenia, hemophilia, etc.)

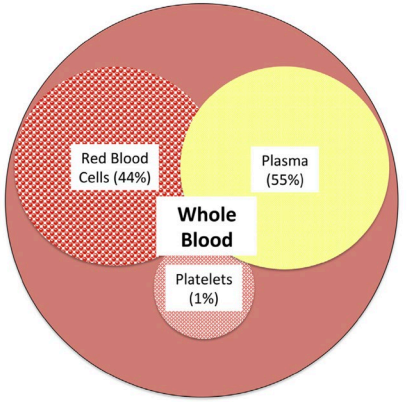


Fig. 2. The 3 primary components of whole blood.

- PRBCs were seen as a substitute for whole blood, but coagulopathy associated with trauma was not recognized in the 1980-1990s
- Recent literature has supported the use of both balanced transfusion of 1:1:1 PRBCs/Plasma/Platelets and use of massive transfusion protocol

Dr. Holcomb – Visiting Professor at Balboa in 2018

What about Pediatric Trauma?

- Data for adult trauma patients suggest improved survival when using hemostatic resuscitation, which includes limiting crystalloids and using closer to 1:1 ratios for both fresh frozen plasma (FFP) and platelets (PLTs) relative to packed red blood cells (PRBCs).

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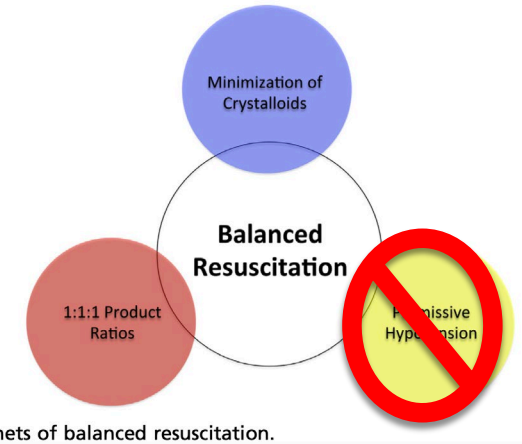


Fig. 1. The 3 tenets of balanced resuscitation.

- Pediatric studies have shown similar but mixed results and often lack measuring crystalloids.

- NO recommendation for permissive hypotension in pediatric trauma

The Journal of Trauma and Acute Care Surgery

J Trauma Acute Care Surg. 2015 Feb;78(2):330-5. doi: 10.1097/TA.0000000000000469.

The effects of balanced blood component resuscitation and crystalloid administration in pediatric trauma patients requiring transfusion in Afghanistan and Iraq 2002 to 2012

Mary J Edwards [1], Michael B Lustik, Margaret E Clark, Kevin M Creamer, David Tuggle

Affiliations + expand

What about Pediatric Trauma?

- Review of DOD Trauma Registry
  - Compared children who received component therapy exclusively vs. whole blood
- Approximately 3400 pediatric casualties
  - 1244 were transfused at least 1 blood product
  - 848 patients without severe head injury
  - 23 children received WARM fresh whole blood
- Our data suggest that warm fresh whole blood may be associated with improved survival in children without severe head injury. Larger prospective studies are needed to assess the efficacy and safety of whole blood in children with severe traumatic bleeding

THE JOURNAL OF AABB
transfusion.org
TRANSFUSION

SUPPLEMENT ARTICLE

An analysis of outcomes for pediatric trauma warm fresh whole blood recipients in Iraq and Afghanistan

Ryann S. Lauby, Camaren M. Cuenca, Matthew A. Borgman, Andrew D. Fisher, Vikhyat S. Bebarta, Earnest E. Moore, Philip C. Spinella, James Bynum, Steven G. Schauer

First published: 16 July 2021 | https://doi.org/10.1111/trf.16504 | Citations: 1

Read the full text › PDF TOOLS SHARE

Abstract

Background

Whole blood therapy—which contains the ideal balance of components, and particularly fresh whole blood—has been shown to be beneficial in adult trauma. It remains unclear whether there is potential benefit in the pediatric population.

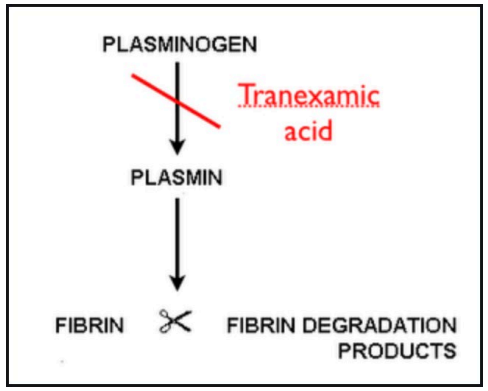
Study Design and Methods

This is a secondary analysis of previously published data analyzing pediatric casualties undergoing massive transfusion in the Department of Defense Trauma Registry. Pediatric patients with traumatic injury who were transfused at least one blood product were included in the analysis. We compared children who received component therapy exclusively to those who received any amount of warm fresh whole blood.

Results

Of the 3439 pediatric casualties within our dataset, 1244 were transfused at least one blood product within the first 24 h. There were 848 patients without severe head injury. Within this cohort, 23 children received warm fresh whole blood overall, 20 of whom did not have severe head injury. In an adjusted analysis, the odds ratio (95% confidence interval [CI]) for survival for warm fresh whole blood recipients was 2.86 (0.40–20.45). After removing children with severe brain injury, there was an independent association with improved survival for warm fresh whole blood recipients with an odds ratio (95% CI) of 58.63 (2.70–1272.67).

What about TXA in Pediatric Trauma?



Copied from https://www.maimonidesem.org/blog/txa-in-trauma

COL (Ret.) Matt Martin

- TXA is an antifibrinolytic that reversibly binds to plasminogen at the lysine binding site, thus preventing the binding of plasmin to fibrin and the subsequent degradation of fibrin

- TXA has successfully reduced blood loss and transfusion requirements with various operations: pediatric cardiac surgery, scoliosis surgery, and craniosynostosis repair

- While the clinical evidence for TXA in pediatric trauma pts is limited, considerations for its use should be given in major trauma with hemodynamic instability or significant risk for ongoing hemorrhage.

Tranexamic acid administration to pediatric trauma patients in a combat setting: the pediatric trauma and tranexamic acid study (PED-TRAX)

Matthew J Eckert [1], Thomas M Wertin, Stuart D Tyner, Daniel W Nelson, Seth Izenberg, Matthew J Martin

Affiliations + expand

PMID: 25423534 DOI: 10.1097/TA.0000000000000443

Abstract

INDEPENDENT SUBMISSION

Resuscitative practices and the use of low-titer group O whole blood in pediatric trauma

The Journal of Trauma and Acute Care Surgery
Articles & Issues | Collections | Multimedia | CME | For Authors | Journal Info | DEI Resources

CONSENSUS STATEMENT

Pediatric traumatic hemorrhagic shock consensus conference recommendations

Russell, Robert T. MD, MPH; Esparaz, Joseph R. MD, MPH; Beckwith, Michael A. MD; Abraham, Peter J. MD; Bembea, Melania M. MD, PhD, MPH; Borgman, Matthew A. MD; Burd, Randall S. MD, PhD; Gaines, Barbara A. MD; Jafri, Mubeen MD; Josephson, Cassandra D. MD; Leeper, Christine MD; Leonard, Julie C. MD, MPH; Muszynski, Jennifer A. MD, MPH; Nicol, Kathleen K. MD; Nishijima, Daniel K. MD, MAS; Stricker, Paul A. MD; Vogel, Adam M. MD; Wong, Trisha E. MD, MS; Spinella, Philip C. MD

Author Information

Journal of Trauma and Acute Care Surgery 94(1S):p S2-S10, January 2023. | *DOI:*

The Journal of Trauma and Acute Care Surgery
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ORIGINAL ARTICLE

Association of Blood Product Ratios with Early Mortality in Pediatric Trauma Resuscitation: A Time-

The Journal of Trauma and Acute Care Surgery
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PTS 2020 PODIUM

Whole blood hemostatic resuscitation in pediatric trauma: A nationwide propensity-matched analysis

Anand, Tanya MD; Obaid, Omar MD; Nelson, Adam MD; Chehab, Mohamad MD; Ditillo, Michael DO; Hammad, Ahmad MD; Douglas, Molly MD; Bible, Letitia MD; Joseph, Bellal MD, FACS

Author Information

Journal of Trauma and Acute Care Surgery 91(4):p 573-578, October 2021. | *DOI:*
10.1097/TA.0000000000003306

The Journal of Trauma and Acute Care Surgery
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ORIGINAL ARTICLE

An assessment of the safety, hemostatic efficacy, and clinical impact of low-titer group O whole blood in children and adolescents

Gerard, Justin; Mueck, Krislynn; Lubkin, David; Hatton, Gabrielle; Wade, Charles; Cotton, Bryan; Brill, Jason; Boukas, Konstantinos; Cox, Charles

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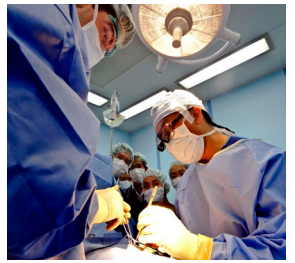
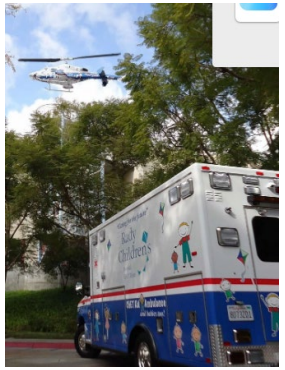
Advances in Trauma in the Military

- Civilian & Military Collaboration
- Joint Trauma Registry/Research
- Resuscitation
- Blood Transfusion
- Hemorrhage Control
- Simulation & Education





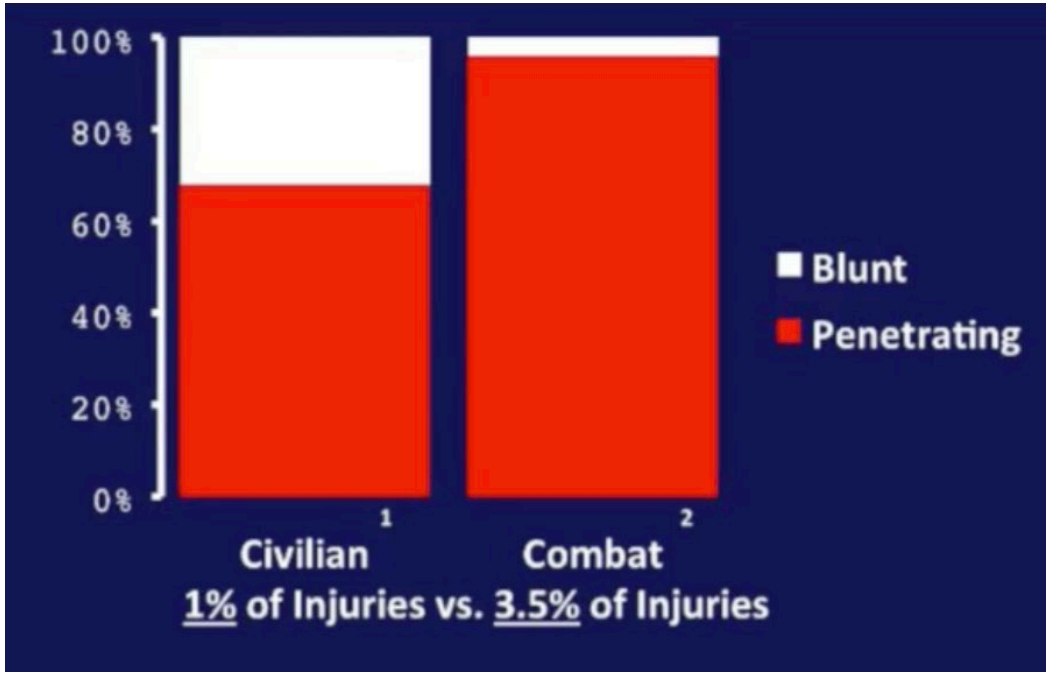
Rady Children's Hospital San Diego

Pediatric Vascular Trauma in Military

- Combat experience is that 3.5% pediatric patients had significant vascular injuries (vs 1% in civilian trauma

- Regions of injury
  - Lower extremity – 38%
  - Upper extremity – 28%
  - Abdominal/Pelvic – 17%
  - Head/Neck – 9%
  - Thoracic – 7%

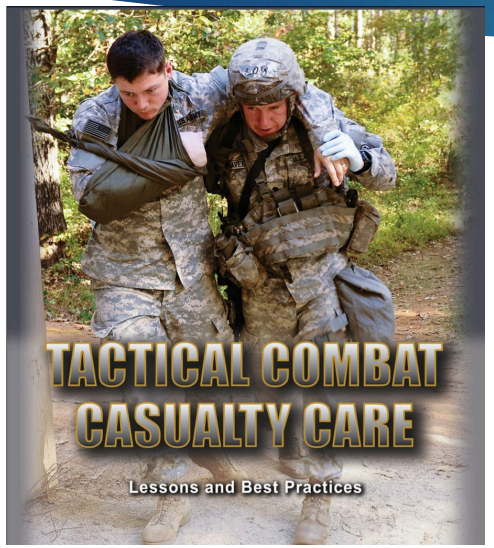
Lt Col (Ret.) Jeremy Cannon



Slide from Presentation by Dr. J. Cannon. https://videolibrary.globalcastmd.com/pediatric-trauma-vascular-injury

(Klinkner et al, J Ped Surg 42:178,2007)(Vilamaria et al, J Ped Surg 2014)

Hemorrhage Control & Limb Salvage



- Hemostatic agents
- Tourniquets
- Damage control procedures
  - Use of vascular shunts
  - REBOA
  - Temporary Closures
  - Wound Vac/Negative Pressure Therapy Dressings

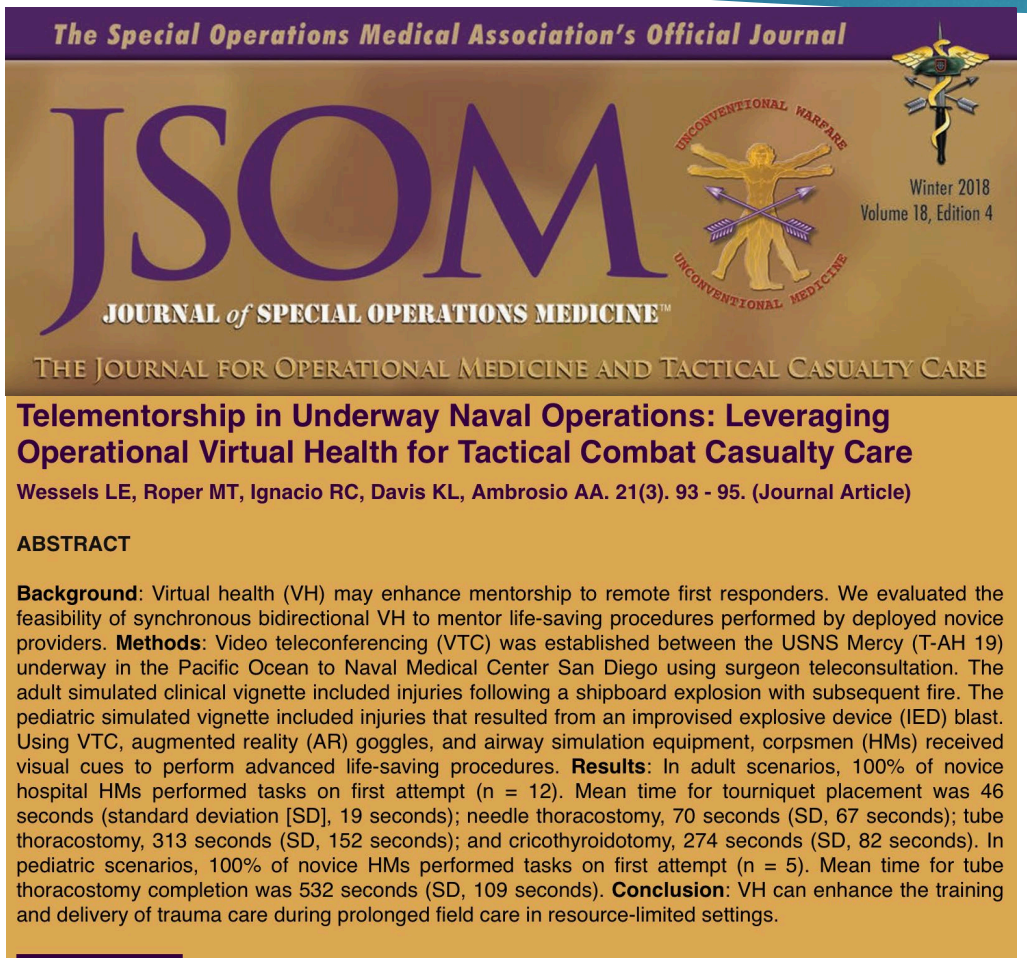
Topical Hemostatic Agents

- **Factor concentrators** - class of hemostatic agents that work through fast absorption of the water content of blood; consequently, concentration of its cellular and protein components results in clot formation. QuikClot (Z-Medica LLC., Newington, CT, USA)

- **Mucoadhesive agents** - these agents act through a strong adherence to the tissues, and physically block bleeding from wounds. HemCon (HemCon Medical Technologies Inc. Portland, OR, USA

- **Procoagulant supplementors**: agents placed in this group act mainly through delivering procoagulant factors to the hemorrhagic wound. Dry fibrin sealant dressing (DFSD)

Learning Lessons from the Frontlines



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Winter 2018
Volume 18, Edition 4

Telementorship in Underway Naval Operations: Leveraging Operational Virtual Health for Tactical Combat Casualty Care

Wessels LE, Roper MT, Ignacio RC, Davis KL, Ambrosio AA. 21(3). 93 - 95. (Journal Article)

ABSTRACT

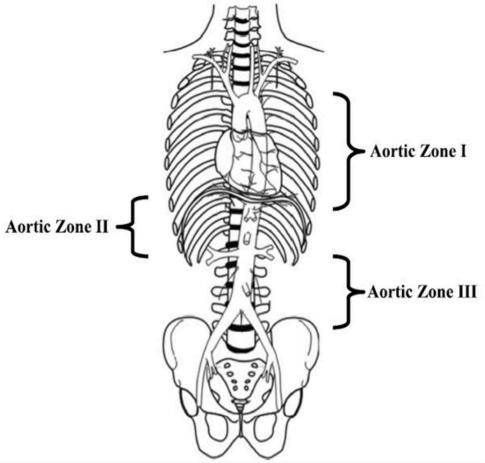
Background: Virtual health (VH) may enhance mentorship to remote first responders. We evaluated the feasibility of synchronous bidirectional VH to mentor life-saving procedures performed by deployed novice providers. **Methods**: Video teleconferencing (VTC) was established between the USNS Mercy (T-AH 19) underway in the Pacific Ocean to Naval Medical Center San Diego using surgeon teleconsultation. The adult simulated clinical vignette included injuries following a shipboard explosion with subsequent fire. The pediatric simulated vignette included injuries that resulted from an improvised explosive device (IED) blast. Using VTC, augmented reality (AR) goggles, and airway simulation equipment, corpsmen (HMs) received visual cues to perform advanced life-saving procedures. **Results**: In adult scenarios, 100% of novice hospital HMs performed tasks on first attempt (n = 12). Mean time for tourniquet placement was 46 seconds (standard deviation [SD], 19 seconds); needle thoracostomy, 70 seconds (SD, 67 seconds); tube thoracostomy, 313 seconds (SD, 152 seconds); and cricothyroidotomy, 274 seconds (SD, 82 seconds). In pediatric scenarios, 100% of novice HMs performed tasks on first attempt (n = 5). Mean time for tube thoracostomy completion was 532 seconds (SD, 109 seconds). **Conclusion**: VH can enhance the training and delivery of trauma care during prolonged field care in resource-limited settings.

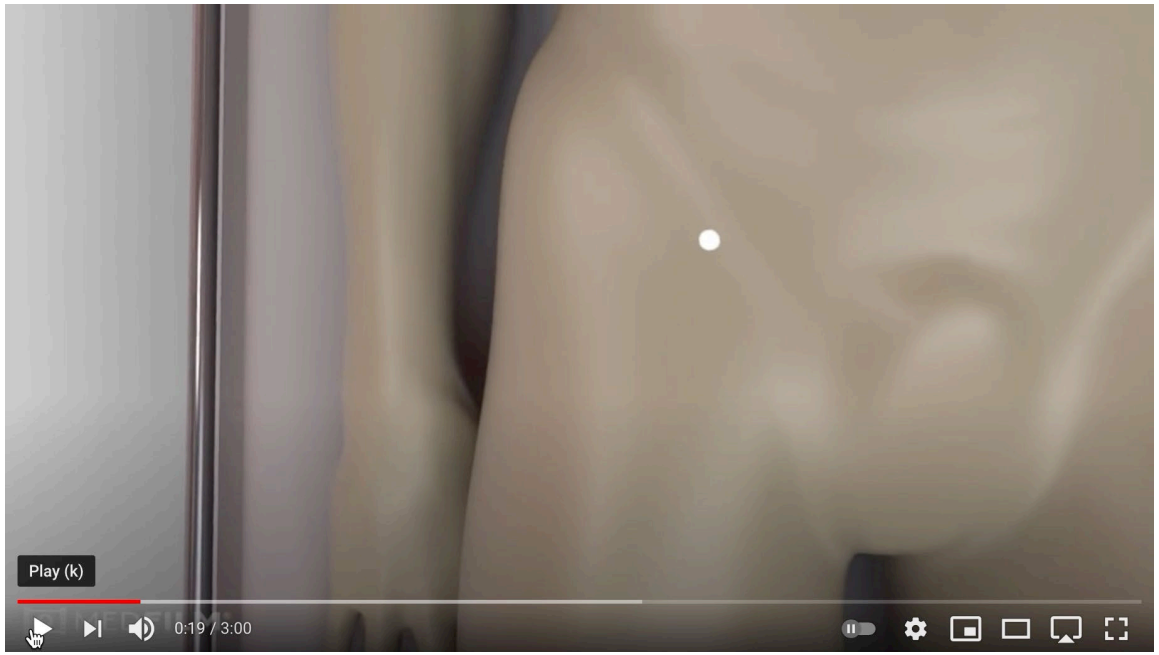
- Video teleconference has provided opportunities not only to receive information from those on ships and overseas deployed areas, but to present pediatric trauma cases

- We have had opportunities in 2014 – 2017 where adult surgeons and pediatric surgeons discuss ways for best practice.
  - Resuscitative thoracotomy
  - REBOA

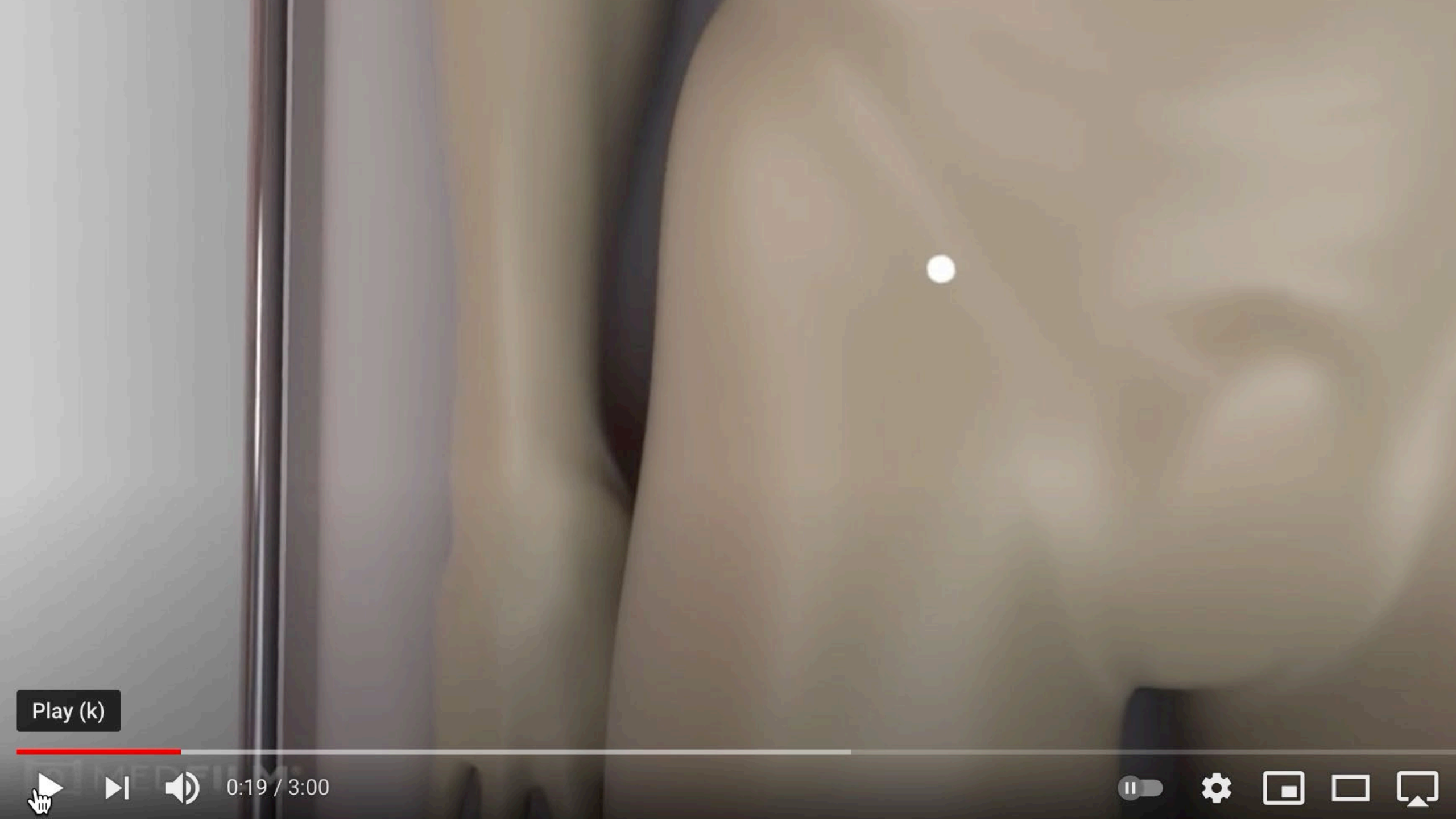
REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta)

COL Todd Rasmussen





- Minimally invasive technique using a balloon catheter to temporarily occlude large vessels in support of hemorrhage control
- Indicated for
  - traumatic life-threatening hemorrhage below the diaphragm in patients in hemorrhagic shock who are unresponsive or transiently responsive to resuscitation.
  - for patients arriving in arrest from injury due to presumed life-threatening hemorrhage below the diaphragm.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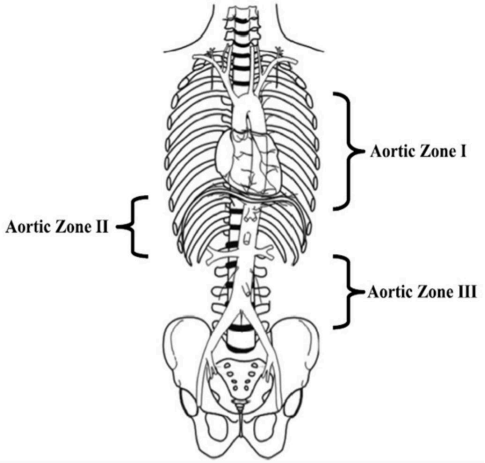
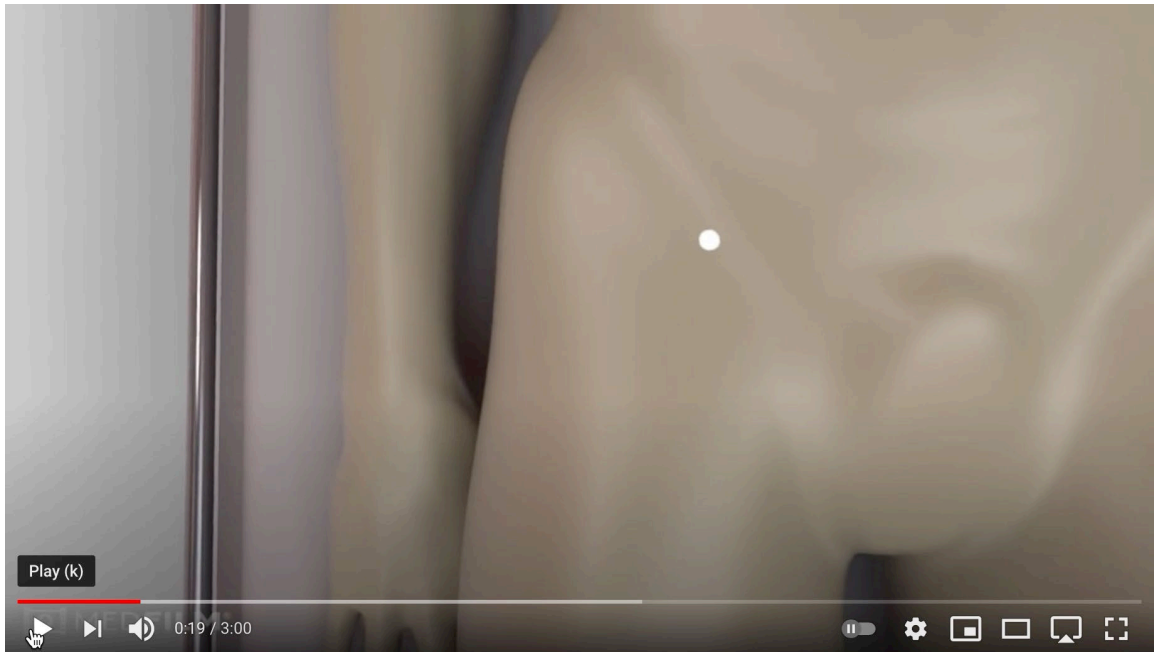
REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta)

COL Todd Rasmussen





- Avoids morbidity and risks of resuscitative thoracotomy.
- Data is limited for pediatrics
- Current RCHSD research study is to establish a “Broselow” measurement to decide how to apply REBOA to pediatric trauma patients with severe hemorrhage

REBOA in children?

Journal of Pediatric Surgery

TRAUMA | VOLUME 56, ISSUE 8, P1395-1400, AUGUST 01, 2021

Quantifying the need for pediatric REBOA: A gap analysis

Christina M. Theodorou • A. Francois Trappey • Carl A. Beyer • ... Joseph M. Galante • Alana L. Beres • Jacob T. Stephenson • Show all authors

Injury International Journal of the Care of the Injured Log in

FULL LENGTH ARTICLE | VOLUME 51, ISSUE 11, P2512-2516, NOVEMBER 01, 2020

Nationwide use of REBOA in adolescent trauma patients: An analysis of the AAST AORTA registry

Christina M. Theodorou • Megan Brenner • Jonathan J. Morrison • ... Joseph J. DuBose • Joseph M. Galante • AAST AORTA Study Group • Show all authors

Published: August 07, 2020 • DOI: https://doi.org/10.1016/j.injury.2020.08.009 • Check for updates

JACS Journal of the American College of Surgeons Log in

SCIENTIFIC POSTER PRESENTATIONS MILITARY | VOLUME 227, ISSUE 4, SUPPLEMENT 2, E182, OCTOBER 01, 2018

Adaptation of the Broselow Tape: Approximation of Pediatric Morphometry for Resuscitative Endovascular Balloon Occlusion of the Aorta

Erik S. DeSoucy, DO • Francois Trappey, MD • Andrew Wishy, DO • ... Michael A. Johnson, MD, PhD • Timothy K. Williams, MD • Jacob T. Stephenson, MD • Show all authors

Journal of Pediatric Surgery Log in

TRAUMA/BURNS | VOLUME 55, ISSUE 10, P2128-2133, OCTOBER 01, 2020

The utility and promise of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the pediatric population: An evidence-based review

Giovanni A. Campagna • Megan E. Cunningham • Jose A. Hernandez • Alex Chau • Adam M. Vogel • Bindi J. Naik-Mathuria

Published: February 12, 2020 • DOI: https://doi.org/10.1016/j.jpedsurg.2020.01.052 • Check for updates

REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta)

Equipment	GRAY* 3-5 kg	PINK Small Infant 6-7 kg	RED Infant 8-9 kg	PURPLE Toddler 10-11 kg	YELLOW Small Child 12-14 kg	WHITE Child 15-18 kg	BLUE Child 19-23 kg	ORANGE Large Child 24-29 kg	GREEN Adult 30-36 kg
Resuscitation bag		Infant/child	Infant/child	Child	Child	Child	Child	Child	Adult
Oxygen mask (NRB)		Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric	Pediatric/ adult
Oral airway (mm)		50	50	60	60	60	70	80	80
Laryngoscope blade (size)		1 Straight	1 Straight	1 Straight	2 Straight	2 Straight	2 Straight or curved	2 Straight or curved	3 Straight or curved
ET tube (mm)†		3.5 Uncuffed 3.0 Cuffed	3.5 Uncuffed 3.0 Cuffed	4.0 Uncuffed 3.5 Cuffed	4.5 Uncuffed 4.0 Cuffed	5.0 Uncuffed 4.5 Cuffed	5.5 Uncuffed 5.0 Cuffed	6.0 Cuffed	6.5 Cuffed
ET tube insertion length (cm)	3 kg 9-9.5 4 kg 9.5-10 5 kg 10-10.5	10.5-11	10.5-11	11-12	13.5	14-15	16.5	17-18	18.5-19.5
Suction catheter (F)		8	8	10	10	10	10	10	10-12
BP cuff	Neonatal #5/infant	Infant/child	Infant/child	Child	Child	Child	Child	Child	Small adult
IV catheter (ga)		22-24	22-24	20-24	18-22	18-22	18-20	18-20	16-20
IO (ga)		18/15	18/15	15	15	15	15	15	15
NG tube (F)		5-8	5-8	8-10	10	10	12-14	14-18	16-18
Urinary catheter (F)	5	8	8	8-10	10	10-12	10-12	12	12
Chest tube (F)		10-12	10-12	16-20	20-24	20-24	24-32	28-32	32-38

- Current RCHSD research study is to establish a “Broselow” measurement to decide how to apply REBOA to pediatric trauma patients with severe hemorrhage

Balloons for Kids: Anatomic Candidacy and Optimal Catheter Size for Pediatric REBOA

ALICIA G. SYKES, WILLIAM B. SISSON, LUCAS WANG,

HARIHARAN THANGARAJAH, MATTHEW MARTIN, NATHANIAL FERNANDEZ,

MEGHAN NELLES, ROMEO C. IGNACIO, JR.

Background

- Hemorrhage is a common cause of potentially preventable death in pediatric trauma patients
- Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) can be potentially life-saving in cases of non-compressible truncal hemorrhage or pelvic trauma
- 46% of pediatric trauma deaths attributed to hemorrhage would have been amenable to REBOA
- REBOA is not currently FDA approved for use in children

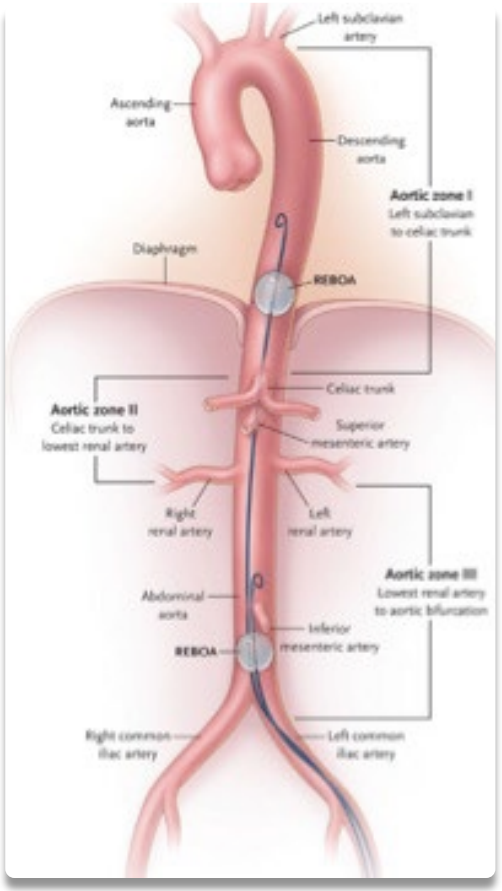


Image source: https://wjes.biomedcentral.com/articles/10.1186/s13017-019-0255-0

Study Aim

- Evaluate the vascular dimensions and anatomic limitations of REBOA use in children
  - ***Zone 1*** of the aorta extends from the left subclavian artery to the celiac artery.
  - ***Zone 2*** continues from the celiac artery to the renal artery.
  - ***Zone 3*** extends from the origin of the lowest renal artery to the aortic bifurcation (infrarenal aorta).

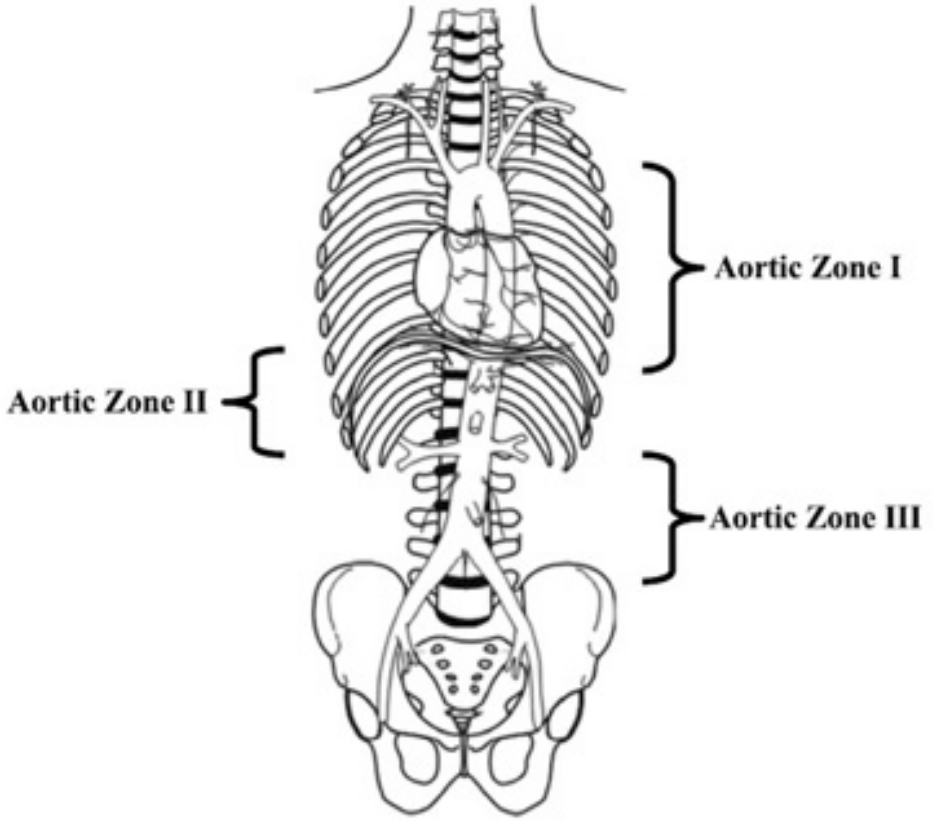


Image source: https://prytimemedical.com/clinical/reboa/

Methods

- CT scans of pediatric patients ≤ 18 years-old (Feb 2016 – Oct 2019) were retrospectively reviewed by two providers

Vessel	Level of Measurement of Vessel Diameter
Aorta, Zone I	Junction between hepatic veins and inferior vena cava (IVC)
Aorta, Zone III	Halfway between distal renal artery and aortic bifurcation
Common Iliac Artery (CIA)	Immediately distal to aortic bifurcation
External Iliac Artery (EIA)	Immediately distal to common iliac artery bifurcation
Common Femoral Artery (CFA)	Mid-femoral heads

Methods

- Inter-rater reliability (IRR) for measurements was determined using intraclass correlation coefficient (ICC)
- Vascular dimensions were correlated to patient height, weight, and BMI using linear regression analysis
- Categorization within Broselow categories were evaluated

Yellow	White	Blue	Orange	Green	Black
12-14 kg	15-18 kg	19-23 kg	24-29 kg	30-36 kg	>36 kg
85-98 cm	98-110 cm	110-121 cm	121-133 cm	133-147 cm	≥ 147 cm

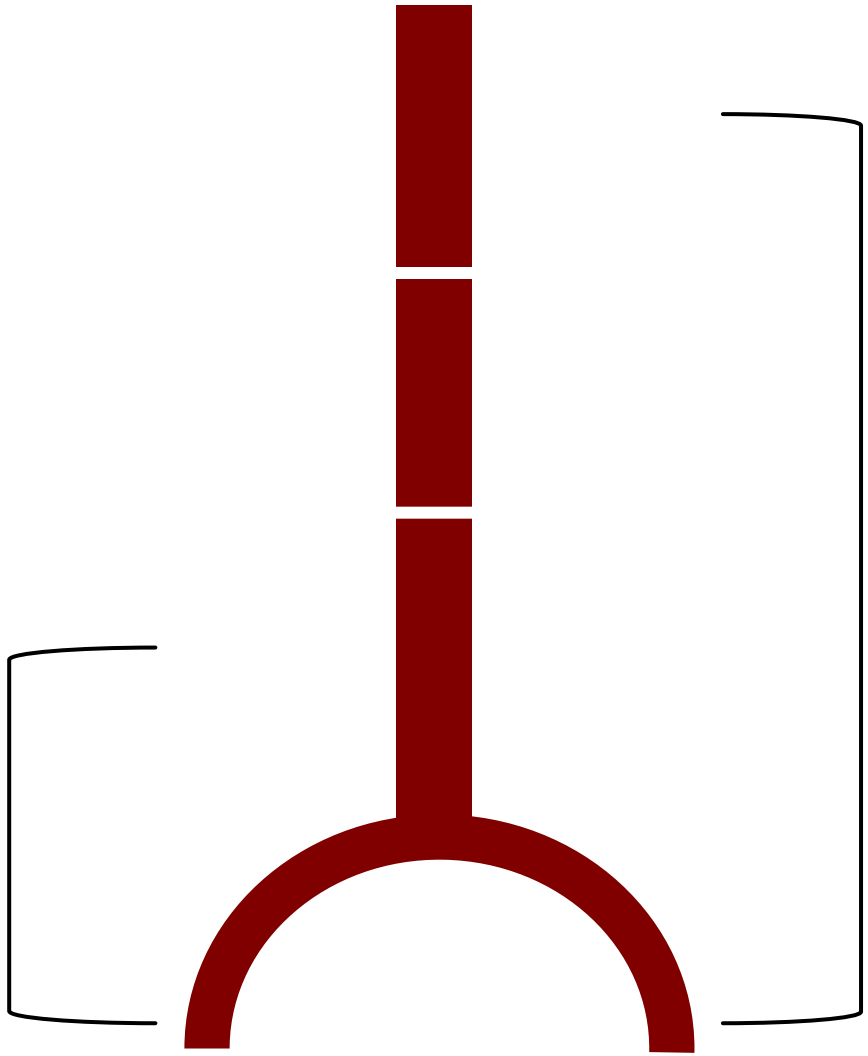
Results

	Yellow 12-14 kg 85-98 cm	**White** 15-18 kg 98-110 cm	**Blue** 19-23 kg 110-121 cm	**Orange** 24-29 kg 121-133 cm	**Green** 30-36 kg 133-147 cm	**Black** >36 kg ≥ 147 cm
CFA diameter, mean mm	3.3	3.8	4.1	4.5	4.9	6.0
EIA diameter, mean mm	3.3	3.8	4.1	4.6	4.9	6.0
CIA diameter, mean mm	4.2	4.9	5.4	6.0	6.5	7.7
Aorta Zone I diameter, mean mm	9.2	10.2	10.9	12.0	13.1	15.3
Aorta Zone III diameter, mean mm	6.3	6.9	7.6	8.8	9.7	11.5

- IRR of vessel measurements was excellent with an ICC ≥ 0.880

Distance from CFA to Aorta Zone III (cm, mean ± SD)

Yellow	19.0 ± 1.3
White	20.8 ± 1.7
Blue	22.5 ± 3.4
Orange	24.3 ± 1.4
Green	26.9 ± 2.1
Black	31.0 ± 3.0

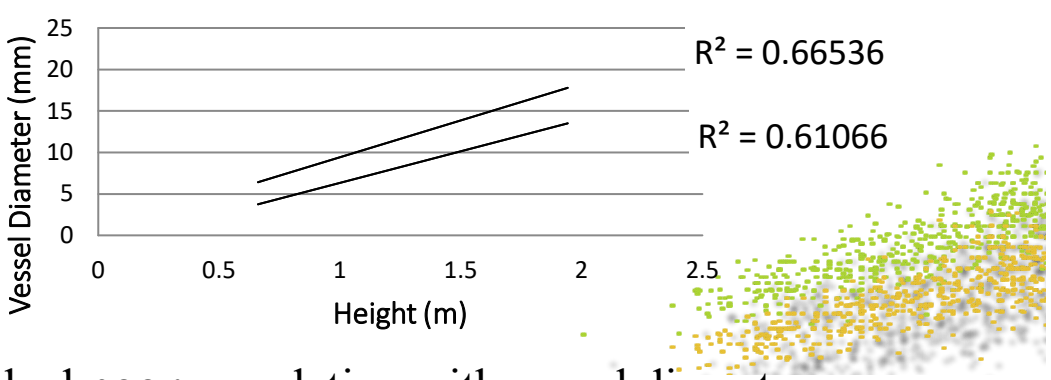


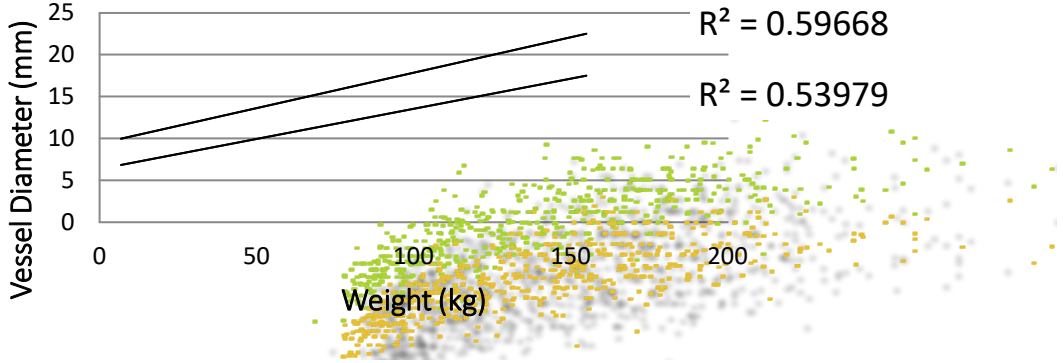
Distance from CFA to Aorta Zone I (cm, mean ± SD)

Yellow	32.7 ± 2.3
White	36.1 ± 2.4
Blue	38.7 ± 1.9
Orange	42.4 ± 2.3
Green	46.4 ± 3.3
Black	54.1 ± 5.1

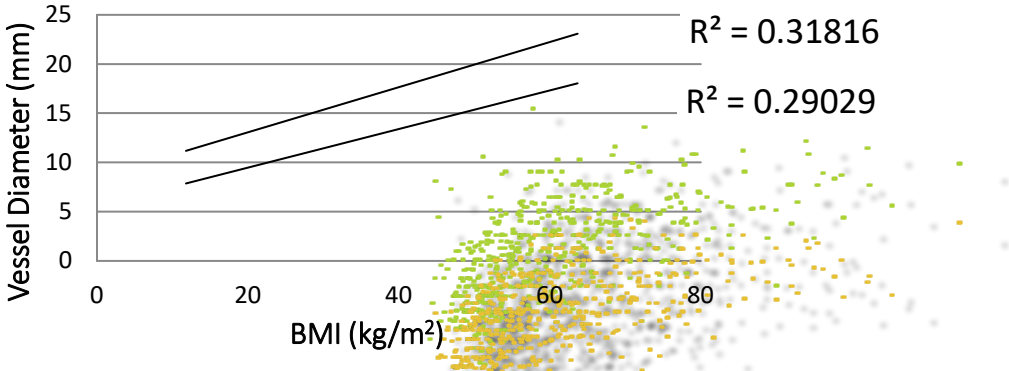
Results

- Height had greatest correlation with vessel diameter (Aorta Zones I and III)

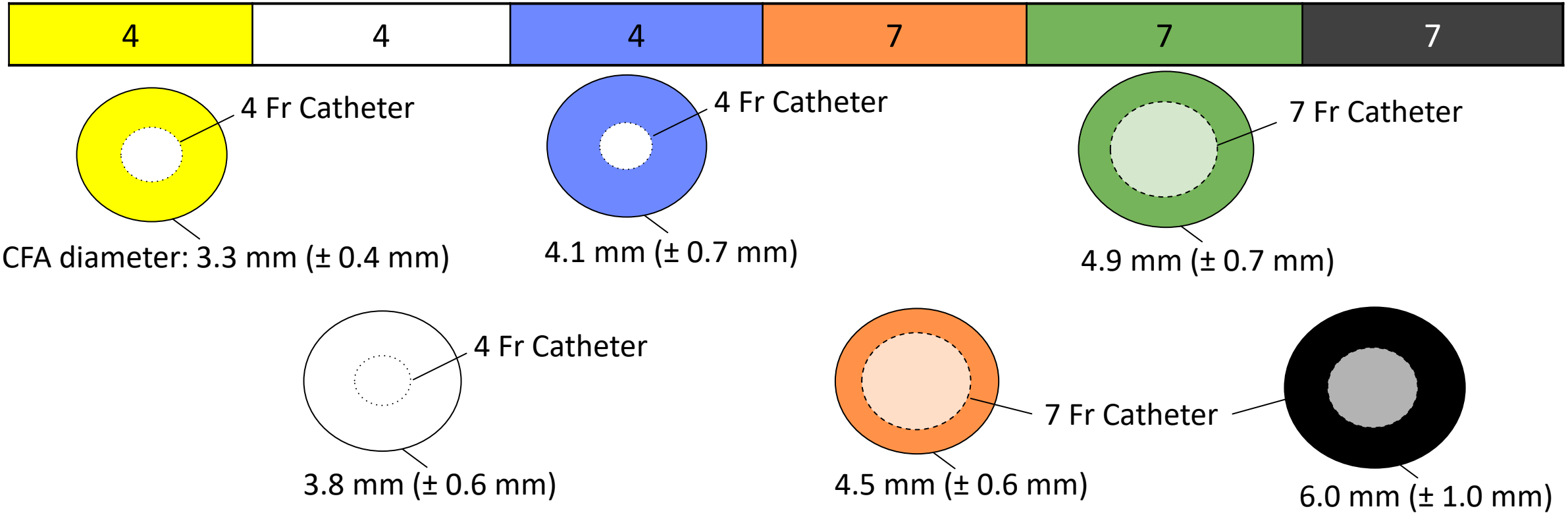




- BMI had **poor** correlation with vessel diameter



Recommended REBOA Catheter Size (Fr)



Conclusions

- Largest compilation of REBOA-related pediatric vessel diameter measurements
- First to provide data on distance between access site and balloon deployment zones for pediatric patients
- Vessel diameters had greater correlation with height and weight than BMI in pediatric patients
- These measurements may assist in appropriate REBOA catheter size selection in pediatric patients

But hold on…

JAMA Surgery | Original Investigation

Nationwide Analysis of Resuscitative Endovascular Balloon Occlusion of the Aorta in Civilian Trauma

Bellal Joseph, MD; Muhammad Zeeshan, MD; Joseph V. Sakran, MD, MPH; Mohammad Hamidi, MD; Narong Kulvatunyou, MD; Muhammad Khan, MD; Terence O'Keeffe, MD; Peter Rhee, MD

IMPORTANCE The need for improved methods of hemorrhage control and resuscitation has resulted in a reappraisal of resuscitative endovascular balloon occlusion of the aorta (REBOA). However, there is a paucity of data regarding the use of REBOA on a multi-institutional level in the United States.

OBJECTIVE To evaluate the outcomes in trauma patients after REBOA placement.

DESIGN, SETTING, AND PARTICIPANTS A case-control retrospective analysis was performed of the 2015-2016 American College of Surgeons Trauma Quality Improvement Program data set, a national multi-institutional database of trauma patients in the United States. A total of 593 818 adult trauma patients (aged ≥18 years) were analyzed and 420 patients were matched and included in the study: patients who were dead on arrival or were transferred from other facilities the ED were identif Both groups were n vital signs, mechani each body region al injuries and fracture

MAIN OUTCOMES AI and mortality.

Invited Commentary page 508

Author Audio Interview

In the News

MAY 12, 2021

To Do REBOA or Not to Do REBOA?

With Conflicting Study Results, Guidelines and Recommendations Are Difficult to Make

By Victoria Stern

After a traumatic injury, a patient with severe internal hemorrhaging faces a ticking clock. Without controlling the bleeding quickly—sometimes within minutes of the injury—the patient may die.

Is it Time for REBOA to be Considered as an Equivalent to Resuscitative Thoracotomy?

Tanya Anand, Samer Asmar & Bellal Joseph

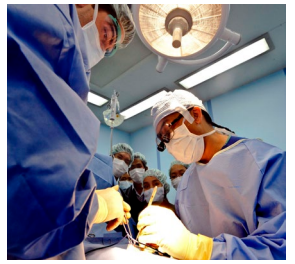
Chapter | First Online: 30 October 2021

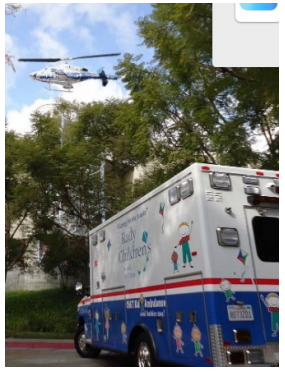
824 Accesses

Part of the Difficult Decisions in Surgery: An Evidence-Based Approach book series (DDSURGERY)

Advances in Trauma in the Military

- Resuscitation
- Blood Transfusion
- Hemorrhage Control
- Simulation & Education





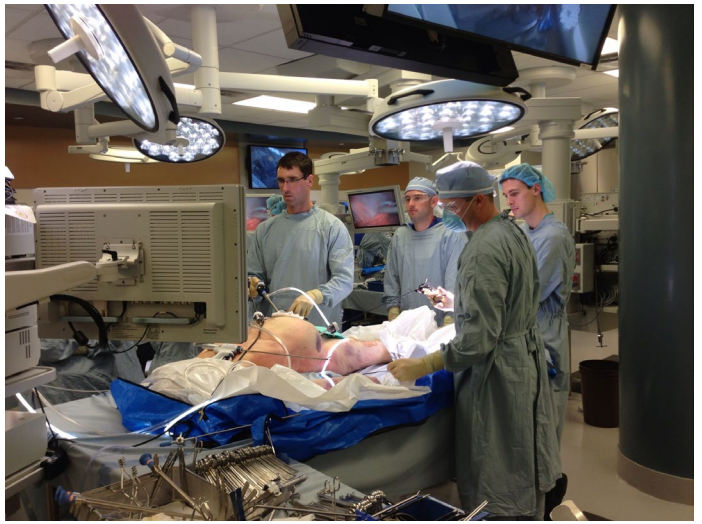
Rady Children's Hospital San Diego

Simulation & Education

Rady Children's Hospital San Diego

- Well proven in both civilian and military institutions.

- There is significant investment by the military for medical/surgical simulation.
  - Skills training
  - Team training
  - Preparation for austere environments



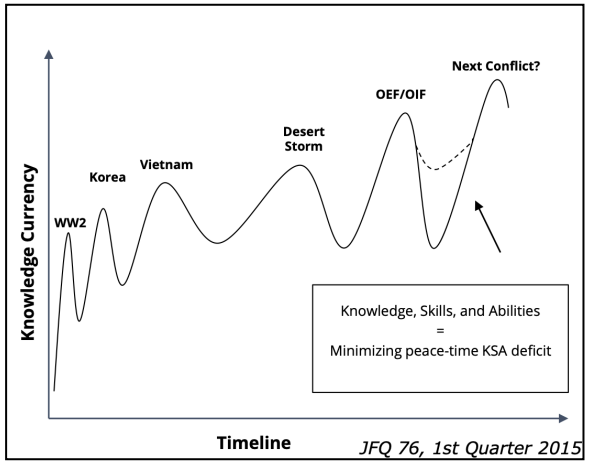
Simulation & Education

- Well proven in both civilian and military institutions.

- There is significant investment by the military for medical/surgical simulation.
  - Skills training
  - Team training
  - Preparation for austere environments
  - Cut suit
  - High Fidelity training

Trauma Education Courses

- ATLS (Advanced Trauma Life Support) courses
- Trauma Nursing Core Course
  - Establish a courses here at RCHSD
- ASSET (Advanced Surgical Skills for Exposure in Trauma)
- BEST (Basic Endovascular Skills for Trauma)
- Multidisciplinary trauma mock
- Mass casualty drills




EXIT
FIRE

Summary

- The experiences in combat medicine have greatly advanced the care for pediatric trauma.
  - Resuscitation
  - Blood Transfusion
  - Hemorrhage Control
  - Simulation & Education
- MTPs, tourniquets and hemostatic agents. are important resuscitation measures and treatments than can be used for pediatric injuries.
- Simulation and routine trauma training are key educational tools for team training and improving the effective care in trauma

QUESTIONS?