PENETRATING TRAUMA: WHEN SECONDS COUNT

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Disclosure Statement of Financial Interest

NOTHING TO DISCLOSE

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- Dr. R. Adams Cowley (Baltimore "Shock" Trauma) is credited with "golden hour"
- Significant improvements → better patient outcomes
  - Speed to hospital
  - Prehospital: Stop The Bleed (tourniquets, packing)
  - Resuscitation (temperature, use of blood products instead of crystalloid)
  - Correction of coagulopathy (Viscoelastic testing: TEG or ROTEM – quantitatively measures the ability of whole blood to form a clot
  - Decreasing time to definitive surgical care (Fly-By Protocol)
  - "Trajectory Begets Injury"
  - CASES

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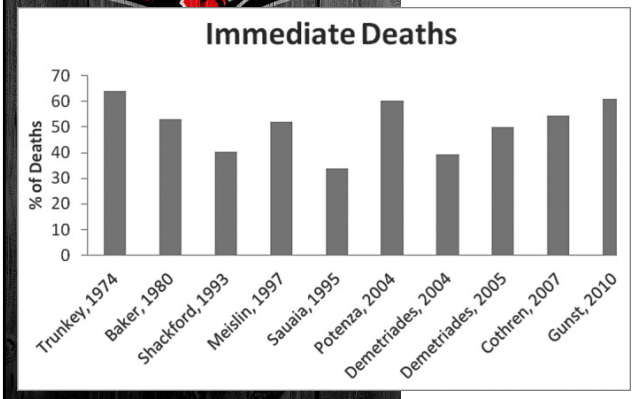
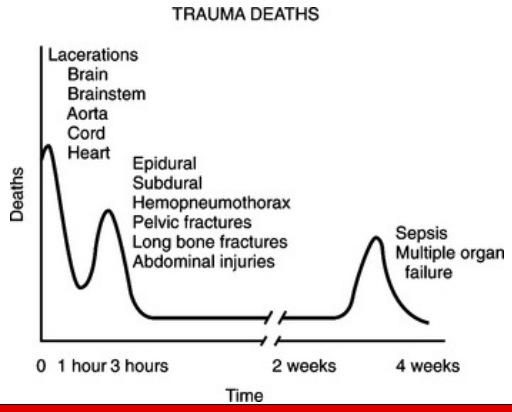
- **Dr, Baker et al. and Dr. Trunkey first advanced the trimodal distribution of death in trauma in 1980**
  - Baker CC, Oppenheimer L, Stephens B, Lewis FR, Trunkey DD. Epidemiology of trauma deaths. *Am J Surg*. 1980;140(1):144–150.
- **In spite of the regionalized trauma systems developed by Dr. Cowley at Baltimore, proportion of deaths remained stable between 50% - 60%**





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Drug	Elimination Half-Life	Removed by Dialysis	Summary of emergent reversal for life-threatening bleeding
Apixaban (Eliquis)	12 hours (longer in renal impairment)	no	If ingested within 2 hours, give activated charcoal 1 g/kg (max 50 g) Administer KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units) Monitor PT/INR and anti-Factor Xa activity level (send-out lab) to confirm reversal
Argatroban	40-50 minutes	20%	Turn off infusion. Monitor aPTT/TCT to confirm clearance Consider KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units)
Bivalirudin (Angiomax)	25 minutes (up to 1 hr in severe renal impairment)	25%	Turn off infusion. Monitor aPTT/TCT to confirm clearance Consider KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units)
Dabigatran (Pradaxa)	14 hours (up to 34 hrs in severe renal impairment)	62-68%	If ingested within 2 hours, give activated charcoal 1g/kg (max 50 g) Consider idarucizumab, administered as 2 consecutive IV infusions of 2.5 g vials over 5 minutes each. The second 2.5g vial must be administered within 15 minutes of the first vial.
Edoxaban (Savaysa)	10 to 14 hours (longer in renal impairment)	no	If ingested within 2 hours, give activated charcoal 1 g/kg (max 50 g) Administer KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units) Monitor PT/INR and anti-Factor Xa activity level (send-out lab) to confirm reversal
Enoxaparin (Lovenox)	3-5 hours (longer in severe renal impairment)	20%	Protamine partially reverses the anticoagulant effect of LMWHs (~ 60%). Administer protamine: (do not exceed rate 5 mg/min, max dose 50 mg) If last dose was < 8 hours PTA: For each 1 mg of enoxaparin, administer 1 mg of protamine If last dose was 8-12 hours PTA: For each 1 mg of enoxaparin, administer 0.5 mg protamine If last dose was >12 hours PTA: Protamine is unlikely to be beneficial For refractory or life threatening bleeding: Administer KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units) Monitor anti Factor Xa activity level to confirm reversal
Fondaparinux (Arixtra)	17-21 hours (significantly longer in renal impairment)	no	Administer KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min (max dose 5000 units) Monitor aPTT/anti Factor Xa activity level (send-out lab) to confirm
Heparin	30-90 minutes (dose-dependent)	partial	Protamine neutralizes heparin Administer protamine: For each 100 units of heparin, administer 1 mg of protamine Do not exceed rate of 5 mg/min, max dose is 50 mg

Drug	Elimination Half-Life	Removed by Dialysis	Summary of emergent reversal for life-threatening bleeding
Rivaroxaban (Xarelto)	Health: 5-9 hrs Elderly: 11-13 hrs (longer in renal impairment)	no	If ingested within 2 hours, give activated charcoal 1g/kg (max 50 g) Administer KCentra® (4-factor PCC) 50 units/kg x1 at 3 units/kg/min, (max dose 5000 units) Monitor PT/INR and anti-Factor Xa activity level (send-out labs) to confirm reversal
	INR	**Clinical Setting**	**Therapeutic Options**
Warfarin (Coumadin, Jantoven)	INR < 4.5	No bleeding	Hold warfarin until INR in therapeutic range
		Rapid reversal required	Hold warfarin Consider vitamin K 2.5 mg po*
	INR 4.5 – 10	No bleeding	Hold warfarin until INR in therapeutic range
		Rapid reversal required	Hold warfarin Give vitamin K 2.5 - 5 mg po*
	INR > 10	No bleeding	Hold warfarin until INR in therapeutic range Consider vitamin K 1.25- 2.5 mg po*
		Rapid reversal required	Hold warfarin Give vitamin K 2.5-5 mg IV
	Any INR	Non-life threatening major bleed or surgery/procedure requiring emergent warfarin reversal	Hold warfarin Give vitamin K 5-10 mg IV infusion over 30 minutes Give KCentra (4-factor PCC) INR 2.0 – 3.9 : 25 units/kg (max 2500 units) INR 4.0 – 6.0 : 35 units/kg (max 3500 units) INR > 6.0 : 50 units/kg (max 5000 units)
	Any INR	Serious or life threatening bleeding	Hold warfarin Give vitamin K 10 mg IV infusion over 30 minutes Give KCentra (4-factor PCC) INR unknown: 35 units/kg (max 3500 units) INR 1.5 – 6.0: 35 units/kg (max 3500 units) INR > 6.0 : 50 units/kg (max 5000 units) Repeat x 2 q15mins prn if INR remains > 1.5

If patient is unable to tolerate PO vitamin K, IV route may be substituted

Correction of Coagulopathy

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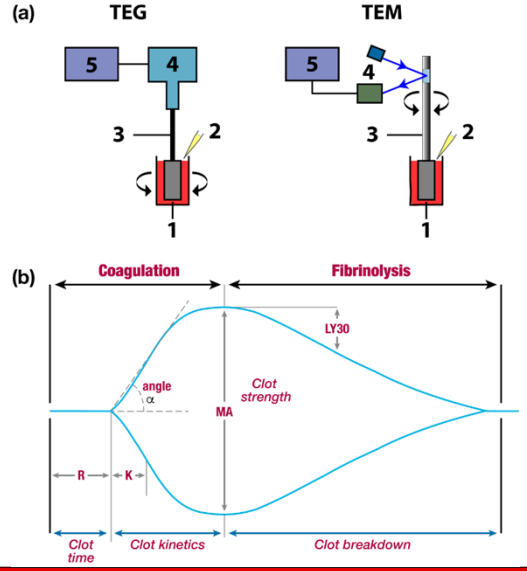

Correction of Coagulopathy

Thrombo**E**lasto**Gram (TEG) and**

ROtational **T**hrombo**E**lasto**M**etry **(ROTEM)**

Viscoelastic tests of clotting

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REVIEW ARTICLE

Postinjury fibrinolysis shutdown: Rationale for selective tranexamic acid

Ernest E. Moore, MD, Hunter B. Moore, MD, Eduardo Gonzalez, MD, Michael P. Chapman, MD, Kirk C. Hansen, PhD, Angela Sauaia, MD, PhD, Christopher C. Silliman, MD, PhD, *and* **Anirban Banerjee, PhD,** *Denver, Colorado*

Three distinct phenotypes of fibrinolysis after severe injury (TEG data):

1. **Hyperfibrinolysis (18%): uninhibited tPA**
   - ↑ need for RBCs, plasma (Massive Transfusion)
   - Death early and due to blood loss
   - May benefit from TXA
2. **Physiologic fibrinolysis (18%):**
3. **Fibrinolysis shutdown (64%): resistance to tPA**
   - Occurs in severely injured patients within 3 hours of insult
   - Delayed mortality due to multisystem organ failure
   - No benefit from early blockade of fibrinolysis
   - May be HARMED by administration of TXA

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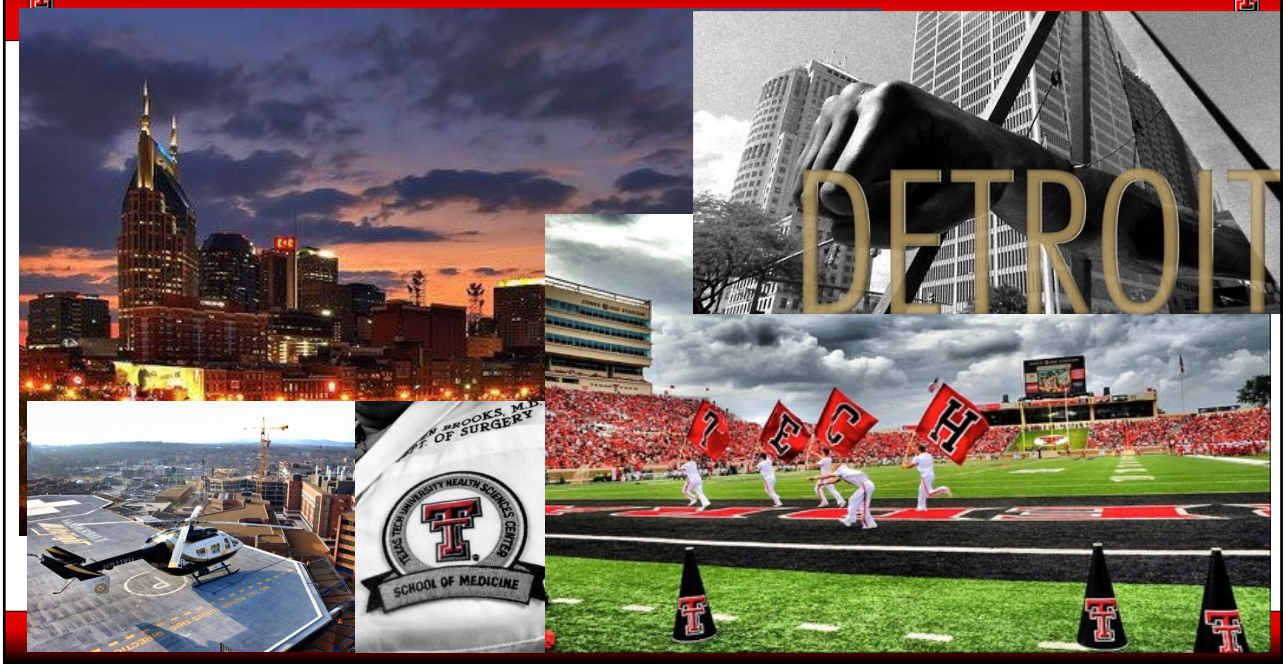

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Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Compliance with a massive transfusion protocol (MTP) impacts patient outcome☆

Bawazeer M.*, Ahmed N.[1], Izadi H.[2], McFarlan A.[3], Nathens A.[4], Pavenski K.[5]

Trauma Program and Transfusion Medicine, Departments of Surgery and Laboratory Medicine, St. Michael's Hospital, University of Toronto, Canada

ARTICLE INFO

Article history:
Accepted 25 September 2014

Keywords:
Massive transfusion protocol
Compliance
Mortality
Outcome

ABSTRACT

Background: About 5% of civilian trauma requires massive transfusion. Protocolized resuscitation with blood products to achieve high plasma:RBC ratio has been advocated to improve survival. Our objectives were to measure compliance to our institutional MTP, to identify quality assurance activities that could improve protocol compliance and to determine if protocol compliance was related to patient outcome. *Methods:* The investigators determined 13 compliance criteria based upon our institutional protocol. We measured compliance in 72 consecutive MTP activations between January 2010 and September 2011 at a Level I trauma centre. Data elements were retrospectively retrieved from blood bank, trauma registry and clinical records. Patients were stratified into three groups based on compliance level, and mortality differences were compared.

- Massive Transfusion
  - > 10units PRBCs in first 24hrs
  - 1.7% - 5% of trauma patients

- **MTP IMPROVES OUTCOMES**

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Transfusion therapy in hemorrhagic shock

Timothy C. Nunez[a] and Bryan A. Cotton[b,c]

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Current Opinion in Critical Care 2009, 15:536–541

Purpose of review
Bleeding and death from hemorrhage remain a leading cause of morbidity and mortality in the trauma population. Early resuscitation of these gravely injured patients has changed significantly over the past several years. The concept of damage control resuscitation has expanded significantly with the experience of the US military in southwest Asia. This review will focus on this resuscitation strategy of transfusing blood products (red cells, plasma, and platelets) early and often in the exsanguinating patient.
Recent findings
In trauma there are no randomized controlled trials comparing the current damage control hematology concept to more traditional resuscitation methods. But the overwhelming conclusion of the data available support the administration of a high ratio of plasma and platelets to packed red blood cells. Several large retrospective studies have shown ratios close to 1 : 1 will result in higher survival.
Summary
The current evidence supports that the acute coagulopathy of trauma is present in a high percentage of trauma patients. Patients who will require a massive transfusion will have improved outcomes the earlier that this is identified and the earlier that damage control hematology is instituted. Current evidence does not describe the best ratio but the preponderance of the data suggests it should be greater than 2 : 3 plasma-to-packed red blood cells.

- **Patients who will require a massive transfusion will have improved outcomes the earlier that this is identified and the earlier that damage control hematology is instituted.**

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ORIGINAL ARTICLE

Ten-year analysis of transfusion in Operation Iraqi Freedom and Operation Enduring Freedom: Increased plasma and platelet use correlates with improved survival

Heather F. Pidcoke, MD, James K. Aden, PhD, Alejandra G. Mora, Matthew A. Borgman, MD, Philip C. Spinella, MD, Michael A. Dubick, PhD, Lorne H. Blackbourne, MD, Andrew P. Cap, MD, PhD

- The Joint Theater Trauma Registry database, begun early in Operation Iraqi Freedom and Operation Enduring Freedom, created a comprehensive repository of information that facilitated research efforts and produced rapid changes in clinical care.
  - INCREASED PLASMA AND PLATELET USE → MORTALITY IMPROVEMENT

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

Improvements in Early Mortality and Coagulopathy are Sustained Better in Patients With Blunt Trauma After Institution of a Massive Transfusion Protocol in a Civilian Level I Trauma Center

Christopher J. Dente, MD, FACS, Beth H. Shaz, MD, Jeffery M. Nicholas, MD, FACS, Robert S. Harris, MD, Amy D. Wyrzykowski, MD, Snehal Patel, BBA, MS, Amit Shah, BS, Gary A. Vercruysse, MD, David V. Feliciano, MD, FACS, Grace S. Rozycki, MD, FACS, Jeffrey P. Salomone, MD, FACS, and Walter L. Ingram, MD, FACS

- In the civilian setting, aggressive use of FFP and platelets drastically reduces 24-hour mortality and early coagulopathy in patients with trauma.

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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

- Plasma to PRBC ratio in 3 groups:
  - 1 : 8 Low ratio group
  - 1 : 2.5 Medium ratio group
  - 1 : 1.4 High ratio group
- High plasma to PRBC ratio (1:1.4) resulted in improved survival by decreasing death from hemorrhage

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

Early Prediction of Massive Transfusion in Trauma: Simple as ABC (Assessment of Blood Consumption)?

Timothy C. Nunez, MD, Igor V. Voskresensky, MD, Lesly A. Dossett, MD, MPH, Ricky Shinall, BS, William D. Dutton, MD, and Bryan A. Cotton, MD

- ❑ + abdominal FAST
- ❑ HR > 120
- ❑ SBP < 90
- ❑ Penetrating Injury Mechanism

✓ Any 2 of these 4…

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- **Delay to the operating room of more than 10 minutes increases the risk of mortality by almost threefold in hypotensive patients with GSW.**
- **Protocols should be designed to shorten time in the emergency department.**
- Patients who arrived to the operating room in 10 minutes or less had 20% overall mortality. After 10 minutes, overall mortality peaked at 45% in patients arriving to the operating room between 11 and 20 minutes.

J Trauma Acute Care Surg. 2016;81: 685–691.

Effect of time to operation on mortality for hypotensive patients with gunshot wounds to the torso: The golden 10 minutes

Jonathan P. Meizoso, MD, MSPH, Juliet J. Ray, MD, MSPH, Charles A. Karcutskie, IV, MD, MA, Casey J. Allen, MD, Tanya L. Zakrison, MD, MPH, Gerd D. Pust, MD, Tulay Koru-Sengul, PhD, Enrique Ginzburg, MD, Louis R. Pizano, MD, MBA, Carl I. Schulman, MD, PhD, MSPH, Alan S. Livingstone, MD, Kenneth G. Proctor, PhD, *and* **Nicholas Namias, MD, MBA**, *Miami, Florida*

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TEXAS TECH "FLY-BY" PROTOCOL:

- **Collaboration**
  - Trauma Surgeons
  - EMS
  - Anesthesiologists
  - ED physicians and staff
  - Radiologists and staff
  - Technicians
  - Pharmacists
- **Table top meetings → 1st draft**
  - List anticipated barriers (general and unique to hospital)
- **Individual meetings with stakeholders → barriers decreased**
- **Test protocol with real-time simulation**
  - All stakeholders analyzed and contributed to refined protocol
- **Actual use in real trauma activations**
  - Qualitative and quantitative feedback
- **Consensus protocol**

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TEXAS TECH "FLY-BY" PROTOCOL:

- **Results**
  - Time to OR: 5 minutes
  - Involved 18 distinct healthcare provider groups
  - Eliminated 12 separate steps of handover process
  - No compromise in safety
  - Increased efficiency
  - Reduced unnecessary clinician workload

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TEXAS TECH "FLY-BY" PROTOCOL:

- **Ensuring patient safety and optimal outcomes**
  - Adding "Fly-By" to trauma activation page
  - Use of code stroke patient registration protocol
  - Assigning CRNA to organize OR while Anesthesiologist traveled to ED
  - Employing EMS for direct transport to OR
  - Implementation of "trauma pharmacy kit" in Pyxis medical dispensing machine

- **Brief EMS report, radiological studies, changing of EMS monitors all occurred in OR**
- **Strict noise discipline and concise communication emphasized and performed**

Conclusion:

"FLY-BY" PROTOCOL DRASTICALLY REDUCES TIME-TO-OR FOR UNSTABLE PENETRATING TRAUMA PATIENTS AND OPTIMIZES TEAM EFFICIENCY IN HANDOVER PROCESS

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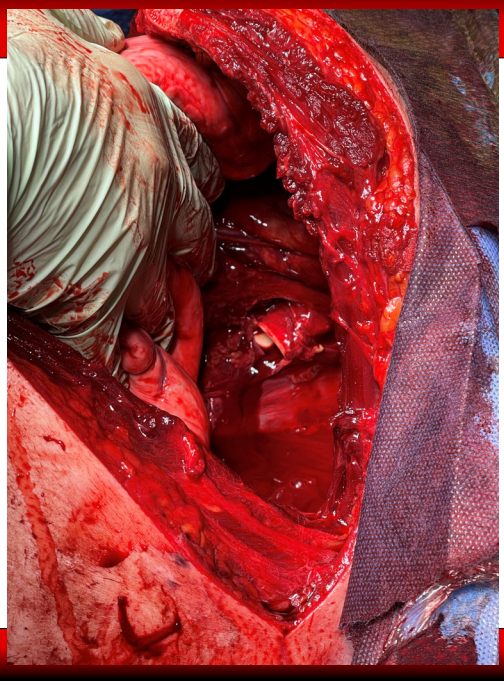

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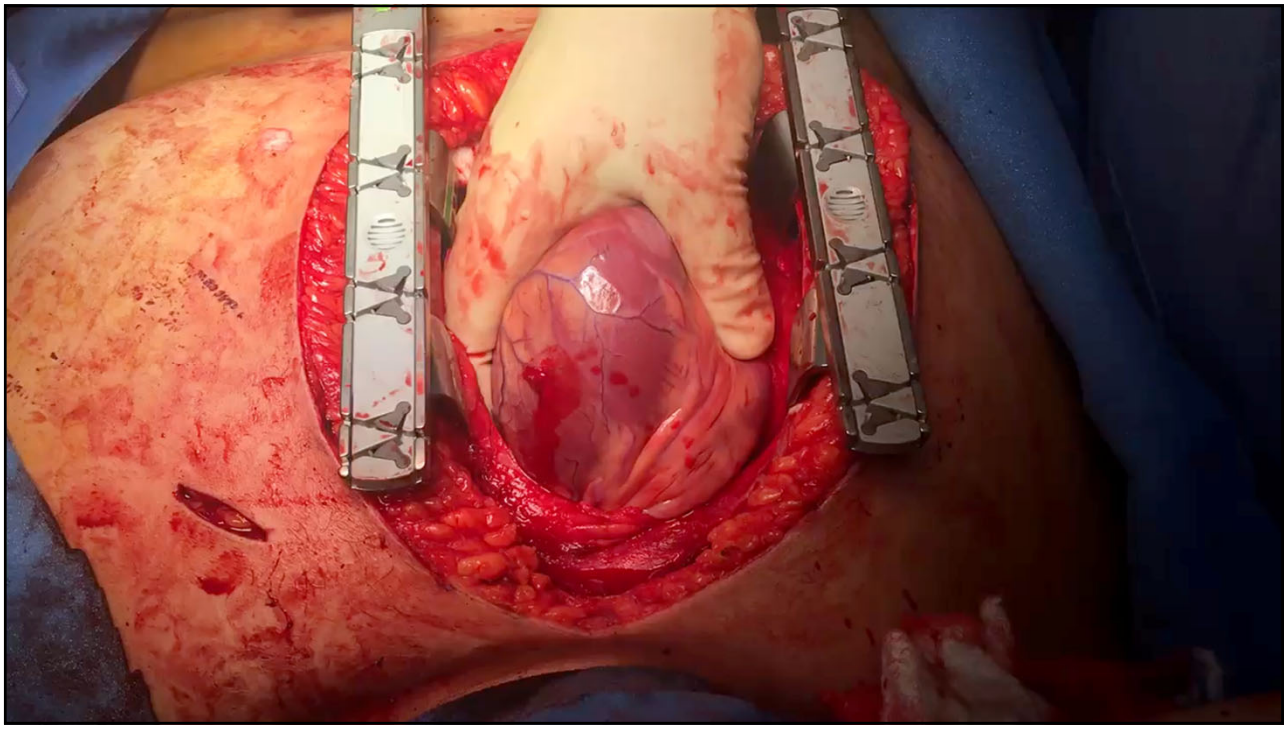
Societal Costs of Inappropriate Emergency Department Thoracotomy

Edward M Passos, MD, Paul T Engels, MD, FACS, Jeffrey D Doyle, MD, Andrew Beckett, MD, Bartolomeu Nascimento Jr, MD, Sandro B Rizoli, MD, PhD, FACS, Homer C Tien, MD, MSC, FACS

- Multi-center study from 1992 – 2009 (n=123 EDTs)
- 51% inappropriate EDTs
  - No survivors, no organ donors
  - 3 cut injuries to healthcare workers
  - 335 units of blood products consumed
- Inappropriate use resulted in substantial costs and waste of resources, exposure of health care workers to blood borne infections, and offered no survival benefit

WTA Statistics

Survival shock + penetrating cardiac injury: 35%
Survival penetrating: 15%
Survival blunt in shock: 2%
Survival blunt with no vital signs: < 1%



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ECMO in Trauma Patients

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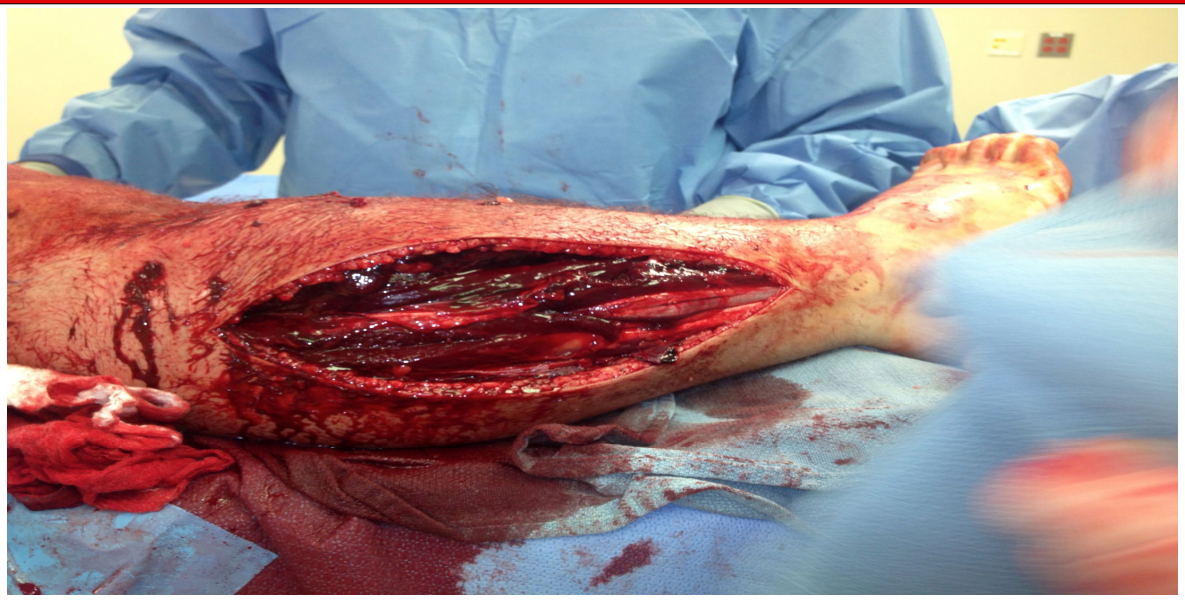

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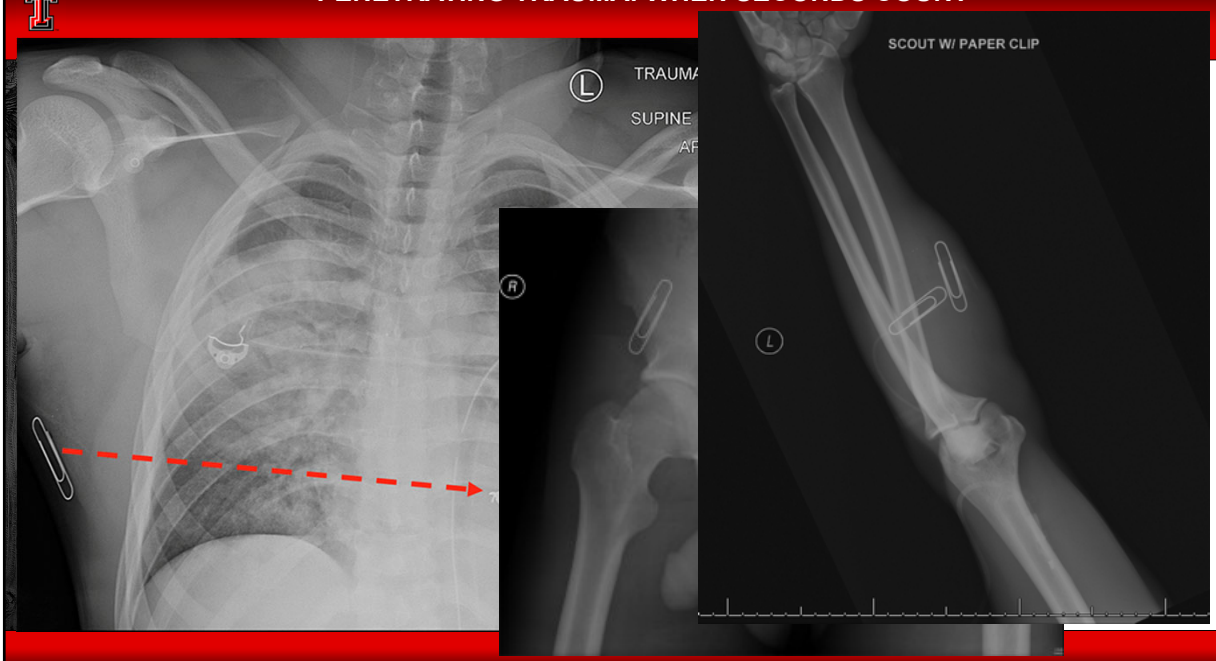

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- **Trajectory Begets Injury**
- **When the Surgery Resident looks like this in the Trauma Bay, it's about to get real…**

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Shotgun to RUQ

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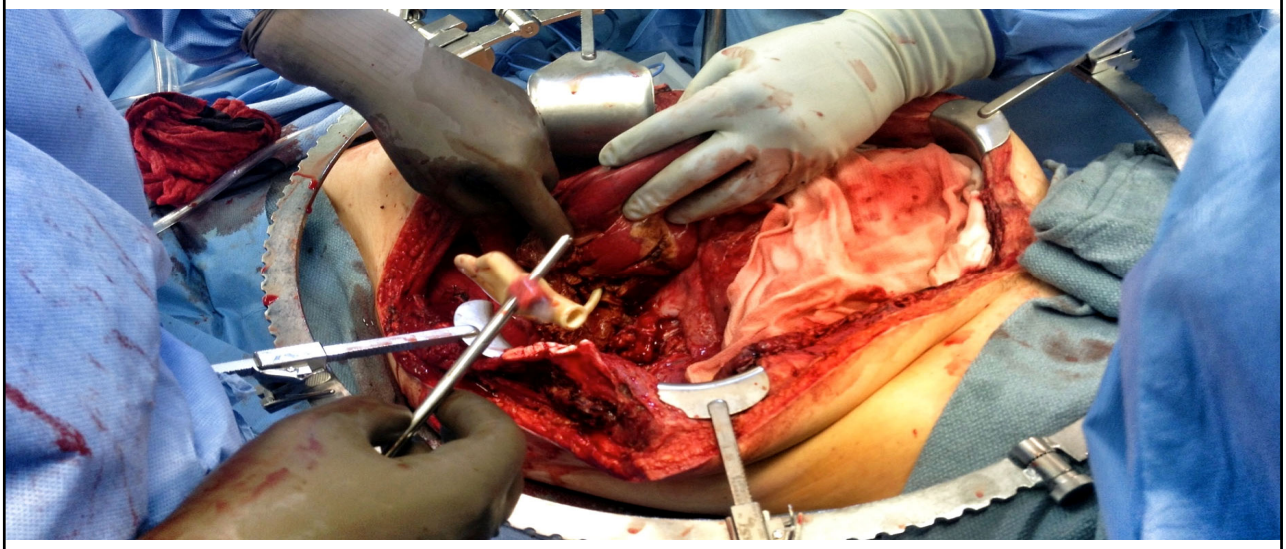

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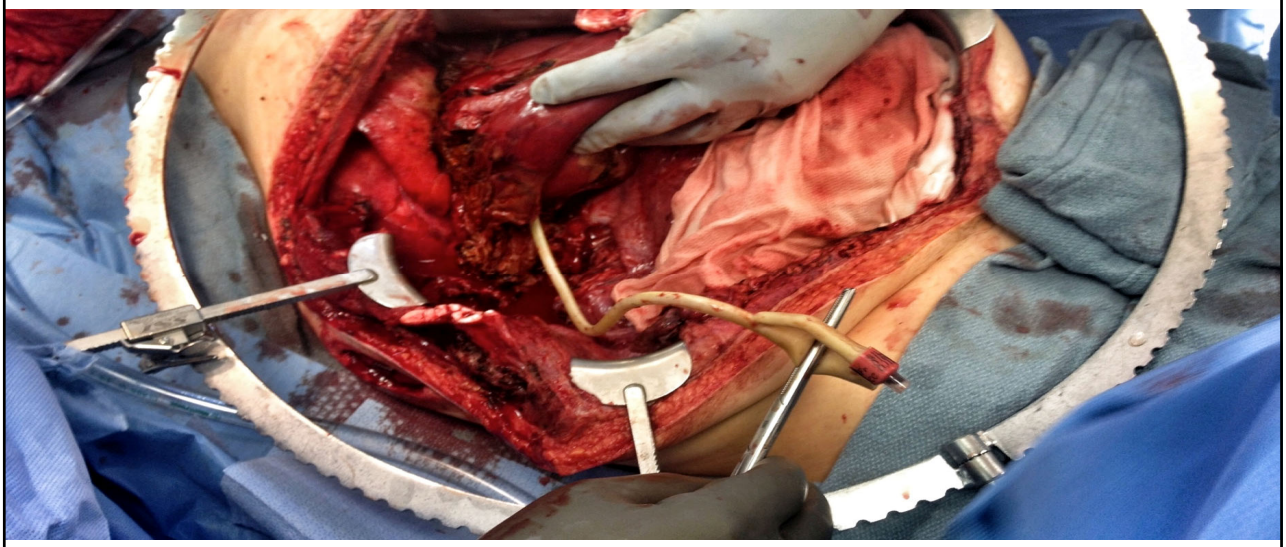

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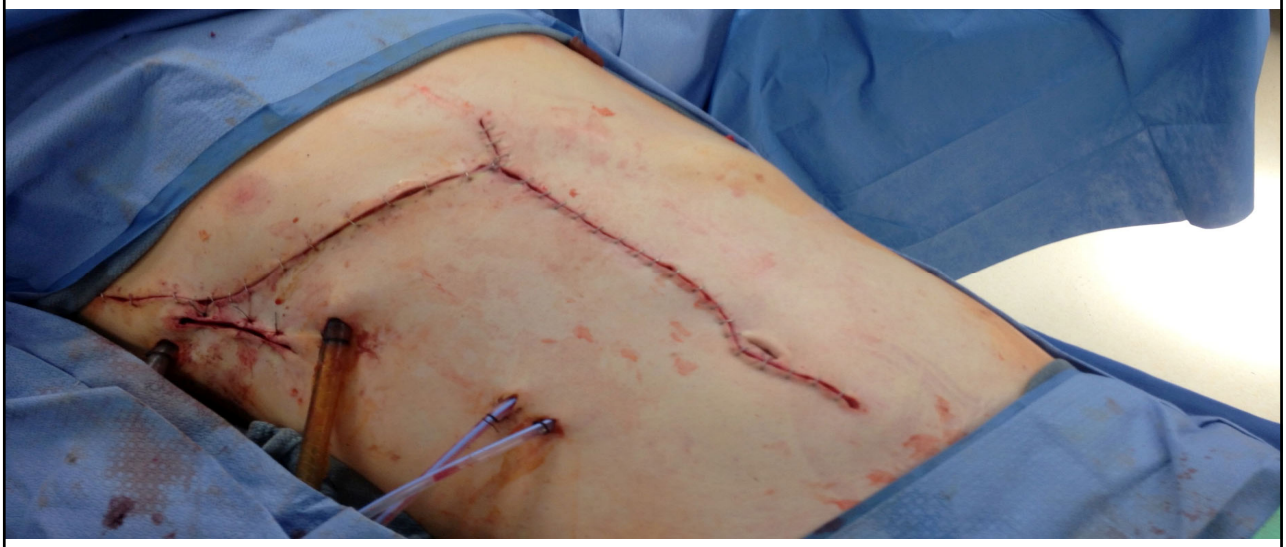

Shotgun to RUQ