# Too Sick to Send, Too Sick to Stay: Early Resuscitation at the Non-Trauma Center

2021 Health Coalition Emergency Management Seminar
Trauma Management for Rural EMS And Community Hospitals

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No disclosures or conflicts of interest

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## Overview

- Benefit of trauma centers/systems
- Transfer to definitive care
- Managing life threatening injuries prior to transfer
  - ABCDE

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## Trauma Centers Save Lives

Trauma system regionalization improves mortality in patients requiring trauma laparotomy

Feature

Improved Functional Outcomes for Major Trauma Patients in a Regionalized, Inclusive Trauma System

Original Article

Trauma Mortality in Mature Trauma Systems: Are We Doing Better? An Analysis of Trauma Mortality Patterns, 1997–2008

Relationship Between Trauma Center Volume and Outcomes

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

A National Evaluation of the Effect of Trauma-Center Care on Mortality

Trauma I

**Development of trauma systems and effect on outcomes after injury**

*Avery B Nathens, Fabrice P Brunet, Ronald V Maier*

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## Trauma Centers Save Lives

SPECIAL ARTICLE

A National Evaluation of the Effect of Trauma-Center Care on Mortality

The NEW ENGLAND JOURNAL of MEDICINE

Table 4. Adjusted Case Fatality Rates and Relative Risks of Death after Treatment in a Trauma Center as Compared with Treatment in a Non–Trauma Center.*

| Variable | Weighted No. of Patients | Death in Hospital | Death within 30 Days after Injury | Death within 90 Days after Injury | Death within 365 Days after Injury |
|---|---|---|---|---|---|
| Overall population | 15,009 | | | | |
| Trauma center (%) | | 7.6 | 7.6 | 8.7 | 10.4 |
| Non–trauma center (%) | | 9.5 | 10.0 | 11.4 | 13.8 |
| Relative risk (95% CI) | | 0.80 (0.66–0.98) | 0.76 (0.58–1.00) | 0.77 (0.60–0.98) | 0.75 (0.60–0.95) |

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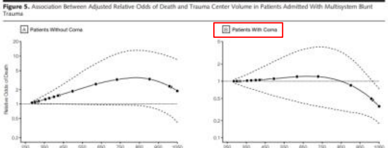
## Trauma Centers Save Lives

Relationship Between Trauma Center Volume and Outcomes

**Figure 5.** Association Between Adjusted Relative Odds of Death and Trauma Center Volume in Patients Admitted With Multisystem Blunt Trauma




Relative odds of death compared with the lowest-volume institution are shown for patients (A) without and (B) with coma. These estimates are adjusted for New Injury Severity Score, age, Glasgow Coma Scale score, and presence of shock on admission. Dashed lines represent 95% confidence intervals for estimated odds ratios.

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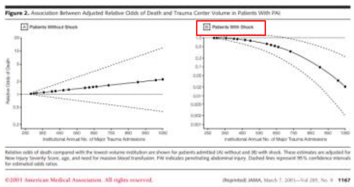
## Trauma Centers Save Lives

Relationship Between Trauma Center Volume and Outcomes






## Non-Transfer

JAMA Surgery | Original Investigation
Factors Associated With Nontransfer in Trauma Patients Meeting American College of Surgeons' Criteria for Transfer at Nontertiary Centers

- Only 20% of patients underwent transfer
  - Age > 65
  - Severe chest injury
  - Commercial insurance
  - Larger bed size
  - University affiliation
  - Non-trauma center (vs. level III)

- Adjusted mortality lower



## ACS Guidelines

Are the American College of Surgeons' Guidelines for the Transfer of Trauma Patients Feasible?

- Goal <5% under-triage
- 69% under-triage in PA Trauma Centers
- <5% = 5X increase in transfers
- Could "save" 99 patients per year

## Transfer to Definitive Care


- Direct from scene vs. transfer patients
- Transfer patients sicker (higher ISS, lower GCS, lower SBP, higher mortality)
- 162 minutes at referring centers (134 minutes with hypotension)
  - GCS 3 = more likely to prompt transfer as opposed to general injury severity



## Transfer to Definitive Care


| | |
|---|---|
| 31% intubated | 1% laparotomy |
| 11% chest tube | 3% had aortic arch angiography |
| 11% blood | 35% had head CT |
| 2% vasopressors | 5% had with hypotension had abdominal CT |



## RTTDC

## RTTDC

TABLE 2. Pre/Post Univariate Analysis, Individualized by Exposure Groups

| Variable | Pre | Post | p |
|---|---|---|---|
| Referring hospital ED LOS (IQR), min | RTTDC | RTTDC | |
| | 195 (120–251) | 122 (91–176) | 0.002* |
| | Control | Control | |
| | 153 (105–205) | 184.5 (110–237.5) | 0.31 |
| Time to call for transfer (IQR), min | RTTDC | RTTDC | |
| | 134 (71–176) | 76 (54–131) | 0.01* |
| | Control | Control | |
| | 100 (65–144) | 121.5 (73.5–165) | 0.28 |
| Pretransfer CT imaging, n (%) | RTTDC | RTTDC | |
| | 36 (59%) | 33 (47.8%) | 0.20 |
| | Control | Control | |
| | 32 (47.8%) | 35 (62.5%) | 0.10 |
| Died, n (%) | RTTDC | RTTDC | |
| | 1 (1.64%) | 5 (7.25%) | 0.13 |
| | Control | Control | |
| | 6 (8.96%) | 7 (12.5%) | 0.52 |

*$p < 0.05$.
IQR, interquartile range.

AAST 2015 Plenary Paper

Rural Trauma Team Development Course decreases time to transfer for trauma patients



## Primary Survey: (C)ABCDE

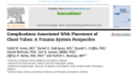
- Circulation (major external hemorrhage)
- Airway
- Breathing
- Circulation
- Disability
- Exposure



## Airway

- Have plan and at least one back-up plan
- Anticipate cardiovascular collapse
- Ketamine has favorable profile (even with TBI)

## Breathing


Complications Associated With Placement of Chest Tubes: A Trauma Systems Perspective

- Non-trauma center placement
  - Increased malposition
  - Increase residual hemothorax/pneumothorax
  - Increased need for second chest tube
  - No difference in mortality

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## Breathing


ORIGINAL RESEARCH

Air Transport of Patients with Pneumothorax: Is Tube Thoracostomy Required Before Flight?

- 66 patients transported by helicopter with PTX and no tube
- 1890 feed, 28 minute transfer time
- 4 patients "deteriorated"
- All successfully treated with needle decompression

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## Circulation: The Hypotensive Patient

Hypotension = bleeding until proven otherwise

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## Circulation: The Hypotensive Patient

- Where are the 7 places into which a human can exsanguinate?
  - Thoracic cavity (x 2)
  - Abdomen
  - Pelvis/retroperitoneum
  - Femur (x 2)
  - Onto the floor (external hemorrhage)



## Circulation: The Hypotensive Patient

- Other causes of hypotension
  - Tension pneumothorax
  - Cardiac tamponade
  - Neurogenic shock (not spinal shock)

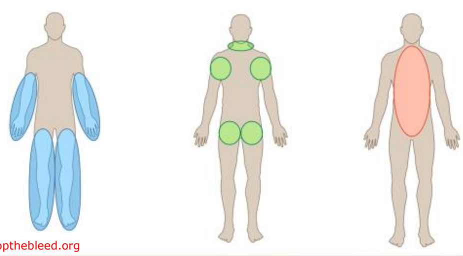


## "Cavitary Triage"

https://www.jems.com/patient-care/trauma/wound-packing-essentials-for-emts-and-paramedics/

## Bleeding "Toolkit"



stopthebleed.org

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## Tourniquet


The trauma center is too late: Major limb trauma without a pre-hospital tourniquet has increased death from hemorrhagic shock


Prehospital tourniquet use in penetrating extremity trauma: Decreased blood transfusions and limb complications

- Tourniquet = higher SBP and less blood products
- No increase in nerve palsy, infection, amputation, or fasciotomy
- Delay associated with higher morbidity and mortality

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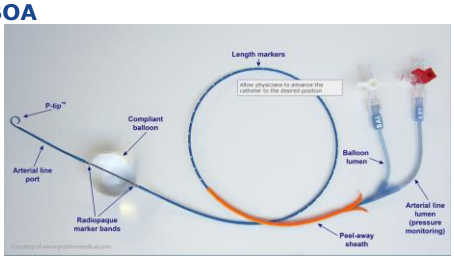
## REBOA

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## Circulation: Loss of Pulses

- Penetrating thoracic trauma < 15 minutes from arrival, "witnessed" blunt trauma
  - Emergency department thoracotomy
- "Unwitnessed" blunt trauma, penetrating trauma > 15 minutes, no surgical capabilities
  - Airway, access, bilateral chest tubes, blood, cardiac US, CPR (ACLS)
  - AABBCC

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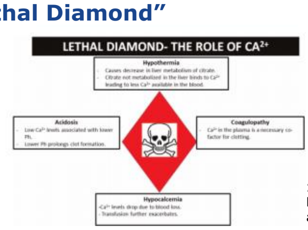
## "Lethal Diamond"





Review Article

A review of transfusion- and trauma-induced hypocalcemia: Is it time to change the lethal triad to the lethal diamond?

**> 50% trauma patients have hypocalcemia on admission**

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## Hypocalcemia

Review Article

A review of transfusion- and trauma-induced hypocalcemia: Is it time to change the lethal triad to the lethal diamond?

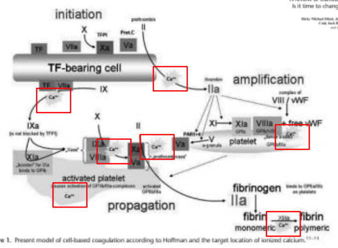


Figure 1. Present model of cell-based coagulation according to Hoffman and the target location of ionized calcium.



## Evolution of Fluid Resuscitation

- Whole blood
- Individual components (around Vietnam)
- Massive crystalloid resuscitation (1990s)
- 1:1:1 resuscitation
- Whole blood

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## PROMMTT

Original Article

Online First

The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study

*Comparative Effectiveness of a Time-Varying Treatment With Competing Risks*

- Prospective cohort study
- Adults surviving > 30 minutes who received blood
- Increased plasma:PRBC and platelet:PRBC = better 6 hour mortality
- <1:2 were 3-4x more likely to die (early) compared with 1:1 or higher

## PROPPR


Research

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma
The PROPPR Randomized Clinical Trial

- RCT of patients predicted to require MTP
- 1:1:1 vs 1:1:2 (plasma/platelets/PRBC)
- Decreased death by exsanguination at 24 hours in 1:1:1
- No difference in overall survival

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## PAMPer Trial


The NEW ENGLAND JOURNAL of MEDICINE

Prehospital Plasma during Air Medical Transport in Trauma Patients at Risk for Hemorrhagic Shock

- RCT of thawed plasma vs. standard resuscitation
- 23% vs 33% 30 day mortality
- 42/40 minute median prehospital transport times

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## Urban Setting


Plasma-first resuscitation to treat haemorrhagic shock during emergency ground transportation in an urban area: a randomised trial

- Hemorrhagic shock patients randomized to plasma vs. crystalloid
- 19/16 minute median transport times
- Not associated with survival benefit

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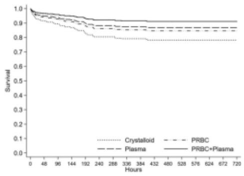
## PAMPer Analysis

•Hypotensive injured patients

ORIGINAL ARTICLE

Prehospital Blood Product and Crystalloid Resuscitation in the Severely Injured Patient

*A Secondary Analysis of the Prehospital Air Medical Plasma Trial*






## Whole Blood

•Cold-stored (1-6 degrees Celcius)

•Low titer (<1:200)

•Type O

•21-35 day shelf life

Rahbar E, at al. *Shock*, 2015;44(5); Yazer MH, et al. *J Trauma Acute Care Surg*, 2018;84(6); Cotton BA, et al. *Ann Surg*, 2013;258(4); Condron M, et al. *Transfusion*, 2019;59; Murdock AD, et al. *Shock*, 2014;41(supplement 1); Nederpelt CJ, et al. *J Am Coll Surg*, 2020;230; Sperry JL, et al. *N Engl J Med*, 2018;379; Holcomb JB, et al. *JAMA*, 2015;313(5); Holcomb JB, et al. *JAMA Surg*, 2013;148(2) Pivalizza EG, et al. *Anesthesia & Analgesia*, 2018;127(1)

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## Whole Blood vs. Components

| | Whole Blood | Components |
|---|---|---|
| Volume (ml) | 570 | 675 |
| Hematocrit (%) | 38-50 | 29 |
| Platelet Count | 150,000-400,000 | 88,000 |
| Factor Activity (%) | 100 | 65 |
| Fibrinogen (mg) | 1000 | 750 |

Leeper CM, et al. JAMA Surg, 2020

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## Potential Benefits

Improved logistics

Faster resolution of shock/coagulopathy

Decreased overall transfusion requirements

Decreased infection

Less citrate

Improve platelet function

Decreased donor exposure

Yazer MH, et al. *J Trauma Acute Care Surg*, 2018;84(6); Murdock AD, et al. *Shock*, 2014;41(supplement 1); Leeper CM, et al. *JAMA Surg*, 2020



## Previous MTP

Cooler 1
- 4U PRBC

Cooler 2
- 4U PRBC

Cooler 3/4
- 4U PRBC/4U FFP/1 PLT *or* 1U Cryo

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## MTP with Whole Blood

Cooler 1
- 4U PRBC *or* 2U WB

Cooler 2
- 2U WB *or* 4U PRBC

Cooler 3/4
- 4U PRBC/4U FFP/1 PLT *or* 1U Cryo

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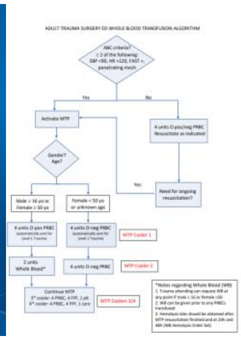


## TXA

- RCT patients with/at risk of bleeding within 8 hours of injury
- Primary outcome = death within 4 weeks
- 10,000 patients in each group
- 14.5% vs 16% mortality

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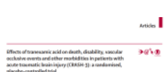
## TXA



- Adults with TBI within 3 hours of injury
- Primary outcome = head-injury related death at 28 days
- No difference between groups
- No difference when exclude dilated pupils/GCS 3
- With mild to moderate head injury, TXA associated RR 0.78
- No increased risk of occlusive events, seizures

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## TXA

- Patients with SBP ≤ 90; or HR ≥ 110 within two hours of injury
- Primary outcome = 30 day mortality
- 8.1% vs 9.9%
- Mortality lower when SBP <70 and in those administered within 1 hour of injury
- No increase in vaso-occlusive events



## TXA

- Patients ≥ 15 years old with GCS ≤ 12 and SBP ≥ 90 within two hours of injury
- TXA vs placebo
- No difference in mortality, 6 month outcomes, ICH progression

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## TXA Summary

- Reasonable for patients with hemorrhage
  - Especially if BP <70 and very early from injury
- ? Higher initial dose better (?2 grams)
- ? Base second dose on TEG results
- Unclear benefit in isolated head injury

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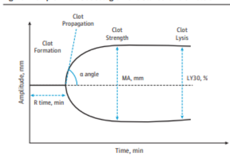
## TEG

Figure. Example Thromboelastogram and Standard Parameters




α Angle indicates the angle of the upward slope of the tracing curve; LY30, the decrease in tracing width at 30 minutes; MA, maximum amplitude; and R time, reaction time.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## Circulation- Laparotomy


- Patients transferred after laparotomy (2003)
- 56 total patients, 14 underwent damage control
- Overall survival 82%
- Transfer for treatment of extra-abdominal injury only significant predictor of survival

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## Circulation- Laparotomy

- Damage control laparotomy at referring facility = 14 % mortality
- Unstable transfer patients = 75% mortality
- Stable transfer patients = 3% mortality

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Prehospital resuscitation in adult patients following injury: A Western Trauma Association critical decisions algorithm

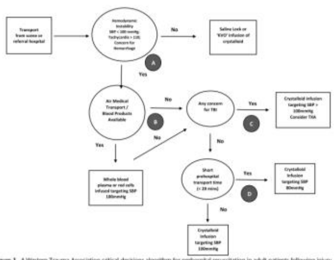


Figure 1. A Western Trauma Association critical decisions algorithm for prehospital resuscitation in adult patients following injury.

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## Gaps in Knowledge

Prehospital resuscitation in adult patients following injury: A Western Trauma Association critical decisions algorithm

TABLE 1. Top Identified Knowledge and Research Gaps Related to Prehospital Resuscitation

| Topic or Research Knowledge Gap | Algorithm Section |
|---|---|
| 1. Vital sign definition of hemodynamic instability | A |
| 2. Specific crystalloid fluid and target administration method | A |
| 3. Cold stored group O whole blood benefits as compared with standard prehospital component resuscitation such as packed red blood cells | B |
| 4. TBI and hemorrhagic shock combined management | C |
| 5. Prehospital TXA administration and specific injured cohort who benefits | C |
| 6. Patient cohorts who benefit from prehospital hypotensive or controlled resuscitation | D |

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## Circulation in Summary

- Humans can exsanguinate into 7 places
- 1:1:1 and whole blood better than crystalloid
- Crystalloid better than nothing?
- TXA should be considered if concern for major hemorrhage
- Give calcium (2 grams for every 2-4 units PRBC)
- Know the tools you have available
- Know what surgical capabilities you have

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## Disability

- **Goal is to prevent secondary injury**
  - **SBP >90 mm Hg (ideally >110 mm Hg)**
  - **$O_2$ saturation >90% (ideally 94-98%)**
- Consider HTS (3%) if lateralizing signs
- DDAVP
- PCC



## Disability: CT Head?

*Head CT before Transfer Does Not Decrease Time to Craniotomy for TBI Patients*

- Neurosurgery OR immediately after arrival
- 86% received HCT prior to transfer
- CT imaging = transfer delay up to 90 minutes
- Did not get to OR faster



## Disability: EPIC Study

Association of Statewide Implementation of the Prehospital Traumatic Brain Injury Treatment Guidelines With Patient Survival Following Traumatic Brain Injury
The Excellence in Prehospital Injury Care (EPIC) Study

After implementation:
- Intubation rate decreased
- BVM use increased
- Hyperventilation decreased
- Survival doubled in severe TBI
- Survival tripled in severe TBI/intubated
- Better survival to hospital admission

## Disability

ACS TQIP
BEST PRACTICES IN
THE MANAGEMENT
OF TRAUMATIC
BRAIN INJURY

**Table 2. Goals of Treatment**

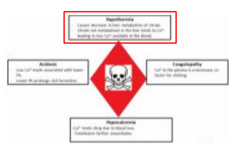
| | | |
|---|---|---|
| Pulse Oximetry ≥ 95% | ICP 20 - 25 mmHg | Serum sodium 135-145 |
| $PaO_2$ ≥ 100 mmHg | $PbtO_2$ ≥ 15 mmHg | INR ≤ 1.4 |
| $PaCO_2$ 35-45 mmHg | CPP ≥ 60 mmHg * | Platelets ≥ 75 x $10^3$ / $mm^3$ |
| SBP ≥ 100 mmHg | Temperature 36.0-38°C | Hemoglobin ≥ 7 g/dl |
| PH 7.35-7.45 | Glucose 80-180 mg/dL | |

PaO2: partial pressure of oxygen; PaCO2: partial pressure of carbon dioxide; SBP: systolic blood pressure; ICP: intracranial pressure; PbtO2: brain tissue oxygen tension; CPP: cerebral perfusion pressure; INR: international normalized ratio; *depending on status of cerebral autoregulation



## Exposure

- Ensure adequate exposure
- Prevent hypothermia
- Ensure safe transport

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