2022

**Trauma Induced Coagulopathy**

Patrick Corey

Follow this and additional works at: [https://scholar.rochesterregional.org/grandrounds_rgh](https://scholar.rochesterregional.org/grandrounds_rgh)

Part of the [Emergency Medicine Commons](https://scholar.rochesterregional.org/grandrounds_rgh), and the [Medical Education Commons](https://scholar.rochesterregional.org/grandrounds_rgh)
Trauma Induced Coagulopathy

Patrick Corey, M.D.
Program Director, Emergency Medicine Residency Program, RGH
Goals

• Discuss how traumatic events affect coagulation of patient

• Steps ED doctor can take to prevent and treat coagulopathy

• New technology and how can help guide trauma care
Trauma

- Massive hemorrhage: 50% if trauma deaths
- Coagulopathy: 7x increase in mortality
Triad of Death

Coagulopathy

Acidosis

Hypothermia
Coagulopathy
Acute Endogenous Coagulopathy

- Trauma
  - Hemostatic Cascade
  - Hemorrhage
    - Shock
      - Hypoxia
        - Acidosis
          - Traumatic Coagulopathy
  - Fibrinolysis

ROCHESTER REGIONAL HEALTH
Acute Traumatic Coagulopathy

- Brohi, J Trauma, 2003

- 25% of patients arrived to ED COAGULOPATHIC
Acute Traumatic Coagulopathy

- No correlation between fluid and coagulopathy
Endothelial Glycocalyx

van den Berg, Vink & Spaan, Circulation Research 2003, 92: 592-594
Trauma and Endothelium

Normal  

Ischemia
Endothelial Breakdown

- Glycocalyx
  - Endothelial cell
  - Tight junction

Inflammation:
- Heparan sulfate
- Syndecan-1
- Hyaluronan
- Versican
- Breakdown of endothelial glycocalyx and tight junction

Coagulation:
- Capillary leakage syndrome
- Hypoxia, edema, MODS

Normal

Trauma

Physiologic
Pathologic (Trauma and Shock)
Prevent the “Lethal Triad”
Damage Control Resuscitation (DCR)$^2$

- Prevent Hypothermia
  - Warm the patient
  - Blood products through fluid warmer

- Massive Transfusion
  - Early transfusion of blood products
  - Minimize IVF

- Permissive Hypotension
  - Don’t ‘pop the clot’

- Administration of TXA
DCR – Preventing Hypothermia

• Hypothermia:
  • Increased heat loss
  • Decreased heat generation

• ↑coagulation times

• Maintaining normothermia shown to improve survival\(^{13}\)
DCR - Massive Transfusion

• Military Conflict: whole blood

• Borgman, J Trauma 2007³
PROMMTT\textsuperscript{10}

- Holcomb, JAMA Surgery, 2013

- Early use of plasma/platelets -> Improved survival
PROPPR\textsuperscript{11}

- Consistent transfusion rations
  - 1:1:1 vs 1:1:2

- No mortality difference
MTP

Start within minutes

Balanced Ratio
Who Gets MTP?

• Nunez, J Trauma, 2010\textsuperscript{12}

• Predictors:
  • Penetrating Mechanism
  • SBP ≤ 90
  • HR ≥ 120
  • Positive FAST

\[ \geq 2 \rightarrow 85\% \text{ sensitive, } 86\% \text{ specific} \]
MTP at RGH

Order Sets
ED Massive Transfusion

- Massive Transfusion Protocol
- Massive Transfusion Orders

**IF THE PATIENT IS ACTIVELY BLEEDING AND HAS RECEIVED OR IS LIKELY TO RECEIVE GREATER THAN OR EQUAL TO 6 UNITS OF PRBC'S IN 2 HOURS (OR AFTER 2 UNITS IN 2 HOURS FOR CHILDREN LESS THAN AGE 12), CONSIDER ACTIVATING THE MASSIVE TRANSFUSION PROTOCOL (MTP) TO PREVENT COAGULOPATHY.**

For CRISIS orders (near code situation) call Blood Bank IMMEDIATELY then place orders.

RGH 2-4083
Newark 3-2380
CSH call 315-462-1600: Dial, 4 then 3, to get directly to Blood Bank
Unity call x1129 from within hospital. Call 585-723-7040 x1129 if calling from outside
CPH/GH call 315-265-3300 x1208
MH call 315-769-4282

For STAT orders (blood needed within 1 hour) place orders, then CALL Blood Bank
R GH 2-4083
Newark 3-2380
CSH call 315-462-1600: Dial, 4 then 3, to get directly to Blood Bank
Unity call x1129 from within hospital 585-723-7040 x1129 if calling from outside
CPH/GH call 315-265-3300 x1208
MH call 315-769-4282

☐ MTP PANEL

- Post-Transfusion Labs
- Additional SmartSet Orders

Click for more
DCR - Permissive Hypotension

- Sterns, Academic Emergency, 1995
  - Resuscitated to MAPs of 40, 60, 80

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Survival Time and Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survival Time (min)</td>
</tr>
<tr>
<td>Group I</td>
<td>58 ± 7</td>
</tr>
<tr>
<td>Group II</td>
<td>57 ± 8</td>
</tr>
<tr>
<td>Group III</td>
<td>44 ± 12*</td>
</tr>
</tbody>
</table>
Table 5. Outcome of Patients with Penetrating Torso Injuries, According to Treatment Group.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>IMMEDIATE RESUSCITATION</th>
<th>DELAYED RESUSCITATION</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to discharge — no. of patients/total patients (%)</td>
<td>193/309 (62)*</td>
<td>203/289 (70)†</td>
<td>0.04</td>
</tr>
<tr>
<td>Estimated intraoperative blood loss — ml‡</td>
<td>3127±4937</td>
<td>2555±3546</td>
<td>0.11</td>
</tr>
<tr>
<td>Length of hospital stay — days§</td>
<td>14±24</td>
<td>11±19</td>
<td>0.006</td>
</tr>
<tr>
<td>Length of ICU stay — days§</td>
<td>8±16</td>
<td>7±11</td>
<td>0.30</td>
</tr>
</tbody>
</table>

- Immediate IVF
  - Promoted ongoing hemorrhage
  - Hydraulic disruption of thrombus
  - Dilution of coagulation factors
## DCR - TXA for Trauma Patients

**Figure 2: Mortality by days from randomisation**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Tranexamic acid (n=10,060)</th>
<th>Placebo (n=10,067)</th>
<th>RR (95% CI)</th>
<th>p value (two-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any cause of death</td>
<td>1463 (14.5%)</td>
<td>1613 (16.0%)</td>
<td>0.91 (0.85-0.97)</td>
<td>0.0035</td>
</tr>
<tr>
<td>Bleeding</td>
<td>489 (4.9%)</td>
<td>574 (5.7%)</td>
<td>0.85 (0.76-0.96)</td>
<td>0.0077</td>
</tr>
<tr>
<td>Vascular occlusion*</td>
<td>33 (0.3%)</td>
<td>48 (0.5%)</td>
<td>0.69 (0.44-1.07)</td>
<td>0.096</td>
</tr>
<tr>
<td>Multiorgan failure</td>
<td>209 (2.1%)</td>
<td>233 (2.3%)</td>
<td>0.90 (0.75-1.08)</td>
<td>0.25</td>
</tr>
<tr>
<td>Head injury</td>
<td>603 (6.0%)</td>
<td>621 (6.2%)</td>
<td>0.97 (0.87-1.08)</td>
<td>0.60</td>
</tr>
<tr>
<td>Other causes</td>
<td>129 (1.3%)</td>
<td>137 (1.4%)</td>
<td>0.94 (0.74-1.20)</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Data are number (%), unless otherwise indicated. RR=relative risk. *Includes myocardial infarction, stroke, and pulmonary embolism.

Table 2: Death by cause
# Table 2: Vascular occlusive events, need for transfusion and surgery, and level of dependency

<table>
<thead>
<tr>
<th></th>
<th>Tranexamic acid (n=10,060)</th>
<th>Placebo (n=10,067)</th>
<th>RR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vascular occlusive events</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any vascular occlusive event</td>
<td>168 (1.7%)</td>
<td>201 (2.0%)</td>
<td>0.84 (0.68-1.02)</td>
<td>0.084</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>35 (0.3%)</td>
<td>55 (0.5%)</td>
<td>0.64 (0.42-0.97)</td>
<td>0.035</td>
</tr>
<tr>
<td>Stroke</td>
<td>57 (0.6%)</td>
<td>66 (0.7%)</td>
<td>0.86 (0.61-1.23)</td>
<td>0.42</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>72 (0.7%)</td>
<td>71 (0.7%)</td>
<td>1.01 (0.73-1.41)</td>
<td>0.93</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>40 (0.4%)</td>
<td>41 (0.4%)</td>
<td>0.98 (0.63-1.51)</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Need for transfusion and surgery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood product transfused</td>
<td>3069 (30.4%)</td>
<td>3160 (31.3%)</td>
<td>0.98 (0.96-1.01)</td>
<td>0.21</td>
</tr>
<tr>
<td>Any surgery</td>
<td>4814 (47.9%)</td>
<td>4836 (48.0%)</td>
<td>1.00 (0.92-1.03)</td>
<td>0.79</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>1040 (10.3%)</td>
<td>2163 (10.5%)</td>
<td>0.98 (0.91-1.07)</td>
<td>0.67</td>
</tr>
<tr>
<td>Chest surgery</td>
<td>1515 (15.1%)</td>
<td>1525 (15.1%)</td>
<td>1.00 (0.93-1.06)</td>
<td>0.91</td>
</tr>
<tr>
<td>Abdominal surgery</td>
<td>2487 (24.7%)</td>
<td>2555 (25.4%)</td>
<td>0.97 (0.93-1.02)</td>
<td>0.28</td>
</tr>
<tr>
<td>Pelvic surgery</td>
<td>683 (6.8%)</td>
<td>648 (6.4%)</td>
<td>1.05 (0.95-1.17)</td>
<td>0.31</td>
</tr>
<tr>
<td>Median (IQR) units of blood product transfused†</td>
<td>3 (2-6)</td>
<td>3 (2-6)</td>
<td>..</td>
<td>0.59†</td>
</tr>
<tr>
<td><strong>Dependency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No symptoms</td>
<td>1483 (14.7%)</td>
<td>1334 (13.3%)</td>
<td>1.11 (1.04-1.18)</td>
<td>0.0023</td>
</tr>
<tr>
<td>Minor symptoms</td>
<td>3054 (30.4%)</td>
<td>3063 (30.4%)</td>
<td>1.00 (0.96-1.04)</td>
<td>0.94</td>
</tr>
<tr>
<td>Some restriction</td>
<td>2016 (20.0%)</td>
<td>2069 (20.6%)</td>
<td>0.97 (0.92-1.03)</td>
<td>0.36</td>
</tr>
<tr>
<td>Dependent (not requiring constant attention)</td>
<td>1294 (12.9%)</td>
<td>1271 (12.6%)</td>
<td>1.02 (0.95-1.09)</td>
<td>0.63</td>
</tr>
<tr>
<td>Fully dependent</td>
<td>696 (6.9%)</td>
<td>676 (6.7%)</td>
<td>1.03 (0.93-1.14)</td>
<td>0.57</td>
</tr>
<tr>
<td>Alive (disability status not known)</td>
<td>54 (5.5%)</td>
<td>41 (4.4%)</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Dead</td>
<td>1463 (14.5%)</td>
<td>1613 (16.0%)</td>
<td>0.91 (0.85-0.97)</td>
<td>0.0035</td>
</tr>
</tbody>
</table>

Data are number (%), unless otherwise indicated. Counts are for numbers of patients with at least one such event. RR=relative risk. *Includes both fatal and non-fatal events. †Transfused patients only. ‡Analysis used logarithmic transformation of mean units of blood products transfused.
Balanced Resuscitation

- Minimize Crystalloid
- 1:1:1 Product Ratio
- TXA
- Permissive Hypotension
Do not define the overall process, just provide pieces of the process!
Thrombelastography (TEG)
• **R**: Reaction Time = Thrombin Generation

• **α**: Clot Formation Time = Fibrinogen

• **MA**: Maximum Amplitude = Platelets

• **Ly30**: Lysis at 30min = Fibrinolysis
Fancy Glasses

ROCHESTER REGIONAL HEALTH
Does it Work?

• Goal-directed Hemostatic Resuscitation of Trauma-induced Coagulopathy

50% reduced mortality
Primary Fibrinolysis in Trauma


• Primary Fibrinolysis – 34% of patients who required MTP
Hyperfibrinolysis

• Cotton, J Trauma Acute Care Surg\textsuperscript{7}

• Hyperfibrinolysis = \ (~2\%)

• Each 1L of crystalloid – 15\% increased odds of hyperfibrinolysis
Hyperfibrinolysis

Mortality rate by percent fibrinolysis

LY-30% 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
Mortality rate (%) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Fibrinolysis and Mortality

The diagram illustrates the percent mortality associated with different levels of fibrinolysis:

- **Shutdown Ly30 < 0.8%**
- **Physiologic Ly30 0.9–2.9%**
- **Hyper Ly30 > 3%**

The graph shows an increasing mortality rate as the fibrinolysis level increases from shutdown to hyper.
Improved Blood Product Use

- Kashuk, Transfusion, 2011\(^9\)
- More efficient transfusion management?
What Have We Learned?

• Many trauma patients ARRIVE to the ED coagulopathic

• Damage Control Resuscitation

• Thromboelastography: bedside application for better trauma care
References


References


