Prehospital Hemorrhage Control and Resuscitation

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Disclosures

Founder and on the board of Decisio Health

The PROPPR Study was Funded by NIH

DoD funded for prehospital multicenter transfusion study

Receive royalties for co-inventing a Junctional tourniquet
Bottom Line Up Front

• Hemorrhage is the leading potentially preventable cause of trauma death

• Crystalloid resuscitation increase blood loss, transfusion requirements and death

• Balanced blood product resuscitation decreases blood loss, transfusion requirements and improves survival
  – Plasma as the primary resuscitation fluid
  – Must have thawed/liquid plasma in the ED or prehospital to really do this well

• Time is critical
• Rapid progress in trauma care occurs during a war.

• Damage control resuscitation addresses **diagnosis and treatment of the entire lethal triad** immediately upon admission.
DCR components

• Stop bleeding
• Hypotensive resuscitation
• Minimize crystalloid
• Use plasma to resuscitate patients
• Increased platelet use
• Reverse hypothermia and acidosis
• Hemostatic adjuncts
Hemorrhage Control

• Resuscitation is much easier (or only possible) when bleeding is controlled

• External compression
  – Tourniquets
  – Junctional

• Truncal Hemostasis
  – Operative (Run faster)
  – New?
Effective Improvised Tourniquet – Somalia 1993
A Preventable Death: 2003

The casualty was wounded by an RPG and sustained a traumatic amputation of the right arm and a right leg wound.

He bled to death from his leg wound despite the placement of three improvised tourniquets.

What could have saved him
   C.A.T. Tourniquet
   TCCC training for all unit members
*Note: Medic killed at onset of action
CAT x 2 applied by non medics

- By 2005 almost all casualties present with CATs on
  - Saving lives and limbs
  - Easy and fast to use by non medical personnel
- Few if any improvised tourniquets
Practical Use of Emergency Tourniquets to Stop Bleeding in Major Limb Trauma

John F. Kragh, Jr., MD, Thomas J. Walters, PhD, David G. Baer, PhD, Charles J. Fox, MD, Charles E. Wade, PhD, Jose Salinas, PhD, and COL John B. Holcomb, MC

• Data from 2006
• 232 patients
  – 220 males
  – ages: 4–70
    • median 28
• 309 limbs
• 428 tourniquets

• Conclusion

• CAT is highly effective and safe
Houston – Hemorrhage Control Achieved with Blended Funding: Philanthropy – Hospital - RAC

- 2008 - Damage Control Resuscitation in Hospital
- 2008 - Tourniquets on Helicopters
- 2010 - Thawed Plasma and RBCs in the ED
- 2012 - Liquid Plasma, RBCs and ultrasound on Helicopters
- 2013 - 3 tourniquets on each of the 600 ground ambulances
- 2014 - 2 Tourniquets and 1 Combat Gauze on all 5000 uniformed Houston Police Officers
- 2014 - Junctional Tourniquets on Helicopter
- 2014 - Liquid Plasma and RBCs in the ED in Level 3 trauma centers
- 2015 - Planning for plasma and RBCs on select ground units
2013
Laceration to ulnar artery treated at scene by police officer
- 2015
- Civilian patient
- LUE traumatic amputation
- Treated with manual compression by immediate responder then CAT and blood products by flight medics
- Home in 5 days
Junctional Hemorrhage

Figure 1  *The Junctional Emergency Treatment Tool (JETT™).*
409 patients were screened.  
324 did not meet criteria  
44 subjects died before informed consent  
25 subjects declined to participate  
11 subjects were excluded for other reasons  
21 recently deceased subjects were successfully enrolled in the study across three sites
Which would you rather have?

Resuscitative Thoracotomy

REBOA
Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage

J Trauma, accepted

Laura J. Moore, MD, Megan Brenner, MD, Rosemary A. Kozar, MD, PhD, Jason Pasley, DO, Charles E. Wade, PhD, Mary S. Baraniuk, PhD, Thomas Scalea, MD, and John B. Holcomb, MD, Houston, Texas

**Total Number of Patients Undergoing REBOA**
N = 24 Patients

- **REBOA with Vitals Present on ER Admission**
  N = 17 Patients
  - **+ FAST ZONE I REBOA**
    N = 13 Patients
    - **46% Survival**
  - **- FAST, + Pelvic Fracture ZONE III REBOA**
    N = 4 Patients
    - **75% Survival**

- **REBOA with CPR in Progress on ER Admission**
  N = 7 Patients*
  - **+ FAST ZONE I REBOA**
    N = 6 Patients
    - **0% Survival**
  - **- FAST, + Pelvic Fracture ZONE III REBOA**
    N = 1 Patients
    - **0% Survival**

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*4 patients missing data regarding definitive source of hemorrhage but all of these patients underwent Zone 1 occlusions
REBOA vs ED Thoracotomy

Figure 3. Graphic depiction of the number of RT and REBOA during the 18-month study period.
Optimal Resuscitation Fluids
The resuscitation fluids of choice for casualties in hemorrhagic shock are (in priority order):

- whole blood,
- plasma, RBCs and platelets in 1:1:1 ratio;
- plasma and RBCs in 1:1 ratio;
- plasma or RBCs alone;
- Hextend;
- crystalloid (lactated Ringer’s or Plasma-Lyte A).
How do you make early blood products happen?

- Work with the Blood bank and Donor Center
- O- RBCs—in the ED and prehospital
- AB or A plasma—in the ED and prehospital
  - Thawed or Liquid plasma
- Platelets—in the ED and prehospital
- Prehospital and in the ED
Prehospital and Hospital

• No distinction
• Should be a seamless continuum
• What works in the hospital should be used prehospital

• Not slow down transport

• Basic premise of EMS

5000 Hospitals
1852 trauma centers
50,000 ambulances
Prehospital plasma and RBC transfusion was associated with improved early outcomes, negligible blood products wastage.

Similar to the data published from the ongoing war, improved early outcomes are associated with placing blood products prehospital.

Thousands of units flown, > 300 patients transfused

1.9% wastage

20% transfusion rate
Houston LifeFlight Capability

- Services 150-mile radius, 3000 missions/yr
- RNs and EMT-P
- Advanced capabilities:
  - Tourniquets and hemostatic dressings
  - Junctional hemorrhage control devices
  - Pre-hospital plasma and RBCs use
  - Ultrasound diagnostics
  - Portable blood warmers
  - LVAD, ECMO

New technology
Utilized first in the ED by trauma surgeons.
If successful, then on LifeFlight
Liquid Plasma and RBCs are the Primary Resuscitation Fluids Pre-Hospital
Base Station (x4) Refrigerator
Plasma and RBCs, prehospital, ED and OR
Several centers have platelets in the ED

Balanced blood product resuscitation of bleeding patients is our standard of care.
A Randomized Controlled Pilot Trial of Modified Whole Blood Versus Component Therapy in Severely Injured Patients Requiring Large Volume Transfusions

Bryan A. Cotton, MD, MPH,* † Jeanette Podbielski, BSN, † Elizabeth Camp, MSPH, † Timothy Welch, NREMT-P, † Deborah del Junco, PhD, † Yu Bai, MD, PhD, ‡ Rhonda Hobbs, MT (ASCP), ‡ Jamie Scroggins, MT (ASCP), § Beth Hartwell, MD, § Rosemary A. Kozar, MD, PhD, * Charles E. Wade, PhD, * † and John B. Holcomb, MD* † on behalf of The Early Whole Blood Investigators

Screened 1695
Enrolled 107

### TABLE 5. Sensitivity Analysis Evaluating the Primary and Secondary Outcomes in Those Patients Without Severe TBI

<table>
<thead>
<tr>
<th></th>
<th>WB Group (n = 33)</th>
<th>COMP Group (n = 34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median 24-hr RBC</td>
<td>4 (2, 6)</td>
<td>6 (2, 13)</td>
<td>0.02</td>
</tr>
<tr>
<td>transfusions, U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median 24-hr plasma</td>
<td>4 (2, 7)</td>
<td>6 (2, 14)</td>
<td>0.02</td>
</tr>
<tr>
<td>transfusions, U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median 24-hr platelet</td>
<td>0 (0, 1)</td>
<td>1 (0, 2)</td>
<td>0.09</td>
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<tr>
<td>transfusions, U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median 24-hr total</td>
<td>11 (5, 17)</td>
<td>16 (4, 41)</td>
<td>0.02</td>
</tr>
<tr>
<td>transfusions, U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-hr mortality, %</td>
<td>6%</td>
<td>9%</td>
<td>0.62</td>
</tr>
<tr>
<td>30-d mortality, %</td>
<td>6%</td>
<td>9%</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Continuous values are presented as median with 25th and 75th interquartile range.
Pre Hospital resuscitation?

• Seems like a consensus is to start in the hospital with 1:1:1

• Why not start this prehospital?
  – 3 bags… storage

• Whole blood?
  – 1 bag….. storage
Ongoing Study

PROHS: Prehospital Resuscitation on Helicopter Study
RBC and/or FFP vs Crystalloid

- 9 US Level 1 trauma centers
  - 5 with blood products prehospital
  - 4 with crystalloid
- Prospective and observational
- Improved arrival status?
- Improved early survival?

Enrolled 699 patients since Jan
21% prehospital transfusion rate
### Enrollment

Enrolled 699 patients since Jan 2015
21% prehospital transfusion rate

<table>
<thead>
<tr>
<th>Site</th>
<th>IRB Approval Date</th>
<th>Actual Enrollment Date</th>
<th># Of Weeks Enrolling</th>
<th>All Trauma Counts (N)</th>
<th>At Risk Criteria N (%)</th>
<th>Highest Risk Criteria, N (% of N at Risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UT Houston</td>
<td>09/23/2014</td>
<td>01/26/2015</td>
<td>30</td>
<td>1844</td>
<td>293 (22.0)</td>
<td>260 (88.7)</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>12/23/2014</td>
<td>02/24/2015</td>
<td>26</td>
<td>477</td>
<td>77 (5.8)</td>
<td>57 (74.0)</td>
</tr>
<tr>
<td>Mayo</td>
<td>11/26/2014</td>
<td>03/02/2015</td>
<td>25</td>
<td>114</td>
<td>46 (3.5)</td>
<td>20 (43.0)</td>
</tr>
<tr>
<td>Portland</td>
<td>11/26/2014</td>
<td>02/02/2015</td>
<td>29</td>
<td>1256</td>
<td>63 (4.7)</td>
<td>28 (44.4)</td>
</tr>
<tr>
<td>Seattle</td>
<td>12/16/2014</td>
<td>02/23/2015</td>
<td>26</td>
<td>489</td>
<td>140 (10.5)</td>
<td>88 (62.9)</td>
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<tr>
<td>Baltimore</td>
<td>11/13/2014</td>
<td>03/28/2015</td>
<td>22</td>
<td>2334</td>
<td>420 (31.5)</td>
<td>143 (34.0)</td>
</tr>
<tr>
<td>USC-LA</td>
<td>10/08/2014</td>
<td>03/18/2015</td>
<td>23</td>
<td>1029</td>
<td>119 (8.9)</td>
<td>17 (14.3)</td>
</tr>
<tr>
<td>Birmingham</td>
<td>03/12/2015</td>
<td>03/26/2015</td>
<td>22</td>
<td>0</td>
<td>101 (7.6)</td>
<td>32 (31.7)</td>
</tr>
<tr>
<td>Tucson</td>
<td>12/22/2014</td>
<td>04/09/2015</td>
<td>20</td>
<td>580</td>
<td>73 (5.5)</td>
<td>24 (32.9)</td>
</tr>
<tr>
<td><strong>All Sites</strong></td>
<td></td>
<td><strong>223</strong></td>
<td><strong>8123</strong></td>
<td></td>
<td><strong>1332 (99.9)</strong></td>
<td><strong>669 (50.2)</strong></td>
</tr>
</tbody>
</table>

*Current Week’s #s*
PROHS

- Solid framework within which to design and execute a prehospital trial
- Ethical and pragmatic approach to future study design
Different Dried Plasmas

Several US companies working on dried plasma

Other ProCoagulant Products

- Prothrombin Complex Concentrate (Human) Kcentra
- Octaplas LG
- Fibrinogen Concentrate (Human) RaStrap
Way Forward

• Stop bleeding ---- devices
  – Extremity
  – Junctional
  – truncal
• Optimal resuscitation
  – Prehospital and hospital
• Improved survival
• Decreased complications (morbidity)
Thank You