Surgical Resuscitation Management in Poly-Trauma Patients

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Presenter Disclosure Information

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Surgical Resuscitation Management in Poly-Trauma Patients

FINANCIAL DISCLOSURE:
No relevant financial relationship exists
Objectives

1. Synthesize evolving strategies in resuscitation
2. Compare available resuscitation fluids for trauma patients
3. Describe high ratio resuscitation and its evidence base
Damage Control Resuscitation (DCR)

1. Permissive hypotension
2. Haemostatic transfusion/resuscitation (FFP, PLT, PRBC, TXA)
3. Damage control surgery or angiography
4. Restore organ perfusion and oxygen delivery


*Emergency department crystalloid resuscitation of 1.5 L or more is associated with increased mortality in elderly and nonelderly trauma patients.*

*J Trauma* 2011;70:398-400.
‘endotheliopathy’

Figure 1. Role of the Endothelial Glycocalyx Layer in the Use of Resuscitation Fluids. The structure and function of the endothelial glycocalyx layer, a web of membrane-bound glycoproteins and proteoglycans on endothelial cells, are key determinants of membrane permeability in various vascular organ systems. Panel A shows a healthy endothelial glycocalyx layer, and Panel B shows a damaged endothelial glycocalyx layer and resultant effect on permeability, including the development of interstitial edema in some patients, particularly those with inflammatory conditions (e.g., sepsis).

The NEW ENGLAND JOURNAL of MEDICINE

Immediate versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injuries

Ideal Resuscitation Fluid

- Predictable and sustained ↑ in intravascular volume
- Chemical composition like ECF
- Metabolized and completely excreted-without accumulation in tissues
- No adverse metabolic or systemic effects
- Cost-effective by improving patient outcomes
PolyHeme®

No Ideal Solution Exists

Crystalloid = Colloid
- Neither superior
- Systematic reviews of RCTs --> no difference\textsuperscript{1-2}

Crystalloid

- 1/3 to ¼ remains intravascular
- Hence 500 mL bolus: 
  - 500 mL x 0.25 = 125 mL
- Circulating plasma volume is ~5L (70 ml/kg IBPWH)
- 2-3% increase in IV volume

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Plasma</th>
<th>0.9% NaCl</th>
<th>Ringer’s lactate, Hartmann’s</th>
<th>Plasma Lyte®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>140</td>
<td>154</td>
<td>131</td>
<td>140</td>
</tr>
<tr>
<td>Potassium</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Chloride</td>
<td>100</td>
<td>154</td>
<td>111</td>
<td>90</td>
</tr>
<tr>
<td>Calcium</td>
<td>2.2</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lactate</td>
<td>1</td>
<td>0</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>Acetate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Gluconate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Malate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Plasma-Lyte® from Baxter International (Deerfield, IL, USA). Sterofundin® from B. Braun (Melsungen, Germany).

- | pH | OSM |
- | 7.4 | 275-295 |
- | 6.5 | 308 |
- | 6.5 | 276 |
- | 7.4 | 294 |
Best Crystalloid-0.9% NaCl?

- renal vasoconstriction
- renal injury
- hyperchloremic acidosis
  - ↓ immunity
  - ↓ renal perfusion
  - ↑ fluid requirement
    - worse acidemia
    - hyperkalemia
    - ↑ coagulopathy
    - ↑ PRBC transfusion

Best Crystalloid-LR?

- Less hyperchloremia
- Better buffer
- Can cause hyperlactatemia
- Is HYPO-thonic after infusion
- You CAN give LR w/blood transfusion
- Does NOT cause hyperkalemia in renal failure
- Not for bad TBI
Best Crystalloid-PlasmaLyte-A?

- Most closely resembles plasma
- No Ca++ so the worrywarts have no fear with transfusion
- Slightly more expensive
- Maintains Mg levels in high volume resus
- Does NOT cause hyperkalemia in renal failure
Better acid-base at 24 hours
Less hyperchloremia
No harm
Cost analysis from their center:

A thorough cost analysis is beyond the scope of this article, but based on information from our center, a 1-L bag of 0.9% NaCl costs $0.86/L and Plasma-Lyte A costs $1.62/L, a cost difference of 76 cents. The cost of standard IV magnesium replacement is $5.19 per 2 g and does not include the cost for nursing care to administer the infusion.
Resuscitation With Normal Saline (NS) vs. Lactated Ringers (LR) Modulates Hypercoagulability and Leads to Increased Blood Loss in an Uncontrolled Hemorrhagic Shock Swine Model

Laszlo N. Kiraly, MD, Jerome A. Differding, MS, T. Miko Enomoto, MD, Rebecca S. Sawai, MD, Patrick J. Muller, MS, Brian Diggs, PhD, Brandon H. Tieu, MD, Michael S. Englehart, MD, Samantha Underwood, MS, Tracy T. Wiesberg, MD, and Martin A. Schreiber, MD

Table 1 Baseline and Postinjury Values. Comparison Between NS and LR Groups of Physiologic Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Study Fluid</th>
<th>Mean ± SE</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survived</td>
<td>NS</td>
<td>9</td>
<td>0.343</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>10</td>
<td>0.166</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>NS</td>
<td>33.6 ± 1.0</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>36.6 ± 0.9</td>
<td>0.225</td>
</tr>
<tr>
<td>Starting Temp (°C)</td>
<td>NS</td>
<td>37.3 ± 0.6</td>
<td>0.356</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>37.8 ± 0.2</td>
<td>0.65</td>
</tr>
<tr>
<td>Baseline MAP (mm Hg)</td>
<td>NS</td>
<td>75.4 ± 2.7</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>68.6 ± 3.3</td>
<td>0.382</td>
</tr>
<tr>
<td>Vains Injured</td>
<td>NS</td>
<td>1.8 ± 0.25</td>
<td>0.811</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>1.5 ± 0.23</td>
<td>0.011</td>
</tr>
<tr>
<td>Splen replacement</td>
<td>NS</td>
<td>627 ± 52</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>LR</td>
<td>612 ± 30</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. pH values at discrete time intervals after injury in NS and LR groups. *Indicates a significant difference (p < 0.05) between groups at that time interval.

Fig. 2. BCO₂ and Base Excess values at discrete time intervals after injury in NS and LR groups. *Indicates a significant difference (p < 0.05) between groups at that time interval.

Resuscitation With Normal Saline (NS) vs. Lactated Ringers (LR) Modulates Hypercoagulability and Leads to Increased Blood Loss in an Uncontrolled Hemorrhagic Shock Swine Model

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• TEG demonstrated hypercoaguability w/LR
• Hypocoag w/NS (acidemia and more volume)

When do I give IVF for resuscitation?

• Evidence of shock or occult shock
• Primarily in trauma, burns and sepsis
• Hypotension <90 or <110s in severe TBI
• Lactate 2-4, >4 mmol/L
• Worsening base deficit < -3 mmol/l
• Decreased UOP (0.5 cc/kg/hr – ideal predicted body weight)
Trauma Resuscitation Principles

- If bleeding, stop it, replace what's lost
- Fill the tank (but don’t overfill)
- Perfuse the patient

Monitor for response

- Should expect to see any/or a combo of the following:
  - increase BP
  - improved MS
  - decreased pulse
  - wider pulse pressure
  - improved UOP
- However these aren’t the only indicators
“Pressure ≠ Flow ≠ Perfusion”

Biochemical markers

• Base deficit
• Serum lactate

• **Must** be followed in tandem
CVP has no correlation to circulating volume
CVP does not predict responsiveness to fluid challenge = 50% chance of predicting responsiveness

Why are we giving fluid?

↑ enhance oxygen delivery (DO₂)
Too much fluid?

- More:
  - $$
  - vent days
  - renal failure
  - ACS
  - anastomotic failure
  - etc

Guidelines for Prehospital Fluid Resuscitation in the Injured Patient

Bryan A. Cotton, MD, MPH, Rebecca Jerome, MLIS, MPH, Bryan R. Collier, DO, Suneel Khetarpal, MD, Michelle Holevar, MD, Brian Tucker, DO, Stan Kurek, DO, Nathan T. Mowery, MD, Kamalesh Shah, MD, William Bromberg, MD, Oliver L. Gunter, MD, and William P. Roerdan, Jr., MD; EAST Practice Parameter Workgroup for Prehospital Fluid Resuscitation

*(J Trauma. 2009;67: 389–402)*

Level I: The recommendation is convincingly justifiable

Level II: The recommendation is reasonably justifiable

Level III: The recommendation is supported by available data but adequate scientific evidence is lacking. Seven Level III
1. Should vascular access be attempted pre-hospital?

Level II: Placement of vascular access at the scene of injury should not be performed as it delays patient transport to definitive care, and there is no evidence to demonstrate any benefit to their placement.

Level III: Placement of vascular access during transport is feasible and does not delay transport to definitive care.

2. If obtained, at what site?

1. If 2 failed attempts I/O
   (Level II)

2. Limit attempts to 2 pre-hospital.
   If failed, use alternative (central or I/O).
   (Level III)
3. Should fluids be given?
1. Withhold in penetrating torso injury (Level II)
2. Saline lock = KVO (in patency) (Level II)
3. Withhold until hemorrhage control (Level III)
4. Titrate to radial pulse, use 250cc boluses (Level III)

4. What fluid?
1. Insufficient data to recommend one:
   - Small volume 7.5% HTS = large volume isotonic
   - Level I

2. Pre-hospital blood is safe and feasible (Level III)
5. If given, how much and how fast?

1. KVO adequate for injured patients
   (Level II)

2. Rapid infusion or “pressure bags” should not be used pre-hospital
   (Level III)
Case Study

- 22 YOM
- Drugstore sales clerk
- ED by ambulance
- GSW lower abdomen during a robbery
- 9 mm handgun
- By ED arrival: lost ~ 2 L
- Conscious but disoriented

BP 85/60 mm Hg
HR 120 BPM
RR 35
Acute Traumatic Coagulopathy (ATC)

“An endogenous impairment of hemostasis that occurs early after injury.”


Hemorrhage and ATC

• Leading cause of death in 1st hour of arrival

• Responsible for over 80% O.R. deaths
  Kauvar DS et al J Trauma 2006

• Accounts for 50% deaths in 1st 24 hours
  Hoyt DB et al J Trauma 1994
  Sauaia A et al J Trauma 2006
How acute and how lethal is ATC?

- 24.4 % (+) coagulopathic on admit

- Coagulopathy: higher mortality (46% vs. 11%)

  Brohi K et al J Trauma 2003

Retrospective, 1,088 trauma patients

How fast and how lethal?

- 211 patients receiving MT or TEP
- Prevalence of coagulopathy 70% (INR>1.5)
- Mortality in non-coagulopathic 42%
- Mortality in coagulopathic 67%

  Cotton BA et al J Trauma 2008
Risk Factors for ATC

1. Extent of tissue damage

2. Shock (SBP ≤90) 3-fold risk increase

3. Prehospital IV fluids ≥3,000 mL

4. Hypothermia (temperature ≤35°C)

5. Acidosis (BE < -10) 3-fold increase

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 R. Holcomb, MD


TABLE 7. Unadjusted and Adjusted ORs for 30-d Survival by Individual PI Measure Compliance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Crude OR</th>
<th>95% CI</th>
<th>Adjusted OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED protocol activation</td>
<td>3.44</td>
<td>1.927–6.157</td>
<td>2.79</td>
<td>1.039–7.497</td>
</tr>
<tr>
<td>Trauma attending activation</td>
<td>2.30</td>
<td>1.402–3.778</td>
<td>0.895</td>
<td>0.960–8.337</td>
</tr>
<tr>
<td>ED type and screen sent</td>
<td>2.15</td>
<td>1.315–3.539</td>
<td>0.195</td>
<td>0.023–1.621</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>0.98</td>
<td>0.968–0.997</td>
<td>0.98</td>
<td>0.957–1.015</td>
</tr>
<tr>
<td>Male</td>
<td>1.12</td>
<td>0.841–1.500</td>
<td>0.75</td>
<td>0.264–2.157</td>
</tr>
<tr>
<td>ISS</td>
<td>0.98</td>
<td>0.963–0.997</td>
<td>0.96</td>
<td>0.941–1.357</td>
</tr>
</tbody>
</table>
Table 3. Multivariable Cox Regression Models Examining the Association of Plasma and Platelet Transfusion Ratios With In-hospital Mortality

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Continuous Transfusion Ratio Variables</th>
<th>Categorical Transfusion Ratio Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR (95% CI) P Value</td>
<td>Low, &lt;1:2 HR P Value Moderate, ≥1:2 to &lt;1:1 HR P Value High, ≥1:1</td>
</tr>
<tr>
<td>Minimun 24 to Hour 6 After ED Admission (n = 876)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early initial and time-varying plasma RBC ratios</td>
<td>0.31 (0.19-0.50) &lt; .001</td>
<td>0.42 &lt; .001 0.66 .16 0.37 .04</td>
</tr>
<tr>
<td>Early initial and time-varying platelet RBC ratios</td>
<td>0.55 (0.37-0.81) .04</td>
<td></td>
</tr>
<tr>
<td>Sum of blood product transfusions</td>
<td>1.05 (1.04-1.06) &lt; .001</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.01 (1.00-1.02) .03</td>
<td></td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>1.02 (1.01-1.04) .001</td>
<td></td>
</tr>
<tr>
<td>Time interval at cohort entry</td>
<td>0.73 (0.63-0.86) &lt; .001</td>
<td></td>
</tr>
<tr>
<td>Bleeding from head</td>
<td>3.73 (2.51-6.45) &lt; .001</td>
<td></td>
</tr>
<tr>
<td>Bleeding from chest</td>
<td>1.52 (0.96-2.39) .07</td>
<td></td>
</tr>
<tr>
<td>Bleeding from limb</td>
<td>0.54 (0.32-0.93) .02</td>
<td></td>
</tr>
</tbody>
</table>
UK Trauma Massive Transfusion Protocol (MTP)

**UK Trauma Protocol Manual**

**Topics**
- Acute Care Surgery (2)
- Acute Complications (1)
- Antimicrobial Therapy and Infection Control (1)
- Bleeding/Coagulation (5)
- Burns (4)
- ED-Abdominal Trauma (1)
- ED-Facial Trauma (1)
- ED-Neck (1)
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 PROPRR Randomized Clinical Trial

- plasma, platelets, and PRBC ratio
- 1:1:1 vs 1:1:2
- No differences in mortality at 24 hours or at 30 days.
- Better hemostasis in 1:1:1
- Lower death due to exsanguination by 24 hours
- More plasma and platelets transfused in the 1:1:1

Summary

- Avoid NS in big trauma
- Plasmalyte-A may be best
- Use any crystalloid judiciously
- Stop the bleeding
- DCR
- Activate MTP’s early
- Use all the controls in shock