Fluid Resuscitation

Kristan Staudenmayer, MD
Stanford University, Stanford, CA

Introduction

• Focus will be mainly on Trauma/ICU
• The wrong way...what we have learned from historical approaches to resuscitation
• Resuscitation Strategies and Controversies
  – What fluid is best?
  – Hypotensive resuscitation
  – Hemostatic resuscitation
  – Massive transfusion protocols
Physiologic Effects of Different Resuscitation Fluids: Crystalloids

- Normal Saline
  - Large volumes of NaCl → nongap acidosis

- Lactated Ringers
  - Buffers acidosis
  - Laboratory data: LR can cause harm
    - Worsens pro-inflammatory response
    - Induces apoptosis in multiple cell lines
  - Thought to be due to racemic mixture
    - L-lactate vs. D-lactate
    - IOM recommended removal of D-lactate from LR solutions

Physiologic Effects of Different Resuscitation Fluids: Crystalloids

- Hypertonic Saline
  - 7.5% NaCl solution
  - Hopeful laboratory findings
    - Intravascular expansion superior to other crystalloids
    - Decreased inflammation
    - Reduced organ dysfunction
  - Often used in conjunction with a colloid
  - Clinical outcomes of HTS (without colloid)
    - Cooper et al., Vassar et al.
      - No difference in outcomes when compared to NS or LR
      - Reduced volume of pre-hospital fluids required
    - Krauz et al.: Increased bleeding and mortality
Resuscitation Outcomes Consortium: HTS study halted for futility

- Prehospital phase
- RCT
- Outcome mortality
- Compared
  - 8oz NaCl vs.
  - 8oz HTS vs.
  - 8oz HTS with dextran

Physiologic Effects of Different Resuscitation Fluids: Colloids

- Types
  - Albumin
  - 6% Hydroxyethylstarch (HES) solutions
    - Hextend: HES in lactated electrolyte solution
    - Hespan: HES in NS
  - Dextran
  - Gelatins
  - Combined Hypertonic-Dextran solutions

*Significant variability of solutions*
Physiologic Effects of Different Resuscitation Fluids: Colloids

• Function
  – Different colloids vary in length of time they remain in the circulatory system
    • LMW molecules leak into interstitial fluid sooner (i.e. albumin and gelatins vs. high MW dydroxyethyl starches)
  – Different molecular structures lead to different rates of complications

• Associated complications
  – Coagulopathy
  – Bleeding
  – Anaphylaxis


• Randomized Controlled Trial
• 16 ICUs in Australia and New Zealand
• 7,000 Patients
• 4% albumin vs. 0.9% NaCl
• Mortality at 28 days
Saline or Albumin for Fluid Resuscitation in Patients with Traumatic Brain Injury

The SAFE Study Investigators

![Graph showing survival rates for saline and albumin]

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number</th>
<th>Pooled RR</th>
<th>95% CI</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>Albumin</td>
<td>23</td>
<td>1.01</td>
<td>0.92</td>
<td>1.10</td>
</tr>
<tr>
<td>HES</td>
<td>17</td>
<td>1.18</td>
<td>0.96</td>
<td>1.44</td>
</tr>
<tr>
<td>Gelatin</td>
<td>11</td>
<td>0.91</td>
<td>0.49</td>
<td>1.72</td>
</tr>
<tr>
<td>Dextran</td>
<td>9</td>
<td>1.24</td>
<td>0.94</td>
<td>1.65</td>
</tr>
<tr>
<td>HTS + Dextran</td>
<td>8</td>
<td>0.88</td>
<td>0.74</td>
<td>1.05</td>
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</tbody>
</table>

Perel et al., Colloids versus crystalloids for fluid resuscitation in critically ill patients. 
*Cochrane Database of Systematic Reviews 2007*
Hemostatic Resuscitation

- Whole blood transfusions → component therapy in the 1980s
  - Allowed longer storage
  - Improved resource utilization

- Products were administered based on lab values (PT/PTT, platelets, etc...)

- Recent literature has highlighted that this might not work for actively bleeding patients

Role of coagulopathy...

Coagulopathy of Trauma

Coagulopathy of Trauma

- 3-4x increased mortality
- 8x higher mortality within 24 hours
- Higher incidence MOF
- Increased transfusion requirements


The Lethal Triad /Bloody Vicious Cycle

- Bleeding
  - Tissue Hypoxia
  - Acidosis
  - Coagulopathy
- Fluid Replacement
- RBC Transfusion
- Dilution
- Hypothermia
Resuscitation with High FFP:RBC Ratios Associated with ↓Mortality


MTP at Stanford

Physiologic Effects of Different Resuscitation Fluids: Blood

- Transfusion reactions
- Infections
- Transfusion-related Immunomodulation
- Higher rates of sepsis, MOF, death

Need for Transfusion
Risks of Transfusion

Increased Mortality in ICU

Increased Mortality in ICU


Which Fluid to Use

- Actively bleeding
  - If massively bleeding, use blood products
    - Hemostatic strategy
    - Trend is to use a 1:1 resuscitation
  - If not massively bleeding, use crystalloid as the first line fluid
    - LR if no D-lactate isomer
    - If bleeding and needs blood but blood is not available, consider non-protein colloid with crystalloid

- If not bleeding
  - Initial fluid should be a crystalloid
  - Consider colloid if have capillary leak or not responding to crystalloid
Immediate versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injuries


• Revelation of methodological errors:
  – Did not consider patients who died in the field
  – Did not point out overlapping confidence intervals
    • 95% CI Immediate resus 57-68%
    • 95% CI Delayed resus 65-75%

• Re-evaluation found:
  – Initial statistics do not confirm difference
  – When consider those who died in the field, lose all statistical differences in mortality.
Animal Studies have more to tell...Is it really blood pressure?

- Used uncontrolled hemorrhage model in rats

- Found hemodilution was more associated with mortality and markers of shock vs. blood pressure
Effects of Hemodilution on Long-Term Survival in an Uncontrolled Hemorrhagic Shock Model in Rats.
Marshall, Harry; Capone, Antonio; Courcoulas, Anita; MD, MPH; Harbrecht, Brian; Billiar, Timothy; Udekwu, Anthony; Peitzman, Andrew


<table>
<thead>
<tr>
<th>Group</th>
<th>Survival</th>
<th>Blood loss (mL/100g)</th>
<th>LR administered (ml)</th>
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</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>None</td>
<td>6.6</td>
<td>151</td>
</tr>
<tr>
<td>Group 2</td>
<td>100%</td>
<td>10.4</td>
<td>69</td>
</tr>
<tr>
<td>Group 3</td>
<td>75%</td>
<td>4.6</td>
<td>29</td>
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<tr>
<td>Group 4</td>
<td>87%</td>
<td>5.3</td>
<td>20</td>
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</tbody>
</table>

Group I, MAP = 80 mm Hg with LR resuscitation only
Group II, MAP = 80 mm Hg with Whole Blood + LR;
Group III, MAP = 40 mm Hg with LR only;
Group IV, MAP = 40 mm Hg with Whole Blood + LR.
Hypotensive Resuscitation

• Most people moving towards *judicious* use of fluids
  – “Normal BP” might not be best target
  – Before surgical control of bleeding, perhaps should target palpable pulse and adequate cerebral perfusion if no head injury is present
• Further work required to support this strategy as a global solution

Conclusions

• How a patient is resuscitated DOES matter
• Bleeding patients need blood and blood products
  – Hemostatic resuscitation
  – Role of massive transfusion protocol
• Patients who are not bleeding should NOT get blood
• Crystalloids should be the first line in patients who do not need immediate blood transfusions
Conclusions

• There is no evidence to support the use of colloids over crystalloids
• There is no evidence of superiority of any commercially available colloid over another
• Colloids may have a role in the following circumstances
  – If blood products needed but not immediately available
  – If not responding to crystalloids or has capillary leak

Conclusions

• Hypotensive resuscitation for bleeding patients who do not have immediate access to surgical control should be considered
• Head injured patients different
  – Hypotension=worse outcomes
  – Albumin=worse outcomes