Just like Adults? Evaluating the Impact of Fluid Resuscitation in Pediatric Trauma

Abbas PI¹,², Carpenter K², Sheikh F¹,², Peterson ML¹,², Kljajic M¹, Naik-Mathuria B¹,²

¹Texas Children’s Hospital and ²The Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, TX

No Disclosures
ATLS fluid algorithm

Fluid Resuscitation for Pediatric Patients

**Fluid Boluses**
Ringer’s lactate, 20 mL/kg IV/IO over 5-20 min. Repeat 2-3 times.

- Hemodynamically Normal
  - Additional evaluation
    - Transfer, Observe, or Operate

- Hemodynamically Abnormal
  - Packed RBCs:
    - 10 mL/kg IV/IO over 20 min
      - Normal
        - Additional evaluation
          - Transfer, Observe, or Operate
      - Abnormal
        - Operate

**Figure:** Fluid Resuscitation for Pediatric Patients
Background

• Adult literature
  o Focuses on resuscitation with blood products
  o Some literature on crystalloid fluid resuscitation

• Aggressive crystalloid resuscitation was associated with:
  o Higher rate of mortality
  o Longer ICU hospital stays
  o Coagulopathy
  o Mechanical ventilation
  o Multisystem organ failure
Background

- Pediatric trauma patients
  - More blunt trauma
  - Less severe injuries
  - Less need for blood transfusions
  - Different physiology
  - Higher threshold for multisystem organ failure
Hypothesis

• Higher volume of crystalloid fluid resuscitation is associated with worse clinical outcomes in pediatric trauma patients
Methods

• IRB approval (H-29836)

• Prospective cohort study

• Level 1 pediatric trauma center

• Data collected from 9/2011 – 7/2014

• Detailed chart review
Clinical Variables

- Patient demographics
- Admission vital signs
- Crystalloid fluid intake (cc/kg/hr)
  - Pre-hospital (scene)
  - Emergency Department (ED)
  - Inpatient up to 24 hours after arrival to ED
Outcomes of interest

- Ileus (NPO >3 days)
- Coagulopathy (INR >1.5) within 24 hours
- Need for intubation within 24 hours
Statistical Analyses

• Univariate analyses for association between clinical variables with outcomes

• Multivariate regression to determine predictors of outcomes

• Receiver Operator Curve (ROC) analysis to identify a fluid threshold for outcomes
Results

- 603 patients
  - Median age of 8.1 years (range 0.1-17.9)
  - 63% males
  - 94% blunt trauma
    - MVC (21%), Falls (19%), Autoped (15%)
  - Only 7% required blood transfusions
    - Median of 14.5 cc/kg PRBCs (IQR 10-27.4)
  - Median ISS 9 (IQR 5-14)
  - Median 24-hr fluid volume: 1.5 cc/kg/hr (IQR 0.9-2.4)
Results

- 10% (n=58) developed ileus
- 3% (n=18) developed coagulopathy
- 11% (n=64) required mechanical ventilation within 24 hours
Higher median fluid volumes associated with worse clinical outcomes

<table>
<thead>
<tr>
<th>Condition</th>
<th>Fluid Volumes (cckg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ileus</td>
<td>2.9</td>
</tr>
<tr>
<td>No ileus</td>
<td>1.5</td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>4</td>
</tr>
<tr>
<td>No Coagulopathy</td>
<td>1.6</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>3</td>
</tr>
<tr>
<td>No Mechanical ventilation</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*p < 0.001
# Predictors of ileus

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ileus (n=58)</th>
<th>No ileus (n=545)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>7.4 ± 5.6</td>
<td>8.6 ± 5.2</td>
<td>0.123</td>
</tr>
<tr>
<td>Male gender N (%)</td>
<td>28 (48)</td>
<td>350 (65)</td>
<td>0.015</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>22.2 (10.6 - 45.1)</td>
<td>29.6 (15.9 - 52.6)</td>
<td>0.015</td>
</tr>
<tr>
<td>Admission HR, Median (IQR)</td>
<td>119.5 (98 - 138.3)</td>
<td>107 (89 - 130)</td>
<td>0.014</td>
</tr>
<tr>
<td>Admission RR, Median (IQR)</td>
<td>28 (20 - 34)</td>
<td>24 (20 - 32)</td>
<td>0.129</td>
</tr>
<tr>
<td>Admission SBP, Median (IQR)</td>
<td>111 (99.5 - 127)</td>
<td>117 (107 - 131)</td>
<td>0.029</td>
</tr>
<tr>
<td>Admission temp, °C, Median (IQR)</td>
<td>36.8 (36.4 - 37.4)</td>
<td>36.7 (36.6 - 37.1)</td>
<td>0.935</td>
</tr>
<tr>
<td>Lowest SBP in first 24 hours, Median (IQR)</td>
<td>90 (78.8 - 97)</td>
<td>95 (88 - 102)</td>
<td>0.001</td>
</tr>
<tr>
<td>ISS, Median (IQR)</td>
<td>17 (10-25.3)</td>
<td>9 (4-10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fluid resuscitation volume, cc/kg/hr, Median (IQR)</td>
<td>3.0 (1.8-4.3)</td>
<td>1.5 (0.85-2.22)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blunt trauma N (%)</td>
<td>56 (97)</td>
<td>507 (94)</td>
<td>0.365</td>
</tr>
<tr>
<td>Surgical intervention N (%)</td>
<td>29 (50)</td>
<td>148 (27)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
### Predictors of mechanical ventilation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Need for intubation (n=67)</th>
<th>No intubation (n=536)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>6.1 ± 5.2</td>
<td>8.7 ± 5.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male gender</td>
<td>41 (61)</td>
<td>340 (64)</td>
<td>0.706</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>18 (10.3 - 38.8)</td>
<td>30 (16 - 53.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Admission HR, bpm</td>
<td>120 (94.8 - 146)</td>
<td>107 (89.8 - 130)</td>
<td>0.025</td>
</tr>
<tr>
<td>Admission RR, bpm</td>
<td>29.5 (20 - 34.3)</td>
<td>24 (20 - 32)</td>
<td>0.084</td>
</tr>
<tr>
<td>Admission SBP, mm Hg</td>
<td>117 (104.5 - 134.3)</td>
<td>117 (106 - 130.8)</td>
<td>0.645</td>
</tr>
<tr>
<td>Admission temp, °C</td>
<td>36.6 (36.2 - 37.1)</td>
<td>36.7 (36.6 - 37.1)</td>
<td>0.007</td>
</tr>
<tr>
<td>Lowest SBP in first 24 hours, mm Hg</td>
<td>83 (72-94.5)</td>
<td>95 (89-102)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ISS Median (IQR)</td>
<td>17 (10-27)</td>
<td>9 (4-10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fluid resuscitation volume, cc/kg/hr</td>
<td>3.0 (2.1-4.3)</td>
<td>1.5 (0.83-2.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blunt trauma</td>
<td>65 (97)</td>
<td>500 (93)</td>
<td>0.253</td>
</tr>
<tr>
<td>Surgical intervention</td>
<td>23 (34)</td>
<td>153 (29)</td>
<td>0.336</td>
</tr>
</tbody>
</table>
# Predictors of coagulopathy

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coagulopathy (n=18)</th>
<th>No coagulopathy (n=585)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>Mean ± SD</td>
<td>6.2 ± 5.6</td>
<td>8.7 ± 5.2</td>
</tr>
<tr>
<td>Male gender</td>
<td>N (%)</td>
<td>11 (61)</td>
<td>343 (64)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>Median (IQR)</td>
<td>18 (10.5 - 45)</td>
<td>30 (16 - 52.8)</td>
</tr>
<tr>
<td>Admission HR</td>
<td>Median (IQR)</td>
<td>120 (85.5 - 129)</td>
<td>107 (89 - 131)</td>
</tr>
<tr>
<td>Admission RR</td>
<td>Median (IQR)</td>
<td>24 (20 - 35.5)</td>
<td>24 (20 - 32)</td>
</tr>
<tr>
<td>Admission SBP</td>
<td>Median (IQR)</td>
<td>117 (109 - 128)</td>
<td>117.5 (106.3 - 132.8)</td>
</tr>
<tr>
<td>Admission temp, °C</td>
<td>Mean ± SD</td>
<td>36.4 ± 2.2</td>
<td>36.8 ± 0.5</td>
</tr>
<tr>
<td>ISS</td>
<td>Median (IQR)</td>
<td>23.5 (16-26.3)</td>
<td>9 (5-12.8)</td>
</tr>
<tr>
<td>Fluid resuscitation volume, cc/kg/hr</td>
<td>Median (IQR)</td>
<td>4.0 (1.9 - 6.7)</td>
<td>1.6 (0.98 - 2.3)</td>
</tr>
<tr>
<td>Blunt trauma</td>
<td>N (%)</td>
<td>17 (94)</td>
<td>499 (94)</td>
</tr>
<tr>
<td>Surgical intervention</td>
<td>N (%)</td>
<td>9 (50)</td>
<td>151 (28)</td>
</tr>
</tbody>
</table>
Fluid threshold to minimize poor outcomes

AUC 0.79, p<0.001
2.2 cc/kg/hr
sensitivity 71%, specificity 75%
NPV 96%, PPV 23%

AUC 0.82, p<0.001
2.15 cc/kg/hr
sensitivity 75%, specificity 73%
NPV 96%, PPV 25%

Fluid resuscitation threshold
2.2 cc/kg/hr (53 cc/kg/day)
Conclusions

• In pediatric trauma patients, limited crystalloid resuscitation within the initial resuscitation period leads to better outcomes.

• Administering less than 50 cc/kg/day (or 2 cc/kg/hr) of fluid correlates with lower incidence of ileus and mechanical ventilation.

• Larger, prospective studies are needed to validate this study and determine the optimal resuscitation algorithm for pediatric trauma.
Correlates

Clinical Implications

Trauma Services

Surgical Consultation
20 mL/kg Ringer’s lactate solution as bolus

Hemodynamics

Normal
Further evaluation
Transfer as necessary
Observe Operation

Abnormal

10 ml/kg pRBCs
Normal
Further evaluation
Transfer as necessary
Observe Operation
Abnormal
Operation

Texas Children's Hospital
Baylor College of Medicine
References


Ley EJ, Clond MA, Srour MK, et al: Emergency department crystalloid resuscitation of 1.5 L or more is associated with increased mortality in elderly and nonelderly trauma patients. Journal of Trauma and Acute Care Surgery 70:398-400, 2011


Thank you!

Questions?

piabbas@texaschildrens.org