Updates in Pediatric Trauma

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Outline

- What's new: Pediatric Massive Transfusion
  - MT definition in pediatrics
  - Use of massive transfusion protocols
  - Use of TEG in pediatric trauma
  - Role of tranexamic acid (TXA)
  - What about Factor VIIa?

Intraosseous access – consider after 90 seconds of unsuccessful PIV placement

- Tibial plateau is most common site
- Long track record for safety
- Few contraindications
- Low complication rate
- Attempt PIV within 3-4 hrs

Pediatric Trauma Pearls - review

- Trauma - #1 cause of death in children over age 1
- 2nd leading cause in infants
- 80% of pediatric trauma victims will have an associated head injury
- 70% of trauma deaths are due to head injury
- Hemorrhage – leading cause of preventable death
- Blunt trauma accounts for > 80-90% of injuries

Hemorrhage: leading cause of preventable death in pediatric trauma

- Multisystem injuries in children may lead to significant blood loss
- Pediatric patients have higher physiologic reserve – maintain SBP longer
  - Blood pressure may remain normal until 60-50% of blood volume lost
- Tachycardia if often the first sign of shock
- Other signs
  - Narrowed pulse pressure
  - Oliguria
  - Poor capillary refill/cool extremities
  - Decreased level of consciousness

Obtain adequate IV access immediately

Intraosseus access – consider after 90 seconds of unsuccessful PIV placement

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http://emedicine.medscape.com/article/940993

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Obtain adequate IV access immediately
Pediatric Massive Transfusion: Current Practice

Cote et al. Practice of Anesthesia for Infants and Children, 5th ed. 2013

- Massive Transfusion – considered when patient loses one blood volume
- Dilutional coagulopathy of massive blood transfusion is reasonably predictable
- When PRBC’s used: clotting factors and platelets may be diluted after 1 blood vol lost
- Only a guide – PT, PTT, fibrinogen and platelet count should be used to guide transfusion

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit/L</th>
<th>Effect</th>
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<tbody>
<tr>
<td>PRBC’s</td>
<td>30-15mL/kg</td>
<td>0 Hgb 2-3 g/dL</td>
</tr>
<tr>
<td>Platelets</td>
<td>5-10mL/kg</td>
<td>PT 50-100K/mm3</td>
</tr>
<tr>
<td>FFP</td>
<td>10-15mL/kg</td>
<td>P factor level 15-20%</td>
</tr>
<tr>
<td>Cryoprecipitate</td>
<td>1-2 units/kg</td>
<td>Fibrinogen by 60-100 mg/dL</td>
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</tbody>
</table>

Common initial doses of blood components and expected effects in children

Massive Transfusion in Pediatrics – Defined


- Massive transfusion – PRBC usage approached 80ml/kg/24 h or 40ml/kg/12 h

Hendrickson et al. Implementation of a pediatric trauma massive transfusion protocol: one institution’s experience. Transfusion 2012

- Massive transfusion – requirement of 1 blood volume of products (70ml/kg)

Neff et al. Clearly defining pediatric massive transfusion: Cutting through the fog and friction with combat data J Trauma Acute Care Surg. 2015

- Massive Transfusion – 40 ml/kg of any blood product in 24 hrs

Massive Transfusion in children & neonates


Defining massive transfusion in children has not been clearly established.

Adult definitions are not applicable in pediatrics as TBV varies according to age and weight

Authors suggest defining ped MT as:
- Transfusing > 50% TBV in 3 hr
- Transfusion > 100% TBV in 24 hr
- Transfusion support to replace ongoing blood loss at >20% TBV/min

Massive Transfusion: Protocols and Transfusion Ratios & Lab Monitoring

- Pediatric data is limited
- Little published on trauma induced coagulopathy, what defines MT, and use of MTP’s
- Most knowledge comes from adult studies or pediatric case series, case reports, small retrospective studies and single center experience
- Unknown adult data can be generalized to pediatric patients

Many support application of MTP in pediatric trauma, protocol development has been challenging

We first need to understand the impact of administering components as ratios before developing evidence-based protocol

Optimal strategy for selection of volumes and types of components to use and for clinical and lab monitoring in ped patients requiring MT remains unclear

Clearly defining pediatric massive transfusion: Cutting through the fog and friction with combat data

J Trauma Acute Care Surg. 2015

- Using the largest existing registry of transfused pediatric trauma patients, authors sought a data-driven MT threshold
- Over 12 year period, 1,113 out of 4,990 combat injured pediatric trauma patients were transfused

- Using their MT definition of 40ml/kg mortality and morbidity were examined between MT+ and MT- groups
- MT+ group: greater shock, coagulopathy, thrombocytopenia, higher S&O, more mechanical-ventilator days, longer ICU stay and overall mortality

- Concluded – threshold of 40ml/kg of all blood products given in the first 24 hours reliably identifies critically injured children at high risk for early and in-hospital death

- This evidence-based definition will provide a consistent framework for future research and protocol development in pediatric resuscitation

Hendrickson et al. Implementation of a pediatric trauma massive transfusion protocol: one institution’s experience. Transfusion 2012

- Retrospective study
- 53 patients in MTP vs 49 pre MTP

- No improvement in mortality

- Median time to FFP transfusion decreased 

- FFP-PRBC transfusion ratio increased 2x

A MTP with fixed ratios is feasible for pediatric trauma…. Implementation has increased RBC/FFP ratios and obtained FFP faster in coagulopathic children. More studies needed to assess outcome.

Although the authors identified multiple limitations to their study, they hope that “the protocol driven description will help to guide other members of the pediatric trauma community who are trying to optimize blood product resuscitation for their patients.”
### Measures of coagulation

- **INR, PT, PTT vs. Thromboelastography (TEG)**
  - CCT's designed for screening heritable bleeding disorders
  - Monitor therapeutic anticoagulants
  - Conventional coagulation tests of blood coagulation are static
  - PT: Poor test for dynamic assessment of clot strength in whole blood
  - Measure platelet poor component of blood – discount interaction of whole blood with platelets
  - Essential for monitoring patients with post-injury coagulopathy
  - Is TEG a better way to monitor coagulopathic trauma patients?
  - TEG guided/goal directed resuscitation has taken off in the adult trauma literature
  - **Very little published in the pediatric trauma population**

### Blood Product Ratios in Pediatric Trauma

- Adult literature has taken off in the last 8-10 years
- Multiple retrospective studies in adult trauma suggest 1:1 FFP:PRBC's & ≥ 1:2 PIP:PRBC's
- There is little to no specific published data to guide transfusion ratios in peads trauma
- Is it appropriate to extrapolate to pediatric trauma?
  - Data obtained from *penetrating trauma* in health young *adult* males

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**Example of weight based pediatric Massive Transfusion Protocol**

<table>
<thead>
<tr>
<th>Component</th>
<th>RBC</th>
<th>FFP</th>
<th>Cryo</th>
<th>Platelets</th>
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<tbody>
<tr>
<td>Adult</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pediatric</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Fixed ratios of RBC:FFP:platelets: cryoprecipitate based on weight**

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**Admission rapid thromboelastography delivers real-time “actionable” data in pediatric trauma**

- RIGGERT, Ami, MD
  - Updates in Pediatric Trauma

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**Admission rapid thromboelastography delivers real-time “actionable” data in pediatric trauma**

- Vogel et al. Admission rapid thromboelastography delivers real-time “actionable” data in pediatric trauma. *J Ped Surg 2013*
Higher ratios were not associated with increased survival
They did find that all deaths were caused by severe head injury
Because of the retrospective nature, small numbers and lack of death due to hemorrhage, it is difficult to draw absolute conclusions from this study
Currently still unclear what constitutes massive transfusion in pediatrics, a MTP should be instituted and what product ratios are best

Additional prospective studies are needed!

The many trauma authors
Because trauma: massively hemorrhage, when a MTP should be instituted and what product ratios are best


RCPCH Evidence Statement Major trauma and the use of tranexamic acid in children November 2012

Key points
- Tranexamic acid reduces mortality in adult trauma
- Early administration is vital for efficacy
- Due to the lack of published data on the use of tranexamic acid in paediatric patients who have undergone major trauma there is no evidence for a specific dose in this situation
- The RCPCH and NIHR MRC/HSU Committee recommend a pragmatic dosage schedule – 10mg/kg tranexamic acid loading dose (max 1g) over 10 minutes followed by 2mg/kg per hour

Dosing schedule based on CRASH-2 data (1g/10d and 3g over 4 hours) but translated to children. Administration within the first 3 hrs of injury is likely beneficial.

Recombinant Activated Factor VIIa

- Only FDA approved for hemophilia patients with factor inhibitors
- The majority of its use has been “off label” – i.e. hemorrhage in trauma
- Induces hemostasis at the site of vascular injury independent of FVIII and FIX by complexing with exposed tissue factor
- Although there have been a small handful of pediatric trauma case reports of its use, there are no prospective studies showing safety and efficacy
- Side effects: EXPENSIVE, risk of thromboembolism, short half life (2.7h)
- If used – ensure repletion of coagulation factors, correction of acidosis and hypothermia

Beno et al. Tranexamic acid in pediatric trauma: why not? Critical Care 2014

- Authors argue “for” strong consideration of TXA in appropriate peds trauma victims
- Trauma induced coagulopathy has been documented in severely injured pediatric patients and has been associated with increased mortality
- Many published doses documented in non-trauma peds literature (10-100mg/kg LD): cardiac, spinal, craniofacial – adverse events are rare
- The emerging concern of post administration seizures has not been reported for the dose used in trauma

"Denying injured children TXA due to the lack of pediatric trauma trial evidence in this indication is likely shortsighted and unnecessary given the ample clinical evidence in other pediatric settings, the excellent safety record of the drug, and the clear mortality benefit seen in adult trauma."