


ISSUES IN THE MANAGEMENT OF
PEDIATRIC TRAUMA

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GOALS

- Illustrate challenges and approaches to the initial management of pediatric trauma, especially in an environment not specifically focused on children.
- Describe a composite case from Harborview as an example.
- Discuss the role of the trauma system for pediatric patients and Harborview's place in that system.



CASE

- 6 yo male, riding a bicycle un-helmeted.
- Crashed at unknown speed.
- Found by passer-by, confused but conscious and ambulating.
- Child vomited awaiting EMS.



CASE

- **At Scene**
- HR 120 BP 100/- RR 24 GCS 14
- Abrasions R cheek, R flank. Slightly tender abdomen.
- Backboard, c-collar.
- 2 antecubital IVs with LR "wide open"

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CASE

- **In ED**
- T 36.9 HR 140 BP 95/42 RR 24 GCS 13
- Sleepy but arousable – complains of abdominal pain and nausea.
- Maintaining an airway.
- Placed on oxygen by NRB.
- Access is 2 antecubital IVs.

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CASE

- **In ED**
- T 36.9 HR 140 BP 95/42 RR 24 GCS 13
- Physician calls for fluid bolus to address tachycardia.
- Orders 20 cc/kg LR.
- *How much does this child weigh?*

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UNDERSTANDING SIZE IN PEDIATRIC CARE

- Most orders in children require accurate assessment of their size.
- Most trauma beds do not weigh critically ill patients.



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CAN WE MAKE A GUESS?



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COLOR CODED, LENGTH BASED RESUSCITATION SYSTEMS


- Recognize that length is a good proxy for size (for equipment) and weight (for resuscitation meds).
- *But is it valid given the increasing prevalence of obesity?*



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COLOR CODED, LENGTH BASED RESUSCITATION SYSTEMS


- Estimated weights accurate ($\pm 10\%$) in 70% of children.
- Much more likely to underestimate than to overestimate size.
- But...
 - Ideal equipment size is not influenced by obesity.
 - Most resuscitation meds are ideally dosed on lean body mass.
 - Pattern in a resuscitation is: *intervene - reassess - respond*
 - Latest tapes updated with new NHANES data



UW Medicine Acad Emer Med13: 1011-1019

COLOR CODED, LENGTH BASED RESUSCITATION SYSTEMS

- Not just a better way to estimate weight
- System removes reliance on weight estimation altogether
- Math-free algorithms:
 - Vitals
 - Dosing
 - Equipment
- Allows critical thinking
- Promotes transparency
- Reduces error



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CASE

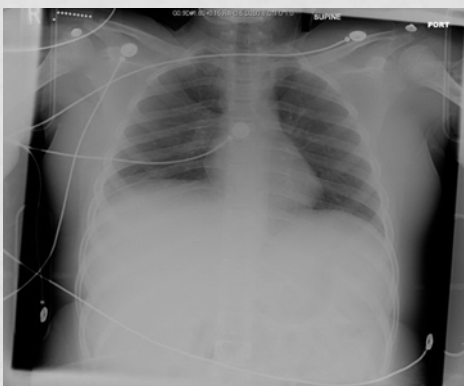
- In ED
- T 36.9 HR 140 BP 95/42 RR 24 GCS 13
- Physician calls for fluid bolus to address tachycardia.
- Orders 20 cc/kg LR.
- Child is **COLOR ZONE BLUE**
- Fluid bolus is 400 mL

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CASE

- In ED
- T 36.9 HR 140 BP 105/42 RR 24 GCS 13
- Labs
 - Hct 31%
 - INR 1.7
 - AST 445 ALT 357
 - UA -
- What about imaging?

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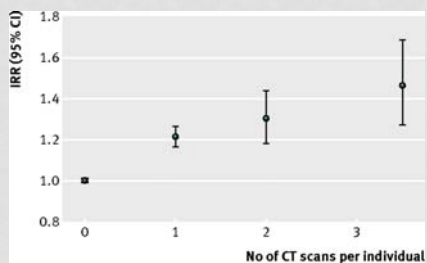
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CASE

- In ED
- Does he need a CT?
 - Of his head?
 - Of his abdomen?

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CANCER RISK IN 680 000 PEOPLE EXPOSED TO COMPUTED TOMOGRAPHY SCANS IN CHILDHOOD OR ADOLESCENCE: DATA LINKAGE STUDY OF 11 MILLION AUSTRALIANS.



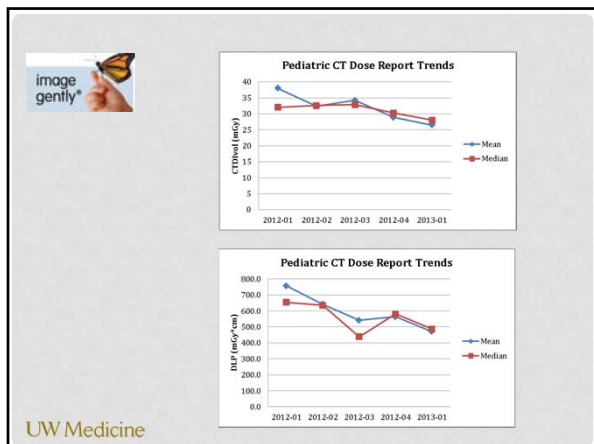
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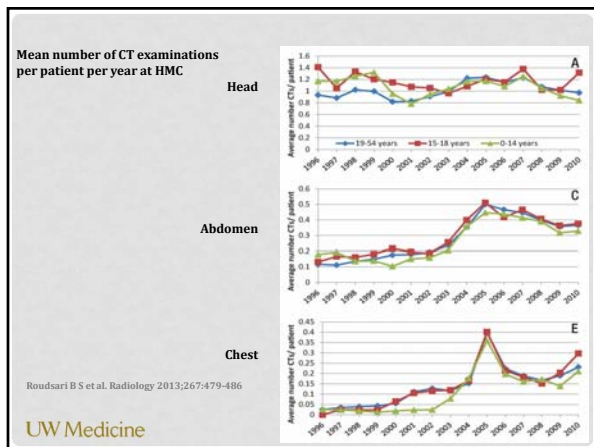
Matthews et al. BMJ 2013;346:f2360

STRATEGIES TO REDUCE EXPOSURE TO IONIZING RADIATION

- Minimize radiation dose by using pediatric specific protocols.
- Use clinical judgment to avoid unneeded scans.
- Minimize repeat scanning.

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CLINICAL DECISION RULES

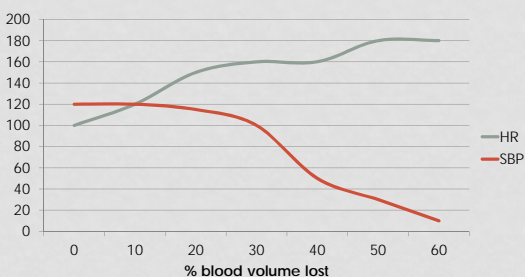
- Balance the immediate need for clinically relevant information against the long term goal to reduce exposure to cancer-causing radiation.
- Developed and validated on large populations of children similar to those treated at our institution.

CASE

- In ED
- T 34.9 HR 150 BP 100/42 RR 24 GCS 13
- Fluid boluses repeated x 3
- Decision to defer head CT until hemodynamically stable.
- Sent to CT scanner for abdominal imaging.

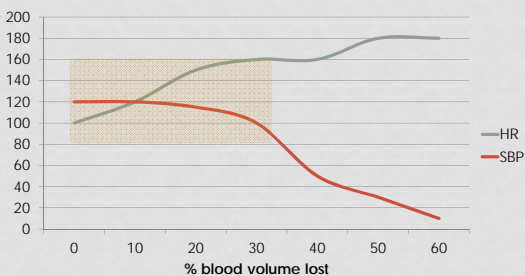
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HEMODYNAMIC RESPONSE TO HEMORRHAGIC SHOCK

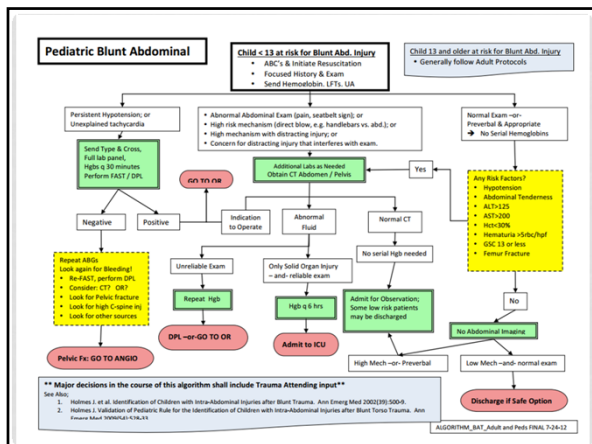


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HEMODYNAMIC RESPONSE TO HEMORRHAGIC SHOCK



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FAST IN CHILDREN

- Should this child have focused abdominal sonography in trauma (FAST)?

ACADEMIC EMERGENCY MEDICINE 2011; 18:477-482

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FAST IN CHILDREN

- Pediatric FAST is very specific for hemoperitoneum (83% to 98.3%), but sensitivity is generally poor.
- For example, if pre-test probability is 6% and FAST is positive, the posttest probability rises to 48%. A negative FAST lowers the probability to 3%.
- A positive FAST scan suggests hemoperitoneum and abdominal injury, while a negative FAST scan aids little in decision-making.

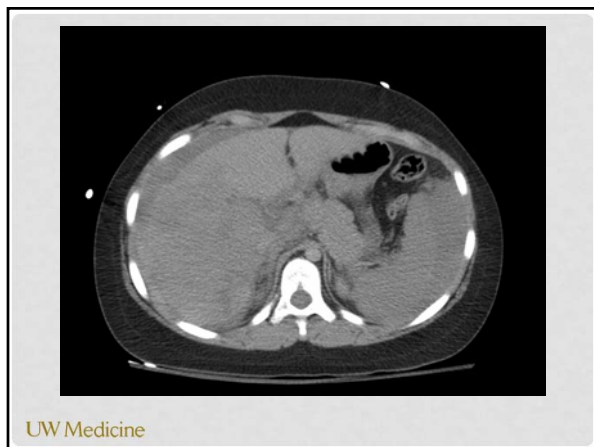
ACADEMIC EMERGENCY MEDICINE 2011; 18:477-482

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CASE

- To CT Scanner
- T 34.9 **HR 155** BP 100/42 RR 24 GCS 13
- IV dislodges during imaging.
 - Resulting images are essentially without contrast.
 - BP drops without continued fluid infusion.

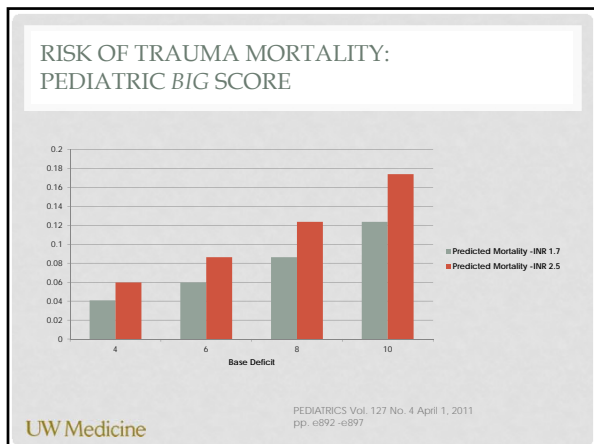
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CASE

- To OR
- T 34.9 **HR 170** **BP 65/42** RR 24 GCS 13
- New labs:
 - Hct 24 %
 - INR 2.5
 - Base Deficit 8.5
- *What is this child's risk of mortality now?*

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CASE

- To OR
- T 34.9 HR 170 BP 65/42 RR 24 GCS 13
- *What about more fluids?*

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MANAGEMENT OF UNSTABLE PATIENTS WITH UNCONTROLLED HEMORRHAGE

- This child has already had 60 mL/kg crystalloid plus ~20 mL/kg in pre-hospital setting.
- Blood volume is a child this size is ~70 mL/kg.
- Blood products are ordered and a pediatric massive transfusion protocol activated.

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Length-based Color-coded Fluid Volume Reference

Meticulous Fluid Management

- Account for all fluids given.
- Convert to mL/kg for interpretation.
- Another use for length based color coding to ease calculations.

Length-based Color-coded Fluid Volume Reference

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Harborview Medical Center Pediatric Massive Transfusion Protocol

* UNCONTROLLED & ONGOING HEMORRHAGE *

Estimated Blood Loss	Stable	Tachycardia	Hemodynamic Instability		
	< 20 mL/kg	20 mL/kg	40 mL/kg	80 mL/kg	Each additional 80 mL/kg
Crystalloid		20-40 mL/kg	reduce crystalloid to maintenance (DS) NS		
Blood Products			PRBC 30 mL/kg FFP 30 mL/kg	PRBC 30 mL/kg FFP 30 mL/kg PLTs 5 mL/kg	PRBC 30 mL/kg FFP 30 mL/kg PLTs 5 mL/kg Cryo 4 mL/kg

may activate MTP before crystalloid

- To activate pediatric massive transfusion protocols call 744.3088
- Obtain labs (EHR, K⁺, Ca²⁺, ABC, lactate) q 20 mins
- Aim for 1:1 (PRBC:plasma) ratio
- Platelets to keep PLT >100k; Cryoprecipitate to keep fibrinogen >150 mg/dL
- Aggressively manage > body temperature, serum Ca, K, and pH.
- Pediatric patient > 40 kg; treat as adult. Transfuse 1:1:1
- Deactivate protocol if hemorrhage controlled AND hemodynamically stable.

Massive Transfusion Pack
 6 PRBC
 4 FFP
 1 apheresis PLT
 1 cryo pool

Modified from Delmer et. al. Seminars in Pediatric Surgery (2010) 19, 286-291

CASE

- To OR
- T 34.9 HR 145 BP 105/75 RR 24 GCS 13
- New labs:
 - Hct 24 %
 - INR 2.5
 - Base Deficit 8.5
- *Why is the INR so high?*

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COAGULOPATHY IN TRAUMA

- "Dilution" - difficult to demonstrate in the lab
- Hypothermia
- Consumption
- Acute Coagulopathy of Trauma
 - Hypoperfusion of tissue beds
 - Local consumption of clotting factors
 - Hyperfibrinolysis

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TRANEXAMIC ACID IN PEDIATRIC TRAUMA

- Tranexamic acid (TXA) is an antifibrinolytic agent.
- CRASH-2 trial showed that administering TXA within 3 hours of trauma reduces the risk of death in bleeding adult trauma patients.
- No data for use in pediatric trauma.

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TRANEXAMIC ACID IN PEDIATRIC TRAUMA

- However, experience suggests TXA yields significant reductions in total blood loss and total blood or blood product transfusion volume
 - In pediatric cardiac surgery
 - In surgical correction of craniosynostosis in children
- Good safety profile in these circumstances.
- Expect pediatric trauma protocols to emerge.

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CASE - CONCLUSION

- In OR
- Shattered R lobe of liver.
- Damage control resuscitation.
- Liver packed; abdomen left open.
- To angiography for embolization of bleeding hepatic arteries.
- Aggressive resuscitation in the PICU
- Multiple returns to the OR.



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TAKE HOME POINTS FOR NON-SURGEONS

- Use length based resuscitation aids to increase safety and efficiency of pediatric care.
- Image thoughtfully – use clinical decision rules to help.
- FAST is useful when it is positive.
- Understand the pediatric response to exsanguinating hemorrhage.
- Track fluids from all settings, and move early to blood product administration in uncontrolled bleeding.

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JUST ONE CASE ...

- Why do kids come to Harborview at all?
- And does it make sense to have a pediatric and adult trauma center co-located?



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TRAUMA SYSTEMS SAVE LIVES

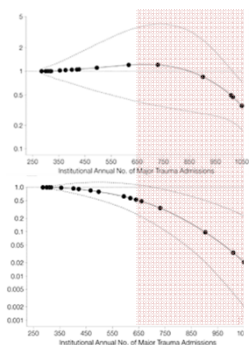
- Integrated trauma systems have been demonstrated repeatedly to be effective.
- One of the most important advances in the care of the injured patient over the last 30 years.
- Most benefit seen for patients who are **younger** and **more severely** injured.
- Premise underlying regionalization of care is that larger volumes of trauma patients cared for in fewer institutions will lead to improved outcomes

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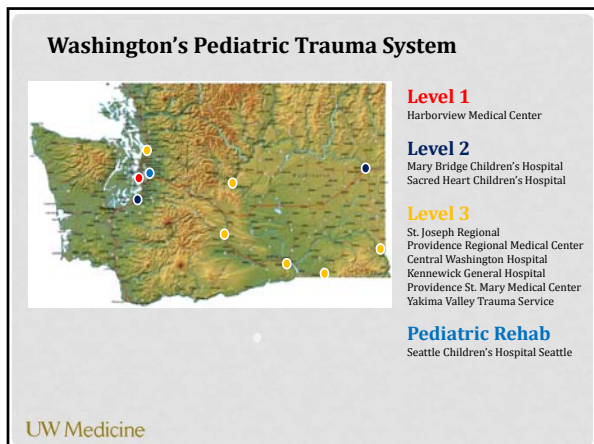
Relative odds of death, by trauma center volume, compared to lowest volume centers:

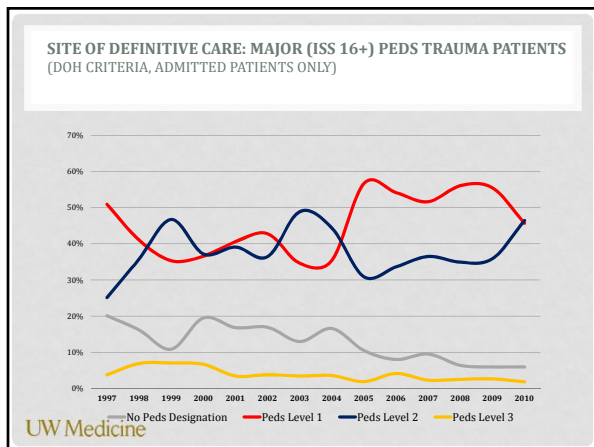
Patients with coma -

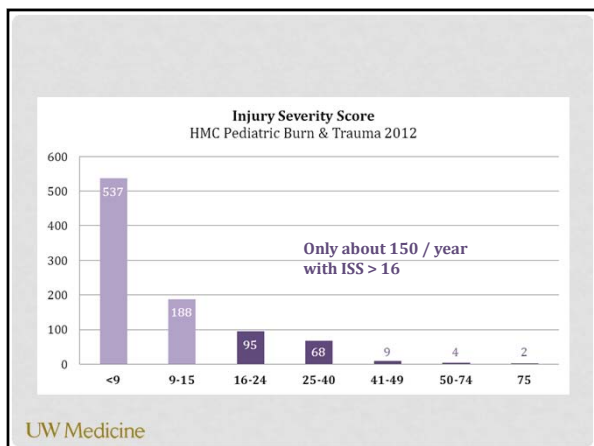
Patients with shock -



Nathens AB, Jurkovich GJ, Maier RV, et al. Relationship Between Trauma Center Volume and Outcomes. JAMA. 2001;285(9):1164-1171







Given the established relationship between trauma volumes & outcome ...

Threshold for benefit ~ 650 cases annually



Nathens AB, Jurkovich GJ, Meier RV, et al. Relationship Between Trauma Center Volume and Outcomes. JAMA. 2001;285(9):1164-1171

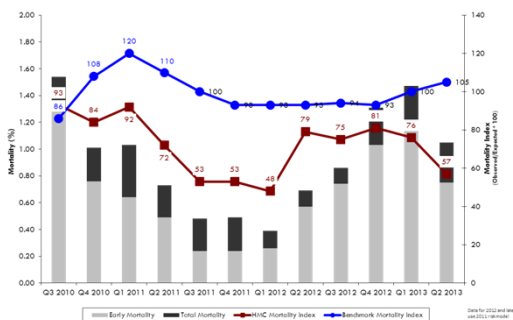
... there is not enough major pediatric trauma *in the state* to reach this threshold.

Children need to be accommodated at the adult trauma center to benefit from our volume and experience.



Pediatric Trauma Mortality Benchmark

Data from ITRC, ITRC, n=8 Level I Pediatric Trauma Centers
12 Month Rolling Data - Quarterly by Calendar Year



THANK YOU!

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