Pediatric Trauma: Pearls of Management

Judith R. Klein, MD
Assistant Professor
UCSF-SFGH
Department of Emergency Medicine
Pediatric Trauma: The Problem

- Leading cause of M/M age 1-24
- 50% of all pediatric deaths < 15 years
- Per year:
  - 1.5 million injuries
  - 500,000 hospitaliz.
  - 20,000 deaths
Why Are Kids So Vulnerable?

- Smaller body → greater distribution of trauma → more injuries
- Improper use of car seat/seatbelt
Objectives

- **ABCDE’s**
  - How are kids different?
  - How do these differences change management?

- **Hot Topics**
  - Trauma series for all?
  - When should I radiate the head? The neck?
  - What about the belly? When do I need to CT?
  - Is ultrasound useful with kids?
Johnny Walker

- **Ringdown**: 4 yr old
  - Ped vs. Auto
- **P 150** **BP 75/P**
  - **RR 35**
- Stridorous cries, pale, CRT>3 sec
- Minimal response to IV placement
What’s my #1 Priority?

AIRWAY

STRIDOR
Airway Differences

- Large tongue
- Floppy epiglottis
- More cephalad/anterior
- Narrowest at cricoid ring until age 8
- Large occiput
- Nose breathers

Fig 1. Configuration of the adult (A) and the infant (B) larynx. Note the cylinder shape of the adult larynx. The infant larynx is funnel shaped because of a narrow, undeveloped cricoid cartilage. A indicates anterior; P, posterior. Reproduced with permission from Coté and Todres.
Airway Implications (cont):

§ Suction liberally
- **NO** NP airway <1 yr
- BVM: proper fit
- Straight blade
- <8 yr: uncuffed tube
- RSI: atropine (up to 6-12 months)
Johnny Walker

- Secretions cleared
- NP airway placed
- No more stridor
- RR 40
- O2 saturation on NRB= 90%

What next?
Priority #2:

BREATHEING
Breathing Differences

- Immature intercostals → diaphragm dependent
- Pliable chest wall → retractions → poor respiratory dynamics
- Mobile mediastinum
Breathing Differences: Implications

- Tire more easily: early aggressive intervention
- Close observation
- Decompress stomach early
- Relieve PTX/HTX quickly
Johnny Can’t Walk

- You intubate Johnny
- His pulse is now 160, BP 70/palp
- On exam, feet and hands are cool
- CRT>3 seconds
- Now what?
Priority #3: Circulation
Circulation Differences

- Smaller volume
- HR dependent CO
- High metabolic demand $\rightarrow$ high CO $\rightarrow$ little reserve
- Maintain BP despite 30-40% blood loss
- Difficult IV access
Circulation Differences: Implications

- Bradycardia → marked BP drop
- Increased metabolic demands poorly tolerated (e.g. hypothermia)
- Hypotension pitfall
Circulation Tools

- Signs of **shock**
  - CRT > 2-3 seconds
  - Cool skin
  - Low urine output
  - Altered mental status
  - Elevated heart rate
  - Narrow pulse pressure
  - Lactate

- Do **NOT** rely on blood pressure
Johnny’s Not Moving Much

- You place an IO needle
- After 20cc/kg x 2, BP=90/p, P=120
- Extremities warmer, CRT improved
- Minimal response to pain
- What now?
Priority #4:

DISABILITY

Brain/Cervical Spine
Disability: Brain differences

- High glucose needs
- Low glycogen stores
- Less myelination
- Thin skull/fontanelle
- Larger head/body size ratio
- MS assessment challenging
Brain Differences: Implications

- Skull Fractures
- More intracranial injury (ICI): 80% of all trauma deaths
- Mental Status assessment: AVPU
- Hypoglycemia common - check FSBG early!
Cervical Spine Differences

- High fulcrum C2-C3
- More cartilage in C spine
- More pre-vertebral soft tissue
- Horizontal facets
- Epiphyses
C spine Differences: Implications

- High cord lesions under 8 years old
- Ligament injuries
- C2/C3 pseudosublux
- SCI WORA
Not quite done yet

- Johnny alerts to pain only
- FSBG=110
- Cervical spine immobilization is carefully maintained
- Cervical spine and head imaging are ordered
- Anything else to worry about?
Priority #5:

EXPOSURE
Exposure Differences

- Higher surface area/body weight ratio
- Johnny’s rectal temperature is 35.5
- You cover him with a Bear-hugger and use warm IVF
Organ Differences

- Pliable rib cage -> vulnerable thorax
- Liver and spleen more anterior/less protected
- Kidney more mobile/less protected

**BUT**

- More sensitive to radiation (long term malignancy rates)
Hot topics in Pediatric Trauma

- Trauma series: therapeutic radiography?
- Mild head injury: whom to radiate?
- Intra-abdominal injury: who needs CT?
- Role of ultrasound in kids
Jane Smilie

- 2 year old rear restrained passenger in rollover
- VS all WNL
- PE all WNL
- Playing with your stethoscope
- Any X-rays needed?
Trauma Series: Who needs it?

- 986 kids <16 years
- Decision rule derivation:
  - Low BP
  - Increased RR
  - Abnormal chest exam
  - GCS<15
  - femur fracture
- 98% NPV
- Needs validation

Trauma Series: Who needs it?

- Retrospective study
  - 91 subjects
  - >2 years; GCS 15
  - Localizing findings?
- No localizing findings -> 100% NPV for CXR/ Pelvis abnormality

* Kevill, Ped Em Care 2002
“I felled down”

- 13 month old
  slipped down 10 wooden steps <1 hr ago
- Cried immediately
- 4 cm temporal scalp hema-tomato
- Vomited x 1
- Looks fine now
- To CT or not to CT?
Who gets imaged?

- 40-50% to ED get imaged!!
- Higher CT rates:
  - White
  - older
  - general vs pediatric hospital
  - more emergent triage status
  - attending treated
- Lifetime CA risk from 1 head CT:
  - 1:2000 (infant) to 1:5000 (older child)
- <10% of CT’s have TBI/0.5% with clinically important TBI
GCS $\geq 14$: To CT or not to CT??

- **Reduce CT’s**
  - Radiation
  - Sedation
  - $$$

- **Identify all TBI or just CI TBI?**
  - Neurosurgical intervention
  - Hospital $\geq 2$ nts /intubation$>24$ hrs
  - Death/long term neurological sequelae
PECARN Minor Head Trauma Decision Rule

- Derivation and validation
- 42K kids GCS $\geq 14$
- $>10K$ under 2 yrs
- $<2$ years:
  - 100% NPV for CI TBI and all TBI
- $>2$ years:
  - 99.9% NPV for CI TBI
  - 98.4% NPV for all TBI
- ↓ CT use by 20-25%
Under 2 years old

Kuppermann et al. Lancet 2009
Over 2 years old

Kuppermann et al. *Lancet* 2009
Severe Mechanism

- MVA ejection, rollover, death of another
- Ped/bike no helmet vs. car
- Fall >3 ft (<2yrs) or >5 ft (>2yrs)
- High impact object to head
What about her neck?

- C spine injuries uncommon
  <8 years old
- Leading causes
  - MVA (<8 yrs)
  - Sports (>8 yrs)
  - PVA
Clearing little c-spines

Ø NEXUS:

- 3065 kids
- 30 CS injuries:
  - Only 4 injuries 2-8 years
  - None < 2 years

Criteria: (100% sens)
- No neck tenderness
- No focal neuro sx
- No distracting injury
- Normal MS
- No intoxication

*Viccellio, Pediatrics 2001*
Applying NEXUS criteria

Ø 187 kids with c-spine injury
--> NEXUS rules applied:
  1. 32 kids < 8 yrs:
     94% sensitivity
  2. 155 kids > 8yrs:
     100% sensitivity

* Garton, Neurosurgery, 2008.
Modified NEXUS: clearing pre-verbal c-spines

- Age approp MS/no LOC
- No distracting injury
- No neck tenderness or obvious pain
- Low force mechanism
- Let them look around
Pediatric Cervical Spine Clearance

1. Bad CNS status
   - Very positive history or physical
   - Positive or inadequate plain films
   - Full Cervical Spine CT

2. <3 years
   - Attempt clinical clearance:
     - Age appropriate mental status
     - No history of LOC
     - No neck pain or tenderness
     - Normal neurological exam
     - No distracting injury
     - Low force mechanism
   - THEN let them look around left/right/flex/extend
   - normal
   - abnormal
   - clinically clear
   - abnormal
   - clinically clear
   - abnormal or inadequate
   - attempt clinical clearance
   - Fails
   - Full cervical spine CT
   - Persistent pain/tenderness/neuro sx
   - MRI

3. 3-8 years:
   - Use NEXUS criteria (as in ≥8 years) to clinically clear
   - normal
   - abnormal
   - clinically clear
   - abnormal
   - normal
   - Start with 3 view plain X-rays
   - clinically clear
   - abnormal or inadequate
   - attempt clinical clearance
   - Fails
   - Full cervical spine CT
   - Persistent pain/tenderness/neuro sx
   - MRI

4. ≥8 years
   - Attempt clinical clearance with NEXUS criteria
     - Normal mental status/no intoxication
     - No neck pain or tenderness
     - Normal neurological exam
     - No distracting injury
   - normal
   - abnormal
   - normal
   - abnormal or inadequate
   - attempt clinical clearance
   - Fails
   - Full cervical spine CT
   - Persistent pain/tenderness/neuro sx
   - MRI

*Low force mechanism:
- Fall <3-5 feet vertical
- Lower speed MVA where patient/car-seat all stay in place
Can we get to the OR quick?

- 3 year old unconscious PVA
- P 140, BP 95/palp
- Cool extremities
- Needs craniotomy
- How can we “clear” the belly of major bleeding?
- Can ultrasound help?
Role of Ultrasound in Kids

- 2007 meta-analysis
- FAST and hemoperitoneum:
  - Sensitivity: 66-80%
  - Specificity: 95-96%
- Role of US in trauma:
  - HD unstable
  - HD stable
  - Urgent OR need (e.g. head)

*Holmes, J Ped Surg 2007.*
Do I have to make this kid glow?

- 6 year old restrained passenger MVA
- Alert, awake, nl VS
- No pain/tenderness but abdominal bruising from seat belt
- Does this child need an abdominal CT?
Well why not?

- 897 kids with abd CT
  - 2% of CT’s abnl
  - 5% of these go to OR
- CT-->unnecessary lap?
- CT radiation risk:
  - Head: 2 mSV
  - Abd: 10-15 mSV
  - 1 extra CA per 2-5K studies

Fenton, *J Ped Surg* 2004
What can help me decide?

- 1119 kids <18 yrs
- Decision rule for CT:
  - Low SBP
  - Abd tenderness
  - Femur Fx
  - Labs: AST>200, ALT>125
    - HCT<30, UA>5RBC/hpf
- Sensitivity: 94.9%
  - Specificity: 37%

*Holmes, Annals EM 2009.*
Abdominal CT Decision Rule

- Missed injuries:
  - low GCS
  - low thoracic tenderness
  - seatbelt sign

- PECARN study in progress
What do we know about seatbelt signs (SBS)?

- Poorly located lap belt --> bruising --> bowel injury
- Lutz 2004: OR for significant IAI 232 if SBS
- Chidester 2009: SBS maybe not so bad
- Sokolove 2009: SBS increased risk of IAI (OR 2.9) but all kids also had pain or tenderness --> consider prolonged obs/admit if SBS but no pain
If I do the CT, what am I looking for?

- Solid organ injury: liver, spleen, kidney, pancreas
- Bowel injury:
  - Unexplained FF
  - Wall thickening
  - Mesenteric infiltration
  - Contrast extravasation from bowel (RARE)
What if the CT is negative: discharge?

- Meta-analysis 2596 kids
- NPV of CT: 99.8%
- If negative CT:
  - Consider 6 hour obs
  - D/C if normal and no SBS

*Hom, Acad EM 2010.*
Pearls:

- Don’t Panic
- Kids are not little adults
- Remember ABCDE differences and apply in management
- Don’t radiate all kids