

Pediatric Trauma

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PEM Conference

Podcast Review

What to expect

Rosen's Emergency Medicine - Concepts and Clinical Practice

17 core “hot topics”

Focus on differences and frequently “forgotten” nuances in pediatrics

Things to remember

What is trauma?

Trauma = transfer of energy to tissues

In children, particularly <8 years old: Larger abdominal organs, More flexible ribs/cartilage organs/stx

What does this mean for our patients? Can compress internal organs without showing structural damage (i.e. bruising, fractures)

6 Anatomic/physiologic differences between children and adults in relation to trauma management

FIRST...anatomy

1. Brain is less protected, thinner cranial bones than adults, less myelination, more prone to injury. More widely distributed forces in a child = multiple injuries more likely to occur. More anterior inner organs with less muscle and fat: liver, spleen, and less protected spleen
2. Ribs may not fracture, BUT...Pulmonary injuries occur without skeletal injuries due to elastic ribs
3. Open growth plates = Salter-Harris type fractures with long term implications.
4. Spinal Cord Injuries without Radiographic Abnormalities (SCIWORA)

Spinal Cord Injuries without Radiographic Abnormalities (**SCIWORA**) injuries occur due to an elastic vertebral column and tenuous blood supply

- SCIWORA describes patients with **neurologic findings suggestive of spinal cord injury** with normal anatomic alignment and **no bony abnormalities** seen on plain film and/or computed tomography of the spine.
 - $\frac{2}{3}$ children with SCIWORA have demonstrable injury to the spinal cord, soft tissue components of the spinal column (ligaments, capsules, or muscles), or vertebral body endplate on MRI
 - SCIWORA typically involves the **c-spine** and occurs with greater severity in children <8 years.
 - MVC, falls, and sports account for most instances of SCIWORA in children.
- SCIWORA may present as **definite** evidence of spinal cord injury on PE or subtle transient neurologic symptoms (eg. paresthesias, weakness).

When to suspect sciwora and what

to do about it MRI should be performed in children who are suspected of having spinal cord injury, but **have normal plain radiographs** (3 view) and/or CT of the cervical spine.

- Acute management:
 - Maintenance of spinal immobilization, Emergent support of A, B, C while treating other life-threatening injuries.
 - Emergent consultation with a neurosurgeon and/or orthopedist with pediatric expertise in patients with spinal column instability
 - The administration of methylprednisolone (eg, 30 mg/kg initial loading dose over one hour followed by 5.4 mg/kg/hour for 23 to 48 hours) within the first three to eight hours after injury in those patients with an abnormal neurologic
 - Definitive therapy should be based on the MRI findings

Physiology and Hemodynamics

Children, compared to adults, have larger surface areas and are more prone to heat loss.

“Little people, big surface area”

More likely to become hypothermic = negative effect on cardiac function (inotropy, LV contractility), platelet function, renal and hepatic drug clearance, metabolic acidemia, and can result in coagulopathy.

Hypoxemia → high risk for DIC and other secondary complications once patient is stabilized

Physiology and hemodynamics

Higher metabolism than adults, and therefore, Higher O₂ consumption and glucose utilization per kg = need energy and calories sooner, due to increased metabolism

Higher proportional requirements for free water, electrolytes, minerals due to higher metabolism

“Kids hold onto their hemodynamics until the very end”

Great capacity to maintain BP **despite 25-30% blood loss**

little role for inotropy (change in strength of contractility): blood pressure mostly dependent on chronotropy (rate) and SVR

LOOK FOR tachycardia and **slow cap. refill** as warning signs of impending

Formulas to remember / take home

points
○ Cuffed ETT size: age in years/4 + 3.5

○ **Uncuffed ET size: age in years/4 + 4**

- Uncuffed tubes in children < 8 years old; if you feel resistance, size down 0.5

○ Tube depth: age in years/2 + 12

■ **Appropriate tube size X 3 = number of cm at the teeth that the ETT should be taped at.**

- Make sure distance at the teeth is exact, be careful transferring (missed occult extubations occur frequently)

review 1-2-3-4 rule

8 airway differences in peds vs.

ad

| | Differences | Implications |
|-------------|--|---|
| Physiologic | Increased vagal response to laryngoscopy | Bradycardia - have atropine on hand! |
| Anatomic | Larger tongue | #1 cause of airway obstruction; need better head positioning +/- OPA/NPA |
| | Larger adenoidal tissues | Nasotracheal intubation and NPA's are tougher to insert |
| | Floppy epiglottis more U shaped | "use miller blade" (false dogma) and change in intubation technique - 'insert Miller blade into the esophagus and then SLOWLY withdraw until you see the glottis' |
| | Cephalad, anterior larynx | tougher to visualize the cords, need to angle 45 deg. forward to see them |
| | Cricoid ring the most narrow part of the airway (the first cricoid cartilage of the trachea) | May need uncuffed tubes in kids <8 yrs (or need to downsize slightly) |
| | Narrow tracheal diameter and distance between rings | Needle cric. for kids <12 yrs: not surgical airway |
| | SHORTER tracheal length; large airways more narrow | Right mainstem intubation (neck extension) and EASY dislodgement of tube (neck flexion) ; greater airway resistance |

Hemorrhagic **SHOCK** and what to do about it

Potential fluid therapies for hemorrhagic shock and their doses

- standard trauma/resus room protocol : MOVIE
- 10-20ml/kg of crystalloid IV bolus repeated up to **three times** then: use blood products
 - PRBCs: **10 ml/kg**
 - Platelets: **10 ml/kg**
 - FFP: **25 ml/kg**

“TEN (P) , TEN (P), 25!”

Access!

List 3 ideal IO sites in pediatrics and describe the procedure

Need to use the mantra “1-2-IO” - get access ASAP

→ this should take less than a minute, first attempt, second attempt if >1 minute, get IO

- IV access: if not do an IO
- (most common, comfortable) proximal medial tibia
- proximal humerus (best flow)
- anterior distal femur

#1 prepare area with chloroprep, #2 use appropriately sized IO #3 Drill, hook up, slow flush with NS before hooking up to infuser #3 arrow “easy IO”

EZ- IO video

Arrow® EZ-IO® Infant Child Needle Selection and Insertion Technique Animation Video

<https://www.youtube.com/watch?v=mpnroZi8t0A>

- don't forget to ensure proper placement with aspiration/drawback of blood.

PEDIATRIC GCS (nonverbal)

AVPU system / age appropriate GCS score

○ *the problem with the peds GCS is that it DOESN'T help you prognosticate neurological outcome as the adult GCS score (no validation) and has poor inter-rater reliability*

Children with poor scores can have great outcomes

A - Alert

V - verbal response/response to stimuli

P - response to painful stimuli

U - unresponsive

Adult**Pediatric**

| | | | | |
|---------------------|---|-----------------------------|-----------------------|---|
| Spontaneously | 4 | Best Eye Opening | Spontaneously | 4 |
| To verbal stimuli | 3 | | To verbal stimuli | 3 |
| To painful stimuli | 2 | | To painful stimuli | 2 |
| No eye opening | 1 | | No eye opening | 1 |
| Oriented | 5 | Best Verbal Response | Appropriate coo & cry | 5 |
| Confused | 4 | | Irritable cry | 4 |
| Inappropriate words | 3 | | Inconsolable crying | 3 |
| Incomprehensible | 2 | | Grunts | 2 |
| No verbal response | 1 | | No verbal response | 1 |
| Obeys commands | 6 | Best Motor Response | Normal spontaneous | 6 |
| Localizes pain | 5 | | Withdraws to touch | 5 |
| Withdraws to pain | 4 | | Withdraws to pain | 4 |
| Flexion to pain | 3 | | Flexion to pain | 3 |
| Extension to pain | 2 | | Extension to pain | 2 |
| No motor response | 1 | | No motor response | 1 |

Signs of ICP

Signs of herniation might be indicated by:

- pupil size and reactivity
- extremity movement and tone
- posturing and reflexes

Treatment:

mannitol 0.5 g/kg IV; maintain CPP of at least 50

assess for spinal injury

6 indications for laparotomy

- hemodynamic instability despite aggressive resuscitation
- **free fluid** on FAST and instability
- massive bleeding (intraperitoneal) despite blood
- pneumoperitoneum / intraperitoneal bladder rupture / grade V renovascular injury
- gunshot wound
- evisceration
- peritonitis

6 signs of increased intracranial

Pressure

Signs of increased ICP in infants -

- full fontanelle
- split sutures
- altered state of consciousness
- paradoxical irritability
- persistent emesis
- setting sun sign

Signs of increased ICP in children

- headache
- stiff neck
- photophobia
- Altered mental status
- persistent emesis
- cranial nerve involvement
- papilledema
- hypertension, bradycardia, hypoventilation (Cushing's response)
- decorticate and decerebrate

Sunsetting



Impact seizures

- important anatomic differences: larger, heavier cranial vault
- high amount of torque on the C spine axis in toddlers and infants : malleable sutures
- brain parenchymal damage without skull fractures (absent skull fracture with massive injury)

Less myelinated brain with higher water content “brain floats in csf space” - more susceptible to shearing forces and injury

Key points on history:

- height of fall, method of landing, surface of impact, use of restraints, helmet use, LOC immediately after injury, signs of progressive lethargy/irritability/ recurrent vomiting/etc.
- vomiting is an unclear prognostic indicator

Impact seizures

- **Impact seizure:** a seizure with immediate return to normal mental status after the postictal period: usually **NOT** associated with parenchymal injury
 - seizures > 20 mins from injury = greater possibility of TBI and need for CT and neurosurgery consult.

Physical exam:

- ABC's interventions
 - maintain oxygenation and perfusion
 - optimize glucose
 - euvolemia
- no matter what a child's neuro presentation in the ED try to resuscitate

Epidural vs. subdural hematoma

Epidural hematoma

- "head injury: lucid interval: followed by rapid deterioration" due to VENOUS bleeds in kids (adults = arterial bleed)
- ***delayed signs and symptoms***
- highly associated with overlying skull fractures

Subdural hematoma

- usually associated with rupture of bridging veins.
- most common in kids <2 yrs. of age
- may be chronic in the child with "shaken baby syndrome" or NAT!
- vague: vomiting failure to thrive, altered LOC, seizures. need fundoscopic exam to rule out retinal hemorrhage pathognomonic of NAT (non-accidental trauma)

Managing ICP

Diagnostic strategies:

- serial exams are key
- absence of focal findings doesn't rule out injury
 - papilledema requires days to develop
- cushing's response is ominous
- monro-kellie doctrine
 - as ICP increases - brain perfusion/ability to autoregulate decreases
- herniation syndromes:
 - uncal herniation
 - unilaterally dilated pupil
 - compression of ipsilateral third nerve, contralateral hemiplegia, hyperventilation

... ..

Treatment of ICP

- ****prophylactic treatment with anticonvulsants **not** recommended ****
- incidence of post-traumatic seizures is low
- treatment of Increased ICP
- **Non-pharmacologic**
 - elevate HOB >30 deg
 - head in midline
 - avoid hyperthermia
 - mild hypothermia
 - maintain euvolemia
 - decompressive craniotomy

Pharmacologic

- Mannitol (0.5 g/kg IV)
 - rapid osmotic diuresis
- Hypertonic saline (0.1-1 mL/kg of 3% saline)
- Pentobarbital / phenobarbital
 - lowers cerebral metabolism
- Neuromuscular blockade
- Sedation, Treat seizures aggressively
- hyperventilation for ACUTE increase in ICP

STOP! Review!

Name 3 non-pharmacologic to decrease ICP

Name 3 pharmacologic interventions to decrease ICP

Choosing chest tube size

4x size of ETT

pediatric specific cardiovascular and abdominal injury patterns:

Thoracic injuries

Pneumothorax

- widespread transmission of breath sounds can mislead the clinician
 - ****listen in the axilla****
- <20% pneumothorax with no need for transport or ventilation may be watched
- Ultrasound highly sensitive and specific for detecting ultrasound

Open pneumothorax

- bidirectional flow of air
- significantly impairs oxygenation and ventilation
- Treatment:

Tension pneumothorax

-can be subtle

- one-way valve
- signs are often SUBTLE in pediatric patients

Hemothorax:

- difficult to identify on supine CXR
- rare; associated with big mechanism of injury
- need large tube drainage
- operating room thoracotomy if: >15ml/kg of blood immediately exudes OR continuous air leak

Pulmonary contusion:

- chest compliance in children puts them at

Abdominal injury/Specific injuries

- Three injuries associated with **lap belt use**:
- small bowel injury/hematomas
 - pancreatitis
 - chance fractures

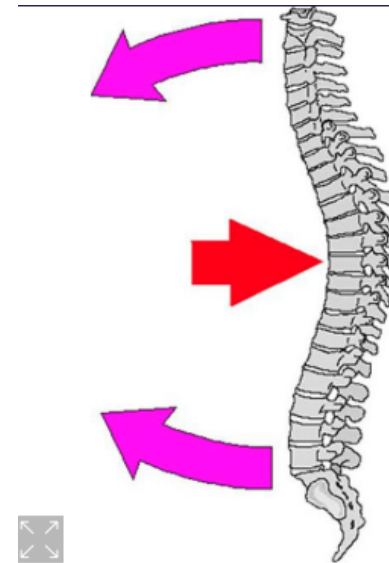
A **Chance fracture** is a **flexion** injury of the spine; compression injury to the anterior portion of the vertebral body and a transverse fracture through the posterior elements of the vertebra and the posterior portion of the vertebral body. It is caused by violent forward flexion, causing distraction injury to the posterior elements. The most common site at which Chance fractures occur is the thoracolumbar junction (T12-L2)

Bike handlebar injuries

- Typically localized to the epigastric area
- duodenal hematoma
- pancreatic transection/trauma

Sports related:

- spleen, kidney, intestinal tract



Abdominal injuries

Diagnostic strategies and management:

- abdominal distention is common due to ingested air
- early foley catheter helps decompress the bladder and assess U/O
- FAST ultrasound: If positive and patient stable --> on to CT +/- angiography
- indications for laparotomy:
 - hemodynamic instability despite aggressive resuscitation
 - free fluid on FAST and instability
 - massive bleeding intraperitoneal despite blood
 - pneumoperitoneum / intraperitoneal bladder rupture / grade V renovasc. injury
 - gunshot wound
 - evisceration
 - peritonitis

Disposition

ED role:

- resuscitation and stabilization and transfer to appropriate facility
- avoid extensive imaging if your center can't deal with the results
- low threshold for admission with serial exams

Cessation of care:

- obvious if: livor mortis, rigor mortis, massive injuries
- attempts should be made if there are signs of life
- parental presence during resuscitation should be encouraged

REMEMBER

1-2-3-4 rule

- 1) ET TUBE size?(uncuffed) → $\text{age in years}/4 + 4$ (can size down $\frac{1}{2}$ size or more) If cuffed, subtract .5 for size
- 2) NG/foley catheter= $2 \times \text{ETT size}$
- 3) Tube depth ($3 \times \text{ETT size}$) = depth should be inserted at the teeth
- 4) Size of chest tube (largest size of chest tube you can use) = $\text{ETT} \times 4$

My thoughts on this podcast...

<https://canadiem.org/crackcast-e038-pediatric-trauma/>