What Makes a Kid a Kid "Not Just a Little Adult":
Pediatric Pearls

Hilary A. Hewes, MD

Objectives:
• Review some basic anatomical, physiologic, and metabolic differences between kids and adults
• Discuss general differences in the approach to, evaluation of, and management of pediatric trauma and resuscitation patients
What Makes a Kid “Not Just a Little Adult”: Pediatric Pearls

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The Correlate is Also True
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• Know that we are panicking whenever a remotely sick adult patient is in our ED
• We can’t hear anything in big adults with our pediatric stethoscopes
• We can’t recognize half the medications adults are on, since they did not exist when we studied pharmacology
• We went into pediatrics to resuscitate the baby, not the delivering mother
Objectives

• Review some basic anatomical, physiologic, and metabolic differences between kids and adults

• Discuss general differences in the approach to, evaluation of, and management of pediatric trauma and resuscitation patients
Background

• >11,000 EMS transports/year in Utah
• Nationally, 10-15% of transports are pediatric patients (probably a little higher in Utah)
• 750,000 ED visits/year in Utah
• 75,000 are pediatric visits
• Only 40,000 seen at PCH
• We count on you guys to take care of the rest of them
Background: General Assessment

• It can be overwhelming trying to remember all the weight-based doses of medications and age-specific vital signs
• The most important thing is your first impression: sick, not sick
Background: General Assessment

Recognition & assessment of the sick child

Pediatric assessment triangle (PAT): A-B-C
Background: Basic Differences

• **Pediatric Vital Signs:**
  • The lower limit of systolic blood pressure (5th percentile) for age may be estimated by the formula: 70 mm Hg + (2× age in years)
  • Some other good reminders:
    – no child's respiratory rate should be >60 breaths/min for a sustained period
    – young kids don’t breathe < 15-20x/minute
    – normal heart rate is roughly 2-3 times normal respiratory rate for age
Basic Differences

- **Relatively small size:**
  - The smaller the child, the greater the likelihood that a single impact will injure multiple organ systems
  - A 2 year old struck by a car will have different injuries than a 14 year old

- **Temperature control:**
  - High body surface area to volume ratio, but low heat production
  - Muscle tone less mature and can’t shiver as well to get heat to core
  - Often less adipose tissue leading to poor insulation
  - All of the above predispose children to hypothermia
  - Hypothermia can be a cause of bradycardia, cardiac instability, and cardiac arrest
Background: Basic Differences

- **Hypoglycemia:**
  - Children (especially small babies and toddlers) are more prone to hypoglycemia
  - Increased glucose requirements because of higher metabolic rate
  - Livers are underdeveloped and they have decreased glycogen stores
  - Stress may induce hypoglycemia in the pediatric patient
  - Consider a bedside glucose level in all infants regardless of the diagnosis, and in all ill appearing children
  - “Normal” glucose is different in a newborn
Background: Basic Differences

• **Blood Volume:**
  • Relative blood volume is larger in kids, but absolute volume is smaller
  • Kids have 70-90ml/kg versus adults have 65-70ml/kg
  • However, relatively small volumes of blood will constitute significant blood loss in small children
    – A 5kg child losing 100 mL of blood represents the loss of approximately 20% of their total blood volume
• Monitor and record all blood loss, including amounts that would be insignificant in the adult patient
Basic Differences: Airway

- **Pediatric airway is smaller**
- In the small airway, there is greater risk of airway obstruction from small foreign bodies (even loose teeth)
- Small amounts of swelling of the airway will result in a relatively greater reduction in airway diameter than would occur in the larger airway of the adult
Basic Differences: Airway

- Tongue: the pediatric tongue is larger than the adult in relation to the amount of free space in the oropharynx, can create problems with airway occlusion, and leaves little room for airway swelling.
- The large tongue is one explanation for why children are obligate nose-breathers.
- Correct positioning of the head and jaw to open the airway is critical.
- Larynx is higher and more anterior, and therefore more difficult to visualize during intubation.
Basic Differences: Thorax

- Children have a larger heart size relative to thoracic cavity volume, and therefore less pulmonary reserve.
- With inspiration the ribs only move up, and not up-and-out, like the adult rib cage; limits the capacity to increase tidal volumes.
- Important to decompress the stomach infants to minimize interference with diaphragm movement because the diaphragm is the most important respiratory muscle in young kids.
Basic Differences: Thorax

• Kids tend to get less severe rib injuries because their ribs are more pliable and compliant
• Blunt chest trauma may not result in rib fractures in infants and young children, due to the increased elasticity and compliance of the chest wall
• Can still have pulmonary contusions, pneumothorax, hemothorax, and/or disruption of the major vessels in the chest even without obvious rib injuries
Basic Differences: Circulatory

• Children have very efficient compensatory mechanisms, and can maintain their blood pressure until they have lost large intravascular volumes (25%)

• However, children can’t increase their cardiac output the same as adults:
  – Adult heart increases its stroke volume by increasing inotropy (strengthening contractions) and chronotropy (increasing heart rate)
  – Pediatric heart can only increase chronotropy in an attempt to increase stroke volume

• Heart rate should be seen as a significant clinical marker when monitoring cardiac output in pediatric patients

• Bradycardia in an adult is often due to cardiac pathology

• Bradycardia is most commonly caused by hypoxia in pediatric patients
Basic Differences: Cervical Spine

• Cervical spine injuries tend to occur at a different position because kids have a relatively large head
• The fulcrum is at C1 - 2 not C 6 – 7
• Therefore, cervical spine injuries in kids <8 usually C1-C3 (more often C4-C7 in adults)
Basic Differences: Cervical Spine

• Kids have lax ligaments, weaker neck muscles, and more flexible spines
• 60-80% of spinal injuries are in the C-spine (vs. 30-40% of adult spinal injuries)
• Children can have spinal cord injury without radiographic abnormality (SCIWORA)
• When in doubt, keep the collar on... even though they hate it
Basic Differences: Abdomen

• In children, the abdomen begins at the level of the nipple; even chest trauma can cause intra-abdominal injury

• The softer rib cage and underdeveloped abdominal muscles afford little protection to internal organs

• Since a child's bones are more flexible than an adult's, it is possible for a child to have serious internal injuries without fracture
Basic Differences: Abdomen

• The diaphragm of the child is flatter and less dome-shaped than that of an adult, and pushes the liver and spleen lower below the rib cage
• The solid organs therefore take up a greater proportion of the abdominal cavity in the child
• Therefore trauma to the abdominal region is more likely to result in liver and/or spleen damage in the child compared to the adult
• The bladder in infants is an intra-abdominal organ, increasing the risk of bladder damage in abdominal trauma
• As a result, multi-organ injury is more frequent than with adults
Case

• EMS responds to a call of a baby with respiratory distress
• 6 month old term baby with 2 days of worsening trouble breathing
• You arrive to find a well nourished baby with a HR of 180, RR 70, O2 sat 89% on room air, and moderate to severe retractions and wheezing with expiration
Case
Case

• You reposition the airway, suction the baby, and place him on a liter of oxygen
• Repeat vitals show HR 165, RR 55, O2 96%
• A lot of the wheezing has resolved
• He is transported to PCH and ends up on high-flow nasal cannula for a few days, eventually discharged home with a diagnosis of bronchilolitis
Respiratory Distress

• When to worry: use your eyes
• How to classify: use your ears
• Upper vs. lower airway disease
• Upper: noise with inspiration, supraclavicular retractions (croup, foreign body)
• Lower: wheezing with expiration, using subcostal/intercostal retractions, long expiratory phase, crackles (bronchiolitis, pneumonia, asthma)
Respiratory Distress

- Resuscitation:
- Start with positioning
- Suctioning is often magic
- Try to keep child calm
- Recognize lower vs. upper airway pathology, and consider steroids (croup, asthma), racemic epi (upper airway), albuterol (lower airway)
- Oxygen to keep sats >90%
- Consider high-flow nasal cannula, CPAP, BIPAP first
- Wear personal protective equipment: at least a mask!
- Don’t forget about DKA
Respiratory Distress

• Bag-mask ventilation a critical skill
• Correct mask size
• 2 hand technique when able
• Correct positioning of child
• Rate: 20-30 breaths/minute
• Try to squeeze only until chest rise
• Consider placing an OG or NG for prolonged bagging
Respiratory Distress
Respiratory Distress

• Distress vs. failure:
• Altered mental status
• Slow respirations
• Apnea
• High pCO2
Airway and Breathing

• In the field, bag-mask ventilation may be preferable for short transit or teams uncomfortable with pediatric intubation
• If you intubating a kid:
• Use a miller blade, especially in younger kids
• Miller 1 up until age 2 or so
• Miller 2 up until age 8 or so
• Use the right sized ETT:
  – use the formula: \( \frac{\text{age in years}}{4} + 4 \) (or +3.5 if cuffed)
  – use your Broselow tape
  – use the kid’s pinky
• Meds-any preferences?
Trauma and Injury

• Accidental injury remains one of the highest causes of childhood death
  – In the US, every hour, 1 child dies from injury
  – About 1 in 5 childhood deaths is from injury
  – Every 4 seconds a child is treated for injury in an ED
  – Utah has a child injury death rate of 11-17.9/100,000 children
  – 1/3 of childhood deaths in Utah are from an injury

• In young children, injuries are often caused by motor vehicle collisions and non-accidental trauma
Case

• A 5 year old female, restrained with a regular seat belt, is involved in a high speed MVA rollover
• On the scene, she is sleepy but arouses to voice, GCS 14, a deep scalp lac but no other obvious head injury
• She has a bruise across her lower abdomen and complains of abdominal pain
• Her belly is slightly distended, and gets bigger during transport and more painful
Case

- In the ED, HR is 130 RR 25 BP 115/78, O2 96% on RA
- Head CT is normal, c-spine x-rays are normal, CXR normal
- Abdomen/pelvic CT shows moderate free fluid with no obvious solid organ or bowel injury
- Her belly gets more distended and her breathing more shallow
- A foley is placed with return of bright red blood
- She is taken to the OR and has a ruptured bladder, but no other obvious injury
Case
Trauma: General Management

- Use your Broselow tape!
- Stick to a system-based approach
- Remember that respiratory distress can lead to arrest quickly in kids
- Know your normal vital signs range so you can recognize bradycardia as a sign of increased intracranial pressure or tachycardia as a sign of shock
- Know that hypotension often results from head injury, not from hemorrhagic shock
Trauma: General Management

- **Fluid resuscitation:**
  - For a critical patient, try to get 2 of the largest bore IV’s possible
  - Don’t be afraid of an IO
  - The size of the child will also determine the amount of fluid required for resuscitation
    - Don’t just hang a liter in little kids
    - Bolus for hypotension or concern for head injury; caution with significant abdominal injury
    - 20cc/kg of NS or LR (we use NS)
    - after 40-60cc/kg or with ongoing bleeding consider PRBC (20cc/kg)
    - The most efficient way to get in a bolus may be with flushes in a small child or with a large 60 cc syringe (push-pull fluids)
Trauma: General Management

• Large amounts crystalloids can cause further problems in trauma patients by worsening bleeding, hypothermia and coagulopathy
• There is a lack of data about the optimal amount of fluid resuscitation and optimal blood pressure in pediatric trauma patients; go by perfusion and remember cerebral perfusion pressure
• For maintenance: run plain NS on most kids; add D5 for young babies
Trauma: General Management

- Don’t forget to treat pain!
- Fentanyl 2mcg/kg intranasal
- Morphine: 0.05-0.1 mg/kg IV
- Versed for significant anxiety: 0.05-0.1 mg/kg/dose IV or 0.4 mg/kg IN
- Distraction: If all else fails...
Talk About Frozen
# Head Injury

## Modified Glasgow Coma Scale for Infants and Children

<table>
<thead>
<tr>
<th></th>
<th>Child</th>
<th>Infant</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye opening</strong></td>
<td>Spontaneous</td>
<td>Spontaneous</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>To speech</td>
<td>To speech</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>To pain only</td>
<td>To pain only</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Best verbal response</strong></td>
<td>Oriented, appropriate</td>
<td>Coos and babbles</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Confused</td>
<td>Irritable cries</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Inappropriate words</td>
<td>Cries to pain</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Incomprehensible sounds</td>
<td>Moans to pain</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
<tr>
<td><strong>Best motor response</strong></td>
<td>Obeys commands</td>
<td>Moves spontaneously and purposefully</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Localizes painful stimulus</td>
<td>Withdrews to touch</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Withdrews in response to pain</td>
<td>Withdrews to response in pain</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Flexion in response to pain</td>
<td>Abnormal flexion posture to pain</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Extension in response to pain</td>
<td>Abnormal extension posture to pain</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>No response</td>
<td>1</td>
</tr>
</tbody>
</table>

*If patient is intubated, unconscious, or preverbal, the most important part of this scale is motor response. Motor response should be carefully evaluated.*
Head Injury

- Luckily, most head injuries are mild
- Recent trend towards avoiding head CT (and radiation in general)
- PECARN head injury study
A

GCS=14 or other signs of altered mental status, or palpable skull fracture

Yes
13.9% of population
4.4% risk of cTBI

→ CT recommended

No

Occipital or parietal or temporal scalp haematoma, or history of LOC ≤5 s, or severe mechanism of injury, or not acting normally per parent

Yes
32.6% of population
0.5% risk of cTBI

→ Observation versus CT on the basis of other clinical factors including:
  - Physician experience
  - Multiple versus isolated findings
  - Worsening symptoms or signs after emergency department observation
  - Age <3 months
  - Parental preference

No
53.5% of population
<0.02% risk of cTBI

→ CT not recommended

B

GCS=14 or other signs of altered mental status, or signs of basilar skull fracture

Yes
14.0% of population
4.3% risk of cTBI

→ CT recommended

No

History of LOC, or history of vomiting, or severe mechanism of injury, or severe headache

Yes
27.7% of population
0.5% risk of cTBI

→ Observation versus CT on the basis of other clinical factors including:
  - Physician experience
  - Multiple versus isolated findings
  - Worsening symptoms or signs after emergency department observation
  - Parental preference

No
58.3% of population
<0.05% risk of cTBI

→ CT not recommended
Head Injury

• Multiple studies showing that untreated hypotension/hypoxia leads to worse outcome
• In one study, 31% of pediatric patients did not have BP and 34% did not have O2 recorded as part of “early care
  – 39% had documented hypotension
  – attempt to treat hypotension only in 48%
• Children who did not have attempt to treat hypotension had 3.4x higher odds of death and 3.7x higher odds of disability than those with treated hypotension
• Zebrack M, Pediatrics, 2009
Head Injury: Management

- ABC’s first
- Intubate/secure airway
- Sedate/paralyze patients
- Goal pCO2 35; can hyperventilate acutely
- 3% Normal Saline: 5cc/kg
- Can loosen C-collar and put head upright to 30 degrees in a sedated patients
- Seizure prophylaxis
- Treat hypotension and hypoxia
Cervical Spine Injury

- Try to avoid CT scans when possible
- Obtain a 2-3 view plain XRAY instead of CT unless:
  - High risk mechanism (diving, ejection)
  - Severe TBI/unlikely to be able to clear c-spine for extensive period of time
  - Neurologic deficits
  - When in doubt, leave the collar on
Abdominal Injuries

- Kids tend to tolerate major liver and spleen injuries better than adults
- Even with high-grade liver and spleen injuries, pediatric trauma surgeons rarely operate
- Decompress the belly: NG/OG, foley
- Minimize aggressive fluid resuscitation unless hypotensive, poor perfusion, or concurrent severe TBI
- Even when no obvious sign of intra-abdominal injury, consider lipase, ALT, AST, Hct to screen because of potential for multi-system injury
- Remember bowel injury can present later (with perforation, obstructing hematoma, etc)
- Consider concurrent bladder injury
Pelvic Injuries

• Very rare in pediatrics
• Different pathology
• Unlikely to be associated with significant hemorrhage
• Lack of utility in pelvic xrays
Case

- A 2 month old male presents with 2 day of vomiting and intermittent jerking of his right arm over the last 2 days
Case

• Saw his pediatrician and was referred for possible seizures
• In the ED he was well appearing, had normal vitals signs, a soft fontanelle, and normal neurologic exam
• Neurology was consulted and an EEG showed no seizures but asymmetry to brain activity with L<R
Case

• CT scan revealed acute-on-chronic L subdural with midline shift
• He was loaded with Keppra and taken to OR for evacuation of hematoma
• Skeletal survey was normal
• Eye exam + for retinal hemorrhages
• ED staff did have concerns about family dynamics in ED
• Safe and Healthy family was involved
• Likely NAT; no known perpetrator
Case
Non-accidental Trauma (NAT)

- Always be wary of child abuse:
  - Kids with multiple ED visits
  - Kids with multiple fractures
  - Kids with unexplained ALTE events, or seizures in young infants
  - Fractures in non-ambulatory kids
  - Multiple stages of bruising, or any bruising on a non-ambulatory kid
  - Subdural hematomas in young kids
  - Stories that keep changing
NAT

• Patterns of injury significantly associated with NAT:
  – Subdural hemorrhage and/or cerebral ischemia
  – Retinal hemorrhages
  – Skull fractures plus intracranial injury
  – Metaphyseal fracture and/or long bone fracture (especially in non-ambulatory)
  – Rib fractures
  – Seizures, apnea, and inadequate history given for injury
• Epidural hemorrhage, scalp swelling, and isolated skull fractures were significantly associated with accidental injury
• Piteau SJ, Pediatrics, 2012
• Remember, babies can have significant injury without many external signs
Conclusions

• Use a general assessment to know when to worry
• Respiratory illness is common in kids and can progress to arrest
• Become skilled at bag-mask ventilation
• Kids are more likely to have multi-system injury with trauma because of small size
• Use a systematic approach to trauma
• Consider observation and serial exams instead of CT scans in stable kids
• Always be thinking of NAT, especially in young kids with unexplained injury or seizures/ALTE events
Thank You!

• For taking such great care of pediatric patients!