EM CASES SUMMARY

Episode 95 – Pediatric Polytrauma

With Drs. Suzanne Beno & Fuad Alnaji
Prepared by Drs. Alex Hart and Shaun Mehta

Common pitfalls leading to bad pediatric trauma outcomes

Failure to:

Manage the airway – indicated for almost all severe TBI, any hypoxia

Appreciate and treat shock – do not wait for hypotension which is a sign of pre-arrest

Prioritize management of injuries – see "CABC" below

Check bedside sugar if altered LOC – ABC**DEFG**
"Don't **E**ver **F**orget the **G**lucose"

Keep the child warm

Preparation before the pediatric trauma patient arrives

Use **Broselow tape** to draw up all anticipated medications in advance of patient arrival: ketamine 2mg/kg or etomidate 0.3mg/kg, rocuronium 1mg/kg or succinylcholine 1-2mg/kg, fentanyl 2-5mcg/kg, atropine 0.02 mg/kg etc., and to size airway equipment (have one size larger and one size smaller ready as well).

Venous access: Prime lines, have IOs ready, central line kit.

Warm the room, turn on the overhead warmer (for infants) or Bair hugger (for older children), warm crystalloids, set the rapid infuser.
Have **pelvic binder** or sheet laid out on stretcher with clamps ready.
Team huddle: see **Andrew Petrosoniak's approach to team-based preparation for a critical event**

PRIMARY SURVEY PEARLS

C-A-B-C: A new paradigm in pediatric trauma

ATLS has revently moved from the ABC approach to the CAB for trauma resuscitation. Our experts suggest the "CABC" approach: First, identify any catastrophic bleeding, then move on to airway and breathing with a plan to return to circulation assessment.
In general, respect the range of vital signs in the pediatric population. 90th percentile normal pediatric vital signs **HERE**

***D**isability:* **AVPU** (**A**lert, **V**oice, **P**ain, **U**nresponsive) is adequate. Pediatric GCS is also acceptable but not always practical as it is difficult to remember.

E*xposure:* Important in any trauma patient, but keep in mind increased heat loss in children

F*amily Presence:* Evidence suggests that family presence reduces stress on families and the patient without compromising team dynamics or medical care.

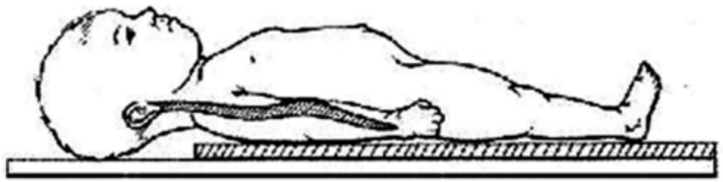
Considerations in pediatric trauma airway

Differences	*Implications*
Increased vagal response to laryngoscopy	Bradycardia during intubation
Larger tongue	Airway obstruction
Larger adenoidal tissue	Difficult nasotracheal intubation and nasopharyngeal airway
Prominent occiput	Positioning difficulties
Floppy, U-shaped epiglottis	Necessitates straight blade
Anterior, cephalad larynx	Difficulty visualizing cords
Cricoid = narrowest portion	Difficulty passing endotracheal tube
Shorter tracheal length	Can lead to R mainstem intubation
Large airways more narrow	Greater airway resistance

Table 1. Adapted from Rosen's Emergency Medicine 8th edition

Pediatric Trauma Airway: 3 P's

Patency – use an oral airway to prevent obstruction by the tongue, suction any blood, secretions, foreign bodies
Position – towel under torso, occiput on bed
Protection – cuffed ETT (*age/4 + 3.5*) in all trauma patients



Elevate the torso to improve airway positioning

RSI pearls and pitfalls in Pediatric Trauma

PEARLS

Use a straight blade laryngoscope
Children have a floppy, U-shaped epiglottis which is easier to pick up to allow a view of the vocal cords with a straight blade, especially during c-spine immobilization.

Have your weight based drugs drawn up in advance

Pre-induction
Consider **atropine 0.02 mg/kg** (minimum 0.1 mg, maximum 0.5 mg) in patients <1 year of age and have it drawn up in case of bradycardic response to intubation in older patients.

Consider **fentanyl 2-5 mcg/kg** 3-5 minutes prior in the head-injured patient to blunt the rise in ICP secondary to intubation.

PITFALLS

Inadequate pre-oxygenation time: Children have lower functional residual capacity and shorter apnea times, so consideration should be given to a modified RSI with **apneic oxygenation**/NIPPV.
Consider early **NG tube placement** for stomach decompression to allow for full diaphragmatic excursion.

Right mainstem endobronchial intubation: Children have a relatively shorter trachea compared to adults and advancing the ETT too far is not uncommon. A rule of thumb to estimate accurate depth of ETT placement: ***3 x* tube size**

Cricoid pressure: 2 lbs of force can occlude the pediatric airway, so cricoid pressure is not recommended. Instead, to help improve your view consider **external laryngeal manipulation** (ELM).

Overbagging: To prevent barotrauma all pediatric BVM units should be equipped with a safety pop-off valve along with a manometer, which limits peak inspiratory pressures between 35 and 40 cm H20 per breath. Each breath should be just enough to make chest rise and no more. Counting out loud or using a metronome for accurate rate of bagging can prevent our natural tendency to overbag in stressful situations.

A large randomized trial out of JAMA in 2000 suggests that the addition of endotracheal intubation to non-invasive ventilation does not improve mortality or neurologic outcome unless prolonged transport times are anticipated.

Shock in Pediatric Trauma

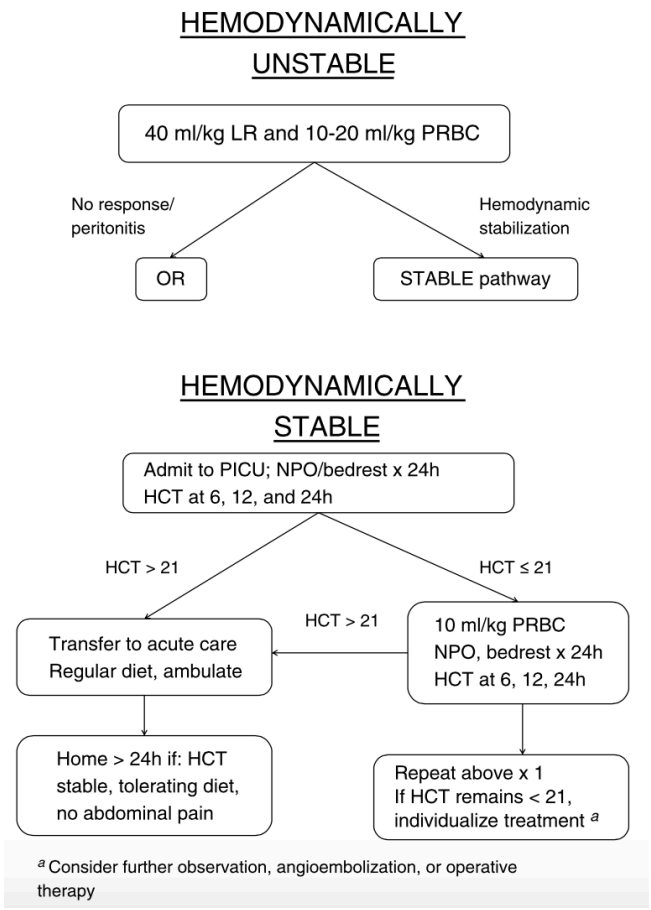
Early recognition of shock is essential in the pediatric polytrauma patient. Look for secondary signs which are often present while the patient is still normotensive (*compensated shock*). Hypovolemia is the most common cause of shock, with tachycardia being the first manifestation. Other manifestations include narrow pulse pressure, skin mottling, delayed capillary refill, cool extremities and altered mental status. Blood pressure is maintained until 30-40% blood loss due to great cardiac reserve, and so hypotension is an ominous sign (*decompensated shock*).

Volume Resuscitation

PALS recommends early IO placement (after 90 seconds or 2 attempts at IV placement). The maximum flow rate is usually around 25 mL/min. The IO is temporary; get a large peripheral IV or central access once adequately resuscitated.

How much crystalloid before blood?

While this a controversial topic, our experts suggest that **10-40 ml/kg** of warmed crystalloid prior to blood is reasonable in pediatric polytrauma patients in *compensated shock*, but that early administration of blood components is vital in patients who present in *decompensated shock*. The principle of permissive hypotension in adult trauma can only be applied to adolescent pediatric patient and is not recommended in younger pediatric patients.



PEDIATRIC TRAUMA SECONDARY SURVEY

Pediatric Severe Head Injury

Brain injury is the leading cause of death in pediatric polytrauma. **Severe head trauma** is defined as a GCS < 8 or if the patient is only responsive to pain or worse on AVPU. The goal in pediatric severe head injury is to prevent secondary brain injury, minimize raised ICP, and maintain cerebral perfusion pressure.

There are 5 parameters that must be aggressively avoided in the pediatric patient with severe head injury:

1. **Hypotension** – maintain normal SBP and euvolemia
2. **Hypoxia** – maintain SaO2 > 90% and PaCO2 35-40mmHg
3. **Hypothermia** – warmed crystalloid and blood, warmed room, overhead warmer or Bair hugger
4. **Hypoglycemia** – the DEFG in ABCDEFG stands for "Don't Ever Forget the Glucose"
5. **Raised ICP** – keep head of bed at 30 degrees, remove collar, pain and anxiety control, treat seizures aggressively, normocapnea

For the patient with signs of brain herniation, our experts recommend hyperventilating to a target of pupillary response of constriction and administering 3% hypertonic saline 3-4mL/kg boluses followed by an infusion in addition to the above, until the patient arrives in the O.R.

For minor and moderate head injury use the PECARN head injury decision instrument (PECARN on MD calc)

Clearing the Pediatric C-spine

The incidence of pediatric c-spine injury in polytrauma patients is <2% with the vast majority of injuries at C1-C3. Clearing the pediatric c-spine is complicated by the higher likelihood of having an unreliable exam and radiation concerns.

Clearing the C spine is age dependent

Reliable exam in >3 years old: Combination of NEXUS and Canadian C-spine Rules
Awake and alert with GCS = 15
Meets NEXUS criteria:

- no midline cervical spine tenderness
- no focal neurologic deficit
- normal alertness
- no intoxication
- no painful, distracting injury

AND moves head in flexion/extension
AND rotate 45 degrees to both sides with no pain
Reliable exam <3 years old: Clinical exam
Unreliable exam < 3 years old: Clinical decision instrument from multicenter study of 12,537 patients in 2009
Four independent predictors of c-spine injury were identified:

1. GCS <14 (3 points)
2. GCS_{EYE}= 1 (2 points)
3. MVC (2 points)
4. Age 2 years or older (1 point)

A score of <2 had a negative predictive value of 99.93% in ruling out c-spine injury and were eligable for c-spine clearance without imaging.

Since the vast majority of pediatric c-spine injuries occur at C1-C3, if a child is getting a CT head to rule out TBI they will usually include slices down to C3 and pick up the vast majority of c-spine injuries.

Pediatric Chest Trauma

Children have compliant chests and thus sustain musculoskeletal thoracic injuries far less frequently (5% of traumas). However, due to this elasticity, the most common injury is a pulmonary contusion. Obvious chest injuries are a red flag for more serious trauma as they are indicate a huge force.

PEARLS

Deflating the stomach can help patient breathing and with chest tube insertion.

POCUS is highly sensitive for pneumothorax

Pigtail Catheters have been shown to be as effective as large bore chest tubes in children with traumatic pneumothorax .

PITFALLS

Don't expect traditional adult injury findings: Absence of chest tenderness, crepitus and flail chests does not preclude injury.

CXR may miss early findings: Pulmonary contusions may only appear days later

Abdominal Pediatric Trauma

The vast majority of pediatric patients with abdominal trauma are treated conservatively with only 5% requiring surgery as most present with solid organ injuries. Any polytrauma patient with hemodynamic instability should be considered to have a serious abdominal injury until proven otherwise. The abdominal physical exam can be misleaded as 20-30% of pediatric trauma patients with a "normal" exam will have significant abdominal injuries on imaging.

Beware the mechanism: Seatbelt or handle bar signs as well as signs of abuse suggest serious injury.

Abdominal imaging in Pediatric Trauma

FAST is very specific but poor sensitivity for abdominal injuries in children

- FAST (+), pt stable -> CT
- FAST (+), pt unstable ->
    - Decompensated shock -> direct to surgery
    - Active bleeding necessitating ongoing blood transfusion -> surgery
    - Resuscitation leading to stable hemodynamics – > CT
- FAST (-), high clinical suspicion of injury or elevated liver enzymes -> CT
- FAST (-), low clinical suspicion – > serial physical exams and FASTs

Indications for CT abdomen depend on whether the patient is considered high risk or low risk for significant injury
HIGH RISK – Indications for CT

- History that suggests severe intraabdominal injury
- Concerning physical – tenderness, peritoneal signs, seatbelt sign or other bruising
- AST >200 or ALT >125
- Decreasing Hb or Hct
- Gross hematuria
- Positive FAST

LOW RISK – Clearing the abdomen without CT (PECARN RULE – 99.9% NPV)

- No evidence of abdominal wall or thoracic wall trauma
- GCS>13
- No abdo pain or tenderness
- Normal breath sounds
- No history of vomiting

The value of the PECARN rule is for the patient that has a worrisome mechanism of injury yet fulfills the criteria of the rule, CT imaging is not required. Note that while the sensitivity of this rule is very high, the specificity is poor. Beware not to assume that a patient requires a CT if they have one or more of the criteria present.

Which pediatric trauma patients do not require an pelvic x-ray?
Based on a study out of The Hospital for Sick Children in Toronto in 2015 a pelvic x-ray can be forgone if the following criteria are fulfilled:

- Hemodynamically stable
- Normal GCS
- No evidence of abdominal injury
- Normal pelvic exam
- No femur fractures
- No hematuria

Lab Monitoring and Prognosis in Pediatric Trauma

The B.I.G. Score: Prognosticating the pediatric trauma patient
Predicts mortality at scores below 16
BASE DEFICIT + (2.5 x INR) + (15 – GCS)

Serial Hb and Hct can be used along with serial physical exams and FASTs to assess for ongoing bleeding.

Tranexamic Acid (TXA)

While TXA use is *not* standard of care in pediatric polytrauma, our experts suggest it's use in adolescent patients based on the CRASH-2 trial, and to consider its use within 3 hours of injury in younger patients who you anticipate will require blood transfusion. An observational military study in 2014 called PED-TRAX of 766 injured pediatric patients suggested that TXA was safe and was independently associated with decreased mortality. It also suggested improved discharged neurologic status and decreased ventilator dependence in the TXA group.

Transport of the pediatric trauma patient

Pediatric Trauma Score: Indications for transport to a pediatric trauma center

The pediatric trauma score predicts mortality and need for transport. A score **>8 imparts 0% mortality**. Those with a score <8 should be transported to a trauma center. CT imaging should never delay transport to a trauma center.

Assessment Component	SCORE		
	+2	+1	-1
Weight	Weight >20 kg	10-20 kg	<10 kg
Airway	Normal	Oral or nasal airway, oxygen	Intubated, cric, trach
Systolic BP	>90 mmHg, good peripheral pulses	50-90 mmHg, palpable carotid/femoral	<50 mmHg, weak/no pulses
Level of Consciousness	Awake	Obtunded, any loss of consciousness	Coma, unresponsive
Fracture	None	Single, closed	Open or multiple
Cutaneous injuries	None	Contusion, abrasion, laceration <7cm not through fascia	Tissue loss, any GSW or stab wound through fascia

Transport Checklist

- ✓ Identify and address life threatening injuries
- ✓ Control airway, secure ETT, ensure sedation
- ✓ EtCO2 monitor
- ✓ Secure tubes (OG, NG, Foley, Chest tubes)
- ✓ Analgesia
- ✓ Vascular access (IV or IO)
- ✓ Bind pelvis
- ✓ Splint Fracture
- ✓ TXA
- ✓ Blood products
- ✓ Paperwork (labs, imaging, notes)

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