APPROACH TO THE INITIALLY STABLE PEDIATRIC TRAUMA PATIENT

Rio Grande Trauma Conference

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Grace Ng, MD

Disclosures

- I have no financial affiliations to disclose

Objectives

- Review normal and abnormal vital signs in pediatric patients
- Review differences in anatomy and physiology of pediatric patients as it relates to injury patterns
- Understand the approach for initial trauma evaluation of the stable pediatric patient
- Discuss work up of non –accidental trauma

Introduction

- Trauma is the number one cause of morbidity and mortality in children.
- 1 in 4 children sustain an unintentional injury requiring medical care each year.
- An estimated 17.4 million children do not have access to a pediatric trauma center within 60 minutes.

Children are **NOT** small adults

Children are not small adults

- Larger body surface area to body mass ratio
- Higher respiratory rate
- Less fluid reserve
- Less circulating volume
- Less fat, more elastic connective tissue, pliable skeleton
- Developmental vulnerabilities

Wathen et al. Pediatric Trauma Module 4. University of Colorado

Pediatric Normal Vital Signs

Age Group	Heart Rate	Respirations	Systolic BP
Preterm	120 - 180	50 - 70	40 - 60
Newborn (0 to 1 Month)	100 - 160	35 - 55	50 - 70
Infant (1 to 12 Months)	80 - 140	30 - 40	70 - 100
Toddler (1 to 3 Years)	80 - 130	20 - 30	70 - 110
Preschool (3 to 6 Years)	80 - 110	20 - 30	80 - 110
School Age (6 to 12 Years)	70 - 100	18 - 24	80 - 120
Adolescents (12+ Years)	60 - 90	14 - 22	100 - 120

Threshold by Age of Systolic Blood Pressure Indicating Hypotension

Age	Systolic Blood Pressure
Term neonates (0 to 28 days)	Less than 60 mm Hg
Infants (1 to 12 months)	Less than 70 mm Hg
Children 1 to 10 years (5th blood pressure percentile)	Less than 70 + (age in years × 2) mm Hg
Children >10 years	Less than 90 mm Hg

Systolic pressure = 70 mm Hg = 2 x (age in years)

Pediatric Trauma Facts

- Motor vehicles accidents - most common cause of death in children of all ages
- Majority of injured children will not deteriorate during treatment, and most injured children have no hemodynamic abnormalities.
- Failure to secure a compromised airway, support breathing, and recognized and respond to intra-abdominal and intracranial hemorrhage are the leading causes of unsuccessful resuscitation in pediatric patients with severe trauma.

ATLS Student Manual, Pediatric Trauma 10th Edition

Preparation

- Have all your tools available!
- Broselow Pediatric Emergency Tape
- Broselow Cart
- Warm the room, have warm blankets available

<u>*REMINDER*:</u>

Pediatric patients require WEIGHT BASED DOSING

Broselow Tape

PURPLE

SEIZURE	
Lorazepam (2 mg/mL)	1 mg (0.5 mL)
(4 mg/mL)	1 mg (0.25 mL)
Diazepam IV (5 mg/mL)	2 mg (0.4 mL)
Phenobarbital (65 mg/mL)	210 mg (3.2 mL)
(130 mg/mL)	210 mg (1.6 mL)
Phenytoin (50 mg/mL)	210 mg (4.2 mL)
Fosphenytoin (50 mg PE/mL)	210 mg PE (4.2 mL)
Levetiracetam (100 mg/mL)	525 mg (5.25 mL)
OVERDOSE/HYPOGLYCEMIA	
$D_{10}W$ (0.1 g/mL)	5.25 g (52.5 mL)
$D_{25}W$ (0.25 g/mL)	5.25 g (21 mL)
Naloxone (1 mg/mL)	1 mg (1 mL)
(0.4 mg/mL)	1 mg (2.5 mL)
Flumazenil (0.1 mg/mL)	0.1 mg (1 mL)
Charcoal (25 g/120 mL)	10 g (50 mL)
Glucagon (1 mg/mL)	0.5 mg (0.5 mL)

ICP	
3% Saline	21-53 mL
Mannitol (20% 0.2 g/mL)	10 g (50 mL)
(25% 0.25 g/mL)	10 g (40 mL)
Furosemide (10 mg/mL)	10 mg (1 mL)
FLUIDS	
Fluid Bolus	
Crystalloid (NS or LR)	210 mL
Colloid/blood	105 mL
Maintenance	
D5 1/2 NS + 20 mEq KCL/L	43 mL/HR
PAIN	
Fentanyl (50 mcg/mL)	10 mcg (0.2 mL)
Morphine (2 mg/mL)	1 mg (0.5 mL)
(4 mg/mL)	1 mg (0.25 mL)

EQUIPMENT	
*E.T. Tube	4.0 Uncuffed/*3.5 Cuffed
E.T. Insertion Length	11-12 cm
Stylet	6 French
*Suction Catheter	8 French
Laryngoscope	1-1.5 Straight
BVM	Child
Oral Airway	60 mm
*Nasopharyngeal Airway	18 French
*LMA	2

EQUIPMENT	
Oxygen Mask	Pediatric NRB
*$ETCO_2$	Pediatric
*Urinary Catheter	8-10 French
*Chest Tube	14-20 French
NG Tube	8-10 French
Vascular Access	20-24 Ga
Intraosseous (IO)	15 Ga
BP Cuff	Child

*May not be included in Organizer System(s).

PINK	6-7kg
RED	8-9kg
PURPLE	10-11kg
YELLOW	12-14kg

WHITE	15-18kg
BLUE	19-23kg
ORANGE	24-29kg
GREEN	30-36kg

The Trauma Evaluation

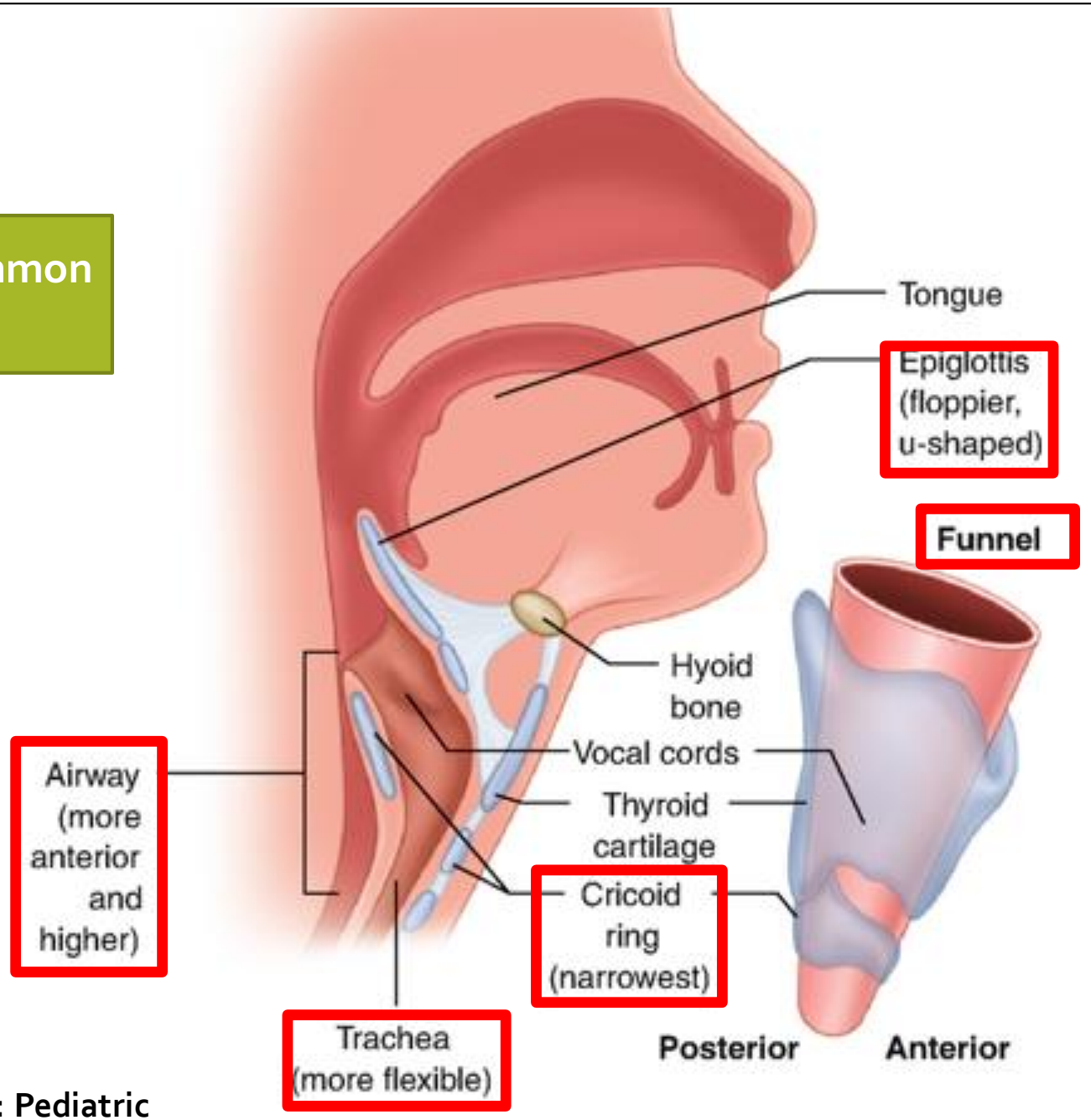
- Airway
- Breathing
- Circulation
- Disability
- Exposure
- Family Presence

ATLS®
ADVANCED TRAUMA LIFE SUPPORT

Airway

Respiratory compromise is the most common cause of cardiac arrest in children.

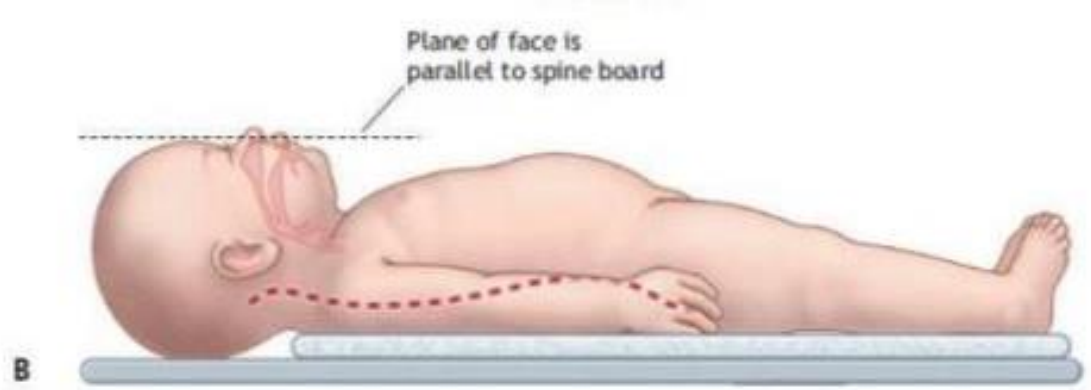
- Larger occiput
- Short trachea
- Smaller airway, larger tongue
- Floppy epiglottis
- Vocal cord slanted
- Larynx is higher and more anterior

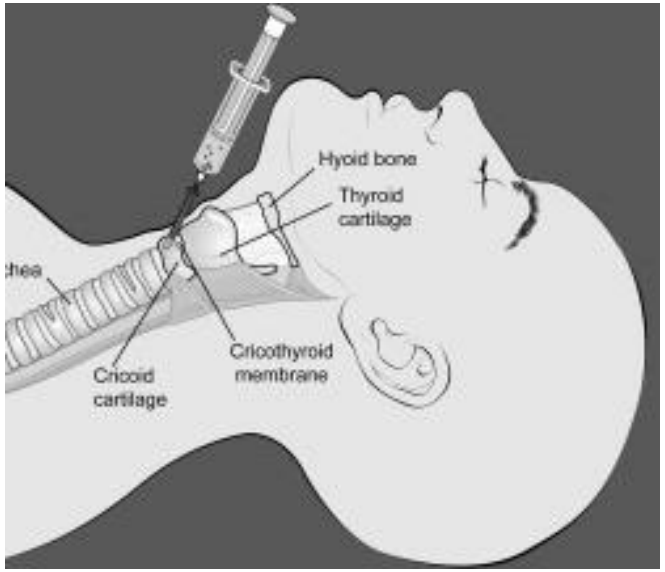


Quick Hits for Pediatric Emergency Medicine pp 1-5 Airway: Pediatric Anatomy, Infants and Children

Airway

- Jaw thrust - maintain c-spine precautions
- BVM
- LMA
- Needle cricothyroidotomy – jet insufflation
- Surgical cricothyroidotomy: age > 12 years
- Intubation

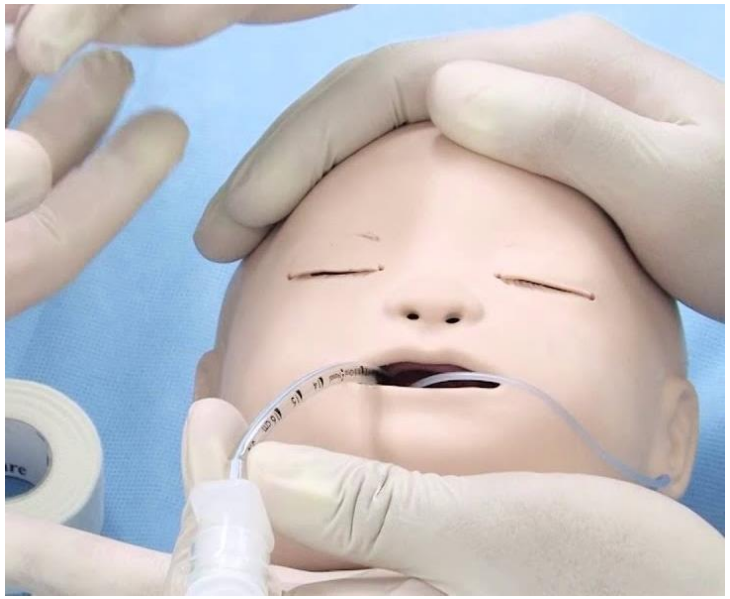




The Pediatric Airway and Rapid Sequence Intubation in Trauma. Sulton et al. 2017

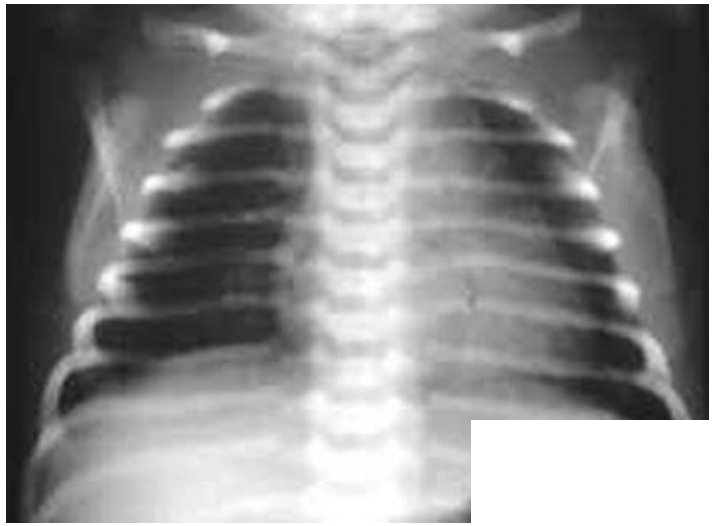
Secure the airway!

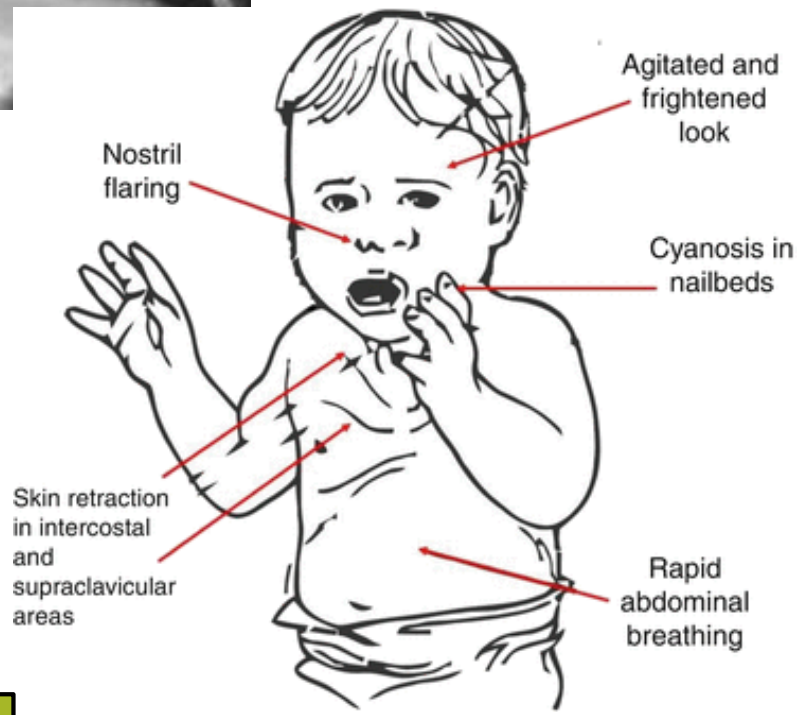
- Young children have short tracheas
  - Right mainstem bronchial intubation
- Any movement may lead to loss of airway:
  - Tube dislodgement
  - Vigorous coughing
  - Inadvertent extubation
- Re-evaluate breath sounds often



Breathing

- Hypoventilation → bradycardia → cardia arrest
- Rib position more horizontal
- Fewer type 1 muscle fibers
- Higher oxygen demand = higher respiratory rates
- Ribs/sternum more elastic
- Underlying injury without outward signs





Hypoxia: most common cause of pediatric cardiac arrest

Marr S. (2017) Respiratory Monitoring. In: Dabbagh A., Conte A., Lubin L. (eds) Congenital Heart Disease in Pediatric and Adult Patients. Springer. https://www.rch.org.au/trauma-service/manual/how-are-children-different

Circulation

- Check perfusion
  - Capillary refill
  - Peripheral pulses
- Do not equate pediatric blood loss to that of adult
  - Total blood volume = 75-80 ml/kg
  - **Initial fluid bolus = 20 ml/kg NS**
  - **Blood bolus: 10 ml/kg PRBC**
- Tachycardia is an EARLY marker of hypovolemia
- Hypotension is a LATE identifier

VENOUS ACCESS:

Consider an IO if unable to obtain peripheral access after two tries. (distal femur/tibia)

- 18 gauge – infants
- 15 gauge – young children

Circulation

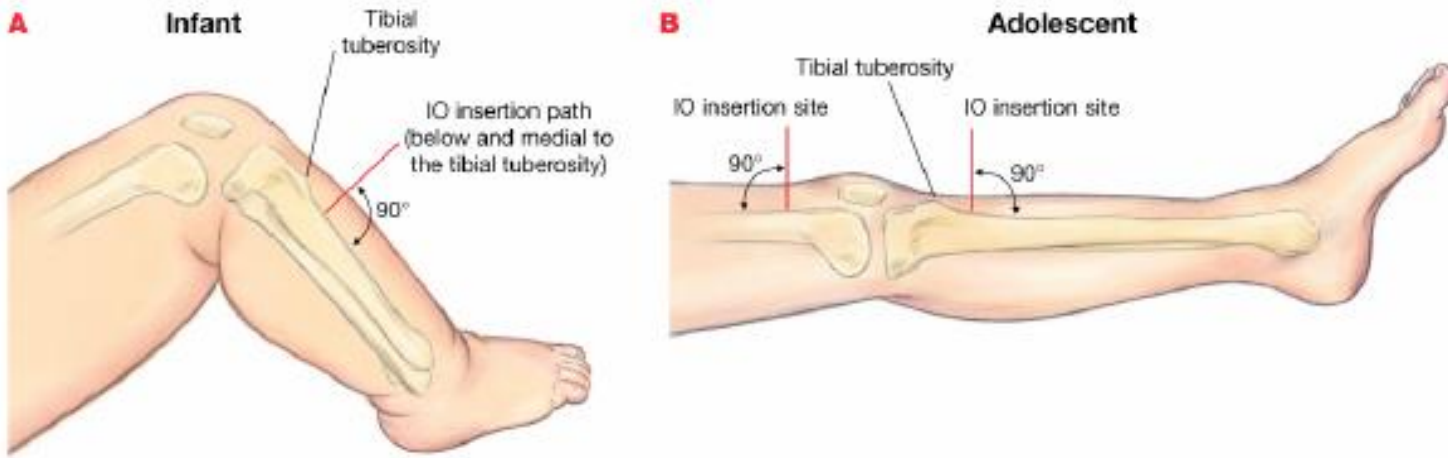
Be aware of the following:

- Vital signs vary by age
- Tachycardia may be the only physiologic abnormality
- Children have increased physiologic reserve

Physical Exam Findings:

- Vital signs
- Narrowed pulse pressure
- Peripheral pulses (weak)
- Skin temperature (cold, cyanotic)
- Skin color (mottled, pale)
- Mental status (anxious, lethargic, dull response to pain, comatose)
- Urine output

Venous Access



EZ-IO®

1. EZ-IO® 15mm (3-39 KG), EZ-IO® 25mm (40 KG AND GREATER) AND EZ-IO® 45mm (EXCESSIVE TISSUE)

DEVICE DESCRIPTION: EZ-IO Needle Sets are comprised of a Safety Cap, a Stylet and a Catheter. When the Stylet is removed a standard Luer lock is exposed. Needle Sets are made of 304 Stainless and Catheters are 15 gauge. Needle Sets are provided sterile, non pyrogenic and in protective packaging. Needle Sets are intended for use with the EZ-IO Power Driver (Figure 1).

EZ-IO Power Driver and Needle Sets (FIGURE 1)

Three responses to fluid resuscitation

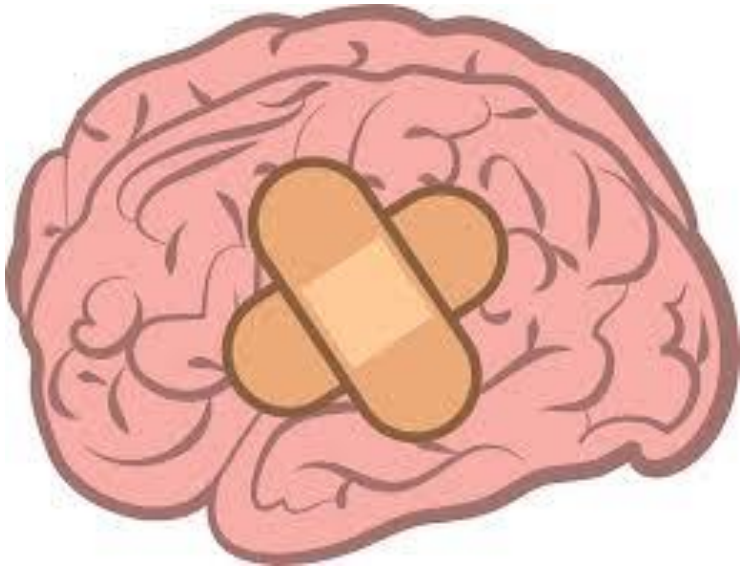
- Responders
  - stabilized with crystalloid fluid only; stabilized with crystalloid and blood
- Transient responders
  - Initial response, followed by subsequent deterioration
- Non responders
  - No response to either fluid or blood

Signs of return toward hemodynamic normality:

- Slowing of heart rate (age appropriate)
- Clearing of sensorium
- Return of peripheral pulses
- Return of normal skin color
- Increased warmth of extremities
- Increased systolic blood pressure (age appropriate)
- Increased pulse pressure (>20 mmHg)
- Urinary output 1-2 ml/kg/hr

Disability

- Check hypoglycemia
- Quick neurologic assessment
  - Alert
  - Responsive to verbal/painful stimuli
  - Unresponsive
  - Pupillary exam
  - Gross movement of all 4 extremities
- Glasgow coma scale for pediatrics



Head Injury

- GCS 13-15: Mild
- GCS 9-12: Moderate
- GCS <8: Severe

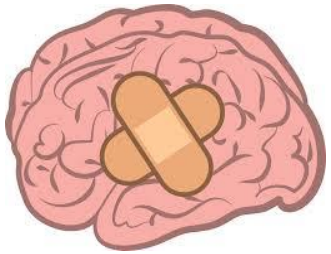
ADULT

E	EYE RESPONSE	No response	Eyes open to painful stimuli	Eyes open to verbal stimuli	Spontaneous	
V	BEST VERBAL RESPONSE	No response	Incomprehensible sounds	Inappropriate words	Confused	Oriented to person, place and time
M	BEST MOTOR RESPONSE	No response	Abnormal extension (Decerebrate)	Abnormal flexion (Decorticate)	Flexion withdrawal from pain	Moves and localizes to pain	Obeys commands
	SCORE	1	2	3	4	5	6

PEDIATRIC

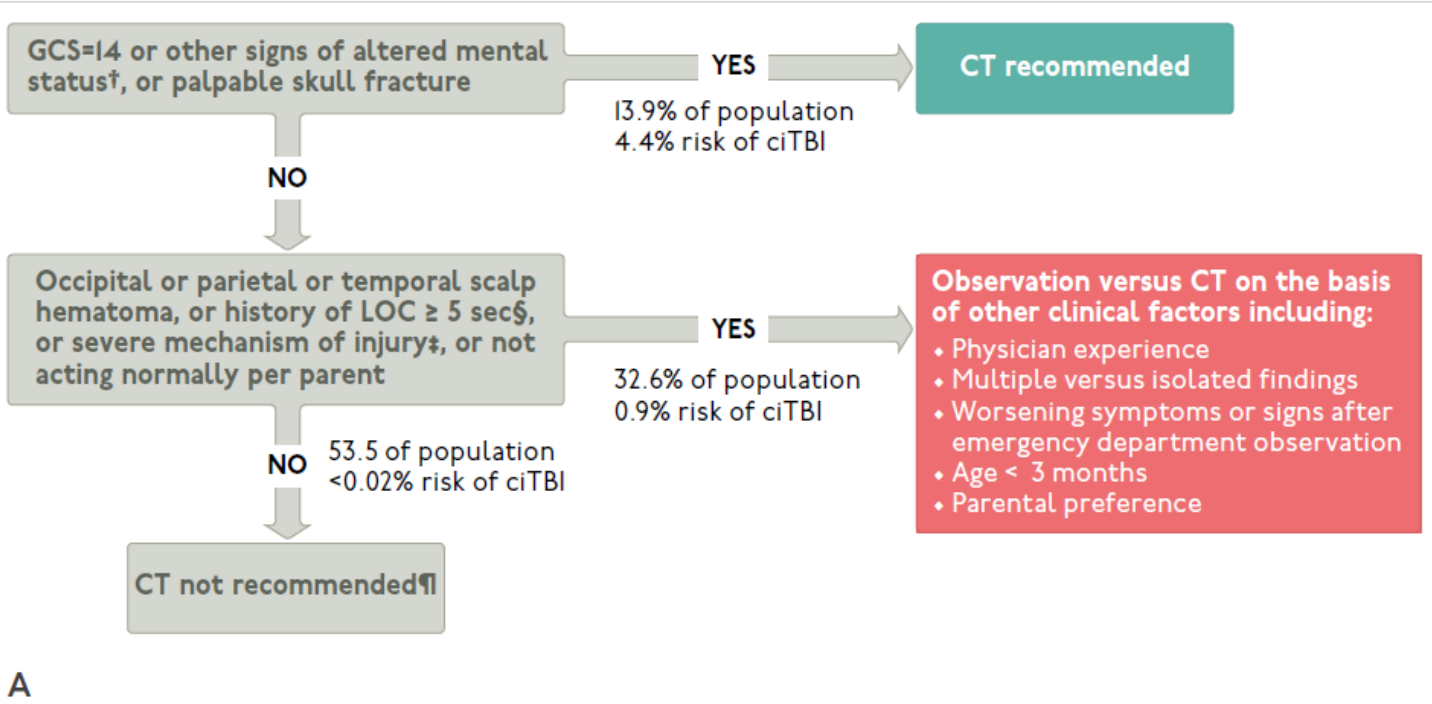
E	EYE RESPONSE	No response	Eyes open to painful stimuli	Eyes open to verbal stimuli	Spontaneous		
V	BEST VERBAL RESPONSE	No response	Grunts, agitated, restless	Inconsistently inconsolable	Cries but consolable	Smiles, follows objects, interacts	<2 years
			Grunts	Persistent cries and screams	Inappropriate words	Appropriate word use	2-5 years
M	BEST MOTOR RESPONSE	No response	Abnormal extension (Decerebrate)	Abnormal flexion (Decorticate)	Flexion withdrawal from pain	Withdraws from being touched	Infant moves spontaneously or purposefully

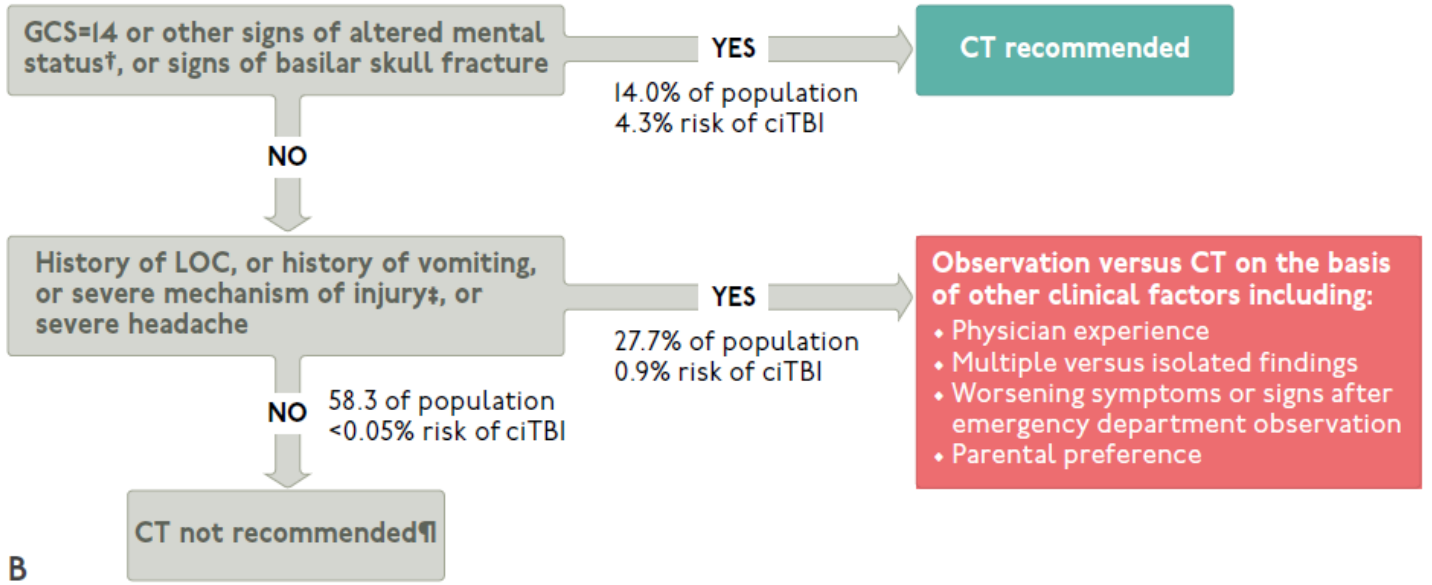
Head Trauma



- Disproportionate in size
  - Doubles first 6 months of life, achieves 80% of adult brain size by age 2
  - Head momentum higher → prone to injury
- Smaller subarachnoid space → less buoyancy
- More susceptible to secondary brain injury (hypoxia/hypovolemia)
- Open fontanelle, mobile cranial sutures → later identification of decompensation
  - **be aware of bulging fontanelles or suture diastasis**

Pediatric Emergency Care applied Research Network (PECARN) Criteria for Head CT



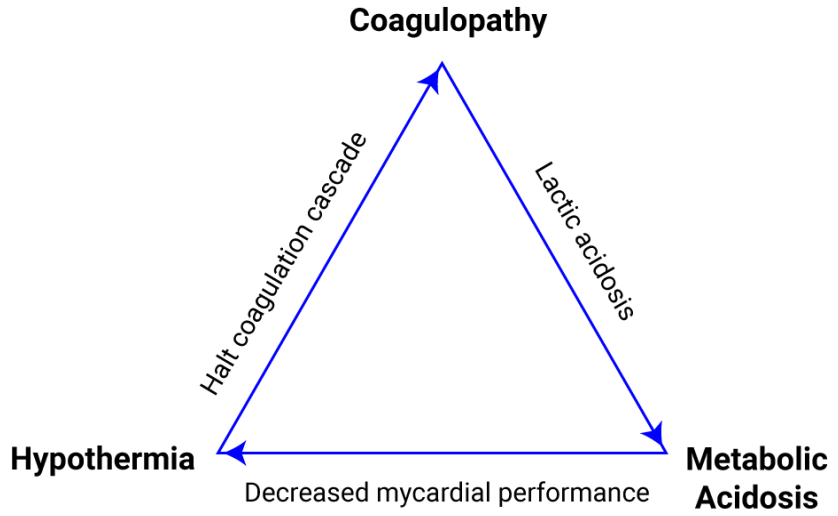


ATLS 10th Edition.

Kuperman N et al. Identification of children at very low risk of clinically important brain injuries after head trauma: a prospective cohort study. Lancet 374: 2009; 1160-1170

Exposure

- Promptly evaluate for external signs of injury
- **Thermoregulation**
  - Higher basal metabolic rate and surface area
  - Larger surface area to body mass ratio → greater heat loss
  - Thin skin, less subcutaneous tissue
- **Warm them up!**
  - **Room, blankets, fluids, blood**



Secondary Survey

- Once the primary survey is adequately assessed
- Perform a detailed head to toe exam
- Let's revisit pediatric vital signs …

Pediatric Normal Vital Signs

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Threshold by Age of Systolic Blood Pressure Indicating Hypotension

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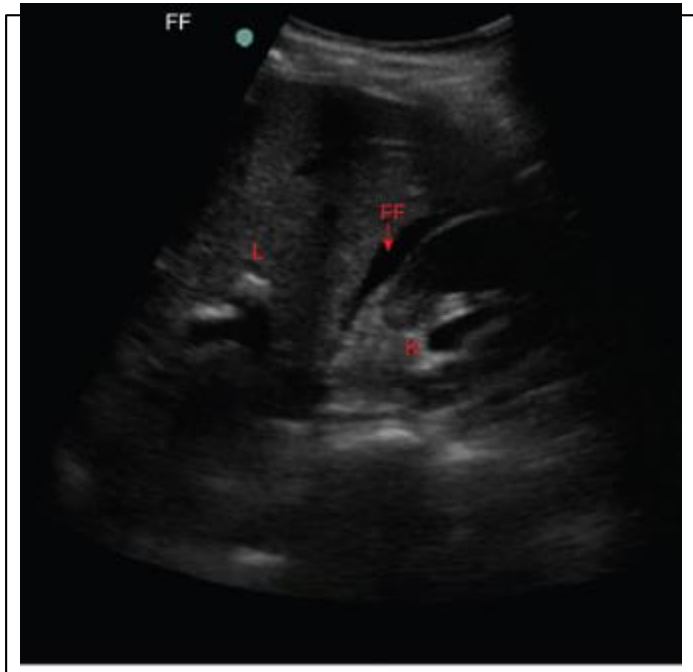
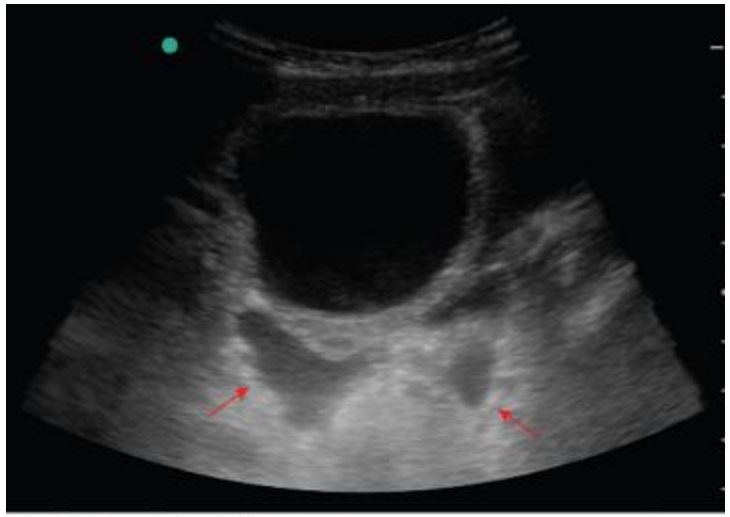
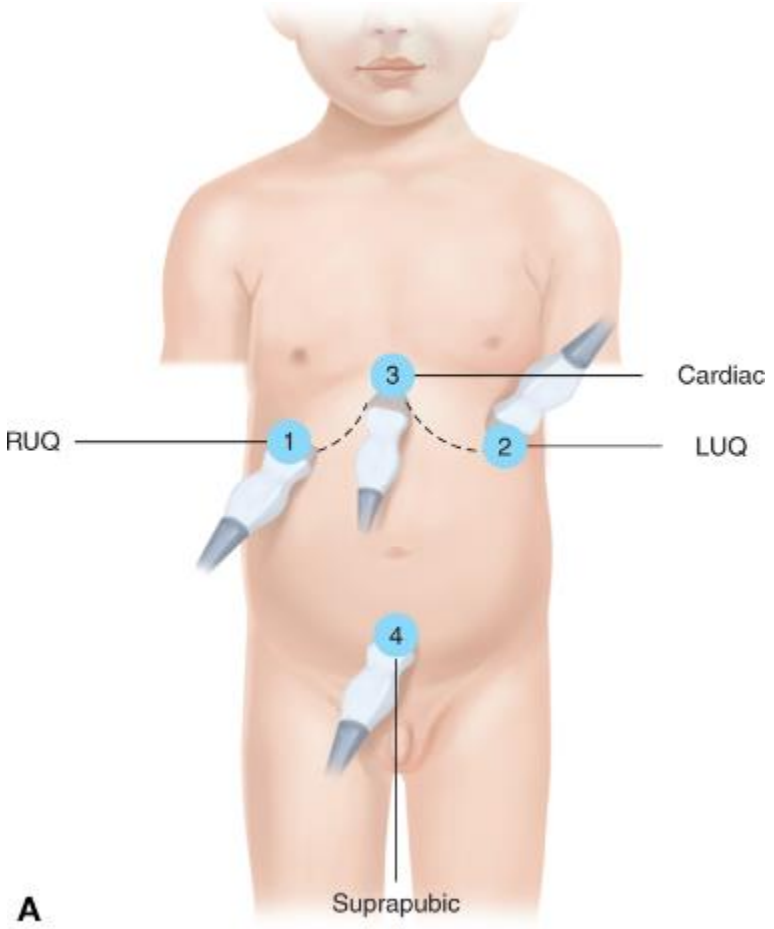
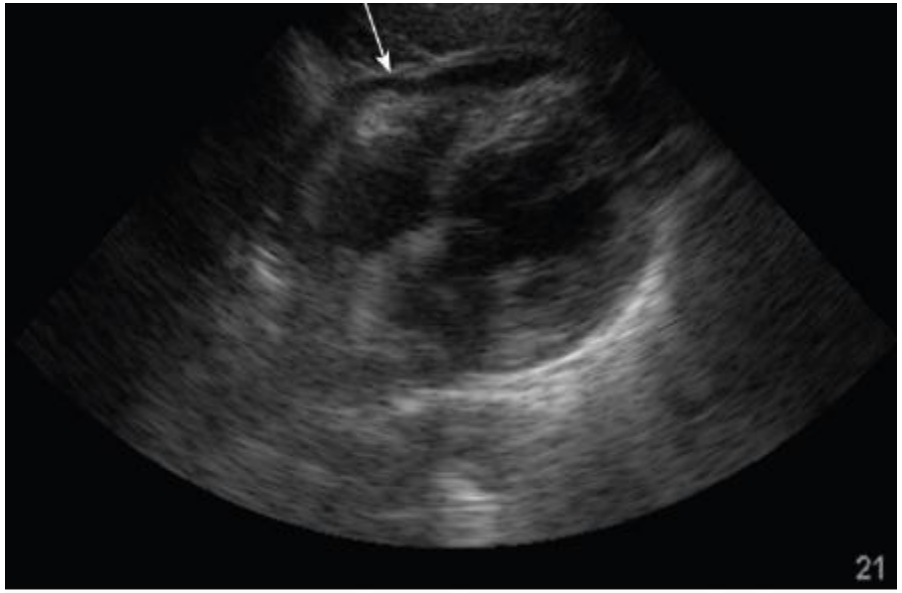
Systolic pressure = 70 mm Hg + 2 x (age in years)

Adjuncts



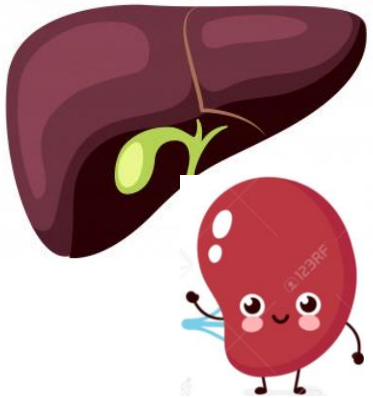






Atlas of Pediatric Emergency Medicine, 2e
Binita R. Shah, Michael Lucchesi, John Amodio, Mark Silverberg

Blunt Abdominal Trauma



- Motor vehicle crash → most common mechanism (>50%)
- The liver and spleen are the most common solid organs injured.
- Other causes: sport injuries, bicycle and all-terrain vehicle injuries, pedestrian injuries, falls, and child abuse.
- Physical examination: ecchymosis, abrasions, lacerations, abdominal tenderness, or abdominal distention.
- The most concerning and often subtle finding results from abrasions or ecchymosis from restraining belts, the "seat belt sign."

Anatomic Considerations

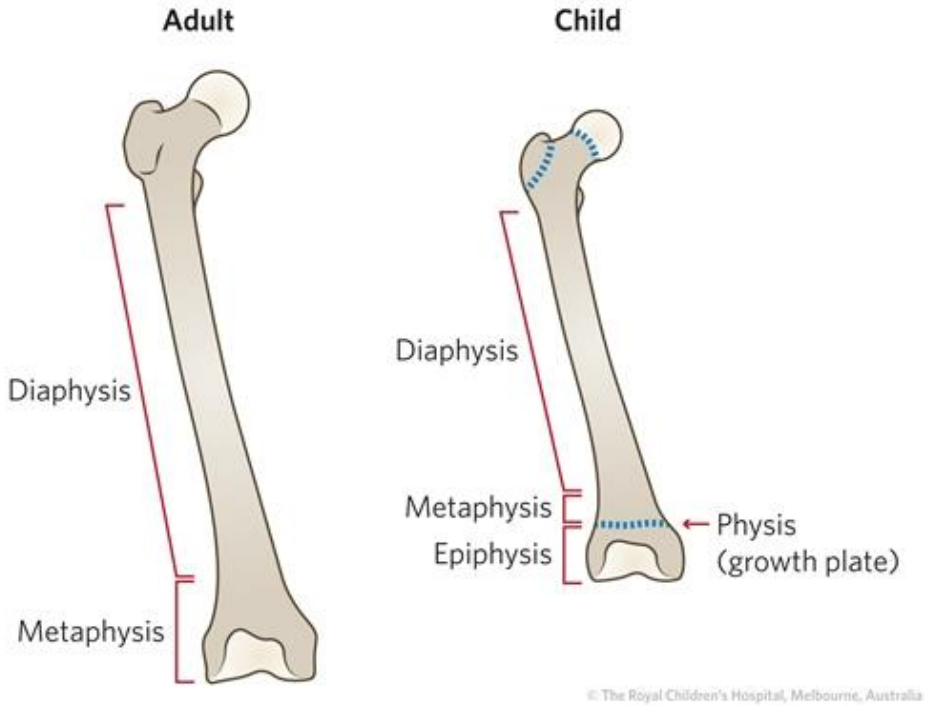
- Smaller body size → greater distribution of injury
- More flexible ribs, cover smaller surface area of the abdomen
- Smaller torso, larger and more mobile viscera, decreased intraabdominal fat
- Thinner abdominal wall and musculature
- Hollow viscus injury due to direct energy transfer usually from direct blow, seat belt, or handlebar
- Lap belts can cause compressive injury of intraabdominal organs by compressing organs between lap belt and spine . Sudden increase in intraluminal pressure as intestines are pushed against the spine increases risk of perforation

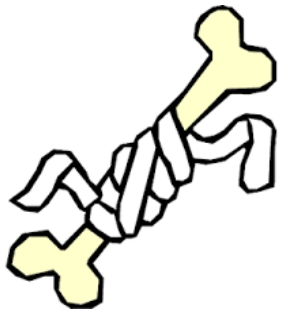
Pediatric Blunt Solid Organ Injury

- **Management based on hemodynamics**
  - Pay attention to examination and vital signs
- **"Less is more":** Non-operative management unless clinical decline or other indications for intervention
- **Follow-up**
  - Spleen/Liver: Reimage if symptomatic
  - Renal: Follow-up blood pressure checks as up to 5% will develop reno-vascular hypertension
  - Pancreas: Management based on tolerance of PO intake

Musculoskeletal

- Immature skeleton → more pliable in nature
- Injuries occurring near articular surfaces at the physis
- Radius/ulnar/femur most common
- Splint/reduce
- Be aware of non accidental trauma





Non Accidental Trauma

- Child maltreatment refers to acts of commission (deliberate or intentional inflicted injury referred to as child abuse or non accidental trauma (NAT) or omission in children under 18 years of age
- 674,000 children classified as victims of maltreatment in 2017
- Estimated 1,720 child deaths from maltreatment in 2017, 11% increase from 2013
- Look for sentinel injuries: injuries suspicious for physical abuse
- Apply clinical screening vigilantly and follow up with appropriate laboratory testing, radiographs, and appropriate consulting services

ACS Trauma Quality Programs Best Practices Guidelines For Trauma Center Recognition of Child Abuse, Elder Abuse, and Intimate Partner Violence

Non Accidental Trauma

- Delay in seeking care
- At risk social factors in the immediate family
- Lack of correlation between history and observed injury
- Note interactions/affect/responses of caretakers
- Injury of mechanism inconsistent with appropriate development
- Note Bruising patterns (frenulum, torso, ear, neck, jaw, cheek, eyelids, subconjunctiva, patterned bruising related to an object)
  - Non bony prominent areas
- Note fracture patterns (Ribs, Femur, Humerus)
- Note burn patterns (i.e. immersion – bilateral feet, limbs, buttock, object shaped)

Work up of Non Accidental Trauma

- Head Trauma
  - CT head without contrast if indicated
  - Eye examination: check for retinal hemorrhages (within 24-48 hrs)
  - MRI if neurologic impairment present
- Abdominal Trauma
  - Bruising absent in up to 80%
  - Screening for high energy blunt abdominal trauma
    - ALT/AST, amylase/lipase
    - Hematocrit - anemia a/w intracranial hemorrhage
    - Urinalysis for hematuria
  - Imaging indicated with tenderness/bruising
  - CT abdomen/pelvis with IV contrast (pediatric dosing -2 ml/kg body weight) . More sensitive than ultrasound
  - Consider upper GI series (duodenal injury)

Work up of Non Accidental Trauma

- Skeletal Injuries
  - Skeletal survey in all children <2 years old
    - 22 separate views
  - Age 2-5 years, use clinical judgment for imaging
  - Consider imaging siblings with high suspicion
  - Check alkaline phosphatase, calcium, phosphate, vitamin D levels
- Other laboratory studies
  - Hematocrit (associated intracranial hemorrhage)
  - Urinalysis
  - Coagulation studies (unexplained hemorrhage i.e bruising, intracranial hemorrhage without fracture)

IN PATIENTS WITH HEMODYNAMIC INSTABILITY….

Re-evaluate ABCD's

Recognize the need for surgical intervention

Will be discussed in the next lecture!

Children are not small adults

THANK YOU!