

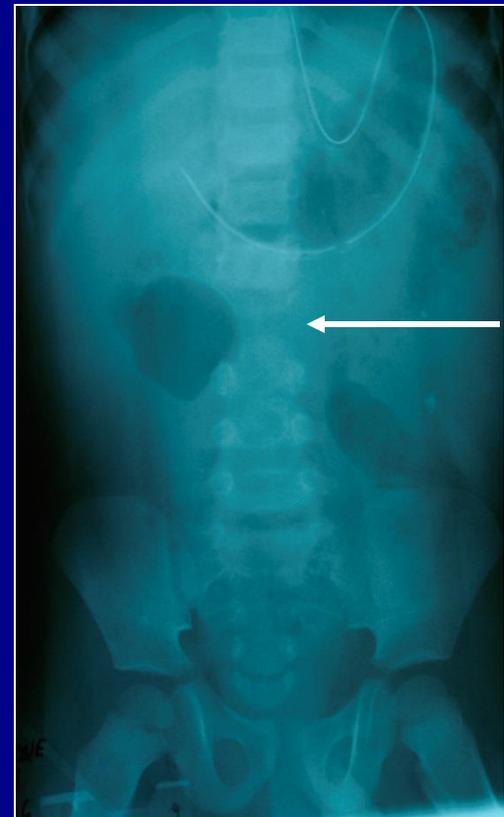


Pediatric Trauma

Khaled Al-Omar

GOAL

- Discuss difference in adult verses pediatric primary survey
- Discuss some common injury patterns
- Recognize warning signs for child abuse





PRIMARY SURVEY

Primary Survey

- Airway, Breathing, and Circulation
- Separated into 3 distinct systems for discussion only
- In reality, assessment must cover all 3 together in real time
- Evaluate simultaneously, not in sequence
- The “Golden Hour”

Airway

- Primary goal to provide effective oxygenation and ventilation
- Provide cervical spine protection
- Reduce increases in ICP
- Any trauma victim is assumed to have a cervical spine injury until proven otherwise

Airway

- Recognition of compromised airway can be difficult
- Cardiopulmonary arrest usually due to respiratory arrest
- Progression from respiratory distress to failure occurs quickly
- Oral and nasopharyngeal airways not as effective

Airway

- Airway complications as high as 25% with pediatric field intubation
- No difference in survival with adequate mask ventilation verses intubation
 - beware occluding airway with tongue
- LMA may provide effective airway control in field until definitive airway can be obtained

Airway

- Orotracheal intubation is the “Gold Standard”
- Nasotracheal intubation should not be attempted in children
- Current ATLS recommendations call for a rapid sequence induction
 - especially with closed head injury
- Don't forget to pre-oxygenate

The Great Debate

- Orotracheal intubation the Gold Standard
- Numerous studies suggest intubated head injury patients had worse outcome
 - Prolonged initial hypoxic period during RSI
 - Significant period of HYPOcarbia post intubation
 - Must monitor both SaO_2 and ETCO_2

Rapid Sequence Intubation

Short Acting Sedatives
Barbiturates

Etomidate

0.2-0.4 mg/kg

Pentothal

2-4 mg/kg

Versed

0.01-0.02 mg/kg

Short Acting Paralytic

Rocuronium

0.6-0.9 mg/kg

Vecuronium

0.1-0.2 mg/kg

Succinyl Choline

1-2 mg/kg

Vagolytic (Infants)

Atropine

0.01-0.02 mg/kg

Avoid Propofol and Ketamine in head injury patients

Watch hypotension with sedatives and barbiturates

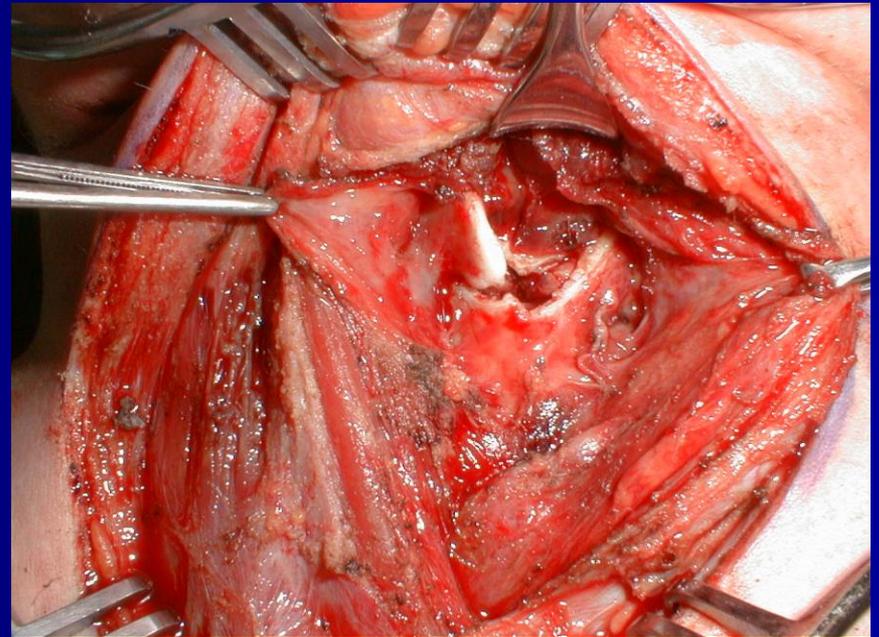
ETT Size

- Broselow Tape
- ID estimated by: $AGE/4 + 4$
- Middle phalanx on 5th digit
- Depth of insertion: $3 \times ID$
- Needle cricothyroidotomy may be life saving
- Fiberoptic techniques, LMA

Airway

- Confirm tube position
 - capnometer
 - listen to axillae bilaterally
 - chest wall excursion
 - CXR
- Significant face and neck burns require immediate airway assessment and control

Larynx Trauma



Breathing

- Pliable thoracic cavity: occult injuries common
- Less protection of upper abdominal organs
- Mobile mediastinum
 - less aortic disruption
 - more tracheobronchial injuries
 - earlier compromise from tension pneumothorax
- Pulmonary contusion common

Pulmonary Contusion

- Most common pediatric thoracic injury
- Often a lack of physical or radiologic abnormalities
 - Suspect with any thoracic cavity bruising, abnormal breath sounds, rib fractures
- Blood gas abnormalities often precede clinical/radiographic signs

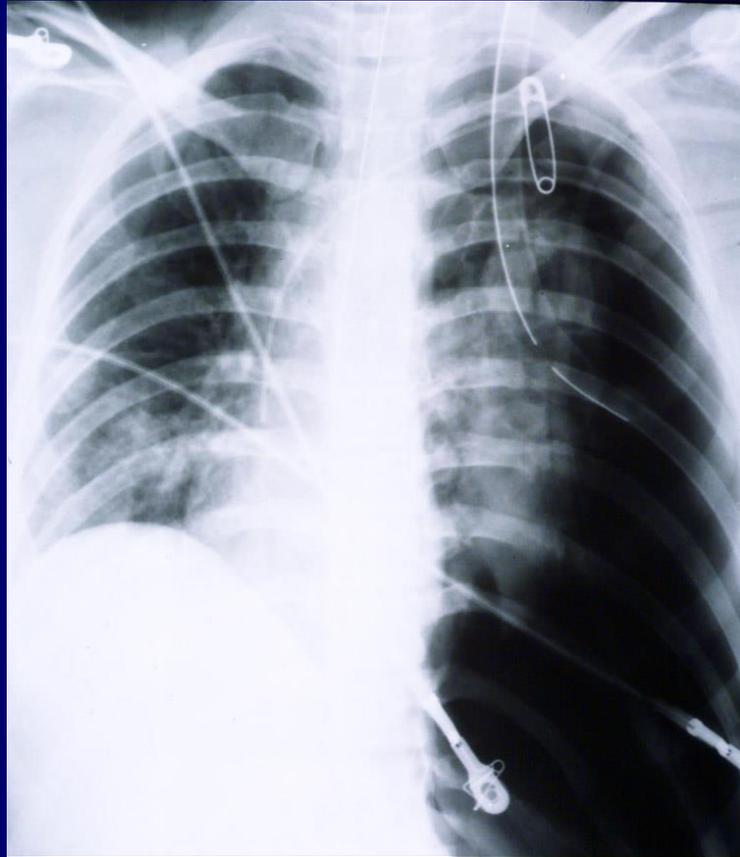
Pulmonary Contusion Rx

- Early recognition and oxygen therapy
- Analgesics and chest physiotherapy
- May need early mechanical ventilation
- Keep them wet or keep them dry?
 - Crystalloid vs colloid

Tension Pneumothorax

- Breath sounds and percussion may be misleading
- Hypotension, distended neck veins and tracheal deviation are reliable but late findings
- Any child with acute loss of consciousness, respiratory distress, and cardiopulmonary arrest should have emergent chest decompression
- Persistent massive air leak warrants investigation for tracheobronchial injury

Pneumothorax



Breathing

- **BEWARE GASTRIC DISTENSION**
- Chest wall is thin: breath sounds transmit easily
- Open pneumothorax rare but easily recognized
 - positive pressure ventilation, flap dressing
- Flail chest may occur with less ribs involved
 - paradoxical movement more debilitating than adult
 - underlying lung injury

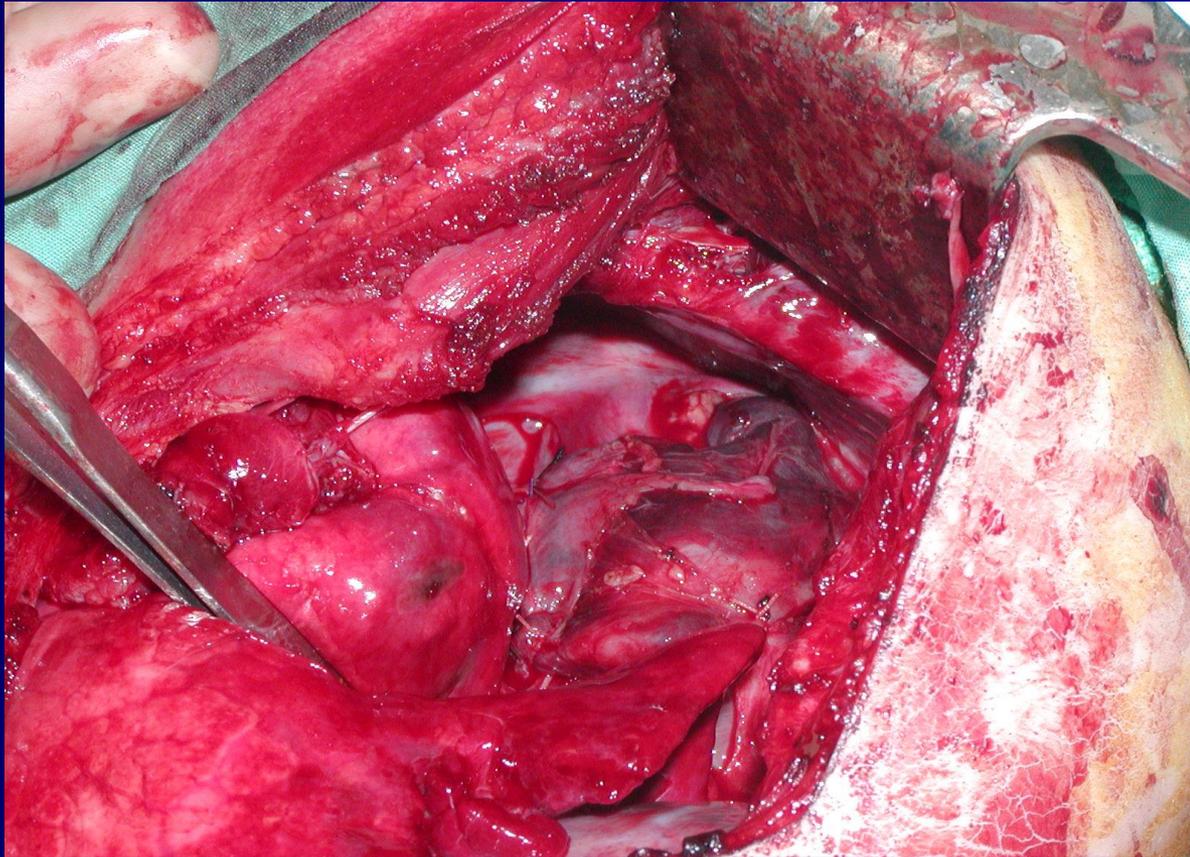
Open Pneumothorax



With penetrating rib injury



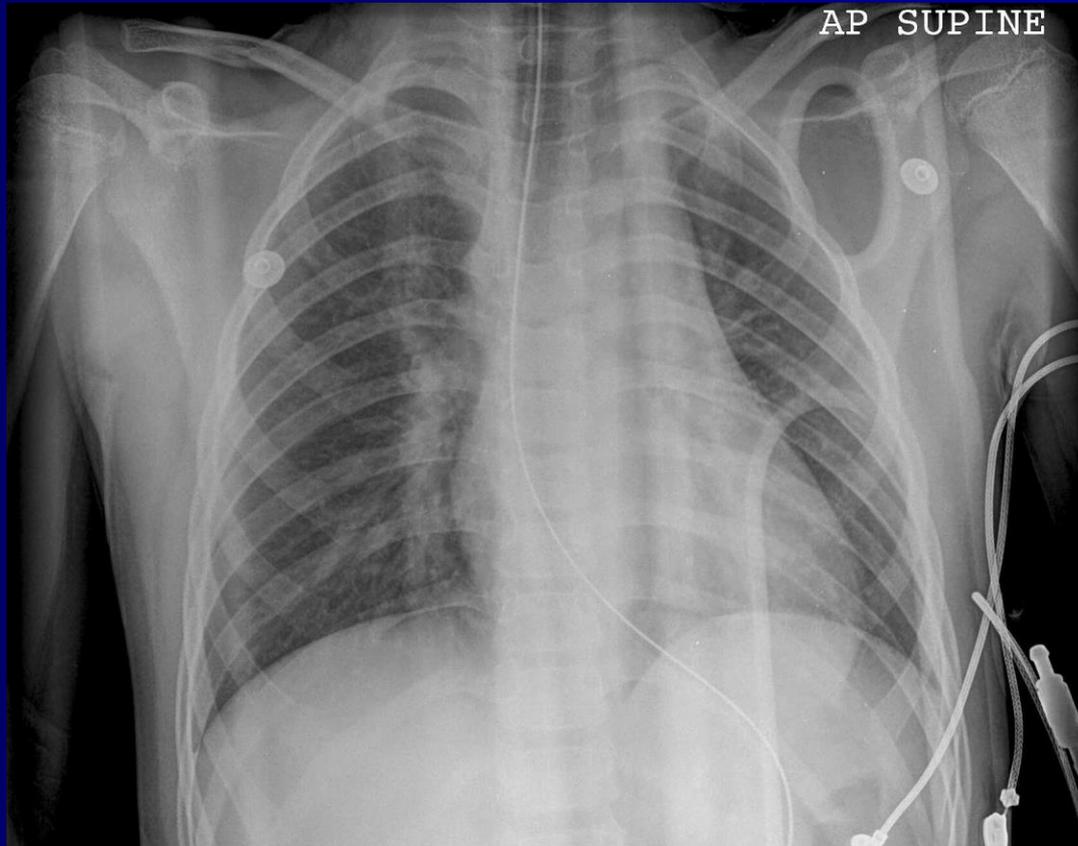
To hilum and RLL



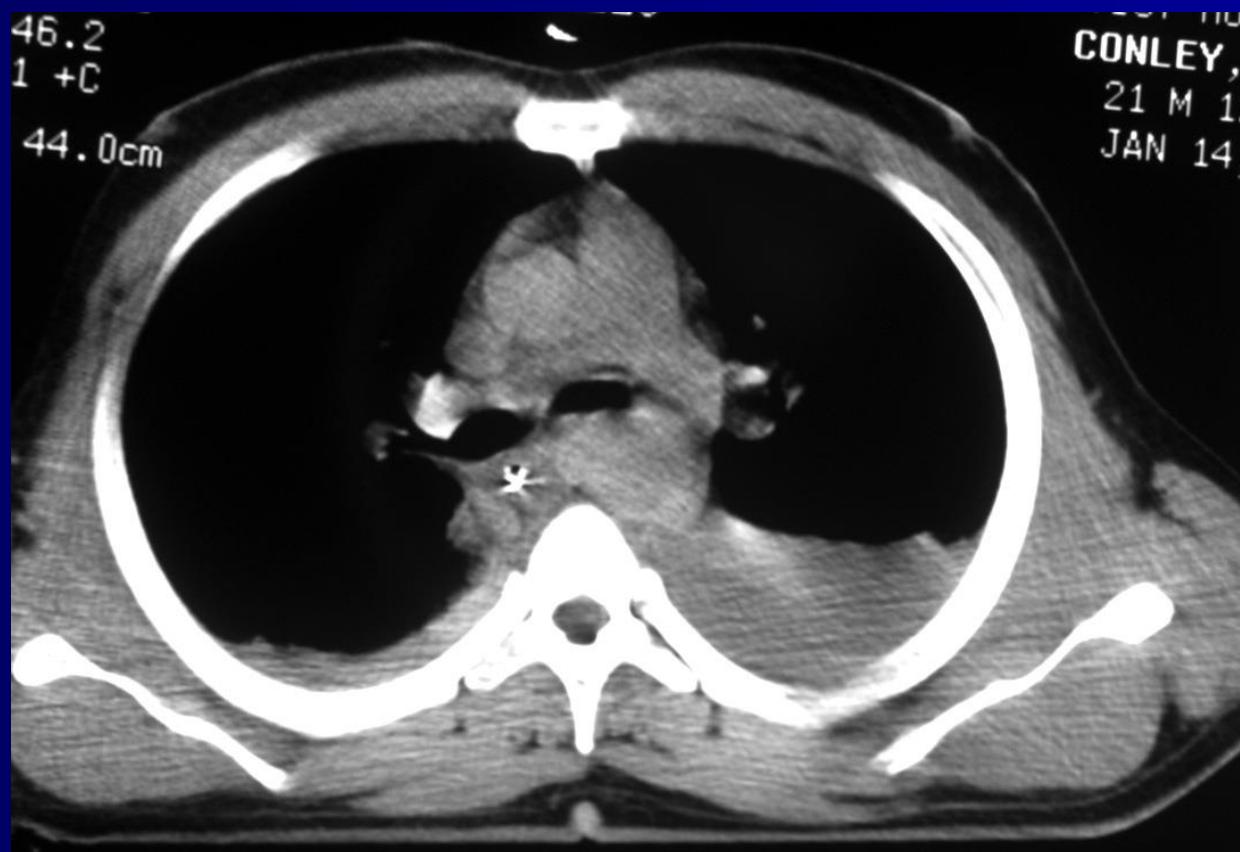
Breathing

- Massive hemothorax rare in blunt trauma
- Diaphragmatic hernia
- Cardiac tamponade rare
- Myocardial contusion
- Torn thoracic aorta
 - Extremely rare if younger than 12
- ER Thoracotomy has absolutely no role in management of blunt pediatric trauma

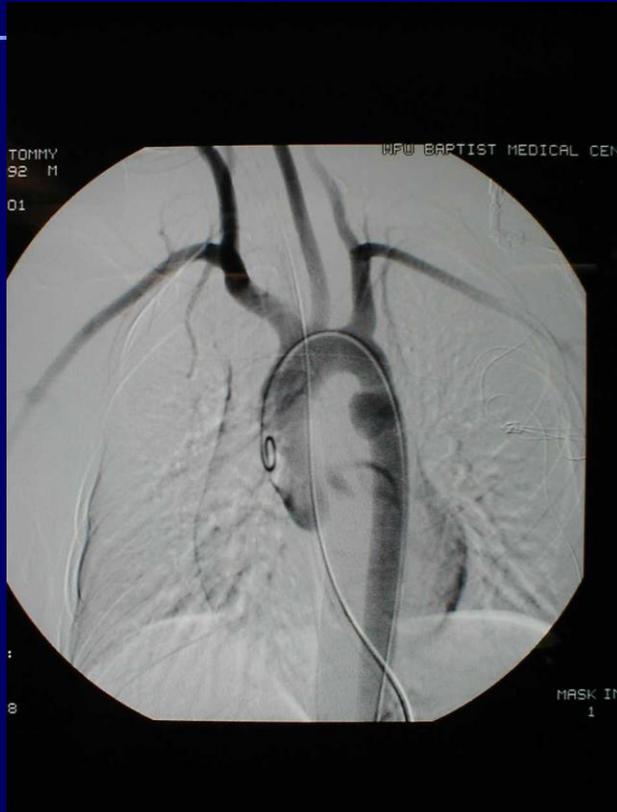
Worrisome CXR???



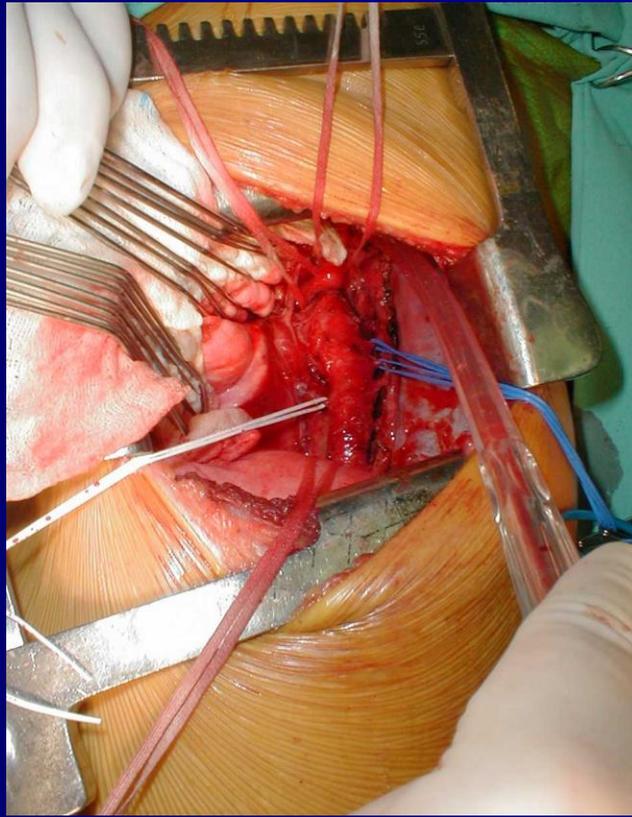
Torn Aorta



Torn aorta



Aortic Tear



Circulation

- After oxygenation and ventilation, assessing shock takes priority
- Shock is the inadequate delivery of oxygen to the tissue beds
- NOTE: Blood pressure is not mentioned in the definition of shock!!!!
- More difficult to recognize shock in children than adults

Circulation

- Children adept at compensating for blood loss
- Tachycardia difficult to appreciate
- Depressed mental status earliest sign
- Monitor perfusion and capillary refill
- Hypotension a "LATE" sign with imminent cardiovascular collapse

Circulation

- Blood volume 70-80 cc/kg
- What appears to be small amount of blood loss adds up quickly
- CONTROL the bleeding!
- 200 ml EBL in 10 kg child is 25% of blood volume

Circulation

- Higher body surface area to mass ratio
- Increased insensible fluid losses = increased heat loss
- VERY susceptible to hypothermia.

Circulation

- Wide variation in normal vital signs
- Normal SBP: $60-70 + 2(\text{age})$
- **Hypotension an ominous finding!**
- Goal is to establish presence of shock before the vital signs change
- No lab test or x-ray that can estimate EBL and shock
 - best lab predictor of shock is base deficit

Pediatric Vital Signs

AGE	Weight (kg)	Heart Rate (beats/min)	Pressure* (mm Hg)	Respirations (breaths/min)	Urine Output (cc/kg/hr)
0-6 months	3-6	160-180	60-80	60	2
Infant	12	160	80	40	1.5
Preschool	16	120	90	30	1
Adolescent	35	100	100	20	0.5

Clinical Signs of Shock

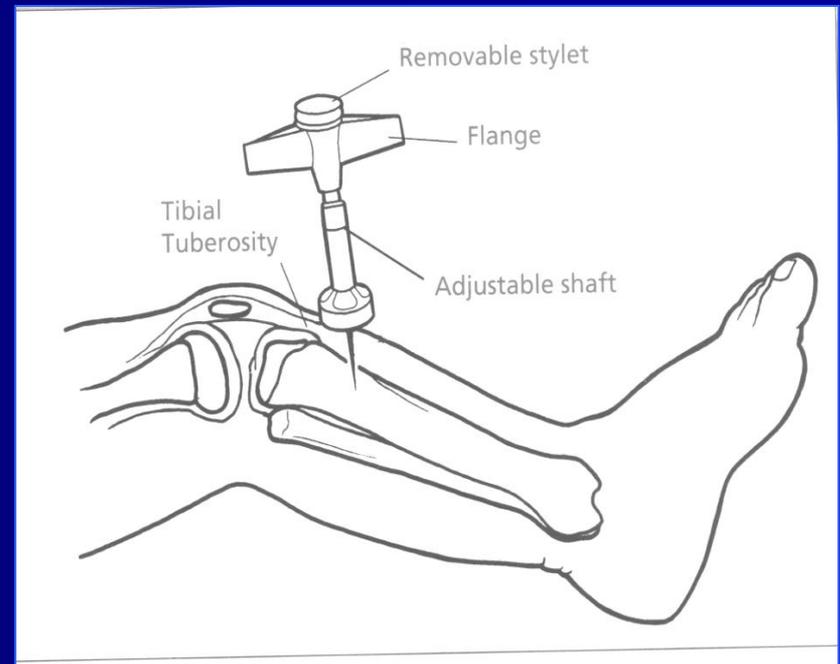
System	< 25% Blood Loss	25%-45% Blood Loss	> 45% Blood Loss
Cardiac	Weak, thready pulse; increased heart rate	Tachycardia	Hypotension, tachycardia to bradycardia
CNS	Lethargic, irritable, confused	Changing level of consciousness; dulled response to pain	Comatose
Skin	Cool, clammy	Cyanotic, decreased capillary refill, cold extremities	Pale, cold
Renal	No decrease in output, increased specific gravity	Decreased urine output	No urine output

Circulation

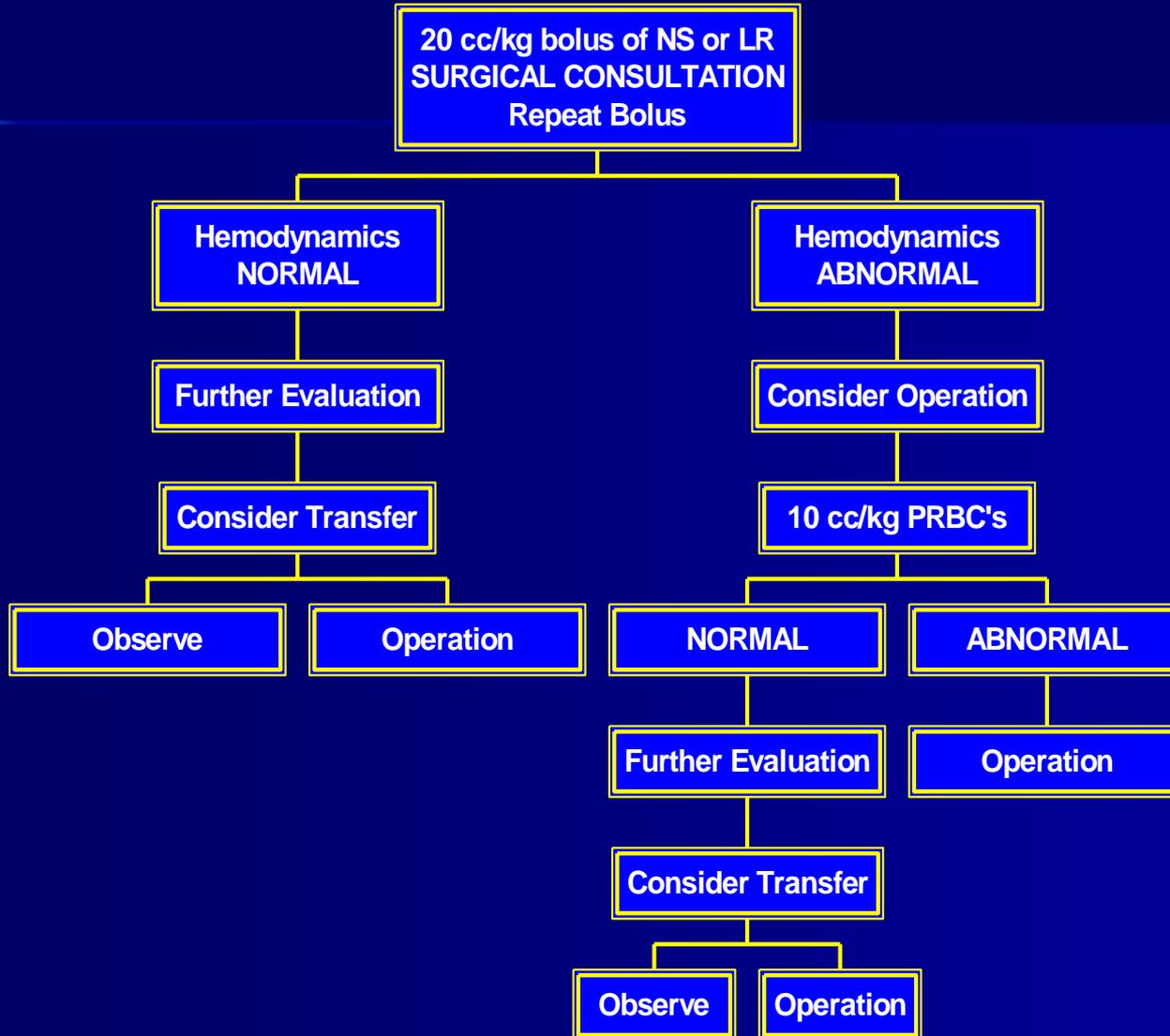
- Must establish I.V. access:
 - peripheral, percutaneous central, intraosseous, peripheral cutdown
- Send blood for trauma panel, type and cross
- Short large bore peripheral catheter better than long central line
- If central route needed, femoral okay in children

Intraosseous Line

- Less than 6 years of age
- Fluids, blood products, and drugs can be given
- Proximal tibia or distal femur best location
- Fracture of the bone only contraindication
- Obtain alternate access ASAP



Fluid Resuscitation



Hypovolemic Shock

- If child acutely hypotensive: rule out tension pneumothorax first
- Most shock in pediatric trauma is hypovolemic
- Need to determine etiology of blood loss
- Only 5 potential sources of massive blood loss

Hypovolemic Shock

- Chest: rule out with CXR
- Pelvis: rule out with pelvic film
- Long bone fractures: look at patient
- “On the floor”: history and exam
 - apply pressure, don’t forget scalp lac’s
- Abdomen: none of the above

Disability

- Closed head injury leading cause of death
- Often occurs with cervical spine injury
 - High c-spine injury with respiratory arrest
- Hypoxic injury often worse than TBI
- Delay in treatment makes ICP more difficult to control
- Early Head CT to rule out mass lesion

Glasgow Coma Score

CRITERIA	SCORE	INFANT	CHILD
Eye opening	4	Spontaneous	Spontaneous
	3	To loud noise	To verbal stimuli
	2	To pain	To pain
	1	No response	No response
Verbal Response	5	Smiles, coos, cries appropriately	Appropriate, oriented
	4	Cries but consolable	Confused
	3	Persistently irritable, crying	Inappropriate
	2	Grunts or moans	Incomprehensible
	1	No response	No response
Motor Response	6	Spontaneous	Follows commands
	5	Withdraws to touch	Localizes pain
	4	Withdraws to pain	Withdrawal to pain
	3	Decorticate (flexion) posturing	Decorticate (flexion) posturing
	2	Decerebrate (extensor) posturing	Decerebrate (extensor) posturing
	1	No Response	No response

Disability

- GCS 13-15 mild TBI; 9-12 moderate TBI; 3-8 severe TBI (70% mortality)
- May have significant blood loss from associated scalp laceration
- Basilar skull fracture
 - Raccoon's eyes, hemotympanum, otorrhea, rhinorrhea
 - Indicates significant force but not important to immediate outcome
 - No prophylactic antibiotics

Prevent Secondary Injury

- Early intubation to avoid hypoxia, hypercapnea
 - Acute hyperventilation decreases CBF
- Evacuation of any mass lesions
- Prevent and treat other systemic complications
 - Tension PTX, significant hypovolemic shock
- Maintain adequate cerebral perfusion pressure

Prevent Secondary Injury

- Common treatable causes of secondary injury
 - HYPOXIA-HYPERCARBIA-HYPERTHERMIA-HYPONATREMIA
- Isotonic fluids: avoid hypovolemia
 - Running them dry is old school
- Ventilation and oxygenation
 - Profound acute hyperventilation is just as bad as hypercarbia

Maintain Adequate Cerebral Perfusion Pressure

- $CPP = MAP - ICP$ (normal > 50 mmHg)
- ICP monitoring in ?? patients??
- Want ICP < 20 :
 - Raise HOB, pCO₂ 30-35, avoid hyponatremia, mannitol, sedation, paralysis, barbituates
- Want MAP $> 60-70$:
 - Euvolemia, pressors after ruling out hypovolemic shock, r/o PTX



**SECONDARY
SURVEY**

Abdominal Trauma

- In the multiple injured trauma victim, evaluation of abdomen problematic
- U/S not as well tested in children
 - less volume present
- DPL invasive
- CT scan only if “metastable” and well “protected”

Abdominal Trauma

Lab Data/Radiology

- CBC, Electrolytes, Amylase, LFT's, Coagulation profile, U/A, Type and Cross
- Establish 2 large bore IV's with one above the diaphragm
 - peripheral, intraosseous, cut-down, percutaneous CVC
- Lateral C-spine, Chest, and Pelvis plain films
- Place NG/OG, Foley Catheter

Abdominal Trauma

Imaging Studies

- **CXR, pelvis films**
- **CT Scan:** If there is evidence of injury or unable to examine abdomen
 - Chest CT in teenagers
- **Retrograde Urethrogram** if blood at urethral meatus
- **Abdominal Ultrasound**
 - to r/o hemoperitoneum in multiple injury trauma
- **Arteriogram:** for pelvic injuries with bleeding

Abdominal Trauma

CT Scan

- Used to evaluate Chest, Abdomen, Pelvis and Retroperitoneum
- Shows free fluid well
- Shows solid organ injury well
- Shows viability of organs based on perfusion
- Hemorrhage shown by extravasation of contrast

Abdominal Trauma

**CT of the
abdomen &
pelvis is not
effective for
ruling out
hollow viscus
injuries**



Abdominal Trauma

Diagnostic Peritoneal Lavage

- For bleeding/perforation in abdominal cavity
- Sensitivity >95% for injury
 - injuries more often stable in children than adults
- False positive blood due to pelvic fracture
- Misses retroperitoneal injuries
- FAST has essentially replaced DPL in ED
- Technically difficult to perform
- Still has role in head injured patient to rule out bowel injury

Abdominal Injuries

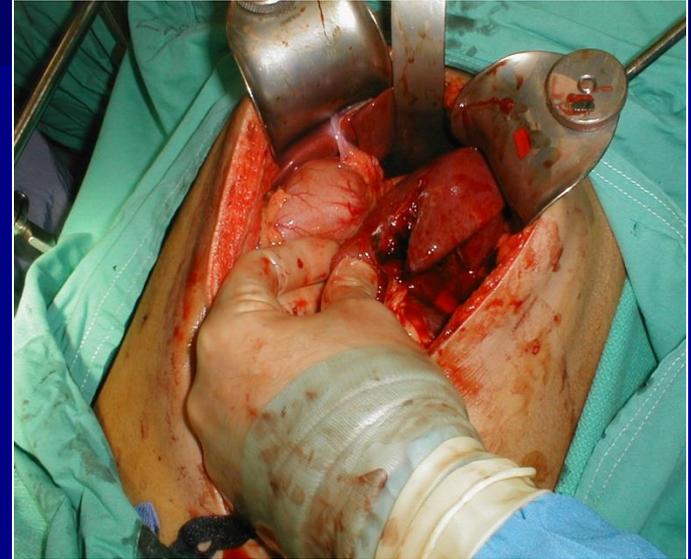
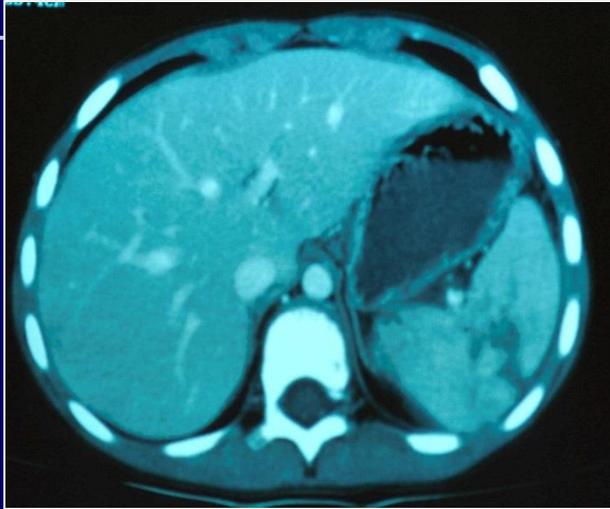
- Blunt trauma in pediatrics has much higher mortality than penetrating trauma
- Multiple organ injury is far more common with blunt than with penetrating trauma
 - High mortality when several organ systems are injured
 - Hemorrhage, sepsis, renal failure

Solid Organ Injury

- Solid organs less protected than adults due to pliable rib cage
- Grading system the same as in adults
- Most solid organ lacerations Grade III or less can be managed conservatively



Solid Organ Injury



- Follow fluid resuscitation algorithm as before
- OR if still in shock after 1st 10 cc/kg of PRBC
 - **or suspect associated bowel injury**
- Bedrest and serial exam if stable

Select organ trauma

- Spleen and liver are the most commonly injured organ.
- Hepatic trauma
 - Abdominal CT (enhanced) is accurate in localizing the site and extent of liver injuries and providing vital information.
 - Subcapsular, intrahepatic hematoma, contusion, vascular injury, biliary disruption.
 - American association for the surgery of trauma liver injury scale

Select organ trauma

Grade	Description
I	Subcapsular hematoma <1cm in maximal thickness, capsular avulsion, superficial laceration <1cm deep, and isolated periportal blood tracking
II	Parenchymal laceration 1-3cm deep and parenchymal/subcapsular hematomas 1-3cm thick
III	Parenchymal laceration >3cm deep and parenchymal or subcapsular hematoma >3cm in diameter
IV	Parenchymal/subcapsular hematoma >10 cm in diameter, lobar destruction, or devascularization
V	Global destruction or devascularization of the liver
VI	Hepatic avulsion

Select organ trauma

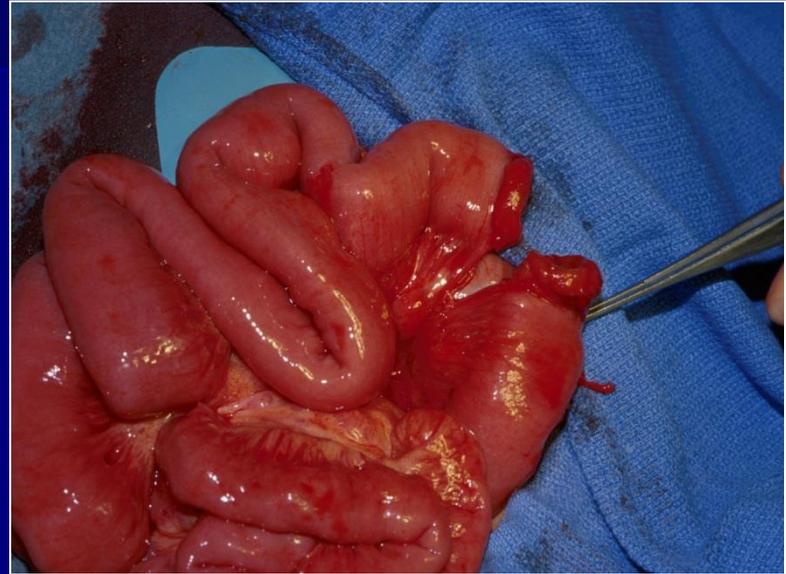
■ Splenic trauma

- LUQ abdominal tenderness, l't lower rib fracture, or evidence of l't lower chest/abdominal contusion.
- managed with bed rest, frequent examination, serial Hb monitoring.
- Massive disruption and hemodynamic instability – absolute surgical indication.
- Splenic rupture and EB virus infection.

Select organ trauma

Grade	Description
I	Subcapsular hematoma < 10% of surface area or capsular tear of < 1cm deep
II	Subcapsular hematoma of <10-50% of surface area, intraparenchymal hematoma <5cm in diameter, or laceration of 1-3cm deep and not involve trabecular vesse
III	Subcapsular hematoma >50% surface area or expanding and ruptured and subcapsular or parenchymal hematoma, intraparenchymal hematoma >5cm or expanding, or laceration >3cm deep or involving trabecular vessels
IV	Laceration involving segmental or hilar vessels with devascularization >25% of the spleen
V	Shattered spleen or hilar vascular injury

Seat Belt Stripe



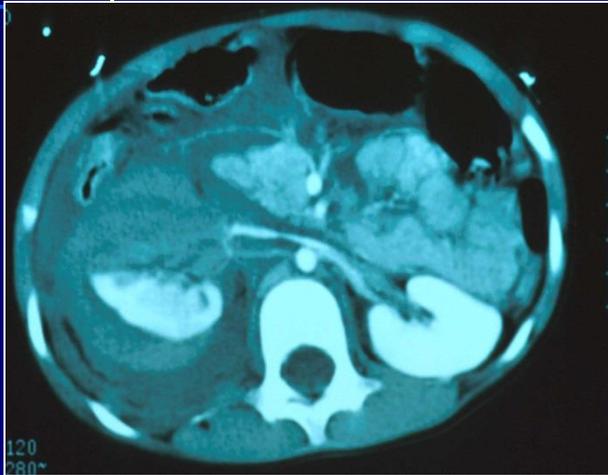
- Bowel injuries associated with seat belt stripe
 - 20% will have seat belt stripe
 - 15-20% of these have significant intestinal injury
- Physical exam can be difficult
 - abdominal wall bruising painful

Seat Belt Stripe

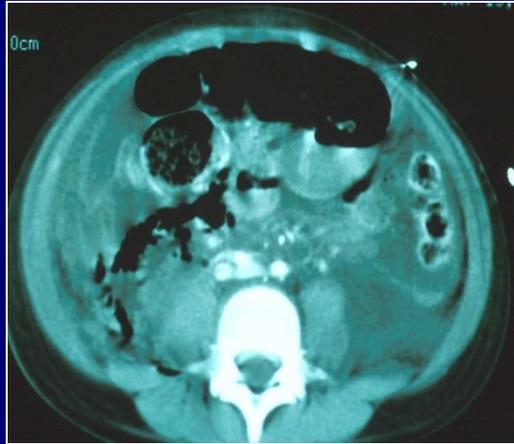


- CT sensitive and specific for solid organ injury
 - Not as sensitive or specific for bowel injury
 - looking for secondary signs of injury

CT Scan and Bowel Injury



Admission



24 HR later



Duodenum

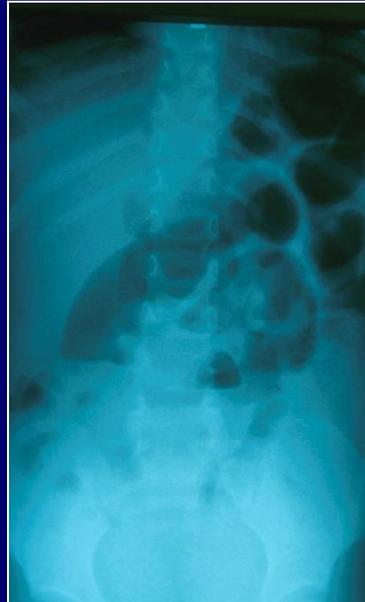
- Free fluid without associated solid organ injury
- Intraperitoneal or retroperitoneal air
- Bowel wall thickening

Seat Belt Stripe



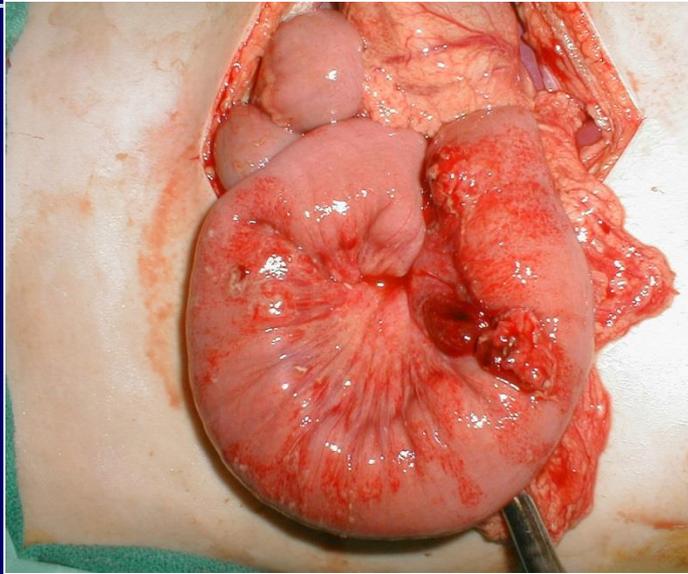
- Serial physical exam if no hard signs on CT scan
- Laparotomy for all seat belt stripes not indicated
- Delay in laparotomy **NOT** associated with increased morbidity

Post-Trauma Bowel Obstruction



- “Negative” laparotomy may be therapeutic
- Mesenteric defects can present as internal hernia
- Pancreas, bladder injury a possibility as well

Bicycle Handlebar Injury



- LUQ usual point of injury
- Spleen, pancreas, bowel and kidney often injured
- Persistent LUQ pain, especially if left "shoulder" pain, warrants investigation

Pancreas Injury



- Conservative management often successful
- Complete transection best managed acutely with distal pancreatectomy
 - pseudocyst formation common, ↑ morbidity

Abdominal Trauma

Genitourinary System

- 10% of all abdominal injuries
- Kidneys most commonly injured
- Hematuria in 90% of children with GU injury
 - hematuria associated with increased risk for other intra-abdominal injury
- CT scan with IV contrast

Abdominal Trauma

Genitourinary System

- Cystogram for gross hematuria
 - observe extraperitoneal rupture, repair intra-peritoneal
- Straddle injuries or pelvic fractures
- Suspect urethral injuries, especially in males
 - blood at urethral meatus
 - retrograde urethrogram prior to passing foley
 - treat with suprapubic tube, delayed repair

Child Abuse "RED" Flags

- Discrepancies in story
- Changing history
- Inappropriate response
 - parents and child
- Multiple injuries in past
- Classic abuse injuries
- Child's development
- Sexual abuse



Child Abuse: Physical Exam

- Multiple SDH, retinal hemorrhage
- Ruptured viscus without antecedent history
- Perianal, genital trauma
- Multiple scars, fractures of varying age
- Long bone fractures less than 3 years old
- Bizarre injuries: bites, cigarette burns, rope marks
- Sharply demarcated burns