

# Module 4 – Pediatric Trauma

(In disaster settings)

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A photograph of three young adults sitting around a wooden table, smiling and looking at laptops. The woman on the left is seen from the back, wearing a white sweater. The woman in the center is smiling broadly, looking at a laptop. The man on the right is wearing glasses and a denim jacket, also smiling. The table has two laptops, a brown leather folder, and glasses of water. The background is a blurred indoor setting with plants.

**Kids are at higher risk  
of injury in disasters**

# Kids are vulnerable to trauma

Big heads and weaker necks – increased head injuries, different C-spine injury pattern

Increased body surface area for weight – lose heat, water quickly

Increased compliance of the chest wall makes injury to lung (and abdominal organs) more likely



Abdominal organs are close together and less protected by rib cage

Shock is more subtle – elevated HR may be only sign, BP preserved until very late

Hypovolemia occurs quickly – less blood volume

# Initial evaluation – on scene or in the ED

- "Trauma is cookbook medicine"
- Primary survey –
  - **X-ABCDE**
  - identify and treat immediately life threatening injuries
- Secondary survey –
  - Head to toe physical exam
  - identify other serious injuries that may need attention
- Tertiary survey –
  - complete and detailed physical exam often done after initial interventions and before patient is released to home
  - Identifies any other injuries that may have been missed due to other distracting injuries

# TRAUMA - PRIMARY SURVEY

**Goal = identify and treat threats to life**

**X- Exsanguinating hemorrhage**

**A - Airway patency (and protect the C-spine)**

**B - Breathing and ventilation**

**C - Circulation with hemorrhage control**

**D - Disability: Mental status**

**E - Exposure: Completely undress patient**

# A – AIRWAY (primary survey)

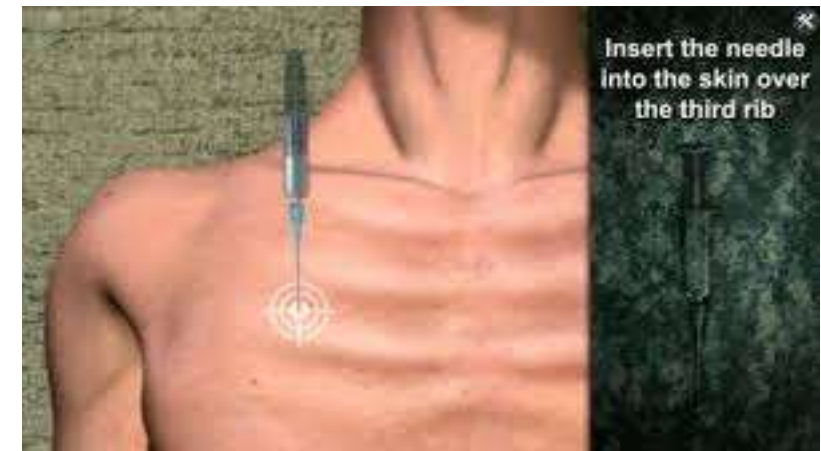
**“Does the patient have a stable and patent airway?”**

- **If YES – move on to Breathing**
- **IF NO - Then address airway NOW**
  - **Position airway while maintaining C-spine protection**
    - **Midline positioning**
    - **jaw thrust to open airway and protect c-spine**
    - **Head tilt and chin lift are contraindicated**
  - **Remove obstructions**
  - **Consider placing airway adjunct (NP, OP airway)**
  - **Attempt BVM ventilation**
  - **Consider intubation or emergent cricothyrotomy**



# B - BREATHING

- Assess minute ventilation
- Assess chest expansion
- Breath sounds
- Heart sounds
- Chest percussion
- Address any tension pneumothorax or "sucking chest"



# C - CIRCULATION

- Control external hemorrhage first!
- Assess pulse, end organ perfusion
  - capillary refill, temperature/appearance of extremities, CNS function
  - Check distal and femoral pulses
  - Assess for tachycardia as BP will lag
  - Place IV/IO
- Treat blood loss by giving blood products!
  - Crystalloid doesn't replace blood – just helps with fluid pressure
- If inadequate circulation remains after 2 units of pRBC (10cc/kg = 1 unit for kids) start MTP if available.

**Key Point: Hypotension in children will not be evident until 25% to 30% of blood volume is lost**



# SHOCK RELATED TO TRAUMA

(it's not all bleeding)

| Classify     | Cause                                                                  |
|--------------|------------------------------------------------------------------------|
| Hypovolemic  | Hemorrhage<br>Burns                                                    |
| Cardiogenic  | <ul style="list-style-type: none"><li>• Myocardial contusion</li></ul> |
| Obstructive  | Massive hemothorax<br>Tension pneumothorax<br>Tamponade                |
| Distributive | <ul style="list-style-type: none"><li>• Spinal cord injury</li></ul>   |

# Hemorrhage control – STOP THE BLEED

- Stop active and massive hemorrhage quickly
- Direct pressure – hold pressure on hemorrhages you can't tie off (head, hip, shoulders)
- Extremities:
  - Apply tourniquet – tight, fast, leave it in place
- Pack the wound
  - Clean (ideally) cloth/bandage
  - Hold or tape pressure



# Massive transfusion protocol — Replace the blood

- Initial treatment for shock from trauma is BLOOD
- Start with pRBC (unmatched) – 2 boluses
  - Adult = 2 units
  - Kids = 10cc/kg x 2
- Then move to MTP
  - 1:1:1 pRBC:platelet:FFP
  - May not be available
    - In an MCI with overwhelmed blood supply
    - In under-resourced medical environments
    - Far from urban areas
- MTP is pre-batched and is sent automatically from the blood bank
- Allow very fast transfusion for ongoing bleeding with shock



# D - DISABILITY

- Determine mental status with rapid assessment
- Is the child responsive?
- Pupil and motor exam
- AVPU evaluation: (**A**lert, responsive to **V**oice, responsive to **P**ain, **U**nresponsive)
- Glasgow Coma Score –
  - Used commonly but difficult to actually calculate
    - Verbal – 6
    - Motor – 5
    - Eye opening -4

# Intervention for AMS / head injury

Signs of increased intracranial pressure

- bradycardia,
- hypertension,
- hypoventilation

Intervention for increased ICP:

- Consider mannitol or 3% NS if suspected increased ICP
- Keep head of bed slightly elevated
- Avoid hypoventilation
- Avoid systemic shock to maintain cerebral perfusion
- Sedation as needed

Consider intubation to protect airway if unresponsive or GCS < 8

Not all AMS in trauma is head – consider and treat shock, drugs, toxins, sepsis



# E - EXPOSURE

- Completely undress patient
    - If blunt trauma – protect the spine
  - Perform complete visual examination
    - log roll and check the back, buttocks and palpate entire spine
  - Don't let the patient get cold
    - Warm blankets
    - Active warming
- “Get'em naked and then cover'em up”



# Secondary Survey

- Perform after primary survey is complete and issues are addressed
- Head to toe examination
  - Vital signs
  - Looking for any signs of injury
  - Include back (with a log-roll to protect the spine) and perineum
  - Palpate everything!
- AMPLE history:
  - Allergies
  - Medications
  - Past medical/surgical history
  - Last meal / LMP
  - Events leading up to the trauma



# Supporting studies

- If resources allow but don't replace primary or secondary survey
- Radiology
  - Xray – Chest, Pelvis, C-spine and injuries
  - CT – if indicated and available
- Labs
  - “Trauma labs” might not be available or appropriate in MCI
  - CBC – shows initial state and doesn't reflect recent bleeding
  - LFT – useful for liver injury
  - TEG / Coag studies – helpful for DIC and to guide MTP
  - Lipase/amylase – useful for pancreatic injury

A photograph of three people (two women and one man) sitting around a wooden table, smiling and looking at laptops. The scene is dimly lit, suggesting an indoor setting like a cafe or office at night. The text 'Specific injury patterns in MCI' is overlaid in white on a dark rectangular background in the center of the image.

# Specific injury patterns in MCI

# Penetrating Trauma

## ~10-20% of all trauma (US)

- 0-18 years (~7.4%)
- gunshot > stab wounds
- More heavily armed society

## Injuries related to velocity

- Bullets can divert in the body
- Shock wave can cause trauma
- Vascular injuries common

## Treatment consists of hemorrhage control



# Penetrating trauma – hemorrhage is key threat

## Torso

- Silent hemorrhage reservoirs
- Ongoing blood products needed
  - MTP
- Will need a surgeon
- High index of suspicion for injury even with small entry wound

## Extremity

- If Active, pulsatile bleed – need tourniquet for control, then surgical care
- Expanding Hematoma
- Absent pulses or ABI/ API <0.9
- Control bleeding
- If large vascular injury will need surgical repair

# Traumatic Brain Injury

## Primary injury

- Can be blunt or penetrating
- May have no external signs of injury and be severe
- Blast injury may be severe
- Concussion, cerebral contusion, diffuse axonal injury, intracranial hemorrhage

## Secondary injury

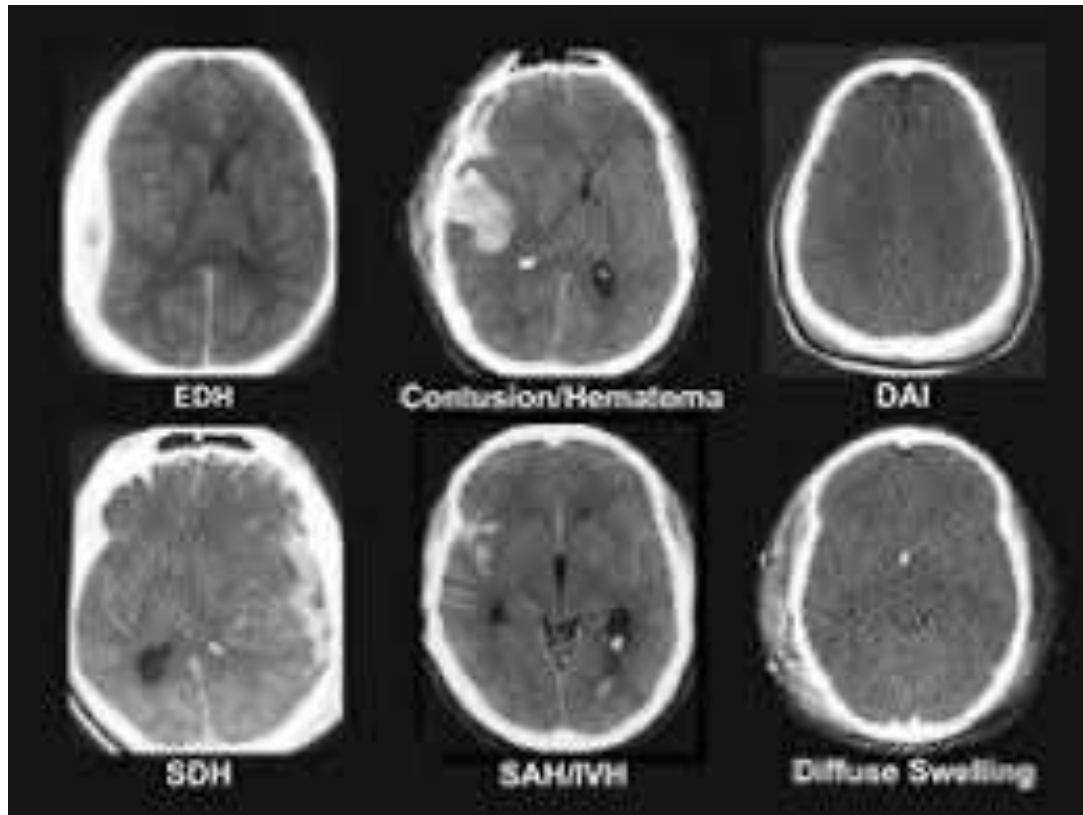
- Metabolic injury
- Reperfusion injury
- Ischemic injury from shock

# Initial evaluation of head injury

- Vital signs
- Level of consciousness – GCS /AVPU
- Brief neuro exam with CN, motor, sensory, coordination
- If resources allow:
  - CT head for moderate/severe injury
  - Immobilize and image C-spine
- Use clinical signs if under-resourced
  - Battle sign/raccoon eyes
  - Serial neuro exam
  - Check pupils frequently



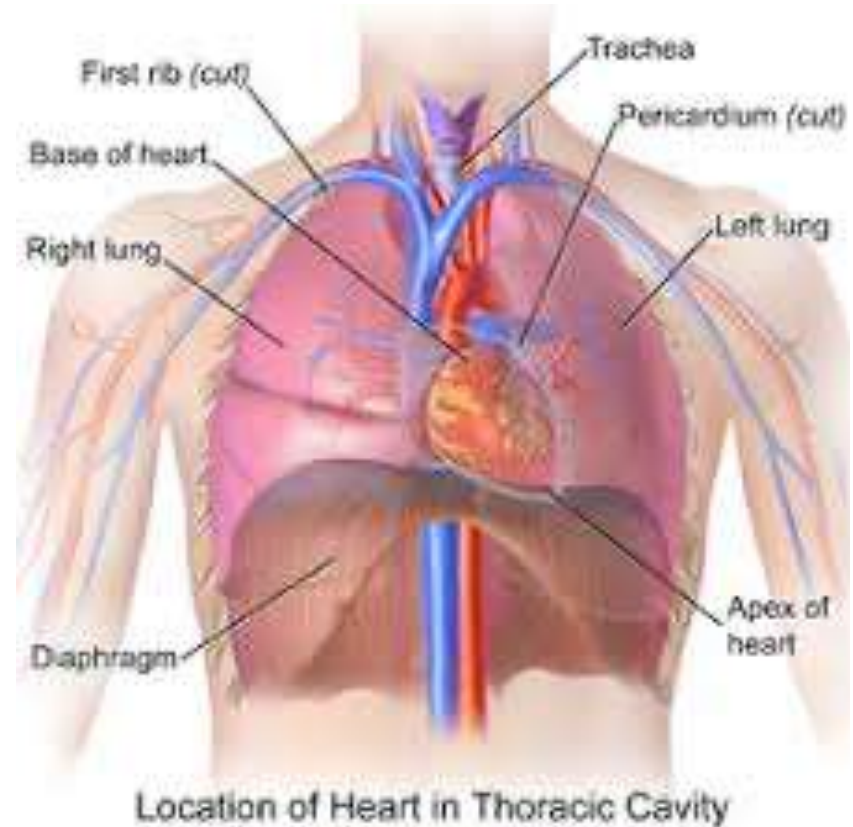
# Management of head injury



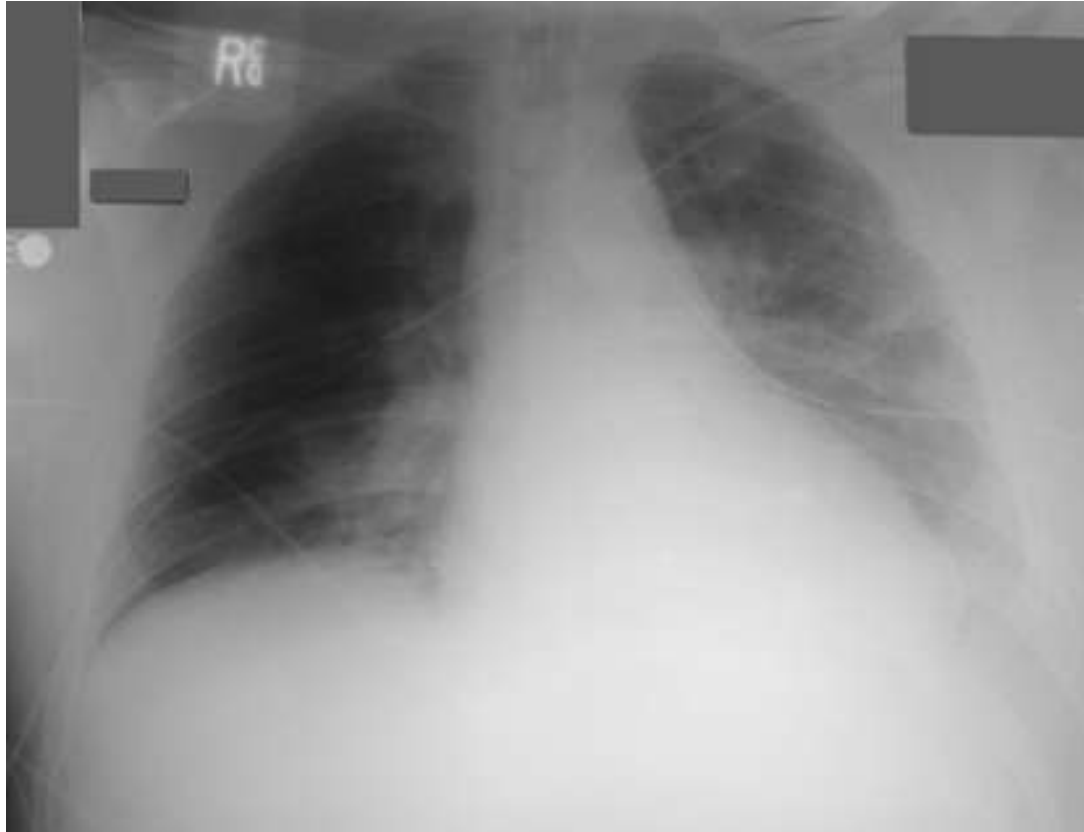
- Elevate head of bed – 30deg
- Ensure adequate oxygenation / ventilation
- Normothermia – avoid fever/hyperthermia
- Avoid hypotension
  - Give volume
  - Consider vasopressors
- Sedation to allow rest
- If signs of increased ICP
  - 3% NS (5cc/kg)
  - Mannitol
- Surgical intervention for space occupying hemorrhage

# Thoracic injuries

- **Pulmonary contusion/laceration (53%)**
- **Pneumothorax/hemothorax (38%)**
- **Rib/sternal fractures (36%)**
- **Other injuries**
  - Cardiac (5%)
  - Diaphragm (2%)
  - Major blood vessels (1%)
- Remember kids have compliant chest wall and may have significant injury with less force



# Pulmonary contusion



- **Most frequent injury**
- **May not have visible signs**
  - Decrease breath sounds, rales
  - tachypnea
- **Pulmonary hematoma:**
  - Blood and fluid in the alveoli
- **Hypoxemia, hypercarbia**
- **Give oxygen 100%**
  - May also need pressure support

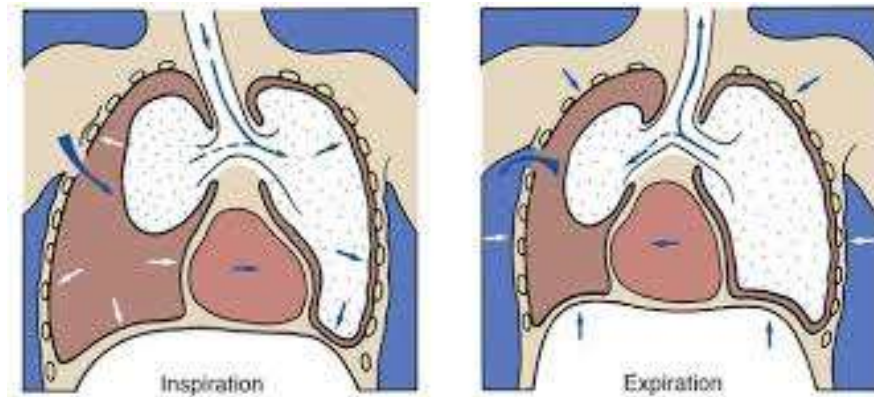
## Simple PTX

- May require chest tube
- Place on O2
- May change



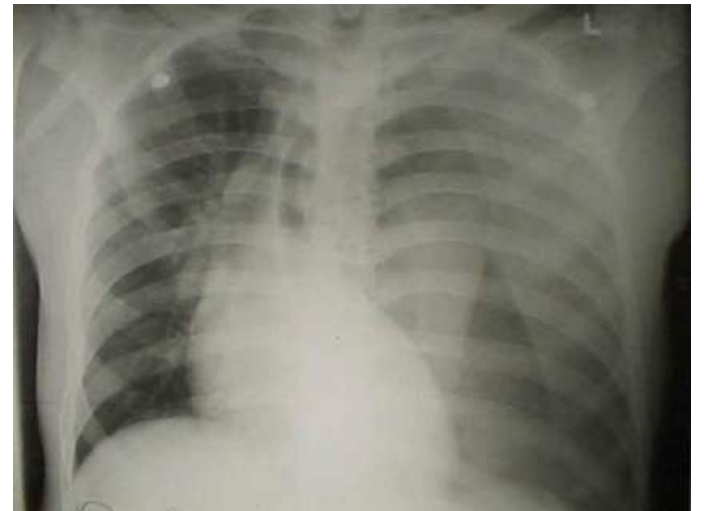
## Open PTX

- “sucking chest wound”
- Pleural space is open to outside
- Occlusive (3 sides only!) dressing



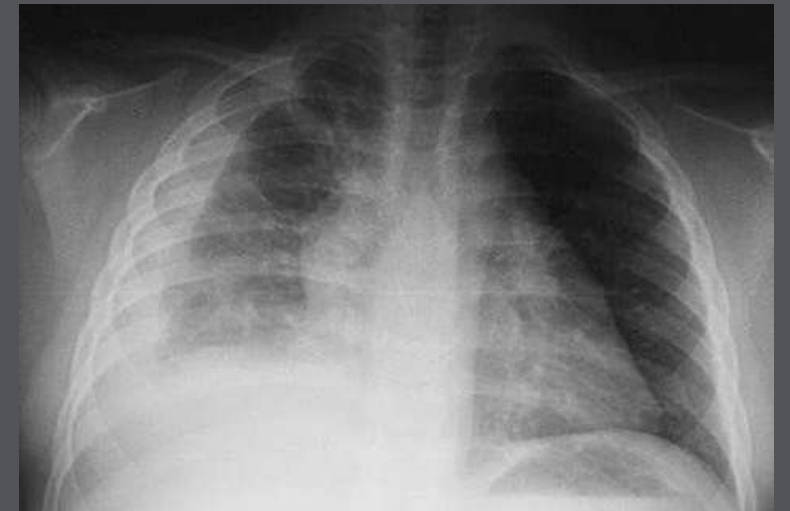
## Tension

- Fatal quickly
- Negative pressure will fill pleural space with air
- Treat with needle decompression and thoracostomy tube



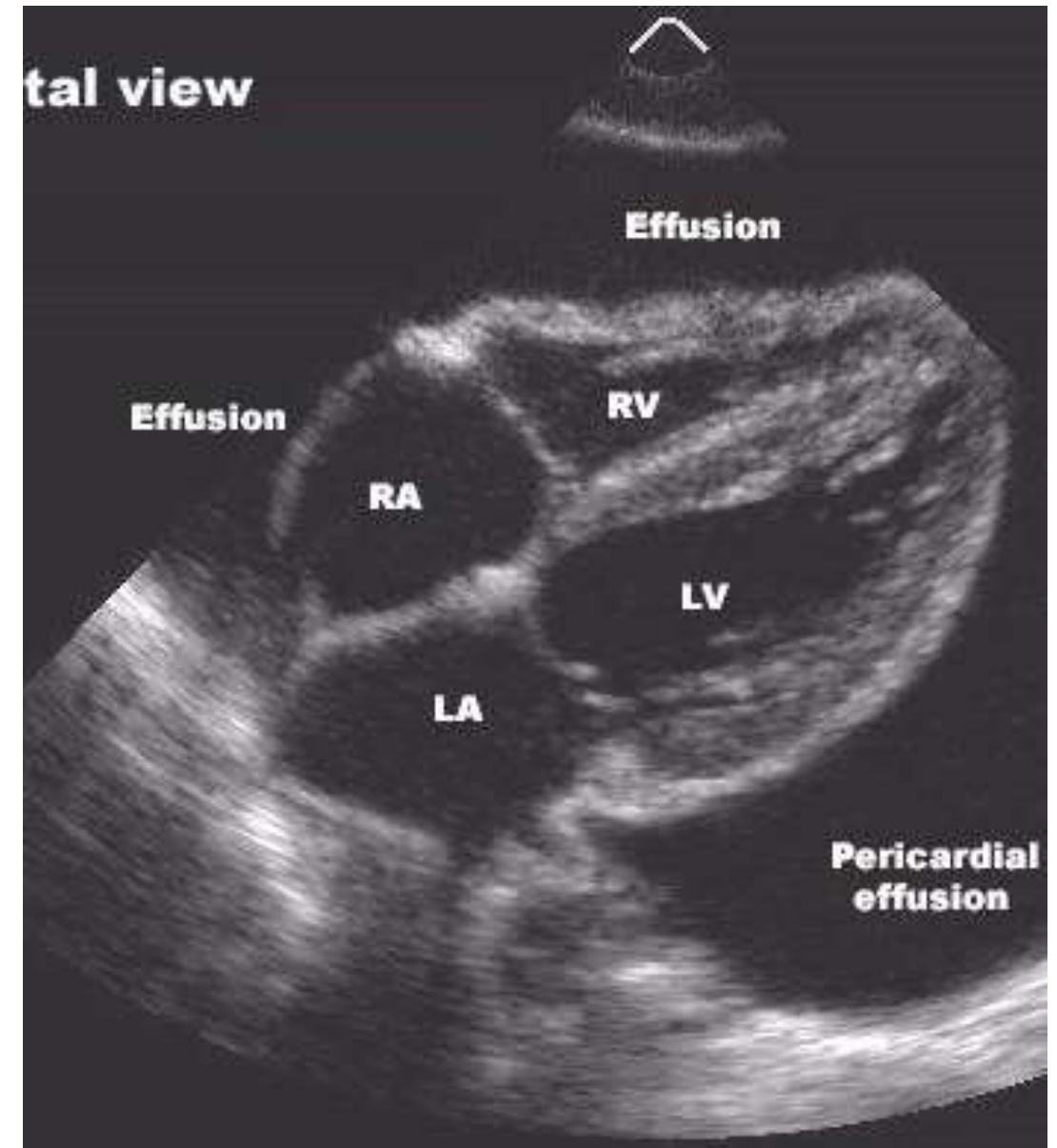
# Hemothorax

- **Blood accumulates in the pleural space**
  - Lung compression
  - Hypoxemia and respiratory distress
- **Type of injury**
  - Large pulmonary injury
  - Large vessels injury
  - Can lead to hypovolemia / shock



# Pericardial Tamponade

- Fluid / blood in the pericardial sac
  - Compresses heart and ↓ cardiac output
  - Impairs venous return
  - Arrhythmias
- Beck's triad:
  - narrow pulse pressure,
  - neck vein distention,
  - muffled heart tones
- Treat with Pericardiocentesis



# Abdominal injuries

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- Third leading cause of death in children, after head and thoracic injuries
  - Weak abdominal wall
  - Poorly protected spleen/liver (no fat, compliant ribcage)
- Silent hypovolemia
  - - elevated HR
  - tender /distended abdomen
- Solid organ vs hollow viscous
  - Spleen most common



# Fractures and extremity injuries

- **SPLINT**, splint, splint...
  - Clean and cover wound
  - Splint to joint above and below the injury
- **Pain management !**
  - Ibuprofen/acetaminophen (paracetamol)
  - Opiates
  - Nerve block

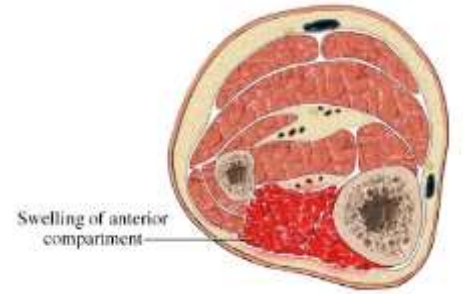


# Open fractures

- **Implies significant force**
  - Look for other injuries
- **Increased complications**
  - Infections, nerve impingement
- **Management**
  - Clean, cover, do not suture
  - IV antibiotics if available (PO if not)
  - immobilize
- **May need surgical debridement/irrigation/fixation**



# Compartment syndrome



- ↑ Intracompartment pressure → ischemia → muscle necrosis and nerve palsies
- Trauma does not have to be severe – crush, fracture, burn
  - Severe trauma interrupts compartment
- ↑ **P**ain, especially with passive extension
- Absent **P**ulse, **P**aresthesia, **P**allor, **P**aralysis/**P**aresis
- May need fasciotomy



# Pelvic fractures

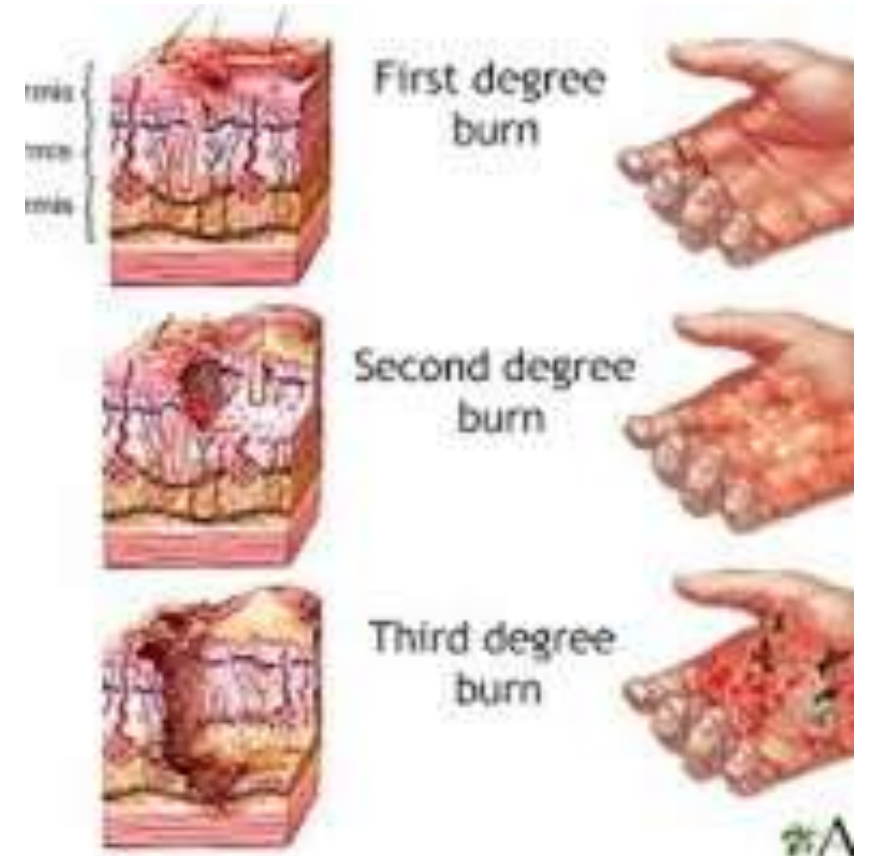
- **Associated with high energy accidents**
  - Blood loss can be significant with “open book” fracture
- **Pelvic ring fracture: single fracture usually stable**
- **Multiple fractures: unstable**
  - Genitourinary injuries
  - Abdominal injuries
  - Vascular abnormalities (pelvic vein section)



# Burn Classification

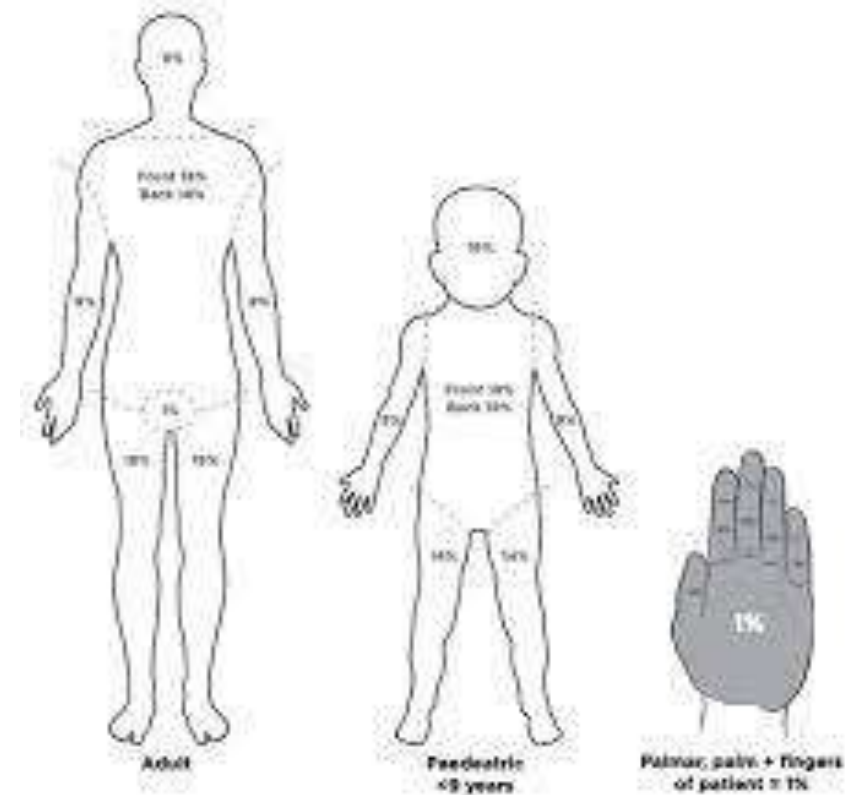
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- Superficial (1<sup>st</sup> degree)
  - Red, painful
  - Sunburn
- Partial thickness (2<sup>nd</sup> degree)
  - Red, painful
  - Forms blisters
  - Injury to the dermal layer –but can recover
- Full thickness (3<sup>rd</sup> degree)
  - White or black
  - Not painful
  - Full injury to the dermis, may involve the subQ or deeper
  - Skin doesn't have layer to regenerate from



# Who needs a burn center?

- **Minor = Nope**
  - No hands, feet, genitals/nipple or circumferential burn
  - < 10% body surface area (BSA) partial thickness
- **Moderate = Yes, but likely can delay by hours if low resource**
  - 10-30% BSA second-degree, 1-10% third-degree
  - Any involvement of hands, feet, face, major joints or genitalia
  - Very young, very old
- **Critical = Yes, needs one now**
  - Inhalational injury
  - > 30% BSA second-degree, > 10% third-degree
  - Complicating fracture
  - Circumferential burns
  - Extensive electric or chemical burns



# Initial burn management

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- **Remove clothing**
- **Dilute\ wash away offending chemicals**
- **Cover burns with clean dry dressing or sheet**
  - **Can use bacitracin/Vaseline to cover burn**
- **Pain medication**
  - Prevents contamination, decreases pain
  - Bacitracin / Vaseline if available
- **Keep warm**
- **Replace fluids based on body surface area (BSA)**
  - >10% BSA in children
  - IV vs. oral (may attempt up to 25%BSA)
  - Parkland formula, monitor UOP – 1cc/kg/hr

# Burn: inhalation injury

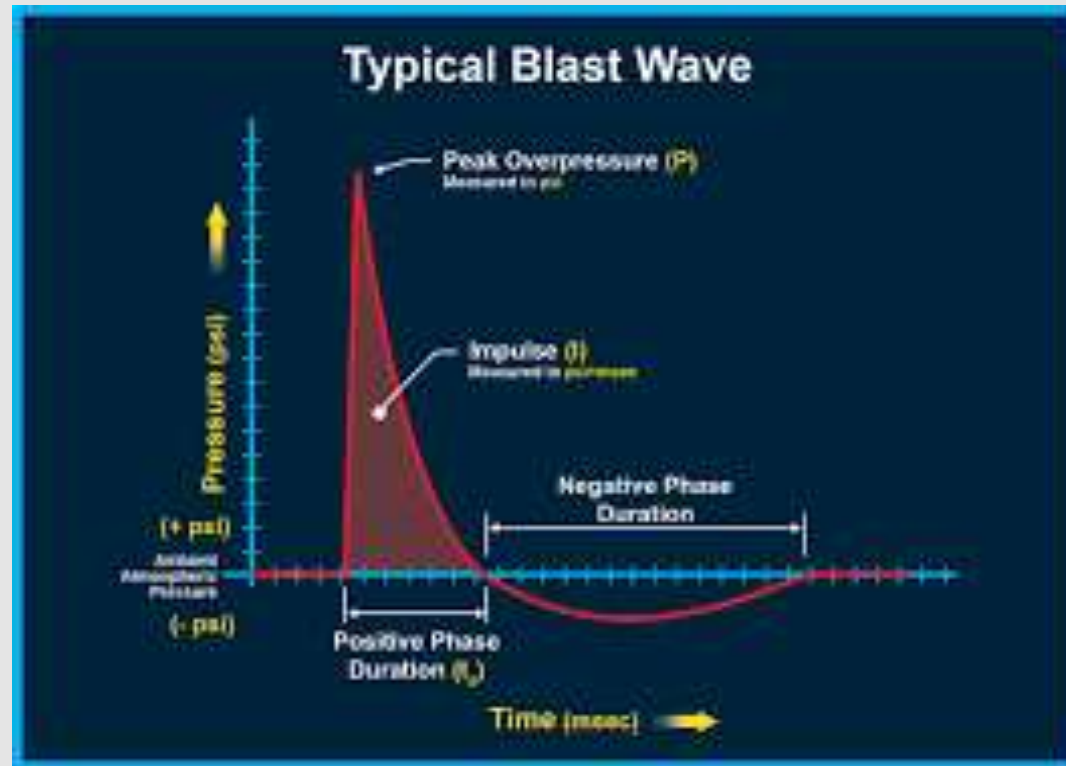
Patient was in enclosed area with fire or smoke

- Suggested by:
  - Soot around the mouth or nose
  - Singed eyebrows, eyelashes
  - Burns around the face or neck
- Signals airway and/or lung injury
- Can progress quickly and over time (usually 6-24 hours)

## Management:

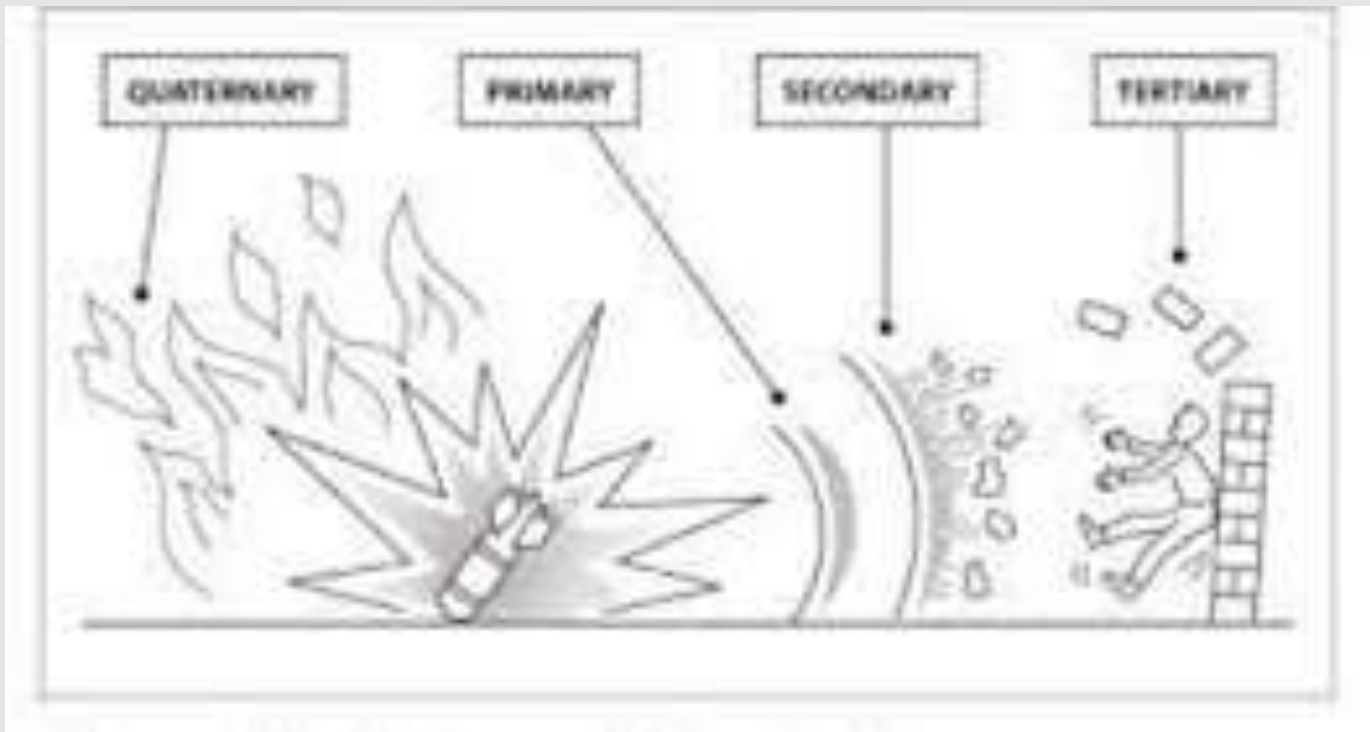
- Remove the patient from the area/smoke
- Early obstruction of the upper airway is managed with intubation
- Oxygen 100% (non-rebreather mask or controlled airway)
- Consider CO and CN exposure

# Blast and explosion injuries



- Unique injuries due to the blast wave
  - Compression/decompression of gasses
  - shock wave
- Penetrating, blunt and shear wave injuries
- Blast lung is the most common lethal injury

# Blast injury classification



- Primary – from the blast wave
- Secondary – shrapnel/projectile
- Tertiary – being thrown into something
- Quaternary – other injuries (burn, toxic, flood, exposure)

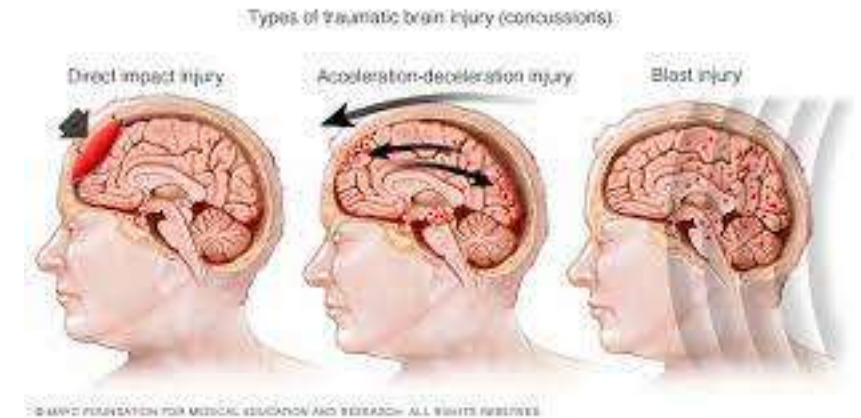
# Blast Lung (primary)

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- **Over-pressurization wave**
  - Tears the airway
  - Vascular injuries
- **Most common fatal injury**
  - CXR: butterfly pattern
  - Progresses over time
- **Pulmonary contusions, hemo/pneumothorax, fistula's, air emboli**
- **Treatment:**
  - Judicious fluids
  - High oxygen
  - Minimize pressure support
  - Permissive hypercarbia
  - Thoracentesis
  - If flight transport, consider early chest tube



# Blast: Brain injuries



- **Severe head injury is a leading cause of death**
  - Subarachnoid, subdural hemorrhage most common (fatalities)
  - Both from blast wave and from secondary / tertiary injuries
- **Mild TBI's are common, but may be subtle**
  - Signs and symptoms may be subtle
  - Memory problems, headaches, dizziness, uneven gait, blurred vision, irritability, confusion...
  - Greater number concussions in the military from blast exposures than from trauma
  - Can be very severe consequences with minimal external appearance and normal imaging

# Blast: Abdominal injury

- **GI gas-containing structures affected**
  - Colon: most common site of injury
- **Intestinal Injuries:**
  - Common: petechiae, hemorrhages, hematomas
  - Severe overpressure leads to intestinal laceration and perforation
- **Ruptures may occur acutely or several days later**
- **Tension pneumoperitoneum may develop**
- **Any interface of gas/tissue/liquid can be injured**

# Blast: secondary injuries

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- Blast wind = flow of superheated air
- Secondary injury mechanism
  - Flying debris = projectiles
  - Blunt and/or penetrating injuries
  - Small hole ..... Big injury
  - High velocity and force



# Structural collapse: Crush injury

Traumatic rhabdomyolysis, ischemia

Prolonged compression (2-6hr)

Severe hypovolemic shock

Metabolic abnormalities

- Hyperkalemia

- Hypocalcemia

- Metabolic acidosis

Acute myoglobinuric renal failure .....dialysis

Arrhythmias, DIC, Sepsis, ARDS



## Treatment:

Massive volume replacement

Start IV/IO in field prior to evacuation

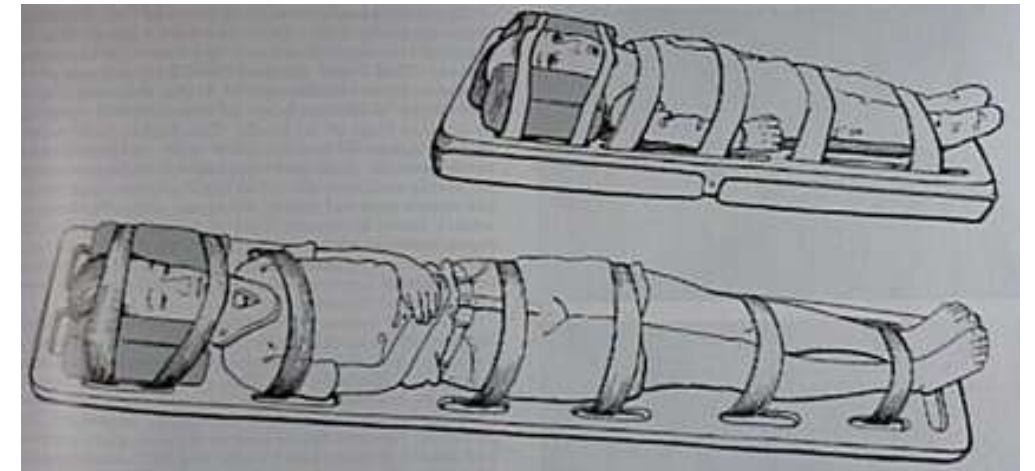
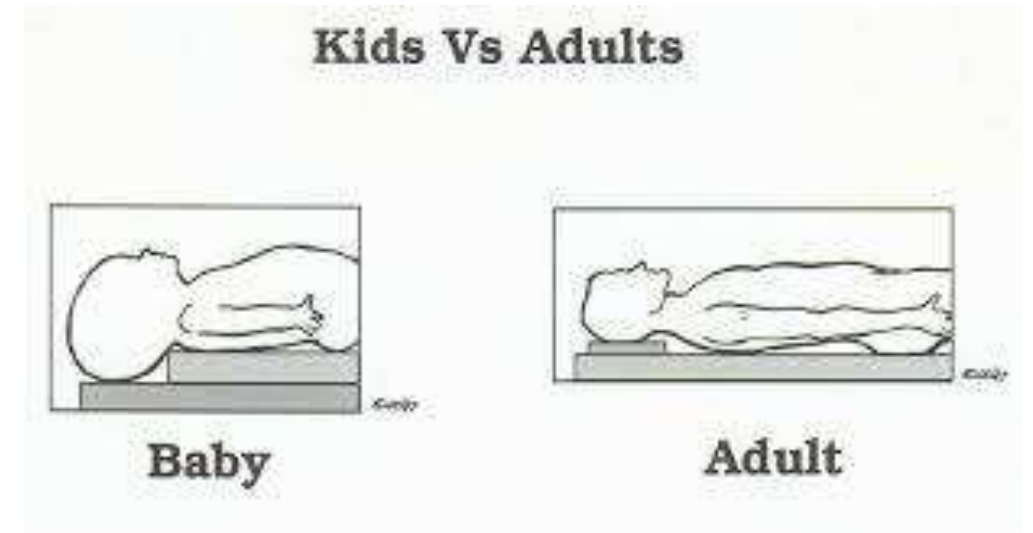
Alkaline diuresis, mannitol

# Transport considerations

- **Ideally transport to (pediatric) Trauma Center:**
  - Blunt injuries: with significant injury and /or physiologic compromise
  - Penetrating injuries to the thorax, abdomen, head and neck
  - Multiple extremity injuries
  - Head injury with any altered mental status
- **Transport to Burn Center: (high risk burns)**
  - > 10% second degree
  - > 5% third degree
  - Any inhalation injury

# To immobilize or not to immobilize?

- Spine immobilization can CAUSE injuries:
  - Backboard = pressure ulcer
  - Poor C-spine immobilization can impair airway
  - Extraction C-collar = pressure ulcer
- Spine immobilization usually not needed for penetrating trauma
- C-spine injuries do occur in kids (but less....)
  - Use proper technique, alignment
  - Pad any extraction equipment
  - Remove backboard as soon as possible (roll and slide) (less than 1 hour)
  - Laying flat on stretcher is good TLS spine precaution (board only for changing beds and transport)



# Summary

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- Trauma in a disaster setting can be overwhelming
  - Primary survey – **X**ABCDE
    - Find the threats to life
    - Fix it first then move on
  - Secondary survey
    - Find the other injuries
- Kids are different
- Re-evaluate frequently
- Use your resources



# Secondary Survey

- Perform after primary survey is complete and issues are addressed
- Head to toe examination
  - Vital signs
  - Looking for any signs of injury
  - Include back (with a log-roll to protect the spine) and perineum
  - Palpate everything!
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