PEDIATRIC TRAUMA/BURNS

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Objectives

1. Identify unique characteristics of children and how this applies to trauma care and evaluation
   - Anatomic, Physiologic, Long-term effects
2. Describe primary management of critical child
   - ABCs
   - Field Assessment
3. Identify injury patterns
4. Pediatric Burns

THE NUMBERS

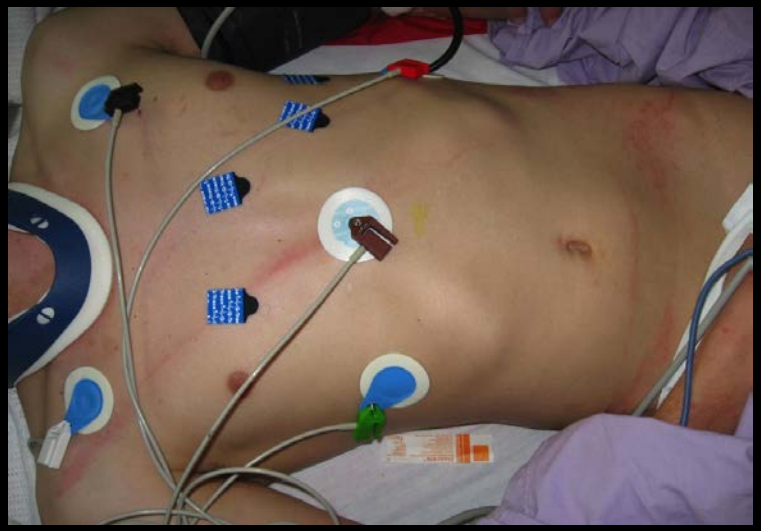
- Injury is the most common cause of death and disability for children over 1-year-old
- 10 million children injured in U.S. annually
- 10,000 fatalities annually
- MVC/Falls/burns/child abuse/Suicide

Case 1

You receive a call that an 8-year-old who was in a motor vehicle crash will require air transport. The child was the unrestrained passenger in the back seat of a sport utility vehicle that was involved in a high-speed collusion on a busy freeway. The child was ejected from the vehicle.

When you arrived on the scene, the child was lying on the side of the road and was moaning in pain. H was noted to have abrasions on his abdomen and swelling of his left thigh.

Case 1



Case 1

En route to the hospital, the child's

- heart rate 115 beats/min,
- respiratory rate 24 breaths/min,
- blood pressure 90/42 mm Hg.

- What injuries should be considered?
- What injuries is he at high risk for?
- What interventions, Labs, Imaging may be required?

Case 2

Dispatched to a 14-year-old girl motor vehicle crash. She was a retrained passenger in the front seat of a car driven by her mother.

When the car in front of them stopped suddenly, the patient’s car slammed into it and was then rear-ended by the car behind theirs. She was wearing both her lap and shoulder restraints, and there was no airbag deployment, passenger space intrusion, or damage to the windshield or windows.

Case 2

The girl denied any head injury of loss of consciousness. The girl was ambulatory at the scene.

You place here in a cervical collar, position on a backboard and brought to the ED.

On arrival, she is alert and oriented but complaining of neck and back pain. She has no other associated injuries.

You wonder whether the patient’s cervical collar and backboard can be safely removed and what, if any, radiographic studies should be ordered.

Case 3

You arrive on the scene of a 3-year-old girl who was involved in a pedestrian-versus-automobile accident.

The child was playing in the front year of her family's home when the ball she was playing with rolled on the driveway.

She ran out to grab the ball just as her father was backing his car out of the driveway; he felt a "thump" as he backed over her.

Case 3

He immediately got out of the car and found his daughter lying on the driveway underneath the car between the front and rear wheels, crying.

You place the child in a cervical collar and position on a backboard and bring to the ED.

On arrival the child is alert and awake with a Glasgow Coma Scale score of 15.

Her head and neck examination are within normal limits, but she appears to have some abdominal tenderness and bruising on the lower portion of her abdomen.

- What injuries should be considered?
- What is her risk based on mechanism of injury?

General considerations

- Blunt trauma
- Multisystem trauma
  - Mortality increases the # of systems involved
- Traumatic Brain Injury
  - Leading cause of death
- Developmental age affects reaction to injury

Take Home Points

- Pitfalls
  - Airway
  - Failure to recognize shock
  - Triage decision
  - Multisystem injuries → Rapid deterioration

What aspects of childhood anatomy do I need to consider?

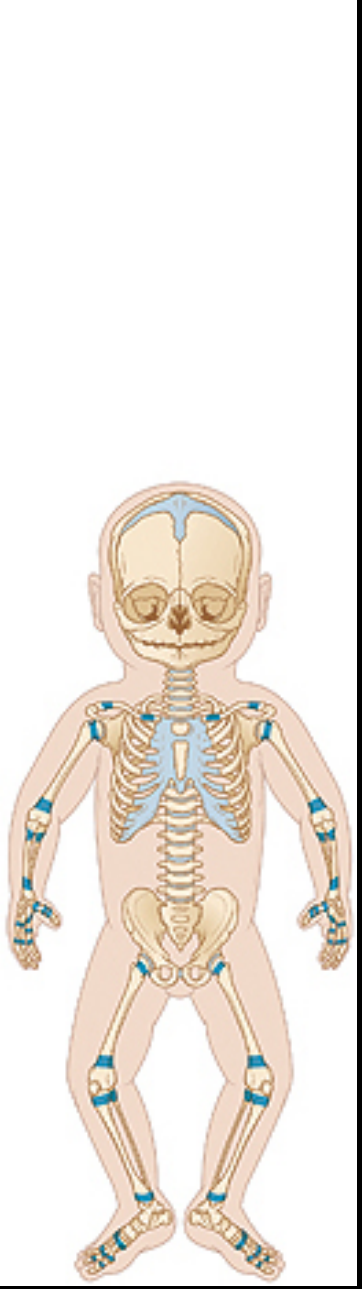
Unique Characteristics

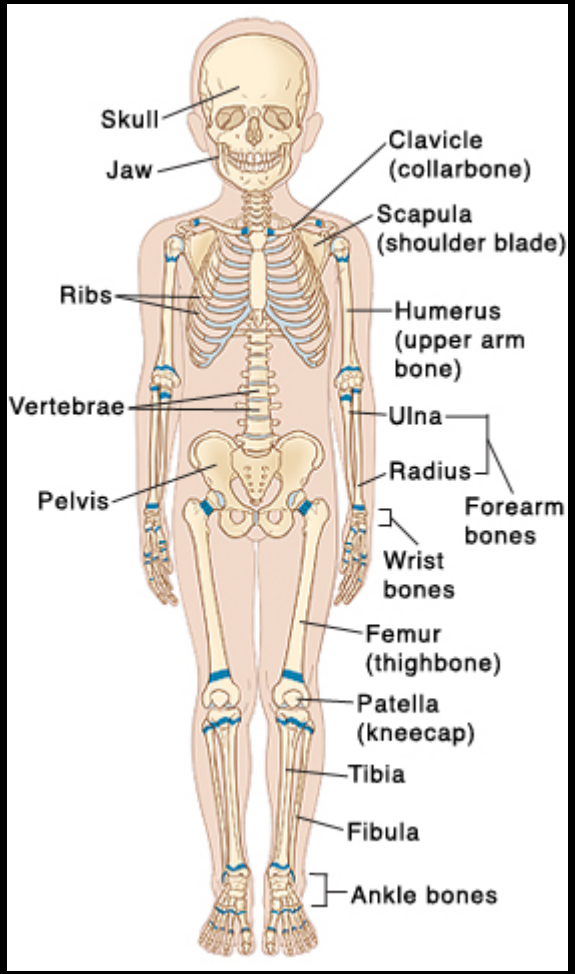
- Size and Shape
- Skeleton
- Surface Area
- Psychological Status
- Long-Term Effects

Size and Shape

- Smaller body mass
- Organs closer to surface
- Multiple injuries more common
- Head proportionately larger

Skeleton




Skull
Jaw
Clavicle (collarbone)
Scapula (shoulder blade)
Ribs
Humerus (upper arm bone)
Vertebrae
Ulna
Radius
Forearm bones
Pelvis
Wrist bones
Femur (thighbone)
Patella (kneecap)
Tibia
Fibula
Ankle bones

Skeleton

- Incompletely calcified
- Active growth centers
- Pliable
- Internal organ damage

Surface Area

- High body surface area to volume ratio
- Thermal energy loss = significant stress factor
- Hypothermia develops quickly
  - Avoid prolonged exposure
  - Complicates treatment of hypotension

Psychological Status

- Emotional instability
- Regressive psychological behavior
  - Pain
  - Stress
  - Perceived threats
- Limited ability to interact with strange individual
  - Sooth
  - Establish good rapport

Long-Term Effects

- Subsequent growth and development
- Must recover from trauma & continue normal process of growth and development
- Prolonged disability
  - Cerebral function
  - Psychological adjustment
  - Organ system disability

Field Assessment

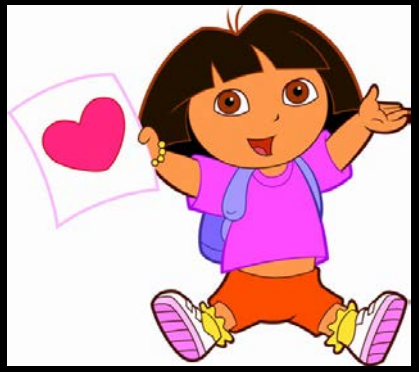
Field assessment

- Scared children are poor historians
- Establish Trust
  - Tell the child who you are
  - If a parent is there have them talk to the child and reassure
  - Have a provider that stays with the child and explains what is happening
  - Don't bargain- do what you must do.

Field assessment

- Observation is most important tool.
  - Child will move all extremities spontaneously

Almost all kids know SpongeBob, Dora, Elmo. Ask them about them- “what color is Elmo? Does Dora have a backpack?”



Role of pre-hospital provider

- Significant impact on outcome of pediatric trauma patient
- Identify the patients with the most severe injuries
- Identify injuries that have potential to result in rapid decompensation of patient
- Transport patients safely and quickly to nearest hospital capable of caring for these injuries
- ATLS guidelines

Assessing child in field

- Airway
- Breathing
- Circulation
- Maneuvers such as jaw thrust, placement of oral airway ad bag-mask ventilation in patients with respiratory failure are indicated to assure patency of the airway and adequate ventilation

Trauma Airway

- Airway maneuvers performed on trauma patients must be done with simultaneous protection of the cervical spine with manual inline stabilization
  - Performed by separate provider

STEINBRECHER

Field Intubation?

- Compared to adult trauma patients, intubation in the field for pediatric patients does not improve mortality rates
  - Rather, complications are increased
    - Compared to bag-mask ventilation
    - Compared to alternative airway adjuncts
      - Laryngeal mask airways

Chen et al. *Pediatrics* 2008

Circulation

- After airway and breathing assessment complete
- Attempt to identify any uncontrolled sources of hemorrhage
- Pediatric trauma patient without evidence of spontaneous circulation, cardiopulmonary resuscitation (CPR) and Pediatric Advanced Life Support (PALS) algorithms should be initiated

Uncontrolled External Hemorrhage

- Direct pressure should be applied to stop hemorrhage

Field Ultimate Goat

- Safe transport
- Rapid transport
- C-spine collar in place
- Backboard in place
- Increased morbidity and mortality associated with longer transport times

A note on carseats & seatbelts

Car Seats

Car seats

- If a kid is in an intact car seat correctly- leave them there and transport them in the seat unless obvious injuries prevent this.
  - An infant/toddler in an intact car seat is unlikely to have major injuries.
  - Examine for bleeding and mental status. If they're moving their neck around and awake CS injury extremely unlikely.
  - Leaving a child in a car seat may be comforting
  - Follow your protocols, but I would argue kids in car seats are already “back-boarded”
  - Double check-up to 70% CS installs incorrect

Seatbelts

Seatbelts

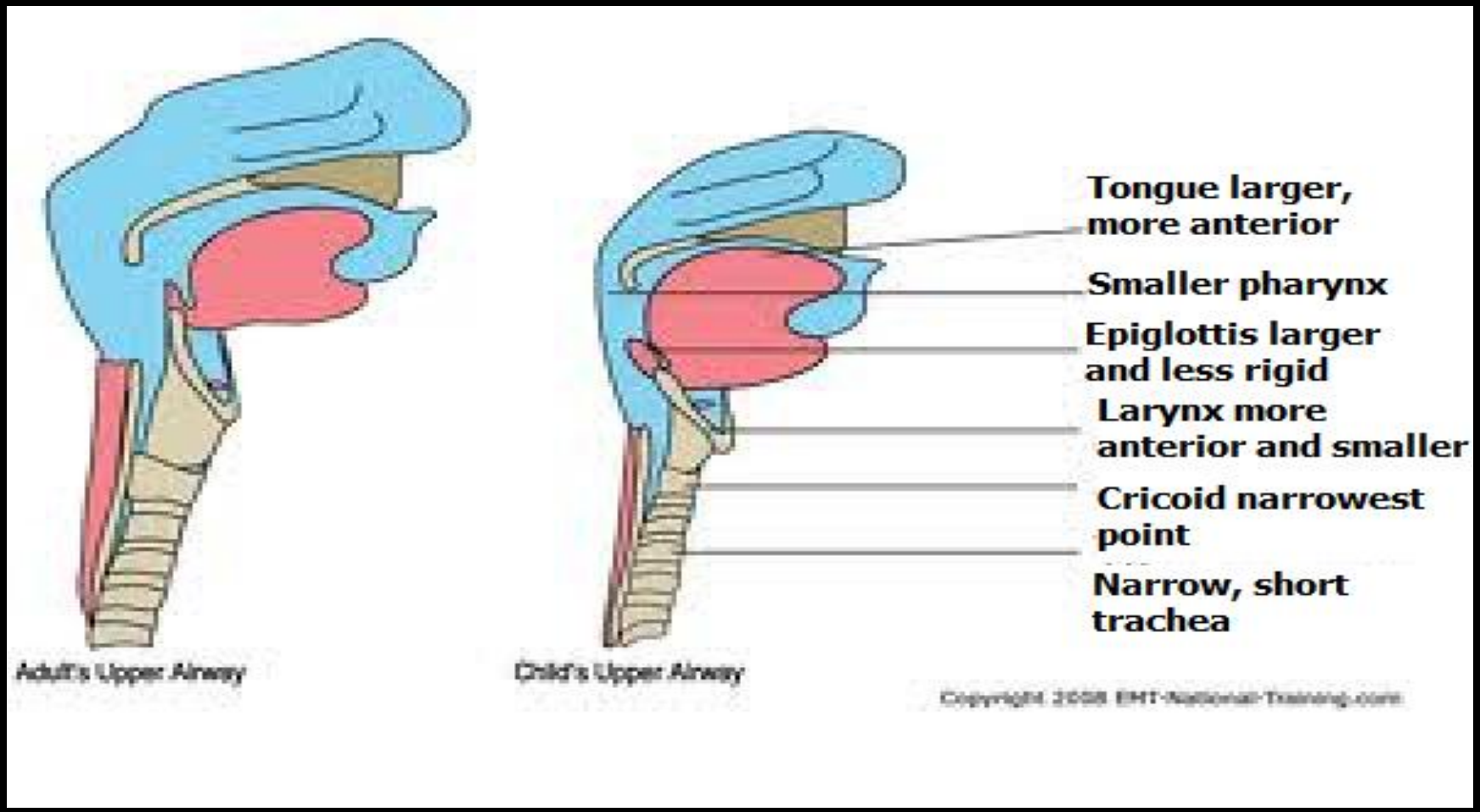
- Improper uses of child passenger safety restraints is associated with the greatest risk of injury
- Automobile belts introduced to U.S. in 1960s
- Significantly reduced injury and severity of injury from MVCs
- Unrestrained children have significant increase risk of head injury, thoracic injury, intra-abdominal injury, fractures, open wounds, spine and spinal cord injury and hospitalization
- Relative risk of head injury for unrestrained child is 4.2 compared to restrained children

Airway: Evaluation & Management

PEDIATRIC AIRWAY

- Diameter smaller and shorter trachea
- Larynx more anterior C3-4
- Relatively enlarged tonsils and adenoid
- Floppy epiglottis and is U shaped
- Cricoid ring is most narrow part
- Young infant is obligate nose breather
- Prominent occiput leading to flexion when supine

Pediatric Airway



Pedi Bag Mask tips

- If not bagging, chin lift/jaw thrust
- Shoulder roll
- OGT if distension of abdomen
- If no pedi mask put whole face in mask, avoid direct pressure on the eyes (can cause hypotension/bradycardia)
- Oral Airway

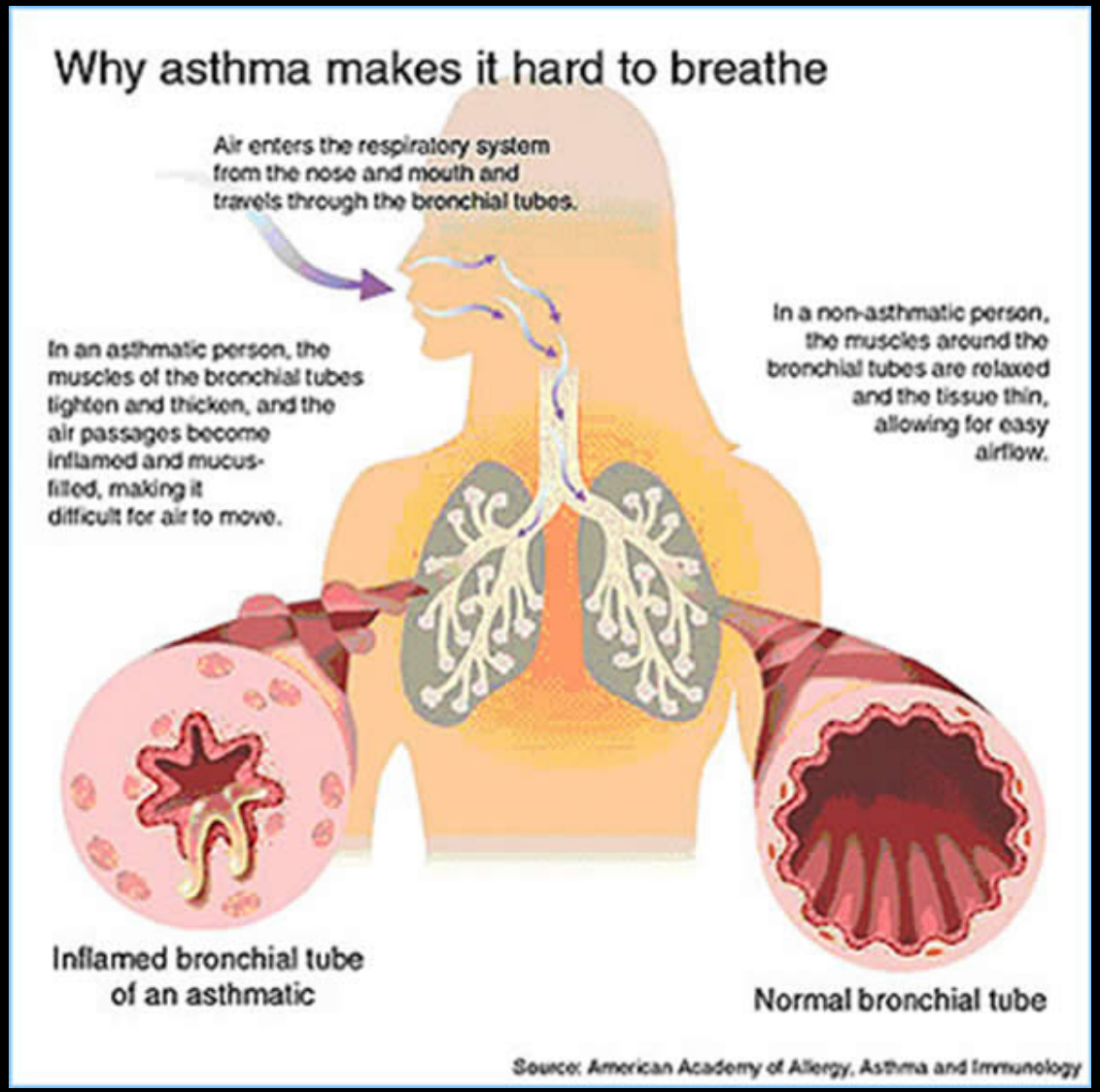
Pediatric Intubation caveats

- Difficult because less practical experience
- Often not needed and can lead to complications
- Difficult to confirm tube placement in the field
- High mortality with esophageal intubation
- Children desaturate quickly, even with pre-oxygenation.
- Oral airways and King/LMA airways

Pediatric Airway

- Tips for intubation:
  - Practice -- Simulation
  - Miller vs Mac in infants/toddlers
  - Shoulder roll, place OGT
  - Tube size- preemie 3, newborn 4, 5yo 5.
  - Don't intubate at all if can bag mask.
    - Many preventable deaths from esophageal tubes
  - Avoid intubation of asthmatics

Asthma & Trauma



Asthmatics and Trauma

- Very common condition in pediatric population
- Stress aggravates the condition, smoke
- If wheezing- give albuterol, epi if needed
- AVOID INTUBATION IF POSSIBLE
    - Asthmatics have increased sympathetic tone and increased blood return to the heart due to increased inspiratory force- if you intubate they often crash and burn catastrophically
- If you must intubate have epinephrine drawn up in case of this complication

Pediatric Shock learning points

- KIDS ARE NOT 'little adults'
- The pediatric heart and circulation is able to handle lower volume without decrease in BP.
- Tachycardia is most sensitive indicator of early shock in the child, but can be difficult because of tachycardia secondary to anxiety
- Observe VS on calm child but when in doubt give IVF aggressively. We can fix Pulmo edema.

Pediatric Circulation

- More subtle signs of shock that can fail to be recognized
  - Tachycardia (early)
  - Tachypnea (early)
  - Altered Mental Status (late)
  - Delayed cap refill (middle)
  - Weak pulses (late)
  - Cool/mottled extremities (middle)
  - Decreased UOP (not applicable)

Pediatric Heart and Circulation

- In a child with a normal heart they compensate very well for early shock, then have collapse
- Pediatric heart compensates for shock by increasing rate unlike adult heart which increases stroke volume
- Sympathetic (fight/flight) reaction very effective at maintaining BP with vasoconstriction, then collapses
- IF YOU SEE STERNOTOMY SCAR PLEASE CALL CHKD- try to find out which surgery was done so we can guide therapy

Pediatric Circulation

- Hypotension (late sign) BP can remain normal until almost 40% circulating blood volume lost.

  SBP Less than 70 + (2 X age) is hypotensive

  - Class I (10 -15%) well tolerated, inc HR and vasoconstriction
  - Class II (25%) Clinically sig. Persistent tachy with diminished pulse pressure, vasoconstriction and metabolic acidosis
  - Class III (30-40%) Tachy and tachypnea, skin cool with delayed capillary refill, changes in mentation. Start of systolic BP changes
  - Class IV greater than 40% Hypotension and absent peripheral pulses decreased respiratory effort, bradycardia and progression to coma.

Resuscitation of circulation

Do not delay if compromised after 2 attempts obtain IO. DON'T DELAY.

- IO is easy to place and VERY WELL TOLERATED. Look for web videos

- 20cc/kg of crystalloid given rapidly after access is established may be repeated x3 or more if other volume expanders are not available. Kids tolerate hypervolemia well.
- Colloid of PRBC or albumin 10cc/kg to start

Pediatric Maxillofacial Injury

- More common in children with increased relative head size
- Decreased mid face fractures but increased mandible fractures
- Many sensitive structures in small space
- Orbital fractures concerning for possible sight complications

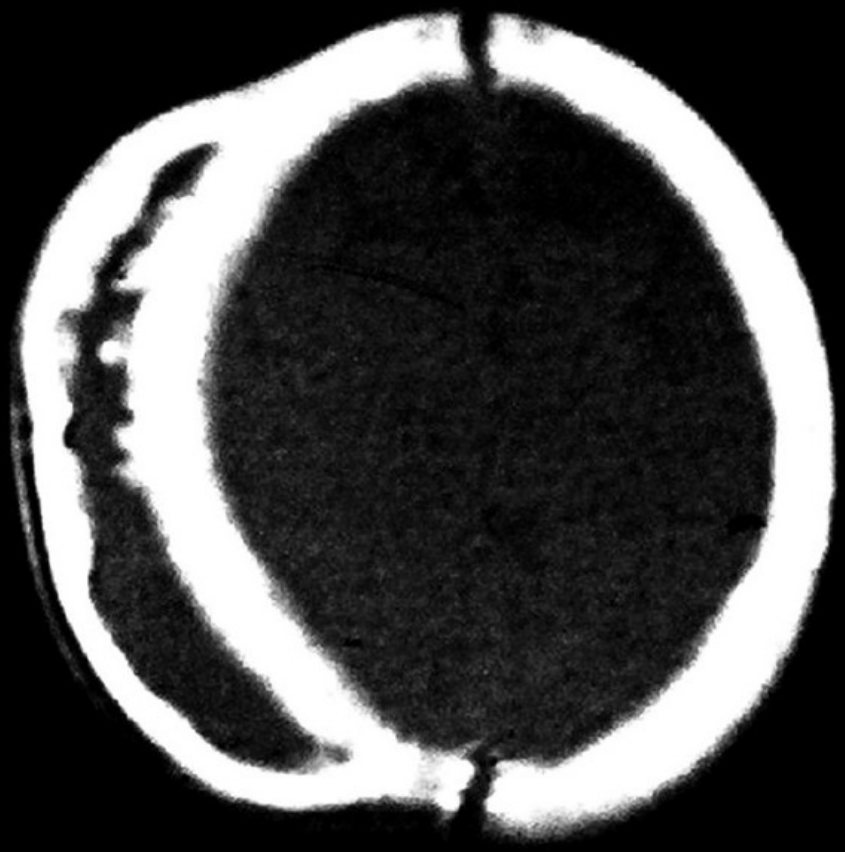
Pediatric Maxillofacial Injury

- In the field can be difficult to manage
  - Difficult to bag/mask
  - Early intubation if possible
  - Alternatives, oral airway

  if tolerated
  - If unable to access airway

  can use jet technique to buy time

Head Injury



PEDIATRIC HEAD INJURIES

- Incidence 80% with blunt trauma and responsible for 85% mortality
- Increased ICP usually assoc with HTN therefore suspicion should be high
- SAH and diffuse brain swelling most common findings
- Secondary injury often caused by
  - Hypotension, hypercarbia, hypoxemia, intracranial hypertension, infection

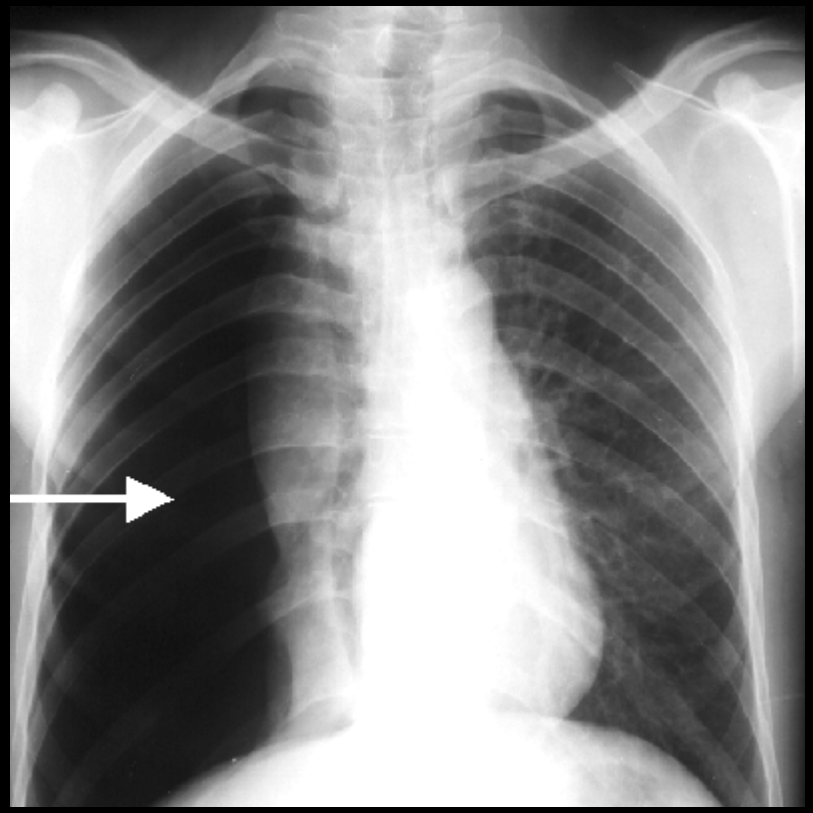
Spinal Injury

Figure 8. Atlanto-occipital dislocation.

Pediatric Spinal Injury

- Must maintain high index of suspicion
- Neck pain or tenderness will usually prevent them actively moving the neck
- Limited mobility
- Abnormal neuro exam
- Hx of significant trauma (high speed MVA, rollover, ped vs MV)
- Follow C spine precaution protocols and use appropriate sized immobilizers. If unavailable, use rolled up towels

Thoracic Trauma



Thoracic Trauma

- Degree of internal damage greater than outside appearance secondary to pliable rib cage (increased pulmonary and myocardial contusions)
- Tension pneumo less well tolerated and aortic dissection less common both due to pliability/mobility of structures
  - Auscultate, low sats, high energy mechanism. If significant difficulty bagging consider 14g angiocath inserted into second intercostal space above the nipple (needle thoracotomy). Rush of air and improvement is diagnostic. Low morbidity with procedure

PEDIATRIC GI TRAUMA

- Difficult to access by PE with hysteria
- High index if lap belt sign or compression history.
  - In the field look for bruising to abdomen, flanks, around umbilicus.
  - Handlebar injury common cause of GI bleeding
  - Most show no PE signs except signs of shock

Cullen's and Grey Turner's signs

- Cullen's sign is bruising below the belly button
- Grey Turner's sign is bruising of the flanks
- Volume
- Sign of serious bleed

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PEDIATRIC SPLENIC/HEPATIC INJURY

- Increased incidence with flexible rib cage and underdeveloped muscles
- If hemodynamically stable and no ongoing blood loss often conservative management prevails
  - Liver is more likely to go to OR
  - Many splenic lacerations now watched

Renal Injury

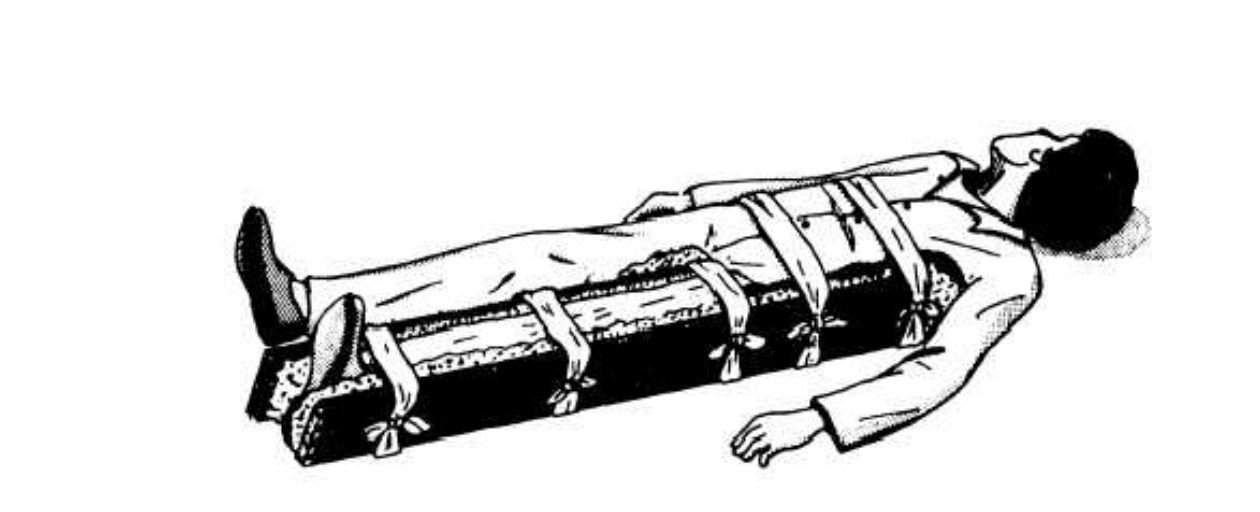
PEDIATRIC RENAL/GU INJURIES

- Pediatric kidney relatively large and anterior increasing injury rate
- Increased if hx of renal system anomalies
- Pediatric pelvis has possibility for single ring fx, and growth plates increase risk for long term deformity
- Straddle injuries and gross hematuria have high concern for urethral injuries.
- Blood at meatus means no cath until Retro Urethrogram

PEDIATRIC PANCREAS INJURIES

- Secondary to contusion or ductal disruption
- 50% will have other abdominal injury
- General treatment with NG suct./rest
- Increased complications:
  - Psuedocyst 30%, fistula formation, hemorrhagic pancreatitis, abscess, diabetes, chronic

Musculoskeletal Injury



Musculoskeletal Injuries

- Splint
- Grossly deformed femur fractures should be put in traction.
  - reduces bleeding and other complications and helps with pain
- Femur fractures and pelvic fractures
  - large amounts of blood loss
  - crush injuries to the pelvis should be wrapped with sheet around pelvis
  - if concerned for either of these fractures, start IVF

Amputations

- Clean cut amputations are more successfully reattached. Limbs/fingers torn off or abraded off do not reattach usually
- Find amputated segment and place in cold container
  - try to avoid direct ice contact because frostbite can occur
  - wrap in dry cloth
- Teeth
  - awake pt put under tongue/in cheek
  - unconscious wrap in moist gauze or place in milk

Pediatric Burns

PEDIATRIC BURNS

- Over 2 million burns per yr in US with over 100K hospitalized and 12K dead
- Over 440K pediatric cases with young children with higher mortality
- Incidence greatest in <6yr old, African American and Native American populations
  - Scald and contact
  - Electrical
  - Smoke inhalation
  - Structure fires account for 45% deaths

PEDIATRIC BURNS

- Survival characteristics
  - Depth of burn
  - % BSA
  - Age
  - Other associated injuries

PEDIATRIC BURNS (0-2)yrs

- Increased risk of scald burns in kitchen and bathroom.
  - Water is most common and has b.p. of 100 C and prolonged exposure to 70 C can cause complete necrosis in 2 sec
  - Kitchen scalds often deal with mixed substance with high b.p. (oil/grease) leads to increased severity
  - Bathroom scalds most likely from tap water and happen when temp > 128 F but may occur in prolonged exposure in temps greater than 120 F
- Aspiration of liquids can compromise airway and need to look for subtle signs
- Heating stoves of any variety assoc with hand burns
- Electric cords of concern as chewing of cords has caused injury.

PEDIATRIC BURNS (3-8)yrs

- Contact and scald burns still prevalent
- Fascination with fire begins along with experimentation and poor coordination to handle the fire
- Increased firework injuries
  - Adult supervision can prevent as many as half of these injuries.

PEDIATRIC BURNS (9-12)

- Increased risk taking behavior and peer pressure
- Increased use of accelerants
  - Gasoline, lighter fluid, hairspray
  - Fireworks
  - “hey look at this”

PEDIATRIC BURNS

- Pathophysiology centers around energy transfer and our inability to dissipate it.
- Thermal injury with adjacent vascular injury leading to permeability and fluid extravasation, all hiding the ischemic injury up to 3-7x greater in size than the initial area injured.

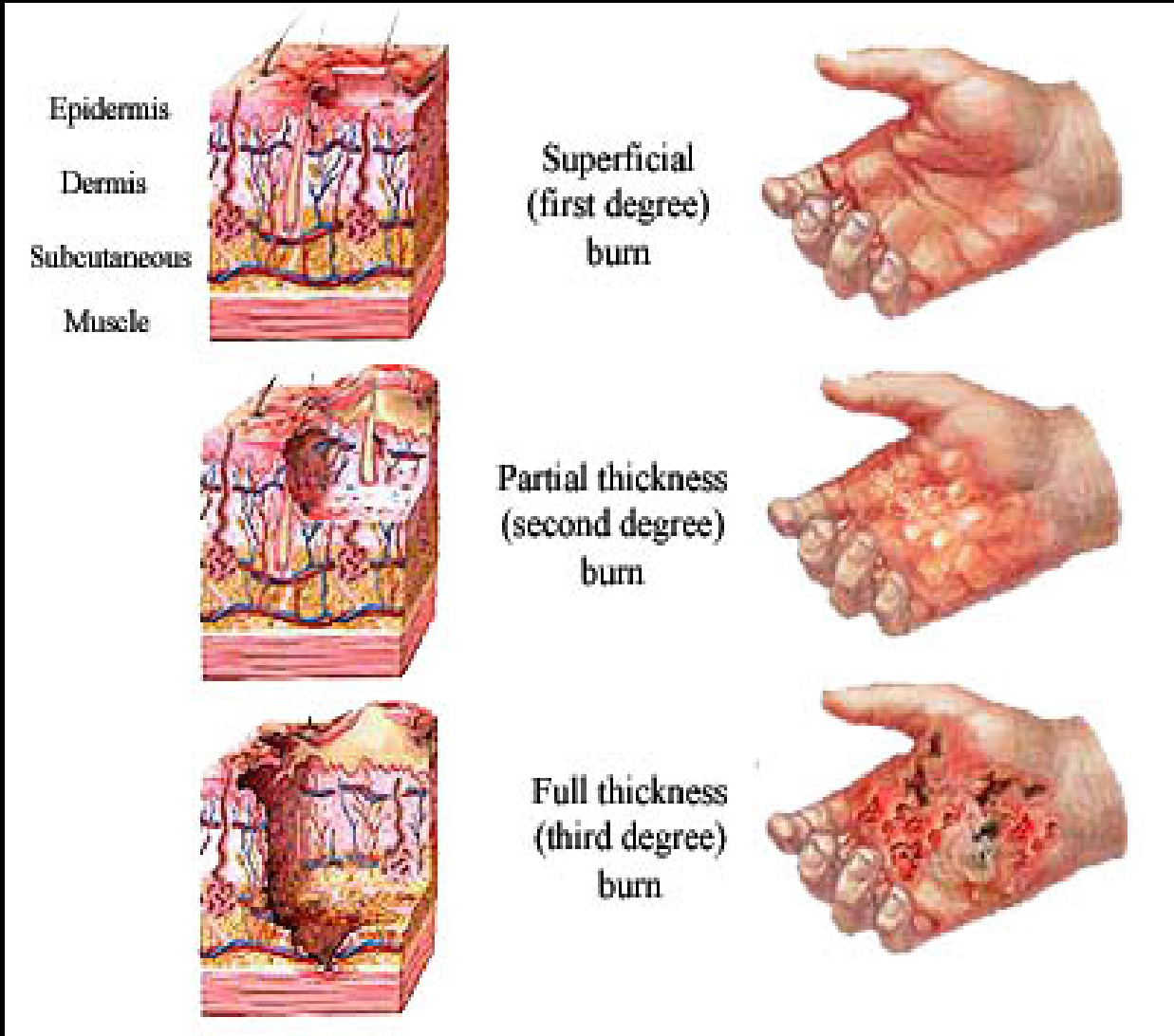
PEDIATRIC BURN WATER LOSSES

- Burns that compromise the epidermis allow 15x water losses compared to normal.
- As H2O evaporates heat is lost and hypothermia can occur
- Extreme hypermetabolism and catabolism also result from these losses and regeneration of tissue

PEDIATRIC BURN INFECTIONS

- With barrier compromised and necrosis blood supply and local defense inadequate pt is set up for bacterial invasion
  - One of the most frequent and fatal complications of severe burn
- Not much first responders can do

Burn classifications



First degree/Superficial thickness

- Often a result of partial scalding or UV ray exposure
- Blanching erythema with peeling a few days later are hallmarks
- Healing not normally assoc with scar formation
- Heal typically in 3-5 days

Second degree/Partial thickness superficial

- Typical with scalding injuries
- Hallmarks include high pain and bullae formation.
  - Bullae are sterile fluid and help retain fluid losses (avoid popping if possible)
- Minimal scar formation with healing taking up to 14-21 days
- Old nomenclature of deep second degree burns less useful

Third degree/Partial thickness deep

- Dry leathery and inelastic, sometimes white to gray with often lack of pain
- Depth of injury does not allow healing without graft or from unburned edges
- Excessive fluid losses to be expected
- Usually extensive second degree burns at the same time on patient

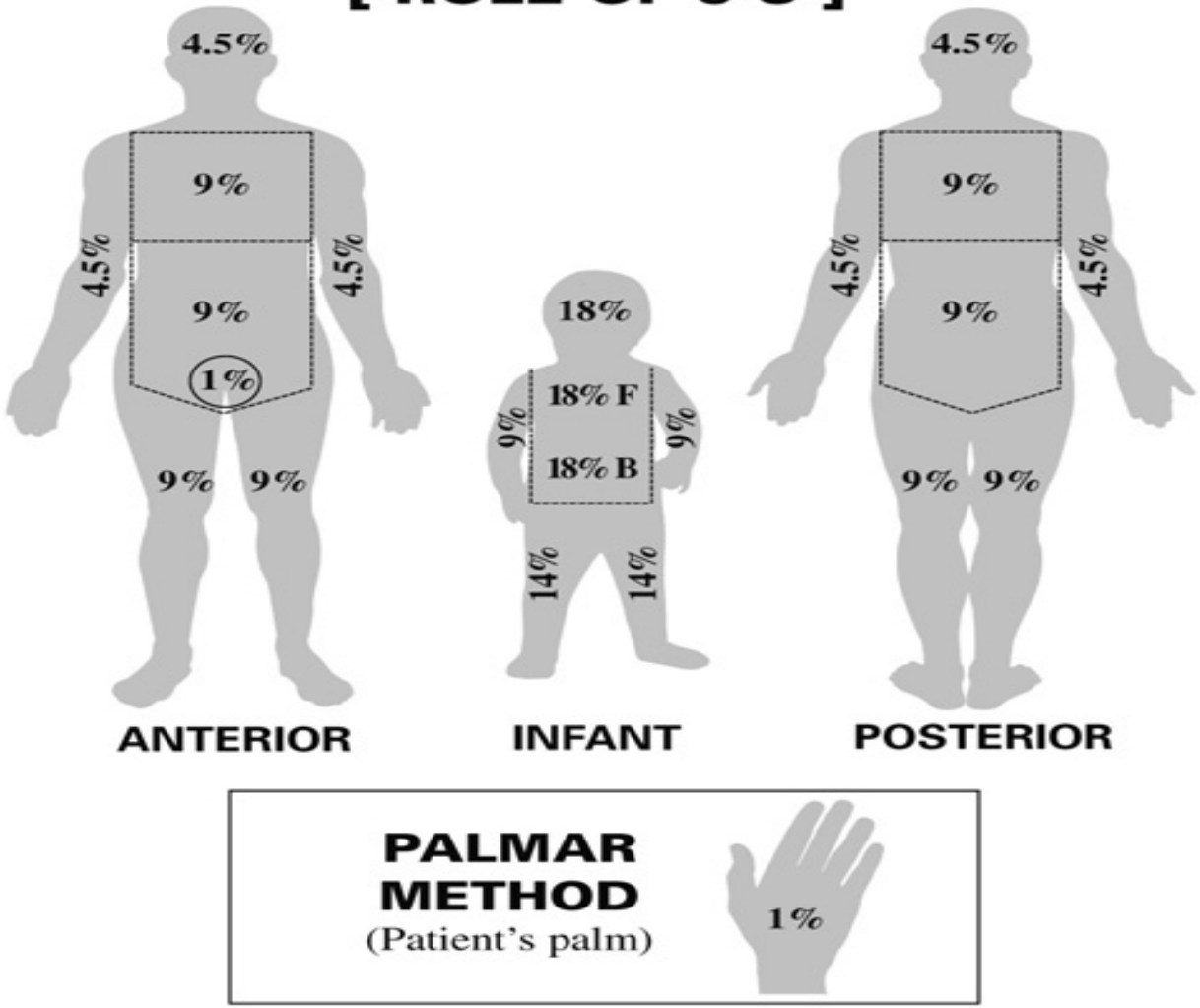
4th degree/Full thickness

- Delineation not used by all
- Involves burn beyond skin
- Most often used with electrical injuries and severe charring
- Hospitalized in all cases.

PEDIATRIC BURN extent of injury

- Lund Browder chart circa 1944 most specific for pediatric use
- Rule of nines. Less accurate but easier to use in ED setting
- Rule of palms. Convenient for small burns with pt's hands accounting for 1% of TBSA (more accurate is 0.8%)

[RULE OF 9'S]


4.5%
9%
4.5%
4.5%
9%
1%
9%
9%
ANTERIOR
18%
18% F
9%
9%
18% B
14%
14%
INFANT
4.5%
9%
4.5%
4.5%
9%
9%
9%
POSTERIOR
PALMAR
METHOD
(Patient's palm)
1%

PEDIATRIC BURNS and location

- Most facial burns are admitted unless very superficial
- Any ocular involvement needs admission and consultation
- Significant facial burns or charring around the mouth requires airway assessment and observation with possible intubation if inhalation concern

PEDIATRIC BURNS and location

- Severe hand and foot injuries also need inpatient treatment
  - Facilitates dressing wound
  - Physical therapy
  - Debridement if needed
  - Allows for less trauma to foot and swelling if not cared for correctly at home
- Severe groin burns also needs open management and good nursing care to prevent infection and maceration

EMS CARE OF PEDIATRIC BURN

- General Goals
  - Treat body and burn
  - May need stabilization and immediate referral depending on treatment location
  - Appropriate fluid requirements
  - Pain control as needed
  - Be aware and anticipate complications and shock

Inhalation injuries

- Post burn lung dysfunction is major cause of morbidity and doubles mortality
- Seen in up to 1/3 of burn victims
- Suspect Carbon monoxide inhalation and possible toxins CN, smoke, etc.
- If airway affected rapid intubation may be life saving
  - Needs ETT, 100% humidified O2
  - Do not rely on pulse ox (CO and HS)
  - If stridor- ominous finding have smaller tubes

Burn shock

- Greatest affect in first 8-12 hrs post burn as protein leak and capillary permeability highest>>>shock
- Critical in children with greater than 10% TBSA affected
  - Parkland formula or Caravajal
  - NS or LR only
  - Remember to institute from time of burn

Parkland formula/Caravajal formula

- Fluid Requirements = TBSA burned(%) x Wt (kg) x 2-4mL
- Fluid requirements= 5000ml/m2 x TBSA (%) + 2000ml/m2 for maintenance
  - BOTH recommend: Give 1/2 of total requirements in 1st 8 hours, then give 2nd half over next 16 hours.

Fluids

- These are nice formulas but not applicable in the field- just for your information. But example calculation on a 10 kg child (toddler size)
    - Normal fluid requirement/hr if NPO = 40ml/hr
    - If 40% burn, 1st 8 hrs = 100ml/hr
        - OVER 2x normal maintenance
    - With significant burns IVF is paramount
    - Estimate burn size, bolus
    - Reassess and bolus

Burn Shock

- Guidelines must be monitored
  - Clear sensorium
  - Normal cap refill times and warm extremities
  - Stable vital signs
  - UOP of 30-50cc/hr in greater than 12 and 0.5-1cc/kg/hr in younger children
- Be careful not to overreact and look at whole picture
- Again, be aggressive with IVF hydration
- Unless bleeding, should stick with NS/LR

Circumferential Burns

- Perfusion distal to wound is imperative
- Deep burns may cause limited arterial supply and hypoxia
- Must remove all rings and elevate wounds
- If signs of compromise (weak or absent pulses, parasthesia, deep tissue pain) escharotomy is indicated
  - Also if tissue pressure >30mmHg
  - Incisions made medial and lateral and across all fields only to depth of eshcar separation

Wound care

- Cover with clean cotton sheets, do not attempt to clean in field- may worsen
- Guiding principles:
  - Prevention of infection
  - Decrease fluid losses
  - Relief of pain
  - Salvaging viable tissue
- No better coverage than real skin

Pain management

- Often the less severe looking the burn the more pain
- Cover area with sheet to avoid environmental aggravation
- IV morphine is appropriate (0.1-0.2mg /kg in small child), rebolus as needed
- If agitated in severe burn do not forget to check oxygenation and volume status

Thank You