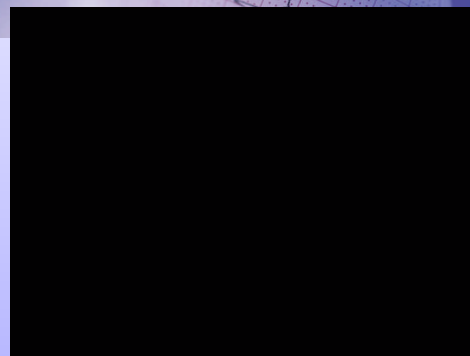


Early Warning Signs in Pediatric Transport

Ami Brownlee, RNC, CFRN, BSN
Memorial STAR Flight Nurse



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Vital Sign Norms for Age

Age	Heart Rate	Systolic BP lower limit	RR
Birth-6 months	140	60	45
7 months - 1 year	135	70	40
2 - 3 years	120	75	30
4 - 5 years	110	80	28
6 - 12 years	85	85	20
13 years - adult	80	90	15

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Broslow Cart



Pediatric Assessment Triangle

- Across the room look
 - Sick vs. Not Sick
 - Appearance
 - Mental status, Muscle tone
 - Breathing
 - Body position, visible chest motion, work of breathing, audible airway sounds
 - Circulation
 - Skin Color

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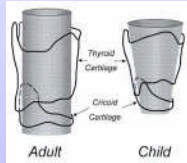
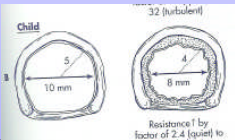
Pediatric Assessment Triangle

- TICLS
 - Tone
 - Interactivity
 - Consolability
 - Look or gaze
 - Speech or cry

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Airway/Cervical Spine Stabilization


- Anatomy –
 - Larynx
 - More anterior
 - Smaller and shorter
 - Epiglottis
 - Floppy – less cartilage
 - Trachea
 - Short and floppy
 - Tongue
 - Larger
- Cervical Spine Stabilization
 - Backboard/cervical collar

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Airway

- **Establish Patency**
 - Mucous, secretions, etc
 - Can the patient maintain their own airway?
- **ET Tube size**
 - Neonates
 - 4kg = 4.0 ET tube
 - 3kg = 3.5 ET tube
 - 2kg = 3.0 ET tube
 - 1kg = 2.5 ET tube
 - < 1kg = 2.0 ET tube
 - 16 + age in years/4

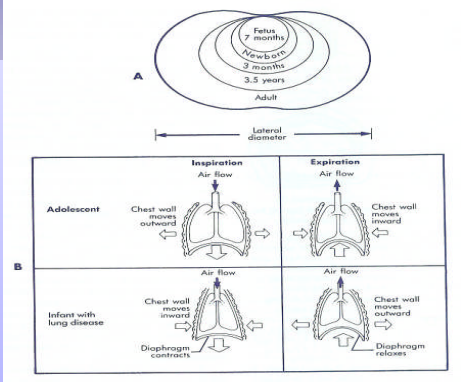


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Breathing

- Anatomy
 - Ribcage is cartilaginous making the chest wall more compliant until the age of 8
 - Chest is round, ribs are horizontal
 - Diaphragm is the main muscle of inspiration
 - Older child and adult chest is wider than it is deep thus allowing expansion

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8 IS GREAT!

- Change to cuffed ETTs
- Chest wall and shape becomes adult shaped
- GCS < 8 - intubate!

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Breathing

- Spontaneous Respirations??
- Effective Respirations??
 - Work of Breathing
 - Retractions
 - Nasal flaring
 - Grunting
 - Head bobbing
 - Sniffing position
- Impending Failure?
 - Tachycardia
 - Tachypnea
 - Cyanosis
 - Decreased level of consciousness

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Oxygenation

- Hypoxic?? Need for Oxygen Therapy
 - Goal – Maximize oxygen delivery and eliminate sufficient carbon dioxide
- Oxygen Delivery Devices
 - Nasal cannula
 - Simple mask
 - Non-rebreather
 - CPAP
 - Effective if chest expands equally and bilateral breath sounds are heard.
 - Watch for gastric distention
 - Need for intubation if spontaneous condition does not improve

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Early Warning Signs

- Resp Rate >20 above normal
- Using accessory muscles
- 40-49% FiO2 not including neb
- ≥ 3 LPM or > 1L infant
- Continuous Neb or 3 intermittent nebs in one hour
- Heliox by mask
- PCO2 >50 acutely with pH <7.35 (not intubated)

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Impending Crash

- Unstable OR Artificial airway
- >25 above normal
- 5 below normal with retractions and/or >50% FiO2 requirement not including neb
- PCO2 >55 acutely with pH <7.35 (not intubated)
- BiPap acutely
- Heliox via ETT/BiPap
- ECMO*
- iNO**

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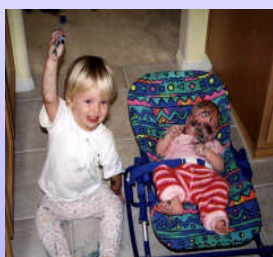
What should be flown?

- Epiglottitis
- Croup with hypoxia, AMS
- Upper airway obstruction secondary to FB
- Unstable intubated patients
- Asthma with AMS
- Angioedema
- Anaphylaxis
- Unstable Airway

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Other Pearls

- NG, Foley and suction catheters are 2X the size of your ET tube
 - ET Tube is 5.0
 - NG, Foley and Sx Cath should be 10



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Cardiovascular

- Circulating blood volumes
 - Newborn – 85 ml/kg
 - Infant – 75 ml/kg
 - 1 yr to Adult – 67-75 ml/kg
 - Adult – 55-75 ml/kg

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Cardiovascular

- Fixed stroke volume
 - Immature sympathetic innervation
 - Control BP by varying heart rate
 - Shock states can have normal HR and BP with inadequate tissue perfusion
 - Cap refill
 - Slight increase in diastolic BP without change in systolic BP
 - Narrowed pulse pressure

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Stages of Shock

- Early
 - Inadequate tissue perfusion without hypotension
 - Preserve vital organ blood flow
 - Blood shunted from skin, kidneys, muscles
 - HR and Respirations increase
 - Pulse pressure narrows
 - Reversible

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Stages of Shock

- Compensated
 - HR WNL
 - Peripheral pulses
 - Weak or bounding
 - AAOX4
 - Cap refill > 3 seconds
 - Skin – cool, clammy
 - Kidney output decreasing

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Stages of Shock

- Late
 - Classic shock symptoms
 - Hypotension
 - Reversible with aggressive treatment
 - Vasopressors?
 - Release of red blood cells
 - Capillaries clogged
 - Lactic acid
 - DIC

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Cardiovascular

- Hypovolemic Shock
 - Tachycardia is most often the first sign
 - Decreased skin perfusion is an early sign
 - Respiratory compromise
 - Delayed capillary refill
 - Weak or absent peripheral pulses
 - Skin pallor
 - Hypotension is most often the last sign
 - Mental changes

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Cardiovascular

- Causes of hypovolemic shock
 - External/internal bleeding
 - Control bleeding
 - Third spacing
 - Stress
 - Dehydration

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Cardiovascular

- Vascular access a priority
 - Large bore IV's if possible
 - Intraosseous access if unable to obtain peripheral access
- Fluid Resuscitation
 - Goal is to restore adequate tissue perfusion
 - 1 ml/kg/hr urinary output
 - Isotonic crystalloid solution
 - Normal saline or Ringer lactate
 - Warm fluids

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Fluid Resuscitation

- Initial volume
 - 20ml/kg IV push (rapid infusion)
- May Repeat initial volume (20ml/kg) twice
- Consider administration of blood products
 - Packed Red Blood cells – 10ml/kg
 - Whole Blood – 20 ml/kg

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Fluid Maintenance

- Maintenance fluids
 - 1st 10 kg of body weight = 100ml/kg/24 hrs
 - 2nd 10 kg of body weight = 50ml/kg/24 hrs
 - Any weight > 20 kg = 20ml/kg/24hrs
 - 40 kg = 100ml/kg (1000 ml) + 50ml/kg (500 ml) + 20 ml/kg (400 ml) = 1900 ml/24 hrs = 79.17 ml/hr

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Cardiogenic Shock

- Impaired muscle leads to decreased cardiac output
- Causes
 - Congenital heart disease
 - Cardiomyopathy – myocarditis
 - Post cardiac surgery
 - Myocardial trauma
 - CHF
 - Hypothermia
 - Drug intoxication
 - Electrolyte imbalances
 - Dysrhythmias

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Cardiogenic Shock

- High flow oxygen
 - What if it gets worse with oxygen?
- CPR for pulse < 60
 - In neonates < 100 after 30 seconds with positive pressure ventilation
- Check glucose
 - Give dextrose 2-4ml/kg for < 60
- IV fluid Bolus judiciously
- Vasodilators – reduce preload and afterload
 - Milrinone
 - Loading dose: 50 mcg/kg IV over 15 minutes
 - Maintenance infusion: 0.25-1 mcg/kg/min.
- Treat dysrhythmias

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Distributive Shock

- Vasodilatation
 - Septic Shock
 - Sepsis with hypotension
 - Early
 - Vasodilatation, compensated, warm shock
 - Responds to aggressive fluid resuscitation
 - Late
 - Vasoconstriction, decompensated, cold shock
 - Refractory to fluid resuscitation

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Distributive Shock

- Vasodilatation
 - Septic Shock
 - Oxygen – titrate Sats > 95%
 - Fluids – MAP > 70
 - Glucose > 60
 - Vasopressors
 - Dopamine 5 mcg/kg/min
 - Epi 0.1 – 0.5 mcg/kg/min
 - Levophed – 0.03 – 1.5 mcg/kg/min

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Distributive Shock

- Vasodilatation
 - Anaphylactic Shock
 - Stridor
 - Wheezing
 - Tachycardia
 - Hypotension
 - NVD
 - Hives
 - Facial Swelling and angioedema

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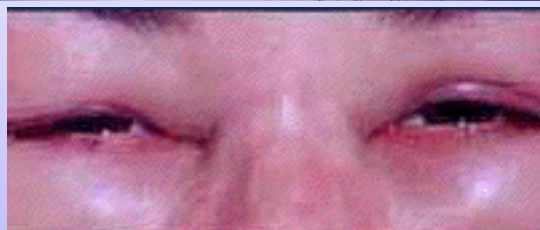
Distributive Shock

- Vasodilatation
 - Anaphylactic Shock
 - Remove cause
 - Oxygen titrate to Sats > 95%
 - Cardiac monitor
 - Epi 0.01 mg/kg of 1:1000 IM or SC
 - Max single dose 0.5 mg every 15 min X 3 doses
 - Glucose
 - Bronchodilator therapy – Albuterol
 - Benadryl 1.0 mg/kg IM or IV
 - Max dose 50 mg
 - Epi drip for decompensated shock

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Neurogenic Shock

- Head or Spinal Injury
- Loss of Peripheral vascular tone
 - Below level of the injury
 - Vasodilation
 - Decreased venous return
 - Decreased stroke volume
 - Decreased cardiac output
 - Decreased tissue perfusion

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Neurogenic Shock

- Skin warm and dry
- No sweating below the level of the injury
- HR WNL or bradycardia
- Hypotension
- Wide pulse pressure
- Respirations may be affected

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Neurogenic Shock

- Spinal immobilization
- Oxygen titrate to Sats > 95%
- CPR for pulse < 60
- Cardiac monitoring
- IV
- Glucose > 60
- Maintain temperature
- Vasopressors

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Obstructive Shock

- Shock that develops as a result of obstruction of blood flow from the heart
 - Cardiac tamponade
 - Tension pneumothorax
 - Pulmonary Embolism
- Decreased LOC
- Hypotension
- Tracheal deviation
- JVD
- Cyanosis

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Obstructive Shock

- C-Spine immobilization
- Oxygen titrate Sats > 95%
- CPR for HR < 60
- IV
- Volume expansion
- Dobutamine
- Glucose > 60
- Maintain temperature

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It's a MIRACLE!



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Cardiac Arrest

- Cardiopulmonary Failure
- RESPIRATORY FAILURE
- Slow respirations
- Delayed cap refill > 5 secs
- Bradycardia
- Weak central pulses with absent peripheral pulses
- Cool Extremities
- Mottled or cyanotic skin
- Decreased LOC

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Cardiac Arrest

- Result of respiratory failure
 - profound hypoxia and acidosis
- Dysrhythmias
 - Uncommon
 - Only lethal rhythms are treated
 - V-Fib, V-Tach, etc.

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Cardiac Arrest

- Causes
- Cardiovascular
 - Hypovolemia, congenital heart defect, dysrhythmias, pericardial effusions
 - Septic shock, Cardiogenic shock, Myocarditis
- Respiratory
 - Epiglottitis, croup, angioedema, pneumonia, drowning, bronchiolitis
 - Foreign body obstruction, severe asthma, respiratory failure, inhalation injury, bronchopulmonary dysplasia

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Cardiac Arrest

- Causes
- Neurologic
 - CNS infection, VP shunt obstruction, botulism, status epilepticus
- Trauma
 - Head trauma, burns, hypovolemic shock, chest trauma
- Other
 - SIDS, metabolic disorders, Drug toxicity, poisoning

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Early Warning Signs

- CRT 4 seconds
- Tachycardia 20 above normal with a temp of < 38 C
- Systolic BP less than normal lower parameters ($70 + 2 \times \text{age in years over 2 years of age}$)
- MAP > 90

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Impending Crash

- Grey in color
- CRT ≥ 5
- Tachycardia 30 above normal with a temp of $< 38^{\circ}\text{C}$
- Bradycardia
- Requiring $> 40\text{ml/kg}$ volume replacement
- Requiring vasopressors or emergent blood products

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What should be flown?

- Transposition of the Great Arteries with intact septum
- Hypoplastic Left Heart Syndrome with intact septum
- Total Anomalous Pulmonary Venous Return
- Shunt dependent patients with poor perfusion
- Unknown diagnosis of CHD needing Prostaglandins
- Unstable arrhythmias: unstable SVT, V Tach

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Disability

- Neurological Assessment
 - Pupillary response
 - Mental Status
 - Remember patients can regress during times of stress
 - Able to follow commands
 - Response to caregivers
 - Consolable
 - Glasgow coma scale
 - Less than 8 intubate
 - Glucose level

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Glasgow Coma Scale

	POSTURALS	EYE OPENING	BEST VERBAL RESPONSE	BEST MOTOR RESPONSE	PUPIL SIZE AND RESPONSE TO LIGHT
1 = best	4 = obeys commands	4 = spontaneous	5 = oriented	6 = obeys	6 = equal, reactive
2 = fair	3 = localizes pain	3 = opens eyes to speech	4 = oriented to person	5 = withdraws from pain	5 = unequal, reactive
3 = poor	2 = withdraws from pain	2 = opens eyes to touch	3 = oriented to person & place	4 = withdraws from pain	4 = unequal, non-reactive
4 = no response	1 = no response	1 = no response	2 = oriented to person	3 = flexion to pain	3 = equal, non-reactive
5 = no response	0 = no response	0 = no response	1 = no response	2 = extension to pain	2 = unequal, non-reactive
6 = no response	0 = no response	0 = no response	0 = no response	1 = no response	1 = equal, non-reactive

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Head Injuries

- Primary Injury
 - Injury that occurs at the time of the trauma
- Secondary Injury
 - Injury that occurs as a result of the trauma
 - Cerebral edema
 - Delayed vascular injury

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Head Injuries

- Mild Head Injury
 - GCS of 13-15 and neurologically "intact"
 - May have had loss of consciousness or memory loss of the events
 - Normal X-Ray or CT scan
 - Consider for discharge home with caretaker and instructions on head injuries

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Head Injuries

- Moderate Head Injury
 - GCS of 9-12
 - Usually treated the same as Severe
- Severe Head Injury
 - GCS of 8 or less
 - Loss or decreasing level of consciousness
 - Control hypertension
 - Control hypoxemia

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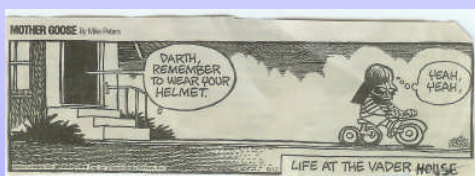
Head Injuries

- Intracranial Pressure (ICP)
 - Keep patient supine. Max elevation 30 degrees
 - Hyperventilation??
 - Controversial at best – No per Dr. Grabb
 - When to initiate treatment
 - Increased risk of cerebral ischemia
 - Fluid Management
 - Preserve blood volume/blood pressure
 - Isotonic fluids – (Consider 3-7% NS in PICU)
 - Limit fluids but maintain BP – dehydrate “old school”
 - Monitor sodium levels

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Head Injuries

- Prevention
 - Safety
 - Helmet, Helmet, Helmet!!!!



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Spinal Cord Injuries

- Uncommon in pediatrics
- Most Common Types when present
 - Cervical fracture of the 1st 2 vertebrae
 - Compression
 - Flexion-distraction (Chance)
 - Inappropriate use of lap belt
- Must be presumed and Treated
 - Spinal precautions
 - Backboard
- SCIWORA syndrome - (Spinal Cord Injury with out radiographic abnormality)
 - Unique to pediatrics
 - Spine can stretch or transiently deform causing changes in neurological assessment or resolution

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Central Nervous System Injuries

- Leading cause of death among injured children
- Cause
 - Physical abuse
 - Falls
 - MVA
 - Bicycle/Scooter

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CNS Injuries

- Overall, pediatric mortality is lower than that of the adult patient
- Children < 1 have particularly high mortality
- Early interventions and aggressive treatment result in lower mortality and better functional outcome

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CNS Injuries

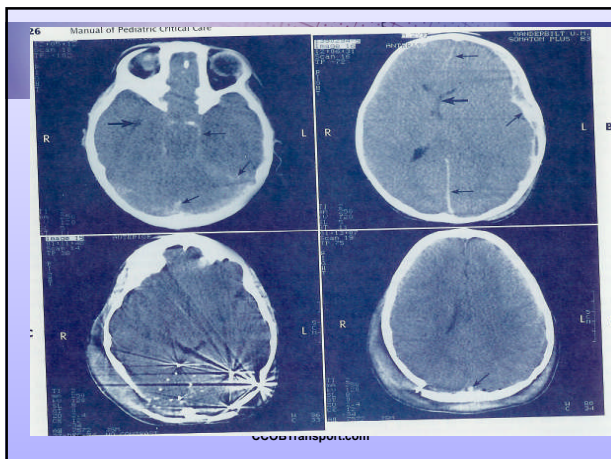
- Size of child's head is disproportionately larger than adult's
- Brain protected well from low-velocity, tangential blows
- Intercranial compartments reduce injury from mild to moderate injury
- Intercranial compartments may serve to magnify severe injury

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CNS Injuries

- Most Common Types of Head Injuries
- Concussion
- Contusions
- Skull Fracture
- Hematomas
 - Epidural
 - Subdural
- Hemorrhage
 - Subdural
 - Subarachnoid
 - Intracerebral/intraventricular
- Coup - Contrecoup

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Early Warning Signs

- Irritable or agitated but *not* consolable
- GCS \leq 12 acutely

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Impending Crash

- Lethargic; confused
- Decreased pain response
- GCS \leq 10 acutely
- Medically paralyzed and sedated

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Environment/Expose

- Environment
 - Keep patient warm
 - Cool the patient



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Thermoregulation

- Hypothalamus is the control center of thermoregulation
- Fever is produced in response to cytokines from either viral or bacterial agents
- In the child less than 3 months old this response is immature and they may have no fever or may be hypothermic

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Thermoregulation

- Heat Conservation
 - Vasoconstriction occurs to conserve heat.
 - Adrenal glands produce epinephrine and norepinephrine to increase metabolism
 - Shivering/chills occur to ↑ heat production
- Thermogenesis (shivering)
 - Increases heart rate and respiratory rate
 - Vasodilation occurs → skin flushes and perspiration takes place

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Cardiothoracic Injuries

- Second leading cause of death in pediatric trauma
- Blunt trauma most common
 - MVA
 - Bicycle handlebars
- Injuries seen in adult trauma uncommon in children
 - Pliable rib cage
 - Mediastinal mobility
 - Interthoracic injury without external injury

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Cardiothoracic Injuries

- Pulmonary Contusions
 - Contribute to majority of injuries to the chest
 - SOB may be delayed up to 24 hours
 - May or may not have chest bruising
 - Treatment
 - Usually resolve on own at home
 - Aggressive pulmonary toilet
 - Clearing of pulmonary secretions
 - Oxygen and ventilatory support rare

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Cardiothoracic Injuries

- Other types of injuries
 - Pneumothorax
 - Including tension
 - Hemothorax
- Pericardial Tamponade
 - Mostly seen in adolescent
 - Treat shock

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Abdominal Injuries

- Children more susceptible due to anatomic differences
 - Abdomen begins at nipple level
 - Small pliable rib cages
 - Underdeveloped abdominal muscles
 - Solid organs (liver, spleen, kidneys) proportionately larger
 - Less fatty tissue
- Most Common Injuries
 - Blunt
 - Usually MVA or pedestrian
 - Falls (Most common in Toddlers)
 - Abuse

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Abdominal Injuries

- Difficult to diagnose without diagnostic studies
 - Small children unable to accurately identify location
 - Older children guard their abdomen
 - Pain medication skews assessment
- Diagnostic Studies
 - CT scan – Most preferred and accurate
 - Abdominal X-RAY
 - Ultrasound
 - Peritoneal lavage
 - Used VERY rarely due to CT scan
 - Increased risk of complications
- Treatment
 - Mostly non-surgical with monitoring of laboratory studies

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Abdominal Injuries

- Spleen
 - Most common solid organ injury
 - Hematoma most common injury to spleen
 - Thick enclosure to spleen limits bleeding and protects spleen tissue
 - Graded on a scale of I to V.
 - Symptoms
 - Children complain of upper abdominal pain over the left quadrant
 - Kehr's sign common
 - Left shoulder pain
 - Left chest pain
 - Unable to Urinate
- Treatment
 - Surgery rare usually only to grade V injury
 - Bed rest for 3 to 5 days
 - Frequent monitoring of Hematocrit
 - ICU not necessary for most children
 - Follow-up CT scan 6 to 8 weeks post-injury

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Abdominal Injuries

- Liver
 - Common due to size and location
 - Highest mortality rate
 - Graded on scale of I to V.
 - V most life-threatening due to massive hemorrhage
 - Symptoms
 - Right upper quadrant pain
 - Persistent hypovolemia
 - Increasing abdominal girth
- Treatment
 - Non-operative if hemodynamically stable
 - Blood transfusions
 - Frequent hematocrit
 - Operative
 - Arterial embolization
- Complications
 - Bile leaks
 - Bilirubin in blood
 - DIC – Disseminated Intravascular Coagulation

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What should be flown?

- Trauma
 - High Spinal cord injuries
 - Tension pneumothorax
 - Cardiac tamponade
 - Liver lacerations
 - Splenic injury with hypotension
 - CHI with GCS ≤ 10
 - CHI with active seizure activity
 - Epidural bleed
 - Subdural bleed with GCS ≤ 10

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What should be flown?

- Surgical Emergencies: (depending on distance)
 - Volvulus
 - Malrotation twisting of bowel
 - Intussusception
 - Telescoping
 - Ovarian Torsion
 - Testicular Torsion
 - NEC (necrotizing enterocolitis)
 - Bowel perforation
- Altitude should be considered in type of flight

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Musculoskeletal Injuries

- Majority of traumatic injuries
- Rapid bone growth leads to quick healing
- Type of injury depends on mechanism of injury
- Types of Injuries
 - Fractures
 - Epiphyseal plate most serious type
 - Dislocations
 - Soft tissue

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Musculoskeletal Injuries

- Diagnostic studies
 - CT scan
 - Radiographic
- Treatment
 - Depends on type of injury
 - Monitor neurovascular function
 - 5 P's – Pain, Pallor, Pulse, Paralysis, Parasthesia
 - Pain management
 - Typically outpatient

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What should be flown?

- **Ortho**
 - Fractures with loss of distal pulse
 - Concern for loss of limb
 - 2 or more pelvic fractures
 - Open book pelvis

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Ingestions

- Common in young children and adolescents
- Treatment depends on type of ingestion
 - Always call poison control center for instructions
- Ingestions continue to change due to experimentation

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Ingestions

- Most Common seen in PICU
 - Hydrocarbons
 - Monitor airway and breathing, no vomiting. Pt continues to breathe poison
 - Acetaminophen
 - Easily accessible
 - Cheap
 - Suicide attempts
 - "Crystal Meth"
 - Labs can be anywhere
 - Toxic ingredients – fumes can be fatal
 - Others
 - Triple C – Coricidin Cough and Cold
 - Dextromethorphan
 - Morning Glory Seeds
 - Salvia
 - Spice
 - Rave Candy Parties
 - Polypharm

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What should be flown?

- **Medical**
 - Post arrest
 - Significant Intracranial Hemorrhage
 - AMS with GCS ≤ 10
 - DKA with AMS
 - Shock, hemodynamic instability, vasopressor dependent
 - Impending respiratory failure
 - Toxic ingestion with hemodynamic instability

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