Anesthesia For Pediatric Trauma

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Introduction

- Trauma is a major cause of morbidity and mortality in children
- Motor vehicle accidents (MVA) account for the most fatalities in infants <6 months old
- The younger the child, the higher the incidence of death when severe trauma occurs.

Evaluation

Airway

- It is important to remember the differences in the pediatric airway during their initial evaluation:
  - **Large head, large tongue**
  - **Anterior larynx**
  - **Floppy, stiff U-shaped epiglottis**
  - **Short trachea**
  - **Cricoid narrowest part of airway**
  - **A shoulder roll may be required to place the head in a "sniffing position"**
- Intubation in children should be considered in:
  - **Combative patients—may be a sign of hypoxia, or just an upset scared little child. Combative children may be at risk to harm themselves or worsen their injuries. It can also be difficult to evaluate such a child.**
  - **Changing mental status –may be an indication of a closed head injury (CHI), or severe dehydration.**
  - **Occluded nasal passage in infants--- infants and neonates are obligate nose breathers, occluded nasal passages from maxillo-facial/head trauma, may prevent them breathing effectively.**
  - **May be needed to facilitate diagnostic procedures—in fairly stable children most of the secondary evaluation utilizes radiological imaging (CT Scan of head, abdomen). Younger children may not be able to cooperate with these procedures and will require some sort of sedation. Since sedation in a traumatized child with unknown injuries is a risky undertaking, it is safer to secure their airway, then provide appropriate sedatives.**

Breathing

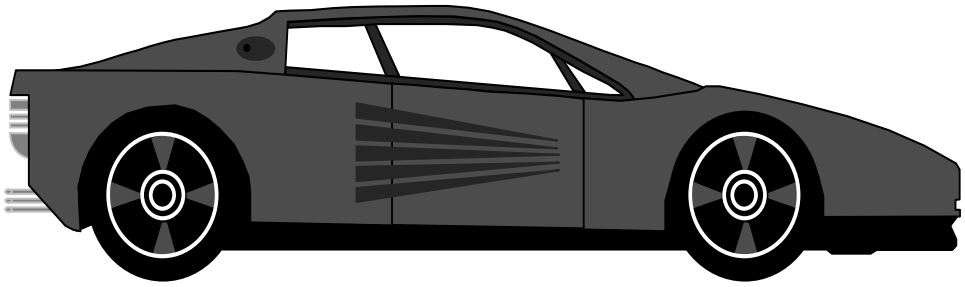
- Nasal flaring, use of accessory muscles and a "rocking boat" pattern may indicate airway obstruction
- Trachea can be easily compressed, therefore look for midline shift and evidence of hematoma formation.
- Upper airway obstruction is not uncommon.

Circulation

- A change in BP occurs only after there is a 30-40% decrease in EBV, therefore BP is not a very good measure of circulatory status. On the other hand decreased BP indicates significant blood loss.
- Check for persistent tachycardia, delayed capillary refill and diminished pulse pressure. Central pulses should be strong. An absent or decreased radial pulse indicates ~ 10 % reduction in intravascular volume. Weakened axillary or femoral pulses signify a loss of ~15%.
- EBV:
  - **90cc/kg—neonate**
  - **80cc/kg—infant**
  - **70cc/kg—child**
  - **Always calculate EBV ASAP**

CNS

- 50% of pediatric trauma patients will have trauma to brain
- Glasgow Coma Scale (GCS) is not reliable in children <1year of age.
- Spontaneous motor movement after CHI is common which can artificially elevate the GCS
- Children may not be able to cooperate and follow commands because of their age or level of anxiety.
- There is a modified scale available for use in children, however it has not been validated in as many patients as has the GCS
- Withdrawal reflexes may look like purposeful movement.
- Spinal cord injuries are rare in patients <2 years old.
- However, when they do occur, 60-70% occur at C1or C2
- Spinal cord injuries can be difficult to diagnose—pseudosubluxation can be a normal finding in children and occurs commonly C2 and C3. Spinal cord injury without radiological abnormalities (SCIWORA) may occur in as many as 40% of children with spinal trauma. These injuries are as a result of flexion-extension disruption of spinal ligaments and displacement of the vertebral bodies. Following the impact, the vertebral column returns to its proper alignment, however edema, vascular compromise and axonal degeneration lead to delayed neurologic deficit.
- A high level of suspicion must be maintained based on mechanism of injury
- Get and be sure to have a pediatric trained radiologist, neurosurgeon or orthopedic surgeon read C-spine X-rays if the patient has:
  - **neck pain,**
  - **abnormal reflexes,**
  - **strength or sensation,**
  - **h/o direct neck trauma,**
  - **limited neck mobility,**
  - **abnormal mental status**



Systemic Injuries --Thoracic Trauma

- Occurs in < 5 % of pediatric patients
- 82% have other associated injuries
- Chest wall is compliant, therefore injury can occur without evidence of external chest wall injury
- Rib fractures in small child = massive energy transfer, and probable other associated injuries

Pneumothorax

- Most common thoracic injury
- 25% $\Rightarrow$ tension pneumothorax
- Profound respiratory depression and circulatory collapse occur, because of the highly compliant mediastinum
- May not manifest until positive pressure ventilation, $\therefore$ in a patient who becomes hypoxic and/or hypotensive after institution of positive pressure ventilation, consider tension pneumothorax.
- May need to decompress with large bore needle
- Definitive treatment is with a chest tube

Hemothorax

- Consider in a patient with unexplained hypotension
- Chest x-ray may show subtle findings
- Poorly tolerated

Flail Chest

- Will be accompanied by a massive pulmonary contusion.
- Treatment consists of fluid restriction after initial resuscitation, insurance of adequate gas exchange and analgesia
- Look for other injuries

Cardiac Tamponnade

- Rare with blunt trauma
- Beck's triad (muffled heart tones, $\Uparrow$ CVP, $\Downarrow$ BP) may be absent
- Consider in refractory patients
- Treat with pericardiocentesis

Myocardial Contusion

- Occur in 43% of patients with pulmonary contusion
- Arrhythmia's are uncommon
- CPK , Echo correlate poorly
- Consider in patient with low CO, & BP and with $\Uparrow$ sensitivity to fluids

Systemic Injuries --Abdominal Trauma

- 10% of patients presenting to pediatric trauma centers have associated abdominal injuries, usually from an MVA or fall
- Diagnosis is by CT scan in stable patients
- Peritoneal lavage is done in an unstable patient or one with a CHI that is being rushed to the OR
- Kidney, liver, spleen injuries are most common
- Isolated or discreet injuries are frequently managed non-operatively.
- Can be associated with massive blood loss

Initial Resuscitation

Airway

- Objectives
  - **Protect airway in unconscious child**
  - **Prevent secondary brain injury from hypoxia**
  - **Provide an airway if it appears to be compromised**
  - **Optimize oxygenation**
  - **Improve gas exchange**
- Management Principles
  - **Limit PIP < 20 cm H_2O. Higher PIP can lead to distention of the stomach, which can decrease diaphragmatic excursion, and decrease FRC ⇒ worsening hypoxia**
  - **Protect neck**

- Intubation -- Handle with Care!!
  - **C-spine must always be protected, leave collar on until absolutely sure there is no neck injury**
  - **Collar or in line immobilization may impede laryngoscopy**
  - **Blind NT intubation--very difficult, potentially dangerous in patients with head injury**
  - **All trauma patients should be considered at risk for aspiration**
  - **Awake look/intubation rarely possible**
  - **Cricoid pressure may destabilize an unstable neck**
  - **In patients with severe pulmonary trauma a larger ETT or cuffed ETT will facilitate ventilation. In these patients maintain a leak of >25-30cm H_2O**
- Suspect a difficult airway if there is : limited mouth opening, limited neck mobility, small mandible, poor visualization of uvula
- Difficult Airway--Management
  - **Fiberoptic intubation +/- wire, however with blood and secretions may be very tricky**
  - **Light wand, the smallest will go through ~ a 4.5 ETT. May need a darkened room,**
  - **LMA—a little harder to place than an adult, may provide a bridge to more definitive management. The smallest Intubating LMA currently available is a 3 (good for ~ a 10 yearold). Smaller sizes may soon be available.**
  - **COPA (Cuffed OroPharyngeal Airway)—Pediatric sizes are being tested**
  - **Bullard® -- there are pediatric Bullards available), but there has been variable success reported with this technique**
  - **Percutaneous Cricothyrotomy or emergency tracheotomy – technique of last resort**

Circulation

- Once the need for volume resuscitation has been determined administer 20 cc/kg balanced salt solution (Lactated Ringers or normal saline most commonly used)
- Repeat x 2 if necessary
- If no improvement -- 10 cc/kg PRBC (or 20 cc/kg whole blood)
- Invasive monitoring will be required (at some point)
- Large bore IV's are necessary and often difficult
- Cutdown on the saphenous vein may be necessary (see figure 1)
- Intraosseous line can be life-saving and should be tired if reliable IV access can't be established in 3 attempts or 90seconds (PALS recommendation) (see figure 2)
- Central lines
  - **Internal Jugular and/or subclavian lines may not be possible because of presence of a neck collar**
  - **Femoral lines are usually the easiest and least risky to place in this situation**
- Hypovolemia ⇒ hypoperfusion ⇒ metabolic acidosis
  - **Metabolic acidosis usually improves with fluid resuscitation**
  - **In patients with severe trauma, the acidosis may need to be treated with NaHCO3+, as long as ventilation is OK.**
  - **Dose = wt x 0.15 x base deficit, however since many of these patients will have a base deficit of >8 mEq/l, 2 x weight is a good starting dose.**

- Maintaining body temperature with radiant warming lights, warm fluids,forced air warmer (Bair Hugger®), warming blankets etc. is important, since hypothermia and vasoconstriction can increase bleeding and adversely effect perfusion. The only exception is in patients with severe CHI, in whom mild hypothermia is preferred.
- Actively warm the patient if they arrive cold
- Re-warming may lead to increased acidosis (re-warming shock)
- Perfusion to previously unperfused areas causes washout of acid ⇒ hypotension
- Fluids most often used are :
  - **Balanced salt solution (BSS)**
  - **Colloid**
    - Albumin—is especially useful in CHI, because smaller volumes can be used
    - Hetastarch/Dextran—limited pediatric experience, Coagulopathy may occurr is >2cc/kg is administered
  - **Hypertonic saline -- limited experience in pediatrics**
- Maintenance
  - **4cc/kg first 10 kg**
  - **2cc/kg next 10 kg**
  - **1 cc/kg for all subsequent kg**
- Estimated wt = (age x 2) +10, Some ED's will have a Breselow tape, which can provide a more accurate weight estimate.
- ∴a 5 year old patient:
  - **estimated weight = 20 kg**
  - **maintenance fluids = 60 cc/hr**
  - **EBV = 1400cc**
  - **MABL = 20-30% EBV = 280-420cc**
- Transfuse for same indications as adults:
  - **10 cc/kg prbc will ⇑ Hct ~ 5%**
  - **10 cc/kg platelets ⇑ platelet count ~ 50,000**
  - **10 cc/kg FFP, usually enough to provide adequate clotting factors, in dilutional coagulopathy.**
  - **Once patient is exposed to a unit, try to use use it all.**
- Consider FFP, platelets after the equivalent ~1 EBV has been transfused.
  In 5yr old , 20kg patient consider transfusion after >2 units prbc's
- FFP has the highest citrate content/unit. Citrate binds with calcium. Severe hypocalcemia may develop from citrate intoxication, especially if FFP is administered rapidly.

Anesthetic Management

Monitors

- EKG
  - **Bradycardia – <u>bad</u>, usually indicative of hypoxia, ischemia, acidosis of hypthermia**
  - **Persistent tachycardia may = hypovolemia and acute blood loss**
- Blood Pressure
  - **Arterial Line**
    - *Radial / femoral / axillary*
    - *Dorsalis pedis / post tibial*
    - *May need cutdown*
- Pulse Oximeter -- in a cold vasoconstricted patients may be difficult to obtain, use multiple probes in several locations
  - **Respiratory variation in waveform = hypovolemia**
- End Tidal Carbon Dioxide
  - **$ETCO_2$ less accurate in smaller patients, because they have a relatively higher dead space to tidal volume ratio than adults and hypovolemic patients will have even more dead space. Increased oxygen flows will dilute measured $ETCO_2$**

- **Low $ETCO_2$ may reflect low Cardiac Output --less blood flow to lungs, increased dead space ventilation, increased (A-a) CO_2 gradient**

■ Central lines are useful for both volume administration and management, but can be very difficult place.

■ Swan Ganz rarely required and can be extremely difficult to insert

■ Temperature monitoring important, and precautions to prevent heat loss include:

- **Warm room, heating blanket, forced air convection blanket**
- **Warm Fluids (Hotline, Level 1, Rapid Infuser device)**
- **Humidifier**
- **Wrap head, extremities**

■ Medications

- **Decreased need for intravenous anesthetics because of a decreased volume of distribution, dilutional hypoprotinemia and the maintenance of blood flow to heart and brain ⇒ relative overdose**
- **Decreased need for inhalational anesthetics because of maintenance of blood flow to heart and brain ⇒ higher concentration of agent reaches these organs ⇒ relative overdose and decreased CO**

■ Induction-Rapid Sequence

- **May need to modify because children can desaturate much more quickly than adults**
- **Careful cricoid in unstable neck**
- **Ketamine, STP, propofol or etomidate in small doses can all be used**
- **Succinylcholine, rocuronium work well for muscle relaxation**

■ Maintenance

- **Give blood**
- **Muscle relaxant/ narcotic/volatile agent/amnestic as tolerated**
- **Give more blood**
- **Keep warm, calculate EBV, MABL,**
- **Consider coagulation factors if more than EBV has been administered**

Common Electrolyte Abnormalities

■ Hyperkalemia can occur with muscle damage or as a result of blood transfusion

- **1 week old blood 5 mEq/L**
- **3 week old blood 22 mEq/L**
- **In a small child this amount of potassium may be significant**
- **Treat with 10 mg/kg CaCL, hyperventilation, bicarbonate initially. If hyperkalemia persists then glucose (0.5 gm/kg) & insulin (l unit/5gms glucose) can be administered.**

■ Hyponatremia can occur as a result of overaggressive fluid therapy with hypotonic fluids (e.g. D51/4NS) , burns or peritonitis and can lead to seizures, coma

- **Treat with 3% NaCl 1 ml/kg or NS + NaHCO3+**
- **Rapid correction can cause central pontine myelinosis**

■ Hypocalcemia occurs with large blood or FFP transfusion (> 20-40% EBV). Fairly common problem that should be considered in any patient that has received a lot of blood/blood products and who remain hypotensive.

- **Treat with 10 mg/kg CaCL or 30 mg/kg Calcium Gluconate**

Summary

■ Trauma remains the #1 killer of children >1 yr.

■ Any anesthesiologist may have to care for such a patient

■ Many of the same principles used in adult patients apply, however the unique anatomy and physiology of children must always be remembered

Appendix

Laryngoscope Blades Needed for Different Age Children

●Premature/Newborn---Miller 0
●< 2 years ---Miller 1 or Wis Hippel 1.5
●2-6 years ---Wis Hippel 1.5 or Mac 2
●6-12 years---**Miller 2** or Mac 2
●> 12 years---Miller 2 or Mac 3

Guidelines For Endotracheal Tube Size

●Newborns: 3.0-3.5 mm ETT
●Newborn-12 months: 3.5-4.0 mm ETT
●12-18 months: 4.0 mm ETT
●2. years : 4.5 mm ETT
●> 2 years: ETT size = 16 + age / 4

Need ETT ½ size above and ½ size below estimated size, leak <20-25 cmH_2O if patient has normal lungs, but >25 cm H_2O if s/he has a pulmonary contusion.

	< 25% Blood Loss	**25=40% Blood Loss**	**>45% Blood Loss**
CARDIAC	weal thready pulse, ↑ HR	↑ HR	↓BP, ↑ or ↓HR
CNS	lethargic, irritable, confused	dulled response to pain, obtunded	comatose
SKIN	cool, clammy	cyanotic, ↓ capillary refill, cold extremities	pale, cold
KIDNEYS	↓ UOP, ↑ specific gravity	minimal UOP	no UOP

Normal BP 80 mmHg + 2 x age (approximate)
Electroshock: 2-6 Joules/kg

Drugs:

Atropine	0.02 mg/kg	dopamine	5-20 ug/kg/min
Epinephrine	10 ug/kg	epinephrine	0.1-1 ug/kg/min
CaCl	10-30 mg/kg	neosynephrine	0.1 - 0.6 ug/kg/min
Lidocaine	1-2 mg/kg	isuprel	0.1 - 1 ug/kg/min
Bretylium	5-10 mg/kg	verapamil	0.05-0.1 mg/kg
Dilantin	15-20 mg/kg		
Decadron	0.5 mg/kg		

Modified Glasgow Coma Scale For Infants and Children

Best Motor Response	Score	Best Verbal Response	Score
obeys commands	6	appropriate words, smiles, fixes & follows	5
localizes pain	5	cries but is consolable	4
withdraws from pain	4	persistently irritable	3
abnormal flexion	3	restless agitated	2
abnormal extension	2	none	1
flaccid	1		
Eye opening			
spontaneous	4		
to voices	3		
to pain	2		
none	1		

Intubate for GCS <8