Pediatrics

ANESTHETIC CONSIDERATIONS:

- Anatomical and physiological considerations of pediatrics:
  - Airway
    - Larger head (relatively) → flexed neck → obstruction
    - Obligate nose breathers as neonates until ~ (concern re: chonal atresia/obstruction with secretions)
    - Larger tongue → obstruction
    - Increased secretions
    - More prone to laryngospasm
    - Vocal cords have anteriosuperior to posteroinferior angle
    - Larger, omega shaped epiglottis
    - Larynx more cephalad (C4) and anterior
    - Trachea short (5cm in neonate) → precise placement and firm fixation of ETT
    - Cricoid cartilage level narrowest portion of trachea/airway
  - Breathing/Resp
    - Ribs are more horizontal therefore ventilation is more diaphragmatic
    - VE has less contribution from VT and more from RR (VT similar to adult on ml/kg basis)
    - Increased oxygen consumption (neonate 6ml/kg, twice adults)
    - FRC slightly less than adults (neonates 30ml/kg vs adults 35ml/kg)
    - Ventilatory response to hypercapnia is less in neonate
    - Neonate sensitive to changes in PaO_2 – FiO_2 1.0 decreases ventilation in the neonate
    - Hering-Breuer reflex in neonate (esp. prems)
      - Pulmonary stretch receptors with inflation send input back via vagus to medulla and apneustic center in pons inhibiting inspiration (inflation reflex; prevents hyperinflation)
    - Closing volume is higher in infants and young children and may exceed FRC to encroach on VT during normal ventilation (may explain the lower PaO_2 in infancy)
  - Circulation (always think of possible cardiac abnormalities or persistent fetal circulation in kids)
    - Foramen ovale functionally closes at birth, anatomically at 3-12 months (though 20-30% adults probe patent FO)
    - Ductus arteriosus functionally closes 10-15 hours post-partum, anatomic closure 4-6 weeks
    - Neonates highly dependent on HR for CO
    - Vasoconstrictive responses less
    - TBW and ECF volumes greater in neonates
    - Estimated blood volumes
      - Prems → 100ml/kg
      - Neonates → 90ml/kg
      - Infants → 80ml/kg
      - >12months → 70ml/kg
  - Drugs/Neuro
    - Neonates require ~25% lower concentrations of volatile anesthetics than infants 1-6 months (even less for pre-term neonates)
    - MAC peaks at 2-3 months then steadily declines with age until puberty (slight peak) then decreases again
      - However, for Sevo, MAC is relatively constant in infants < 6months (3.2%) and 6months-12 years (2.5%); reason unclear
    - Uptake of volatiles more rapid due to high VA relative to FRC
    - Induction with propofol higher doses in infants (3mg/kg) than in older children 10-16yr (2.4mg/kg)
    - NMBAs
      - Non-depolarizing: more sensitive but larger Vd therefore initial doses similar to adult
        - Immature hepatic and renal function can decrease clearance
        - Antagonism of NMBAs normal
      - Depolarizing: neonates and infants require larger doses due to increased ECF volume/Vd
  - GI
    - Swallowing and respiratory control don't mature until 4-5 months of age and GER more common in infants
  - GU
    - GFR greatly decreased in neonates (normalizes by 3-5 weeks) – excrete volume loads more slowly
    - Neonates obligate sodium losers and cannot concentrate urine as effectively
  - Heme
    - HbF P50 of 19mmHg (leftward shift) vs 26mmHg for HbA (i.e. increased affinity of HbF for O_2)
      - Decreased unloading at tissues offset by increased Hb/Hct
    - Physiologic anemia at 2-3 months; by 4-6 months, Hct ~ adult values
  - Metabolic
    - Thermoregulation impaired
      - Larger BSA relative to weight, thin insulating layer, decreased shivering
      - Neonates have non-shivering thermogenesis (brown fat at posterior neck, interscapular and vertebral areas, surrounding kidneys and adrenals; stimulated by NE)
    - Neonate prone to hypoglycemia (many factors)
      - Controversy re: maintenance fluid (D5 ½ NS or D5NS likely best but use isotonic crystalloid like RL for losses, 3rd spacing, etc.)
      - For neonate, check glucose intra-op for prolonged procedures

- Current issues/controversies in pediatrics (Barash):
  - Upper respiratory infection
  - OSA
  - Asthma
  - Former preterm infant
  - Laboratory investigations
  - Preoperative fasting period
  - Preoperative sedatives
  - Maximum allowable blood loss (MABL)

- Altered pharmacokinetics / pharmacodynamics:
  - See above "Drugs/Neuro" section

ANESTHETIC GOALS:

- Ensure optimization of multisystem derangements including respiratory, cardiovascular, hepatic, renal and hematological
- Anticipate fluid / electrolyte / glucose derangements and optimize preoperatively
- Ensure continuous temperature monitoring and maintain normothermia

HISTORY

- Prenatal history including gestational age at birth (increased risk of multiple conditions associated with prematurity)
- Obstetric and perinatal history including birth details, resuscitation, need for intubation / ventilation / ICU care
- Consider presence of congenital abnormalities especially heart disease and any treatments being utilized
- Review previous surgical/anesthetic charts
- Ask about recent URTIs as implications for general anesthesia
- Note family history of adverse reactions to anesthetics if no previous history

PHYSICAL

- **GENERAL**
  - Interaction with health care team; concern re: separation anxiety (typically 6months-4yrs) and need for pre-op sedation vs. parental presence during induction/emergence
  - Note dysmorphic features and potential congenital anomalies
  - Normal growth and development (ensure height and weight documented and up-to-date)
  - Note vitals signs and current IV access if any; presence of topical LAs to facilitate access
- **A/W**
  - A/w exam paying particular attention to congenital conditions/dysmorphic features (e.g. Treacher-Collins, Pierre-Robin, Down syndrome, retrognathia, macroglossia, maxillary hypoplasia and other known conditions with a/w implications)
- **RESP**
  - Note presence of increased WOB and auscultatory findings suggestive of underlying resp disease
- **CVS**
  - Particular attention to heart murmurs, presence of cyanosis, cap refill/volume status, surgical scars indicating previous cardiac surgery, etc.
  - Note vital signs
- **CNS**
  - General growth and development
  - Reaching milestones or delayed
  - Interaction and level of consciousness

INVESTIGATIONS

- **Labs**
  - None required if healthy child
  - Dictated by underlying conditions
- **Imaging**
  - None required if healthy child
  - Dictated by underlying conditions
    - CXR - BPD, CHF, pneumonia
    - AXR - NEC
    - ECHO PRN (biventricular function / congenital anomalies)

OPTIMIZATION

- Ensure on treatment for underlying conditions and at baseline/optimal function if possible (e.g. asthma)

ANESTHETIC OPTIONS

- Local
- Regional
  - Spinal
  - Caudal
  - Epidural
  - Specific nerve blocks (e.g. ilioinguinal, iliohypogastric for hernia surgery)
- GA
  - Spontaneous vs. mechanical ventilation
  - Mask vs. endotracheal intubation vs. LMA, etc.
- Combined (e.g. GA + regional, etc.)

ANESTHETIC SETUP

- **Drugs**
  - Standard emergency drugs
  - Consider pre-drawn fluid boluses for very small infants/prems
- **Equipment**
  - Standard CAS monitors + temperature

- Temperature considerations – increase the OR temperature, use radiant heater pre-induction and forced air intraoperatively, and monitor temperature continuously (don't overheat)
- Precordial stethoscope
- Appropriate sizes of circuits, masks, ETTs and consider cuffed ETT if expecting high ventilatory pressures, spirometry

Table 82-6 -- Recommended Sizes and Distance of Insertion of Endotracheal Tubes and Laryngoscope Blades for Use in Pediatric Patients

Age of Patient	Internal Diameter of Endotracheal Tube (mm)	Recommended Size of Laryngoscope Straight Blade	Distance of Insertion * (cm)
Preterm (<1250 g)	2.5 uncuffed	0	6-7
Full term	3.0 uncuffed	0-1	8-10
1 yr	3.5-4.0 cuffed	1	11
2 yr	4.5-5.0 cuffed	1-1.5	12
6 yr	5.0-5.5 cuffed	1.5-2	15
10 yr	6.0-6.5 cuffed	2-3	17
18 yr	7-8 cuffed	3	19

* Inserting the endotracheal tube this distance from the alveolar ridge of the mandible or maxilla places the distal end of the tube in the midtrachea.

MANAGEMENT OF ANESTHESIA

- **Induction**
  - IV vs. inhalational (vs IM, rectal, etc.)
    - Inhalational
      - Uptake of inhalational agents more rapid owing to high VA and decreased FRC (higher ratio VA:FRC compared to adults)
      - High inspired concentrations (overpressure) can yield very high tissue concentrations → cardiac depression and arrhythmias)
      - Theoretically, a R → L shunt should decrease uptake of agents and L→ R should increase it (rarely seen clinically, though)
      - Basically only Sevo and Halothane used for this purpose
    - Note dosage adjustments of IV agents based on age (above in anesthetic considerations section)
      - Adjustments also made for pre-op sedation
      - Propofol induction doses 3-4mg/kg for children < 2 yrs, 2.5-3mg/kg for older children
      - Consider atropine co-administration with ketamine (for secretions) or SCh (for bradycardia)
    - SCh
      - 1.5-2mg/kg IV; 4mg/kg IM
      - Use recommended only for situations requiring ultra-rapid onset and short duration (laryngospasm) or when muscle relaxation when no IV access established (i.e. IM SCh)
    - Non-depolarizing NMBAs
      - Neonates and infants have larger Vd but are more sensitive to these drugs so dosages same as for adults (but duration is slightly longer)
  - ETT: allow leak at 20 cmH_2O
    - Watch for kinking of ETT and high risk of endobronchial displacement (short distance to carina) in small infants
- **Maintenance**
  - Anesthetic maintenance recognizing increased MAC requirements of most children
  - Balanced anesthetic including opiates, acetaminophen, NSAIDS, NMDA R antagonists, adjuvants if applicable
  - Propofol maintenance dose for GA ~ 200-300mcg/kg/min
  - Opiates may induce chest wall rigidity in children as well (especially drug-naïve neonates and infants)
    - Opiates also depress central respiratory effort in infants < 6months
    - Morphine 0.05-0.1 mg/kg, fentanyl 0.5-1 mcg/kg boluses (doses obviously very procedure and duration of surgery dependent)
  - Balanced salt solution (NS, RL, etc.) sufficient for most
  - Prevent air embolism
  - PONV prophylaxis
    - Especially important after orchidopexy, strabismus and tonsillectomy
    - Ondansetron 0.05-**0.15mg/kg** effective for tonsils and strabs
    - Dexamethasone 0.15-1.0 mg/kg good for tonsils
    - Metoclopramide 0.15mg/kg
    - Most effective is 5HT3 R antagonist and a second drug from a different class
- **Emergence**
  - Reverse any muscle relaxation at end of the procedure if considering extubation
  - Dependent on disposition and any underlying problems (smooth emergence is always a goal to strive for)
  - Consider parental presence on emergence
  - Be wary of laryngospasm in partially anesthetized patient or at any time in PACU

DISPOSITION & MONITORING

- Post operative apnea in infants
  - See Prematurity seminar
- Hypothermia
  - Monitor and treat in PACU adequately
- Emergence agitation
  - Probably worse with pure sevo anesthesia, better with TIVA/TCI with Propofol
  - May be treated with variety of sedative/analgesics (fentanyl, midaz, ketamine, etc.)

CURRENT ISSUES/CONTROVERSIES IN PEDIATRICS

- **Upper respiratory infection:**
  - Multiple investigations indicate children with current URI are at creased risk of
    - Laryngospasm
    - Bronchospasm
    - Postextubation croup
    - Postoperative atelectasis
  - Unsure how long surgery should be delayted following URI (maybe up to 7 weeks)
  - Mask anesthesia associated with lower rate of perioperative complications

- LMA and ETT equivocal

- **OSA:**
  - At risk of obstruction if preop sedative premedication used
  - Especially bad for children < 3yr old
  - Most children undergoing T&A can be d/c home after 4 hr observation in PACU, those with sever OSA require overnight monitoring and admission
- **Asthma:**
  - Optimize treatment pre-op and continue all meds up to and including day of surgery
  - Salbutamol prior to induction eliminates increased a/w pressures seen in asthmatics
- **Former preterm infant:**
  - (See Prematurity seminar)
  - Generally agreed that postconceptual age (PCA) <52-60 wks need to be admitted to hospital after GA
  - Post-op apnea inversely related to PCA
- **Laboratory investigations:**
  - Healthy children do not need routine lab work
  - Labs guided by underlying illness and disease state
  - Routine coags not needed
    - Consider coags for the following
      - Children with hx suggesting hemostatic defect
      - Surgical procedures that might induce hemostatic defects (e.g.CPB)
      - Cases requiring intact hemostatic pathways
      - Patients for whom minimal post-op bleeding may be life threatening
- **Pre-operative fasting:**
  - Risk of aspiration < 1 in 10,000
  - ASA guidelines
    - Solids: 6-8 hours
    - Formula: 6 hours
    - Breast milk: 4 hours
    - Clear fluids: 2 hours
  - Encouraging clear fluids up to 2 hours may decrease gastric volume
  - Younger children have lesser glycogen stores and more prone to hypoglycemia

- **Preoperative sedatives:**
  - Goals: amnesia, anxiolysis, prevention of physiologic stress, analgesia
  - Midazolam
    - Oral: 0.5-0.75mg/kg
      - Does not delay emergence from GA (but may delay d/c if ultra-short procedures)
      - Need adult supervision after taking
      - Peak effect in 30 min
      - Superior to parental presence in decreasing pre-op stress
  - Ketamine
    - Oral: 5-6 mg/kg
      - Max sedation in 20 min
      - N/V slightly increased compared to midaz alone
    - IM: 0.3mg/kg (anxiolysis); 3-4 mg/kg (dissociated state, quiet, breathing)
  - Fentanyl – not used as too many adverse effects
  - Clonidine
    - Oral: 4mcg/kg
      - a2-agonist
      - pre-op sedation, decreases anesthetic requirements, increased mask acceptance in 45 min, decreased post-op analgesia, attenuates hemodynamic response
  - Dexmedetomidine
    - More selective a2-agonist
    - Transmucosally: 1mcg/kg
    - Oral: 3-4mcg/kg
    - Sedation similar to midaz or clonidine

Table 45-2 Premedication—Drugs Options and Doses

MEDICATION	ROUTE	DOSE (mg/kg)	TIME TO ONSET (min)	ELIMINATION HALF-LIFE $T_{½}$ (hr)
Midazolam	Oral	0.25–1.0	10	2
	Intranasal	0.2–0.3	<10	2–3
	Rectal	0.3–1.0	10	2–3
Ketamine	Oral	3.0–6.0	10	2–3
	Intranasal	3.0–5.0	<10	3
	Rectal	5.0–6.0	20–30	3
Clonidine	Oral	0.002–0.004	45	8–12

- **Maximum Allowable Blood Loss**
  - Certain procedures accompanied by blood loss and calculation of acceptable blood loss is vital
  - Take into account patient's total blood volume, starting Hct and estimated target Hct before you would transfuse
  - Each 1ml/kg of PRBCs raises Hct by 1.5%
  - $$\text{MABL} = \frac{\text{EBV} \times (\text{Starting hematocrit} - \text{Target hematocrit})}{\text{Starting hematocrit}}$$

REFERENCES

- Stoelting's Coexisting Disease 6th, Barash, Steward, Cote, Miller