Episode 36: Pediatric respiratory anatomy and physiology with Dr. Schwengel

On this episode: Dr. Jed Wolpaw and Dr. Deb Schwengel

In this episode, episode 36, I welcome Dr. Deb Schwengel, one of our pediatric anesthesiologists and our residency program director, to the show to discuss the differences in anatomy and physiology in pediatric versus adult patients.

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Pediatric Airway Anatomy

- Infants have larger occiput so automatically in sniffing position → stabilize with head ring ± shoulder roll
- Larynx is higher (adult at C5 vs. newborn at ~C3) → do not tilt back with laryngoscope on DL
- Mandible slightly retrognathic and midface hypoplasia →airway easily obstructed so do jaw thrust when mask ventilating
- Tongue larger
- Epiglottis stiffer and longer → lift up epiglottis with straight blade; may not have perfect view
- Laryngeal structure more cartilaginous with less ligamentous development → larger arytenoids relative to size of glottis
- Pediatric trachea elliptical, not round
- Cricoid ring narrowest → based on cadaveric specimens and may not be true
    - Narrowest portion of airway of adults is glottis
- Length of trachea is short: full term baby has 4 to 5cm trachea, 1kg preterm has 2cm trachea
- Tip: advance ETT until lose breath sounds on left side to determine height of carina. Then, position tube properly depending on patient's head positioning for surgery
- Tracheal ring not complete in infants → external pressure could easily compress trachea

ETT Choice

- Typically use cuffed tubes → reduce number of passes to find proper sized tube
- Historically, did not use cuff tubes because older cuffed tubes did not fit properly around pediatric cricoid ring and carina

Pediatric Physiology

- Kids have ↑ respiratory rate → increased minute ventilation
    - Tidal volume is the same; ~5 to 7mL/kg to ~6 to 8mL/kg
- Oxygen consumption ~3x higher → adults 2 to 4mL/kg/min vs. infants 6 to 9mL/kg/min
    - Highest oxygen consumption at 4 to 6 weeks of life when going through growth spurt
- Functional residual capacity (FRC) is similar to adults; ~ 30 to 35mL/kg
    - Infants chest wall is excessively compliant, but lungs are stiffer → more effort needed to maintain FRC and avoid atelectasis → ↓ FRC when anesthetized
        - School aged children have FRC of 20mL/kg when anesthetized
        - Toddlers have FRC of 17mL/kg when anesthetized
- Kids have 6x higher risk of desaturation when apneic
- Loss of expiratory braking → infants create auto PEEP with partial glottis closure and stenting of intercostal muscles
    - Use of PEEP, faster rate, peak inspiratory pressure (PIP), and longer inspiratory time when mask ventilating to prevent FRC loss
        - Longer inspiratory time prevents alveoli collapse

Pediatric Diaphragm

- Pediatric diaphragm is flatter structure → ↓movement so ↓negative intrathoracic pressure
- Immature respiratory fibers of diaphragm → more easily fatigued
- Resistance inversely proportional to radius^4 → more resistance

Mask Induction

- Less vessel rich organs (ie. skeletal muscle) so large amount of cardiac output goes to brain → faster onset of anesthetic agents allows use of mask induction
- Three breath technique → take whole vital capacity breathes and hold
- Start mask induction with nitrous oxide because sevoflurane smells bad

Circuit Differences

- Pediatric circuit has smaller bore tubing
- $EtCO_2$ harder to measure because machine dead space is significant for smaller infant
- Rely on chest rise and fall because longer spirometry circuits (eg. for MRIs) unreliable

Anesthetic Agent Dosages

- MAC higher in kids → MAC curve different for each volatile agent
    - Unsure of mechanism
- Propofol dosages larger:
    - Induction doses of 5mg/kg is not uncommon
    - Infusion dosing at 200mcg/kg/min to 500mcg/kg/min

Laryngospasm

- Higher risk of laryngospasm in pediatrics
- Don't usually use IV induction which bypasses stage II anesthesia
- Mask induction prolongs stage II anesthesia
- Initial management: PEEP and jaw thrust; if airway maneuvers unsuccessful, use IM succinylcholine and atropine
- Awake vs. deep extubation depends on patient and procedure

Mapleson Circuits

- Mapleson circuit used for transporting patients → green bag does not stay inflated unless actively inflating it
- More dead space
- Don't conserve heat, water vapor, anesthetic vapor

What techniques do you use for pediatric anesthesia?
What circuits do you use for pediatric anesthesia?