Pediatric Considerations

Chapter 5

Pediatric airways provoke lots of anxiety for those who do not manage them routinely. Fortunately, most children are relatively easy to intubate and BVMV. The same general pharmacology and multiple attempts algorithm also apply to children with only a few minor modifications. There are still plenty of ways to get into trouble if you are not careful. It is important to recognize anatomical and physiological differences between adults and children, the importance of weight-based dosing and the importance of using equipment designed for, and sized for, pediatric patients.

Anatomical and Physiological Differences in Children

- **The larynx is more superior and anterior in the neck**
  - External laryngeal manipulation is particularly useful
  - A bougie may be helpful
- **The trachea is shorter**
  - It is easier to place a tube in the mainstem bronchus
  - It is easy to accidentally extubate
- **The trachea is smaller in diameter and more fragile**
  - Overly aggressive cricoid pressure could occlude the airway
- **The epiglottis is relatively large and floppy**
  - Straight blades may be preferred

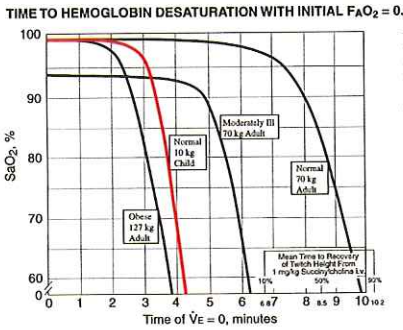
- **The narrowest point in the upper airway is below the vocal cords at the cricoid ring rather than at the cords themselves**
  - Traditionally uncuffed endotracheal tubes have been used in pediatric patients
  - Many clinicians and centers are now moving towards routine use of cuffed tubes in pediatric patients
    - The cuff need not be blown up unless an air leak is detected
    - Consider using 1/2 size smaller tube if cuffed

- **The tongue is relatively large for the size of the mouth**
  - A curved blade may be required to manage the tongue
  - Appropriately sized oral and nasal airways may be very helpful

- **The head and occiput are relatively large**
  - Towel roll placed under the shoulders in an infant will achieve optimal airway positioning rather than sniffing position

Here we see an infant with a shoulder roll to compensate for her large occiput and achieve perfect airway positioning.

- **The functional residual capacity is small and basal metabolism is high**
  - Children may desaturate rapidly despite pre-oxygenation, especially if the indication for intubation was hypoxemia
  - Be prepared to perform optimal BVM ventilation and have the appropriately sized extraglottic airway available



From Benumof J, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg succinylcholine. Anesthesiology 1997;87(4):979-982 with permission.

- **High resting vagal tone**
  - Hypoxemia, airway stimulation and medications (especially succinylcholine) may all result in bradycardia
  - Atropine should be readily available at the bedside during any pediatric RSI, especially if using succinylcholine

- **Small lungs**
  - Children are more prone to barotrauma from over-aggressive ventilation
    - Use the lowest possible tidal volume to achieve gentle chest rise
    - Watch ventilator pressures closely and use pressure-controlled ventilation when possible
    - When bagging use the "squeeze, release, release" method to allow adequate exhalation time and avoid breath stacking

So I'm confused. Is it straight-blades or curved-blades for children? *Many of us were taught that you must use a straight-blade for children to control the relatively large and floppy epiglottis. If this were always true there would be no reason that we all carry curved-blades in pediatric sizes! It turns out that it is a case-by-case decision depending on whether the obstacle to laryngoscopy is the epiglottis (straight-blade may be better) or a big, floppy tongue (curved-blade is probably better). I usually start with a straight blade but always have an appropriately sized curved blade ready to go.*

What's the deal with all the cuffed ET tubes being used on kids these days?

Even though the narrowest portion of the pediatric airway is below the vocal cords it is not surprising that an uncuffed endotracheal tube may not seal the airway well for optimal ventilation or airway protection. When used, you may need to select a cuffed tube one-half size smaller than the appropriately sized uncuffed tube for that patient. The cuffs are not generally inflated unless an air leak is detected and then only the minimum amount of air necessary to overcome the leak is used; this pressure is then meticulously monitored. It is still appropriate to use an uncuffed tube and most EMS services and general EDs are not stocking cuffed tubes unless specifically requested by the pediatric ICU specialists in their area.

RSI Pharmacology for Children

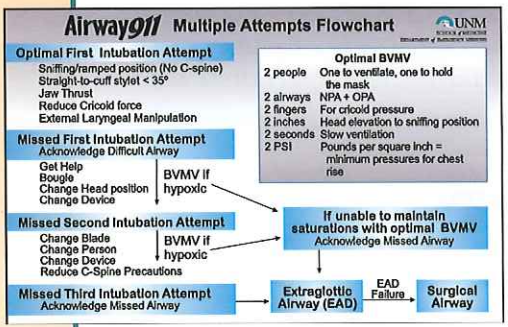
Visual estimates are notoriously inaccurate. In children it is very important to base dosages upon body weight. If the child's weight is not accurately known the parent's estimate is the next best thing. After that use the length-based Broselow tape or another validated estimation tool. Note that with many medications children require a higher, rather than lower, dose per body weight, i.e. propofol and midazolam.

All of the pre-medications, induction agents, paralytics, sedatives and analgesics included in this text are appropriate for children. Some providers consider succinylcholine relatively contraindicated in children due to the propensity for bradycardia and the risk of fatal hyperkalemia in the setting of undiagnosed muscular dystrophies. While a non-depolarizing agent is a modestly better choice for children, millions of children have been intubated uneventfully with succinylcholine. It is highly recommended, however, that atropine be readily available. *Airway911* is no longer recommending routine pretreatment with atropine.

RSI Technique for Pediatric Patients

Overall, RSI technique for adults and pediatric patients is very similar. Clearly, drug dosages and equipment sizes vary and should be based on known weight or estimated height, using the Broselow Tape or other validated tool.

The Multiple Attempts Algorithm is essentially the same for children with a few caveats. The optimal position for the pediatric airway and intubation varies with the age, from a towel roll behind the shoulders in infants, nothing in toddlers and sniffing position in school-age children. Stylet shape may be better with a bit more of a "hockey-stick" shpape than the less than 35 degree straight-to-cuff shape recommended in adults. A straight-blade is the usual starting point but appropriately sized curved-blades should also be available if tongue control is difficult. Be sure to use ELM to help visualize anterior airways and be gentle with cricoid pressure to avoid occluding the airway. Pediatric bougies are manufactured though not yet used as commonly as in adults. Surgical airways are not performed in patients less than 6 - 8 years of age.



Tube confirmation may be done with end-tidal CO_2 detection at any age but there are specific pediatric products for qualitative capnography. In very small infants these devices may represent enough dead-space to be problematic and are removed after confirmation. Esophageal detector devices are FDA approved down to 20 kg but well studied down to 10 kg using the "off-deflate" method.

Nellcor adult CO_2 detector on the left and pediatric detector on the right.

It is noteworthy that children without unusual congenital malformations are usually easier to intubate than adults and, unlike adults, children can almost always be oxygenated and ventilated with a BVM.

Pediatric Difficult Airways

Causes of difficult airways in children are often the same as in adults but there are several issues that are either specific to children or much more common in children. These include:

- Infections: epiglottitis, retropharyngeal abscess, tracheitis
- Non-Infectious: foreign body, airway edema, congenital defects

The same decision tree for adults may be used for pediatric patients. Whenever possible obtain expert help when dealing with pediatric difficult airways.

Pediatric Back-Up Airways

BVMV is the first back-up as most children can be easily ventilated and oxygenated with this technique. Gastric distention from BVMV is common and may limit ventilation, cause bradycardia through vagal stimulation, and predispose to regurgitation and aspiration. To prevent this, use only enough pressure and tidal volume to cause chest rise and maintain cricoid pressure. Also, be sure to use a 450ml BVM for pediatric patients less than 40 kg or smaller for neonates. When abdominal distension occurs it should be treated with a gastric tube.

Until recently only the LMA-Classic and LMA-Unique were available in pediatric sizes. Extraglottic airways currently available in pediatric sizes include many of the laryngeal airways as well as the King LTS-D airway. Many of the other EADs are being developed for pediatric patients. There is little information available at this time to tell us if any of these devices are clearly superior.

Do you recommend anesthesia bags?

Anesthesia bags (i.e. those floppy thin walled bags found on every anesthesia machine) do not self-inflate. Instead, inflation is controlled by a valve on the end of the bag and the amount of oxygen flow. These bags require some practice to use but allow much better assessment of lung complance and therefore limit the potential for barotrauma. I use them whenever possible in very young infants and neonates.

Pediatric Alternative Airways

Surgical cricothyroidotomies are contraindicated in children; most physicians use a cut-off around 8 years of age. Transtracheal jet insufflation (TTJI) is acceptable, though rarely indicated. For this reason it has been taken out of the prehospital scope of practice for paramedics in many jurisdictions.

Nasal intubation is rarely used in pediatric patients due to the small caliber of endotracheal tube that would be required.

Digital intubation is not possible in all but the largest children and/or by practitioners with very small hands.

Non-invasive positive pressure ventilation is being used much more commonly in pediatrics as in adults. There is generally less experience with this technology in children outside of the PICU setting.

Retrograde intubation can be performed in children though it is very rare.

Awake intubation is a very reasonable pediatric procedure using the techniques described in Chapter 4. This manner of emergency awake intubation is a bit of a misnomer in that the patients are quite sedated and not expected to be cooperative.

Take Home Points

- Children have distinct anatomical and physiological differences with important clinical correlations for airway management.
- RSI medications should be based upon a reliable weight estimate.
- External laryngeal manipulation is particularly useful in children due to their anterior larynx.
- Succinylcholine is relatively contraindicated for children yet commonly used in emergency settings.
  1. Atropine should be available at the bedside.
- Children are more prone to hypoxemia during RSI because of high resting oxygen metabolism.
- Children are usually easier to bag-valve-mask ventilate than adults. This is the primary back-up.
- Gastric insufflation in children may result in profound bradycardia. Use the minimum pressure and volumes necessary and place a gastric tube after intubation to decompress the stomach.
- Back-up airways available in pediatric sizes include the LMA-Unique, LMA-Classic, AmbuLMA, AirQ, CobraPLA and King LT-D. Have at least one available at the bedside.
- Surgical airways are contraindicated under 6 - 8 years of age and TTJI is rarely used.

Case Scenario

Peds Case

A 1-year old ex-28 week premature female with some residual bronchopulmonary dysplasia but no other medical problems is referred to a Pediatric Emergency Department by her primary pediatrician because of difficulty breathing and presumed RSV bronchiolitis. On exam she is sitting up in Mom's arms, lethargic, and in severe respiratory distress with grunting, retractions and accessory muscle use. Lung sounds are diminished but remarkable for scattered wheezes and crackles. Oxygen saturation is 89% on blow-by with a non-rebreather. Her heart rate after rectal Tylenol and a 40 cc/kg fluid bolus is 160. Chest x-ray is consistent with bronchiolitis and a focal infiltrate. The decision is made to intubate. What is your assessment and plan?

PREOXYGENATE: the patient is unlikely to tolerate any assisted respirations unless extremely lethargic. Blow-by in the position of comfort, likely held by parent, is probably the best available option.

PROTECT C-SPINE: Not indicated.

PRESSURE TO CRICOID: Will be used, but very gently, from the time induction medication is given until the tube is confirmed in the trachea, unless the intubation proves difficult.

PONDER: This represents an unfortunately routine intubation for a busy pediatric referral center. On LEMONS assessment the major difficulty will be the oxygen saturation. Given that even healthy pediatric patients have less oxygen reserve it can be anticipated that the patient will desaturate quickly after induction and paralysis. Fortunately she is also likely to tolerate the hypoxemia relatively well for a brief period. The intubation will probably be relatively easy and she most likely can be oxygenated very well with BVMV or an EAD. I would consult with the PICU and the patient's parents before RSI.

PREPARE EQUIPMENT AND PEOPLE: I would have at least two sizes of cuffed endotracheal tubes available. I would also have a pediatric bougie and two sizes of EAD available though they probably do not need to be taken out of the package. I would have both straight and curved laryngoscope blades available. Assistants prepared to monitor saturations, assist with cricoid pressure/ELM, assist with the bougie and hold the tube will be very important so the intubator can stay focused on the airway.

PREMEDICATE: I would not premedicate this patient though I would have atropine available.

POSITION THE PATIENT OPTIMALLY: The patient should probably stay in the position of comfort until induced unless she is lethargic enough to tolerate assisted respirations. BVMV and intubation should start with a towel roll behind the shoulders.

PARALYZE AND INDUCE: Any induction agent would be fine for this patient including etomidate, ketamine and midazolam. Paralysis with rocuronium would be slightly preferable to succinylcholine to avoid additional risk of bradycardia and the extremely rare chance of undiagnosed muscular diseases. Succinylcholine is perfectly acceptable however. Whichever agents are selected I would have atropine available at the bedside though I would not pretreat.

PASS THE TUBE: Optimal first attempt would include age-appropriate positioning, selection of a straight-blade and appropriate management of cricoid pressure and use of ELM. If the initial attempt were missed, most likely because time runs out due to hypoxemia, the patient would be oxygenated with BVMV while preparations made for a second attempt. If the problem was tongue control I would switch to a curved blade. If the problem was an anterior airway despite ELM I would try the bougie. If the problem were none of the above I would probably switch intubators if someone else were available and/or try repositioning the patient.

POST-INTUBATION MANAGEMENT: The tube will be confirmed with end-tidal CO_2 and secured with a commercial pediatric tube holder or tape. A cervical collar or towel rolls can be considered to minimize head movement. The patient will be placed on the ventilator with continuous end-tidal CO_2 monitoring to monitor for tube displacement. Sedation and analgesia with midazolam and fentanyl is appropriate.