Revista Mexicana de Anestesiología

CONFERENCIAS MAGISTRALES
Vol. 39. Supl. 1 Abril-Junio 2016
pp S294-S296

What makes the pediatric airway so difficult?

Jerrold Lerman MD, FRCPC, FANZCA*

* Women and Children's Hospital of Buffalo, Buffalo, NY.

Preoperative evaluation

The most important evaluation of the child's airway is observation: generally, «what you see is what you get». Two conditions should be met in order to adequately evaluate the child's airway. First, observe the child face on and in profile. Symmetry of the mandible/maxilla is essential, but if the mandible is receded compared with the maxilla in the profile, be prepared for a challenging laryngoscopy. If the child has a syndrome, BE CAREFUL. Some children appear normal, depending on their age (eg., arthrogryposis) but present challenges to intubate the trachea. This occurs decidedly less commonly in children than adults but it does occur. Second, have the child open the mouth fully, sticks out their tongue and move the neck in a full range of motion. If all conditions are satisfactorily met, then laryngoscopy and tracheal intubation should be straightforward. The Mallampati and Cormack Lehane scores, BMI, neck circumference and thyromental distance do not predict difficult intubations in children. Previous difficulties with tracheal intubation may suggest that tracheal intubation could be difficult, although this varies with the airway pathology.

Several features distinguish the upper airway in the neonate compared with the adult:

1. Larger head and occiput in the infant compared with the adult.
2. Larger tongue relative to the mouth size in the infant.
3. Long floppy, omega-shaped epiglottis in the infant.
4. Edentulous, for the most part.
5. Larynx is cephalad at C3-C4 level, unlike the adult, at C5-C6.
6. Vocal cords are deceptively angled more anterior in infants.
7. Cricoid ring is the narrowest part of the infant airway… prone to edema.
8. Shorter trachea (4-5 cm) in the infant compared with the adult.

These unique characteristics present several challenges to managing the airway during facemask ventilation and laryngoscopy as presented below. Recently, some have re-evaluated previously held maxims and redefined some myths. In 1951, Eckenhoff reported that the subglottic region in the child is funnel-shaped[1]. However, several have challenged this finding with evidence from CT scans that suggest that the subglottis may be narrower in the transverse than the anterior-posterior dimensions and narrower overall than the cricoid ring[2]. It should be noted that these were averaged dimensions from children 1 month -10 years of age (mean of 4 years) and in sedated, spontaneously breathing subjects. Data from neonates and infants were not presented separately. This does not change our management of the pediatric airway nor does it alter our basic understanding that a tube that does not pass through the subglottis (wherever the narrowing is located) should be exchanged for a tube with a smaller external diameter.

Numerous sources have repeated the misconception that airflow in the upper airway is laminar in nature (Reynold's number < 2,300). This has resulted in an incorrect relationship that suggested that the increased pressure drop (or work of breathing) across a narrowed cricoid ring varied inversely with the decrease in the radius to the fourth power. However, laminar flow only occurs beyond the fifth bronchial division of the tracheobronchial tree. Up to that level in the tracheobronchial tree, flow must be much faster than below that level, eg., turbulent (Reynold's number > 4,000). With turbulent flow, the pressure drop across a narrowing is inversely related to the radius to the fifth power. Thus, a 50% reduction in radius of the cricoid ring (as may be seen in croup) increases the pressure drop across the ring by radius to the fifth power or 32 fold. This is the primary reason infants fatigue without resolution of the decrease in radius of the upper airway.

Mask ventilation

Although this is the most critical aspect of managing the pediatric airway, it is a skill that is rapidly being lost. The introduction of the laryngeal mask airway has made it increasingly difficult to acquire experience in managing the airway with a mask in neonates and children.

The anatomical features of the pediatric airway present increasing challenges during anesthesia with collapse of most intraoral structures. This combined with the presence of masses within the airway (such as large tonsils and adenoids) obstruct the upper airway. Optimizing the patency of the child's upper airway is achieved by understanding the «ultimate» jaw thrust and the physiology of the temporomandibular joint[3]. To maximize patency of the upper airway, not only should the mandible be anteriorly displaced, but the temporomandibular joint must be rotated to open the mouth. Both anterior displacement and rotation of the joint can be accomplished simultaneously by application of anterior pressure by a digit bilaterally at the apex of the condyle of the ascending ramus of the mandible under anesthesia. This will be demonstrated in a video during the lecture.

Laryngoscopy

Most practitioners were never taught how to use laryngoscope blades nor how to perform laryngoscopy. This becomes readily apparent when they are faced with a difficult or challenging airway to instrument. We shall review some of these basic principles.

The child is first positioned supine on the bed without a headrest. There is no need for a shoulder roll as the child is naturally in a sniffing position; the roll undermines the occiput, raising the larynx and causing the operator to sit down to visualize the larynx.

Because infants and children have long floppy epiglottises, most lift the epiglottis to fully expose the laryngeal inlet. It is possible to use a Macintosh blade to expose the larynx, although most textbooks recommend only the straight (Miller) blade for use in infants and children. To determine whether these two blades have equipoise in the view of the vocal cords, we compared the view of the larynx with the Macintosh and Miller blades in 50 young infants and children < 2 years of age[4]. The Miller blade above and below the epiglottis and the MAC blade above the epiglottis yielded similar views of the larynx although when the MAC lifted the epiglottis, the view was inferior as the blade partially blocked the view of the larynx.

Miller first described his blade in adults inserting it in the midline with the maxillary teeth covered with a lead toothguard[5]. In a subsequent report describing a pediatric version of the same blade, he inserted the blade into the mouth at the right commissure with the tip pointed towards the vocal cords[6]. Here, the blade rests on the bicuspids and lateral incisors, which have two roots that are deeper than the single shallow rooted central incisor. These teeth cannot easily be dislodged by the laryngoscope blade, unlike the central incisors, which can be easily dislodged if the blade is inserted in the midline. Furthermore, the angle and distance from the commissure to the glottic opening is more favorable than a blade inserted in the midline, rendering this approach (known as the paraglossal approach) superior for difficult tracheal intubations in children (and adults)[7].

Tracheal intubation in the neonatal intensive care unit has been heavily criticized in the past. For the most part, this has been attributed to the lack of skills on the part of pediatric residents performing the intubation. In a randomized trial aimed at identifying how best to teach intubation in neonates, the use of a videolaryngoscope yielded more successful intubations compared with direct laryngoscopies, presumably from the timely feedback offered by the instructor watching the laryngoscopy[8].

Orotracheal intubation

Many have transitioned from uncuffed to cuffed tracheal tubes in the recent past with the introduction of the Microcuff tracheal tube[9,10]. Some justify the additional cost of these tubes with savings from the reduced gas flows (but we were already using low flows). I find this argument specious since we always use flows of 2 liters or less. Their use may be more justified because of the reduction in the number of laryngoscopies and tube changes required to seal the airway and to adequately ventilate the lungs of children in whom high airway pressures are required. In any case, the several-fold greater cost of these new tubes remains a difficult pill to swallow in my estimation.

The Microcuff tracheal tubes are optimally designed for use in children with elliptically shaped cuffs (to seal the airway at reduced cuff pressures), a soft (high compliance), distally applied cuff and no Murphy eye. The clinician should be advised that these tubes are ideally positioned based on the markings on the distal tube rather than the cm numerals.

Although these tubes have been safe and effective in children, we discovered post-extubation stridor in a retrospective review of neonates and infants in whom the Microcuff tube was compared with uncuffed tubes[11]. In some instances, the choice of the Microcuff tube size was not consistent with the manufacturer's recommendations and in others, the cuff pressure was not assessed. Nonetheless, for the meantime, the limited evidence that these tubes are safe in neonates and young infants should cause clinicians to be circumspect when considering their use in this age group.

Nasotracheal intubation

We studied the severity of nosebleeding during nasotracheal intubation and reported (as did others) that when the distal tip of tracheal tubes was covered with a red rubber catheter, bleeding was almost non-existent[12]. In the absence of mucosal vasoconstrictors, we demonstrated a 10-fold reduction in the severity and presence of bleeding compared with no pretreatment. Which nostril is preferred? This is often a question most residents fail to answer correctly. The answer is the left nostril. Can you figure out why? The answer will be presented in the lecture.

The recent enthusiasm with cuffed orotracheal tubes has spilled over into the use of cuffed preformed tubes. Manufacturers seem to have scaled down the dimensions of their cuffed preformed nasotracheal tubes for adults to diameters appropriate for children but without compensatory reductions in the tube length from the nasotracheal curve to the tip of the tube. As demonstrated in a very careful analysis, the length of most cuffed preformed nasotracheal tubes were 1.5-2 cm greater from the preformed bend to the mid-trachea[13]. Awareness of this extra length should allow one to anticipate this and build up the tube outside the nares to avoid an endobronchial intubation.

Laryngospasm

The most serious airway complication is laryngospasm, unplanned closure of the glottic aperture, which occurs in 3-14% of pediatric anesthetics. Factors that predispose to laryngospasm include young age, recent upper respiratory tract infection, bleeding or other fluids in the airway, light anesthesia (or certain anesthetics such as desflurane), inexperienced operator, passive smoking and airway surgery[14]. As it develops, stridor may be heard along with suprasternal and supraclavicular retractions. If unabated, the vocal cords close leaving silent respiratory efforts described as «rocking horse movement» of the chest. The reservoir bag remains still and the capnogram becomes flat. If uninterrupted, hemoglobin desaturation follows, along with bradycardia and possibly cardiac arrest.

Management of laryngospasm begins with early identification and intervention to prevent complete closure of the cords[15]. As soon as early laryngospasm is identified, constant positive airway pressure should be applied with 100% oxygen using a tight-fitting facemask. Do NOT attempt to ventilate the lungs with the mask, but rather maintain positive pressure by simply closing the adjustable pressure limiting valve. I do not use oral airways as the problem is almost always beyond the tongue. I apply digital pressure at the condyles of the mandible while propofol is prepared for IV administration[16]. Digital pressure at the condyles is very painful, stimulating the child to squirm and attempt to scream. In so doing, the child will open his/her vocal cords. Patience is important, although if the course of the laryngospasm continues to deteriorate, I administer atropine (20 μg/kg) followed by succinylcholine (0.5-1 mg/kg) IV rather than wait for a cardiac arrest to ensue.

REFERENCES

1. Eckenhoff JE. Some anatomic considerations of the infant larynx influencing endotracheal anesthesia. Anesthesiology. 1951;12:401-410.
2. Wani TM, Bissonnette B, Rafiq-Malik M, Hayes D Jr, Ramesh AS, Al Sohaibani M, et al. Age-based analysis of pediatric upper airway dimensions using computed tomography imaging. Pediatr Pulmonol. 2016;51:267-271.
3. Larson CP Jr. Laryngospasm-the best treatment. Anesthesiology. 1998;89:1293-1294.
4. Passi Y, Sathyamoorthy M, Lerman J, Heard C, Marino M. Comparison of the laryngoscopy views with the size 1 Miller and Macintosh laryngoscope blades lifting the epiglottis or the base of the tongue in infants and children <2 yr of age. Br J Anaesth. 2014;113:869-874.
5. Miller RA. A new laryngoscope. Anesthesiology. 1941;2:317-320.
6. Miller RA. A new laryngoscope for intubation of infants. Anesthesiology. 1946;7:205.
7. Henderson JJ. The use of paraglossal straight blade laryngoscopy in difficult tracheal intubation. Anaesthesia. 1997;52:552-560.
8. O'Shea JE, Thio M, Kamlin CO, McGrory L, Wong C, John J, et al. Videolaryngoscopy to teach neonatal intubation: a randomized trial. Pediatrics. 2015;1336:912.
9. Dullenkopf A, Gerber AC, Weiss M. Fit and seal characteristics of a new paediatric tracheal tube with high volume-low pressure polyurethane cuff. Acta Anaesthesiol Scand. 2005;49:232-237.
10. Weiss M, Dullenkopf A, Fischer JE, Keller C, Gerber AC; European Paediatric Endotracheal Intubation Study Group. Prospective randomized controlled multi-centre trial of cuffed or uncuffed endotracheal tubes in small children. Br J Anaesth. 2009;103:867-873.
11. Sathyamoorthy M, Lerman J, Asariparampil R, Penman AD, Lakshminrusimha S. Stridor in neonates after using the Microcuff® and uncuffed tracheal tubes: a retrospective review. Anesth Analg. 2015;121:1321-1324.
12. Watt S, Pickhardt D, Lerman J, Armstrong J, Creighton PR, Feldman L. Telescoping tracheal tubes into catheters minimizes epistaxis during nasotracheal intubation in children. Anesthesiology. 2007;106:238-242.
13. Hunyady AI, Jonmarker C. Are preformed endotracheal tubes appropriately designed for pediatric patients? Paediatr Anaesth. 2015;25:929-935.
14. Flick RP, Wilder RT, Pieper SF, van Koeverden K, Ellison KM, Marienau ME, et al. Risk factors for laryngospasm in children during general anesthesia. Paediatr Anaesth. 2008;18:289-296.
15. Hampson-Evans D, Morgan P, Farrar M. Pediatric laryngospasm. Paediatr Anaesth. 2008;18:303-307.
16. Batra YK, Ivanova M, Ali SS, Shamsah M, Al Qattan AR, Belani KG. The efficacy of a subhypnotic dose of propofol in preventing laryngospasm following tonsillectomy and adenoidectomy in children. Paediatr Anaesth. 2005;15:1094-1097.