Pediatric Airway Management: A Critical Review

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Endotracheal tubes (ETT): tube size—choosing correct size important; Suominen et al (2006) studied 234 children 0 to 9 yr of age; tube size determined by formula; concluded that absence of acceptable air leak at pressure of 25 cm of H2O increases likelihood of problems with airway during emergence from anesthesia; cuffed ETT—Khine et al (1997) concluded that replacement needed less often with use of cuffed tubes than with uncuffed tubes, with associated benefits of reduced trauma from repeat laryngoscopy, less operating room pollution, and use of lower gas flows, without any increase in problems; prospective randomized trial of 2246 children 0 to 5 yr of age demonstrated that change of tube required in almost one-third of patients with uncuffed tubes, compared with 2.1% of those with cuffed tubes; study of very young infants found use of overly large ETT (cuffed or uncuffed) associated with complications

Measuring cuff pressure: Tobias et al (2012) demonstrated that cuff pressures often higher than recommended; Calder et al (2012) reported that reintubation required in 1.2% of patients with cuffed tubes, compared with 2.1% of those with cuffed tubes; study of very young infants found use of overly large ETT (cuffed or uncuffed) associated with complications

Pressure of cuff: optimal pressure preferred (pressure too high or too low result in leaks)
Failure of LMA: in survey of >11,000 cases, predictors of failure included otolaryngology cases, long procedures performed on inpatients, procedures requiring transport of patient, and airway abnormalities

Second-generation LMA devices: Proseal—improved pharyngeal seal helps control ventilation; improved esophageal seal lessens risk for aspiration; permits insertion of gastric tube (allows performance of upper gastrointestinal endoscopy through airway); easier to insert than classic LMA (has higher success rate in small infants); speaker suggests inserting gum elastic catheter through gastric orifice (used to slide airway into optimal position)

Removal of LMA: may be removed while patient still anesthetized or when awake; when making decision, consider patient factors (eg, age, airway, upper respiratory infection), anesthetic agents used (eg, premedications, total intravenous [IV] anesthesia, volatile agents), type of procedure (eg, otolaryngologic procedure with blood in airway and local pain); removal while patient still anesthetized recommended when using sevoflurane; when using desflurane, tube may be removed when patient awake

LMA vs ETT: in meta-analysis of >700 patients undergoing each method, incidence of desaturation or laryngospasm tended to be lower with LMA; concerns associated with LMA—risk for and prevention of aspiration; air leak during controlled ventilation, which may cause hyperventilation and gastric distention; displacement of device; UK survey described 2 cases of significant aspiration in pediatric patients, both of whom had undergone manipulation of fractures in late evening; in this scenario, patients commonly present with full stomachs, and vomiting often occurs during emergence; reducing complications associated with LMA—limit use to appropriate patients and expert practitioners; understand limits of LMA; use correct size; exercise vigilance; ensure appropriate precautions, timing, and removal

Newer LMA devices: single-use gel-like noninflatable supraglottic device (i-gel)—in review of 154 children, incidence of complications 23%; blood seen on device in almost 10%; in randomized equivalence trial, i-gel associated with much higher rate of complications than single-use LMA (LMA Supreme); perilaryngeal airway (PLA; CobraPLA)—in one study, associated with higher leak pressure, compared with single-use LMA (LMA Unique); although both devices reportedly performed well, conflict of interest may exist because one coauthor invented device; another study halted because of 2 cases of aspiration; PLA has been successfully used in children

Educational Objectives

The goals of this program are to improve airway management in children and the anesthetic care of children with confirmed or suspected obstructive sleep apnea. After hearing and assimilating this program, the clinician will be better able to:

1. Choose an appropriate endotracheal tube for a child.
2. Weigh the risks and benefits of different supraglottic airway devices in children.
3. Identify the signs, symptoms, and predictors of obstructive sleep apnea (OSA) in children.
4. Choose a preferred technique for the anesthetic management of a child with OSA.
5. Avoid complications related to the use of opioids in children with OSA.

Faculty Disclosure

In adherence to ACCME Standards for Commercial Support, Audio Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, members of the faculty and planning committee reported nothing to disclose.
but shows tendency toward easy displacement, associated with blood on device, and may increase risk for aspiration

**Use of LMA for difficult airway: study** — looked at 109 pediatric patients with difficult airway undergoing procedures lasting >4 hr; LMA used as primary airway; 4 patients required change of airway during procedure (difficult to perform during complex surgery); paper — recommends awake fiberoptic intubation or fiberoptic intubation through LMA, which may offer lower-risk alternative to LMA

**Updates on the Snoring Child**

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**Obstructive sleep apnea (OSA) in children:** clinical criteria for making diagnosis not established; STOPBang and other questionnaires do not work well for children; clinician must rely on clinical judgment of sleep study; since most children presenting for tonsillectomy have not had sleep study, presence of OSA usually undetermined; sensitivity to opioids primary concern

**Morbidity and mortality associated with tonsillectomy:** mortality 1 in 10,000 to 1 in 100,000, but substantially higher morbidity and mortality seen in some subsets of patients; Cote et al (2014) — reviewed >100 cases of tonsillectomy and adenoidectomy resulting serious adverse outcomes (including death and neurologic injury); some, but not all, had OSA; ≈40% of events occurred in postanesthesia care unit (PACU) or OR; 50% occurred at home; events that lead to neurologic problems or death primarily followed period of apnea, while patients who did not have OSA had consequences related to bleeding; concluded that approximately one-half of events that occurred in perioperative period preventable, and substantial number could have been prevented by adequate monitoring

Causes of complications after tonsillectomy: attributed to cardiovascular factors, drugs, and hemorrhage; comorbidities include neurologic disease and obesity; most events occur <48 hr after surgery; apnea and opioid overdose particular problems within 3 days of operation (in contrast with hemorrhage, which can be more delayed); children with OSA seem to have higher incidence of bleeding than those without OSA

**Case report:** 8-yr-old weighing 85 kg with history of Ebstein anomaly presented for tonsillectomy in ambulatory center; anesthesiologist saw patient, took history, and went to research Epstein anomaly on internet; patient given 15 mg midazolam; anesthesiologist saw patient, took history, and went to research Epstein anomaly on internet; patient given 15 mg midazolam orally; shortly after IV line started, code called, but no arrest cart present in preoperative area; cardiopulmonary resuscitation unsuccessful; assessment of case — patient arrived in borderline condition with right heart failure; had not seen cardiologist in 2 yr and had not lost weight as advised; had pulmonary hypertension secondary to hypoxia, obesity, and Ebstein anomaly (tricuspid defect), which resulted in right ventricular overload; starting of IV may have triggered catecholamine response significant enough to increase pulmonary artery pressure; backup of intensive care unit needed in such cases

**Snoring child:** primary snoring occurs in 20% to 30% of children, with no significant consequences in most; OSA (characterized by intermittent complete upper airway obstruction associated with hypoxia and hypercapnia) represents extreme end of continuum of sleep-disordered breathing; intermediate syndromes include upper airway resistance syndrome and obstructive hypopnea (not well understood); ≤10% of children with primary snoring have OSA

**Pathophysiology of OSA:** obstruction of airway leads to fragmentation of sleep; loss of muscle tone causes asphyxiation; increasing airway resistance results in progressive hypoxemia; obstruction most often in upper airway, ie, displacement of soft palate against pharynx causing dramatic increase in negative pressures as child attempts to breathe against closed upper airway; edges of nasopharyngeal airway and soft palate become ragged because of huge negative pressures applied to sensitive epidermis; this causes edema, massive airway obstruction, and progressive hypoxemia

**Signs and symptoms of OSA in children:** not same as in adults (not correlated with sex); primarily caused by upper airway obstruction; complicated by comorbidities, eg, Cruzan disease, other craniofacial abnormalities, obesity, chromosomal abnormalities; body habitus ranges from failure to thrive to obesity (associated neurocognitive dysfunction can cause failure to thrive because of indifference to food, avoidance of swallowing, and lack of appetite); morning somnolence may or may not be present; hyperactivity, developmental delay, enuresis, and disruptive behavior common; systemic inflammatory response — association with OSA identified in children; resolution of inflammatory response may occur after tonsillectomy; intermittent hypoxia, hypercapnia, and sleep deprivation promote proinflammatory reaction (eg, interleukin-6) and diminish anti-inflammatory proteins (eg, interleukin-10); Gonzal et al (2008) — classified OSA in children; type 1 defined as pure problem of airway; type 2 associated with obesity and systemic inflammatory response; patients with type 1 typically present with hyperactivity and large tonsils; type 2 typically present with excessive daytime sleepiness, obesity, and problems associated with obesity

**Obesity and OSA:** in general, OSA more severe and quality of life poorer in patients with obesity; improvement in OSA after tonsillectomy less dramatic in patients with obesity than in slender children

**Predictors of OSA:** positive predictive value of history only 65%; physical examination equally poor; when history and physical examination combined with abbreviated polysomnography, sensitivity and specificity still poor; with addition of, eg, radiologic testing, rhinomanometry, positive predictive value approaches 90%; Gozal et al (2009) — observed increase in urinary proteins in children with OSA; proteins not present in urine of typical children or children with snoring; demonstrated 100% sensitivity and 95% specificity for OSA when 2 proteins present; if 3 proteins present, specificity nearly 100%; prospective randomized trial needed to validate results

**OSA in young children:** severity often associated with comorbidities; prematurity, genetic syndromes, and neuromuscular anomalies contribute to OSA; suspicion of OSA heightened if any comorbidities or syndromes present

**Anesthetic management:** oral midazolam may be used and has limited side effects; anesthesia by mask good option; LMA may not be helpful given possible upper airway obstruction; jaw thrust should be performed from behind pinna at coronoid process rather than at angle of mandible; ETT with spontaneous respirations preferred

**OSA and opioids:** Waters et al (2002) — compared children with known OSA with normal control group; patients anesthetized with halothane and allowed to breathe spontaneously, then given fentanyl 0.5 μg/kg IV; demonstrated 10-fold greater incidence of apnea in patients with OSA (occurred in almost half of patients with OSA, compared with <4% of patients in control group); Brown et al (2004) — children with severe OSA and oxygen saturation <85% displayed increased sensitivity to opioids (required ≤50% morphine in PACU); sensitivity to opioids and altitude — study compared use of opioids in children in Lima, Peru (sea-level) vs Cuzco, Peru (high altitude); dose of opioids required by patients in Cuzco half of that in Lima

Pathophysiology of sensitivity to opioids: high altitude upregulates neurohormones and genes (eg, c-FOS, c-Jun) and inflammatory response (eg, hypoxia-inducing factor [HIF]-1); small doses of opioids (eg, 10 μg/kg of morphine, 0.5 μg/kg of fentanyl) may cause apnea

**Detection of sensitivity to opioids:** not possible with ETT and mechanical ventilation; giving normal dose of opioid risks apnea in PACU; speaker recommends that, for patients suspected of having OSA, administer anesthesia that allows for spontaneous respirations, and then give test dose of opioid; with negative respiratory response (eg, apnea), avoid further
administration of opioids; in these patients, small test dose sufficient for ongoing analgesia; surgeons and nurses must then be notified of sensitivity to opioids; admitting and monitoring these patients in hospital postoperatively prudent

Management of children with sleep apnea: may substitute with celecoxib, acetaminophen, ketamine, or dexmedetomidine; however, safe analgesia after discharge remains challenging; criteria for inpatient admission — severe OSA; OSA with complications; pulmonary hypertension; age <3 yr (some suggest <2 yr); obesity and other associated comorbidities; complex diseases; admission patterns widely vary among hospitals

Codeine and OSA: most common analgesia used postoperatively in children; children with OSA and obesity commonly given codeine with dose based on weight, which may greatly exceed safe dose; genetic polymorphisms — result in wide range of clinical effects of codeine; hyperactive genes lead to rapid conversion to morphine (has resulted in deaths at home); codeine a prodrug primarily metabolized by CY2D6; some individuals ultrarapid metabolizers (prevalence in some populations as high as 5%-7%); spectrum of polymorphism includes extensive metabolizers, intermediate metabolizers, and poor metabolizers (latter may derive no benefit from codeine because they cannot convert prodrug to active drug); Food and Drug Administration has issued black box warning about use of codeine for children with OSA

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Suggested Reading


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1. All the following are advantages of cuffed endotracheal tubes (ETT) over uncuffed ETT, except:
   (A) Less need for repeat laryngoscopy    (C) Less operating room pollution
   (B) Greater margin of safety for placement (D) Lower gas flow

2. According to a study by Calder et al, the incidence of sore throat is very high when ETT cuff pressures have exceeded:
   (A) 25 cm H₂O   (C) 35 cm H₂O
   (B) 30 cm H₂O   (D) 40 cm H₂O

3. Which of the following are predictors of failure of a laryngeal mask airway (LMA)?
   1. Age <4 yr
   2. Transport of patient
   3. Long procedure performed on an inpatient
   4. Otolaryngologic procedure
      (A) 1,3,4  (B) 2,4  (C) 1,2,3  (D) 2,3,4

4. When a patient is ________, it is advisable to remove the LMA while the patient is still anesthetized.
   (A) Receiving total intravenous sedation  (C) Anesthetized with desflurane
   (B) Undergoing an otolaryngologic procedure (D) Anesthetized with sevoflurane

5. According to a meta-analysis, LMAs are associated with lower risk for which of the following, compared with ETT?
   1. Laryngospasm
   2. Aspiration
   3. Desaturation
   4. Gastric distention
      (A) 1 (B) 1,3 (C) 1,2,3 (D) 1,2,3,4

6. What percentage of children with primary snoring have obstructive sleep apnea (OSA)?
   (A) 2%  (B) 8%  (C) 15%  (D) 20%

7. Which of the following are characteristics that have been associated with OSA in children?
   1. Failure to thrive
   2. Predominance of male sex
   3. Disruptive behavior
   4. Morning somnolence
      (A) 1 (B) 1,3 (C) 1,2,3 (D) 1,2,3,4

8. Which of the following methods shows the highest sensitivity and specificity for independently diagnosing OSA in children?
   (A) Patient history  (C) Rhinomanometry
   (B) Abbreviated polysomnography  (D) Urinary proteins

9. Which of the following is a recommended technique for anesthetizing children with OSA?
   (A) Administration of oral midazolam
   (B) Use of an LMA
   (C) Application of jaw thrust at the angle of the mandible
   (D) Placement of ETT with mechanical ventilation

10. A study by Waters et al (2002), in which pediatric patients were anesthetized with halothane and allowed to breathe spontaneously, found that children with OSA are _______ more likely to experience apnea when given low-dose fentanyl than are children without OSA.
    (A) 4-fold  (B) 6-fold  (C) 8-fold  (D) 10-fold

   NOTE: On Audio Digest Anesthesiology Volume 57, Issue 13, question 1 should have appeared as follows: “. . . propofol was _______ as likely as etomidate to evoke hypotension.”

Answers to Audio Digest Anesthesiology Volume 57, Issue 17: 1-C, 2-D, 3-A, 4-D, 5-A, 6-A, 7-D, 8-D, 9-C, 10-C