Anesthesia for Pediatric Airway Surgery: Recommendations and Review from a Pediatric Referral Center

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The intrinsic risks of surgery on the pediatric airway are significant and well documented. The provider who accepts responsibility for these children should do so with due consideration of the safety of the proposed surgery, the anesthesia department’s ability to provide a continuity of care that minimizes risk, and the provision of care within the standards of local medical centers. In this review, the experience of the Massachusetts Eye and Ear Infirmary’s Department of Anesthesia is used as a basis for the description of the variety of clinical cases that present to our operating room.

Many clinician readers will recognize the calendar of cases: adenotonsillectomy in obese children with obstructive sleep apnea (OSA); direct laryngoscopy (DL) on the former preterm infant with stridor; foreign body in the airway. Others will have similar experience with tertiary referral cases such as revision laryngotracheal resection or intralaryngeal juvenile recurrent papillomata. For those with low-acuity pediatric practice, the review of perioperative challenges with these examples should serve to illustrate the approach necessary to safely anesthetize these children and contribute to broad competency in the management of the pediatric airway.

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KEYWORDS
- Pediatric anesthesia
- Airway surgery
- Tracheostomy
- Laryngotracheal reconstruction
- Anesthesia risk
- Spontaneous ventilation anesthesia

Anesthesiology Clin 28 (2010) 505–517
1932-2275/10/$ – see front matter © 2010 Elsevier Inc. All rights reserved.
PEDIATRIC AIRWAY SURGERY INCIDENCE, RISK, AND COMPETENCE

Demographic and incidence data on pediatric airway surgical procedures in the United States are difficult to estimate and would require a survey of each type of surgery considered. The most informative data may be gleaned from analysis of nearly 700,000 tonsillectomies, with or without adenoidectomy, performed in 2006 as the predominate airway surgery in children. Other surgeries are rare by comparison with most complex airway surgeries referred to tertiary centers. The major sources of other data on perioperative adverse events are the American Society of Anesthesiologists (ASA) Closed Claims Database, the Pediatric Perioperative Cardiac Arrest Database, and large single-center outcomes reports (eg, Mayo Clinic), or national registries such as the United Kingdom Report of the National Confidential Enquiry into Perioperative Deaths. Head and neck surgery remains a high-risk arena for pediatric anesthesia, with no significant decline in its representation among ASA closed claims cases across 3 decades. Ostensibly, the higher risk of ear, nose, and throat (ENT) surgery is caused by surgical manipulation of the pediatric airway and the incumbent risk of subsequent airway event. From 1990 to 2000, 23% of damaging events were caused by respiratory events, with 35% of cases associated with ENT surgery. Other datasets do not find this same association with critical events. The British review of perioperative deaths in 1989 clearly advocated for pediatric patients to receive care from experienced, high-volume providers. Clearly, children categorized as high-acuity (ASA 3–5) require significant experience and expertise to minimize risk; a more difficult debate reflects the rare critical event affecting the child who is ASA 1 to 2 having routine ENT surgery. Recognition of risk requires thorough evaluation of each patient and concurrent medical disease. Although preoperative consultation seems to be a requisite step before anesthesia for airway surgery, often children are acutely symptomatic or referred to an airway specialist with extensive disease. In our center, such children are often fast-tracked to the operating room. Concurrent consultations with gastroenterologists and pulmonologists permit rapid evaluation in our aerodigestive disorders clinic; ideally, the child receives a pediatric anesthesia consultation at this time. Thorough evaluation of specific risks for cardiac, neuromuscular, neurologic, or developmental diseases require prompt referral to other specialists. The anesthesia-related risks are often predicted by concurrent disease (Table 1).

DIAGNOSTIC PROCEDURES

Frequently, children present with significant respiratory symptoms and require anesthesia to permit a diagnostic procedure. Although most children tolerate flexible nasopharyngoscopy in the ENT clinic, it is less likely that a child will permit an examination below the larynx without general anesthesia or deep sedation. Although diagnostic DL can be completed in minutes, the necessity to ensure safe induction and emergence can add significant time and resources. For example, the child with a history of congenital heart disease may require thorough diagnostic cardiac evaluation despite the brevity of a proposed procedure. Similarly, the clinician is cautioned to minimize instrumentation of the pediatric airway without peripheral intravenous (IV) access to minimize the risk of adverse airway events. The most common reasons for DL and bronchoscopy are stridor, pulmonary aspiration, dysphagia, dysphonia, croup, recurrent pneumonia, or suspected foreign body aspiration. Younger children are more likely to exhibit stridor, croup, or recurrent choking spells from congenital causes, whereas the older child is more likely to have an acquired condition such as foreign body, pathologic mass, or trauma.
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In our center, triple endoscopies are frequently performed on children of a variety of ages. This includes DL, flexible fiber optic bronchoscopy and esophagogastroduodenoscopy (EGD). Following inhalational induction of anesthesia with sevoflurane and IV cannulation, a DL/rigid bronchoscopy is performed with spontaneous ventilation to assess laryngeal anatomy and function. Specifically, the laryngeal architecture is studied for evidence of laryngeal lesions, clefts, webs, vocal fold movement, and laryngomalacia. Proximal examination of the airway is focused on the subglottis for evidence of stenosis, lesions, and malacia. The examination is terminated with inspection to the carina and proximal bronchi. Spontaneous ventilation yields important information to the surgeon regarding dynamic characteristics of the larynx and airways. Furthermore, the anesthetic can be rapidly decreased to permit vigorous vocal fold movement should vocal cord paralysis be considered. To facilitate longer examinations, it can become necessary to insufflate anesthetic vapor into the hypopharynx via an oral or nasal conduit, or to transition to an IV technique to ensure adequate anesthesia depth. This technique seems preferable to an apneic intermittent intubation technique because it avoids repeated intubation, reduces subsequent mucosal trauma, decreases the risks associated with episodic desaturation, and shortens procedural duration. A total IV technique can provide equivalent conditions, although titration of infusions to such rapidly changing clinical stimulation while avoiding apnea or light anesthesia can be problematic and lead to higher rates of rescue maneuvers such as intubation, interrupted bronchoscopy, or administration of paralytics.

Potential complications during DL/bronchoscopy include laryngospasm, bronchospasm, airway trauma, cardiac dysrhythmia caused by enhanced vagal tone, cardiac events caused by occult or concurrent structural cardiac disease, or aspiration of pulmonary contents. Certainly, adverse airway events are most likely to occur should a light plane of anesthesia occur without careful airway management. Maneuvers that seem to decrease these events include aerosolized lidocaine to the vocal folds and carina to a total dose of less than 3 mg/kg, close observation of the child for any movement or response to the initial stimulation of the airway (placement of tooth guards, insertion of the laryngoscope, engagement of the suspension apparatus), and immediate withdrawal of all equipment with patient response.

Flexible bronchoscopy is next performed via a laryngeal mask airway (LMA) to assess distal airways and obtain bronchial lavage specimens. The LMA serves as a ready conduit for delivery of the bronchoscope to the larynx, permits modest control of respiratory rate and depth through continuous positive airway pressure or assisted ventilation, maintains spontaneous ventilation as needed to document dynamic airway pathophysiology (tracheomalacia), and minimizes additional traumatic irritation to the subglottic airway. The presence of lipid-laden macrophages is suspicious for chronic aspiration of gastric fluid, although the specificity and sensitivity is low. Brushings may be obtained to assess for abnormal mucosal epithelium (eg, cystic fibrosis, Kartagener syndrome). Should an LMA not permit safe bronchoscopy conditions, the study can be performed via an endotracheal tube (ETT), although this may increase resistance to delivery of tidal volumes, limit visualization of the subglottis, or underestimate the degree of tracheomalacia. The diameter of the smallest flexible bronchoscope is 2.5 mm; although this will pass through smaller ETTs (>3.5 mm outer diameter), the procedure is likely to be difficult because of friction, high airway resistance, and increased risk of dislodgement of the ETT. Despite the risks and challenges, an ETT may be preferable in children who are syndromic if the hypopharynx anatomy is abnormal, children with cardiac disease when careful avoidance of hypoxemia and hypercarbia is necessary, a history of difficult mask ventilation or laryngoscopy, or safe ventilation via an LMA is unlikely.
Lastly, an EGD is performed. Airway management is predicated on the child’s condition and requirements for a safe procedure, and may include spontaneous ventilation with moderate sedation or general anesthesia. The LMA placed for the fiber optic bronchoscope is often left in situ, the cuff deflated, and the gastroscope passed while the patient breathes spontaneously. Because this procedure is generally performed last in the series, previous adverse events can necessitate a need for more invasive and controlled airway management, especially after instrumentation of the lower airways. For example, vigorous coughing with bronchial lavage may make it unsafe to attempt EGD minutes later. In these cases, an ETT is placed and the anesthetic deepened. Insufflation of the stomach with 10 to 15 cm H₂O air will impede ventilation in a spontaneously breathing child; smaller children or infants often desaturate during this period and may require interventions such as withdrawal of the scope and decompression of the stomach, positive pressure assistance via the LMA, or endotracheal intubation.

Complication rates are low overall for diagnostic procedures and are related to higher ASA classification, younger age, and experience of the anesthesia staff. In our center, these children are routinely discharged the same day.

AIRWAY TRAUMA

Recent advances in public safety initiatives have resulted in significant declines in pediatric trauma resulting from motor vehicle accidents and sports injuries. However, burns and gunshot wounds remain a consistent source of airway injury to children. Overall, reports from tertiary pediatric trauma centers suggest that pediatric trauma and subsequent airway surgery is rare. Gwely reported 34 cases of pediatric blunt bronchial trauma between 2000 and 2007. Wootten and colleagues reported 35 patients between 1997 and 2008. In our center, children occasionally present for diagnostic evaluation of airway trauma; more frequently, we are involved in the chronic management of posttraumatic airway reconstruction including laryngotracheal reconstruction, laryngoplasty, excision of suprastomal granulation tissue, or postdecannulation excision of tracheocutaneous fistula. The patients are usually easily managed with age-appropriate induction techniques and airway management dictated by the expected degree of airway stenosis, risk of trauma to scar tissue or granulation tissue, or the risks of positive pressure ventilation versus spontaneous ventilation.

The management of an acute traumatic airway demands careful planning with the surgical and nursing teams. Induction strategy must be discussed, with alternative pathways to a secure airway in place, including immediate surgical airway. Although an awake tracheostomy can be a challenge in a pediatric patient, this may be advisable. Similarly, awake fiber optic examination of the larynx and endotracheal intubation must be considered in certain settings. Numerous sedative strategies may be used to decrease psychological trauma to the child, including small-dose opiate, benzodiazepine, or sedatives such as ketamine (with an antisialagogue), although precise dosing and careful titration is mandatory. Inhalational induction can be considered to protect spontaneous ventilation and support a gentle transition to an anesthetized state.

The risk of a full stomach often confounds clinical decisions; although the morbidity risk for pediatric aspiration with anesthesia induction is low, standard recommendations suggest that rapid sequence induction and intubation remains the gold standard for pediatric airway trauma management. Collective experience with inhaled foreign bodies suggests that inhalational techniques can be safely employed with a full stomach and therefore may be reasonable to consider in a patient with spontaneous ventilation and currently patent airway after trauma. In the setting of a potentially
challenging airway and no IV access, our practice is to accept the risk of aspiration of stomach contents and proceed with an inhalational induction, maintain spontaneous ventilation, prepare for immediate surgical airway access, or move immediately to a tracheostomy under mask general anesthesia.

AIRWAY RECONSTRUCTION

Reconstructive surgery for the pediatric patient is necessary following trauma, acquired or congenital stenosis, or failure to maintain a safe airway following endotracheal extubation because of laryngotracheal malacia, webs, or scarring. Excellent reviews on the surgical options are available for the interested clinician.\textsuperscript{15–18} Anesthesia management has been reviewed.\textsuperscript{19} In our center, the most common indications for airway reconstructions include acquired subglottic stenosis secondary to prolonged endotracheal intubation, severe subglottic tracheomalacia, chronic aspiration of gastric fluid, or prior tracheostomy. Some recent uncommon reasons for laryngeal reconstruction have included a child with junctional epidermolysis bullosa with a scarred occluded larynx, an infant with capillary hemangioma at the cricoid level, and subglottic stenosis resulting from a skateboarding accident in a 12 year old.

In our experience, the anesthetic management begins with a careful preoperative evaluation to assess the cause for airway disease and the risks of possible anesthetic regimens. Specific concerns include cardiac history: structural heart disease and prior cardiac surgery. Communication is critical between team members. Important transition points during surgery must be anticipated. These include (1) tracheal incision and the risk of cough, damage to the endotracheal cuff, or extravasation of air into the mediastinum; (2) risk of pneumothorax or pneumopericardium; (3) replacement of the oral ETT for a proximal ETT with an attendant risk of loss of tracheal lumen; (4) hemorrhage with injury to a thymic, innominate, or thyroid vessel; (5) mainstem bronchus intubation if the ETT is too deeply placed; (6) ETT plugging with blood or mucus, or ETT kinking with high resistance to inspiratory ventilation; and (7) replacement of an oral or nasal ETT with additional risk of trauma to the surgical anastamosis or loss of the airway. Paralysis is often necessary to reduce these risks. At times, flexible fiber optic bronchoscopy is necessary to assist in the diagnosis of acute changes in oxygenation during any of these critical transitions.

Postoperative communication is critical to the safety of the child. Although the surgical team will likely report specific instructions to the intensive care team, the anesthesiologist is wise to discuss airway issues with the intensive care unit (ICU) team as well. Specifically, ease of mask ventilation; laryngoscopic view on initial intubation; recommended LMA size; ETT depth; patient response to intraoperative medications such as opiates; and intraoperative challenges such as desaturation, dysrhythmias, high peak inspiratory pressures, or peripheral venous access should be transmitted. Clear communication regarding such important observations and data improves the safety of the child’s recovery and assessment of postoperative abnormalities.

JUVENILE-ONSET RECURRENT RESPIRATORY PAPILLOMATOSIS

Juvenile-onset recurrent respiratory papillomatosis is a rare cause of pediatric airway obstruction and disease; estimated incidence is 4.3 per 100,000 children. Surgical management was reviewed in 2008 by Derkay and Wiatrak.\textsuperscript{20} Diagnosis may occur at any age, although 75% of cases are diagnosed by age 5 years, and it is heralded by hoarseness, stridor, or abnormal cry. Lesions rarely threaten the airway initially, although aggressive disease can cause near-complete occlusion of the larynx, spread...
to the bronchial or pulmonary airways, and undergo malignant transformation to squamous cell carcinoma.\textsuperscript{21}

For the child with aggressive disease, frequent anesthetics are needed for debulking procedures, sometimes as often as every 2 to 4 weeks. This frequent surgical requirement is difficult for many children and the anesthesia team must be attentive to the child’s needs. Although premedication may be warranted or requested, it is our practice to eschew preoperative sedative administration to optimize postoperative transition through to discharge.

Anesthesia and airway management for patients with respiratory papillomatosis has been described using jet ventilation,\textsuperscript{22,23} intermittent apnea/intubation, or tubeless spontaneous ventilation.\textsuperscript{24} No technique has been clearly demonstrated as superior, and benefits to each can be argued.

Jet ventilation has been described using a variety of technical innovations to permit the delivery of high-flow, high-pressure gases to the airway using catheters or specifically designed jet laryngoscopes. This technique relies on the delivered gas jet to entrain ambient room gases to supplement the delivery of a tidal volume to the lungs and prevent hypoxia. A recent risk analysis suggests that jet ventilation techniques resulted in less hypoxia than spontaneous ventilation during airway foreign body removal from children less than 5 years of age.\textsuperscript{25} This technique is well described as an effective, safe, and advantageous method of ventilating children of all ages during challenging anesthetics.\textsuperscript{26,27} However, in a single-center analysis of 661 children and adults undergoing microlaryngoscopy with a variety of anesthetic techniques, Jaquet and colleagues\textsuperscript{28} associated jet ventilation with significant barotrauma and the highest rate of laryngospasm. Transtracheal catheters were clearly more problematic than transglottic catheters, likely because of expiratory obstruction.

Intermittent apnea/intubation techniques provide an unobstructed surgical field for laser ablation or electrodissection. The airway is episodically protected with an ETT and oxygenation is normalized between episodes of deoxygenation. Paralytics are typically used, although not required, to establish apnea. This technique exposes the child to an intermittent threat of significant deoxygenation, hypercarbia, and the trauma of repeated subglottic intubation. Some authorities have expressed concern that passing an ETT through mucosa with papillomata can translocate virus to naive distal mucosa and increase the likelihood for more significant subglottic disease. Surgical experience with tracheostomies\textsuperscript{29} and airway reconstructions\textsuperscript{17} suggests that spread to lower airways is likely a factor of aggressive disease or other intrinsic variables and not surgical intervention of the cervical airway. However, the significant morbidity of papillomata once present in the lower airway argues against routine endotracheal intubation through a diseased glottis.

In our center, we prefer to use spontaneous ventilation techniques for juvenile-onset recurrent respiratory papillomatosis surgery.\textsuperscript{30} Anesthesia induction is via gentle inhalation with transition to an IV infusion of propofol and an ultra–short-acting opiate such as remifentanil. Doses are titrated to effect with careful avoidance of apnea. Our typical dosage range is propofol 150 to 250 $\mu$g/kg/min with remifentanil 0.05 to 0.1 $\mu$g/kg/min. A recent report by Malherbe and colleagues\textsuperscript{31} reported higher dose ranges (propofol 200–500 $\mu$g/kg/min and remifentanil 0.1–0.2 $\mu$g/kg/min). Topical lidocaine (0.5–1 mL 1\%–4\%) aerosolized spray on the vocal folds and subglottis can minimize sensitivity to manipulation.\textsuperscript{32} We use 1\% for infants, 2\% for smaller children, and 4\% in children more than 25 kg to minimize risk of toxicity (>3 mg/kg). As described by Barker and colleagues,\textsuperscript{33} a respiratory rate of 10 breaths per minute or less predicts higher risk of subsequent apnea. This study is also useful for predicting the complexity
of dosing remifentanil infusion in children of different ages. Even at our center, there are broad dosing ranges among anesthesiologists for these drugs, and all may provide suitable surgical conditions; this underscores the inherent challenge to controlling the response of pediatric patients to anesthetics, predicting the patient response to airway manipulation and surgery, and the role experience plays in the ultimate techniques used for these procedures.

During suspension laryngoscopy and ablative surgery, medications are titrated to effect. Supplemental oxygen can be supplied via the side port of the Lindholm laryngoscope or directly insufflated into the hypopharynx via an ETT in the oral cavity or affixed to a nasal airway. It has been noted by this author that the standard sampling line for end-tidal carbon dioxide monitors can directly attach to the Luer fitting on the Lindholm sideport to permit nonquantitative measurement of end-tidal carbon dioxide and direct monitoring of the respiratory rate. With due attention to pollution of the operating room atmosphere, additional anesthetic depth can be rapidly provided by the insufflation of sevoflurane with the airway gases; this can minimize the inherent delay of IV infusion pharmacodynamics in the setting of sudden changes in surgical stimulation. For example, the complex calculations needed to predict the infusion rates for target-controlled infusion techniques quantify the time inherently necessary to establish steady-state kinetics; once there is a clinical change in stimulation during a procedure, steady state is disrupted and further time is necessary to adjust the systems to reestablish clinical steady-state pharmacology. Using inhalational agents as an adjunct permits nearly immediate end-organ delivery of additional anesthetic and maintains safe and adequate anesthesia depth until infusions can be adjusted. Dosing the agent in this fashion requires some experimentation because no end-tidal measurement can be tracked and clinical response and indicators of anesthetic depth must be relied on.

As with many challenging techniques, vigilance is necessary to decrease complications; a precordial stethoscope and a monitoring hand on the child’s abdomen provides important instantaneous and immediate information and feedback regarding the patient’s condition throughout the anesthetic course. Clear communication should signs of inadequate anesthesia become apparent permit adjustment in anesthetic depth and likely decrease the apnea rate and expedite surgery. Our surgeons often place a vocal fold spreader to abduct the vocal folds; this device improves visualization and surgical access to more diseased mucosa, although it also increases laryngeal stimulation. Release of this device can precipitate laryngospasm.

After surgery, most children remain spontaneously breathing as they are transferred to the recovery suite. With a young child with aggressive disease, an ETT is occasionally required during emergence. Pain management is often accomplished with topical lidocaine and low-dose morphine (0.05–0.1 mg/kg IV). Ketorolac is an option to avoid narcosis. Nebulized epinephrine can mitigate stridor. Should stridor persist, airway edema, hemorrhage, aspiration, or gastric reflux should be considered and may require helium-oxygen therapy, continuous positive airway pressure ventilation, or endotracheal intubation.

ADENOTONSILLECTOMY

The frequency of adenotonsillectomy in the United States has declined recently, although it remains the most common pediatric surgery. Indications for surgery include recurrent streptococcal pharyngitis/tonsillitis, significant sleep-disordered breathing/OSA with enlarged palatine tonsils, asymmetric tonsillar hyperplasia, or significant enlargement affecting swallowing and speech.
There are a variety of surgical techniques, instruments, interventions, and approaches to the pediatric patient needing tonsillectomy, including unique surgical devices purported to decreasing pain and bleeding,\(^{36}\) LMA airway management intended to facilitate shorter recovery times and decreased anesthetic requirements,\(^{37}\) departmental guidelines intended to decrease interoperator variability and adhere to an empiric approach to anesthetic-related decisions,\(^{38}\) or expert recommendations on the complexities of sleep-disordered breathing and pediatric anesthesia care.\(^{39}\)

The best anesthetic technique is the culmination of a variety of dependent and independent variables that coexist around a specific patient at a specific time and are incorporated into an anesthetic (and surgical) plan that acknowledges the pertinent identifiable risks and seeks to usher the child through a successful surgical experience with the least realization of possible adverse events. Every provider must accept the responsibility for this process and adjust their care to the limitations of their training, experience, available clinical data, and the environment present at the time of induction.

Preoperative evaluation and data collection have been discussed recently by Lerman.\(^{39}\) Although these recommendations apply specifically to patients with OSA, the discussion regarding occult cardiac manifestations, the tendency for airway challenges (more difficult mask ventilation, lower Cormack-Lehane airway laryngoscopy score), and the laboratory assays recommended are worth considering in all children having tonsillectomy. Invasive cardiac examination, electrocardiogram, or liver enzyme assay may be reserved for symptomatic, syndromic, or children with a higher pretest probability for an abnormal result.

The general approach to adenotonsillectomy is broadly defined in the available literature; a wide variety of techniques have been studied and compared, underscoring the paucity of objective conclusions. Variations in technique across the world illustrate the many methods of induction (mask, IV, premedication), airway management (ETT, LMA), pain management (opioid based, opioid sparing, local anesthetic based, nonsteroidal antiinflammatory drug), emergence strategy (awake vs deep extubation, no-touch emergence with ETT or LMA), or observation policy (routine day case discharge vs, 23-hour observation vs ICU admission). The debate regarding nonsteroidal antiinflammatory agents is evidence of the substantial barriers to increased uniformity in how we care for patients having tonsillectomy.\(^{40,41}\)

However, tonsillectomy has incumbent risks for serious perioperative events including aspiration pneumonitis, refractory laryngospasm, exsanguinating hemorrhage, anoxic injury, or death. Survey data from Germany in 2008 shed some light on the characteristics of lethal posttonsillectomy hemorrhages (PTHs), with specific recognition emphasis to treat recurrent bleeding with the highest concern.\(^{42}\) New York closed claims data confirm that anesthesiologists are more likely to be sued than surgeons after tonsillectomy complications.\(^{43}\) Postoperative nausea and vomiting occurs in 50% to 89% of these patients because of swallowed blood, opioid administration, or pharyngeal stimulation, and significantly increases the risk of overnight admission, delayed oral intake, and patient satisfaction.\(^{44}\) With increasing production pressure on operating room teams, these routine cases may receive less preoperative consideration or evaluation, and subtle clues that may predict complications may be missed or dismissed. In addition, constrained staffing models may render resources unavailable to assist should an event occur.

At our center, most children older than 3 years are tracked for same-day discharge by modified Aldrete score readiness criteria. Many children referred to our center exhibit moderate to severe OSA prompting a review of our risk for morphine-related complications. Data from Brown and colleagues\(^{45}\) provided important awareness of opioid sensitivity among these patients. Most children receive modest morphine
and acetaminophen doses for analgesia, dexamethasone and ondansatran for anti-emetic prophylaxis, and deep extubation of the trachea to minimize coughing and airway stimulation when prudent. A small subset of children is observed in the intensive care ward if there are sufficient age, comorbidity, or perioperative concerns.

Our surgeons use all modern surgical options including Coblation, Cold steel, snare, harmonic scalpel, and hot knife. Surgical literature on the various techniques suggests certain benefits to each: Coblation should yield lower pain scores at the risk of slightly higher bleeding rates, electrocautery/dissection proponents argue lower bleeding rates but with increased pain scores and duration of analgesic requirement, and harmonic scalpel seems to decrease intraoperative blood loss with comparable pain and recovery scores to other techniques. The anesthesia team should be aware of the techniques used in their own centers because some techniques significantly affect operative times, intraoperative blood losses, postoperative pain scores, or time to resumption of oral intake.

Overall, the approach to the patient needing tonsillectomy requires a comprehensive awareness of multiple, sometimes conflicting, concerns, and challenges the anesthesia provider to balance risk with reality. As the science and evidence develops to guide our decisions, improvements will emerge, yielding continued advances in pain management, postoperative nausea and vomiting prophylaxis, decreased adverse event rates, and increased patient satisfaction.

**PTH**

PTH warrants specific discussion because it is the most common emergency pediatric airway surgery. PTH rates are between 0.5% and 7.5% and are most common in patients more than 15 years of age, boys, patients with frequent infectious tonsillitis, and after hot (electrocautery) versus cold (scalpel) techniques. Considering the possibility for lethal hemorrhage, anesthetic management is often required on an emergency basis, with minimal opportunity to evaluate a child’s previous anesthetic history or to modify anesthesia-related risks. At a minimum, a rapid sequence induction should be planned with consideration for possible transfusion should uncontrolled bleeding ensue. Care with laryngoscopy is necessary to prevent traumatic dislodgement of an in situ clot. Gastric decompression is performed to assess for occult blood loss and decrease the risk of subsequent pulmonary aspiration. Intravascular fluid repletion is guided by estimated blood loss or vital signs. Other intraoperative concerns include hypovolemic shock, dysrhythmia, or coagulopathy. Occasional vascular abnormalities can precipitate PTH, and proximal vascular control may be needed. After control of the hemorrhage, postoperative nausea can be minimized with irrigation of the oropharynx and the stomach can be suctioned or lavaged. Emergence and extubation of the trachea should occur after return of protective laryngeal reflexes.

Despite the concern for vigorous hemorrhage, the need for transfusion seems to be low following PTH in developed nations. In a retrospective review of ambulatory tonsillectomy in the United States, Bhattacharyya noted that no transfusions were needed after more than 500,000 tonsillectomies, although, in Sweden, a 4-year retrospective review noted that only 3 of 2813 patients required transfusions. However, Windfuhr and colleagues remind us that recurrent bleeding is an ominous sign, and evidence of serious compensated or uncompensated shock requires aggressive resuscitation.

**SUMMARY**

This article discusses the management of the child having airway surgery, with specific detail on our practice environment at a tertiary specialty pediatric referral
center. In our center, the close communication between all teams ensures efficient, safe, and gratifying interventions for our patients. Although many specific technical obstacles arise during the course of any airway procedure, the prepared clinical team can use reasonable tools, experience, and available assistance to choose a safe anesthetic plan. Excellent available references elaborate on the myriad of factors pertaining to any given surgery; however, the higher-order issues included here are intended to expound on these technical issues. The approaches discussed here are not comprehensive or intended to be prescriptive, and in many ways represent the best of our anecdotal wisdom. The reader is offered these items for consideration and scrutiny, criticism and challenge, as the realities of complex patient care continue slowly toward empirical data and conclusive science.

REFERENCES