EAR NOSE AND THROAT (ENT) SURGERY: OVERVIEW

INTRODUCTION

Hasbro Children's Hospital has an active ENT service; prior to 1996, "bread and butter" cases, such as myringotomy and tubes placement, tonsillectomy and adenoidectomy, and routine sinus surgery predominated. Although these "routine" cases still make up the bulk of our volume, the arrival in July, 1996 of Drs. Sharon Gibson and Brian Duff has led to the advent of more complex interventions, including tracheal reconstruction, airway laser procedures, and meticulous middle ear reconstructive surgery.

Although ENT surgery is generally performed on an outpatient basis, and is relatively straightforward in most instances, it possesses a disproportionate potential for complications. Contributing factors include:

1. airway shared with surgeon
2. patient often angled from anesthesia provider
3. propensity of children to have irritable airways due to frequent URI's
4. postoperative blood and oral secretions compromising airway
5. airway obstruction exacerbated by sedation
6. excessive blood loss leading to hypovolemia
7. associated congenital anomalies, especially involving airway
8. high incidence of nausea and vomiting (T & A, middle ear surgery)

The following outline delineates some of the specific anesthetic considerations associated with ENT procedures. Complications in these patients are best avoided through meticulous airway management, vigilance, and timely intervention before problems can become severe. This can be a great challenge when caring for 16 children in little more than 4-5 hours!

BILATERAL MYRINGOTOMY TUBE PLACEMENT (BMT)

Due to the unique anatomy of children, recurrent otitis media with accumulated fluid is a common condition warranting frequent surgical intervention, usually through myringotomy (opening in tympanic membrane through which fluid can drain) and placement of a small, plastic tympanostomy tube which serves as a stent for the ostium and continued drainage of the middle ear. The usual “life” of such tubes is six months to a year; occasionally, these are not naturally extruded and require surgical removal, when appropriate. Risk factors for chronic otitis media with effusion include male, age < 2 years, anatomical factors such as cleft palate, Down syndrome, bottle-feeding, group day-care, and passive smoke exposure. Factors favoring surgical treatment of middle ear effusion include bilateral disease, hearing loss, speech delay, behavioral disturbances, structural changes in tympanic membrane, antibiotic allergy, and high-risk for acute recurrent otitis media. BMT is the most common procedure performed on children in the US, with approximately 500,000 each year.

BMT is a short procedure (range 3-15 minutes for majority of our cases at HCH) generally accomplished with potent inhalational anesthesia, nitrous oxide and oxygen by face mask. Premedication is rare, as it may delay discharge. An intravenous is not started, unless made necessary by cardiorespiratory events. SBE prophylaxis is not indicated. The choice of inhalational anesthetic has been discussed in other areas. Sevoflurane may occasionally be indicated for hemodynamic reasons (such as children with Down syndrome particular sensitive to negative chronotropy with halothane) or for a rapid 8% induction on an uncooperative toddler.

The ideal mode of perioperative analgesia remains elusive; the most common technique at the present time is probably some form of fentanyl, 1-2 mcg/kg, immediately after induction. Some staff prefer to administer the fentanyl IM, while others use the intranasal route. Galinko found that when fentanyl was administered, emergence delirium was no different with sevoflurane as compared to halothane.

ADENOIDECTOMY

Theoretically, adenoidectomy removes a chronic reservoir for pathogenic bacteria that cause acute otitis media. The treatment of chronic middle ear effusion with BMT alone versus BMT with adenoidectomy has been demonstrated to be associated with an increased need (24% vs 12%) for repeat surgical procedure (Gates. *NEJM*, 1987). This must be weighed against the increased anesthetic risk for adenoidectomy vs BMT (often, age is the final factor; in children < 3 years, BMT is performed alone, while > 3 years, BMT w/adenoidectomy is probably a more common procedure). In addition to chronic serous middle ear effusion secondary to adenoidal hypertrophy, indications for adenoidectomy include recurrent adenitis/sinusitis, and/or adenoidal hypertrophy leading to chronic nasopharyngeal obstruction, speech and sleep disturbances, failure to thrive, and dental abnormalities.

Generally, the anesthetic considerations for adenoidectomy alone are similar to those for tonsillectomy and adenoidectomy. Surgical time for adenoidectomy varies between 5-20 minutes. Airway is generally controlled with an endotracheal tube, although LMA (especially the flexible reinforced LMA) can be used as well, and this is becoming a common practice at HCH. Postoperative considerations are similar to tonsillectomy (pain, nausea and vomiting, airway obstruction, bleeding) but generally less severe. In particular, bleeding is exceedingly uncommon. Discharge from the PACU occurs after 90 minutes, as compared to a minimum of three hours after tonsillectomy (see below).

TONSILLECTOMY

Indications

The major indications for tonsillectomy are chronic or recurrent tonsillitis and obstructive tonsillar hyperplasia. Chronic tonsillitis refractory to medical

treatment may be accompanied by halitosis, persistent pharyngitis and/or cervical adenitis. Surgery is always indicated when chronic tonsillitis is accompanied by airway obstruction or peritonsillar abscess. Tonsillar hyperplasia may lead to chronic airway obstruction with resultant sleep apnea, swallowing and speech disorders, failure to thrive, and eventually cor pulmonale and right heart failure. Sleep apnea patients respond to tonsillectomy in approximately 66% of cases.

Obstructive sleep apnea is an important clinical syndrome. Airway obstruction (most commonly at level of soft palate and base of the tongue) and apnea occur during sleep, with associated findings which may include baseline hypoxemia, hypercarbia, and partial awake airway obstruction. Long-standing hypoxemia and hypercarbia may develop cor pulmonale, with ECG evidence of RVH. Each apneic episode progressively increases pulmonary artery pressure; ventricular dysfunction and arrhythmias may occur by the end of the night. Patients at particular risk for cor pulmonale include those with CNS dysfunction or global psychomotor retardation. This category of patient may be insensitive to hypercapnia despite hypoxemia, predisposing them to respiratory failure; in addition, pulmonary hypertension tends to be more severe.

Preoperative Evaluation

These patients generally suffer from frequent URI or tonsillitis (possibly exacerbated by chronic passive tobacco smoke) and have often been diagnosed with reactive airway disease. Recent exacerbations, concurrent medications, presence of lower airway disease etc. may be of importance. Certainly, a history of sleep apnea or obstructive symptoms such as snoring or mouth breathing should be sought. Chronic mouth breathers may have characteristic features such as retrognathia and high arched palate. Preoperative examination (as always) should include the search for loose teeth.

Laboratory evaluation is a somewhat controversial area. Historically, all tonsillectomy patients had CBC with platelet count, PT and PTT, and often a bleeding time. However, in the absence of historical or family evidence that suggests coagulopathy, most pediatric anesthesiologists now feel that "routine" labs are no longer indicated. The American Academy of Otolaryngology indicates that bleeding profile is ordered "at the discretion of the physician." Despite these recommendations, many surgeons and pediatric hematologists still advocate routine coagulogram prior to tonsillectomy, and it is important for the anesthesiologist to check any ordered bloodwork prior to induction of anesthesia.

Surgical Considerations

The surgical dissection is carried out with patient supine, and shoulders elevated on a small pillow. Table is turned 90^0. Either an OR table or (increasingly) a stretcher is used, often an “eye” stretcher. A mouth gag is inserted; if adenoids are being done concurrently, these are removed with a curette, and nasopharynx is packed. Tonsil is grasped at upper pole and pulled medially, with incision over

anterior faucial pillar. The tonsil is dissected from its bed and removed. A snare may be used to snip tonsil at lower pole. Hemostasis is with gauze packs and cautery or coblator. Packs are removed prior to extubation, and oral airway inserted. Surgical time varies between 20 and 45 minutes. Typical blood loss is 50-200 ml.

Bleeding occurs in an estimated 4% of cases (range 0.1-8.1%) with majority occurring within 6 hours, and very small number that might occur as late as POD 6. 67% of post-op bleeding originates in the tonsillar fossa. Initial attempts to control bleeding may be made with pharyngeal packs and cautery, but failing this, patients must return to the OR for surgical hemostasis.

Anesthetic Considerations

Preoperative sedation should be avoided in sleep apnea patients. Anesthetic technique is generally GETA, usually with inhalation induction. Careful attention to airway patency is crucial; many of these patients will require oral airways. An IV is inserted and lactated Ringer's essentially run "wide open." Endotracheal intubation is usually "deep inhalational" (we use standard ett taped in the middle; other institutions may use oral RAE tubes); in older children intubation may need to be facilitated with succinylcholine or a short-acting muscle relaxant such as mivacurium. Spontaneous ventilation is encouraged, and patients are extubated awake after protective reflexes have returned and the oropharynx carefully suctioned. Laryngospasm (0-22% incidence) may be prevented in most cases through fully-awake extubation associated with a pseudo-cough.

Patients with a preoperative diagnosis of OSA are approximately twice as likely to have respiratory complications, most commonly airway obstruction on induction and emergence (Sanders. *Anesth Analg* 103:1115;2006). In older children (> 3), this study suggested that postoperative complications and time to discharge was similar.

An alternative to GETA is use of a flexible LMA, still utilized by the minority of pediatric anesthesiologists, but gaining increased enthusiasm (as of 2007). Major advantages include the ease of insertion without NMB and (presumed) fewer airway complications related to the ETT itself, especially in the presence of URI symptoms (common in these patients) and RAD. In fact, aspirated blood is less common with LMA than ETT, according to some studies in which a bronchoscopic examination was performed at end surgery (Yun 2005). Less swallowed blood may result in a lower incidence of PONV, although this has not been studied. The LMA may not be the best choice in obese patients, or those with significant OSA.

Pain Control

Pain is moderate-severe after tonsillectomy, and patients generally require parenteral opioids. Perioperatively, meperidine 0.75 - 1 mg/kg or morphine 0.075-0.1 mg/kg are administered. Care must be taken when administering

opioids to patients with obstructive sleep apnea. Generally, a reduced dose of opioid is given, with judicious rescue doses in the PACU. Up-regulation of central opioid receptors due to recurrent hypoxemia may lead to reduced opioid requirement in children with OSA (Brown. *Anesthesiology* 100:806;2004), although a recent prospective study suggested no difference in opioid requirements (Sanders. *Anesth Analg* 103:1115;2006). The difference may be related to the severity of OSA and degree of hypoxemia. Unfortunately, ketorolac is contraindicated in tonsillectomy patients, as it has been demonstrated to result in increased blood loss (Rusy et al. *Anesth Analg* 80:226;1995). The administration of dexamethasone intraoperatively may decrease edema formation and subsequent patient discomfort. A prospective, randomized, double-blinded study determined that a single dose of dexamethasone (8 mg/m^2) results in earlier return to full diet in children undergoing tonsillectomy (Catlin.*Arch Otolaryngol Head Neck Surg* 117:649;1991). Local anesthetic infiltraton in the peritonsillar space has not been shown to decrease postoperative pain, although blood loss may be reduced if epinephrine is used.

Postoperative Vomiting

Nausea and vomiting occurs in approximately 60% of patients, with a multitude of causative factors, including irritant blood in the stomach, interference of the gag reflex by surgical inflammation, anesthetic agents such as opioids or nitrous oxide, and pain. Dehydration is possible, and care must be taken to replace losses from vomiting, bleeding and poor PO intake with isotonic fluid (see McRae et al.; Chapter 6). Of note, a randomized, double-blind study failed to demonstrate *any* correlation between nitrous oxide and no nitrous oxide (even during induction and postoperative vomiting in children undergoing tonsillectomy (Pandit et al. *Anesth Analg* 80:230;1995)

Choice of anti-emetic therapy is a balance of cost, side effects and efficacy. Furst and Rodarte found ondansetron to be "highly effective" (15% incidence of vomiting as compared to 57% in untreated) in the reduction of nausea and vomiting following tonsillectomy in children as compared to droperidol and metoclopramide, which were found to be relatively ineffective (*Anesthesiology* 81:799;1994). Increasing the dose from 0.075 mg/kg to 0.15 mg/kg showed no improvement in efficacy. In contrast, Rose et al. demonstrated the efficacy of preoperative *oral* ondansetron at the dose of 0.15 mg/kg, but **not** at 0.075 mg/kg (*Anesth Analg* 82:558;1996). Dexamethasone (0.15 mg/kg up to 8 mg) was shown to decrease incidence of vomiting after tonsillectomy from 72% to 40% (Splinter and Roberts. *Anesth Analg* 83:913;1996).

What does this all mean? Nausea and vomiting is a significant event after tonsillectomy with potential adverse outcome in terms of patient comfort and overall well-being. Some treatment is indicated, but the *best* treatment (arguably) may be somewhat expensive for global use. I tend to use metoclopramide (0.2 mg/kg) as a first line anti-emetic due to low cost and lack of sedative side effect. Ondansetron (0.075 - 0.1 mg/kg) is then utilized as a

"rescue" anti-emetic in the PACU, but responsible health care providers should be aware of its high cost (approximately $35 for 8 mg vial). Single-dose dexamethasone is a relatively benign intervention which may have benefit in several potential complications associated with tonsillectomy (airway edema, pain, vomiting, diminished PO intake).

Outpatient Tonsillectomy Guidelines

In April, 1997, the Rhode Island Department of Health convened a small group to decide upon guidelines for hospitalization in children who have undergone tonsillectomy. This group included Drs. Gibson (Pediatric Otolaryngology), Triebwasser (Pediatric Anesthesia), Arnold (Pediatrics) and Hollinshead (Public Health). The American Academy of Otolaryngology guidelines from 1996 were reviewed and adapted. Conditions warranting overnight admission include:

- age two years or less
- abnormal coagulation profile
- any obstructive sleep disorder in a child < 4 years, or *severe* obstruction due to tonsillar hypertrophy at **any** age
- systemic disorders that predispose to increased perioperative risk
- craniofacial anomalies which predispose to airway complications
- procedure performed due to acute peritonsillar abscess
- home conditions (distance, weather, social) inconsistent with close observation and ability to quickly return to hospital, if needed

Special Surgical Considerations

The bleeding tonsil is a serious complication that may be associated with hypovolemia and pallor. Much of the blood may be swallowed, and patients should be considered at high risk for aspiration. Ketamine might be a reasonable induction agent for rapid sequence induction in hypovolemic patients. Suction must be immediately available to clear the oropharynx; duplicate ett and suction should be available since plugging with blood is a possibility.

Peritonsillar abscess (Quinsy tonsil) may require immediate surgical intervention due to large lateral pharynx abscess interfering with swallowing and breathing. Trismus is often present, due to compression of nerves and inflammation of muscles in the face and neck. Usually, visualization of the cords is not impaired; intubation should be gentle to avoid rupture of the abscess and spillage of purulent material into the trachea.

TYMPANOPLASTY

Tympanoplasty and mastoidectomy are fairly common operations performed on the middle ear. At HCH, these are generally performed by Dr. Brian Duff, a neuro-otologist with interest in ossicular chain reconstruction and cochlear implant surgery. Many of his patients have had multiple surgical interventions and tend to be anxious, often (in my experience) requiring premedication.

Induction is either inhalational or with an intravenous agent, such as propofol. Airway management is usually with a flexible LMA. Alternatively, endotracheal intubation may be utilized; a short or intermediate acting muscle relaxant must be used, since surgical identification of the facial nerve will be necessary. The ett is taped on the contralateral side, and head positioned in a foam rest (Dr. Duff reports anecdotally that the incidence of pressure-related complications, such as alopecia, is reduced with foam as compared to gel headrest). The table is turned 180^0, IV extensions and long precordial stethoscope tubing are needed.

Anesthetic technique is generally deep inhalational; as noted above, muscle relaxants are discontinued. Volatile anesthetics may aid in keeping the MAP at approximately 25% below baseline, if possible, to minimize bleeding. Nitrous oxide is generally avoided, as it will diffuse into the air-filled middle ear space more rapidly than nitrogen moves out, leading to pressure build-up. Subsequent intermittent venting of the middle ear will lead to movement of the tympanic membrane. Avoiding nitrous oxide is even more important if a tympanic membrane graft is utilized. Nitrous oxide may also contribute to post-operative nausea, due to negative middle ear pressure in the recovery period. This places traction on the vestibular apparatus via the round window. Dr. Duff advocates the vigorous use of anti-emetics in his patients, requesting the administration of ondansetron 30 minutes prior to closure. He prefers that ketorolac be avoided, due to bleeding risk.

LARYNGOSCOPY AND BRONCHOSCOPY

Indications for bronchoscopy include stridor, possible airway foreign body, and evaluation of persistent pneumonia. At HCH, virtually all bronchoscopy is performed with a rigid bronchoscope (superior optics, better ability to remove debris, obtain cultures). The size of a bronchoscope refers to internal diameter; it is important to remember that the external diameter of a rigid bronchoscope is *greater* than the external diameter of a similarly sized ett (e.g. 3.5 ID: for ett the external diameter is 4.9 mm, for bronchoscope the external diameter is 5.7 mm).

Rigid bronchoscopy is generally performed in the operating room, under general anesthesia. Surgical requirements will, to some degree, depend on the indications for bronchoscopy. If a condition such as laryngomalacia is suspected, the patient must be breathing spontaneously, such that vocal cord motion is appreciated. On the other hand, if Dr. Luks is performing rigid bronchoscopy to help evaluate and possibly treat a persistent lobar infiltrate, it might be advantageous to provide a short acting NMB agent to facilitate passage of the bronchosope without coughing or laryngospasm.

Typically, Dr. Gibson's patients are infants or toddlers referred for the evaluation of recurrent stridor. There may be an associated history of prematurity or neonatal intubation for other reasons. Diagnoses such as tracheomalacia, subglottic stenosis, airway cysts, polyps, hemangiomas etc. must be ruled out. There may be an associated diagnosis of GERD, and perioperative acid aspiration prophylaxis may be indicated.

Anesthetic induction is generally inhalation; if loss of airway is a concern, 100% oxygen may be used in lieu of oxygen:nitrous oxide. Equipment to perform emergency tracheostomy or cricothyroidotomy is always immediately available. When the patient is sufficiently anesthetized, an IV is started; at this point I always consider the use of an anticholinergic agent to a. decrease secretions and improve visibility for the endoscopist and b. allow for increased anesthetic depth without bradycardia. The table is then turned 90^0 while mask anesthesia is continued. Dr. Gibson will perform laryngoscopy, assess vocal cord motion, and topicalize the airway with lidocaine. She will then withdraw the laryngoscope and mask ventilation is resumed and anesthetic depth once again assured. Dr. Gibson will then insert the rigid bronchoscope and spontaneous ventilation accomplished via the side port. When the telescope is in place, there is high resistance to ventilation, and it may be necessary to increase fresh gas flow. However, remember to assess the patient for adequate exhalation; I would rather briefly hypoventilate than forcefully ventilate and create air trapping and barotrauma.

At the conclusion of rigid bronchoscopy, an endotracheal tube may be placed or, alternatively, the patient allowed to emerge with mask ventilation. This decision will depend upon the nature of the case, potential airway difficulties, and the need to empty the stomach with a protected airway prior to emergence. Virtually all patients undergoing bronchoscopy receive dexamethasone. In some patients, the risk of postoperative airway edema is great enough that they remain electively intubated. In most cases, these patients are paralyzed and sedated prior to transport to the ICU.

Alternative Modes off Ventilation During Bronchoscopy

Alternative modes of ventilation during bronchoscopy include Sanders jet ventilation, which utilizes the Venturi effect with intermittent bursts of oxygen delivered through a 16 g catheter attached to a suspension laryngoscope. This technique gains more importance in the laser treatment of laryngeal lesions. General anesthesia is maintained via intravenous anesthetics, such as propofol, and neuromuscular blockade is generally preferred. High inflation pressures with smaller bronchoscopes lead to significant risk of barotrauma.

The Airway Foreign Body

Aspiration of foreign body is a major cause of morbidity and mortality in children. The history is generally coughing, choking or cyanosis while eating (popcorn, peanuts, jelly beans, hot dogs); in the absence of this history, foreign body aspiration should be suspected in a child who presents to the ER with refractory wheezing. Physical findings include decreased breath sounds, tachypnea, stridor, wheezing, and fever. Chest x-ray may reveal volume loss or air trapping distal to the obstruction. All aspirated foreign bodies in the airway should be removed and considered to be an emergency situation.

The induction of anesthesia is topic for debate: rapid IV vs inhalation induction. To some degree this decision depends upon the location of the foreign body, severity of respiratory distress, presence (or ease of placement in an awake state) of IV catheter, relative risk of aspiration, and comfort of the practitioner. The major concerns regarding inhalation induction are aspiration risk and slow, unpredictable induction due to poor anesthetic delivery. The major concerns regarding IV induction are abrupt loss of airway, potential for dislodging foreign body to less advantageous position, and creating ball-valve effect with air trapping and increased emphysema.

Advantages of Inhalation Induction:
•controlled induction with 100% oxygen
•more comfortable for child who does not already have IV in place
•smooth transition from induction to maintenance
•less theoretical risk of forcing foreign body to more distal location
•ball-valve effect not a factor

Advantages of Rapid Sequence Induction:
•assured level of anesthetic agent
•less concern about aspiration of gastric contents

Once anesthesia is induced, and endotracheal intubation achieved the patient's stomach should be evacuated with orogastric tube. A rigid bronchoscope is placed by the surgeon while the ett is withdrawn. Ventilation during the procedure is via the bronchoscope side port. Inadequate ventilation may necessitate frequent removal of the telescope and withdrawal of the bronchoscope to mid trachea so that both lungs may be ventilated; close communication with the surgeon is crucial. Pneumothorax is a rare but significant complication.

SPECIAL TOPIC: CARDIAC ARREST ASSOCIATED WITH PHENYLEPHRINE DROPS

In 2000, Groudine reported on a 4 year old who developed severe hypertension following phenlyephrine drops instilled locally during an adenoidectomy. This was treated with labetolol, which resulted in pulmonary edema and cardiac arrest. The mechanism is that phenylephrine markedly increased afterload, and the beta-blockade inhibits the physiological response (increase in contractility). An advisory recommended limiting phenylephrine exposure (20 mcg/kg) and avoiding beta and (probably) calcium channel blockers as a response if HTN does occur. Appropriate Rx (after observation for 10-15 minutes) include direct vasodilators and/or alpha antagonists. Successful resolution of pulmonary edema has been reported with administration of glucagon.

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