Chapter 17
ANESTHESIA FOR EAR, NOSE AND THROAT (ENT) SURGERY

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Introduction

Ear, Nose and Throat (ENT) surgeries are the most common surgeries performed in children, and very often require the surgeon and anesthetist to share the same workspace. Hence communication between them is essential. Tracheal tubes are more likely to become dislodged from the trachea during these procedures than during most other procedures because the surgeon must frequently move the patient’s head to accomplish the surgery. This chapter discusses common ENT surgeries and the special precautions required for some procedures.

Middle Ear Procedures

Myringotomy & Insertion of Pressure Equalization Tubes

*Chronic otitis media* (OM) is characterized by fevers and ear pain (plus or minus ear discharge) and is common in young children. It often occurs in association with upper respiratory tract infections of viral or bacterial origins. In many instances OM is treated with and responds to oral antibiotics, but repetitive infections usually require surgery, which entails creation of a hole in the eardrum (myringotomy) to relieve pressure and to drain middle ear secretions. A small pressure equalizing metal or plastic tube is commonly inserted to keep the hole open and prevent fluid accumulation. These tubes remain in place for up to six months and fall out spontaneously; occasionally they have to be surgically removed if they become impacted. Surgery for placement of these tubes is very short but requires the child to remain very still; hence anesthesia is usually required.

Anesthesia for insertion of pressure equalizing or myringotomy tubes usually includes inhalation induction of anesthesia with halothane or sevoflurane with or without nitrous oxide (if available) and oxygen. N₂O may distend the eardrum and make it easier for the surgeon. Spontaneous ventilation is maintained throughout surgery and is delivered through a facemask. An oral airway prevents airway obstruction and movement with breathing. If available, surgeons use a microscope or magnifying glasses to perform myringotomies. These magnifying devices improve
the surgeon’s ability to see the operative field and improves tube placement. During insertion, the patient must lie perfectly still because any movement is magnified by the microscope and makes it harder to perform the surgery. The procedure usually lasts 10-15 minutes, even when tubes are placed in both ears. Children with Trisomy 21 (Down syndrome) have very narrow ear canals, which makes it more challenging for the surgeon and prolongs the surgery and anesthesia. Since most of these surgeries are very short, some practitioners do not feel it necessary to place and IV for surgery. If this is done, the anesthetist must know beforehand where there is an adequate vein into which he/she can quickly place an IV if a problem arises. Pain is usually minimal after these procedures, and only mild analgesics are typically required (oral acetaminophen 10-15mg/kg, intra-operative rectal acetaminophen 40-45mg/kg, intranasal fentanyl 2mcg/kg or intramuscular morphine 0.1mg/kg up to 2mg total).

Tympanoplasty

Severe ear infections may progress to chronic middle ear infections, especially the mastoid bone (mastoiditis). Persistent repeated ear infection may cause a large hole in the eardrum that cannot be easily closed with a patch. In this case a fat graft may be required to close the holes. These holes, together with skin growth into a persistent hole in the ear drum produces a condition known as cholesteatoma. Repair of cholesteatomas requires a posterior auricular approach rather than the transauricular approach for surgical repair of the tympanic membrane (tympanoplasty) and lasts much longer than myringotomy and/or placement of ear tubes. It also requires rotation of the operating room bed 180 degrees away from the anesthetist and requires tracheal intubation. Inhalation induction of anesthesia is performed with halothane or sevoflurane in oxygen and nitrous oxide, if the latter is available. However, continued use of nitrous oxide during surgery is not recommended because N₂O easily expands any air in the middle ear. Discontinuing the N₂O allows the gas in the middle ear to be rapidly absorbed, which may change the configuration of the eardrum and displace the graft from its normal position. Therefore, nitrous oxide is contraindicated for maintenance of anesthesia in these patients. Nitrous oxide can also aggravate the postoperative nausea and vomiting that commonly accompany middle ear surgery.

After induction of anesthesia, intravenous access is obtained and a sedative hypnotic agent, e.g., propofol 2-3mg/kg, or ketamine 2mg/kg, is administered to facilitate tracheal intubation. The use of muscle relaxants is avoided because facial nerve monitoring is required for this surgery to help the surgeon from inadvertently cutting the facial nerve. Intra-operative opioids or additional ketamine may be required for pain control during and after surgery. Because postoperative nausea and vomiting are common following middle ear procedures, intravenous decadron 0.15-0.5mg/kg and ondansetron 0.15mg/kg should be administered at the beginning and near the end of surgery respectively when possible.
Tonsillectomy With or Without Adenoidectomy

Tonsillectomy and adenoidectomy (T&A) are two of the most common surgical procedures performed in children. Approximately 530,000 tonsillectomies are performed annually in the United States in children below 15 years of age. The indication for tonsillectomy without adenoidectomy is frequent tonsillitis, while the indication for both tonsillectomy and adenoidectomy is usually airway obstruction from enlarged tonsils and adenoids (adenotonsillar hypertrophy) Figure 17-1. Adenotonsillectomy is a frequent cause of obstructive sleep apnea (OSA).

Figure 17-1: Hypertrophied Tonsils

This photography shows massively hypertrophied tonsils. The arrows are pointing at the hypertrophied tonsils, which leaves very little space between them for breathing. It may be difficult to insert an oral airway in patients with large tonsils; doing so may cause bleeding. Oral airways should be inserted gently. *- Uvula. Courtesy of Carla Giannoni, MD

Pathophysiologic Consequences of Adenotonsillar Hypertrophy:

Sleep Apnea

Severe airway obstruction from adenotonsillar hypertrophy leads to disordered sleep patterns and obstructive sleep apnea (OSA). The latter is characterized by heavy snoring and pauses in breathing during sleep that last >20sec and in lack of air movement during the obstructive
periods. Gasping for air while asleep, mouth breathing, and daytime somnolence also occur. Halitosis (bad mouth odor) is also present when patients with adenotonsillar hypertrophy who also have an intra-oral infection. Because affected children typically have disturbed restless sleep, they are tired when they awaken in the morning and may remain so throughout the day. This lack of sleep occasionally results in poor school performance. Persistently impaired breathing chronically elevates blood CO\textsubscript{2} levels, which constrict the pulmonary artery and can cause pulmonary hypertension.

**Pulmonary Hypertension**

*Pulmonary hypertension* elevates the PaCO\textsubscript{2} levels and leads to worse hypoxemia during sleep, both of which constrict the pulmonary arteries. The increased intra-arterial pressure induces new muscle formation in the arteries, and this causes the pressures in the pulmonary arteries to be continuously elevated. Pulmonary hypertension is suspected during physical examination when the second heart sound of patients who have adenotonsillar hypertrophy is loud and the systolic murmur of tricuspid regurgitation is present. Other signs include neck vein distention and a prominent right ventricular heave, i.e., a lifting of the chest just to the right of the sternum, which can be both seen and felt. The liver is often enlarged (i.e., >2cm below the right costal margin) and its edge is rounded and not sharp, due to liver congestion. The chest X-ray of children with pulmonary hypertension shows evidence of cardiomegaly, right ventricular hypertrophy, and prominent enlargement of the right atrium. The electrocardiogram also shows evidence of right atrial enlargement (increased amplitude of the p wave). If the pulmonary hypertension is left untreated, cor pulmonale and right heart failure occur. The signs and symptoms of right heart failure include liver congestion and enlargement (hepatomegaly). It may also be pulsatile on palpation. In addition, there may be jugular vein distention. In severe cases, edema of the lower extremities is also present.

Where available, patients with severe OSA and pulmonary hypertension can be treated with a continuous or bi-level positive airway pressure-breathing device for a few days before surgery, particularly during nighttime sleep. This improves breathing, reduces decrease carbon dioxide levels, and decreases the amount of pulmonary hypertension. Prompt surgical management of adenotonsillar hypertrophy and treatment of obstructive sleep apnea-induced pulmonary hypertension usually prevents progression of the pathophysiology of pulmonary hypertension.

**Surgical Management**

To gain access to the adenoids and/or tonsils, the surgeon inserts an oral mouth gag that holds the mouth open. It is helpful if a special preformed tracheal tube can be used to facilitate mouth gag insertion, make it easier for the surgeon to see the tonsils, palate and upper lip, and minimize tracheal tube compression or obstruction by the mouth gag Figure 17-2.
Figure 17-2: Oral RAE Tracheal Tube

This figure shows an oral RAE tube for use during oral surgery. It is preformed so that the tube connector is over the chest when the tube is in place. This gets the anesthesia circuit out of the surgeon’s way so he/she can see. The cuff is inflated to reduce aspiration of blood and to decrease the leak of anesthetic gases and oxygen into the mouth. The latter could cause an airway fire (See Chapter 8).

Following tracheal intubation, the outer portion of this tube is taped in the midline onto the child’s chin Figure 17-3.
Figure 17-3: Oral RAE Tube and Mouth Gag in Place for Surgery.

This picture shows a mouth gag present in the patient’s mouth, which is overlying, but not compressing, an oral RAE tracheal tube. The mouth is held open by the gag.

The surgeon should open the mouth gag carefully to ensure that doing so does not compress or obstruct the tracheal tube. If the tracheal tube is compressed by the mouth-gag, there will be difficulty positive pressure ventilating the patient’s lungs; much higher ventilation pressures will be required. Spontaneously breathing patients show signs of obstructed breathing, including indrawing of the chest and simultaneous outward movement of the abdomen (rocking respirations) plus intercostal, suprasternal and infrasternal retractions. In severe cases, air movement ceases completely. This requires immediate release and repositioning of the mouth gag.

**Anesthetic Management**

Anesthesia induction is commonly accomplished by inhalation of either halothane or sevoflurane. If the child has an IV in place before surgery, and intravenous anesthesia induction with thiopental 4-6mg/kg, propofol 2-3mg/kg, or ketamine 1-2mg/kg can be used. Again, if the child does not have an IV, the anesthetist should determine where he/she will rapidly place and IV in an emergency. Tracheal intubation can be achieved during deep inhalation anesthesia (without muscle relaxants) with sevoflurane or halothane, or it can be done following administration of an intravenous induction agent, with or without a short acting muscle relaxant. Depending on availability, short to intermediate acting muscle relaxants, including intravenous succinylcholine 1-2mg/kg, rocuronium 0.6mg/kg, atracurium 0.5mg/kg or cis-atracurium 0.2mg/kg can be administered along with the sedative-hypnotic agents to facilitate tracheal intubation. Muscle
relaxants should only be given if the anesthetist is fairly certain he/she can maintain an adequate airway and easily ventilate the patient’s lungs when he/she becomes unconscious. This is not always easy to determine in patients with enlarged tonsils and adenoids. In the United States, succinylcholine is only used to emergently place a tracheal tube in patients who are considered to have a full stomach. This restriction is the result of reports of hyperkalemia and cardiac arrest during induction of anesthesia and succinylcholine administration, particularly in young males who have not yet started walking. These patients may have an undetected/undiagnosed form of muscular dystrophy that predisposes them to muscle break down and severe hyperkalemia with succinylcholine-induced muscle contractions. Since succinylcholine is the only muscle relaxant available in some countries, it should be used with great caution in this patient population.

Patients with severe obstructive sleep apnea are very sensitive to opioids. Therefore, the recommendation is to not give opioids until the trachea has been extubated. The dose of opioid must be titrated to effect, i.e., give enough opioid to prevent pain but not enough to cause apnea. This can be done by administering small amounts of opioid at a time and waiting 3-5 minutes to determine their effect before giving more drug. Another option in patients undergoing adenotonsillectomy includes giving intra-operative intravenous ketamine 1-2mg/kg for pain management. Ketamine has the benefit of not depressing respiratory efforts. However, it may cause hallucinations, which are disadvantageous for older children. Hallucinations usually do not occur with these low doses of ketamine. Use of intravenous diclofenac 0.3mg/kg can also be considered. Administration of intraoperative dexamethasone 0.15 to 0.5mg/kg, reduces edema at the surgery site, decreases postoperative pain, and reduces the incidence of nausea and vomiting after surgery.

During surgery, the inspired oxygen concentration (FiO₂) should be below 30% to reduce the risk of an airway fire (See Chapter 8). The use of cuffed endotracheal tubes decreases the potential for an airway fire by reducing the amount of oxygen-containing gas in the pharynx. The three components needed for an airway fire to occur include an oxygen-rich environment (FiO₂ ≥0.30% and/or nitrous oxide), an ignition source (electrosurgical devices or laser), and fuel (endotracheal tubes, surgical drapes, gauze, alcohol containing solution and masks). Most airway fires are occur when an electrocautery burns through an endotracheal tube that has >30 percent oxygen flowing through it.

If an airway fire occurs, the flaming endotracheal tube should be immediately removed from the airway, the oxygen source completely turned off, and the airway flooded with saline or water. After the fire has been extinguished, the extracted endotracheal tube should be inspected to verify that it is intact and no fragments are left in the airway. Ventilation should be managed via a facemask. Bronchoscopy is done to detect the extent of mucosal damage and to remove burned, coagulated tissue. A tracheal tube is then inserted to assure and airway.
Post-Operative Management

Young children, particularly those under three years of age, should be monitored overnight in an intensive care unit (ICU) when possible to provide a higher level of supervision. Obstructive symptoms, if they exist, may worsen after surgery due as the operative area swells. Close monitoring during this early post-operative period will allow prompt detection of respiratory depression if it develops in response to the giving pain medication after surgery.

Post Tonsillectomy Bleed

Post tonsillectomy bleeding may occur immediately after surgery while the child is still in the recovery room, in which case the child should be taken quickly back to the operating room for re-exploration and cauterization of the bleeding source. Bleeding may also occur 7-10 days after surgery when the wound scab or eschar peels off. When bleeding occurs, the child initially swallows the blood. By the time he/she starts coughing up or regurgitating blood, the stomach typically contains significant amounts of blood and the hemoglobin concentration has decreased. By the time the child arrives at the hospital, he/she may be dehydrated from not drinking and hypovolemic from bleeding, making it very challenging to secure intravenous access. History obtained from the parents and child may indicate that vomiting of frank red blood (recent) or dark brown old blood. However, this does not always indicate either the duration or severity of the bleeding. A good history and physical examination are required to determine the severity of bleeding (See Chapter 1). Dry, parched lips and decreased skin turgor (persistent tenting of skin when it is lifted up) are signs of significant bleeding and severe volume loss. Emergency surgery is needed to stop the bleeding. When no available site exists for percutaneous intravenous access, the anesthetist should consider using the intraosseous route to institute fluid resuscitation and/or blood transfusion as indicated. To obtain intraosseous access a specially made needle or a large bore intravenous catheter, (such as a 16g catheter) is inserted into the tibial tuberosity, which is located approximately 1cm below the head of the tibia. Figure 17-4 shows one technique for intraosseous needle placement.
Figure 17-4: Technique for Insertion of an Intraosseous Needle

This figure shows insertion of an intra-osseous needle using an electric drill. Note the needle is being inserted at 90° to the long axis of the bone.

Care must be taken to avoid placing the needle in the growth plate, which could prevent that extremity from growing. Firm pressure is applied to the needle until definite loss of resistance is felt. Easy aspiration of bone marrow verifies correct placement of the needle in the marrow cavity. Alternative locations for intraosseous needle insertion include: head of the humerus and the upper 1/3 of the sternum. Figure 17-5 shows these sites.
Anesthetic Management of Post Tonsillectomy Bleeding

A hemoglobin value obtained after the bleeding occurred should be evaluated to determine the need for peri-operative blood transfusion. Regardless of when the patient last TE, he/she has a stomach full of blood and must be managed by rapid sequence induction of anesthesia and rapid tracheal intubation. Once adequate intravenous access has been obtained, the intravascular volume is expanded with boluses of normal saline 20ml/kg until the arterial blood pressure is normal and perfusion has improved. This may require as much a 60ml/kg of normal saline. Then the patient can breath 100% oxygen for five minutes before giving intravenous propofol 2-3mg/kg or ketamine 1-2mg/kg and intravenous succinylcholine 2mg/kg or rocuronium 1mg/kg to facilitate rapid sequence induction of anesthesia and tracheal intubation. Propofol should be used with caution in these potentially volume-depleted patients because propofol decreases peripheral vascular resistance and may cause profound hypotension. Ketamine may be a better choice as an induction agent because it causes the release of catecholamines and increases peripheral vascular
resistance of patients with relatively normal intravascular volumes. However, volume depleted patients will become hypotensive when the drug is injected.

Two separate large bore Yankauer type suction tips should be available for removing blood from the oropharynx during tracheal intubation. Bleeding may be aggravated by direct laryngoscopy and obscure visibility of the vocal cords during tracheal intubation. If there is a lot of blood in the larynx, it may be difficult to view the glottis and vocal cords. If bubbles are identified coming through the blood during expiration, this often serves as a guide to the location of the vocal cords. Correct placement of the tracheal tube should be confirmed by noting bilateral chest rise with inspiration, seeing condensation inside the tracheal tube with positive pressure ventilation and the presence of an end-tidal carbon dioxide waveform on a capnograph, if available.

The surgical procedure to control bleeding usually only lasts a few minutes and involves identification/localization and cauterization of the bleeding site. Because the duration of surgery is short and the patient has a full stomach, succinylcholine is the drug most commonly used for tracheal intubation of patients with a full stomach. Rocuronium 1mg/kg can also be used, but it may not be possible to adequately reverse the neuromuscular block at the end of the short procedure. Likewise, pain medication should be administered judiciously, if at all, as surgery is short and narcotics may cause respiratory depression and make it difficult to extubate the trachea. It is usually better to wait until after the trachea has been extubated before giving pain medications. All volatile anesthetic agents can be utilized for maintenance of anesthesia. However, the drug should be titrated to an end-tidal anesthetic concentration that will allow rapid awakening from anesthesia and tracheal extubation. The tracheal tube should only be removed when the patient is awake.

**Tracheomalacia**

*Tracheomalacia* is due to underdevelopment of the tracheal rings or widening of the membranous portion of the trachea and is observed in extremely premature babies; particularly those who have had a tracheal tube in place for weeks. As a result, tracheomalacia usually occurs in tertiary care centers. The classic presentation of tracheomalacia is stridulous breathing or wheezing, especially during expiration because the intrathoracic airways collapse during exhalation because the extra tracheal pressure is more positive. Other symptoms include recurrent breath holding or apnea spells or a chronic cough in older children. This condition also occurs when an extrinsic vascular ring compresses the trachea (Figure 17-6).
Figure 17-6: Endoscopic View of Distal Tracheal Lumen Compression by Innominate Artery.

This figure shows tracheal compression by an extra thoracic ring. Photograph courtesy of Deidre Larrier, MD

Diagnosis and Treatment: Diagnosis and differentiation of these two conditions (tracheomalacia and vascular ring) involves rigid or fiberoptic bronchoscopy. Both require general anesthesia, commonly a combination of intravenous and inhalation anesthesia. Management of tracheomalacia and tracheal rings is initially medical and application of continuous positive airway pressure and bi-level positive airway pressure to prevent tracheal collapse during expiration. If symptoms persist, surgical approaches are employed to improve airway patency, such as airway stenting with tracheostomy and aortopexy. Aortopexy is performed in specialized institutions via video assisted thoracoscopic surgery and is described in more specialized textbooks.

Anesthetic Management

Diagnostic bronchoscopy: Inhalation induction of anesthesia is performed and intravenous access is secured once the monitors have been applied. The anesthetic goal during this surgery is to provide a sufficiently deep plane of anesthesia that prevents coughing during bronchoscopy while maintaining spontaneous ventilation. Spontaneous ventilation is needed so the surgeons can watch tracheal movement during inspiration and exhalation to determine if it collapses during exhalation. Intravenous access allows the anesthetist to administer intermittent boluses of
propofol or ketamine or to continuously infuse these drugs. Chest rise must be continuously verified during surgery, especially as it is difficult to ascertain end-tidal carbon dioxide (EtCO\textsubscript{2}) concentrations due to lack of complete airway seal during surgery.

Tracheostomy: Tracheostomy is typically performed when it is difficult to wean a child from mechanical ventilation or when a baby has severe tracheomalacia or laryngomalacia. Inhalation induction of anesthesia is done via the indwelling tracheal tube. Giving muscle relaxants prevents patient movement while the tracheostomy tube is being inserted. Once the surgeon has opened the trachea, he/she will direct the anesthetist to slowly withdraw the tracheal tube to a position just above the hole in the trachea without removing it from the trachea. This allows reinsertion of the tracheal tube beyond the hole in the trachea if necessary. Once the tracheotomy tube is in place, the tracheal tube can be removed from the mouth. The anesthesia circuit is then connected to the tracheostomy, and the anesthesiologist manually ventilates the patient’s lungs to ensure bilateral chest rise and the presence of carbon dioxide in the expired gases. Once correct placement of the tracheostomy tube is confirmed, it is secured around the neck by tracheal ties. Surgeons ensure that the ties are not too tight by confirming that he/she can easily get two fingers between the ties and the neck. If the ties are too tight, the jugular vein may be obstructed.

Airway granulomas or Subglottic narrowing: Both of these conditions can occur when a child’s trachea has been intubated for long periods of time. The tube causes mucosal edema, which narrows the airway and causes stridulous breathing. Prolonged tracheal intubation may also cause formation of granulation tissue within the airway. Airway narrowing and stridor characterize both conditions. Airway granulomas Figure 17-7, often present with more severe symptoms of airway obstruction, particularly if the granuloma is large enough to obstruct the airway and is pedunculated. This may cause a ball-valve effect during breathing.
Figure 17-7: Airway Granuloma Resulting from Tracheal Intubation

This figure shows polyps in a bronchus, some of which are partially occluding the bronchus. Photograph courtesy of Mathew Sitton, MD

Management: The only effective treatment for airway granulomas is removal of the lesions under direct vision, i.e., via direct bronchoscopy and laryngoscopy. Subglottic narrowing is managed by laser resection of the excess tissue or radial incisions into the larynx using a laser. Occasionally, the stenosis recurs and is treated with mitomycin-C, an anti-cancer drug, which is applied directly to the incised laryngeal surfaces to prevent re-adhesion of the freshly separated mucosal tissue.

Laryngeal Papillomas: Laryngeal papillomas are usually referred to as recurrent respiratory papillomas. They are small, assorted cystic-appearing masses that are found in the airways of children following transmission of human papilloma virus types 6 and 11 from the mother during passage through the birth canal at birth Figure 17-8. This occurs in approximately 4.5 per 100,000 births. There do not have to be active lesions in the birth canal at the time of delivery for the infectious agent to be transmitted to the child. Latent maternal infections with human papilloma virus can also cause airway papillomas in children.
Presentation and Pathophysiology: These airway masses are initially detected when a child develops respiratory distress and some element of airway occlusion. The amount of respiratory distress depends on how severely the airway is obstructed. Other symptoms include a weak cry, noisy breathing (stridor), chronic cough, and difficulty swallowing (dysphagia). Another indication of the severity of the airway obstruction is a voice that is barely audible. When this occurs, additional, signs of airway obstruction, such as suprasternal and intercostal retractions, may also be observed on physical examination.

Management: There is no permanent cure for polyposis. Some lesions spontaneously resolve, but some do not and are responsible for the patient’s death, especially if the child’s compliance with doctor visits was poor and he/she did not benefit from frequent airway examinations and/or resection of papillomas. Without regular follow-up and care, the papillomas usually grow and extend from the larynx or trachea into the tracheobronchial tree, at which point surgical management may be impossible. The anti-viral agent, interferon has been used for management of papillomas but does not prevent recurrence of airway lesions. Surgical management involves resection of the airway lesions with carbon dioxide laser or coblation (cold cutting and coagulation) via direct laryngoscopy and bronchoscopy under general anesthesia.

Anesthetic Management: Following inhalation induction of anesthesia and application of routine monitors (electrocardiogram, blood pressure, pulse oximeter and temperature) intravenous access is secured. With the patient spontaneously breathing anesthetic and oxygen through a
facemask, the table is turned 90 degrees to facilitate direct laryngoscopy or suspension laryngoscopy by the surgeon. The anesthesia circuit is attached to the ventilating port of the bronchoscope to deliver anesthetic gas and oxygen during the procedure. Since the patient’s mouth and the anesthesia system are open, it is usually necessary to give intermittent bolus of either ketamine or propofol to maintain the required deep plane of anesthesia. Alternatively, a continuous infusion of propofol 100-200mcg/kg/min can be used to maintain anesthesia. Intravenous lidocaine 2mg/kg will reduce airway reactivity or the surgeons can spray the airway with aerosolized lidocaine under direct vision, both of which decrease airway reactivity. Coblation or laser ablation of laryngeal papillomas can be performed with general anesthesia, spontaneous ventilation, and no tracheal tube. However, if frequent oxygen desaturation occurs, it may be necessary to intermittently insert a tracheal tube and ventilate the lungs with oxygen between laser treatments. At all times during this surgery, anesthesia providers and surgical team members must ensure that the inspired oxygen concentration is below 30% to prevent an airway fire (See Chapter 8). If higher oxygen concentrations are required, a special laser tracheal tube or a regular tracheal tube with aluminum foil wrapped around the exposed portion of the tube i.e., the part above the vocal cords. This decreases (but does not eliminate) the possibility of an airway fire. The dangers associated with using foil include the possibility of a piece of loose foil getting into the airway or an inadvertently exposed portion of the endotracheal tube catching fire during laser treatment.

Management of an airway fire includes immediate removal of the flaming object (tube, sponge), turning off the oxygen, and flooding of the airway with saline. The airway must be examined afterward with bronchoscopy to determine the extent of injury and the presence of airway debris that can be removed.

**Foreign body aspiration** is relatively common in the 1-5 year old children because they place objects in their mouths, including peanuts, seeds and toys that can be aspirated. Aspiration of small batteries is particularly dangerous because they contain corrosive matter that can severely damage the airway. Surgical removal of suspected batteries should be treated as an emergency.

**Presentation:** It is uncommon for someone to actually witness foreign body aspiration in children. Signs that this has happened include: sudden onset of drooling (caused by inability to swallow), wheezing, or persistent cough. In some instances, foreign body aspiration presents as pneumonia or reactive airway disease that is refractory to medical treatment.

**Diagnosis:** A chest X-ray may show that the lung on the affected side is collapsed. If the foreign body is lucent, it will be seen on X-ray. If it is not (plastic toys, glass) only the effects of airway blockage will be seen. Auscultation of the lung reveals decreased breath sounds on the affected side. In clinically stable patients, flexible diagnostic bronchoscopy is often performed to search for aspirated foreign bodies. However this requires two separate anesthetics because foreign bodies cannot be removed during flexible bronchoscopy.
Surgical management: Removal of the foreign body is indicated shortly after the diagnosis is made. Removal of objects from the airway is usually achieved during rigid bronchoscopy. The object is grasped with an airway forceps (Figure 17-9).

Figure 17-9: Ventilating Bronchoscope, Optical Telescope, and Foreign Body Grasper.

This picture shows a ventilating bronchoscope with an optical telescope (middle) and grasping forceps for removal of tissue or foreign objects.

Anesthetic management: Having an IV before surgery allows the anesthetist to administer anticholinergic agents to dry up watery secretions and improve visibility throughout the procedure. If no IV is available, once anesthesia has been induced and intravenous access is obtained, anticholinergic drugs can be given. Following induction of anesthesia and placement of routine monitors, the head of the bed is turned 90 degrees away from the anesthetist to allow the surgeon to have access to the patient’s head.

Surgeons require an unobstructed view of the larynx for direct laryngoscopy and bronchoscopy. A rigid bronchoscope is inserted into the larynx and advanced into the trachea after the vocal cords are sprayed with lidocaine 3-5mg/kg or with nebulized lidocaine. These local anesthetics reduce vocal cord irritation during the procedure. Ventilation during the procedure can be provided either with a jet ventilator (if available) or bag connected to the side port of a rigid bronchoscope.

Jet ventilation administers high concentrations of oxygen at 50psi (pounds per square inch) down the larynx through a 14-16-gauge cannula. The high-pressure oxygen delivered down the narrow tube creates a negative pressure at the end of the cannula, which causes room air to be drawn (entrained) into the lungs. This system requires an unobstructed open glottis to allow the entrained air to be expelled during exhalation. Therefore, patients with complete airway obstruction are not good candidates for jet ventilation, as inability to exhale leads to barotrauma and pneumothorax. Other disadvantages of jet ventilation include inability to measure end-tidal
carbon dioxide and peak airway pressures. Gastric distension may also occur. Rigid bronchoscopy requires that the mouth remain open during the procedure to allow gases to escape. Therefore intravenous agents, boluses or infusions of propofol or ketamine, are useful for supplementing inhalation anesthetics. The side port of a rigid ventilating bronchoscope can be attached to the anesthetic circuit for delivery of inhaled anesthetic during bronchoscopy. Spontaneous ventilation and deep anesthesia are maintained while the surgeon is identifying the foreign body. A small grasping or biopsy forceps is inserted through the scope to retrieve the foreign body. In small children, the optical telescope used to visualize the airway may completely obstruct ventilation through the ventilating scope. If this occurs, the telescope must be removed intermittently and the proximal end of the ventilating scope occluded with a finger or thumb to allow the anesthetist to manually ventilate the patient’s lungs. Figure 17-9 shows the ventilating bronchoscope, optical style and grasping forceps. A small amount of non-depolarizing muscle relaxant or a bolus of propofol may be required just before the foreign object is retrieved to ensure that the patient does not move at this critical time. If the foreign body gets dislodged in the trachea as it is being retrieved, it is often best to push it back into the bronchi from which it was originally retrieved to prevent complete airway obstruction and inability to ventilate the lungs due to tracheal obstruction. Organic materials, such as peanuts, are particularly difficult to retrieve as they can fragment into many small pieces while being retrieved and require multiple attempts to retrieve and remove all of the pieces. In general, intravenous steroids, such as dexamethasone 0.5-1.0mg/kg, should be administered at the beginning of surgery to decrease mucosal swelling. Racemic epinephrine may also be required after surgery, depending on the degree of swelling and the presence of stridor.

References:

