POST-TONSILLECTOMY BLEEDING

Tonsillectomy, whether accompanied by adenoidectomy or not, is one of the most commonly performed surgical procedures. Post-tonsillectomy bleeding is considered a surgical emergency. It can occur within the first 24 hours (i.e., primary) or 5 to 10 days after surgery when the eschar covering the tonsillar bed retracts (i.e., secondary). Primary bleeding is more serious than secondary bleeding, because it usually is more brisk and profuse. The incidence has been reported to be less than 1% in a large series of 9409 cases performed by using mechanical dissection. The management of anesthesia can be challenging, even in the hands of an experienced pediatric anesthesiologist. It often requires dealing with anxious parents; upset surgeons; and frightened, anemic, hypovolemic children with stomachs full of blood.

Preoperative Preparation

A thorough review of the anesthetic record of the original surgery provides pertinent information about any existing medical condition, use of medications (e.g., aspirin), and a rough estimate of intraoperative blood loss and fluid replacement. A quick history and examination of the child provides vital information about the patient’s current volume status. History of dizziness and presence of orthostatic
hypotension may suggest a loss of over 20% of blood volume and the need for aggressive fluid resuscitation. Even when severe hypotension is not present, the child with the bleeding tonsil is hypovolemic, and has decreased cardiac output secondary to ongoing blood loss. If blood loss is severe or fluid resuscitation is not vigorous, lactic acidosis and shock develop. The attempt of the body to compensate for the loss of blood volume by an outpouring of catecholamines leads to peripheral vasoconstriction, which delays the clinical onset of severe hypotension in the awake child. When anesthesia-induced vasodilation occurs, profound hypotension is observed. Vigorous fluid resuscitation with crystalloids or colloids is the key to improving cardiac output and achieving hemodynamic stability before anesthesia. Hemoglobin or hematocrit determination can be helpful if interpreted in light of the patient's volume status and the type of fluid correction used. If the hemoglobin concentration is low, blood may be required; however, blood is rarely the primary solution for volume replacement in these children. There is controversy regarding the need for routine laboratory testing for coagulopathies in patients before elective tonsillectomies. If a patient has post-tonsillectomy bleeding and no specific bleeder is identified, however, it might be necessary to obtain a prothrombin, partial thromboplastin time, platelet count, and a bleeding time to rule out a bleeding diathesis. The patient must be adequately volume resuscitated before proceeding to the operating room.

Anesthetic Management

A child who presents with a bleeding tonsil has a full stomach (filled with swallowed blood) and still may be hypovolemic. The anesthesiologist may have difficulty in visualizing the larynx because of the bleeding tonsillar bed and clots in the pharynx. A styletted endotracheal tube, two sets of well-illuminated laryngoscopes, and a large-bore rigid suction catheter must be available before anesthetic induction. The patient is brought into the operating room, and monitors are placed before induction of anesthesia. Preoxygenation can be done with the patient in the lateral, head-down position to encourage blood to drain out of the mouth. The child then is turned supine; a rapid-sequence induction with cricoid pressure (Sellick's maneuver) applied by an assistant is the safest technique to avoid aspiration of blood into the lungs. A full dose of pentothal or propofol in a child with hypovolemia could cause significant hypotension. Reduced doses of these drugs (e.g., pentothal, 2–3 mg/kg, or propofol, 1–2 mg/kg), or ketamine, 1 to 2 mg/kg for induction, followed by succinylcholine, 1.5 to 2 mg/kg for intubation, allow rapid control of the airway without producing hypotension.

In patients older than 4 years, a cuffed endotracheal tube usually is selected to minimize the chance of blood aspiration around the tube. The use of a stylet is recommended despite a previous history of easy
intubation. The blood pressure after induction often reflects the volume status of the patient.

A nondepolarizing muscle relaxant—such as vecuronium, 0.05 to 0.1 mg/kg, after the effects of succinylcholine have worn off helps maintain a lighter level of anesthesia. Titration of a volatile anesthetic—such as sevoflurane or desflurane with nitrous oxide and oxygen51 supplemented with an opioid, such as fentanyl, 1 to 2 μg/kg—enables one to awaken patients rapidly at the end of surgery.14 Securing the bleeder in the tonsillar bed can be accomplished rapidly by the surgeon if the blood pressure is maintained in the normal range. Suctioning the stomach with a large-bore suction catheter under direct vision after the procedure does not guarantee an empty stomach—because blood clots may still remain—but may reduce postoperative vomiting. The use of prophylactic antiemetic therapy (e.g., ondansetron, 0.1 mg/kg,31 or metoclopramide, 0.15 mg/kg) is indicated in these patients.

The most important postoperative consideration is to extubate these children when they are fully awake and can control their airway reflexes. Extubating them in the lateral position when they open their eyes and purposefully can respond to verbal commands is the safest way to avoid aspiration. Postoperatively, a repeat determination of the hemoglobin level may be indicated.

ASPIRATED FOREIGN BODIES

Foreign body aspiration is most common in toddlers 1 to 3 years of age. Most (95%) foreign bodies lodge in the right mainstem bronchus.6 History of choking while eating or playing, persistent cough, or wheezing that is not ameliorated with medical treatment may be the only presenting findings. If the foreign body completely obstructs a bronchus or creates a ball-valve phenomenon, distal hyperinflation from air trapping may occur; a hyperinflated lung during the expiratory phase may be seen on chest radiographs (Fig. 1). The more distal the object in the airway, the more atelectatic changes are noted.

A foreign body in the trachea (less than 5% of airway foreign bodies) lodges there if it is too large to pass the carina.15 The signs of a tracheal foreign body may include a brassy cough with or without abnormal voice, bidirectional stridor, or complete airway obstruction in the case of laryngeal foreign bodies.

Any sharp object or any object causing acute upper airway obstruction with cyanosis and an inability to maintain ventilation requires emergent removal. Peanuts should be removed promptly because salt and oil can cause an inflammatory response and subsequent pneumonia.12 In addition, peanuts tend to swell, fragment, and crumble, making removal en bloc extremely difficult.
Figure 1. A chest radiograph may appear normal during inspiration (A) following foreign body aspiration. A hyperinflated right lung and a leftward mediastinal shift during expiration (B) suggest a foreign body in the right mainstem bronchus.

Anesthetic Management

The approach to the anesthetic management of these children depends on the level, degree, and duration of obstruction. A child who aspirates a foreign body while eating or soon thereafter further challenges the anesthesiologist with the presence of a full stomach. Waiting for the stomach to empty may not be possible or even effective in the acute situation. Intravenous metoclopramide, 0.15 mg/kg, may hasten stomach emptying, but does not guarantee an empty stomach. If time permits, the administration of an anticholinergic agent may be useful to reduce secretions.

A major controversy in the anesthetic management of foreign body aspiration is whether to control ventilation or allow spontaneous respirations during bronchoscopy. Some endoscopists prefer a spontaneously ventilating patient to prevent dislodgement of the foreign body as it is being retrieved out of the airway. Based on the child’s NPO status, anesthesia can be induced by inhalational (if there is no concern of full stomach) or intravenous techniques. Sevoflurane is preferred over halothane for inhalational induction in these children because of its tendency not to induce coughing and better cardiovascular stability. Anesthesia usually is maintained with 100% oxygen and halothane or isoflurane or a propofol-based total intravenous anesthetic technique. Halothane and isoflurane have some advantage over sevoflurane during maintenance because they are more soluble and are associated with slower elimination—which allows more time for airway manipulations without the possibility of the patient becoming too lightly anesthetized and reacting to the procedure. A propofol total intravenous anesthetic
The technique is more superior because it allows a steady level of anesthesia that is independent of ventilation, and does not expose the operating room personnel to waste anesthetic agents that inevitably spill around the bronchoscope. Often, these children have irritable airways because of the presence of the foreign body. The use of topical lidocaine, 3 to 4 mg/kg, divided between the laryngeal structures and tracheal mucosa, is essential to suppress airway reflexes and to prevent coughing and bronchospasm.

The use of short-acting (e.g., mivacurium) or intermediate-acting (e.g., vecuronium) muscle relaxants mandates positive pressure ventilation, but enables a lighter level of anesthesia and ensures a quieter field for the surgeon. The use of a ventilating bronchoscope equipped with a 15-mm side port normally allows for easy control of ventilation; however, ventilation may need to be interrupted for brief periods when the endoscopist removes the window (lens) that occludes the proximal end of the bronchoscope to insert a telescope or a large grasping forceps. Double-action (center action) forceps are advantageous because they have a slim shaft and can be opened against the bronchial wall on each side of the foreign body to help free it by slight bronchial dilatation.

Because of wide-spread atelectasis, these patients often have low functional residual capacity, and little reserve; their oxygen saturation drops rapidly; and their PaCO₂ rises rapidly during periods of apnea. Clinical vigilance is key, with constant monitoring of chest excursion, breath sounds, and oxygen saturation. As in all airway cases, communication between the endoscopist and anesthesiologist is important. Both parties must cooperate in the care of the airway. If the endoscopist is taking too long to grasp the object with the bronchoscope in a distal airway and ventilation is inadequate, the endoscopist needs to retreat momentarily to the midtrachea so that the patient can be ventilated.

When the foreign body is in the grasp of the forceps, the upper airway and glottis need to be quiet and relaxed. At this point, the depth of anesthesia may need to be increased if the child is breathing spontaneously, or manual ventilation may need to be stopped temporarily in the paralyzed patient. Supplemental intravenous lidocaine, 1 mg/kg, is helpful to attenuate the airway reflexes. When the foreign body is retrieved, the forceps and the bronchoscope may need to come out as a unit. The airway should be anesthetized adequately so the foreign body is not dropped from the forceps by a cough or a closing glottis. After removal of the foreign body, the airway should be re-evaluated for any other foreign bodies, and the impact site should be assessed for trauma, bleeding, or granulations.

Once the endoscopy and foreign body removal are complete, β-agonist bronchodilators, such as albuterol, may help with postoperative wheezing. Upper airway edema and secondary stridor from airway manipulation are helped by racemic epinephrine inhalation (0.5 mL of 2.25% solution diluted 1:6) or prophylactic steroid therapy (dexamethasone, 0.5 to 1 mg/kg to a maximum dose of 20 mg). The length of stay
in the hospital after surgery depends on the condition of the lungs and the need for continuing chest physical therapy.

**ACUTE EPIGLOTTITIS**

Acute epiglottitis can be fatal because it can produce seemingly unprovoked sudden and complete airway obstruction. It is a clinical and pathologic entity that more correctly should be called supraglottitis because the arytenoids and aryepiglottic folds and the epiglottis usually are affected. All structures become swollen and stiffened by inflammatory edema. Although the main focus of infection is in the supraglottic structures, the disease produces a generalized toxemia. Epiglottitis is most common between the ages of 3 and 5 years, but it can occur in any age. The causative organism in acute epiglottitis typically is *Hemophilus influenzae* type B; however, infection with group A β-hemolytic *Streptococcus* recently has become more frequent. A decreased incidence of acute epiglottitis from 3.47 per 100,000 in 1980 to 0.63 per 100,000 in 1990 recently has been ascribed to the routine use of *Hemophilus influenzae* vaccination.

**Clinical Presentation**

The onset of acute epiglottitis is usually abrupt, with a brief history of high fever, severe sore throat, and difficulty in swallowing. Stridor, if present, is usually inspiratory, and because the subglottic structures usually are unaffected, there is little or no hoarseness. The child appears toxic, and to improve airflow past the swollen epiglottis, insists on sitting up and leaning forward in the sniffing position (Fig. 2). The mouth is open, with the tongue protruding. The child frequently drools because of difficulty and pain on swallowing.

In addition to high fever, other signs of generalized toxemia may include tachycardia, a flushed face, and prostration. The respiratory pattern is usually slow and quiet to allow more comfortable breathing.

**Diagnosis**

Acute epiglottitis is a clinical diagnosis. It must remain prominent in the differential diagnosis of a child presenting with signs and symptoms of upper airway obstruction. In some early cases, however, the clinical presentation alone may not be conclusive. If so, a lateral radiograph of the neck usually shows the swollen epiglottis and aryepiglottic folds (Fig. 3). The vallecula may be obliterated, but subglottic structures are usually clear. A physician who can establish an airway should always be in attendance, because total airway obstruction can develop during the time necessary to complete the radiograph, especially if the
child is forced to lie supine—one reason why the use of lateral neck radiographs in the differential diagnosis of upper airway obstruction is considered controversial. Examination of the pharynx and larynx should be attempted only in an area with adequate equipment and staff prepared to intervene should upper airway obstruction develop (ideally, the operating room).

**Principles of Management**

The safest, most conservative approach to the management of epiglottitis is to establish an artificial airway as soon as the diagnosis is made, and then, with the airway secured, to proceed with appropriate antibiotic and supportive therapy.

A child suspected of having acute epiglottitis immediately should be transported to the ICU or to the operating room by a physician capable of and equipped for establishing an airway. The child should be kept sitting up at all times and never should be forced to lie on his or her back. No attempts to examine the larynx should be made in the emergency room.

In the operating room, with equipment and personnel who can
insert a surgical airway immediately present, a precordial stethoscope, pulse oximeter, and other standard monitors are applied.

Unless the child is moribund—when awake intubation is preferred—general inhalational anesthesia is induced with oxygen and sevoflurane or halothane, with the child maintained in the sitting position. Intravenous induction agents or muscle relaxants should be avoided at this time to prevent loss of spontaneous ventilation.

When the surgical stage of anesthesia is achieved, an intravenous access is established and secured, followed by direct laryngoscopy, which confirms the diagnosis (Fig. 4). A styletted orotracheal tube is first inserted, followed by a nasotracheal tube of appropriate size. The endotracheal tube used should be one or two sizes smaller than recommended for the age of the child. An air leak at 20 to 25 cm H₂O, when present, confirms the election of an appropriately sized tube. A larger tube is not necessary, and may contribute to the possible development of serious laryngeal complications, such as subglottic stenosis. The child should be able to breathe around and through the tube.

Once the airway is secured, aggressive medical therapy should be started. Intravenous antibiotics are essential. It is recommended that cephalosporins (e.g., ceftriaxone, 50 mg/kg/d) be used initially for antibiotic therapy, being commenced immediately after the diagnosis is made and appropriate cultures are taken. The duration of treatment is controversial, but at least 3 to 5 days of intravenous antibiotics followed by oral therapy usually is the minimum. Supportive measures include
Figure 4. A swollen epiglottis seen on direct laryngoscopy.

intravenous hydration, airway care, sedation as necessary, and acetaminophen for high fever. Pulmonary edema can develop after intubation in children with severe epiglottitis.

The child is usually ready for extubation in 24 to 48 hours. The best clinical indication is resolution of the signs of toxemia, even if the epiglottis is still slightly swollen. Although controversial, direct laryngoscopy under propofol sedation can be performed in the ICU to visualize the epiglottis before extubation.

Epiglottitis does not recur. With the airway always secured in a timely manner as described, the life-threatening potential of epiglottitis is eliminated. However, there still is an unacceptable morbidity and mortality associated with epiglottitis in the pediatric population.

CROUP

Croup is a symptom complex of inspiratory stridor; suprasternal, intercostal, and substernal retractions; barking cough; and hoarseness that results from swelling of the mucosa in the subglottic area of the larynx. There are two common entities that account for most cases of croup: spasmodic croup and laryngotracheobronchitis. Spasmodic croup has been diagnosed in approximately 3% of pediatric patients with stridor. The patient is fairly well and afebrile, presenting with nocturnal episodes of spasmodic cough, which is described as barking and high pitched. The disease is self-limiting. Besides viruses, allergic and psychologic factors are blamed for this acute phenomenon. It differs from acute laryngotracheitis, in that it is considered an allergic reaction to
viral antigens rather than a true infection with the viruses. Besides lack of fever, spasmodic croup is usually remarkable for lack of severe laryngeal inflammation, and supportive therapy on an outpatient basis is all that is recommended.

Viral laryngotracheitis is the most common form of infectious croup. The disease has a gradual onset, usually after an upper respiratory infection in a young child. Low-grade fever is common. Children who have more than two episodes of croup requiring hospitalization should be examined for subglottic narrowing from stenosis or cysts.

Clinical scoring systems based on objective criteria are helpful for following the progress of the disease and for judging the effectiveness of therapy (Table 1).

Anteroposterior radiographs of the neck confirm the diagnosis, and rule out acute epiglottitis or the possibility of a foreign body in the airway (Table 2). The viral infection affects the subglottic region of the larynx, causing edema. The characteristic radiograph of croup includes blurring of the tracheal air shadow on lateral neck films and symmetric narrowing of the subglottic air shadow, described as the church steeple sign on anteroposterior films (Fig. 5). The lateral neck radiographs show normal supraglottic structures and normal epiglottic shadow, having the configuration of an adult’s little finger, described as the little finger sign.

Treatment

Croup is a fairly common medical disease. Most cases resolve quickly with simple conservative measures, such as breathing humidified air or oxygen. Less than 10% of cases require hospitalization because of significant respiratory difficulty, and fewer still require an artificial airway. Humidification of inspired gases usually is effective in improving respiratory distress, and it prevents drying of secretions. Oxygen is obviously essential to prevent or to treat hypoxemia, which may result from ventilation and perfusion mismatching caused by accumulation of

<table>
<thead>
<tr>
<th>Table 1. CLINICAL CROUP SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inspiratory breath</strong></td>
</tr>
<tr>
<td><strong>Stridor</strong></td>
</tr>
<tr>
<td><strong>Cough</strong></td>
</tr>
<tr>
<td><strong>Retractions</strong></td>
</tr>
<tr>
<td><strong>Cyanosis</strong></td>
</tr>
</tbody>
</table>

Adapted from Downes JJ, Raphaely RC: Pediatric intensive care. Anesthesiology 43:238, 1975; with permission.
### Table 2. DIFFERENTIAL DIAGNOSIS OF CROUP AND EPIGLOTTITIS*

<table>
<thead>
<tr>
<th>Croup</th>
<th>Epiglottitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence</td>
<td>More common</td>
</tr>
<tr>
<td>Obstruction</td>
<td>Subglottic</td>
</tr>
<tr>
<td>Age</td>
<td>Younger (&lt;3 y)</td>
</tr>
<tr>
<td>Cause</td>
<td>Viral</td>
</tr>
<tr>
<td>Recurrence</td>
<td>Possible (5%)</td>
</tr>
<tr>
<td><strong>Clinical Features</strong></td>
<td></td>
</tr>
<tr>
<td>Onset</td>
<td>Gradual (days)</td>
</tr>
<tr>
<td>Fever</td>
<td>Low-grade</td>
</tr>
<tr>
<td>Dysphagia</td>
<td>None</td>
</tr>
<tr>
<td>Drooling</td>
<td>None</td>
</tr>
<tr>
<td>Posture</td>
<td>Recumbent</td>
</tr>
<tr>
<td>Toxemia</td>
<td>None</td>
</tr>
<tr>
<td>Cough</td>
<td>Barking</td>
</tr>
<tr>
<td>Voice</td>
<td>Hoarse</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>Rapid</td>
</tr>
<tr>
<td>Larynx palpation</td>
<td>Not tender</td>
</tr>
<tr>
<td>Leukocytosis</td>
<td>+ (lymphocytic)</td>
</tr>
<tr>
<td>Neck radiographs</td>
<td>AP: steeple sign</td>
</tr>
<tr>
<td>Clinical course</td>
<td>Longer</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
</tr>
<tr>
<td>Primary therapy</td>
<td>Medical and supportive</td>
</tr>
<tr>
<td>Oxygen and humidity</td>
<td>Essential</td>
</tr>
<tr>
<td>Hydration</td>
<td>Oral or intravenous</td>
</tr>
<tr>
<td>Racemic epinephrine</td>
<td>Usually effective</td>
</tr>
<tr>
<td>Steroids</td>
<td>Controversial</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Not indicated</td>
</tr>
<tr>
<td>Airway support</td>
<td>Occasionally needed (&lt; 3%)</td>
</tr>
<tr>
<td>Preferred airway</td>
<td>Nasotracheal</td>
</tr>
<tr>
<td>Extubation</td>
<td>4–7 d</td>
</tr>
</tbody>
</table>

*Foreign bodies in the airway also should be considered.

+ = mild; AP = antero-posterior; + + + = numerous; Polys = polymorphonuclear cells.


Secretions. Hydration prevents thickening of tracheal secretions. It must be accomplished intravenously and attained quickly in hospitalized cases.

Racemic epinephrine is the most effective drug therapy in these patients, although the use of L-epinephrine also has been satisfactory. Racemic epinephrine is available as a 2.25% solution, usually diluted 1:6 in water, and is administered by intermittent positive-pressure ventilation through a face-mask or nebulization. Nebulized racemic epinephrine is administered in cases of mild-to-moderate obstruction. The solution is prepared by diluting 2.25% racemic epinephrine in saline or sterile water to make a 2-mL volume of appropriate concentration for the patient’s weight in kilograms (e.g., 1:8 for a child less than 5 kg, 1:6 for a child weighing 10 kg, 1:4 for a child weighing 15 kg, and 1:3 for children over 20 kg). Because of the short duration of action of racemic
epinephrine, rebound edema may occur. Treatments are required every 1 to 2 hours, and the child should be kept under observation for at least 2 hours after treatment.

Steroid therapy in viral croup is controversial. Recent reports suggest that dexamethasone, 0.5 to 1 mg/kg administered intravenously, may be effective. There is significant clinical improvement 12 and 24 hours after steroid treatment, which significantly reduces the incidence of endotracheal intubation. Antibiotics generally are not indicated in the treatment of uncomplicated viral croup.

**Airway Support**

If there is progressive airway obstruction that is not responding to maximal medical therapy or if the child is showing signs of exhaustion from the increased work of breathing, an artificial airway must be inserted. When indicated, intubation should be performed in an acute care setting, with a physician who can perform rigid bronchoscopy and tracheostomy and the necessary equipment at hand. A wide selection of endotracheal tubes in various sizes should be available, including many that are much smaller than the predicted size for the child’s age because
of subglottic narrowing. No anesthesia is required if the child is in extremis. Otherwise, careful inhalational induction with oxygen and sevoflurane or halothane is recommended while oxygen saturation and heart and breath sounds are monitored continuously with a precordial stethoscope. After laryngoscopy, an orotracheal tube should be inserted. Once the airway is secured under anesthesia, a decision should be made to change to a nasotracheal tube or to (rarely) proceed with an elective tracheostomy.

The child is usually ready for extubation within 2 to 4 days. Criteria to consider include abatement of fever, diminished tracheal secretions, change in the character of secretions to a thin and watery type, and an audible air leak that develops around the nasotracheal tube as the edema subsides.

**OBSTRUCTIVE LARYNGEAL PAPILLOMATOSIS**

Recurrent respiratory papillomatosis, also known as juvenile laryngeal papillomatosis, is the most commonly found tumor in the larynx and upper airway in children. Recurrent respiratory papillomatosis is caused by the human papilloma virus. The incidence is only 1 in 400 births despite evidence of active or latent viral infection in 10% to 25% of pregnant women. The papillomas usually are found in the larynx on the vocal cord margins, epiglottis, pharynx, or trachea (Fig. 6).

Respiratory papillomatosis presents in the young child with hoarseness of voice, stridor, aphonia, history of chronic cough, and respiratory infections. Stridor can be inspiratory or biphasic and accompanied with nasal flaring and chest wall retractions. Younger children usually have worse obstructive symptoms and prognosis than older patients.

The current treatment of papilloma is mainly surgical removal of the...
papillomatous tissue by using carbon dioxide laser under microscopic visualization. Large papillomas can be surgically debulked with an ultrasonic microdebrider or cup forceps before laser treatment. Nonsurgical treatment with interferon-alfa-nl has been beneficial in some patients. The main goal of these treatments is to eliminate the bulk of the lesion without producing scarring and permanent damage to the underlying mucosa.

Because of the recurrent nature of this condition, most of these children are likely to return many times for treatment. Many may require monthly scheduled visits to the operating room to prevent recurring obstruction. If some of these scheduled sessions are missed or if the progress of the disease is accelerated, the child presents with acute exacerbation of obstructive symptoms that requires emergent endoscopic resection.

**Anesthetic Management**

Premedication usually is avoided in these children if the degree of airway obstruction is significant and there are concerns about compromising spontaneous ventilation. In selected cases, the parents may be allowed to be present in the operating room during induction to support these usually upset children emotionally.

The perioperative care of these children can be challenging, and often depends on the degree of obstruction to airflow and the type and location of the papilloma. Pedunculated papillomas can produce complete obstruction in certain patient positions. It would be prudent not to paralyze these patients but allow them to maintain spontaneous ventilation until the airway is examined and the anesthesiologist is certain that assisted or controlled ventilation is possible. These children must be approached as one would any child with anticipated severe airway obstruction (e.g., acute epiglottitis). The surgeon must be present in the operating room, with equipment to treat total airway obstruction, including rigid bronchoscopes, immediately available. The problem of sharing the already compromised airway with the surgeon is worsened by the need to use a laser beam to excise these lesions. The advantages of laser use include precision, lack of bleeding, sterility, and reduced tissue reaction. The hazards of laser use include risk of airway fire, atmospheric contamination, the potential for damage to normal tissue by a reflected or misdirected laser beam, and the need for the operating room personnel to wear protective goggles.

The anesthetic management of these children depends on the approach the surgeon uses to remove the lesions. The basic choice is between intubation and nonintubation techniques. For the latter approach, the use of intermittent apnea versus jet ventilation must be considered. An excellent review of these techniques recently was presented by Orr and Elwood in this series.

In the authors' institution (after the airway is secured), an intermit-
tent apneic technique using paralysis, total intravenous anesthetic technique, and topical lidocaine is the usual approach. An antisialagogue, such as glycopyrrolate, is given at the beginning, along with dexamethasone, 0.5 mg/kg (maximum dose, 20 mg), to reduce mucosal swelling resulting from repeated intubations. A slow, careful inhalational induction with oxygen and sevoflurane, with the patient initiating each breath is recommended. This enables the anesthesiologist to assist ventilation until the required depth of anesthesia for laryngoscopy is achieved. An intravenous access is established and well secured before manipulation of the airway. The larynx is anesthetized by spraying 3 to 4 mg/kg of topical lidocaine, and tracheal intubation is then performed. The endotracheal tube usually chosen is several sizes smaller than what is normally appropriate for the patient’s age because most of these children have some degree of laryngeal scarring from repeated resections.

Although the goal is to achieve the desired depth of anesthesia to secure the airway with the child spontaneously still breathing, frequently partial obstruction is encountered before an adequate depth of anesthesia for laryngoscopy is achieved. In most of these cases, thrusting the jaw forward and applying positive pressure in the anesthetic circuit will maintain an open airway. If complete obstruction is encountered, a single intravenous bolus of propofol, 2 to 3 mg/kg, or a short-acting muscle relaxant (e.g., succinylcholine, 1 mg/kg, or rapacuronium, 2 mg/kg) may be necessary for immediate laryngoscopy and intubation or to allow the surgeon to perform rigid bronchoscopy.

Once the correct position of the endotracheal tube is confirmed, a neuromuscular blocking agent (e.g., rocuronium) can be administered, and the total intravenous anesthetic technique with propofol, 200 to 300 μg/kg per minute, and fentanyl, 1 to 2 μg/kg, or remifentanil infusion, 0.2 to 0.5 μg/kg per minute, is started. Muscle relaxation is desirable to produce an immobile surgical field, and its adequacy should be monitored by using the neuromuscular blockade monitor during the procedure.

An apneic anesthetic technique without an endotracheal tube offers the best unobstructed view of the larynx, and avoids the presence of flammable material (e.g., the endotracheal tube) in the path of the laser beam. The patient is positioned for suspension laryngoscopy, eyes are protected with moist eye pads, and the otomicroscope and CO₂ laser equipment are aligned. The endotracheal tube then is removed, and surgical resection is performed during repeated periods of apnea. The need for reintubation is guided by the patient's oxygenation, as reflected by the pulse oximeter. Reintubation can be performed readily by the surgeon by introducing the tracheal tube through the suspension laryngoscope under direct vision using the metal suction as a stylet. After each reintubation, the extent of CO₂ retention is assessed by monitoring the end-tidal CO₂, and hyperventilation with 100% oxygen is continued until the tube is removed and surgery is resumed.

When surgery is completed, the tracheal tube is reinserted and secured until the child is awakened completely. Postoperative measures
to prevent laryngeal edema, such as racemic epinephrine inhalation or
the use of dexamethasone, usually are required.

PERITONSILLAR ABSCESS

Peritonsillar abscess tends to occur in older children or young
adults. It is the most common deep neck space infection treated by
otolaryngologists. Infection originates in the tonsil, spreading to the
peritonsillar space between the tonsillar capsule and the superior con-
strictor muscle usually into the soft palate in the region of the superior
pole of the tonsil. Common cultured organisms are aerobes, such as
Streptococcus pyogenes, Streptococcus milleri, Streptococcus viridans, β-hemo-
lytic streptococci, and H. influenzae, and anaerobes, such as Fusobacterium
prevotella species.\textsuperscript{28, 45}

Clinically, these patients present with fever, pharyngeal swelling,
sore throat, difficulty in swallowing, and often trismus that results from
the spasm of the pterygoid muscles. Dehydration can ensue because of
fever and the persistent difficulty with swallowing.

Preoperative evaluation of these patients includes careful assess-
ment of the airway with special emphasis on the degree of trismus.
Blood should be drawn for total blood count and differential blood
count to ascertain the response to the infection, and blood cultures
should be done for appropriate antibiotic therapy. A CT scan of the
tonsillar area to see any airway deviation and extent of the abscess
spread is usually necessary (Fig. 7).

Treatment should begin with intravenous line placement, fluid hy-
dration, and appropriate antibiotic coverage while awaiting culture re-
sults. Most organisms, even the anaerobes, remain penicillin sensitive;
and penicillin is the antibiotic of choice.\textsuperscript{45} The three different procedures
presently used to drain a peritonsillar abscess are needle aspiration,
incision and drainage, and abscess tonsillectomy.\textsuperscript{26} Most children un-
dergo general anesthesia for treatment of peritonsillar abscess by incision
and drainage, although some have reported good results when conscious
sedation was used.\textsuperscript{46} If the abscess is small and well confined, immediate
tonsillectomy is performed. Needle aspiration of the peritonsillar abscess
in an awake adolescent is sometimes possible.\textsuperscript{50}

Anesthetic Management

Rupture of the abscess and possible aspiration of pus during intuba-
tion carefully should be avoided during the induction of anesthesia in
these patients. Pharyngeal swelling, the distortion of normal anatomy,
and excess mouth secretions may make laryngoscopy and intubation
difficult. For any difficult airway case, the operating room should be
prepared with different sizes of endotracheal tubes, stylets, two sets of
well-illuminated laryngoscopes, and a tonsil tip suction catheter attached
Figure 7. Axial enhanced CT scan through the oropharynx showing a 3-cm ring enhancing low-density mass replacing the left tonsil, typical of a tonsillar abscess.

to a powerful suction device. The surgeon must be present in the operating room, ready to start as the induction of anesthesia starts.

The patient is usually an older child, and can be brought to the operating room with no preoperative sedation. If trismus is present, a slow inhalational induction performed with sevoflurane and oxygen allows the anesthesiologist to assess the jaw relaxation under anesthesia. Usually, the apparent trismus often resolves with adequate depth of anesthesia. When this is confirmed or if trismus was minimal to begin with, a short-acting muscle relaxant is given to allow for an atraumatic laryngoscopy and intubation. Alternatively, if there is minimal trismus and the airway assessment indicates minimal distortion, a rapid-sequence intravenous induction after adequate preoxygenation may be the best way to avoid trauma to the pharyngeal structures while struggling with a mask induction and possibly causing the abscess to rupture.

To avoid aspiration of pus during intubation and drainage, the patient may be positioned in a slightly head-down position, and a cuffed endotracheal tube should be inserted carefully without touching the abscess. At the end of surgery, the patient must be extubated awake, preferably in the lateral position.
LARYNGEAL AND TRACHEAL TRAUMA

Closed or open injuries to the larynx and trachea in children can be caused by bike accidents, falls, direct trauma from sharp objects, and rarely clothesline injury. The higher cervical position of the pediatric larynx behind the mandibular arch and the pliability of the cricothyroid structures limit the extent of injury and prevent severe fractures; however, the small size of the laryngotracheal airway and the potential for massive soft-tissue swelling because of the loose attachment of the submucosal tissue to the perichondrium make early diagnosis and treatment critical. The injury can range from minor laryngeal hematoma to a severe form of laryngotracheal separation. This extreme and often fatal condition can occur after a clothesline mechanism of injury, and often is associated with bilateral vocal cord paralysis caused by recurrent laryngeal nerve damage. Hoarseness, cough, dyspnea, hemoptysis, and voice changes suggest laryngeal damage. Clinical subcutaneous emphysema, pneumothorax, and pneumomediastinum signify definite disruption of the laryngotracheal complex. A CT scan is the most appropriate imaging modality to identify the extent of laryngeal injury.

Positive pressure ventilation by mask, excessive coughing, or struggling can worsen the subcutaneous emphysema and cause further deterioration of the airway. Administration of nitrous oxide, application of cricoid pressure, multiple vigorous attempts at laryngoscopy and intubation, and passage of blind nasotracheal tubes or nasogastric tubes must be avoided to prevent further trauma by creating a false passage through a mucosal tear. A safe approach to this type of injury is to use the fiberoptic bronchoscope to visualize the airway before intubation if the patient is stable. Ideally, the airway should be secured in the operating room after induction of general anesthesia with an inhalational agent and the patient breathing spontaneously. Tracheostomy below the level of the injury under local anesthesia or over a bronchoscope, however, may be necessary if there is extensive injury to the mouth and larynx that requires major reconstruction.

Postoperatively, these patients require management in a monitored setting, usually the ICU. The resolution of other complications (e.g., subcutaneous emphysema, pneumothorax, pneumomediastinum) dictates the length of the patient's stay in the hospital. Postoperative analgesia must be titrated carefully to balance the need for pain relief with the adequacy of ventilation.

References


Address reprint requests to
Raafat S. Hannallah, MD
Department of Anesthesiology
Children's National Medical Center
111 Michigan Avenue, NW
Washington, DC 20010
e-mail: rhannall@cnmc.org