Anticipated Difficult Intubation

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Unanticipated Difficult Ventilation
Desperate Measures

Anesthetic management of the difficult pediatric airway is the same as that for adults, with two important exceptions:
1. Awake intubations are rarely feasible.
2. The smaller airway anatomy of the child requires use of smaller intubating equipment that may not be readily available or easy to use.

The broad topic of the difficult airway can be divided into two major aspects: difficult intubation and difficult ventilation. Each of these can be further divided into anticipated or unanticipated. Difficult ventilation can be further subdivided into causes above and below the glottis. Only those entities that cause airway obstruction above the glottis are considered in this chapter. Those that occur below the glottis (foreign bodies, vascular rings, etc.) are considered in separate chapters.

The most important aspect of anesthetic management of the difficult airway is having a clear vision of the plan, as well as the multiple steps of the back-up plans. It is not enough to have only one or even two back-up plans, but rather three or four, and an exact plan for the worse possible situation - the development of life-threatening hypoxemia. Every anesthesiologist must know precisely the method he or she will use to alleviate it and save the child’s life. This usually entails a cricothyrotomy or tracheostomy, which are more technically difficult in small children than in adults.

Proper preparation is essential and will depend on the cause of the expected difficulty. A full explanation of the nature of the anesthetic and the risks should be explained to the child’s family. An indwelling intravenous catheter is preferred, except when the anesthesiologist feels that provoking or painfully stimulating the child may worsen the upper airway obstruction, as may occur with acute epiglottitis. Pharmacologic preparation consists of an antisialagogue (0.02 mg/kg atropine or 0.01 mg/kg glycopyrrolate) given at least 10–15 minutes prior to the induction of anesthesia.

One of the most important aspects of all difficult airway management is the continuous presence of another experienced anesthesiologist or surgeon with airway expertise.

The difficult airway is an important cause of cardiac arrest during anesthesia in children. In the pediatric Perioperative Cardiac Arrest (POCA) Registry, respiratory complications accounted for 30 of the 55 reported cardiac arrests and many of these cases were associated with difficult ventilation or intubation (Table 18-1).

ANTICIPATED DIFFICULT INTUBATION

Unlike adults, normal-appearing children rarely present with an unexpected difficult intubation. Therefore, in this chapter, only the anticipated difficult intubation will be reviewed.
Preanesthetic Preparation

The most reliable predictor of a difficult intubation is the patient’s history. Parents of children who were previously difficult to intubate are frequently concerned with this particular aspect of anesthetic management. Parents of children with congenital airway syndromes will often belong to a support group and will learn about the specific anesthetic problems encountered by children similar to their own. Perhaps the most important predictor of a difficult intubation is a previous anesthetic record. If one is available, it should be reviewed before administration of any subsequent anesthetic.

Physical examination should focus on anatomic anomalies that involve the head, face, or neck, especially if the child carries the diagnosis of a congenital airway syndrome (Table 18-2). Most importantly, the anesthesiologist should evaluate the size and mobility of the mandible. The most likely factor that predicts difficulty with intubation in pediatric patients is a small, malformed, or immobile mandible. Scoring systems that predict the likelihood of a difficult intubation do not exist. The Mallampati classification for prediction of the difficult intubation is not useful, except perhaps for larger adolescents.

The technical approach to securing tracheal intubation should be well thought out prior to the time of surgery (Fig. 18-1). All necessary airway equipment should be present in the OR, including the equipment necessary for the second, third, and even fourth options should initial attempts fail. In pediatrics, different sized laryngoscope blades and endotracheal tubes should also be within easy reach.

In children with a known difficult intubation, it is preferable to secure venous access while the child is still awake. However, if the child is not amenable, or inspection of the limbs does not show promising possibilities, and if one

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**Table 18-1 Respiratory Causes of Cardiac Arrest from the POCA Registry**

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Number of Cardiac Arrests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngospasm</td>
<td>9</td>
</tr>
<tr>
<td>Airway obstruction</td>
<td>8</td>
</tr>
<tr>
<td>Difficult intubation</td>
<td>4</td>
</tr>
<tr>
<td>Inadequate oxygenation</td>
<td>5</td>
</tr>
<tr>
<td>Inadvertent extubation</td>
<td>2</td>
</tr>
<tr>
<td>Unclear etiology, presumed respiratory</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate ventilation</td>
<td>1</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>

*Perioperative Cardiac Arrest.

a Two children who arrested because of difficult intubation were 4 months of age or younger: two had congenital heart disease, one had trisomy 18, and one had Pierre-Robin sequence. One of these patients died.

b All children who arrested because of difficult intubation were 4 months of age or younger: two had congenital heart disease, one had trisomy 18, and one had Pierre-Robin sequence. One of these patients died.


**Table 18-2 Examples of Congenital Airway Syndromes**

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Clinical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckwith-Wiedemann</td>
<td>Macroglossia, organomegaly, omphalocele, hypoglycemia</td>
</tr>
<tr>
<td>Down (trisomy 21)</td>
<td>Macroglossia</td>
</tr>
<tr>
<td>Pierre–Robin sequence</td>
<td>Micrognathia, cleft palate, glossophtosis</td>
</tr>
<tr>
<td>Treacher-Collins</td>
<td>Hypoplasia of the maxilla and mandible, variable eye and ear deformities</td>
</tr>
<tr>
<td>Hemifacial microsomia</td>
<td>Unilateral or bilateral mandibular hypoplasia, variable microphthalmia, microtia, macrostomia</td>
</tr>
<tr>
<td>Apert</td>
<td>Craniosynostosis, syndactyly</td>
</tr>
<tr>
<td>Freeman-Sheldon</td>
<td>Microstomia, facial anomalies, hand anomalies</td>
</tr>
<tr>
<td>Mucopolysaccharidoses</td>
<td>Reundant facial and pharyngeal soft tissue</td>
</tr>
<tr>
<td>Klippel–Feil</td>
<td>Cervical vertebral fusion</td>
</tr>
<tr>
<td>Crouzon</td>
<td>Craniosynostosis</td>
</tr>
<tr>
<td>Stickler</td>
<td>Mandibular hypoplasia, myopia, retinal detachment, joint stiffness</td>
</tr>
<tr>
<td>Pfeiffer</td>
<td>Craniosynostosis, polydactyl</td>
</tr>
</tbody>
</table>

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**Figure 18-1** Algorithm for the child with an anticipated difficult intubation.
believes the child will not be difficult to ventilate, then general anesthesia may be induced without prior IV access. An antisialagogue should be administered prior to induction, either intravenously (if available) or via the oral route.

An anticipated difficult intubation can be loosely defined as that which the anesthesiologist feels would be too difficult to justify attempts at direct glottic visualization with standard techniques. In other words, the very nature of the anticipated difficult intubation implies that specialized indirect methods are required for tracheal intubation, and direct laryngoscopy should not be attempted first. Although tempting, with each direct laryngoscopy attempt, the severity of airway edema and bleeding will increase and will ultimately decrease the chance of eventual success with more specialized methods.

**Techniques**

When faced with a potentially difficult intubation, most pediatric anesthesiologists will choose one of two techniques: the lighted stylet, or the flexible fiberoptic bronchoscope. This choice is largely dependent on the experience and personal preference of the anesthesiologist, and may be influenced by the patient’s airway anatomy. There is certainly a role in pediatrics for the use of intubating stylets, but if the airway is prospectively identified as difficult, direct methods should not be initially used. Intubating stylets are most effective when direct laryngoscopy reveals at least a portion of the epiglottis, and are used primarily when the difficult intubation was unanticipated.

**Lighted Stylet**

The lighted stylet (also know as a lightwand) is useful when the child has an anatomically normal larynx that is difficult to visualize with direct methods. This may occur with micrognathia, temporomandibular joint disease (or any condition that limits mandibular mobility), cervical spine instability, or facial trauma. Recent innovative solutions to the size limitations have been overcome, so the lighted stylet can now be used with endotracheal tubes as small as 2.5 mm internal diameter. It is particularly suited to children with limited neck and mandible mobility, but it will not be useful in cases of fixed upper or lower airway obstructive pathology, or the presence of a foreign body. *If the lightwand is used as the first choice for a difficult intubation, the number of attempts should be limited so as not to incur edema or bleeding, should fiberoptic bronchoscopy then be required.*

![Figure 18-2](image.png)

*Figure 18-2 Technique for lightwand placement. The mandible is pulled anteriorly as the lightwand is introduced behind the tongue.*

The use of a lighted stylet for endotracheal intubation in children is not different from adults. The endotracheal tube that contains the lightwand is fashioned in the shape of a hockey stick with a distal bend. The anesthesiologist places a thumb inside the lower teeth and pulls the mandible anteriorly, while the lightwand is introduced into the mouth and immediately posterior to the back of the tongue (Fig. 18-2). It is at this exact point that so many inexperienced practitioners have difficulty because the lightwand is advanced too far too quickly. The first important maneuver is to orient the lightwand anteriorly as soon as it is positioned at the back of the tongue. In children it is easy to advance it into the esophagus sooner than expected. The second important maneuver is to manipulate or twist the lightwand into the midline position by observing the transillumination on the anterior neck. Two common reasons for not seeing a light on the anterior surface of the neck are because it has already passed into the esophagus and because it is not in the midline. Once the bright light is seen in the midline, the lighted stylet is advanced further until the light is seen to form a cone into the trachea. Usually, while advancing the lightwand, one will feel a transient obstruction as the lightwand passes the epiglottis. At this point the lightwand may veer off the midline - it should then be reoriented so that the cone of light projects down into the trachea. The lightwand is then held steady while the endotracheal tube is slid into the trachea. The lightwand itself does not need to be situated into the laryngeal inlet prior to passing the endotracheal tube. As long as the cone of light is seen to be directed down into the trachea, the endotracheal tube can be advanced correctly. If the cone of light disappears with caudal advancement, it has most likely entered the esophagus. This can be remedied in subsequent attempts by orienting the lightwand more anteriorly in a higher (more cephalad) position behind the tongue.

An important difference in technique between adults and children stems from the fact that the neck tissues of children are thinner than adults’, so the transillumination characteristics will differ. In particular, the light will appear brighter on the skin surface than it does in adults,
and may cause some confusion as to its proper placement in the larynx. For this reason it is preferable in smaller children to use a lightwand with an adjustable light source. At The Children’s Hospital of Philadelphia, we use a home-grown lightwand for small infants and neonates. It consists of a 20-gauge fiberoptic illuminating lightpipe (Storz Ophthalmics Inc., St Louis, MO) attached to any standard fiberoptic light source (Fig. 18-3).

In children with an immobile mandible, it may be difficult to maneuver the lightwand into an optimal position. In these cases, a particularly useful technique is to combine direct laryngoscopy with a lightwand. Although limited by mandibular immobility, the blade of the laryngoscope may provide greater maneuverability of the lightwand for greater chance of successful tracheal intubation.

**Fiberoptic Bronchoscopy**

Flexible fiberoptic bronchoscopy is probably the most popular definitive method for the difficult tracheal intubation in children. In recent years anesthesiologists have become more adept at manipulating the ultrathin bronchoscope, which may be used inside a 2.5-mm or 3.0-mm internal diameter endotracheal tube (depending on the manufacturer). In addition, the optical aspects of the equipment have improved to allow better screen resolution. An important aspect of its use is that the technique must be practiced on normal children prior to encountering the difficult airway, when its use becomes essential.

There are several reasons why bronchoscopy is different or more difficult in children compared to adults. First, because of the inherently smaller size of children, ultrathin bronchoscopes are required. These ultrathin bronchoscopes may not be manufactured with suction ports. Therefore, secretions or blood are more likely to obscure the view in smaller children. For this reason, it is important to use an antisialagogue prior to beginning the procedure, and then briefly and gently suctions the oropharynx prior to the bronchoscopic attempt.

**Figure 18-3**  
A. A thin fiberoptic bundle is used as a lightwand. B. The fiberoptic bundle can be attached to any commercially available light source with adjustable light intensity. C. The fiberoptic bundle is inserted alongside a thin pliable stylet into an endotracheal tube.
Some ultrathin bronchoscopes do contain a suction port, but it is too narrow to allow effective suctioning of secretions. Furthermore, oxygen insufflation should not be performed via this port in small children because of the possibility of generating dangerously high intrabronchial pressures and development of a tension pneumothorax.

Second, apneic ventilation is usually ineffective in small children because of their limited time to oxyhemoglobin desaturation. This is caused by the markedly reduced functional residual capacity (FRC) in anesthetized small children and their relatively high oxygen consumption. Ventilation can be accomplished during bronchoscopy by the use of a special anesthesia mask that incorporates a conduit for passage of the bronchoscope.

Third, in smaller children, flexible bronchoscopy performed through a laryngeal mask airway (LMA) is more difficult than in adults because LMA placement in children is associated with a higher incidence of malpositioning, which leads to an obscured view of the glottic opening. When possible, fiberoptic bronchoscopy should be initially attempted without an LMA. For those times when an LMA is required for proper visualization of the glottic opening, we keep a reference on hand (taped to the top of the difficult airway cart) of the sizes of endotracheal tubes and fiberoptic scopes that will fit through pediatric LMAs (Table 18-3).

Finally, the unique anatomical variance of infants and children may influence successful fiberoptic bronchoscopy. If a nasal route is chosen, enlarged adenoidal and tonsillar tissue may obstruct the view and is likely to bleed upon contact. The relatively stiff epiglottis of infancy may render glottic visualization more difficult than in adults. This may be overcome by having an assistant provide chin lift with head extension and jaw thrust during the bronchoscopic attempt. The relatively more anterior location of the infant glottis may require more extensive anteflexion of the bronchoscope for adequate visualization of the glottic opening.

There will always be the rare child in whom one of these conventional techniques doesn’t work, and the anesthesiologist then must choose an alternative method for securing tracheal intubation. This choice then depends on the urgency and importance of tracheal intubation, and whether or not the surgical procedure is urgent or elective. If the procedure is elective, the anesthesiologist may choose to cancel the case and awaken the child with the eventual plan of trying again on a different day with different personnel. More often, however, the procedure is performed as planned with an alternative means of airway support, such as an LMA, or the trachea is eventually intubated by another method. There are many procedures for which an LMA is not ideal but will suffice instead of an endotracheal tube. These are too numerous to list, and are largely dependent upon the comfort level of the anesthesiologist and surgeon. If either the anesthesiologist or surgeon feels that tracheal intubation is necessary to proceed with the procedure, other alternatives exist for securing tracheal intubation (Box 18-1). These are mainly used by specialists in pediatric anesthesia, and details of these techniques are beyond the scope of this discussion.

### Table 18-3  Pediatric-sized Laryngeal Mask Airways and Compatible Endotracheal Tubes

<table>
<thead>
<tr>
<th>LMA Size</th>
<th>Maximum Lubricated Uncuffed Standard ETT Inner Diameter (mm)</th>
<th>Maximum Lubricated Cuffed Standard ETT Inner Diameter (mm)</th>
<th>Maximum FOB Size&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.5</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>11/2</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>21/2</td>
<td>6.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>6.0</td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>6.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on experiments performed by the author.

<sup>b</sup>As per LMA North America.

<sup>c</sup>Largest available uncuffed endotracheal tube available at The Children’s Hospital of Philadelphia.

### Box 18-1  Nontraditional Methods of Pediatric Tracheal Intubation

- Digital intubation
- Direct laryngoscopy with intubating stylet (gum bougie)
- Bullard scope
- Anterior commissure scope (used primarily by otolaryngologists)
- Combitube in adolescents
- Retrograde wire technique (standard or through LMA)
- Surgical tracheostomy
The most drastic measures are use of a retrograde wire and surgical tracheostomy. The inherently smaller size of children makes these techniques more difficult to perform, and undesirable side-effects such as bleeding into the airway are more likely. These techniques are used when fiberoptic bronchoscopy has failed because of excessive blood or secretions in the airway, in children with markedly abnormal upper airway anatomy, or when a mass is obscuring the upper airway. A tracheostomy is also helpful when it is known that the child will undergo multiple procedures within the foreseeable future.

**Etiologies of Difficult Intubation**

**Pierre–Robin Sequence**

The Pierre-Robin sequence (Fig. 18-4) consists of micrognathia, glossoptosis, and cleft palate. These infants may have an obstructed upper airway from the small anatomic space afforded by their small mandible. The condition is most severe at birth and tends to improve with age. If airway obstruction is severe and life-threatening at birth, tracheostomy is indicated, and is followed by a more definitive mandibular advancement procedure. Concomitant congenital anomalies may lead to other necessary surgical interventions such as cleft palate repair or placement of tympanostomy tubes. Tracheal intubation in these infants may be extremely difficult or impossible. Fortunately, mask ventilation in these infants is often easily accomplished, especially when aided by placement of an oral airway. LMA placement is often essential for establishing ventilation or to provide a guide for tracheal intubation. In many cases, the LMA is used as a temporizing measure to ventilate and oxygenate the infant between attempts at tracheal intubation with either a flexible fiberoptic bronchoscope or a lighted stylet.

**Treacher–Collins Syndrome**

Treacher–Collins syndrome (Fig. 18-5) consists of hypoplasia of the maxilla and mandible, and variable eye and ear deformities. It results from failure of the first branchial arch to develop between the 3rd and 5th weeks of gestation. These children are notoriously difficult, or impossible, to intubate and may also be difficult to ventilate. Like other severe airway anomalies, the LMA is indispensable for airway management.

**Hemifacial Microsomia**

The most important anomaly in hemifacial microsomia that renders these children difficult to intubate is mandibular hypoplasia (Fig. 18-6). Additional variable clinical features include microphthalmia, microtia, and macrostomia, which result from a malformation of the first and second pharyngeal arches. These infants are usually easy to mask-ventilate, and may often be easily intubated by direct laryngoscopy. Difficult intubation is likely when the unilateral mandibular hypoplasia is severe, or bilateral (10–33%). As with the aforementioned congenital facial anomalies, the LMA is an effective method for ventilating and facilitating intubation in this patient population.
The expected difficult ventilation is one of the most angst-provoking situations in pediatric anesthesia. There is good reason for this: small children with transient or mild upper airway obstruction may rapidly become hypoxemic. How does one know when a child will be difficult to ventilate? The history and physical exam, and possibly some radiological studies, will almost always indicate the answer to this question. One of the most reliable indicators is previous difficulty with ventilation during a recent anesthetic, assuming there were no clinical changes since that time. Conversely, if the child was easy to ventilate during a recent anesthetic, then one can be reasonably confident that the child will still be easy to ventilate. For these reasons, it is imperative to obtain the previous anesthetic record or directly talk to the anesthesiologist who was present. If there were no previous anesthetics, other aspects of the history can indicate ease of ventilation. Was the child previously sedated for a radiological procedure? If so, were there any ventilation difficulties? How does the child sleep at night? Are there obstructive episodes? Are they related to the position of the child?

On physical exam, signs of clinically important upper airway obstruction include the presence of neck and chest wall retractions, and inspiratory stridor. Intrathoracic airway obstruction is characterized by expiratory stridor or wheezing. The oxyhemoglobin saturation is another indicator of airway patency. A value below 94% on room air is indicative of important upper airway obstruction in the absence of additional lung disease.

If radiological studies have been performed, they should be examined by the anesthesiologist to help determine the possibility of difficulty with ventilation. Important examples include:
1. Lateral neck radiograph for the “thumb sign” of epiglottitis
2. Neck radiograph or computed tomography (CT) for evaluation of the severity of a retropharyngeal abscess
3. Neck CT for evaluation of masses encroaching on the upper airway that are not visible externally (e.g., lymphangioma)

### Articles To Know


Prospective studies on difficult airway management techniques are scarce. The vast majority of the useful literature on management of difficult airways, especially in the pediatric population, is case reports or case series of successful techniques. Two publications stand out as having influence over the way we practice.

The first article is a report on a series of three infants with Pierre–Robin sequence who were successfully managed by initially placing an LMA while they were awake. Once manual positive-pressure ventilation was confirmed, neuromuscular blockade was administered, and tracheal intubation was accomplished using lighted stylets.

The second publication reported two children with Treacher–Collins syndrome who were successfully managed with laryngeal masks when tracheal intubation had failed.

Reports such as these established the usefulness of the LMA in managing children who were known to be potentially difficult to ventilate. Thus began the era of declining awake intubations in children, and the confidence that children with certain congenital airway syndromes could be adequately managed once anesthetized. Since the publication of these reports, a vast amount of clinical experience in children with congenital airway syndromes has confirmed that use of the LMA in anesthetized children with presumed difficult airways is associated with successful outcomes.
4. Neck and chest CT for evaluation of the extent to which an anterior mediastinal mass impinges on the trachea (a 50% reduction of the tracheal diameter may indicate critical tracheal compression and the inability to ventilate adequately following induction of general anesthesia)

5. Thoracic magnetic resonance imaging (MRI) for diagnosis of a vascular ring, to evaluate the severity of tracheal compression

6. Chest radiograph of a child who has aspirated a foreign body (this may not indicate ease of ventilation but will indicate additional problems that may impact on anesthetic management, such as extent of pneumonitis or degree of unilateral hyperinflation).

When approaching the child who may be difficult to ventilate, the first and most important decision is whether or not to proceed with tracheal intubation with the child awake with mild sedation or fully anesthetized (Fig. 18-7). Awake intubations are rarely performed in children because of their inability to cooperate despite administration of sedative agents. However, if one seriously believes that there exists the real possibility of hypoxemia despite LMA placement, then an awake technique should be performed. Fortunately, this situation is rare in pediatric patients for the very reason that there exist few situations where one feels that LMA insertion would be unsuccessful. Whether or not an LMA is inserted, the most important principle of airway management is to maintain spontaneous ventilation until it is proven that positive pressure ventilation can be accomplished.

If an awake intubation is planned, it is helpful to anesthetize the child's upper airway passages with local anesthesia. This is usually performed after the child is sedated. A local anesthetic solution can be administered by nebulizer, but this is variably effective because of the

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**Figure 18-7** Algorithm for the child with anticipated difficult ventilation.
uncooperative nature of children. Most anesthesiologists prefer to sedate children using a combination of a benzodiazepine and opioid because the effects can be rapidly reversed. Others prefer small titrations of ketamine (0.25-mg/kg doses) because of its tendency to preserve upper airway patency at concentrations that reliably impair consciousness. Propofol, when used judiciously, can also be used effectively when one suspects a reasonable chance of being able to successfully ventilate using positive pressure. Inhalational general anesthetic agents may also be used. Sevoflurane will provide rapid loss of consciousness but greater possibility of apnea than halothane. A classic and time-honored technique is to maintain spontaneous ventilation while slowly deepening the level of anesthesia. While maintaining spontaneous ventilation, direct laryngoscopy is performed slowly while progressively applying topical local anesthetic to more distal portions of the pharynx and larynx. If direct laryngoscopy is unsuccessful, specialized techniques such as those discussed in the prior section are then used. If central or obstructive apnea occurs during this procedure, the anesthesiologist must be prepared to either rapidly attempt endotracheal intubation or insert a laryngeal mask to prevent development of hypoxemia.

### Etiologies of Difficult Ventilation

#### Congenital Airway Syndromes

Congenital airway syndromes probably represent the most common reason for an anesthesiologist to suspect difficulty with ventilation. These are discussed in the preceding section.

#### Table 18-4 Comparison of Infectious Causes of Upper Airway Obstruction

<table>
<thead>
<tr>
<th>Laryngotracheobronchitis</th>
<th>Epiglottitis</th>
<th>Retropharyngeal Abscess</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organism</strong></td>
<td>Bacterial: <em>Hemophilus</em> influenza type b in children; mixed organisms in adults 2-5 years</td>
<td>Bacterial: usually <em>Streptococcus</em> or <em>Staphylococcus</em> 2-8 years</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>Supraglottitis: severe swelling of epiglottis, arytenoids, and surrounding tissue</td>
<td>Lymphatic drainage or contiguous spread of pharyngeal or oral infections</td>
</tr>
<tr>
<td><strong>Pathology</strong></td>
<td>High fever, toxic appearing, seated position, and leaning forward preferred, drooling, throat pain, difficulty swallowing, stridor</td>
<td>Sore throat, fever, neck stiffness, difficulty swallowing, neck swelling, tonsillitis, pharyngitis, cervical lymphadenopathy</td>
</tr>
<tr>
<td><strong>Prominent clinical features</strong></td>
<td>Viral prodrome (upper respiratory tract infection), low-grade fever, barking cough, variable degree of inspiratory stridor, hoarseness, rarely progresses to fatigue and respiratory failure</td>
<td>Lateral neck radiograph: ‘thumb’ sign of swollen epiglottis, prevertebral thickening, hypopharyngeal enlargement on lateral view</td>
</tr>
<tr>
<td><strong>Radiologic study</strong></td>
<td>Lateral neck radiograph: ‘steeple’ sign indicating tracheal mucosal edema</td>
<td>Lateral neck radiograph: widening of the retropharyngeal soft tissues; also identified on CT scan.</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Cool mist, steroids, nebulized 2.25% racemic epinephrine</td>
<td>Tracheal intubation until resolved (usually 2-4 days), antibiotics</td>
</tr>
</tbody>
</table>
Box 18-2 Epiglottitis Protocol

1. Every attempt should be made to keep the child calm. A parent should be allowed to comfort the child up to and including the induction of general anesthesia. No attempt should be made to place the child supine. If the diagnosis of epiglottitis is seriously entertained, radiographs should not be performed.

2. The following departments should be immediately consulted:
   a. Anesthesiology
   b. Otolaryngology
   c. Surgical suite: If OR space is not immediately available, the child should be taken to the ICU or recovery room; the child should not be transported until appropriate notifications and preparations are complete.

3. Prepare the child for transport:
   a. Have a gurney available to travel with the patient, but do not lay the child supine.
   b. The child can remain in the parent’s arms.
   c. A full O₂ tank should accompany the patient and provide supplemental blow-by oxygen.
   d. Have an Ambu-bag with appropriately sized face mask.
   e. Have an intubating laryngoscope with appropriately sized and smaller sized endotracheal tubes.
   f. Have portable suction.
   g. Be ready with atropine 0.02 mg/kg (minimum 0.2 mg, maximum 1.0 mg) and succinylcholine (2 mg/kg).
   h. Transport the child and the parents only when physician experienced in emergency airway management is in attendance. The anesthesiology attending is always in charge.

4. During the vulnerable period before intubation, handling of the child should be kept to a minimum - no oral examinations and no unnecessary needle sticks. The intravenous catheter is inserted by the best qualified person.

5. When ready for intubation, the anesthesiologist performs an inhalation induction with a volatile agent, with the otolaryngologist present in the room for possible emergency tracheotomy.

6. After the endotracheal tube is appropriately inserted and ventilation is assured, less urgent procedures such as changing to a nasotracheal tube, blood work, and administration of intravenous antibiotics may be performed. Routine paperwork should be dealt with only after the child is safe.

7. Following tracheal intubation, the child is transported to the ICU with adequate sedation and possibly paralysis. Restraints may be required to prevent life-threatening self-extubation.

8. If intensive care monitoring and support are not available, the child should be transported with a physician skilled in emergency airway management to an appropriate facility.

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Figure 18-8 Swelling of the epiglottis is seen in a case of acute epiglottitis.

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The child should also be afebrile, an indication that the intubation in small children is to place the mask too low on the neck while simultaneously checking for appropriate facemask placement. A common error in facemask placement is similar in all cases. The anesthesiologist should first seek to optimally reposition the head and neck maneuvers is similar in all cases. The anesthesiologist should first seek to optimally reposition the head and neck while simultaneously checking for appropriate facemask placement. A common error in facemask placement in small children is to place the mask too low on the face such that a portion of the nose is obstructed. Chin lift with or without jaw thrust may also alleviate obstruction at this point. Continuous positive airway pressure (CPAP) can be applied to the upper airway by closing the pop-off valve. Rapid ventilations are delivered at a high inspiratory pressure until the child's chest is seen to rise, and adequate ventilation is confirmed by capnography and rise in oxyhemoglobin saturation. This technique will effectively relieve upper airway obstruction in many cases caused by passive collapse of the pharynx or adenotonsillar hypertrophy, but will not alleviate complete laryngospasm. The next action to take is to place an oral airway. In cases of airway obstruction caused by enlarged tonsils or adenoids, this will almost always be curative unless there is additional cause for the obstruction.

These are the basic maneuvers that should alleviate upper airway obstruction in nearly all cases prior to the development of life-threatening hypoxemia. If these fail, and the oxyhemoglobin saturation is still decreasing, the anesthesiologist is faced with a dire situation and must take immediate action. One of three possible actions is appropriate at this point (or any time earlier in this time sequence):

1. **Immediately insert an LMA.** Insertion of an LMA will establish adequate ventilation except when the obstruction is caused by laryngospasm or if the LMA is malpositioned, which occurs more often in children than adults. One would have to be very confident that the obstruction is not being caused by laryngospasm if placing an LMA during a severe hypoxic episode. Appropriately sized LMAs should be immediately available in every anesthetizing location.

2. **Immediate tracheal intubation can be performed** when one is confident of his or her intubating skills and doubts exist as to the cause of the obstruction. This option is commonly considered in neonates. If laryngospasm is occurring, it is sometimes possible to introduce a styletted endotracheal tube into the glottic opening.

3. **Administer succinylcholine.** Since laryngospasm is a common cause of unrelenting upper airway obstruction in children, succinylcholine should be administered if conventional methods fail to reverse hypoxemia. It should be administered intravenously if possible, but can also be given via the intramuscular route as well, with relief of laryngospasm within a minute. *One should never withhold succinylcholine during hypoxemia for fear of provoking bradycardia.* If the child developed bradycardia as a result of the hypoxemia, the heart rate will increase with the establishment of normoxemia and will not be made worse because of administration of succinylcholine. If laryngospasm occurs but is not associated with hypoxemia, other options for relief include a bolus of propofol (1–2 mg/kg) or remifentanil (1 μg/kg), or
administration of a nondepolarizing neuromuscular blocker. These would also be viable options if there were absolute contraindications to succinylcholine (e.g., myopathy, malignant hyperthermia (MH)-susceptibility).

Desperate Measures

In the rare instance that none of the above measures is successful, and the child is becoming dangerously hypoxic, desperate last-chance measures must be performed immediately. These include the following.

Reposition the Patient

If an anterior mediastinal mass is suspected and conventional measures (e.g., rigid bronchoscope) have failed to reestablish ventilation and normoxemia, the child should be repositioned to the lateral or prone position. This maneuver may alleviate obstruction of the lower trachea or great vessels surrounding the heart.

Cricothyrotomy

There are several techniques available for creating a surgical airway. A tracheotomy is preferred but may not be rapid enough even if appropriate personnel are available. The most feasible action at this point is usually percutaneous placement of a cricothyrotomy, an opening in the cricothyroid membrane located between the cricoid and thyroid cartilages. Though several commercially made kits are available, the most efficient method is to place a 14- or 16-gauge angiocatheter through the cricothyroid membrane. Once this is properly placed into the child's trachea, one has several options with which to provide oxygenation. Every anesthesiologist should have a plan for oxygenation through a cricothyrotomy for every case, every day. One method is to attach a 3.0 endotracheal tube adapter to the hub of the angiocatheter, which can then be connected to the anesthesia breathing circuit. Another method is to attach the barrel of a 10-mL syringe to the angiocatheter and place a cuffed endotracheal tube within the barrel. Many other successful methods of oxygenation have been described. It does not matter which method is used, as long as the anesthesiologist has a definite prospective plan should cricothyrotomy be performed. Known complications from this technique in children include pneumothorax, pneumomediastinum, bleeding into the airway, and misplacement of the angiocatheter through the trachea or into a false lumen within the tracheal wall.

Tracheotomy

If a qualified surgeon is present, and it is feasible that a tracheotomy can be rapidly secured, this option may be preferable over cricothyrotomy. However, it cannot be overstated how difficult this technique is in small children. Therefore, this should be regarded as a true last resort in the event that cricothyrotomy is unsuccessful.

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