Chapter 30: Acute laryngeal infections in childhood

Andrew P. Freeland

Laryngeal infections in childhood result in airway obstruction, the prime symptom of which is stridor. This chapter discusses the various causes of laryngeal infection and their management so that a safe course of action is followed, resulting in a favourable outcome.

The first aim in management is to establish a diagnosis rapidly and this is dependent on a good knowledge of the various possibilities. From a practical point of view it is vital to distinguish inflammation above the glottis (epiglottitis or supraglottitis) from inflammation at or below the glottis (laryngo-tracheobronchitis). A variety of organisms, both bacterial and viral, have replaced *Corynebacterium diphtheriae* as the commonest cause of acute laryngeal infection. Diphtheria, however, still needs to be considered, as do conditions which may mimic laryngeal infections, such as acute retropharyngeal abscesses and foreign bodies.

*Stridor* is the noise caused by obstruction of airflow due to narrowing in the respiratory tract. It may be inspiratory, biphasic or expiratory, but in most cases of acute laryngeal infection, inspiratory stridor dominates. An expiratory phase is very common when the tracheal lumen is also narrowed by oedema or inflammation. Inspiratory stridor alone usually indicates that the lesion is at vocal cord level or above. Tucker (1979) has pointed out that in a full-term baby's larynx measuring 7 x 4 mm, 1 mm of oedema reduces the lumen to 35% of normal. It is therefore not surprising that the child with laryngeal infection develops airway obstruction, whereas the adult with similar disease does not.

*Croup*, as defined by the Shorter Oxford English Dictionary (1973) is 'an inflammatory disease of the larynx and trachea of children marked by a peculiar, sharp, ringing cough'. An alternative definition is 'to cry hoarsely, or to make the hoarse, ringing cough of croup'. There is tremendous variation in the diseases included in the literature under the term 'croup'. It appears to be more of a lay term rather than a pathological entity and parents seem to adhere more to the dictionary definition by referring to their children as having 'croupy coughs' than do the medical profession who usually imply it to mean airway obstruction. Since it is an imprecise term, it would seem more acceptable to classify all children as having an acute inflammatory stridor until a more specific diagnosis can be established. Margolis (1980) pointed out that there is a major problem in deciding whether drug therapy is effective if the definition of the disease is inaccurate in the first place. There is even confusion as to whether croup includes epiglottitis. Since there is no generally agreed classification of this group of diseases, the author feels that epiglottitis is a separate entity and that 'croup' includes acute viral laryngotracheobronchitis, bacterial laryngotracheobronchitis (pseudomembranous croup), spasmodic croup, and diphtheria.

Anatomy of the larynx

The larynx is relatively and absolutely smaller than in the adult (Pracy, 1979) and is higher in the neck and more difficult to see. The coronal and sagittal whole organ laryngeal sections show two important points in relation to childhood infections. The epiglottis is surrounded by loose connective tissue - the pre-epiglottic and paraglottic spaces - and inflammation may spread quickly from the epiglottis within these spaces. Rough
instrumentation or even tongue depression, may encourage the inflammatory oedema to surround the laryngeal inlet completely. This is a hazard referred to in the section on management of epiglottitis. Secondly, the mucosa in the subglottis (within the cricoid ring) is lax and full of mucous glands, and easily becomes oedematous. If it does so, a biphasic stridor occurs since this is the only part of the laryngotracheobronchial tree that is completely surrounded by cartilage; it is therefore rigid and the airflow is restricted in both inspiratory and expiratory phases. It is also worth noting that laryngeal spasm occurs more easily in the child than in the adult. The childhood larynx seems to be physiologically more brittle.

**Causes of laryngeal infection childhood**

The causes of acute laryngeal infection in childhood will be considered first, in isolation. Their management, however, will be discussed together since in most cases the child will present in the casualty department as an acute infective airway obstruction of unknown cause. The correct management depends on a logical sequence of events leading to an accurate diagnosis and a successful outcome for each condition.

**Acute epiglottitis (acute supraglottic laryngitis, acute supraglottitis)**

Acute epiglottitis is the most frightening of paediatric emergencies; if unrecognised, it can kill and all medical practitioners should be aware of its existence and significance. It is rare, occurring 43 times less frequently than laryngotracheobronchitis, but the mortality even in experienced hands is 3-4% (Fearon, 1975). *Haemophilus influenzae* type B is, in the vast majority of cases, the causative organism. The beta-haemolytic streptococcus, Pneumococcus and Staphylococcus have also been reported as causal agents (Schwartz et al., 1982). *H. influenzae* type B epiglottitis may present at any time during the year, although it is more common in the winter months. Drake-Lee, Broughton and Grace (1984) found no cases in the months of July, August or September over a 7-year-period.

The disease is concentrated maximally on the epiglottis, but it is common to find inflammation involving the whole supraglottic compartment of the larynx. The infection spreads in the loose connective tissue anterior and posterolateral to the epiglottis. The laryngeal surface of the epiglottis is largely spared from the inflammation.

Most cases are seen in children between the ages of one and 6 years with the peak incidence occurring between the ages of 3 and 4. This is in contrast to laryngotracheobronchitis which usually affects younger children, the peak incidence being 18 months of age. Epiglottitis is occasionally seen in adults but most children over the age of six have protective antibodies against *H. influenzae* type B and it also seems that some immunity exists below the age of 2 years. However, in this younger age group, haemophilus meningitis is more common. Why the organism spares the epiglottis in preference to the meninges is not clear. It has been suggested that previous contact with *H. influenzae* in early childhood may later be followed by a type III Arthus hypersensitivity reaction which would account for the rapid onset of epiglottitis (Broniatowski, 1985).
Clinical features

The sudden transformation of a fit child into one who is desperately ill, often within a period of only a few hours, is the most striking feature of this disease. However, not all cases present in this classical manner and Welch and Price (1983) found that one-third of their patients with epiglottitis had a history of an upper respiratory tract infection during the previous 24 hours and some had a surprisingly long history of stridor prior to admission. The classical picture is described below.

A fit child, aged about 3 years, complains of a sore throat which intensifies and within half an hour dysphagia is reported. Inspiratory stridor then occurs and within 2 hours a critically ill child presents to the casualty department. The child will be sitting up and leaning forward, as if he lies back, suffocation may occur as a result of the epiglottis occluding the laryngeal inlet. Dribbling of saliva will be profuse since dysphagia is total. His voice, if he is strong enough to speak, will not be hoarse but muffled. Inspiratory stridor is usually present but, as time goes by, the child will become quiet and floppy and respiratory distress seems to lessen. This is an ominous sign caused by extreme fatigue and indicates that respiratory and cardiac arrest are imminent.

Unlike laryngotracheobronchitis where children are restless and pink, most children with epiglottitis are quiet, pale and look terrified. This is a systemic infection and the bacteraemia causes shock which gives rise to the pallor. Pyrexia is always present, although the degree is variable. Some authors feel that marked cervical lymphadenopathy is always present and in the casualty department this is the only physical sign, other than observation from a distance, that it is safe to elicit. On no account should the pharynx be examined since immediate asphyxia may occur.

Radiology of this condition is discussed in the section on management, but it is the author's view that, although X-rays of the epiglottis in this condition are frequently to be found in articles and textbooks, the taking of an X-ray may be a dangerous practice. This is due to the delay and distress caused in aligning a child for an X-ray which is usually quite unnecessary for the diagnosis to be made.

The above picture is enough to be highly suspicious that the child has epiglottitis and no investigations should be carried out until an alternative airway has been established. Throat swabs, taking of blood for cultures, and needling for blood gases are liable to agitate the child and increase the likelihood of airway obstruction.

The only time to confirm the suspected diagnosis is as the child is being provided with an alternative airway. The further management of epiglottitis is considered later.

Laryngotracheobronchitis
(croup, acute subglottic laryngitis, non-diphtheric croup, acute laryngotracheitis)

As the name implies, laryngotracheobronchitis involves a larger proportion of the respiratory tract than epiglottitis and the maximum effect is in the subglottic area. In most cases the causative organism is parainfluenza virus type I, but parainfluenza virus types II and III, influenza virus type A, respiratory syncytial and rhinoviruses may also occur.
Laryngotracheobronchitis may also follow measles. It is not uncommon for secondary bacterial infection to supervene.

The vocal cords are inflamed and may be ulcerated, but it is the subglottis that seems to take the brunt of the disease. Here there is gross oedema and occasionally ulceration. As the name implies, the rest of the tracheobronchial tree may also be affected.

As mentioned previously the incidence of hospital admissions for laryngotracheobronchitis is about 40 times more frequent than for epiglottitis (Fearon, 1975). The mean age is about 18 months and boys are more frequently affected than girls. Denny et al. (1983) reported that boys are affected 1.43 times more commonly as girls and also state that November is the peak month for the disease in North Carolina. It is certainly more common in the winter months in temperate climates, particularly in October, November and December, and there is often another peak in early spring.

**Clinical features**

Unlike epiglottitis, laryngotracheobronchitis is always preceded by an upper respiratory tract infection, usually of at least 48 hours' duration. It is not uncommon for the child to have had a previous history of inflammatory stridor. The initial symptom is hoarseness and this is followed by a ‘croupy’ cough which is described as a 'musical cough of crowing quality', or 'the bark of a seal'. Signs of respiratory distress then appear, often at night. The temperature is usually raised, but not unduly so. Although stridor is initially inspiratory, it soon becomes biphasic as subglottic oedema develops. Flaring of the ala nasi, and suprasternal and intercostal recession develop as respiratory distress increases. At this stage, the child becomes very restless and prefers to lie down. Crying and coughing occur, which make the stridor worse and give rise to the physician's natural inclination to sedate the child. The safety of this will be discussed later. Very careful assessment is needed if the child's stridor and chest retraction diminish; it may mean there is genuine improvement, but occasionally it represents exhaustion with imminent respiratory failure.

It is unknown how many children are managed at home, usually with some form of moist inhalation administered by their parents and family doctors, and how many are admitted to hospital. It is therefore difficult to know the true incidence of this disease. According to Mitchell and Thomas (1980), only 5-10% of all croup cases need hospital admission and, in the USA, an overall incidence of 5-10/1000 preschool children is quoted (Hall and Hall, 1975). A rough estimate from 10 Oxford general practitioners suggests that they request hospital admission for one in every six cases they are called to see. The management in hospital will be discussed later, approximately one out of 20 of these admissions needs an alternative airway. Milner (1984) quoted an even lower incidence of 1% requiring intubation. This is in contrast to epiglottitis where all patients need an alternative airway.

**Bacterial laryngotracheobronchitis (pseudomembranous croup)**

This condition may be a separate disease or be caused by a secondary bacterial infection of viral laryngotracheobronchitis. Some authors call this disease bacterial tracheitis since it seems to involve the trachea predominantly. It is a much more severe illness than laryngotracheobronchitis, but very much less common. Henry (1983), over a 2-year period,
reported seven children who had this condition and exhibited severe sloughing of the respiratory epithelium. The children were older than is normally associated with laryngotracheobronchitis and they had more severe obstruction. An artificial airway is often needed and this may easily obstruct with thick crusts of sloughed epithelium. The causative organism is, in most cases, *Staphylococcus aureus*. A similar experience with this condition was reported by Friedman et al (1985), who quoted 10 patients ranging in age from 3 months to 12 years, three of whom required intubation and seven needed bronchoscopy for diagnosis and treatment.

**Clinical features**

Bacterial laryngotracheobronchitis begins in a fairly insidious way with a history of an upper respiratory tract infection. It progresses, however, and is accompanied by a brassy cough and high fever. The child becomes toxic and the white blood cell count is greatly elevated. It is likely, on admission, that the child will be diagnosed as having severe laryngotracheobronchitis and, because of the respiratory distress, an alternative airway will be considered. If a bronchoscopy is performed at this stage, the trachea will be seen to be ulcerated and sloughed epithelium will be aspirated. This should be sent for bacterial culture since, if bacterial laryngotracheobronchitis is suspected, appropriate antibiotic therapy is essential.

This condition poses major problems for intensive care nurses because of a strong tendency to endotracheal tube obstruction. Very efficient humidity and expert nursing care are necessary to manage these patients successfully. A tracheostomy may be safer, since there is less risk of obstruction of the tube, from inspissated secretions.

**Spasmodic laryngitis (spasmodic croup, acute subglottic oedema, laryngismus stridulus)**

This condition is not universally recognized in all classification but it has the following characteristics. Recurrent attacks are common. The bouts usually begin very suddenly at night without any prodromal features and, equally, disappear just as rapidly, often in the morning. The attacks respond to mist therapy or even vomiting (Davis et al, 1981). If the child is bronchoscoped for any reason, subglottic oedema is the only abnormal feature. Most cases, however, do not require an alternative airway.

Zach (1983) studied immunoglobulin levels in recurrent croup and demonstrated low IgA levels in spasmodic laryngitis and showed that an association existed between the disease activity and the IgA levels. Some children seem to grow out of these attacks only to develop asthma or other allergic states.

There may be a place for treating spasmodic laryngitis with anti-asthma inhalants such as topical steroids or sodium cromoglycate. Systemic corticosteroids also relieve this condition (Koren et al, 1983). These authors found that dexamethasone 0.6 mg/kg as a single dose was useful in spasmodic laryngitis but had no effect in laryngotracheobronchitis.
Diphtheria

Diphtheria is extremely rare in countries where routine immunization is the rule. In 1984 there were only 70 cases in the USA (Broniatowski, 1985), but it is still an important differential diagnosis of airway obstruction in children, especially in immigrants who may not always be immunized. Laryngeal diphtheria nearly always follows pharyngeal infection.

The causative organism is Corynebacterium diphtheriae and of the three strains - gravis, intermedius and mitis - it is nearly always the gravis strain that has been responsible for the major epidemics and high mortality rates. Clinical variants are being reported as causing membranous pharyngitis. It is rare to see diphtheria in children over the age of 10 years.

It is not only the laryngeal obstruction that causes mortality in this condition, but also the production of an endotoxin with the risk of myocarditis and peripheral neuritis. The initial lesion is usually in the region of the tonsil where necrosis is seen and the characteristic grey membrane is formed - a mixture of necrotic tissue, a rich fibrinous exudate and a large number of bacteria. Attempts to remove the membrane often produce bleeding. The membrane appears to become thicker later in the disease process and is easier to separate from the underlying mucosa. The characteristic bull neck appearance is due to cellulitis and regional lymphadenopathy.

Clinical features

The onset is insidious and begins with a barking cough, followed by inspiratory stridor with chest wall recession as the disease spreads from the pharynx to the larynx. General symptoms of malaise, pyrexia and sore throat are often present early in the disease but, occasionally, a membrane over the faucial pillars is the only sign during the early stages. General signs of toxaemia then occur and dysphagia increases prior to laryngeal involvement which is evidenced by a barking cough and stridor. The cough comes in paroxysms, and exhaustion from coughing and toxaemia soon occur unless an alternative airway is provided. Many children die, however, from acute toxic myocarditis occurring during the second week of the illness. Palatal paralysis is the most common of the peripheral neuropathies to occur and presents with nasal regurgitation of food and 'nasal escape' to the voice.

Management

The main problem nowadays is to remember that laryngeal diphtheria still exists. Corynebacterium diphtheriae is penicillin sensitive and penicillin therapy is therefore a mainstay in treatment but, because of the danger of diphtheric toxins, antitoxin treatment is also essential and both should be used early in the management. Intravenous benzyl penicillin 600 mg 6-hourly, should be used and the dose of antitoxin, which may also be given intravenously, varies from 10,000 - 100,000 units, dependent on the severity of the infection.

It may also be necessary to remove the membrane from the larynx and insert an endotracheal tube for airway support. The decision to do this will depend entirely on the clinical situation and will probably be reserved for failed conservative treatment which should include humidification and oxygen therapy. Extubation (if intubation has been necessary) can
be commenced early since the disease responds very well to medical therapy. Once the airway obstruction has been successfully managed, the child will need careful assessment and possibly total bed rest for 2-4 weeks until the danger of myocarditis is past.

**Conditions which mimic laryngeal infections in childhood**

Conditions that must be eliminated as mimics of acute laryngeal infections are foreign bodies, infectious mononucleosis (glandular fever), peritonsillar abscess, retropharyngeal abscess and paraquat poisoning.

**Foreign bodies**

This subject is beyond the scope of this chapter since it appears elsewhere in this volume (see Chapter 29) but a history of a child who is apyrexial, who has been playing with small objects and who then begins to have paroxysms of coughing suggests an inhaled foreign body and removal via endoscopy is obviously essential. Absence of pyrexia is the most obvious way to distinguish foreign body impaction from acute inflammatory disease of the childhood larynx.

**Infectious mononucleosis (glandular fever)**

Airway obstruction may occasionally occur in glandular fever. The membrane is less adherent than in diphtheria but tonsillar hypertrophy may be massive and may result in inspiratory stridor. Glandular fever is more common in young adults, but is not infrequently found in children. if the airway is becoming embarrassed and the stridor increasing, large doses of intravenous hydrocortisone often alleviate the need for an alternative airway. Ampicillin and amoxycillin should be avoided.

**Peritonsillar abscess (quinsy)**

Peritonsillar abscess occurs more commonly in adolescence than retropharyngeal abscess, but the reverse is true in infancy (White, 1985). The clinical features are of trismus, dribbling and airway obstruction which occurs as a result of the tonsils being displaced medially to threaten the oropharyngeal airway. There may be a history of antecedent recurrent tonsillitis.

It may be difficult to decide whether frank pus is present or whether the disease is in the cellulitic stage. If the airway is in jeopardy, it is recommended that surgical drainage of the abscess is carried out. The usual site of the incision for the evacuation of pus is at a point which is transected by a line drawn horizontally from the base of the uvula with one drawn vertically from the anterior pillar of the tonsil. Release of pus by open drainage results in rapid improvement of the symptoms and of the child's well-being.

**Retropharyngeal abscess**

Retropharyngeal abscess is the commonest of the deep neck space infections occurring in infancy and may well mimic laryngotraechoebronchitis by presenting with airway embarrassment. Young children have many retropharyngeal lymph nodes and these may
become infected via lymphatics from the tonsils, teeth, nasopharynx or paranasal sinuses. Most children will have a history of a previous upper respiratory tract infection. Unsuspected foreign bodies are another important cause. Syphilis and tuberculosis affecting the cervical spine may also present with a retropharyngeal abscess. Children over the age of 4 years have far fewer nodes in the retropharyngeal space, hence this infection is more common in very young children (Grodinski and Holyoke, 1938).

Once necrosis of a retropharyngeal lymph node takes place or there is direct extension from tuberculosis of the cervical spine, an abscess is formed which bulges anteriorly into the pharynx. The child becomes toxic, has dysphagia and may dribble. His head is held stiffly and is eventually hyperextended. Prominent cervical glands are present. Inspiratory stridor may occur from associated laryngeal oedema or forward displacement of the laryngopharynx.

Examination is difficult, for apart from the signs referred to above, the oropharynx is not easy to see in an infant, especially with unswallowed secretions pooling in the throat. The retropharyngeal space is in direct continuity with the posterior mediastinum and palpation of the pharynx may well strip the abscess inferiorly or else cause it to be inadvertently ruptured with a consequent risk of inhalation of pus.

The management of this condition is considered later but by far the most reliable way of diagnosing a retropharyngeal abscess is with a lateral soft tissue neck X-ray.

Paraquat poisoning

Paraquat (1,1'-dimethyl 4,4'-bipyridylium dichloride) is a herbicide which is occasionally ingested and gives rise to a pseudo-diphtheric picture (Broniatowski, 1985). It causes a marked pharyngeal membrane which is less adherent to underlying tissues than that in diphtheria. The tongue, characteristically, is more heavily involved with membrane than are the tonsils (Stevens, Walker, Schaffner, 1981). Systemic signs of shock and sepsis are also present.

The management of acute laryngeal infection in childhood

The two aims in management are to arrive swiftly at the correct diagnosis and to treat safely the child's airway obstruction. In order that this may be achieved, there must be a laid down admissions policy in each district which all family doctors are aware of and adhere to. The ambulance crew must also know of the arrangements and the hospital staff from different specialties must cooperate smoothly together. There is a necessity for frequent reminders in the form of postgraduate seminars to all grades of staff to keep those that may have only just joined a general practice or hospital department informed as to the local procedures.

It is only by adhering to a rigid protocol that safety in the management of airway obstruction in the child will be maintained. Each hospital receiving such children should work out their own arrangements, but cooperation between anaesthetists, otolaryngologists and paediatricians (alphabetical order only!) is essential. Ideally, there should be a special resuscitation room near the main emergency department and adjacent to an operating theatre suite where children may be revived. Personnel involved in the management should be as
senior as possible. It is not the situation for the newly appointed anaesthetist or otolaryngology resident.

The equipment in the resuscitation room needs to be checked daily to make sure it is complete and in working order - particularly bulbs, fibre light cables and suction equipment. The room must have enough space to house the mother and child, an anaesthetist, nurse, an otolaryngologist, theatre nurse, and a paediatrician. In practice, other personnel frequently swell the numbers. The resuscitation trolley requirements include a full range of naso- and orotracheal tubes ranging from 2.5 mm upwards. Introducers for the endotracheal tubes are essential. Two laryngoscopes with straight blades should be available in case one fails. A complete anaesthetic machine is also in the room with all necessary anaesthetic drugs and intravenous equipment. There will also need to be bronchoscopy equipment and the Storz, rigid fibre light bronchoscopes are a personal preference, six sizes being available ranging from 2.5 mm to 5 mm. These need to be equipped with side arms for anaesthetic ventilation. Venturi systems are dangerous, since there may be little room for escape of gases around a tightly fitting bronchoscope and pneumothoraces may occur with their use. Various foreign body forceps for use down the bronchoscope need to be at hand, as do the correct lengths of suction cannulae. A paediatric tracheostomy set is also available, although rarely used in the author's practice.

One of the most important pieces of equipment is the suction apparatus. There need to be two separate units, one, a large pharyngeal sucker such as a Yankauer, for pharyngeal secretions and occasional sudden vomits, and the other for fine catheters or rigid fine metal suction tubes required for the bronchoscopes.

The first stage of management is to arrive at a sensible diagnosis in a short space of time. Unnecessary questioning of parents for irrelevant information causes a waste of precious time. The most important consideration is to distinguish epiglottitis and laryngeal foreign body from laryngotraceobronchitis and its mimics, since the former need immediate attention, whereas the latter can usually be managed in a more leisurely fashion. Although not all cases are typical, the boundary between the supraglottic compartment, the rest of the larynx and the tracheobronchial tree is crossed in both directions by both groups of infections.

If all cases were typical, which sadly they are not, there would be no difficulty in distinguishing one disease from another! The signs of retropharyngeal abscess and epiglottitis appear to be much the same, except that the former is usually accompanied by a history of a previous upper respiratory tract infection and is of a much slower onset. A laryngeal foreign body can be excluded from epiglottitis, despite its rapid onset, by the absence of pyrexia and the common history of a foreign body being actually inhaled. The most important decision to be made in the emergency department is whether the child has epiglottitis or, if his airway is immediately threatened by one of the other causes. In either event, an alternative airway must be secured without delay and no further investigations or radiology should be carried out.
Management of epiglottitis

If it is thought the child is suffering from epiglottitis, the following is considered a safe protocol.

The terrified child is comforted and his mother allowed to hold him upright. No attempt should be made to restrain or undress him, carry out venepuncture, X-ray or examine him further since all these procedures may cause crying and precipitate immediate respiratory arrest. Radiology is not advised but a lateral neck X-ray may show the classical 'thumb' sign of the swollen epiglottis. If radiological services are present in the emergency room and the child's condition is so stable as to throw some doubt on the diagnosis of epiglottitis, then there may be justification for radiology. If the clinical situation suggests that the diagnosis is epiglottitis, there is no point in confirming it with what might turn out to be a fatal X-ray.

Examination of the throat by tongue depression is particularly dangerous and in no circumstances should be carried out since respiratory obstruction may occur suddenly - possibly from increase and spread of the swelling in the pre-epiglottic space or from vagal stimulation.

The child is carried by his mother to the resuscitation room, described above, where experienced anaesthetic, otolaryngologic and paediatric staff will prepare to secure an alternative airway. Since the airway may obstruct completely if the child is supine, he should be anaesthetized in the upright position. Occasionally, the child collapses prior to anaesthesia, in which case, intubation or bronchoscopy is required without delay and without induction of anaesthesia.

The otolaryngologist is present in case intubation fails, in which case rigid bronchoscopy is necessary followed, possibly, by tracheostomy onto the bronchoscope through which anaesthesia is maintained. However, in most cases, the anaesthetist will perform the intubation. The author prefers inhalation anaesthesia with halothane plus 100% oxygen delivered to the child in the sitting position.

If a mask is too frightening, the gases are applied as near to the child's face as possible using the anaesthetist's hand as a mask. Muscle relaxants are not used as there is a risk of producing an apnoeic patient with a mechanically obstructed airway. Intravenous induction is also avoided since obstruction may occur if the child cries as the needle is inserted.

As soon as the child loses consciousness, the mother is shown from the room and the child laid on his back ready to be intubated. A laryngoscope is inserted and the diagnosis of epiglottitis is confirmed. The usual description is of a cherry red, swollen epiglottis, but very often the aryepiglottic folds are grossly oedematous and the picture is more one of supraglottitis rather than inflammation being confined to the epiglottis. It is at this stage that a powerful pharyngeal sucker may be necessary to clear all the secretions. If the entrance to the laryngeal inlet is not apparent, sudden compression of the child's chest will often produce a bubble of air in the mucus to indicate the position of the glottis. An appropriately sized orotracheal tube is inserted and hopefully the airway is fully and suddenly restored.
If the first attempt at intubation fails, further manipulation may increase soft tissue oedema and obscure the airway as well as causing marked vagal stimulation resulting in severe bradycardia or cardiac arrest. Further attempts at intubation with floppy plastic tubes will probably also fail. The patient should be handed over to the otolaryngologist who should be able to insert a rigid bronchoscope behind the epiglottis and into the trachea. Experience has shown that if a bronchoscope is not available, intubation can often be achieved using a metal, round-tipped, female urethral cannula which has the advantage of being rigid. Once the airway is secured, by whichever method, the immediate danger is over and at this stage an intravenous cannula is inserted to allow the anaesthetist better control.

The decision now has to be made about the type of airway to stay in place for the next 48 hours. The author prefers nasotracheal intubation, but if the orotracheal tube was only inserted with great difficulty, then it would seem unwise to remove it. Usually, however, a nasotracheal tube can be inserted via the nose to a position adjacent to the oral tube behind the epiglottis and then the latter removed with immediate replacement of the former. If bronchoscopy has been necessary, it is probably safer to perform a tracheostomy onto the bronchoscope, although recent personal experience has not required this, the bronchoscope being replaced with a nasotracheal tube as described above.

At this stage culture swabs are taken from the epiglottis, and a blood culture performed. A good intravenous infusion line is inserted for fluid replacement and for antibiotic therapy. A nasogastric tube should also be inserted for feeding since the child will have to be heavily sedated to avoid swallowing and struggling against the endotracheal tube, which would otherwise cause it to abrade the inflamed epiglottis. One advantage of a tracheostomy is that it allows the child to be ambulant and swallow normally. Cantrell, Bell and Morioka (1978) reviewed 19 series, totalling 738 cases of epiglottitis, and found that the mortality rate if tracheostomy was performed was 0.86% compared with 0.92% if endotracheal intubation had been utilized. However, this rate rose to 6.1% if an artificial airway of some sort was not used in the treatment of epiglottitis. It seems clear, therefore, that whether a tracheostomy or an endotracheal tube is used, there is little change for the outcome of the patient, but there is a significant difference if the child is treated without an alternative airway. The morbidity of tracheostomy and endotracheal intubation will be considered later.

The child is now transferred from the emergency room to a paediatric intensive care unit. If he has been intubated, sedation is necessary prior to transfer to avoid the risk of extubation during the move. Intravenous diazepam 0.1 mg/kg as a bolus followed by a continuous infusion of approximately 0.1 mg/kg per hour is an effective method. The choice of antibiotic is difficult since the emergence of ampicillin and occasionally chloramphenicol resistant strains of *Haemophilus influenzae* type B has been reported (Philpott-Howard and Williams, 1982). It has been suggested that one of the newer cephalosporins-cefotaxime (Claforan) - is highly effective against both ampicillin- and chloramphenicol-resistant strains (Drake-Lee, Broughton and Grace, 1984). Other organisms, such as beta-haemolytic streptococcus, pneumococcus and staphylococcus, causing epiglottitis require appropriate treatment once blood cultures and epiglottic swabs are available. The current choice of antibiotic is chloramphenicol, 100 mg/kg of body weight per 24 hours.

Steroids are not indicated for the treatment of epiglottitis, although Cantrell, Bell and Morioka (1978) reported their widespread use.
The most important feature about the care of nasotracheal tubes is the personnel who look after the airway. It requires highly trained nurses, and enough of them, to care for these patients and it is only in an intensive care situation that these criteria are likely to be met. If an alternative airway has had to be secured in a hospital without intensive care facilities, then a tracheostomy is likely to be safest, since it requires less intense nursing skills in the immediate postoperative period.

Intravenous fluids are necessary to keep the child hydrated. The nasogastric tube is used more for aspiration of stomach contents to prevent vomiting than for feeding.

Extubation is usually possible within 48 hours. Corticosteroids may be given just before extubation to help reduce oedema by the tube. The airway will need to be carefully observed after extubation. It is also advisable to keep the child in a humidified atmosphere for a few hours.

One of the rewarding features about managing this most frightening of paediatric emergencies is that, if cared for correctly, most children with epiglottitis are extubated within 48 hours - having been transformed from a moribund to a fully active, apparently healthy child within that time.

Deaths still occur (Welch and Price, 1983) but with a protocol such as suggested above the outcome should be favourable. Since it is the observed cases that die, it is essential that every practitioner is aware of this condition. If there is the slightest suspicion that a child may have epiglottitis, then immediate transference to hospital is mandatory, if necessary in the practitioner's car, so that an alternative airway can be secured as soon as possible.

Management of laryngotracheobronchitis

Some children with acute laryngotracheobronchitis will need an alternative airway on admission, especially if the diagnosis is bacterial laryngotracheobronchitis (pseudomembranous croup), in which case, the preceding protocol for epiglottitis will serve as the management. However, since only approximately 1% of laryngotracheobronchitis will need intubation (Milner, 1984), a different approach is adopted.

Provided epiglottitis is unlikely, then conservative management with careful observation is usually all that is required while the disease settles. There are many controversial aspects of the management of laryngotracheobronchitis and these will be discussed.

Radiology

While in the emergency department lateral, anteroposterior neck, and chest X-rays are performed. The lateral neck X-ray is the only reliable way to exclude a retropharyngeal abscess and hopefully will not demonstrate a swollen epiglottis which should have been excluded clinically. Foreign bodies may also be seen. The neck X-ray may show a narrowed subglottis, with the so-called ‘steeple’ sign typical of laryngotracheobronchitis and may also show ‘ballooning’ of the hypopharynx. The chest X-ray is a helpful baseline to exclude
collapsed lobes and mediastinal shift or obstructive emphysema as may occur with bronchial foreign bodies. Pulmonary oedema and pneumonia are also occasionally seen.

Once the X-ray has been taken, the child is admitted to the appropriate ward for observation.

**Observation**

Croup scoring systems are used in some hospitals (Davis et al, 1981) but a numerical score has not been found to influence the clinical management of patients. It is hoped that observations will show the stridor lessening, the restlessness settling, the colour remaining pink and the respiration and cardiac rates reducing. These parameters will not improve readily if the child is frightened and to remove a child from his mother, place him in a cold fog in a dripping plastic tent (Henry, 1983) where he cannot see his surroundings and painful blood gas estimations does not help the situation.

**Reassurance**

Most of the treatments suggested for laryngotracheobronchitis are controversial, but the one aspect on which all authors agree is that the child needs strong reassurance, as does the mother. It is a recommended practice not to separate mother and child and once in a calm, confident, reassuring atmosphere both seem to relax. Sedation is rarely necessary and there are serious dangers of suppressing the central drive to respiration with some drugs. If sedation seems essential, then chloral hydrate 30 mg/kg is the safest choice.

**Humidification**

Most authors agree that warm, moist air does little harm (Henry, 1983) and others suggest it should be delivered via a head box in very young children or in a tent in those who are older (Davis et al, 1981). Most parents whose children have had recurrent problems will report the beneficial effects of a steam kettle at home, but there has been no controlled trial giving evidence that humidity is efficacious, although there seems to be evidence that spasmodic laryngitis responds to mist therapy (Fogel et al, 1982). However, since it does no harm and probably helps to prevent drying of secretions from the respiratory tract, some form of humidity should be given. There is no place for cold mist. Jet nebulizers have no effect on humidifying the larynx and ultrasonically generated mist increases airway obstruction in children with abnormally labile airways (Henry, 1983).

The ideal situation is to have a 'croup room' where the relative humidity of the atmosphere in the whole room can be kept high. Placing the child in a plastic humidified tent, may increase his anxiety and make careful observation more difficult through the fog, and is not recommended. If a 'croup room' is not available a nebulizer, blowing warm, wet air as near as possible to the face of the child is of some help. Hydration is also essential with oral fluids if possible, but if the child is not willing to drink, then intravenous fluids are necessary.
Oxygen

Oxygen therapy is also controversial. If a decision is made that the child needs an alternative airway, then obviously it is used until the airway is secured. In less severe cases, there is one view (Welch and Prince, 1983) that its use may mask early signs of hypoxia but, on the other hand, Broniatowski (1985) feels that oxygen is mandatory since hypoxia is the most important blood gas abnormality. It is also suggested that supplemental humidified oxygen in the presence of diffuse bronchial involvement will help to prevent reflex bronchoconstriction, sputum retention and pulmonary oedema (Levison, Tabchnik and Newth, 1982). If oxygen is not used for fear of missing cyanosis, it should be pointed out that this is a late clinical sign, when arterial oxygen saturation is less than 40%. The problem with oxygen therapy is in its mode of application. Unless it is given via a face mask, the inspired percentage is variable and certainly the concentration of oxygen in an average plastic tent when 100% is delivered is only 35%. Unless there is evidence of severe bronchial involvement, or a decision has been made to intubate, the routine use of oxygen is not advised because of the fear induced by a face mask.

Steroids

The place of steroids is not settled, probably because response has not been related to the cause of the airway obstruction. A recent double-blind trial (Koren et al, 1983) using dexamethasone 0.6 mg/kg as a single dose against placebo, found the steroid to be helpful in spasmodic laryngitis, but not in laryngotracheobronchitis. Severe cases of laryngotracheobronchitis were not accepted into the study and the difficulty in clinically distinguishing spasmodic laryngitis from laryngotracheobronchitis was pointed out. A totally opposite opinion was expressed in another report (Asher and Beaudry, 1981), where steroids were found to have a dramatic effect on laryngotracheobronchitis but not on spasmodic laryngitis. A previous study showed no significant benefit from steroid usage (Eden, Kaufman and Yu, 1967).

Since there is confusion the routine use of steroids is not recommended except possibly as a last resort to resuscitate a child in the hope of avoiding intubation, and occasionally to reduce oedema prior to extubation if this has previously failed.

Antibiotics

There is no evidence that antibiotics are of benefit in viral laryngotracheobronchitis except when a secondary bacterial bronchitis supervenes. Bacterial laryngotracheitis (pseudomembranous croup) is probably a separate disease and since Staphylococcus aureus is normally the causative organism, flucloxacillin is given. In practice, most children who are intubated for laryngotracheobronchitis receive antibiotics which are changed depending on clinical response and the culture sensitivities from aspirates.

Racemic adrenaline (epinephrine)

There has been enthusiasm for this form of treatment in the USA, Canada, Australia and more recently in the UK. According to Fogel et al (1982) racemic adrenaline, nebulized and delivered by intermittent positive pressure breathing in uncontrolled studies seems
effective, but in other controlled studies it has been shown to be no more beneficial than nebulized saline. Fogel et al (1982) designed a randomized trial whereby nebulized racemic adrenaline was compared with its delivery via intermittent positive pressure breathing. They included only patients who failed to respond to nebulized saline. The results show that delivery via intermittent positive pressure breathing was not necessary for the effect and that it did reduce obstruction for up to 30 minutes in laryngotracheobronchitis. Spasmodic laryngitis responded to normal saline mist alone. These authors used 0.25 mL of 2.25% racemic adrenaline diluted with isotonic saline, nebulized and given via tight fitting face mask. Continuous ECG monitoring is necessary and there are dangers of a rebound effect. It is therefore only appropriate as a hospital management. The use of a tight fitting mask is controversial and because of its uncertain value, the application of this treatment as a routine form of therapy is not recommended.

**Summary of management of laryngotracheobronchitis**

Since only 1% of children with laryngotracheobronchitis fail to respond to conservative management, however controversial, the main reason for admission to hospital is to observe and secure safely an airway should that be necessary. Recommended management includes effective reassurance and possibly efficient humidification. It does not include routine use of oxygen, steroids, antibiotics or racemic adrenaline. Careful monitoring of the progress of the child is the most important aspect.

**Monitoring of laryngotracheobronchitis**

As mentioned previously, croup scoring systems have been suggested. They are useful as an initial baseline measurement but need to be continuously updated by the same nurses and the same medical staff, since they are very subjective. Objective methods of monitoring include pulse and respiration rates and blood gas estimation. Blood gas analysis is only used on rare occasions because it is a disturbing and painful procedure. It is necessary when there is significant bronchial involvement. Unfortunately, transcutaneous oxygen and carbon dioxide probes are not easy to use in restless children as the transducers move and their readings are unreliable.

A quarter-hourly pulse rate charted from a monitor is of most value. Respiration rates can also be used and, according to Newth, Levison and Brown (1972), they correlate best with arterial oxygen tension. In practice, it is often a combination of a falling pulse rate, relaxation of a restless child, quietening of stridor and maintenance of a good colour that suggest favourable progress. There is no substitute for experience in assessing this condition and a good deal can be learnt by trainee doctors and nurses sitting for 2 or 3 hours with the child and observing progress. If a decision is made that a child needs an alternative airway, the same anaesthetic care is required as was described for epiglottitis.

**Management of retropharyngeal abscess**

As mentioned in the description of the clinical features of this infection, a lateral neck X-ray is the most reliable method of establishing the diagnosis. Computerized tomographic scanning has also been shown to be of value, especially in assessing the extent of the abscess cavity (White, 1985). This makes it easier to decide which route to use for drainage. X-rays,
however, must be interpreted correctly and a true lateral X-ray is necessary (Seid, Dunbar, Cotton, 1979).

Normal variance must not be confused with disease, for instance neck flexion causes a widening of the retropharyngeal space and a reversed lordosis of the cervical spine can be caused by any condition that gives rise to muscle spasm and not just by infection. A useful rule is that the anteroposterior diameter of the prevertebral soft tissues should not exceed the diameter of the vertebral bodies. Pathological lesions of the vertebral bodies and discs must also be assessed. A chest X-ray needs to be performed to exclude spread from the neck into the posterior mediastinum. Providing that the child is not in immediate danger of serious airway embarrassment and if the X-rays suggest a retropharyngeal abscess, intravenous antibiotics should be the first line of treatment. *Staphylococcus aureus*, *Streptococcus pyogenes* and anaerobic bacteria are the most common organisms in deep neck space infections (White, 1985). It is personal practice to use a combination of penicillin, flucloxacillin and metronidazole in appropriate doses for the weight of the child.

If the airway is compromised, or if there is no response to antibiotic therapy, drainage will be necessary. The safety of modern anaesthesia is such that, with an experienced anaesthetist, intubation is possible without trauma. The danger exists, however, of rupturing the abscess before the airway is secured or stripping the abscess into the posterior mediastinum.

Once the child is safely intubated, the posterior pharyngeal wall can be examined using a standard tonsillectomy gag. The abscess can then be aspirated or incised through the pharynx. External approaches, either anterior or posterior to the sternomastoid muscle have been suggested (Levitt, 1976) and are appropriate if extension of the abscess has occurred into the parapharyngeal space or posterior mediastinum. Cultures of the pus evacuated can now be obtained and the antibiotic therapy adjusted depending on the bacteria found.

It is recommended that intubation is continued for at least 24 hours after aspiration or incision of the abscess or until there is an obvious clinical improvement in the child's condition as judged by radiology and a settling of the pyrexia.

**Choice and care of an alternative airway in inflammatory laryngeal obstruction**

Tracheostomy is discussed in Chapter 32 and only brief comments relevant to the infected airway will be made here.

The choice as to whether endotracheal intubation or tracheostomy is performed may be a personal one or may be dependent upon local nursing services. There is no doubt that specialized intensive care facilities are necessary for the management of endotracheal tubes, whereas tracheostomy care need less specialized personnel. Therefore, individual hospitals will have different criteria depending on local circumstances. The mortality rates between the two modalities of intubation and tracheostomy for epiglottitis are said to be very similar at 0.92% and 0.86% respectively (Cantrell, Bell and Morioka, 1978). However, Friedberg and Morrison (1974) demonstrated a 3% mortality rate due to childhood tracheostomy from pneumothoraces, displacement or obstruction of the tube.
The differences in morbidity rates are more striking. Mitchell and Thomas (1980) reporting a series of 2567 patients with laryngotracheobronchitis admitted to the Hospital for Sick Children, Toronto, stated that 2.5% required airway support. When they used tracheostomy, the tubes were in place for a mean time of 11 days, whereas endotracheal tubes stayed in situ for only 6 days. There were no deaths in the tracheostomy group, but there was one fatality caused by tube obstruction among the children treated with endotracheal tubes. Despite this, their management has changed from tracheostomy to endotracheal tubes, but they do emphasize the need for experienced nursing care in the management of the intubated patient.

**Endotracheal intubation**

Whether intubation is via naso- or oroendotracheal routes, the major complication is tube obstruction. Occasionally multiple intubations are necessary to replace blocked tubes or because of failed trials of extubation. Mitchell and Thomas (1980) found that there were no cases of subglottic stenosis from intubation, but it did occur four times in 30 tracheostomies.

It must be emphasized that an endotracheal tube used in an inflammatory disease of the larynx will pass through the affected site. It is therefore essential that good fixation of the tube is achieved and that the child is sedated enough to avoid struggling which might cause movements of the tube which would further damage the inflamed larynx. The vocal cords are, of course, splinted apart by the tube and this prevents the child from being able to cough or talk. A nasogastric tube is also necessary for feeding. Expert nursing care is obviously required not only to manage the above problems, but also to provide adequate humidity and regular aspiration of the tube to prevent obstruction.

The type of tube is a matter of preference. Most units use polyvinyl chloride (PVC) endotracheal tubes. It may be sensible to spray these with a silicone compound to increase the lubrication of the tube. Silastic tubes are available but are expensive and have a thicker wall which tends to increase the size of the tube necessary to maintain adequate ventilation. The size of tube is extremely important. It should be as small as possible to prevent traumatizing already damaged tissue. A rough guide to the size of tube needed in normal patients without inflammatory airway disease can be worked out by the formula of dividing the child's age by four and adding 4.5 mm. It is recommended that a tube one size smaller than would be required for the normal child is selected for the inflamed larynx.

Fixation of a nasotracheal tube is easier than an oroendotracheal tube and requires a brace onto the forehead. Regular aspiration with suction catheters is necessary to prevent accumulation of secretions. Humidification is vital to prevent the secretions becoming too tenacious. This may take the form of a warm nebulizer attached by a T-tube to the endotracheal tube with or without added oxygen depending on the child's blood gases. Humidification may be supplemented by the installation of 2 mL of normal saline immediately prior to aspiration. The suction catheters used should be graduated and measured against the known length of the endotracheal tube. It is important that the catheter goes beyond the endotracheal tube to clear it, but not so far that it continually abrades the carina of the trachea, thereby causing a granuloma. Regular physiotherapy is essential to prevent bronchopneumonia.
Extubation is usually possible within 48 hours with epiglottitis but, as mentioned previously, 6 days seems an average length of time in laryngotracheobronchitis (Mitchell and Thomas, 1980). Every child will be different but it would seem reasonable to attempt extubation when there is no evidence of any chest infection and the secretions are less tenacious. There should be an obvious leak around the tube indicating that the oedema has lessened. It may be worth using corticosteroids for 6 hours prior to extubation to reduce any postintubation oedema. Racemic adrenaline can also be used via a nebulizer prior to extubation for similar purposes. Once the child has been extubated, then efficient humidification is necessary as is very careful observation for the first few hours. It is usually obvious within an hour or two whether the child will be able to cope without the need for reintubation. The parents will need to be reassured about the very weak, husky voice that often follows prolonged intubation, but this is usually nearly back to normal within 24 hours.

**Tracheostomy**

The main advantages of tracheostomy are that the disease process is bypassed, the child does not need sedating and normal feeding is usually possible. Occlusion of the tube with a finger on expiration or with the use of valve allows talking and coughing to occur. However, tracheostomy has major disadvantages. The mortality rate and increased length of time before extubation is possible, have already been mentioned. The operation of tracheostomy leaves a scar which, in some instances, can be quite unsightly. Although tracheostomy on the whole requires less skilled nursing care, there is a risk of accidental extubation, especially on return from the operating theatre. It may be extremely difficult to replace the tube in this situation, with disastrous consequences.

A less serious complication but, nevertheless, a well recognized one, is pneumothorax and air tracking in the neck. It is recommended that immediately after a tracheostomy has been performed a chest X-ray is carried out to make sure there is no pneumothorax present. It is also recommended that, on the first postoperative day a lateral neck X-ray is taken to make sure that the tracheostomy tube is in line with the trachea and not causing backward displacement of the anterior wall of the trachea immediately above the tracheostomy site. If this complication is seen on X-ray it is worth changing the tracheostomy tube for one with a different shape which hopefully will not produce this deformity. If it is unrecognized, then there may be a permanent tracheal stenosis which will cause difficulties in extubation.

A personal preference in design of tracheostomy tube is the Great Ormond Street pattern which is usually made from polyvinyl chloride (PVC). Silastic may be a preferable material. Although this does not have the advantage of an inner tube, or a fenestra and valve to aid in extubation, it becomes soft at body temperature and moulds itself well to the correct shape of the trachea.

In ideal situations, it would seem that endotracheal intubation is preferable to tracheostomy as an alternative airway in acute laryngeal inflammatory obstruction in childhood.
## Summary of differential diagnosis

<table>
<thead>
<tr>
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<th>E</th>
<th>LTB</th>
<th>LFB</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td></td>
<td><em>H. influenzae</em></td>
<td>Parainfluenza virus</td>
<td></td>
<td><em>S. aureus</em></td>
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<td></td>
<td>type B</td>
<td>type I</td>
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<td></td>
</tr>
<tr>
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<td>Under 3 yrs</td>
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<td>1-4 yrs</td>
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<td>Slow - usually</td>
<td>Rapid</td>
<td>Slow - usually</td>
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<td></td>
<td>6 hrs</td>
<td>48 hrs</td>
<td></td>
<td>history of tonsillitis or URTI</td>
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<td>Quite often</td>
<td>Occasional</td>
<td>Not reported</td>
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<td>Severe</td>
</tr>
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<td>Inspiratory</td>
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<td>Apyrexial</td>
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<td>Lying on back</td>
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<td>Hoarse</td>
<td>Hoarse</td>
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<td>'Steeple sign'</td>
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<td>dangerous to perform</td>
<td></td>
<td>IF opaque</td>
<td>widening of retropharyngeal space.</td>
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E - epiglottitis  
LTB - laryngotracheobronchitis  
LFB - laryngeal foreign body  
RA - retropharyngeal abscess.