Acute Upper Airway Obstruction: Croup and Epiglottitis

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In few pediatric conditions are the benefits of optimal management and the risks of inappropriate action so clear as they are in acute upper airway obstruction. Infants and small children are uniquely susceptible to these disorders as a consequence of several anatomic and physiologic factors, and though severity of obstruction and rapidity of progression vary depending upon cause and time of presentation, precipitous decompensation to complete obstruction and/or respiratory failure is an ever present possibility.

Critical management decisions depend upon rapid assessment of the approximate level of the airway affected and of the degree of respiratory distress. In view of the difficulties of anesthetic delivery and securing the compromised airway of a small child, the services of a team of physicians experienced in such management are required in severe cases. Finally, all measures must be carried out in a manner that does not upset the child in order to avoid exacerbating his condition. Appreciation of these factors, greater understanding of the various distinct disordrs, and advances in techniques of medical and surgical care have substantially reduced resultant morbidity and mortality. At our institution we have found that in addition to having a skilled team and advanced facilities, the use of a standard protocol greatly facilitates management.

With the goal of sharing practical information concerning approach and management, this article is devoted to presentation of an overview of the clinical features of acute upper airway disorders followed by more detailed discussions of croup and epiglottitis, two of the most common and important of these conditions. Emphasis is on providing guidelines for assessment, initial intervention, and airway stabilization and management, which we have found useful and successful.

General Approach to Acute Upper Airway Obstruction

Level of Airway Involvement

All forms of acute upper airway obstruction tend to present with stridor, retractions that are primarily suprasternal and subcostal (with mild distress), and mild to moderate increases in respiratory rate and heart rate. Beyond this there is considerable variability among the conditions. From a management standpoint, the major causes can be divided conveniently into two main categories: those involving supraglottic structures (severe tonsillitis with adenoidal enlargement, peritonsillar and retropharyngeal abscesses, epighlottitis/supraglottitis), and those affecting subglottic areas (croup, foreign bdy aspiration, and angioedema). Table 1 depicts the major similarities and differences between the two categories in terms of clinical signs and symptoms. The mode of onset and the age of the patient can also help to distinguish among etiologies (Table 2).

Severity of Respiratory Distress

Since studies such as blood gases and x-rays can prove hazardous, less precise clinical means of determining severity of distress must be used. As a general rule, stridor tends to worsen as obstruction increases; however, when airway compromise becomes severe, air entry is so diminished that audible sounds decrease. Cyanosis does not become evident until the PO_2 is less than 40, and thus is a late sign. Anxiety or restlessness and tachycardia at reast are early indicators of hypoxia. Bearing the above in mind, the signs enumerated in Table 3 can be used to help roughly gauge severity. If the child has severe symptoms in any one category, he must be considered to be in severe distress and treated accordingly.

Table 1. Clinical Features of Acute Upper Airway Disorders

	Supraglottic Disorders	Subglottic Disorders
Stridor	Quiet and wet	Loud
Voice alteration	Muffled	Hoarse
Dysphagia	+	-
Postural preference	+	-
Barky cough	-	+ especially with croup
Fever	+	+ usually in croup
Toxicity	+	-
Trismus	+ usually in quinsy	-
Facial Edema	-	+ usually with angioedema.

Assessment Techniques

The major errors in initial management of upper airway problems are underestimation of distress, overzealous examination, and performance of laboratory studies that disturb the child, thereby worsening his condition and defeating therapeutic goals. Every effort should be made to keep the patient calm, to maintain his sense of security, and not to separate him from his parents. Parents should be encouraged to hold the child or sit next to him and assist as needed. The child should be allowed to maintain the positon in which he is most comfortable, and at no time be restrained. Fast movements that might be seen as threatening should be avoided. If supraglottic disease is likely or distress is moderate to severe, laboratory studies should be withheld and visualization of the mouth and airway should be deferred until this can be done under controlled conditions by a team skilled in establishing an airway.

History

A brief chronology of the illness with questions concerning mode of onset and signs and symptoms is needed, along with information about antecedent illness and events. Past history of cardiorespiratory and allergic disorders is also important.

Table 2. Additional Features of Acute Upper Airway Disorders

	Age Group	Mode of Onset of Respiratory Distress
Severe tonsillitis	Late preschool or school age	Gradual
Peritonsiallar abscess	Usually > 10 years	Sudden raise in temperature, toxicity and distress with unilateral throat pain, following earlier tonsillitis
Retropharyngeal abscess	Infancy to 3 years	Sudden raise in temperature, toxicity and distress after preceding URI or pharyngitis
Epiglottitis	2 to 7 years	Very acute onset of high temperature with rapid progression of dysphagia and distress in previously well child
Croup	3 months to 3 years	Sudden onset (usually at night) of loud stridor and barky cough after preceding URI
Foreign body aspiration	Late infancy to 4 years	Sudden choking episode while eating nuts, carrots, or chewing on small object, followed by onset of distress either immediately or, more typically, following a silent period of a few hours
Angioedema	Usually school age or older	Sudden onset shortly after eating, bee sting, or environ. exposure.

Table 3. Estimation of Severity of Respiratory Disress

	Mild	Moderate	Severe
Color	Normal	Normal	Pale, dusky or cyanotic
Retractions	Absent to mild	Moderate	Severe and generalized with use of accessory muscles
Air entry reduction	Mild	Moderate	Severe
State of consciousness	Normal or restless when disturbed	Anxious, restless when undisturbed	Lethargic, depressed.

Physical Examination

In addition to the attention to emotional needs described above, the practice of doing most of the examination from a distance minimize disturbance and enables more reliable observation by avoiding the increases in heart rate, respiratory rate, and retractions produced by crying. The parent is asked to remove the child's shirt, and the following are rapidly assessed from a few feet away: general appearance, color, respiratory rate, audible sounds, retractions and use of accessory muscles, drooling, and state of consciousness. Thereafter, the patient can be approached slowly in order to check the pulse and auscultate the chest. If these efforts provoke upset, they should be abandoned, as pulse will be unreliable and auscultatory findings altered. If the child has fever and sore throat without evidence of respiratory distress and without drooling or if drooling is present without respiratory distress and history is not typical for epiglottitis, a gentle attempt to examine the mouth may be made.

Note: Lethargy and depression, especially when accompanied by pallor and/or cyanosis, are ominous signs. In the absence of a skilled team, do not attempt more than the above examination if these signs are present, if the child is drooling, or if he demonstrates postural preference. Most particularly, do not attempt to examine the mouth, as this may precipitate laryngeal spasm, massive vagal discharge, and cardiorespiratory arrest.

Following rapid assessment, the approximate degree of distress and level of involvement can be determined, enabling the physician to select appropriate initial therapeutic measures (see protocols below).

Guidelines for Management if Patient Is Initially Seen in Office or Hospital Without Necessary Personnel and Facilities

Assess as described above.

If signs of supraglottic disease or moderate to severe subglottic disease:

Provide with oxygen, allowing parent to hold the mask.
Arrange transport by ambulance.
If child is small, have parent carry him to the ambulance.
Allow parent to hold or sit next to child in transit.
Let patient maintain position in which he is most comfortable, without restraints.
Transport with personnel capable of advanced life support.
Speed and use of siren should depend on child's tolerance.

Note: If the child should suffer a respiratory arrest in transit, brief suctioning of the pharynx followed by bag and mask ventilation with oxygen can be life-saving. Force of ventilation should be gauged to adequately expand the patient's chest. Attempting to bypass the obstruction using a large bore needle inserted through the cricothyroid membrane has been found unsuccessful.

Protocol for Initial Hospital Management of Acute Upper Airway Obstruction

Team members: Otolaryngology resident, ICU fellow, and anesthesiologist (all skilled at intubation), pediatric resident, and respiratory therapist.

1. Triage nurse rapidly assesses the child's status on arrival in the emergency room and takes him to a treatment room.

2. Room assignment:

Moderate or severe distress of Signs of supraglottic disease --> Critical Care Room (Equipped for advanced cardiopulmonary resuscitation).

Mild distress with Subglottic symptoms --> Observation / Intermediate care.

3. Critical care or intermediate care nurse asks parent to remove the patient's shirt and provides humidified oxygen.

Note: If the patient is under 5 or evinces fear of the mask, it is given to the parent to hold as close as the child will tolerate.

4. As this is being done, the clerk summons the pediatric resident who comes immediately and assesses as described above.

5. As the pediatrician evaluates, the nurse prepares equipment that may be needed for direct visualization and intubation.

6. Action following initial assessment:

a. Signs of supraglottic disease, severe subglottic disease, possible foreign body aspiration or angioedema --> Team is paged to emergency room immediately.

b. Mild to moderate croup --> Trial of mist and medical therapy (see section on croup).

7. When the team arrive, the patient is rapidly assessed with a view to measures needed to secure the airway.

Note: If the patient is in severe distress, direct examination and all studies are deferred until after an artificial airway has been established in the operating room.

5. Possible disposition

a. To operating room if intubation, tracheotomy, or other surgery is urgently required.

b. To intensive care unit or ward depending on condition for observation and therapy if operative intervention is not required or is best deferred.

c. Trial of mist and/or racemic epinephrine for croup with disposition dependent upon response (see section on croup).

d. Administration of epinephrine, benadryl, and steroids for angioedema (with team present).

Note: The parent is allowed to accompany the child to his destination and is separated from him only upon entering the operating suite.

9. Laboratory studies

a. X-rays may be obtained in cases of croup to assess degree of subglottic narrowing, in suspected epiglottitis in which direct visualization reveals a normal epiglottis, when diagnosis is unclear, and in cases of foreign body aspiration, provided distress is not severe and patient is accompanied by the parent and a physician. Portable films done in the emergency room are preferred.

b. Blood work and cultures are done only after the airway is felt to be secure. The same applies for starting an intravenous line.

Croup

The croup syndrome is rather unique in that it can cover the spectrum of minimal to life-threatening symptoms, and tends to have a highly variable course. Few diseases have generated greater emotion and less factual information regarding treatment; racemic epinephrine, steroids, intubation versus tracheostomy are just a few areas of controversy. Interpretation of research findings has been difficult because of major design flaws in most studies. Furthermore, the fluctuation in symptomatology typical of the syndrome and the number of individual factors that appear to affect outcome (anatomic and physiologic features unique to small children, age, sex, atopy, reactivity of lower airways, underlying illness, nutritional status, and emotional state of patient and parents) have made research design difficult and have complicated attempts to assess response to therapy. This review attempts to place our current view of croup into historical perspective and also presents our own approach based on the limited data available.

Historical Background

Prior to World War II, diseases such as diphtheria, epiglottitis, and infectious croup were considered together in discussions of upper airway obstruction. Since that time microbiologic and clinical research has allowed more appropriate separation. In 1941, Sinclair identified *Haemophilus influenzae* type b as the etiologic agent of acute supraglottitis, and Rabe in the late 1940s defined acute laryngotracheobronchitis as a separate, presumably viral illness. In 1974, Bucan et al identified parainfluenza viruses 1 and 3 and influenza virus as the primary etiologic agents of the disease. Additional epidemilogic studies in this country have confirmed that the largest outbreaks of croup tend to occur in the autumn of even numbered years and correlate with parainfluenza I virus activity.

Clinical Entities

Subsequent to separation from supraglottic disorders, the croup syndrome (involving edema and/or inflammation primarily in the subglottic area) has been subdivided into at least three different disorders: viral or infectious croup, bacterial tracheitis, and spasmodic croup. The clinical picture of viral croup is well known to all modern pediatricians: mild upper respiratory tract symptoms for a few days, then sudden onset of harsh "barking" cough with varying degrees of inspiratory stridor, waxing and waning course over several days (with symptoms usually worse at night), followed by full recovery in most patients without treatment; some patients need to be hospitalized and a few require intensive care and intubation or tracheostomy.

Earlier discussions of laryngotracheobronchitis are at variance with the current picture. In the 1940s Orton and others described a form of croup characterized by extreme toxicity and included autopsied cases with thick, mucopurulent material found throughout the upper airways. Secondary pyrogenic infection was strongly suspected. The cases of "bacterial tracheitis" recently reported by Jones et al strikingly resemble these earlier case histories. Their patients had a viral croup prodrome but then developed high fever, toxicity, and airway obstruction requiring intubation and suctioning. Purulent material, laden with bacteria, was found below the glottis. Over the past 18 months we have seen several patients resembling those with bacterial tracheitis. Typical viral isolates were obtained in two patients, suggesting that this entity may actually represent the reemergence of severe viral laryngotracheobronchitis, a possibility first mentioned by Cherry. Further studies with careful attempts at viral and bacterial isolation will be necessary in order to determine whether the bacterial infection is primary or secondary in these cases.

Spasmodic croup is another, and probably clinically distinct, entity. Patients have no fever and minimal, if any, prodrome. Stridor develops almost instantaneously, usually at night after one or two brief coughs. Mist, cold air, or emesis can bring relief just as quickly. This illness may recur and may rarely, as we have seen, cause complete airway obstruction requiring intubation. The pathogenesis and relation to atopy are unknown but endoscopy in some patients has revealed edema and pallor rather than the inflammation and crusting characteristic of infectious croup. Table 4 offers a short comparison of the croup entities.

Management

Croup includes a number of disorders with different courses. Even if viral croup alone is considered, each seasonal epidemic may be secondary to a different virus and have variable severity. Over the past few years we have seen tracheostomy rates vary from four or five per season to several times this number. Bearing this and the complexities introduced by individual factors in mind, we will review current therapeutic modalities and our own clinical approach.

Initial recognition of croup and its separation from supraglottitis and foreign body aspiration are vital. Although the clinical picture is usually quite distinct, when doubt exists we evaluate and stabilize in the emergency room, and then either obtain posteroanterior and lateral x-rays of the neck if distress is mild, or bring the patient to the operating foom for endoscopy under general anesthesia if distress is moderate to severe. We feel strongly that it

is better for an occasional child with croup to undergo controlled laryngeal inspection than to run the risk of precipitating a cardiorespiratory arrest in a child with unrecognized supraglottitis.

Table 4. Croup Syndrome - Comparison of Major Entities

	Viral Croup	Bacterial Tracheitis	Spasmodic Croup
Age	< 3yrs (mean 21 mo)	1 mo-6 yrs (N=6) Viral/bact (?)	Childhood
Etiology	Viral	Prior URI	Atopy (?)
Onset	Prior URI	Rapidly progressive, toxicity, airway obstr	Sudden, usually no prior URI
Course	Waxing and waning, usually worse at night, generally mild	Edema, inflammation, pus below cricoid	Rapid resolution
Endoscopic Findings	Edema, inflammation, and crusting, primarily in subglottic area	Artificial airway, antibiotics	Subglottic pallor and edema
Management	See text and Table 6		Self-limited, induced emesis.

Patients with typical croup are evaluated clinically using a croup scoring system (Table 5) modified from Taussig by Davis and Galvis. This enables assessment of the approximate degree of distress not only initially, but also over time, when repeated at intervals. It is also useful in determining response to short-term modes of therapy such as mist and racemic epinephrine. Finally, the score or pattern of scores can be used to help determine disposition (Table 6).

Humidification and Oxygen

Humidification of inspired gases to prevent drying of secretions makes sense in croup therapy, as droplets are actually delivered to at least a portion of the diseased area. Several studies show improvement in croup scores when saline (by intermittent positive pressure breathing (IPPB)) and mist therapy ("croup room") are used alone. We usually use Plexiglas hoods for infants in they fit properly and are tolerated, and croup tents for larger preschool age children who are too young to tolerate use of a mask. In addition to humidification, adequate hydration by oral and intravenous routes is emphasized in order to further decrease the likelihood of inspissation of secretions.

Table 5. Subjective Assessment of Clinical Severity of Croup

	0	1	2	3
Stridor	None	Mild	Moderate at rest	Severe on inspiration and expirations or none with markedly decreased air entry
Retraction	None	Mild	Moderate	Severe, marked use of accessory muscles
Air entry	Normal	Mild decrease	Moderate decrease	Marked decrease
Color	Normal	Normal (0-score)	Normal (0-score)	Dusky or cyanotic
Level of conscious.	Normal	Restless when disturbed	Anxious, agitated; restless when undisturbed	Lethargic, depressed.

Table 6. Guidelines for Disposition of Cases of Croup

Mild Cases (Score 4-5 or Less)

Child is given trial of mist therapy and usually improves significantly. He is then sent home with recommendations for observation, use of a vaporizer, emphasis on oral fluids, and antipyretics as needed. Symptoms of increasing distress (such as increased stridor, retractions, and anxiety at rest) are described so that parent has a clear idea of when to return to hospital.

Mild to Moderate Cases (Score of 5-6)

Disposition depends largely on child's response to mist. Patient's age, time of day, distance from hospital, and parent's condition are also taken into consideration. Older children who present at night, respond well to mist, and live nearby are probably best managed at home. Infants, children with known increased risk factors (history of prior intubation, known subglottic stenosis), those presenting during the day time, and those who live a great distance away are considered for admission.

Moderate Cases (Score of 7-8)

Patient is admitted unless he is older, lives nearby, and has an outstanding response to mist. Otherwise he is given racemic epinephrine in the emergency room prior to transfer to ward or intensive care unit.

Severe Cases (Score > 8, or Child Has Any One Sign in Severe Category)

Team is mobilized as per protocol and racemic epinephrine is given as soon as possible. Older patients who respond well to this may be admitted to the ward for close

observation; younger patients and older children who have a fair response are admitted to the intensive care unit; those who have a poor response, or are tiring or cyanotic are admitted directly to the operating room for establishment of an artificial airway.

Oxygen use stems from the work of Newth who found hypoxemia as the predominant blood gas abnormality in croup and showed the correlation between oxygenation and respiratory rate. Although the authors recommended frequent blood gas determinations, we generally refrain from these outside an intensive care setting. Progressive airway obstruction should be observed clinically as the need for intubation or tracheostomy may precede a rise in pCO_2.

Racemic Epinephrine

Studies of postintubation croup and large uncontrolled studies of croup syndrome suggested that racemic epinephrine had dramatic effects on airway edema and obstruction. The first small controlled study indicated that mist rather than the drug was most important in therapy. A larger study by Westley showed that racemic epinephrine (delivered by IPPB) provided better temporary reief than saline (IPPB) for patients who failed to respond to initial mist therapy. Most observers believe that the drug works locally as a vasoconstrictor to decrease edema. Although racemic epinephrine (2.25 per cent) has been utilized in most studies, L-epinephrine (1 per cent) should work equally well, as it contains only the active isomer. Our present routine is to use racemic epinephrine (0.5 mL per 4 mL of normal saline) only on patients who are being admitted or are hospitalized as rebound may occur, though usually only to the croup score prior to therapy. The patient's response is noted using the croup scoring system. The need for increasingly frequent treatments with lesser degrees of improvement over time may indicate the need for an artificial airway. Thirty minutes is a minimum time between treatments. We generally use inhalation alone with a mask and nebulizer in struggling patients, reserving IPPB therapy for more cooperative children. As noted by Barker, IPPB may provide better entry of particulate material into the airway if there is tracheal collapse during inspiration.

Steroids

Perhaps the greatest controversy in the treatment of croup centers upon the role of steroids. Their known anti-inflammatory effects, particularly their actions to stabilize lysosomal membranes and to diminish capillary dilatation and permeability, have stimulated much interest in their application and a great deal of research. A recent article carefully analyzes the studies to date and finds significant methodologic problems with each, raising questions about validity of results.

A detailed analysis of each study is beyond the scope of this article, but several points may be made. Steroids may have beneficial effects in certain types of croup, but may also be potentially harmful, as in bacterial tracheitis. The most beneficial results from steroids appear to have been obtained when a single high dose was given early in the course; there are no data to support numerous repetitive doses.

Table reviews the controlled studies of croup; dosages have been converted to dexamethasone activity for a 10 kg child. While opinion on the use of steroids for croup is

divided at our institution, most clinicians use 1 to 1.5 mg/kg of dexamethasone (maximum 30 mg) intramuscularly as early as possible in the course of the illness.

Airway Management

Provision of an artificial airway is necessary in some patients with viral croup and certainly in most patients with bacterial superinfection. Tracheostomy was for many years the procedure of choice, as initial studies suggested that nasotracheal intubation might cause serious airway injury. However, a number of more recent studies suggest that carefully done nasotracheal intubation provides effective treatment for croup and may actually reduce morbidity when compared to tracheostomy. As there is currently no prospective, controlled study of this question, we have designed a protocol to be initiated in the near future. Until that time severe croup is treated by tracheostomy at our institution.

Several factors point to the need for airway support: patient fatigue, cyanosis, worsening obstruction (croup score), decreasing response to racemic epinephrine (both in terms of response to treatment and duration of interval between treatments), and toxicity with evidence of superinfection. As time is necessary to arrange for controlled intubation or tracheostomy, a worsening course must be appreciated promptly.

Epiglottitis

Epiglottitis (supraglottitis) is one of the most distinctive and dramatic diseases of childhood. The clinical course is fulminant and includes unique inflammatory and obstructive manifestations which interfere with swallowing, vocalization, and respiration. The disease is almost always caused by a single organism. *Haemophilus influenzae* type b. With early recognition and careful airway management, the once high case fatality rate can be reduced nearly to zero. This section described the principal clinical features and treatment of this condition, with special emphasis on early diagnosis and initial management. Much of the information for this report comes from our extensive experience with *Haemophilus* epiglottitis at Children's Hospital of Pittsburgh, and a review of the medical records of 100 consecutive bacteremic cases successfully treated at this institution during the past nine years.

Clinical Picture

Epiglottitis is the term commonly used for an inflammatory condition that involves not only the epiglottis but also adjacent tissues, including the ventricular bands, arytenoids, and aryepiglottic folds. These structures may be involved in varying degrees, but the process typically does not extend down to the vocal cords or subglottic tissues. This distinctive supraglottic pathology accounts for the unique symptomatology and particularly for differences between the condition and that of laryngotracheobronchitis or croup. Stridor and respiratory distress may occur in both, but sore throat and dysphagia suggest epiglottitis whereas hoarseness and cough are more characteristic of croup. Epiglottitis also tends to occur in older children; the average age for our patients was 3.1 years (range seven months to 10 years), and more than one third were four years of age or older (see Tables 1 and 2).

The clinical presentation of our 100 cases is summarized in Table 7. The various manifestations are grouped by usual order of appearance and anatomic region involved. For

example, fever and sore throat were generally followed by swallowing difficulty, and this soon progressed to respiratory distress. The timing of complaints is related to the first medical visit, whether in a physician's office or in a hospital emergency room. This distinction might be clarified by an example: respiratory distress was present in 56 patients prior to the first medical visit but was noted in 67 by the time of hospital admission.

The earliest manifestation was often the sudden onset of high fever. Fever was also the most common complaint and was noted in 88 of the 100 patients; fever with sore throat was observed in 46 patients. It is therefore not surprising that 11 children were originally thought to have pharyngitis. Four of the 11, however, also had one or more of the following associated problems: drooling, dysphagia, voice change, or preference for a sitting position.

The second group of complaints included various manifestations of swallowing difficulty. These were the most prominent complaints for many patients and were nearly always associated with fever (sometimes with sore throat). Excessive drooling was the most frequent of these complaints (noted in 49), and tended to occur several hours after the fever was first noted. Review of the medical records sent from other hospitals at the time of transfer of patients with epiglottitis showed that problems with swallowing were not always recognized or deemed important enough to record, probably accounting for mistaken initial diagnosis in several cases.

Table 7. Frequency of Early Complaints from 100 Consecutive Patients with Epiglottitis (Supraglottitis) at Children's Hospital of Pittsburgh

Sore throat and feverishness (16 hours)*	46
Swallowing difficulties (one or more)	69
Excessive drooling (8 hours)	49
True dysphagia	27
Refusal to drink or eat	21
Respiratory or vocal problems (one or more)	84
Respiratory distress (5 hours)	56
Stridor or noisy breathing	30
Change in voice	28
Preference for sitting	16
Cough	6

* Time in parenthesis represents the mean duration of the three most common complaints prior to the first medical examination.

Respiratory and vocal manifestations formed the third and most common group of complaints. An indication of the rapidity of the course of this infection is the fact that the onset of respiratory distress usually occurred within 12 hours of the first clinical manifestation. Our children with epiglottitis were often reluctant to speak or had a muffled voice, quite unlike the hoarse voice of croup. Stridor, if present, was softer than that of croup and cough was infrequent (present in only six). The children with epiglottitis usually appeared quite ill and often assumed a characteristic position during the later stages of the illness. There was refusal to lie down and a preference for a sitting position with head forward, neck extended, and mouth open. The child often drooled and there was an anxious expression. We

feel that it is important to stress these features since misdiagnoses continue to occur. Five of our patients were initially diagnosed as having croup despite the fact that three had a history of excessive drooling, and two of these three preferred the sitting position for easier breathing.

Associated Problems

All of our patients had been in good health prior to the onset of epiglottitis. Acute otitis media, however, was found in 14 children during the initial examination. A previous publication reported the frequent occurrence of cervical adenitis and pneumonia with epiglottitis, but we found only three children with enlarged, tender cervical lymph nodes and another five with probable pneumonia, two with pleural effusion. Nearly half of our patients had abnormal chest radiographs as some time during their hospital stay, but they probably represented atelectasis in most cases. Six of our children had clinical and radiographic changes consistent with pulmonary edema following intubation. There were no examples of other major manifestations of *H. influenzae* type b infection (meningitis or arthritis), and this is in agreement with other recent studies in which these conditions were specifically mentioned. Nine of our children had spinal fluid examination, with normal results in each case. Meningitis has rarely been associated with epiglottitis, possibly because of genetic differences is susceptibility to the two disorders; however there is one Scandinavian report noting this association in four of 25 cases of epiglottitis.

Assessment and Initial Management

Not infrequently parents call on the telephone for advice concerning a child with respiratory distress. In such situations, after taking a brief history, experienced physicians have found that either having the parent imitate the child's noisy respirations or listening to the child breathe over the telephone can enable them to assess the degree of distress and probable diagnosis with a fair degree of accuracy.

Guidelines for assessment and initial management, whether the child is first seen in the office or a hospital with the necessary facilities, have been described in the introductory section of this article. The importance of minimizing disturbance and avoiding attempts at visualization of the epiglottis in the absence of a skilled team cannot be overemphasized. There were five instances of respiratory arrest in our series. Three occurred at the time of initial examination, and one occurred in a child who had been strapped down on a stretcher for ambulance transport.

The clinical picture and course are usually so characteristic as to make diagnostic studies such as x-rays and cultures unnecessary prior to securing the airway. Furthermore, the risk of precipitating complete obstruction while doing them generally contraindicates them. There are exceptions, however. Occasionally a child will present with a history and signs suggestive of epiglottitis, but with minimal signs of obstruction and little drooling, or has fever, sore throat, and mild drooling with an atypical history. In such cases visualization may be attempted and may reveal pharyngeal infection with no epiglottic swelling or other pathologic findings may be evident. In the former instance, a portable lateral neck x-ray can be extremely helpful, often demonstrating swelling of the aryepiglottic folds and ventricular bands with sparing of the epiglottis. Whether this supraglottitis represents an earlier phase or a milder form of the disease is unclear, but the cause is also *H. influenzae* type b, and

recognition is important because progression of obstruction will occur without appropriate treatment.

Airway Stabilization

The most important aspect of management, of course, is to maintain or establish an adequate airway. If decompensation occurs before the patient reaches the hospital, ventilation with bag and mask or even mouth to mouth resuscitation can overcome laryngeal spasm and prove life-saving. Once the diagnosis is apparent and the patient has reached the hospital, our current choice of procedure is nasotracheal intubation, rather than tracheostomy, to avoid surgery and the somewhat longer period of recovery. Early elective tracheostomy should be employed if personnel experienced in nasotracheal intubation and its aftercare are not available. Steroids and antibiotics with bag and mask ventilation have been successfully utilized without intubation in mild or even moderately severe cases, but should never be attempted without excellent monitoring facilities and constant attention by personnel skilled in airway management.

Antibiotics

Once the airway is secure, antibiotic management should include parenteral therapy with a drug effective against *H. influenzae.* High doses of ampicillin (200 mg/kg/day) have been employed in most cases at this institution. With the appearance of ampicillin-resistant strains, chloramphenicol has been suggested as additional initial therapy. Since maintenance of an adequate airway is the crucial aspect of therapy for epiglottitis, and since meningitis and other major medical complications are rare, we generally prefer to avoid this potentially toxic drug and treat with ampicillin alone. Chloramphenicol was added in several patients with persistent fever or a report of ampicillin resistance. Three of our five patients with ampicillin-resistant *H. influenzae* were treated successfully with ampicillin as the sole antibiotic, and the other two children were already afebrile by the time chloramphenicol was added. Similar results have been reported by others. Intravenous therapy is continued until the child has defervesced, been extubated, and is able to take and retain oral fluids. Thereafter oral therapy is given to complete a seven day course.

Anesthetic Management and Intubation

Securing the airway of a child suffering from acute epiglottitis or severe croup challenges even the most experienced anesthesiologist. Success depends on the close communication and collaboration of a well organized team following an established protocol.

Preparation

Since complete obstruction of the airway can occur at any time either prior to or during induction, the anesthesiologist must be prepared for all possible events. An array of nasotracheal tubes and laryngoscope blades should be available in the operating suite. Nasotracheal tubes are preferred because they are easier to fasten securely and enable provision of better oral hygiene. Table 8 demonstrates the guides used in our institution for selecting the appropriate sized tube. An endotracheal tube at least 1 mm internal diameter smaller than normal should be ready for use. Generally, the appropriate sized tube can be used

when intubating children with epiglottitis. For croup, however, the initial tube tried should be 0.5 mm internal diameter smaller, as the subglottic narrowing produced by this disease often necessitates use of a tube much smaller in size than that which would otherwise be appropriate. Although nasotracheal intubation is usually successful, an oral tube with stylet in place should also be prepared in the event of loss of airway. Laryngoscope blade sizes are as follows: premature - premature (0); infant (newborn to 3 mos) - Miller 1; 3 mos to 3 yrs - No 1.5; child 3 yrs to 9 yrs - No 2; child over 9 yrs - No 3.

Because all patients should be presumed to have full stomachs and therefore to be at risk for regurgitation and aspiration, a large suction catheter (minimum size 14 French) must be included in the preparation.

Prior to the start of anesthetic induction the otolaryngologist must be prepared to perform an emergency tracheostomy if it should prove necessary. A rigid bronchoscope, completely assembled and functional, must also be available in the operating suite.

Table 8. Approximate Sizes of Endotracheal Tubes

Age	Internal Diameter (mm)	French
Premature	3.0	12
Newborn	3.0-3.5	12-14
Infant	3.5-4.0	14-16
10-12 mos	4.5	18
13-24 mos	5.0	20
2-3 yrs	5.5	22
4-5 yrs	6.0	24
6-7 yrs	6.5	26
8-9 yrs	7.0	28
10 yrs and up	7.0 (cuffed)	28

Finally, preparation of the patient is important whether or not he appears to be interested in his surroundings. The parent is allowed to accompany the child to the entrance of the operating suite. In transit from the emergency room, the anesthesiologist talks to the patient constantly in calm, soothing, hypnotic tones, providing reassurance and explaining in simple terms what is happening and why. This running conversation is continued until induction has occurred. In addition, movements are slow and deliberate, and the child's positional preference is honored to further minimize disturbance.

Anesthetic Delivery

Since most children who suffer from epiglottitis or croup prefer an upright position, anesthesia should be delivered with the child in this position. The anesthetic technique of choice in this institution is that of a spontaneous inhalation induction using halothane and 100 per cent oxygen. An intravenous technique using thiopentone and succinylcholine may be used, but should be attempted only by anesthetists experienced with problems of the compromised airway. Nitrous oxide will hasten the induction, but with the risk of diffusion hypoxia its use is not justified until the airway has been secured. While the induction is

proceeding, it is usually possible to insert a No 20 or 22 Teflon intravenous catheter to provide ready access for medications and to enable adequate hydration.

Intubation

Children with epiglottitis are treated with nasotracheal intubation. It has been our experience and that of others that with the majority of these patients it is possible to assist and control ventilation manually, using a bag and mask, prior to insertion of the nasotracheal tube. However, should this become impossible, it is important to attempt an oral intubation using the prepared oral tube. If this is unsuccessful, a rigid bronchoscope should be tried. Only when these attempts fail should an emergency tracheostomy be performed. If manual ventilation is possible, a depolarizing muscle relaxant, such as succinylcholine, can be used to facilitate intubation once the patient is anesthetized. Otherwise it is safer to avoid using muscle relaxants. Following insertion, the nasotracheal tube is held in place while tincture of benzoin is applied from ear to ear, over the lips, and over the tube segment just outside the nostril. After this has dried, strips of half-inch adhesive tape are applied over the benzoin and wrapped around the tube from both above and below.

For patients with croup, oral intubation is performed first. Then a tracheostomy is performed over the endotracheal tube. Following tracheostomy, direct laryngoscopy and bronchoscopy are performed (see article on tracheostomy).

Laboratory Studies and Medication

Once the airway is secured, blood can be drawn and cultures obtained while the patient is still anesthetized. An initial dose of antibiotic is administered to patients with epiglottitis. Since it is our opinion that these children require sedation in the intensive care unit (ICU) during the period of intubation and observation, an initial intravenous injection of morphine sulphate, 0.1 mg/kg, is also given in the operating room. This has been found to minimize the agitation and thrashing that commonly occur during transfer from operating room to ICU.

Intensive Care Unit Management

Children who have undergone intubation or tracheostomy for epiglottitis or croup require the facilities of an ICU for monitoring and treatment. Because tracheostomy care is discussed in the preceding article, management of the intubated patient with epiglottitis will be stressed here. Upon arrival in the ICU, the chest should be auscultated to insure that both lungs are being ventilated, and the position of the tube should be confirmed by chest radiographs. The tip of the tube should always be about mid-trachea. It is prudent, once it has been established that the tube is appropriately placed, to mark it at the level of the nostril. Thus, if the tube is inadvertently withdrawn or advanced, this will be recognized quickly.

Monitoring

In all patients with artificial airways, the electrocardiogram should be displayed on an oscilloscope continuously so that arrythmias, which may be early signs of blood gas abnormalities, may be easily detected. Blood pressure must be monitored accurately. Body

temperature is checked at intervals, and should hyperthermia develop, it is treated with antipyretics. Serial determination of arterial blood gases is important in the first few hours since pulmonary complications may develop which may necessitate supplemental oxygen and assisted ventilation. Intermittent samples can be obtained with the use of 25 gauge needles, but if frequent blood samples are required the radial artery should be cannulated.

Supervision and Sedation

Despite use of measures to restrict movement such as elbow restraints, constant nursing observing is necessary to keep children from accidentally removing the tubes. Heavy sedation is also helpful. It obviates the fear, stress, and anxiety produced by the ICU environment, and by separation from the parents (especially in the preschool age child); in reducing agitation and movement, sedation minimizes the risk of trauma to the glottis and subglottic areas that can result from the to-and-fro motion of the endotracheal tube. effective sedation can be accomplished by alternating morphine and diazepam, 0.1 to 0.2 mg/kg each, intravenously every four hours. Occasionally a very restless child may require more frequent doses during the early course of management. If this depresses respirations, use of assisted ventilation is then necessary to avoid hypoventilation. It is, however, crucial to rule out hypoxia as the source of agitation before increasing sedation.

Respiratory Care Program

A few principles and steps are essential in caring for patients with artificial airways. Adequate humidification must be provided to avoid blockage of the airway by inspissated secretions. A minimum of 2 cm of water of continuous positive airway pressure must be applied to the airway to maintain a normal functional residual capacity, and to prevent closure of small airways. One to two minutes prior to endotracheal suctioning, the lungs should be hyperinflated with 100 per cent oxygen. Gentle bagging is required to promote adequate ventilation past the mucus without driving it deeper into the distal airways. Using the single-glove sterile technique, 1 to 5 ml of sterile saline without preservative (depending on the child's size) should be instilled into the endotracheal tube to facilitate removal of secretions. The child should be bagged again and a vibratory squeeze should be applied. This is done by placing one hand over each side of the chest and simultaneously vibrating and compressing it after a manually accomplished deep inspiration. With repetitive vibratory squeezes, the gas present in the lung forces secretions up and out of small airways into the major bronchi where they can be reached by the suction catheter. The catheter should have a diameter less than 50 per cent of the diameter of the airway, and have side and end holes. When inserted, it should pass the tip of the endotracheal tube. A suction pressure of about 15 mm Hg is recommended. As the catheter is withdrawn rapidly, a twisting motion should be applied to enhance the removal of secretions that may be clinging to the bronchial mucosa. This procedure is repeated every two to four hours, or more often if the tracheobronchial secretions are abundant.

Postintubation Course

Segmental atelectasis is frequently observed in patients in whom an artificial airway is used. However, in children with epiglottitis, it may be related to the child's primary disease. The incidence of this complication is about 25 per cent, and it is most likely related to

inspissation of secretions. Poor fluid intake secondary to severe dysphagia, the increase in insensible water loss that accompanies high fever, and inadequate coughing also contribute. In some instances this problem has been confused with pneumonitis; however, sequential radiographic examination will demonstrate rapid clearing of the atelectasis owing to intubation and tracheobronchial suctioning, usually before the endotracheal tube is removed.

The second most frequent complication of epiglottitis is pneumonia. In our experience, this develops in about 8 per cent of all patients admitted with epiglottitis.

Pulmonary edema associated with relief of airway obstruction has been described recently. In our institution it has been observed in about 7 per cent of the cases admitted. It should be anticipated in those children in whom airway obstruction has been severe and prolonged, often necessitating emergency insertion of an artificial airway. In these patients, bypassing the obstruction often fails to bring about dramatic improvement of their respiratory distress. Major physiologic changes, such as hypoxemia and massive sympathetic discharge, have been postulated to contribute to this type of pulmonary edema. It is likely that the extremely high transpulmonary pressure generated during inspiration with a severely obstructed airway increases the pulmonary blood volume markedly. The obstruction provides some degree of protection from this by decreasing venous return to the thorax during exhalation. When an artificial airway is inserted and the obstruction bypassed, a sudden increase in venous return to the central circulation occurs, along with a marked increase in the intravascular hydrostatic pressure. At this point true pulmonary edema develops. Prevention of this situation must begin the moment the airway is inserted and involves the application of 4 to 5 cm of water of continuous positive airway pressure to the airway, which can be discontinued gradually over the next 24 to 36 hours. If severe pulmonary edema develops, assisted ventilation should be instituted immediately, fluids restricted, diuretics given as indicated, and measurement of the pulmonary artery capillary wedge pressure considered.

Extubation

The duration of intubation is often more related to the availability of the operating room than to the patient's clinical course. The great majority of children can be extubated safely 36 hours after intubation. In our institution extubation occurs between 36 and 72 hours, with a mean of 48 hours. Prior to this it is advisable to examine the epiglottis at the bedside by direct laryngoscopy to determine if the swelling has decreased significantly. If this is so, the child is taken to the operating room for decannulation and complete endoscopy. It is wise to discontinue sedation at least 6 to 8 hours prior to extubation so that the child is fully awake after the anesthetic for the endoscopy wears off, and is thus able to maintain his protective reflexes.

Postextubation subglottic edema, if present, is usually detected during endoscopy. In this situation, as soon as the endotracheal tube is removed, nebulized 2 per cent racemic epinephrine diluted with sterile saline to a total volume of 3.5 mL is delivered by face mask or IPPB for 15 minutes. Additional doses of racemic epinephrine are indicated if postextubation airway obstruction persists. If the response to racemic epinephrine is not long-lasting and the obstruction becomes severe, reintubation with a tube smaller than the one used originally is indicated. A course of dexamethasone, 0.5 to 1 mg/kg every 6 hours for 24

hours, should be given before attempting extubation again. Fortunately, reintubation is rarely necessary.

Following successful decannulation, the patient is given mist by mask or face tent and is transferred to a ward for observation for an additional one to two days.