

## **Chapter 131: Acute Airway Management**

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This chapter focuses on the various options available for control of the airway in both the acute and the chronic situation. In most instances airway intervention is needed either to relieve obstruction of the upper airway or to control ventilation. The goal of the otolaryngologist-head and neck surgeon is relatively simple: to provide the most expeditious form of management that has the lowest potential for injury and the greatest potential for control of the airway. Certain limiting factors affect the decision for intervention and the selection of an appropriate device. First and foremost is an accurate assessment of the nature and level of the airway problem so that appropriate intervention may be accomplished. Also of concern are the potential for injury that any form of intervention carries and the limitations imposed by personal experience and the immediate setting in which the airway problem exists.

Any maneuver that the physician performs to secure an airway carries with it a risk for further damage to the structures involved. This chapter attempts to clarify the appropriate role for each form of intervention and discusses the benefits and potential risks of each modality. The discussion will be divided into management of acute and chronic airway problems. The discussion of the specific disease entities and the appropriate management of each is left to the individual chapters on specific diseases.

### **Acute Conditions**

A number of factors are involved when a patient has an acute airway problem. The problem should be approached with some basic principles in mind. First, the simplest adequate form of control should be selected. Second, the lowest level of airway obstruction should be ascertained; control should be established by securing an airway below that level. Third, acute airway problems often evolve in association with other medical problems. The physician must be fully aware of the potential for cervical spine trauma, vascular injury, and so on in the patient who develops an airway problem subsequent to multiple trauma. The physician also must be sensitive to the threat of sepsis and pulmonary deterioration in the patient who has an airway problem as part of an infectious disease process such as epiglottitis. Although the airway requires the most immediate attention, these other factors must be considered in the management of the patient.

### **Indications for intervention**

#### *Symptoms*

The common symptoms of acute airway obstruction are voice change, dyspnea, dysphagia, local pain, and cough. These symptoms are all nonspecific and can be associated with any degree of airway pathology. If a patient becomes progressively dyspneic, one must suspect an increasing degree of airway obstruction. However, deceptively few symptoms except for progressive dyspnea may accompany nearly complete upper airway obstruction.

## *Physical findings*

**Hoarseness.** Hoarseness occurs with the slightest change from normal in the contour of the vocal cords. It is a sign of abnormal vibratory function of the cords and can result from any injury, including nerve paralysis, mucosal tear, or edema. When complete aphonia exists, a severe injury should be suspected.

**Stridor.** Stridor refers to noisy breathing. From a clinical standpoint dividing stridor into inspiratory and expiratory phases is helpful. *Inspiratory stridor* tends to occur with swelling at or above the level of the vocal cords as air is drawn inward and the edematous tissue is sucked into the airway. On expiration the same edematous tissue is blown clear; therefore less noise occurs during this phase. *Expiratory stridor* tends to occur with lesions at or below the vocal cords and is most typical in croup. Obstructing lesions at the level of the glottis or trachea can cause stridor in both phases of respiration, known as *to-fro stridor*.

The degree of stridor is related not only to the percentage of airway obstruction, but also to the rapidity with which air is moved through the obstructing lesion. A classic example of the inadequacy of stridor is a predictor of the degree of airway obstruction occurs in epiglottitis. Often the individual with acute epiglottitis will take long, slow respiratory excursions in order to allow passage of air through the supraglottis with relatively little stridor; the patient has already learned that a rapid inspiration will close the airway. Therefore the physician cannot rely on stridor being a clear-cut indicator of the degree of obstruction.

**Restlessness.** When evaluating a patient with ongoing airway obstruction, restlessness must be considered a sign of hypoxia that may also result from other causes, include acute parenchymal lung disease or hemorrhagic shock.

**Drooling.** The neuromuscular apparatus of the pharynx becomes less functional when it is traumatized or acutely infected. Pain and muscular dysfunction limit the ability to swallow, and patients tend to drool in an attempt to avoid the act of deglutition.

**Bleeding.** Bleeding in the upper airway is a sign of mucosal disruption. In the early evaluation of the patient, assessing whether the bleeding is coming from above or below the level of the palate is important. Suctioning in the posterior pharynx under good lighting can help to differentiate nasal and sinus bleeding from hemorrhage occurring lower in the respiratory tract.

**Subcutaneous emphysema.** Air in the soft tissues is diagnostic of a rupture in the continuity of the aerodigestive tract. Subcutaneous emphysema in the neck or face can be the result of an injury to the sinuses, the hypopharynx, the laryngotracheal complex, the pulmonary parenchyma, or the esophagus.

**Palpable fracture.** The upper airway may be compromised by fractures involving any portion of the facial skeleton or the cartilaginous framework of the larynx and trachea. Examination must include palpation of the palate and mandible because major disruption of the bony framework will cause oropharyngeal airway obstruction. The integrity of the thyroid and cricoid cartilages is also assessed. Fractures of any of these structures will require evaluation of the degree of injury and plans for repair.

**Abnormal laryngoscopy.** In assessing the patient with mild to moderate upper airway injury the physician may find mirror laryngoscopy or fiberoptic laryngoscopy extremely helpful. These procedures are most productive when performed by an experienced examiner and will help to assess neuromuscular function and the degree of obstruction of the laryngopharynx.

**Suprasternal retraction.** When maximal inspiratory effort is being exerted against upper airway obstruction, the accessory muscles of respiration become accentuated because of retraction of the soft tissues of the neck and supraclavicular region. If airway obstruction is sufficient to cause retraction, some form of intervention must be considered to immediately stabilize the airway.

### *Diagnostic assessment*

Therapy for a patient with evolving upper airway obstruction relies primarily on clinical judgment. Once having assessed the symptoms and physical findings, the physician should be ready in most instances to make a decision regarding management of the airway. If any doubt exists regarding the status of the airway, it is imperative that it be controlled without hesitation. The following studies may assist further evaluation of a patient whose airway is stable and whose status is indeterminate.

**Indirect or fiberoptic examination.** If the patient is moderately stable, indirect mirror examination or flexible fiberoptic examination of the upper airway can contribute a significant amount of information regarding the degree of airway compromise and neuromuscular function of the larynx.

**Blood gases.** Decisions regarding the need for intubation or tracheotomy in the acutely evolving airway should not be made on the basis of blood gas determinations. Quite possibly a patient with near obstruction may have essentially normal blood gas levels.

**Radiography.** Several radiographic studies may be necessary to thoroughly evaluate the status of the patient with acute airway trauma.

**Cervical spine.** The cervical spine, which may require neurosurgical evaluation and special radiographic studies, should be assessed as early as possible in the management of a patient with upper airway trauma. Decisions regarding head positioning in manipulation for endotracheal intubation or tracheotomy should be made with full knowledge of the status of the cervical spine.

**Soft tissue airway** (Fig. 131-1). A lateral radiograph of the neck tissues can be obtained using a "soft tissue technique". The radiograph is shot at approximately 10 kV less than is used for a standard cervical spine film. A soft tissue film of the neck emphasizes the laryngeal and tracheal air column. Familiarity with the normal lateral neck film will allow interpretation of such findings as supraglottic edema and obliteration of the laryngeal ventricle. Picking up small amounts of subcutaneous emphysema is also possible. Anteroposterior films of the soft tissues of the neck will be helpful in determining lateral deviation of the laryngotracheal complex.

**Chest.** Many reasons exist for obtaining a chest radiograph of the patient with massive trauma. With reference to the acute airway, attention should be directed to the possibility of pneumothorax, mediastinal bleeding, and abnormal tracheal contour.

**Face.** When indicated clinically, radiographs should be taken to determine the structural integrity of the facial bones, including the mandible.

**Barium swallow.** The barium swallow may be helpful in determining the presence of a tear in the hypopharynx or esophagus. However, the physician should remember that 15% to 20% of esophageal tears will be missed by barium radiographic studies.

**Arteriography.** When major blunt or penetrating trauma occurs to the neck or face, consideration of arteriographic evaluation is appropriate. Indications for arteriography are discussed elsewhere in the text.

**Endoscopy.** Whenever there is a suggestion of major injury to the oropharynx, hypopharynx, laryngotracheal complex, or esophagus, evaluation by direct inspection is indicated. This examination includes direct laryngoscopy, tracheoscopy, bronchoscopy, and esophagoscopy. These procedures ideally should be performed before invasive surgery of the neck because the neuromuscular integrity of the laryngotracheal complex should be documented and considered as part of the surgical plan.

## **Therapeutic options**

### ***Observation and medical support***

One of the options that must be considered is a decision for no intervention. At times traumatic, infectious, or neoplastic disease creates a moderate airway problem that the physician judges to be acceptably stable. In this situation one may elect to observe the patient and institute various forms of medical therapy. It is imperative that the physician consider this a potentially dangerous situation; when the condition is an acutely evolving one, the decision for observation must include a commitment to intervene rapidly if the patient's condition deteriorates. The patient should be placed in an intensive care unit where personnel who are capable of judging his or her airway status are immediately available and where persons competent to intervene for control of the airway are on hand around the clock. The physician is responsible for personally observing this patient or delegating this responsibility to someone who has an adequate clinical background to judge the presence or absence of a deteriorating airway. The physician should decide what equipment might be useful and have it available at the patient's bedside. The options to be considered are discussed below. Medical management of an acutely evolving problem may include administration of oxygen, steroids, and antibiotics.

**Oxygen.** Increasing the amount of inspiratory oxygen ( $FiO_2$ ) can be accomplished with humidified oxygen via a close-fitting face mask. It should be remembered that, at best, this action will provide only approximately 50% inspired oxygen. The addition of humidification will provide liquefaction of secretions and make the clearance of partially obstructing secretions easier for the patient.

**Glucocorticoids.** Accumulating evidence regarding the use of corticosteroids in acutely evolving airway problems strongly suggests that the only significant error in their use is administering an inadequate dose (Hawkins and Crockett, 1983). In the presence of mild to moderate trauma or inflammatory and infectious processes, hydrocortisone should be given. The recommended dosage is 100 mg initially and 50 mg every 8 hours for 24 to 48 hours. No significant data exists to suggest that the steroids will have a detrimental impact on the evolution of infectious processes when delivered in bolus form on a short-term basis.

**Antibiotics.** If any suggestion of infection or transmucosal injury as a part of the obstructing process exists, a short course of antibiotics should be given in hopes of reversing whatever influence bacterial infection might have in the evolution of the process. The recommended dosage is 1 million units of penicillin every 6 hours intravenously for 3 to 5 days.

### *Options for intervention (Table 131-1)*

**Heimlich maneuver.** Acute airway obstruction by a food bolus should first be managed by using the Heimlich maneuver in combination with a back slap. If these measures fail, cricothyroidotomy is the next option. The Heimlich maneuver uses residual air in the lungs to expel a foreign body. Pressure should be exerted by a rapid squeezing motion applied against the subxiphoid region or the sternum (a debated point). The back slap creates a more rapid increase in pressure with a higher peak pressure and should be used in conjunction with the hug if the foreign body does not dislodge.

**Nasopharyngeal airway** (Fig. 131-2). The nasopharyngeal airway is a surprisingly useful form of control that is especially applicable in patients recovering from a general anesthetic or who have sustained a mild to moderate head injury with obtundation but with normal respiratory drive. The soft nasopharyngeal trumpet in a patient whose airway problem basically relates to relaxation of the palate and base of the tongue often provides a well-tolerated and fully adequate airway. It is particularly useful because it is tolerated by patients much more readily than is an oral or oropharyngeal airway. Insertion of the nasopharyngeal airway is facilitated by instillation of topical nasal decongestant drops and lubrication of the airway device.

**Oral airway** (Fig. 131-2). The oral airway is easy to insert. Its effectiveness depends on a normal ventilatory drive and on essentially normal airway anatomy. The airway, which is curved and semirigid, can be used to bypass obstruction in the nose or mouth. However, it is not well tolerated and is easily dislodged by a semiconscious and struggling patient.

**Esophageal airway.** The esophageal airway is inserted "blind" into the esophagus and a balloon is distended. Air is then insufflated through the device into the hypopharynx with presumptive ventilation. Significant problems have occurred with this device. Inappropriate placement into the larynx can completely obstruct the airway; the instrument can also lacerate the esophageal mucosa or it can worsen an evolving supraglottic edema process by physically obstructing the airway. In my opinion this form of airway management should be avoided because better options are available.

**Transoral intubation.** Endotracheal intubation is the standard of comparison for airway control. It should be instituted either immediately or after failure of the previously mentioned simple measures. Intubation is appropriate when there is progressive upper airway obstruction, deteriorating pulmonary mechanics, or loss of respiratory drive. Relative contraindications to endotracheal intubation include the presence of (1) cervical spine fracture because hyperextension of the neck in the process of intubation might complete an unstable or incomplete neurologic injury; (2) laryngeal trauma because passage of the tube through an injured larynx may be difficult and may further aggravate the laryngeal injury; and (3) severe oral trauma because trismus, blood, and mucosal tears may preclude the surgeon's obtaining an adequate view of the vocal cords with a standard laryngoscope.

To perform adequate intubation the physician must have a range of endotracheal tubes, a stylet to give some rigidity to the tip of the tube, adequate suction, and a functioning laryngoscope. The stylet should not be allowed to protrude from the tip of the endotracheal tube, and the tube should be molded in a C-shaped contour before insertion. Extreme care should be exercised to avoid penetration of the hypopharyngeal mucosa with the rigid stylet. A transmucosal injury from overaggressive attempts at intubation can cause life-threatening periesophageal infection.

**Nasal intubation** (Fig. 131-3). Individuals who lack experience with blind nasal intubation should not use it for acute airway management. However, it is very useful in special situations such as when treating a patient with combined cervical spine fracture and chest injury. Nasal intubation is most reasonably performed in the operating room in which preparations have been made to perform an urgent tracheotomy should obstructive symptoms develop or intubation fail.

The addition of fiberoptic endoscopy has improved the status of blind nasal intubation. Nasotracheal intubation using an endotracheal tube that has been passed in sleeve-like fashion over a flexible bronchoscope converts blind intubation into a direct procedure allowing visualization of the process. It does, however, require previous experience and should not be attempted in an emergency by those unfamiliar with the technique. If there are significant secretions or bleeding within the airway, the procedure becomes increasingly difficult to perform. It is a useful option in patients with cervical spine injury where control of ventilation is necessary without manipulation of the neck.

**Transtacheal needle ventilation** (Fig. 131-4). The transtacheal needle ventilation technique can be used to great advantage in the emergency setting. It provides rapid control while a patient is being stabilized before more definitive measures can be introduced. The necessary equipment includes oxygen under pressure (50 pounds per square inch), connecting hose with Luer-Lok connectors, and a 16-gauge plastic-sheathed needle. The needle is directed through the cricothyroid membrane and attached to the oxygen line with an interruptor in place. The patient can be fully ventilated with this technique for at least 30 minutes. I favor this measure as a method of temporizing to avoid a period of hypoxia while more definitive management is under way.

Occasional complications of this technique occur, especially in the patient struggling for air. The catheter may become dislodged, with resultant subcutaneous emphysema, and catheters may become kinked, obstructing the inflow of oxygen. Like blind nasal intubation, this technique should be used only after experience is gained in a controlled setting. In most instances, even with mass lesions in the larynx, the elastic recoil of the expanded chest wall establishes adequate expiratory flow. I have encountered one instance in which complete laryngeal obstruction occurred. In such a case an expiratory outlet must be provided, and a cricothyroidotomy is immediately necessary (Rone et al, 1982; Smith, 1974).

**Cricothyroidotomy** (Fig. 131-5). In some instances endotracheal intubation or transtracheal ventilation will be impossible. When the patient has total upper airway obstruction, a cricothyroidotomy is the procedure of choice. This operation can be rapidly performed under less-than-optimal conditions, and the potential for laryngeal injury is quite high. Once the patient is stabilized, the wound should be examined in the operating room and the larynx examined endoscopically. If there is any sign of significant injury or if long-term ventilation will be necessary, the cricothyroidotomy should be converted to a formal tracheotomy.

**Tracheotomy** (Fig. 131-6). Cricothyroidotomy is preferred over a tracheotomy for complete airway obstruction. Performing a tracheotomy on a patient who has urgent need of an improved airway is often difficult. The patient must be given a local anesthetic and usually must be allowed to sit upright to help relieve air hunger. It is especially helpful to bring these patients to the operating theater and have an anesthetist at the head of the table delivering 100% oxygen and assisting the patient to maintain some degree of equanimity. Urgent tracheotomies should be performed through a vertical incision and by the most experienced surgeon available.

## **Chronic Conditions**

Careful assessment is the keystone for management of patients with chronic upper airway problems. Before intervening, the physician must evaluate the nature of the lesion thoroughly and consider various therapeutic options in light of the wishes and functional capabilities of the individual patient. This usually requires a balancing act between the need for an airway versus the need for communication versus the risk of aspiration. The underlying disease process and the willingness of the patient and the physician to persevere will strongly influence the final outcome.

## **Indications for intervention**

A wide variety of problems can cause the need for airway intervention. The pathology is usually localized to the upper airway, the nervous system, or the lungs. The airway problem often results from combined dysfunction of two or even all three of the above, and selection of the proper form of intervention can be difficult. Decisions must be founded on experience plus an accumulation of data from the studies discussed in the following section.

## **Diagnostic assessment**

### ***Patient history***

A thorough review of the patient's past and current medical status is essential. The rate of progression of underlying disease and the immediate and long-term prognosis should be assessed. The physician must also learn of the patient's understanding of the disorder and his or her desires regarding the outcome with particular reference to the airway. Diseases such as diabetes and other disorders that alter normal healing should trigger a very conservative attitude regarding forms of intervention. Progressive neurologic or pulmonary disease is also an indication for extreme conservatism.

Specific historical information regarding aspiration, recurrent pneumonia, exercise tolerance, and voice change is important when considering laryngeal surgery. One must also consider esophageal disease when assessing a patient whose main problem is aspiration. During history taking the physician should evaluate the patient's intelligence because the complexity of some options is beyond the capabilities of some patients.

### ***Physical examination***

Examination of the oropharynx and larynx is critical. First, one must list to the patient. Both articulation and hoarseness are evaluated as indicators of lower motor neuron function as well as structural integrity of the upper airway. Second, the physician listens for stridor, which is a sign of fixed airway obstruction.

Upon viewing the mouth, the physician assesses tongue mobility and status of the palate, the palate is also tested for sensation. During mirror or, preferably, fiberoptic examination, the physician observes the range of vocal cord motion during quiet respiration, rapid breathing, swallowing (fiberoptic examination), and phonation. The fiberoptic instrument is used to test for areas of laryngeal anesthesia in any patient with aspiration. Tracheal lesions may also be assessed with the fiberoptic scope. (A scope with suction and biopsy capability such as the Olympus fiberoptic bronchoscope is recommended.)

During examination the patient should be asked to swallow water so that the physician can observe for signs of a muscular or mechanical cause for aspiration (immediate coughing) or an insensate larynx (delayed coughing). The larynx is palpated during swallowing to evaluate laryngeal elevation. Fixation implies a mechanical or neurologic lesion.

Examination under general anesthesia is less reliable because of the central nervous system effects of anesthetic agents. Paradoxical vocal cord motion under light anesthetic, which becomes normal in the awake patient, can be misleading.

**Pulmonary status.** Emphysema and decreased exercise tolerance indicate poor pulmonary reserve and are relative contraindications for any procedure that has the potential for increased aspiration.



**Arthritis.** Cervical arthritis may be a major limiting factor in endoscopic surgery such as laser excision or vocal cord lateralization. Arthritis of the hands may be a major limiting factor in self-care for patients who receive a tracheotomy. Similar problems can occur in patients with burn contracture of the neck or hands.

### *Pulmonary evaluation*

When history and physical examination suggest concomitant pulmonary disease, further evaluation is appropriate. The most helpful screening pulmonary function study is to ask the patient to climb a flight of stairs. Additional screening may include spirometry to assess the forced vital capacity and the forced expiratory volume (FEV1).

Flow volume loop and blood gases may (or may not) document the upper airway component of the problem. They should be considered ancillary studies of the upper airway, although they may be very valuable in further evaluation of the lower airway.

### *Radiographs*

**Plain films and standard tomography.** Lateral and anteroposterior radiographs of the neck can be very helpful in identifying areas of stenosis. The lateral film should be taken at soft tissue density and with the neck in extension. The laryngeal airway can be highlighted on the anteroposterior film by having the patient perform inspiratory phonation while the film is taken. Anteroposterior and lateral linear tomography is excellent for evaluating tracheostenosis, but it is less helpful in laryngostenosis because of the dynamic activity of the glottis.

**Computed tomography.** Although computed tomography (CT) is becoming the established precision technique, I do not believe that it is significantly better than linear tomography for assessing laryngotracheal stenosis.

**Contrast studies.** Diatrizoate meglumine (Hypaque) laryngotracheography is another way to outline an area of stenosis but it does not offer any special advantage compared with other studies. Contrast studies are particularly important in assessing patients with aspiration to rule out esophageal stenosis and tracheoesophageal fistula.

### *Endoscopy*

By the time endoscopy is scheduled the physician should have specific questions in mind that the procedure is designed to answer. Usually the issues of concern are (1) the nature of the stenosis (ie, length, level of internal diameter, and consistency), (2) the degree of glottic fixation, (3) the neuromuscular integrity of glottis, and (4) determination of whether the pathology is tracheal or esophageal.

If a tracheostomy is not in place, the type of anesthesia to be used must be discussed thoroughly with the anesthesiologist before arriving in the operating room. Options for management include local tracheotomy followed by general anesthetic, transtracheal jet ventilation, or inhalational anesthetic via the endoscope. Plans usually must include temporary paralysis of the patient to assess passive mobility of the arytenoid region.

During endoscopy a precise measurement of the diameter, level, and length of the stenotic area is accomplished. Vocal cord mobility is assessed in two ways. When assessing *active mobility*, the physician visualizes the full range of abduction, being careful to avoid distortion of laryngeal contour with the tip of the endoscope. Thorough topical anesthesia may be necessary to reduce reflex glottic spasm, which can be a confounding factor during evaluation. The tracheotomy tube can be occluded for brief periods of time to stimulate maximal glottic abduction.

Assessment of *passive mobility* is accomplished after complete paralysis. The arytenoid region is palpated with a small spatula to assess the degree of mechanical fixation. Repeated examination of the normal larynx is the best preparation for making this a meaningful evaluation.

### ***Overall assessment***

Having accumulated the available objective data, the physician must tailor treatment to the individual patient. The patient and/or family must be educated regarding the various options and their limitations. They must be made to understand the complexity of balancing airway, aspiration, and voice and that intervention may not fully resolve the problems at hand. Also to be discussed is the possibility of multiple procedures.

Generally, one opts for conservative management (prolonged intubation or tracheotomy) if the patient has an active inflammatory or progressively deteriorating condition. The corrective procedures, for the most part, are reserved for patients with a stable, chronic situation.

### **Therapeutic options**

#### ***Maintenance of current status***

If the patient has a chronic airway problem that is stable either because of the patient's tolerance level or because of a tracheotomy, one must seriously consider the option of doing nothing. The doctrine of *primum non nocere* was never more aptly applied. Each form of intervention carries risks of worsening the patient's status.

#### **Prolonged endotracheal intubation**

Because of generally favorable experience with prolonged intubation, practitioners of intensive care medicine have gradually been extending their guidelines for acceptable duration of translaryngeal intubation. A review of current practice found 2 to 3 weeks acceptable (Watson, 1983). This must be contrasted with Whited's study (1983) of 200 patients that documented a time-related incidence of postintubation laryngostenosis:

- 0% in 50 patients intubated for less than 5 days
- 5% in 100 patients intubated for 6 to 10 days
- 14% in 50 patients intubated for more than 10 days.

Personal research on this issue suggests that the intubation lesion is initiated on day 1 and is fully established in less than 2 weeks. Experience with prolonged intubation (39 surviving patients intubated on average of 18 days) suggests a low incidence of subsequent stenosis when patients with significant laryngeal abnormalities are managed with endoscopic removal of granulation tissue and intralaryngeal injection of depot steroids. Concluding that any obvious time limit exists beyond which prolonged intubation is improper is not possible. Early tracheotomy would overtreat about 80% of patients, and the incidence of postintubation stenosis is quite small if patients are carefully monitored.

### *Tracheotomy*

**Temporary tracheotomy.** Temporary tracheotomy is an excellent choice for airway control if the need for prolonged airway management can be anticipated early in the course of management for acutely ill patients (maxillofacial trauma, quadriplegia, laryngeal trauma) and for patients having surgery for neoplastic disorders of the head and neck.

The temporary tracheotomy is so named because removal of the cannula will result in closure of the stoma. The cannula certainly can remain permanently in place if it is necessary for airway management, as in chronic pulmonary disease and neurologic disorders with aspiration and obstruction. The major drawback of this form of tracheotomy is the chronic local infection associated with the indwelling cannula and the potential for tracheostenosis. Its benefit is that airway, voice, and deglutition can be balanced, making tracheotomy one of the best choices for long-term management of severe laryngeal stenosis. Tracheotomy is also indicated when active inflammatory disease or progressive systemic disease makes other forms of intervention untenable.

For reasons previously mentioned, prolonged intubation is not considered an indication for tracheotomy. However, if a patient being managed with prolonged intubation is conscious, tracheotomy is justified for the purposes of patient comfort, oral alimentation, and verbal communication. In this situation the larynx must be carefully monitored and treated because laryngostenosis can follow tracheotomy (Kirchner and Sasaki, 1973).

**Permanent tracheotomy** (Fig. 131-7). Permanent tracheotomy has two forms. Both depend on elevation of local skin flaps, but the flaps have different purposes. For patients with a normal upper airway but in need of frequent suctioning (eg, patients with chronic obstructive pulmonary disease or bronchiectasis), flaps are rolled on themselves to form an occlusive mass over the tracheal lumen, thus allowing easy access for suctioning while retaining trouble-free airway and phonation. The benefit is avoidance of an indwelling tracheotomy tube. In patients with an abnormal upper airway (eg, some patients with sleep apnea, those with uncorrectable laryngeal stenosis, and high-risk surgical candidates), a permanent tracheotomy is constructed by sewing laterally based skin flaps to the anterior tracheal wall. These require care for approximately 1 month as they heal. Once established they form a trouble-free airway but obviously must be occluded for phonation, a disturbing process to some patients.

### *Corrective laryngeal surgery*

**Laser resection.** In most practitioners' hands the laser is effective only in the removal of "soft" stenosis, that is, granulation tissue or early scar. It has the advantage of being very gentle to tissues and does not cause irreversible damage; it is a good choice as an initial procedure for mild to moderate stenosis. Because the laser must be delivered down the length of an endoscope, aiming at posterior laryngeal lesion is difficult.

**Endoscopic cord lateralization.** For patients with bilateral abductor paralysis and mobile arytenoid cartilages the endoscopic approach popularized by Kirchner (1981) has been successful. It is technically simple and has a high incidence of success without a significant incidence of complications.

**Arytenoidectomy.** When the airway is narrowed by fixed abduction of the cords, arytenoidectomy is to be considered. This procedure (in many forms) is appealing in concept but not highly reliable (Cummings et al, 1984). Healing after arytenoidectomy is unpredictable, and frequently residual stenosis is a problem.

**Open laryngeal surgery.** Thick scar causing stenosis of the larynx or trachea will require an open surgical approach. Numerous variations on this theme exist, and the surgeon must be familiar with multiple options. In general, the procedure depend on a vertical midline anterior (and sometimes posterior) split of the larynx, excision of scar, and use of a stent to establish and maintain a better airway (Cummings et al, 1984). Because these procedures carry a high morbidity and possible mortality, they should be selected only when lesser procedures cannot possibly benefit the patient.

### *Laryngectomy and diversion procedures*

In a selected group of patients with fixed, irreversible neurologic problems, poor airway and poor phonation combine to create the so-called useless larynx. Usually recurrent aspiration pneumonia and sometimes chronic laryngeal pain are the major health problems these patients face. Narrow-field laryngectomy provides a major benefit for these patients (Cummings et al, 1984). They can once again enjoy eating and can look forward to resolution of chronic pneumonia.

In some instances when the possibility of slow recovery of the neurologic deficit exists, laryngectomy should be avoided. The various laryngeal closure procedures (epiglottic flap, vocal cord plication) and laryngeal diversion procedures were devised as temporizing measures (Cummings et al, 1984). It is, however, a rare occasion for one of these severely compromised individuals to recover to the point where reversal of the laryngeal procedure can be realistically considered.