

## **Paparella: Volume III: Head and Neck**

### **Section 2: Disorders of the Head and Neck**

#### **Part 5: The Larynx, Trachea, and Esophagus**

#### **Chapter 32: Cysts and Tumors of the Larynx**

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#### **Cysts of the Larynx**

Cysts of the larynx are benign lesions that are usually easily recognized and managed. DeSanto proposed a classification of laryngeal cysts based on the following considerations: (1) site in the larynx, (2) size and content, and (3) relation to the laryngeal mucosa. In this scheme, most laryngeal cysts are classified as either saccular or ductal. There is also a very rare thyroid cartilage foraminal cyst. Symptoms vary with the age of the patient and size of the cyst. They may range in size from a few millimeters to several centimeters. In adults, the symptoms are usually those of hoarseness and weakness of the voice. In infants, dyspnea and difficult respiration are the usual symptoms.

The histologic character of the cyst cannot be used to define which cysts are congenital. More than half are lined by respiratory epithelium, whereas others have a squamous epithelial lining. Others may have combinations of the two types of epithelium or may not have any epithelial lining. Treatment of the cysts can usually be accomplished by direct transoral laryngoscopy.

#### **Saccular Cysts**

A saccular cyst is a mucus-filled dilatation of the saccule of the ventricle. These cysts are submucosal and are covered with normal mucous membrane. They cannot be classified on the basis of histologic findings, but more useful information is gained from symptomatology, location, depth and size, and surgical exploration at the time of direct laryngoscopy.

The saccular cyst is distinguished from the laryngocele in that its lumen does not communicate with the interior of the larynx and it does not contain air. There are two types of saccular cysts. The *lateral* saccular cysts extend in a more superior and lateral direction, bulging the false vocal cord, the aryepiglottic fold, and the ventricle. They may extend through the thyrohyoid membrane and present in the neck. The *anterior* saccular cyst extends medially and posteriorly and bulges from the ventricle into the lumen of the larynx between the true and false vocal cords. When the saccular cyst occurs in infancy, it may appear even at birth as respiratory distress with inspiratory stridor. An abnormal cry, cyanosis, and dysphagia may be present. In adults, hoarseness and coughing are the most common complaints, although dyspnea, dysphagia, and a lateral neck mass may also occur.

On physical examination, the anterior saccular cyst is perceived as a small swelling arising from the anterior ventricle and covering the anterior part of the ipsilateral vocal cord.

The lateral saccular cyst appears as a mucosa-covered swelling of the false vocal cord and aryepiglottic fold. With enlargement, the cyst may distort the pyriform sinus and vallecula, and with extension through the thyrohyoid membrane, one may palpate a mass in the lateral portion of the neck. Computed tomography (CT) scans reveal the extent of the lesions and help in planning their removal.

Treatment of these saccular cysts is usually accomplished by direct laryngoscopy. In infants, the cysts are usually removed by simple cup forceps unroofing. At times and under certain circumstances, the cysts may simply be aspirated. The lesions may recur, and repeated laryngoscopies may be necessary. Occasionally, laryngofissure may be required to excise lesions that have recurrent multiple times. Rarely, saccular cysts may be found associated with laryngeal carcinoma, emphasizing the need for pathologic evaluation of these lesions.

An external approach may be required in patients with large lateral saccular cysts. This is usually accomplished by tracing the cysts to the thyrohyoid membrane and down into the saccular area of origin. Most of these procedures can be accomplished without disturbing the thyroid cartilage; however, a small segment of the superior ala of the thyroid cartilage may be resected in order to enhance exposure.

### **Ductal Cysts**

Ductal cysts, which are formed by distention of obstructed collecting glandular ducts, are the most common type of laryngeal cysts (75 per cent of cases). Ductal cysts occur in almost any site within the larynx except for the free edge of the true vocal cords, which are devoid of glands and ducts. The most common site of ductal cysts is the true vocal cords (40 per cent), but an almost equal number are present on the epiglottis. Other locations include the vallecula, ventricles, false vocal cords, aryepiglottic folds, pyriform fossa, and subglottic area. In general, ductal cysts are small lesions that are usually less than 1 cm in diameter and are superficial within the mucous membrane. Ductal cysts may also arise from the ducts of mucous glands with the saccule and, therefore, may present with the appearance of a saccular cyst. Ductal cysts may be asymptomatic and may simply be noted on a routine examination. If they are in the true vocal cord or false vocal cord area, they may produce hoarseness, cough, throat pain, and dyspnea. Most ductal cysts may be treated by laryngoscopic removal. When the cysts occur on the true vocal cord, great care must be exercised to preserve the underlying musculature of the vocal cord.

### **Thyroid Cartilage Foraminal Cysts**

A foraminal cyst of the thyroid cartilage is a very rare cyst that is apparently secondary to the projection of the laryngeal mucosa through a congenital defect in the lateral laryngeal cartilage at a site of the venous vessel penetration

### **Laryngocele**

The laryngeal ventricle is a normal finding in humans and other mammals. A laryngocele is an air-filled dilatation of the saccule or appendix of the laryngeal ventricle. Usually the saccule of the laryngeal ventricle regresses in size as the individual matures. Saccules are said to be more common in men than in women. In a significant number of

asymptomatic patients, there is enlargement of the saccules. The connective tissue layer of the laryngeal ventricle is thinner than that found elsewhere in the larynx and is a minimal barrier separating the ventricle from the supraglottic space and the pyriform fossa. Laryngoceles presumably result from an abnormally large saccule that extends up above the thyroid cartilage. These anomalies communicate freely with the laryngeal lumen and as such are filled with air.

Laryngoceles are to be differentiated from saccular cysts - the latter are filled with mucus and do not communicate with the laryngeal lumen. Saccular cysts are more common in infants, whereas laryngoceles tend to occur later in life.

### **Classification**

Three types of laryngoceles have been described:

1. An *internal laryngocele* is confined to the interior of the larynx, extending into the paraglottic region of the false vocal cord and aryepiglottic fold.

2. An *external laryngocele* extends superiorly to the thyrohyoid membrane, which it may penetrate at the point at which the superior laryngeal nerve enters. It is called external because it frequently presents as a mass lateral to the thyrohyoid membrane.

3. A *combined internal-external laryngocele* has both internal and external components existing simultaneously.

### **Pathophysiology**

If the communication between a laryngocele and the laryngeal lumen becomes obstructed, fluid may accumulate within the sac. If mucus is found, a more appropriate term for the anomaly is a *laryngomucocele*, and if pus is found, it is called a *laryngopyocele*. If a laryngocele becomes completely filled with fluid, it is difficult to distinguish it from a saccular cyst. Several causes have been cited for the development of laryngoceles. They include an increase in transglottic pressure, a long saccule, and obstruction of the saccular orifice. Some authors have associated these findings with an increase in laryngeal pressure, citing examples in trumpet players, glass blowers, and weight lifters. Historically, they were noted to occur by Larrey, Napoleon's surgeon-in-chief during the Egyptian campaign, who commented on the bilateral air-containing masses in the necks of the Muezzins, who shouted the Koran from the roofs of the Mosques. In all cases of laryngoceles, the clinician must be suspicious for laryngeal carcinoma of the ventricle and saccule-producing obstruction, which may lead to laryngocele formation.

### **Clinical Manifestations**

Many laryngoceles are discovered incidentally when radiographs of the neck or endolaryngeal examinations are performed for unrelated symptoms. When symptoms are present, they include hoarseness, cough, and the sensation of a foreign body in the throat. External or combined laryngoceles may present with a cervical mass adjacent to the thyrohyoid membrane. If large enough, internal or combined laryngoceles may cause airway

distress.

Diagnosis is most easily accomplished by laryngoscopy and soft tissue radiography. Internal and combined laryngoceles appear as submucosal masses in the region of the false vocal cord and aryepiglottic fold. With the use of a flexible fiberscope, these masses may be seen to enlarge during the Valsalva maneuver. Compression of the external or combined laryngocele may produce a hissing sound as air escapes endolaryngeally. This compression maneuver is, however, dangerous, particularly in the combined laryngoceles, as air may be forced from the external component to the internal component, precipitating airway compromise. With purely external laryngoceles, the endolaryngeal examination may be normal.

The typical radiographic appearance of an air-filled external or combined laryngocele is one of a well-defined radiolucent area protruding into the soft tissues of the neck lateral to the thyrohyoid membrane. Internal laryngoceles are less well defined. CT scans in the transverse and coronal planes may aid in defining the precise extent of the lesion.

Carcinoma of the larynx has been associated with unilateral laryngoceles. In autopsy series, the incidence varies from 2 to 18 per cent. Laryngoceles may be rarely bilateral or associated with carcinoma of the larynx. This association mandates a careful examination of the larynx in all cases of adult laryngoceles to rule out the presence of a neoplasm.

### **Surgical Management**

In the past, laryngoscopy with *marsupialization* of the laryngocele has been recommended. Although this technique does serve to decompress large internal laryngoceles and saccular cysts, the drainage site rarely remains patent and there is often recurrence. Its major purpose is that of relieving impending airway obstruction. Use of the laser may be appropriate. *Laryngofissure* technique has been described for resection of these lesions, particularly for internal laryngoceles. A submucosal or transmucosal technique may be used via this approach. The laryngofissure approach runs the risk of blunting the anterior commissure and subglottic stenosis. Many favor the *external lateral neck approach* for the surgical management of virtually all laryngoceles, citing the improved exposure, minimal morbidity, and reduced chance of recurrence associated with this approach. Internal laryngoceles may require removal of a minimal portion of the superior aspect of the thyroid cartilage to allow adequate surgical exposure. External and combined laryngoceles are dissected through the thyrohyoid membrane, and the proximal opening of the laryngocele is closed on itself after complete dissection of the sac.

Potential complications include edema with airway compromise, laryngocutaneous fistula, subcutaneous emphysema, injury to the superior or internal laryngeal nerve, and recurrence of the lesion.

### **Prolapse of the Laryngeal Ventricle**

When prolapse of the laryngeal ventricle occurs, mucosa protrudes from the laryngeal ventricle. True eversion of ventricle mucosa is rare but occasionally may occur secondary to a ventricular cyst or tumor that pushes mucosa from the ventricle into the vestibule. More

frequently, the protruding mucosal tissue is a result of chronic laryngitis, and the mucosa protrudes secondary to inflammatory infiltration and tissue hypertrophy. As protruding mucosa encroaches on the true vocal cord, intermittent or constant hoarseness accompanied by a cough occurs. On examination, one visualizes a mass protruding from the ventricle. When the mass is palpated on direct laryngoscopy, it can be moved freely, and one can ascertain that its attachment lies within the ventricle and that it is not a mass of true vocal cord. This lesion must be distinguished from other entities within the larynx; therefore, it should be removed for pathologic examination at the time of direct laryngoscopy. Finally, these lesions are removed by using a laser and severing the excess mucosa from its laryngeal attachment. Once the lesion is removed, the symptoms of hoarseness and coughing usually improve. The associated underlying conditions producing the laryngitis must be treated.

### **Benign Tumors of the Larynx**

True benign neoplastic tumors of the larynx, other than squamous papilloma, are uncommon. These tumors should be differentiated from non-neoplastic "tumors" of inflammatory, traumatic, and degenerative origin (polyps, nodules, granulomas). Benign tumors originate from either epithelium or connective tissue elements. They are generally characterized by slow growth, insidious symptoms, and a tendency for recurrence if incompletely removed.

The symptoms produced depend on the location and size of the tumors. Those located on the true or false vocal cords may present initially with hoarseness, and dysphagia may occur as the tumor enlarges. Subglottic tumors present with dyspnea, and hoarseness may be lacking. Supraglottic lesions may present with dysphagia, muffled voice, and dyspnea as the tumor enlarges. A sensation of tightness or a lump in the throat may be the primary complaint. Benign lesions may produce cough, or if ulcerated, they may be associated with hemoptysis. Malignant tumors frequently produce severe or referred pain, which is not a common symptom with benign lesions.

The treatment of benign tumors is usually surgical. The surgical approach may be transoral using a laryngoscope and forceps or a laser, via thyrotomy, or by direct transcervical pharyngotomy. The choice of approach depends upon the location, size, and type of tumor. A small lesion that can be easily excised without injury to the larynx may be removed transorally. In general, large supraglottic lesions are removed through a pharyngotomy. Occasionally, sessile supraglottic lesions may be removed submucosally without entering the pharynx. Subglottic and vocal cord lesions may require a thyrotomy.

### **Tumors of Epithelial Origin**

#### **Squamous Papillomas**

Squamous papillomas are the most common benign laryngeal neoplasms, accounting for about 80 per cent of benign laryngeal tumors. They are the most common laryngeal tumor in children.

Papillomas generally are divided into juvenile and adult-onset forms. The true vocal cords and anterior commissure are the most common laryngeal sites, but the supraglottic and

subglottic areas may be affected alone or in combination. Tracheal and bronchial lesions are not uncommon in children. Papillomas are of epithelial origin and consist of fronds of connective tissue covered by a well-differentiated squamous epithelial covering with no invasion of stroma or submucosal tissues. Papillomas have a characteristic appearance at laryngoscopy; they appear as white to pinkish red, glistening, mulberry-like nodules. They are friable and bleed easily upon removal. They may be sessile or pedunculated. Multiple papillomas are the rule in children, whereas single papillomas are more common in adults.

*Juvenile* papillomas are considered to represent an abnormal tissue response to a viral agent. An increased incidence of skin warts, lesions of known viral cause, has been reported in patients and in families of patients. A higher incidence of laryngeal papillomas has been reported in children whose mothers have genital warts during pregnancy. Virus-like particles resembling the papillomavirus have been found in excised lesions. There is no malignant potential in juvenile papillomas unless the lesion has been previously irradiated. Although not malignant, morbidity is high, with frequent recurrences requiring multiple excisions. Some of the lesions appear to be hormonally dependent, with occasional remissions during pregnancy and a definite decrease in the recurrence rate after puberty. The juvenile form commonly occurs in infancy or childhood and presents as hoarseness and stridor. At direct laryngoscopy, exuberant tissue may be seen in the glottic and supraglottic areas in children. It commonly resembles small grapes and has a warty appearance. The bulk of the lesion may be so great as to obscure laryngeal landmarks. The juvenile form of papillomatosis is often aggressive and resistant to treatment, requiring frequent removal by multiple laryngoscopies.

*Adult-onset* papillomas are commonly solitary and smaller than those seen in children. Their behavior is also less aggressive, and in many cases a single removal may produce a cure. In other cases, the tumors may be recurrent, but the intervals between occurrences are long. Although papillary carcinomas are occasionally reported in adults, most pathologists doubt that they result from malignant degeneration but rather are malignant from the onset.

Once the diagnosis has been established, these lesions should be removed to maintain an airway and also to improve the voice quality. In the past, removal via cup forceps, cryotherapy, and microelectrocautery has been used. However, the most widely accepted treatment for papillomas of the larynx today is removal with the CO<sub>2</sub> laser. The laser is favored because of its hemostatic properties, and its precision allows for removal of the lesion with minimal damage to the underlying laryngeal structures. Multiple recurrences in children are common, requiring multiple laser laryngoscopies. During removal of papillomas, care must be taken not to allow the removed lesion to fall into the subglottic or tracheal areas, as seeding may occur. Surgical trauma to the surrounding areas and local infection seem to increase the rate of recurrence. The newest therapy for papillomatosis is interferon. It is hoped that this method of therapy will decrease the recurrences in the childhood form of the disease. Interferon's long-term role in the treatment of laryngeal papillomatosis is still being determined. There are large trials of interferon therapy currently in progress at various medical centers. There have been some dramatic responses to this therapy, whereas in other cases no response has been noted. At the present time proper treatment seems to be careful serial laser laryngoscopies, with investigational use of interferon in the hope that it will decrease the need for multiple surgical procedures in patients with the severe form of this disease.

## **Neoplasms of Cartilaginous Origin**

### **Chondroma and Chondrosarcoma**

It is difficult to distinguish histologically between chondroma and chondrosarcoma, and their similar behavior makes this distinction even more difficult. Some pathologists feel that previously reported benign chondromas were underdiagnosed low-grade chondrosarcomas.

It is important to differentiate the cartilaginous lesions arising in hyaline cartilage (cricoid cartilage, thyroid ala, and body of the arytenoid cartilage) from those arising in elastic cartilage (epiglottis and vocal process of the arytenoid cartilage). In general, those lesions arising from elastic cartilage are composed of small uniform chondrocytes without nuclear abnormalities. This suggests that they represent foci of metaplastic elastic cartilage rather than true neoplasms.

In contrast, true cartilaginous neoplasms of the larynx are derived from the hyaline cartilage of the cricoid cartilage (70 per cent), thyroid cartilage (20 per cent), and body of the arytenoid cartilage (10 per cent). In these lesions, it is difficult to distinguish between benign and malignant, and even well-differentiated lesions may recur locally and kill the patient. Although the histologic grading of these tumors has been shown to have some prognostic significance, more important factors seem to be the location of the primary lesion and the adequacy of its surgical removal. These lesions affect men more than women in a ratio of 5:1. Most of these tumors occur between the ages of 40 and 60 years. The most frequent site of origin is the internal aspect of the posterolateral plate of the cricoid cartilage. Because of the common subglottic location of the tumor, hoarseness may be minimized and dyspnea may be the presenting symptom. As the tumor enlarges, hoarseness related to restriction of vocal cord mobility by the expanding mass may occur. Lesions arising from the posterior aspect of the cricoid plate may cause a full sensation within the throat and dysphagia. These symptoms are usually insidious because of the slow growth of the tumor.

Laryngoscopy reveals a smooth, firm, round, or nodular fixed tumor covered by normal mucosa. Pallor of the overlying mucosa may be present. Palpation of the lesion during direct laryngoscopy confirms the firmness of the mass. A chondroma may present as a neck mass owing to extension of the lesion attached to the thyroid or cricoid area. Biopsy is frequently unrewarding, because the firmness of the mass may permit removal of only the overlying mucosa. Soft tissue x-ray films and CT scans will delineate the extent and site of origin of the lesion. These techniques usually reveal a unilateral tumor bulging into the airway. The majority of patients exhibit calcification in the region of the tumor.

Conservation laryngeal procedures are indicated if the age and physical condition of the patient and the size and location of the tumor permit. Poorly differentiated chondrosarcomas and extensive tumors may require total laryngectomy. The extent of cricoid involvement is a major factor in deciding between a conservative procedure and a total laryngectomy. Lesions of the anterior aspect of the cricoid cartilage may be approached by a thyrotomy. Lesions of the thyroid cartilage, posterior aspect of the cricoid cartilage, and arytenoid cartilage may be approached by a lateral external incision with or without a pharyngotomy. The entire lesion must be removed or it will recur. Local recurrences occur in 25 to 60 per cent of patients. Usually, recurrences grow slowly and are locally treatable

even after long intervals. There are very rare reports of distant metastatic spread as well as local lymph node involvement. Benign as well as malignant lesions may kill the patient because of the local invasion.

## **Neoplasms of Neural Origin**

### **Granular Cell Tumors**

Previously, granular cell tumors were called granular cell myoblastomas because of their resemblance to muscle tissue. However, the most current theory considers them to be of neural origin, probably derived from Schwann cells. Debate continues over whether these lesions are neoplastic, degenerative, regenerative, or congenital. More than 100 examples of granular cell tumors arising in the larynx have been reported. Most occur in young adults, 30 to 50 years old, with about an equal male to female ratio. Most occur as a solitary polypoid mass on the medial to posterior portion of the true vocal cord. However, they have also been described in the subglottic and supraglottic areas. There are abundant, strikingly granular cytoplasm-containing granules that are strongly periodic acid-Schiff (PAS)-positive. An important associated phenomenon is the prominent pseudoepitheliomatous hyperplasia commonly present in the overlying squamous epithelium. A superficial biopsy from a such lesion may be erroneously diagnosed as well-differentiated squamous carcinoma. These lesions are benign, and complete removal is the recommended therapy.

### **Neurofibroma and Neurilemmoma**

Neurofibromas occur in patients with von Recklinghausen's disease. They may also occur independent of this disease. These lesions commonly involve the arytenoid cartilage or aryepiglottic fold. Neurilemmomas are less common than neurofibromas and usually involve the aryepiglottic fold and false vocal cord. Both of these lesions may be bulky because of their slow development, and symptoms include a sensation of fullness in the throat, voice change, and the slow onset of respiratory distress. Complete excision is recommended, with transoral removal of small lesions at the time of direct laryngoscopy. Larger supraglottic lesions may require lateral pharyngotomy or supraglottic laryngectomy.

## **Neoplasms of Glandular Origin**

### **Oncocytic Lesions of the Larynx**

These lesions are rare and have been described in the literature under a variety of different names: oncocytoma, oncocytic papillary cystadenoma, papillary cystadenoma, oxyphilic granular cell adenoma, and oncocytic hyperplasia. Oncocytes are found in the supraglottic regions of the larynx. They are closely associated with the glandular structures found in the false vocal cords and laryngeal ventricle areas. Oncocytic lesions of the larynx are small, benign cystic growths usually found in the false vocal cord. Most are cystic in nature, and microscopic examinations show that they are frequently multiple. It is generally agreed that these lesions represent oncocytic metaplasia and hyperplasia of the ductal cell portion of the glandular tissue. Most of these lesions occur in elderly patients, and the common symptom is hoarseness. Most can be removed using direct laryngoscopy, although the larger lesions may require a pharyngotomy. Most lesions do not recur after excision, but



recurrences have been reported, probably owing to the frequent multiplicity of these lesions, which may be apparent only on microscopic examination.

These lesions are extremely uncommon, the most common location being in the subglottic laryngeal area. The next most common site is in the supraglottis. Complete excision, the technique employed depending on size, should result in cure.

## **Neoplasms of Vascular Origin**

### **Hemangioma**

One must distinguish hemangioma pathologically from polypoid vascular granulation tissue, which may be produced by laryngeal biopsy, intubation, or various other laryngeal traumas. Laryngeal vascular granulation tissue may be adequately treated by biopsy and laser excision.

Hemangiomas may appear in either children or adults. Hemangiomas in children tend to occur anteriorly in the subglottic region of the larynx. Infantile lesions are usually asymptomatic at birth but produce signs and symptoms by the age of 3 months. The typical history is one of dyspnea and inspiratory stridor that may become biphasic. The symptoms may first appear in association with an upper respiratory tract infection and then persist after the infection resolves. A diagnostic sign of infantile hemangioma is the fluctuating character of the respiratory distress, which may vary daily and become worse during excitement, crying, or infection. The cry and voice quality are usually normal.

Approximately 50 per cent of children with laryngeal hemangiomas have hemangiomatous lesions elsewhere on the body, particularly in the head and neck area. On laryngoscopic examination, the hemangioma usually appears as a compressible, sessile mass between the true vocal cord and the cricoid cartilage area; it is usually located on the anterior subglottic wall. The lesion usually presents on one side of the subglottic area but may circumscribe the lumen. It rarely extends superiorly to involve the true vocal cord. Biopsy is generally condemned as dangerous and unnecessary even in the presence of a tracheostomy, as hemorrhage may be very difficult to control. The clinical history and typical endoscopic appearance are considered sufficiently diagnostic for therapy without confirmation biopsy.

In general, the natural history of this lesion favors cessation of growth and some spontaneous regression as the child matures. In the past, some of these lesions have been treated with radiation. Some large hemangiomas may not respond to radiation, and considering the response of the trachea and general neck tissues to radiation, at the present time this treatment is not indicated in most cases. Instead, tracheotomy is suggested if there is a risk to the airway. This allows the child to mature and gives the hemangioma an opportunity to involute spontaneously. Some clinicians have used the CO<sub>2</sub> laser for endoscopic treatment of this lesion.

Hemangiomas in adults are usually found at or above the level of the true vocal cords. Usually, patients have been hoarse for many years. In contrast to the young child, respiratory distress is not seen. Most of these benign lesions are not treated unless there is a tendency for involvement of other parts of the larynx. Laser removal is an option; however, this is

considered to be less successful in adults than in children because of the increased diameter of the vascular spaces in adults. In certain large lesions, radiation or steroid therapy may be considered.

### **Neoplasms of Adipose Origin**

#### **Lipoma**

Lipomas of the larynx are rare. Most are isolated occurrences without other lipomas in other parts of the body. Some cases may involve other tissues and include fibrolipomas, myxolipomas, and angioliipomas. Most arise from the aryepiglottic folds or epiglottis. Pedunculated lipomas may cause acute respiratory obstruction if the mass suddenly obstructs the glottic areas. Submucosal lipomas distort the larynx as the tumor enlarges. These lesions should be cured by adequate removal, the technique depending on the size of the lesion.

### **Neoplasms of Muscular Origin**

#### **Rhabdomyoma**

Rhabdomyomas are extremely rare within the larynx. Very few cases have been reported. It is important to differentiate rhabdomyomas from granular cell tumors or rhabdomyosarcomas. These lesions are benign, and complete excision is curative.

### **Neoplasms of Fibrous Tissue Origin**

#### **Fibromas**

Fibromas are small pedunculated lesions that usually arise from the true vocal cords. Hoarseness is the only symptom. These lesions are probably not true neoplasms but represent localized fibrous overgrowth of the tissue. Their clinical and histologic course is benign, and laryngoscopic removal is adequate. Recurrence is rare.

### **Malignant Neoplasms of the Larynx**

The most common malignancy of the larynx is squamous cell carcinoma. Unless stated otherwise, the following discussion of cancer of the larynx refers to epidermoid or squamous cell carcinoma.

#### **Incidence and Epidemiology**

Cancer of the larynx occurs in every country in the world but varies in incidence from country to country. Laryngeal cancer represents 2.3 per cent of all malignant tumors in males and 0.4 per cent of all malignant tumors in females, excluding basal and squamous cell carcinomas of the skin. The National Cancer Institute estimates that cancer of the larynx accounts for approximately 1.3 per cent of all new cancer diagnoses and 0.83 per cent of all cancer deaths in the USA. There are approximately 11,000 cases of laryngeal malignancy/year within the USA. Approximately 60 per cent of patients with laryngeal cancers have the diagnosis made when the tumor is localized within the larynx; 25 per cent are diagnosed with

the primary tumor plus metastasis confined to the regional lymph nodes; and 15 per cent are identified once the tumor has spread to other parts of the body at the time of diagnosis. Cancer of the larynx is basically a disease of the elderly. The incidence peaks in the sixth and seventh decades of life. A number of cases have been reported in patients less than 20 years of age, with very rare cases being reported in children.

In the USA, the percentages of tumor occurrence in the different areas of the larynx are as follows: supraglottic, 40 per cent; glottic, 59 per cent; subglottic, 1 per cent.

### **Risk Factors**

The risk factors for laryngeal cancer include tobacco, alcohol, industrial exposure, radiation exposure, and laryngeal papilloma.

#### **Tobacco**

Laryngeal cancer is rare in nonsmokers. Cigarette smoking is the principal risk factor for development of cancer of the larynx, a strong correlation having been demonstrated between tobacco use and laryngeal cancer. Atypical histologic changes have also been related to the development of laryngeal cancer, and these changes are also clearly related to cigarette smoking. Smoking is a causative factor for cancers in all portions of the larynx, whereas it appears that drinking alcohol produces an increase only in supraglottic carcinoma.

#### **Alcohol**

The combination of smoking and drinking alcohol appears to produce an increased incidence of cancers in the supraglottic area. The effects of tobacco and alcohol may have synergistic rather than additive effects. A study demonstrated that exposure to the combination of tobacco and alcohol increases the risk approximately 50 per cent over the expected incidence if the effects were simply additive.

#### **Industrial Exposure**

Occupational exposures have been related to laryngeal carcinoma; however, the relationships remain somewhat indefinite because of the inability to eliminate the effects of tobacco and alcohol. Substances that have possibly been related to laryngeal carcinoma include asbestos, mustard gas, woodworking products, refinery products, diethyl sulfate, and various other chemical and petroleum products. None of these substances has the high relationship to laryngeal carcinoma that tobacco and alcohol do.

#### **Radiation Exposure**

There have been a few reported cases of radiation-induced carcinomas occurring in the larynx. They include squamous cell carcinomas and some sarcomas. It is difficult to produce strong evidence that tumors are produced by radiation to the larynx. The occurrence is so low that demonstrating an excess greater than the expected occurrence of these tumors is difficult.

## **Laryngeal Keratosis**

The natural history of laryngeal keratosis has been well documented and basically demonstrates that keratosis associated with increasing atypical changes leads to a higher incidence of laryngeal carcinoma when compared with laryngeal keratosis with minimal or no atypical changes. Crissman reported that the incidence of laryngeal keratosis progressing to invasive cancer ranges from 3.25 to 4.3 per cent. Hellquist and colleagues demonstrated that the progressively increasing percentage of patients in whom laryngeal carcinoma develops is related to the progressively increasing atypical cellular changes in the keratosis in these patients.

## **Laryngeal Papilloma**

Most patients with carcinomas arising in laryngeal papilloma have received previous radiation therapy. Malignancy arising in nonirradiated juvenile papillomas is rare.

## **Prevention**

At the present time, prevention of cancer of the larynx rests on cessation of smoking. Less than 5 per cent of all laryngeal cancers occur in nonsmokers. In patients who are smokers, cessation of smoking diminishes the risks significantly after 6 years. It is close to that of nonsmokers in about 15 years.

## **Diagnosis**

Laryngeal cancers commonly produce early symptoms, which hopefully lead to early diagnosis and treatment.

## **Symptoms**

Voice changes and hoarseness are usually the first symptoms of glottic carcinoma, since these lesions involve the mucosa of the true vocal cord. Supraglottic tumors may enlarge to produce a muffled voice quality. Glottic and supraglottic lesions may produce a tickling sensation or irritation of the throat. As the tumor enlarges, hemoptysis may occur along with airway obstruction. Vocal cord tumors may produce difficult swallowing, throat pain, and referred ear pain as they enlarge. A neck mass or fullness may be produced by direct tumor invasion through the laryngeal cartilage or more commonly by a metastatic cervical lymph node.

## **Diagnostic Techniques**

The importance of an early, precise diagnosis of carcinoma of the larynx cannot be overemphasized. Following the history of hoarseness or throat pain, or both, the larynx should be examined using the indirect mirror method or a fiberoptic instrument. This examination should search for the appearance of the mucosa, the mobility of the cords, and the condition of the airway. Careful neck examination, searching for direct extension or metastatic spread to cervical lymph nodes, or both, should be performed. Direct laryngoscopy may be performed with the patient under local or general anesthesia. An anterior commissure

laryngoscope is used to examine systematically all of the anatomic areas of the larynx and hypopharynx. It is necessary to delineate the exact extent of the tumor at the time of laryngoscopy in order to make a rational decision regarding future therapy. This demands visualization of all margins of the tumor and assessment of vocal cord mobility. The lesion is drawn on a diagram and becomes a permanent part of the patient's record. Generous biopsy specimens should be taken at the time of direct laryngoscopy. Multiple biopsies may be required if the extent of the tumor is in question. Hyperkeratosis in one area may appear virtually the same as carcinoma in another and these conditions must be differentiated by the surgical pathologist. In the past, contrast laryngograms, xeroradiography, and laminagraphy were used to evaluate laryngeal lesions by x-ray techniques. However, currently the CT examination has replaced these techniques. It is especially helpful in determining subglottic tumor extension, cartilage invasion, and extension into soft tissues of the hypopharynx. It is less helpful in demonstrating clinically undetectable cervical lymph node metastasis. Direct laryngoscopy still remains the best diagnostic and staging technique for most laryngeal lesions.

### **Clinicopathologic Factors**

**Anatomy.** The superior boundary of the larynx is the tip and lateral border of the epiglottis. The anterior limit is the lingual surface of the epiglottis, thyrohyoid membrane, thyroid cartilage, cricothyroid membrane, and cricoid cartilage. Posteriorly, the boundaries are the aryepiglottic folds, the arytenoid cartilages, the interarytenoid space, and the mucosa overlying the cricoid cartilage. The lower border is the inferior margin of the cricoid cartilage. The vallecula, pyriform fossa, and postcricoid region are areas of the superior and inferior hypopharynx.

The larynx is divided into three parts: the supraglottis, the glottis, and the subglottis. The *supraglottic area* extends from the tip of the epiglottis, including its free border superiorly and laterally, to the false vocal cords and laryngeal ventricles inferiorly - this includes the laryngeal surface of the epiglottis, the aryepiglottic folds, the laryngeal surface of the arytenoid cartilage, the false vocal cords, and the ventricles. Historically, a *marginal zone* of the larynx including the suprahyoid portion of the epiglottis and aryepiglottic folds was known as the *epilarynx*. This region is currently included within the supraglottic larynx, although tumors in this marginal region behave more like hypopharyngeal lesions. The superior limit of the supraglottic area is considered to be the hyoepiglottic ligament, and the thyrohyoid membrane is its anterior border. The mucosa of the lingual surface of the epiglottis is considered part of the supraglottic larynx. The vallecular mucosa covering the hyoepiglottic ligament is considered oropharyngeal.

The supraglottis and the glottis are separated at the ventricle. Anatomically, the true border is at the junction of the respiratory mucosa of the ventricle with the squamous epithelium of the true vocal cord. Clinically this is difficult to ascertain, and a more practical boundary is the lateral angle of the ventricle at which point it reflects superiorly. The floor of the ventricle is considered part of the glottic area, and the lateral wall, roof of the ventricle, and sacculae are considered part of the supraglottic larynx.

The *glottic segment* of the larynx consists of both true vocal cords and anterior and posterior commissures, which surround the glottic chink. The glottis is tallest at the

midportion of the true vocal cord, measuring about 5 mm, and then tapers to 2 to 3 mm at the anterior commissure. The posterior commissure is a strip of mucosa measuring 5 mm in height and extending from one vocal process to the other across the interarytenoid space. The superior border of the glottis is the ventricle that separates it from the supraglottic region.

The *subglottic segment of the larynx* is that portion bounded by the true vocal cord superiorly and the lower margin of the cricoid cartilage inferiorly. The upper limit is generally accepted to be 5 mm below the free edge of the vocal cord at which point the squamous epithelium ends.

**Connective Tissue Barriers of the Larynx.** The division of laryngeal cancers into supraglottic, glottic, and subglottic is based on laryngeal anatomy as well as tumor behavior. Early anatomic studies demonstrated connective tissue barriers that serve as boundaries for laryngeal compartments. These barriers and compartments were suggested by earlier dye studies and were confirmed later by whole-organ serial sectioning. Embryologic development has been related to subdivisions of the larynx. The right and left sides develop independently. The supraglottic larynx arises from the buccopharyngeal anlage (third and fourth arches), whereas the glottis and subglottis probably arise from the tracheal bronchial anlage (fifth and sixth arches). The vascular, lymphatic, and nerve supplies generally follow the same patterns, with the supraglottic area being supplied by the superior laryngeal artery and the lymphatic drainage occurring through the thyrohyoid membrane. The glottic and subglottic areas are generally supplied by the inferior thyroid artery with lymphatic drainage proceeding inferiorly.

Connective tissue barriers of the larynx are part of a broad sheath of fibrous tissue containing elastic fibers that are well developed in some areas but rudimentary in others. The lower portion, or *conus elasticus*, is separated from the less-developed upper quadrangular membrane by the ventricles, in which elastic tissue is lacking. The conus elasticus is fused anteriorly with the medial and cricothyroid ligaments. Laterally it extends from the superior border of the cricoid cartilage to the vocal ligament with which it is continuous. It is the thicker upper border of the conus that forms the vocal ligament. Vocal cord tumors may follow the barrier of the conus inferiorly.

The *anterior commissure tendon* is a fibrous structure that extends from the lower edge of the thyroid notch superiorly down to the insertion of the vocal ligaments inferiorly. There is no internal perichondrium on the thyroid cartilage adjacent to the anterior commissure tendon, and consequently these structures are in direct contact. At the true vocal cord level, the mucosa of the anterior commissure is separated from the thyroid cartilage by only the anterior commissure tendon and a few submucosal glands. Tumors may pass along this route to involve supraglottic, glottic, and subglottic areas. Insertion of the anterior commissure tendon directly into the thyroid cartilage and the close proximity of the laryngeal anterior commissure and subglottic mucosa in this area may account for the frequency with which tumors are found invading cartilage at this point. Many times this is a limiting factor when a horizontal supraglottic laryngectomy is performed, since the ventricular level is the inferior margin of this resection. The anterior commissure region may serve as a limiting area for lateral supraglottic tumors, but it is a potential pathway for large glottic and midline supraglottic cancers.

The *quadrangular membranes* are attached anteriorly to the lateral margin of the epiglottis and extend on either side posteriorly to the medial surface of the arytenoid cartilages. These membranes generally separate the supraglottis from the lateral paraglottic space.

**Compartments of the Larynx.** Because the mucosa covering the vocal ligaments is attached loosely, there is a potential space, *Reinke's space*, extending submucosally for almost the whole length of the membranous vocal cord. It serves as a "bursa", allowing the overlying mucosa to be stripped away from the underlying ligament. The fact that there is minimal lymphatic drainage from this space may explain the low incidence of regional lymph node metastasis from early vocal cord carcinoma.

The *pre-epiglottic space* is usually defined as being bounded superiorly by the hyoepiglottic ligament and vallecular mucosa, anteriorly by the thyrohyoid membrane and thyroid cartilage, and posteriorly by the epiglottis and thyroepiglottic ligament. It contains fat, areolar tissue, occasional lymphatics and blood vessels, and frequently the saccule. Simply, it is the space anterior to the epiglottis extending to the anterior portions of the larynx.

The *paraglottic space* is lateral to the ventricle. It is bounded by the thyroid ala, conus elasticus, quadrangular membrane, and posteriorly to a varying degree by the mucosa of the pyriform fossa. Inferolaterally this space is continuous with the gap between the thyroid cartilage and the cricoid cartilage, allowing tumors a readily accessible route to spread outside the confines of the larynx. Its significance is related to the ease with which tumors invading the ventricle or deeply penetrating glottic and supraglottic carcinomas may invade this space with potential risks of reaching the subglottis or extending extralaryngeally. The frequency with which transglottic tumors invade the thyroid cartilage is well recognized. This may be because of the close proximity of the cartilage to the paraglottic space.

Knowledge of these connective tissue barriers and spaces is helpful for understanding the spread of tumors; however, many factors influence the spread of tumor and these membranes and spaces practically offer resistance only to earlier cancers and do not influence the spread of more extensive neoplasms.

**Cartilage and Vascular Factors.** The cartilage of the epiglottis has numerous pits, allowing potential transmission of tumor from the surface of the epiglottis through the pits and into the epiglottic space. Once the epiglottic space is invaded, the tumor may extend inferiorly into the anterior commissure area as well as anteriorly into the thyrohyoid membrane. The thyroid cartilage may be invaded by laryngeal tumors, particularly in areas of ossification and anteriorly at the junction of the anterior commissure tendon and the laryngeal cartilage.

Studies of laryngeal microcirculation have demonstrated the bilateral supply of the immediate subglottic area. This may help to explain the not uncommon occurrence of bilateral cervical metastasis seen with subglottic tumors.

**Lymphatic Drainage.** Supraglottic lymphatic drainage takes place through the thyrohyoid membrane, whereas the subglottic lymphatics pass laterally through the cricothyroid membrane into the cervical and paratracheal lymph nodes and anteriorly through

the cricothyroid membrane to the Delphian node. The glottic area may drain superiorly or inferiorly, depending on whether the lesion spreads superiorly or inferiorly within the paraglottic space.

### **Classification of Laryngeal Tumors**

The American Joint Committee defines carcinoma of the larynx as a tumor arising from the laryngeal tissue. This excludes tumors of the pyriform fossa, pharyngeal wall, vallecula, and base of the tongue. Anatomically, the larynx extends from the inferior margin of the cricoid cartilage to the superior tip of the epiglottis. The anterior surface of the epiglottis is included. The aryepiglottic folds, the arytenoid cartilage, and the interarytenoid space are also included. As stated previously, the larynx is divided into three regions - supraglottis, glottis, and subglottis. The glottis and the subglottis are divided by a horizontal line that passes through the apex of the ventricle. Histologically, the junction of the squamous epithelium of the vocal cord and the respiratory epithelium of the ventricle is the border. The lower boundary of the glottis is the horizontal plane 1 cm below the apex of the ventricle. The American Joint Committee places the boundary here; however, many consider 5 mm below the free margin to be the border. The subglottis extends from the lower boundary of the glottis to the inferior margin of the cricoid cartilage. The supraglottis includes the ventricular bands, the arytenoid cartilages, the epiglottis, including its lingual aspects, and the aryepiglottic folds. The glottis includes the true vocal cords, the anterior commissure, and the posterior commissure. The subglottic area is, as its name implies, the area from the lower border of the vocal cords to the cervical trachea.

Tumors are staged according to their involvement of the primary location (T) as well as the nodal involvement (N) and distant metastasis (M). A stage grouping includes characteristics of the primary lesion, nodal status, and distant metastases (TNM) (Table 1).

**Table 1. TNM Classification for Cancer of the Larynx**

#### **Primary Tumor (T)**

T <sub>x</sub>	Tumor that cannot be assessed by rules
T <sub>0</sub>	No evidence of primary tumor
T <sub>is</sub>	Carcinoma in situ

#### **Supraglottis**

T <sub>1</sub>	Tumor confined to region of origin with normal mobility
T <sub>2</sub>	Tumor involving adjacent supraglottic site or sites or glottis without fixation
T <sub>3</sub>	Tumor limited to larynx with fixation or extension, or both, to involve postericoid area, medial wall of pyriform sinus, or pre-epiglottic space
T <sub>4</sub>	Massive tumor extending beyond the larynx to involve oropharynx, soft tissues of neck, or destruction of thyroid cartilage



## **Glottis**

- T<sub>1</sub> Tumor confined to vocal cord or cords with normal mobility (including involvement of anterior or posterior commissures)
- T<sub>2</sub> Supraglottic or subglottic extension, or both, of tumor with normal or impaired cord mobility
- T<sub>3</sub> Tumor confined to larynx with vocal cord fixation
- T<sub>4</sub> Massive tumor with thyroid cartilage destruction or extension, or both, beyond confines of larynx

## **Supraglottis**

- T<sub>1</sub> Tumor confined to subglottic region
- T<sub>2</sub> Tumor extension to vocal cords with normal or impaired vocal cord mobility
- T<sub>3</sub> Tumor confined to larynx with vocal cord fixation
- T<sub>4</sub> Massive tumor with cartilage destruction, extension beyond confines of larynx, or both

## **Nodal Involvement (N)**

- N<sub>x</sub> Nodes that cannot be assessed
- N<sub>0</sub> No clinically positive nodes
- N<sub>1</sub> Single clinically positive homolateral node less than 3 cm in diameter
- N<sub>2</sub> Single clinically positive homolateral node 3 to 6 cm in diameter or multiple clinically positive homolateral nodes, none greater than 6 cm in diameter
- N<sub>2a</sub> Single clinically positive homolateral node 3 to 6 cm in diameter
- N<sub>2b</sub> Multiple clinically positive homolateral nodes, none greater than 6 cm in diameter
- N<sub>3</sub> Massive homolateral node or nodes, bilateral nodes, or contralateral node or nodes
- N<sub>3a</sub> Clinically positive homolateral node or nodes, none greater than 6 cm in diameter
- N<sub>3b</sub> Bilateral clinically positive nodes (in this situation, each side of the neck should be staged separately: that is, N<sub>3b</sub>: right, N<sub>2a</sub>: left, N<sub>1</sub>)
- N<sub>3c</sub> Contralateral clinically positive node or nodes only

## **Distant Metastasis (M)**

- M<sub>x</sub> Not assessed
- N<sub>0</sub> No (known) distant metastasis
- N<sub>1</sub> Distant metastasis present (specify sites according to the following notations: PUL, Pulmonary; OSS, osseous; HEP, hepatic; BRA, brain; LYM, lymphatic nodes; MAR, bone marrow; PLE, pleura; SKI, skin; EYE, eye; OTH, other)

Some authors include the *differentiation* of the tumor as part of the staging process. It has long been recognized that the histologic grade of an epithelial tumor may have a significant influence on the eventual prognosis. In general, glottic carcinomas are well differentiated and keratinizing, but they tend to have an infiltrative growth pattern. In contrast,

supraglottic carcinomas are often rather bulky, poorly differentiated, nonkeratinizing tumors that invade on a broad front with "pushing" margins. Subglottic carcinomas tend to be poorly differentiated with an infiltrative growth pattern, features that are held in common with transglottic carcinomas. A number of features have been analyzed to determine the presence or lack of metastasis to the cervical lymph nodes. In addition to the degree of differentiation of the tumor, the major determinants are the size of the tumor and its location. Metastasis is more common if the primary neoplasm is greater than 2 cm in diameter. Glottic tumors confined to the glottic region rarely produces metastasis.

### **Supraglottic Carcinoma**

**Clinicopathologic Behavior.** The supraglottic lymphatics drain through the thyrohyoid space in association with the superior laryngeal vessels. The concept of supraglottic laryngectomy and neck dissection encompasses the principle of resection of the primary lesion in continuity with the routes of lymphatic drainage, as well as the cervical lymph nodes.

The spread is facilitated by the numerous mucous glands within the supraglottic area. The epiglottic cartilage may also facilitate tumor spread through the numerous pits within this cartilage into the pre-epiglottic space. The behavior of supraglottic carcinoma is influenced by the site of origin of the tumor. Lesions arising on the laryngeal surface of the epiglottis may spread superficially and laterally to involve most of the epiglottic surface. These tumors frequently invade the epiglottic cartilage, extending through the pits into the pre-epiglottic space. These openings are normally filled with mucous glands. The pre-epiglottic space may also be invaded by spread of tumor around the lateral edge of the epiglottis. Once the tumors involve the pre-epiglottic space, they may spread inferiorly, extending to the epiglottic petiole and the anterior commissure.

Supraglottic cancers tend to remain confined above the ventricle. Although quite large, the tumors may be confined to the supraglottic area anatomically, allowing a supraglottic laryngectomy to encompass the lesion. The hyoepiglottic ligament may also serve as a barrier to tumor spread from the epiglottis. Lesions arising on the false vocal cords may extend superiorly to the epiglottis, posteriorly to the aryepiglottic folds and arytenoid cartilages, or anteriorly to the anterior commissure area. As the lesion spreads deeply, the paraglottic space is invaded and there is little limitation to superior or inferior spread. The anterior commissure tendon serves as a barrier to inferior spread of supraglottic tumors; however, if this tendon becomes involved with tumor it may then serve as a route of invasion to the thyroid cartilage. If thyroid cartilage is invaded from a supraglottic cancer, it is most likely to occur at the anterior commissure.

Although primary *tumors of the ventricle* are rare, they may be especially deceptive because extensive paraglottic spread involving the supraglottic and glottic portions of the larynx may have already occurred by the time of initial examination. A surface lesion may not be visible, and only a subtle fullness may alert the clinician to the extensive nature of the underlying disease. Because these ventricular lesions invade the paraglottic space early, they rapidly become transglottic, invade cartilage, and spread to extralaryngeal areas. These tumors are treacherous. Frequently there are no visible surface lesions. Symptoms may be only minimal with slight voice changes over months. Even if the physician is concerned enough to perform direct laryngoscopy, the biopsy specimen may be normal. In some cases, these

lesions may be diagnosed only after repeated laryngoscopies and deep biopsies by incision of the bulging area.

Some investigators have reported that most supraglottic carcinomas remain limited to the supraglottic area, whereas others have reported a significant percentage of these tumors with extension to the glottis, vallecula, and pyriform fossa. Once the lesions cross the ventricle inferiorly, either by mucosal spread or by paraglottic space extension, they are termed *transglottic tumors*. Transglottic lesions demonstrate high propensity to invade cartilage and to penetrate the cricothyroid membrane. Vocal cord fixation may occur by direct surface extension of the lesion in the area of the arytenoid cartilage or by deep invasion. The finding of vocal cord fixation usually indicates an advanced tumor with extension within the paraglottic space. Deep invasion of this space may produce vocal cord fixation with minimal mucosal findings.

The growth pattern at the periphery of the tumor may be distinctive. Two recognized growth patterns are pushing and infiltrating peripheral margins. Pushing margins are found more often in supraglottic tumors than in other laryngeal cancers. These cancers are usually exophytic, more differentiated, and less-invasive than lesions with infiltrating margins. Some authors believe that exophytic supraglottic lesions tend to remain confined above the ventricle and are less likely to invade the anterior commissure and thyroid cartilage. Lesions with infiltrating margins are more likely to be ulcerative, to extend inferior across the anterior commissure, and to invade the anterior thyroid cartilage.

**Clinical Manifestations.** The voice may have a muffled quality rather than true hoarseness, which is more typical of glottic lesions. Hoarseness may result from lesions that have extended onto the true vocal cords or it may be produced by a lesion of a false vocal cord overhanging a glottic area. Lesions may be relatively asymptomatic until they extend to the hypopharynx, vallecula, or base of the tongue. A large tumor mass may stimulate a persistent chronic cough or stridor. Pain in the ear with a normal ear examination may be the presenting symptom with supraglottic lesions. Some patients with asymptomatic primary lesions may present with a metastatic lymph node as the initial finding.

**Lymph Node Metastasis.** The incidence of cervical metastasis generally ranges from 25 to 50 per cent, with 30 to 50 per cent being reported as clinically palpable and 20 to 40 per cent of the necks with no clinically apparent disease ( $N_0$ ) having occult metastasis. Occult lymphatic metastasis is higher for tumors of the marginal supraglottis when compared with lesions of the central supraglottis. Metastatic rates for  $T_1$  lesions range from 15 to 40 per cent; for  $T_2$  lesions, they are 35 to 42 per cent; for  $T_3$  lesions, they are 50 to 65 per cent; and for  $T_4$  lesions, the metastatic rate is 65 per cent.

**Therapy and Management.**  $T_1$ ,  $T_2$ , and  $N_0$  disease is associated with excellent cure rates by either surgery or radiation alone in the range of 75 per cent or more. Thus, there appears to be little justification for combination therapy in early disease. The choice between surgery and radiation for the treatment of the primary lesion will depend upon the philosophy of those involved. A consideration to be remembered is the probability that a second or third primary tumor may develop in the aerodigestive tract in the event that control of the first primary site is achieved. The incidence of second primary tumor development in a typical patient with cancer of the aerodigestive tract is high (20 to 30 per cent). Some clinicians

consider surgical resection to be more appropriate in these early lesions, especially in younger patients, and they reserve radiation therapy for the possibility of treatment of a second primary tumor if one develops. Stage IV cancers (T<sub>4</sub> with or without cervical metastasis) are associated with a very poor prognosis, and treatment will usually involve total laryngectomy followed by postoperative radiation therapy consisting of 6000 rad. If these patients are treated with full-course radiation for cure, recurrences are common, necessitating a salvage total laryngectomy at a later date. The salvage surgery in a fully irradiated field is associated with markedly increased morbidity and poor function in terms of swallowing and verbal communication.

In stage II and stage III disease, the best treatment is not as easy to identify as in stages I and IV. The outcome of the various forms of treatment appears to be controlled by factors that are more subtle than simply the various treatment combinations used. The status of the individual patient's immune system may determine the final outcome provided that the cancer has been adequately treated by surgery or irradiation, or both. In patients with similar stages of disease, it is impossible to forecast which patients will do well and which ones will have recurrences. If combination therapy is selected, the increase in morbidity must be considered. The possibility of improving survival must be balanced against the hazards of the complications of combined irradiation and surgery. With the use of preoperative radiation therapy in the past, these complications were considerable. At present, the use of postoperative radiation therapy seems to be justified because the complication rate is low and acceptable. It is acceptable to treat stage II or stage III supraglottic cancers with curative radiation, reserving surgery for failures, or to treat with a supraglottic laryngectomy if the lesion is surgically amenable to the procedure, followed by postoperative radiation therapy.

**Radiation Therapy.** Radiation therapy produces the most predictable control in small exophytic lesions with no palpable neck nodes and in nonfixed larger tumors in the suprahoid epiglottis. Survival decreases with the presence of regional metastasis, tumors of the epilarynx (marginal zone), and larger primary tumors. Wang and co-workers reported 3-year cure rates of 74 per cent for T<sub>1</sub> and T<sub>2</sub> lesions and 23 per cent for T<sub>3</sub> and T<sub>4</sub> supraglottic cancers. Cachin reported a 43 per cent cure rate for marginal lesions, compared with 60 per cent for cancers located in the remainder of the supraglottic larynx.

Survival rates decrease for larger tumors that have produced vocal cord fixation, destroyed cartilage, or shown involvement of the pharyngeal wall, vallecula, or base of the tongue. Combinations of radiation and surgery have been used in a variety of modes, including radiation with intent to cure followed by a surgical salvage if recurrence develops, planned preoperative radiation, and planned postoperative radiation. Postoperative radiation is recommended following surgery if there is evidence of tumor extension near the surgical margins, if there are multiple metastatic lymph nodes, or if there is evidence of rupture of disease through the lymph node capsule. Generally, radiation therapy will begin after the patient has healed - in approximately 3 to 6 weeks. Most recurrences after radiation therapy alone occur at the primary site.

**Management of Neck Disease.** This can differ for patients with N<sub>0</sub> necks and for those with clinically apparent lesions in the neck. The latter patients may be treated with either surgery or radiation or with a combination of these modalities. In patients with N<sub>1</sub> or N<sub>2a</sub> disease, neck dissection is generally considered adequate treatment. Individual surgical

judgment should be made concerning the type of neck dissection. This will vary according to the disease present. In modified or functional neck dissections, the lymphatics and lymph node tissue are removed, whereas the sternocleidomastoid muscle, internal jugular vein, and spinal accessory nerve are preserved. Various combinations of neck dissections that preserve specific structures can be performed, depending on the disease and the skills of the surgeon. Indications for using radiation therapy initially include radiation for cure of the primary lesion or for treatment of cervical metastasis that is fixed or questionably resectable. Radiation therapy can be used postoperatively when the initial radical neck dissection demonstrates tumor invasion through the capsule of the node, when there are multiple metastatic nodes, and when there is a direct invasion of vessels, nerves, or muscles. Large fixed nodes (greater than 5 cm) may be treated with radiation initially in the hope that the cervical metastasis will shrink and become more resectable. Neck dissection is indicated for treating N<sub>1</sub> neck disease that persists following therapeutic radiation.

There is controversy about the effectiveness of elective neck irradiation for necks with no clinically apparent disease in patients who have primary supraglottic cancers. The question of whether to irradiate the neck depends on the rate of occult metastasis. The practice of electively irradiating all patients with N<sub>0</sub> necks may result in the unnecessary irradiation of those patients without cancer in the lymph nodes and exposing the patient to the risk and expense of unnecessary treatment. The rate of occult neck metastasis increases as one proceeds from the central portion of the larynx outward. The reported incidence of patients with N<sub>0</sub> necks having occult metastasis ranges from 20 to 40 per cent. Marks and associates reported that cancers of the glottis and central supraglottis were associated with the lowest percentage of occult metastasis (14 to 16 per cent). The rate of occult disease was higher for cancers of the glossoepiglottis and the marginal supraglottis (20 to 38 per cent) and highest for cancers of the pyriform fossa (47 per cent).

Adjuvant irradiation to the neck following surgical resection of the primary tumor and ipsilateral neck dissection should be reserved for those who have the greatest risk of tumor recurrence in the neck. This risk is greatest for patients with cancer in the lymph nodes and least for those with no cancer in the lymph nodes. Only those with no cancer in the lymph nodes have a risk of nodal recurrence low enough to justify observation in the neck. Conglomerate analysis of the value of elective neck irradiation for a variety of head and neck sites may be misleading, because the irradiation may be more effective for some sites than for others. It has been observed that elective neck irradiation is more effective for cancers of the oral cavity than for cancers of the larynx and pharynx, and many believe that success of this modality for occult disease must be evaluated separately for each head and neck site.

**Results of Treatment.** The cure rates for T<sub>1</sub> and T<sub>2</sub> supraglottic lesions are about the same for surgery or radiation, about 85 per cent. With larger T<sub>3</sub> and T<sub>4</sub> lesions, surgery plays an increasing role. Supraglottic or total laryngectomy and planned postoperative radiation therapy control the primary tumor and lymph nodes in about 65 per cent of cases. A recent study of T<sub>2</sub> and T<sub>3</sub> supraglottic carcinomas gave control rates of 89 per cent for supraglottic resection, 78 per cent for total laryngectomy, and 70 per cent for radiation. The reasons for failure within the radiation group were gross infiltrative lesions, base of tongue involvement, and large tumor bulk. This suggested that surgery might be more appropriate for these lesions.

**Surgery.** The concept of conservation surgery of the supraglottic area is based on the limitation of early tumors to the supraglottic area and on the knowledge that these tumors metastasize through the thyrohyoid membrane into the upper cervical nodes. This has allowed for the development of the en bloc concept of limited supraglottic resection including the cervical lymph drainage pathways and the cervical nodes. There are various modifications of the supraglottic laryngectomy depending on the stage of the disease.

**Transoral Subtotal Supraglottic Laryngectomy with Laser.** This technique may be used for small T<sub>1</sub> supraglottic cancers involving the epiglottis with no extension to the pre-epiglottic space. The surgery is contraindicated if tumor involves the petiole of the epiglottis or free margin of the false vocal cord. There should not be any palpable cervical node metastasis and the supraglottic tumor should not be more than 2 mm outside the larynx on the aryepiglottic fold. This surgery is performed under general anesthesia, and adequate laser protection of the anesthesia intubation equipment is performed. A laser beam is directed across the vallecula and inferiorly down to the level of the petiole. The laser incision is carried across the free margin of the false vocal cord bilaterally. The resection is completed. The endotracheal tube is usually left in place until the following morning, and oral alimentation is begun on the fifth to seventh day. To date, there are no large series with data on long-term follow-up using this technique.

**Horizontal Subtotal Supraglottic Laryngectomy Without Arytenoidectomy.** Indications for this surgery include T<sub>1</sub> to T<sub>3</sub> and selected T<sub>4</sub> supraglottic cancers. Contraindications include fixation of the true vocal cords from the supraglottic primary tumor, thyroid cartilage invasion, and tumor involvement of the arytenoid cartilage, laryngeal ventricle, apex of the pyriform fossa, interarytenoid area, soft tissue of the neck, anterior commissure, and base of the tongue.

The advantage of this technique is that it is a single-stage resection with excellent cure rates for early lesions with satisfactory maintenance of laryngeal function including voice and deglutition. Within the larynx, the resection margins may be close to the tumor; the valleculae and base of the tongue margins must be wider. Subtotal supraglottic laryngectomy may be indicated for recurrent or persistent supraglottic cancers following failure of radiation therapy.

**Technique.** If a neck dissection is performed, it is based at the thyrohyoid membrane. Following general anesthesia and tracheotomy, subplatysmal muscle skin flaps are elevated. The strap muscles are transected along the superior border of the thyroid cartilage, resulting in exposure of the perichondrium. An incision is carried through the perichondrium on the superior aspect of the thyroid cartilage, and inferiorly based muscle and perichondrium flaps are elevated. Care must be taken to preserve the perichondrium because it serves as a closure to the base of the tongue following the supraglottic resection.

Cartilage cuts are made at the level of the laryngeal ventricle just superior to the anterior commissure anteriorly. In general, the anterior commissure is about halfway between the thyroid notch and the inferior margin. On the involved side, a cut is made from the anterior commissure area posteriorly to bisect the posterior edge of the thyroid ala. On the uninvolved side, the cut is extended for a few millimeters posteriorly and then directed superiorly and laterally to transect the superior margin of the thyroid ala.

The suprahyoid muscles are incised along the superior border of the hyoid bone from the greater cornu on the involved side to the lesser cornu on the uninvolved side. Cutting the hyoid bone at the lesser cornu on the uninvolved side ensures preservation of the pre-epiglottic space. If the lesion does not involve the vallecula, the mucosa underlying the superior hyoid cornu is pushed medially to preserve that area. The mucosa underlying the superior cornu of the thyroid ala is mobilized to preserve the pyriform fossa mucosa. If the pharynx is to be entered through the vallecula, the incision is performed just superior to the hyoid bone and is extended posteriorly. If the tip of the epiglottis or vallecula is involved with tumor, entry is made via the contralateral pyriform fossa. After the pharynx has been entered, the epiglottis is grasped and scissors are used to extend the incision inferiorly along the lateral aspect of the epiglottis on the less involved side. Under direct vision, the incision is extended down the lateral aspect of the epiglottis on the involved side, and care is taken to ensure an adequate margin. A single hook is placed on the aryepiglottic fold on the involved side near the arytenoid cartilage, and a clamp is used to push the contralateral arytenoid cartilage laterally, providing visualization of the tumor, arytenoid cartilages, and glottic area. The aryepiglottic fold on the contralateral side is transected superior to the arytenoid cartilage by aiming the cut toward the posterior aspect of the ventricle, connecting it with the lateral cartilage cut. Once the ventricle has been entered, the scissors must be directed in a much more anterior plane, thus avoiding transection of the true vocal cord. The incision is extended anteriorly through the ventricle just superior to the anterior commissure, connecting the soft tissue cuts with the external cartilage cuts. This allows the supraglottic larynx to be rotated toward the tumor side, resulting in excellent visualization of the supraglottic lesion in the area to be resected.

The resection continues on the involved side by extending the incision in the ventricle posteriorly, and the aryepiglottic fold is transected as on the less involved side. This incision is carried just superior and anterior to the arytenoid cartilage and is joined with the previous incision, completing the resection, and the specimen is removed.

A cricopharyngeal myotomy may be performed to facilitate postoperative swallowing. It is performed posteriorly to prevent injury to the recurrent laryngeal nerve.

The pharyngotomy closure is performed with interrupted 3-0 Vicryl sutures. Sutures are placed from the base of the tongue to the perichondrial flap of the thyroid cartilage. Closure involves suturing the thyroid perichondrium to the raw surface of the tongue rather than to the mucosal edge of the tongue base. This creates a small ledge on the base of the tongue to overlie the glottic area, thus allowing a shunting of the bolus of the food posteriorly into the pharynx. The neck should be partially flexed during the closure to relieve the tension from the suture line. A second layer of Vicryl sutures is placed from the base of the tongue area to the fascia of the strap muscles overlying the thyroid cartilage remnant.

An alternate technique involves a hyoid strap muscle flap formed by transecting the suprahyoid muscles and rotating the hyoid bone inferiorly. The dissection continues in the plane just posterior to the infrahyoid musculature. By definition, this transects the anterior aspect of the pre-epiglottic space; thus, this technique is contraindicated in supraglottic tumors that involve the pre-epiglottic space. The potential advantages of this technique are a more secure closure and improved early postoperative swallowing.

**Horizontal Subtotal Supraglottic Laryngectomy with Arytenoidectomy.** This procedure is indicated for selective supraglottic cancers with extension onto the body of the arytenoid cartilage. It is contraindicated in patients who have complete paralysis of the true vocal cord. Other contraindications include invasion of the thyroid cartilage with tumor; involvement of the apex of the pyriform fossa, postcricoid area, and interarytenoid area; and invasion of the soft tissue of the neck.

**Technique.** The technique is similar to a standard supraglottic resection except that the arytenoid cartilage is included in the resection. As the surgeon approaches the arytenoid cartilage on the involved side, the interarytenoid mucosa resection margin is outlined with a knife blade, and the musculature is severed with scissors. The cricoarytenoid joint is dislocated and the arytenoid cartilage is removed en bloc with the supraglottic resection. The vocal cord remnant on the side of the arytenoid resection must be medialized with a suture or it may scar laterally, allowing posterior commissure glottic incompetence with the resultant complications of aspiration and pneumonia. This technique is performed by suturing the remnant vocal cord to the midline of the superior border of the cricoid cartilage using a 2-0 nylon suture. If the length of the vocal cord remnant is insufficient, the resected area may be reconstructed by cartilage transplant. The area is covered by a mucosal flap from the pyriform fossa. It may not be necessary to remove the entire arytenoid cartilage, and often only the superior aspect is resected.

**Horizontal Subtotal Supraglottic Laryngectomy with Ipsilateral True Vocal Cord Resection (Three-quarter Laryngectomy).** A combination of supraglottic resection and hemilaryngectomy (three-quarter laryngectomy), this operation is indicated for transglottic carcinoma that crosses the ventricle involving both the false and true vocal cords. The tumor may be supraglottic in origin, with extension inferiorly into the paraglottic space to involve the true vocal cord, or it may have originated on the true vocal cord or ventricle and extended superiorly. These tumors have a high rate of paraglottic space involvement, cartilage invasion, and cervical lymph node metastasis. During a standard supraglottic laryngectomy, as the inferior cuts are made it may be noted that there is extension of tumor submucosally to the paraglottic area of the true vocal cord. If the procedure is not converted to a total laryngectomy or tree-quarter laryngectomy, tumor seeding of the inferior margin will result. Generally, this procedure is not recommended for patients who have (1) vocal cord fixation, (2) subglottic tumor extension, or (3) evidence of cartilage invasion, or (4) who have undergone prior radiotherapy. These extended procedures are more likely to result in postoperative functional problems and are indicated only in selected cases. All of these procedures requires reconstruction of the resected ipsilateral true vocal cord for maintenance of long-term glottic competency.

**Reconstruction with Cartilage Fold-over.** This technique is basically the same as for the standard supraglottic laryngectomy except for the modification of laryngeal cartilage cuts, inclusion of the true vocal cord with the resection, and vocal cord reconstruction. This procedure is planned preoperatively and is usually indicated only for those selected supraglottic tumors with superficial extension onto the mobile ipsilateral true vocal cord. An extra inferior cartilage cut is made on the thyroid cartilage; this cartilage segment is fractured medially and attached inferiorly to the cricoid cartilage in the midline. A mucosal flap from the pyriform area is rotated to cover this cartilage, and the supraglottic resection is closed in a standard fashion. It is to be emphasized that indications for this technique are very limited,



and few cases are amenable to this procedure.

**Reconstruction with Muscle Flap.** The cartilage cuts for this procedure are modified from the standard supraglottic laryngectomy by removal of the entire thyroid lamina on the involved (ipsilateral) side. The resection is similar to a standard supraglottic laryngectomy except for the vocal cord excision. The resected ipsilateral vocal cord is reconstructed by means of a large, inferiorly based flap from the sternohyoid muscle. This is sutured posteriorly to the cricoid cartilage as close as possible to the remaining contralateral vocal cord. A flap of pyriform fossa and postcricoid mucosa is used to cover the muscle flap. The remainder of the closure is the same as in a standard supraglottic laryngectomy. A potential problem with this reconstruction is that there may be reabsorption of the muscle tissue resulting in glottic incompetency that produces recurrent aspiration problems.

**Reconstruction with Contralateral Superior Cornu of the Thyroid Cartilage.** In this technique, the vocal cord and arytenoid area are reconstructed using the contralateral superior thyroid cornu covered by its perichondrium and based on the inferior and middle pharyngeal constrictor muscles. Mucosa from the pyriform fossa and hypopharyngeal areas is advanced to cover the muscle cartilage pedicle. This technique is obviously dependent on the sufficient length of the opposite superior cornu. It has not been widely used and therefore is not recommended except under unusual circumstances.

**Reconstruction Using Posterior Thyroid Cartilage.** This procedure is limited to patients having supraglottic tumors 2 cm in diameter or less, with no involvement of the anterior commissure, no evidence of vocal cord fixation, no subglottic extension or cartilage invasion, and no history of prior radiation therapy. This form of resection ensures removal of tumor in the false vocal cord area, the pre-epiglottic space, and the paraglottic space. Since this technique leaves a portion of the ipsilateral thyroid cartilage, it should not be used when tumors extend behind the posterior vertical cartilage cut. The cartilage cuts are made as demonstrated. The posterior thyroid cartilage remnant is rotated and sutured medially to reconstruct the resected cord. A pyriform fossa mucosal flap is rotated to cover the cartilage graft. This technique has the advantage of using a large piece of cartilage with attached muscle, ensuring a potentially more stable reconstructed vocal cord area.

**Extended Horizontal Subtotal Supraglottic Laryngectomy.** This technique is indicated for (1) tumors of the lingual surface of the epiglottis that have spread into the vallecula or for primary tumors of the vallecula, (2) supraglottic tumors that have extended through the epiglottic cartilage to involve the vallecula, (3) tumors of the supraglottic area that have spread to involve posterior portions of the base of the tongue, and (4) primary base of the tongue lesions that have spread inferiorly to involve the supraglottic portions of the larynx. It is contraindicated if there is invasion of the thyroid cartilage or extensive deep involvement of the base of the tongue.

Of all the partial laryngectomy techniques, the combination of the supraglottic resection with a base of the tongue resection is most commonly associated with persistent long-term swallowing difficulties. The surgery is similar to the standard supraglottic resection, except for the entry into the pharynx because of the tumor in the vallecula. The entry can be performed either in the uninvolved pyriform fossa or directly at the anterior commissure area. The resection is extended superiorly to include the primary tumor of the supraglottis as well

as the vallecula and base of the tongue area. The resection should not be extended anteriorly to the circumvallate papillae. Generally, if more than half of the base of the tongue is resected, permanent deglutition problems will result. The surgical margin at the base of the tongue should be at least 2 cm by palpation. The contralateral lingual artery and cranial nerve XII should be preserved. For smaller base of the tongue resections, the defect can be closed primarily by suturing the raw surface of the remnant of the base of the tongue to the thyroid perichondrium. However, for larger resections, some of flap reconstruction is mandatory. Options include the pectoralis major, trapezius myocutaneous, forehead, or deltopectoral flap. Elderly or debilitated patients with chronic lung disease will not tolerate this extended type of surgery and will require total laryngectomy to prevent aspiration.

**Postoperative Management of Supraglottic Resections.** Patients receiving supraglottic laryngectomies are usually placed in an intensive care unit for at least several days. Suction drains are routinely used until the drainage is minimal. The nasogastric tube is attached to suction drainage for the first 48 hours, and tube feedings are usually begun on the third postoperative day if there are signs of intestinal motility. Patients with tracheotomies are given routine tracheostomy care with frequent suctioning. The cuff on the tracheotomy tube is left inflated for several hours postoperatively and is then deflated to avoid pressure necrosis in the tracheal area. In most patients who have had supraglottic resections, the airway is adequate at 10 to 14 days, and decannulation is begun. The size of the tube is decreased and the tube is plugged. If this is tolerated, the tracheostomy tube is removed the following day. Swallowing is usually not begun until the tracheal stoma is closed and healed so that adequate subglottic pressures may be present to assist in the swallowing process.

Swallowing training is done with the help of a dietician, nurse, and deglutition therapist, as well as the surgeon. The feeding tube is removed prior to attempted swallowing. Leaving it in place aggravates the learning of deglutition. Diet usually consists of pureed foods and thick liquids such as nectars and milk. Sticky foods and clear liquids are avoided except for clear carbonated beverages. Clear liquids will commonly pass through the glottic area before the patient is able to sense that they are in the pharynx. Patients are instructed to chew the food and to inhale and hold the breath while they swallow and strain simultaneously to close the glottic area to increase subglottic pressure. After swallowing and before inhalation, they must cough to clear the vocal cord surface of any material that may be present. They should then swallow again, exhale partially, and then inhale. If aspiration is significant, deglutition training must be temporarily suspended. If swallowing is a problem for more than 4 to 7 days, or if aspiration or other complications develop, the nasogastric tube is replaced, and the patient commonly is sent home for stabilization and recuperation. If the tube is required for more than 6 to 8 weeks, a feeding gastrostomy is considered.

**Complications of Partial Laryngectomy.** These include delayed decannulation, fistula formation, impaired swallowing, chondritis, chronic aspiration, and laryngeal stenosis. These complications are uncommon after standard hemilaryngectomy, which leaves the arytenoid cartilage intact, but they become more common with extended procedures that remove the arytenoid and cricoid cartilages and portions of both vocal cords. Restoration of the anteroposterior diameter of the larynx and posterior glottic competence is mandatory with such procedures. Predisposing factors to postoperative sequelae are prior radiation therapy, debilitation, and systemic medical disease. Patients with chronic pulmonary disease may not tolerate the continuous low grade aspiration that commonly occurs in the immediate

postsurgical period, a factor that should be carefully considered in case selection. The following sections discuss other complications.

**Wound Breakdown.** This is uncommon but may occur with high doses of radiation therapy. Careful planning of surgical flaps should include a wide base and avoidance of the trifurcation point over the carotid artery.

**Perichondritis and Chondritis.** When cartilage is transected and exposed, the potential for infection exists, especially if the cartilage is exposed to saliva. When this condition exists, prophylactic antibiotics are given. The incidence of perichondritis is increased in patients in whom primary curative radiation has failed and in those who have received postoperative radiation therapy. Patients with perichondritis usually experience erythema of the skin overlying the infected cartilage within the first 1 to 2 postoperative weeks. They become febrile and have a characteristic and distinct odor. Deglutition should be discontinued and the feeding tube replaced. High doses of intravenous antibiotics should be given and the wound drained if appropriate. Portions of the cartilage may be debrided; functional strictures may result in some patients, and in unusual severe cases complete total laryngectomy may be required.

**Fistulas.** The incidence of pharyngocutaneous fistulas is associated with the size of the lesion, the dose of preoperative radiation, the presence of systemic disease, operative techniques, and failure of prior treatment modalities. The incidence of fistulas has generally decreased, since most surgeons are now using postoperative rather than preoperative radiation. Also, the increased use of myocutaneous and microvascular flaps for reconstruction of the larger defects has helped to decrease the incidence of fistulas.

Fistulas usually present as infection of the skin overlying the lateral suture of the neopharynx. This area becomes swollen, and if suspicious it should be aspirated with a large-bore needle. If a fistula is diagnosed, it should be exteriorized immediately to prevent elevation of the skin flap with potential loss of that tissue. The fistula should be redirected away from the carotid artery. A small drain is placed for several days, and topical care is given. Usually, unless the fistula is quite large, granulation tissue forms around the edges, and many small fistulas will gradually heal. Larger fistulas that fail to heal may require some type of reconstructive technique.

**Dysphagia and Aspiration.** Deglutition problems causing dysphagia and aspiration are the most common sequelae after supraglottic laryngectomy. These patients are prone to aspiration because the protective mechanism of the supraglottic structures, including the epiglottis and false vocal cords, have been removed. If the arytenoid cartilage of a portion of the vocal cord is included in the resection, the rate for aspiration increases significantly. In normal swallowing, the food is prevented from entering the upper airway by depression of the epiglottis over the laryngeal inlet, the closure of the true vocal cords, and the elevation of the larynx to oppose the base of the tongue. Supraglottic laryngectomy interferes with one or all of these variables. The single most important factor in the success or failure of deglutition is the sacrifice of an arytenoid cartilage. Cricopharyngeal myotomies have been proposed by some surgeons in order to improve postoperative swallowing, but no study has demonstrated that there is a consistent improvement in deglutition in patients who have had this procedure. Suspension of the larynx has been recommended to decrease postoperative

aspiration. In this procedure, the thyroid cartilage remnant is fixed to the mentum of the mandible with heavy suture material. This technique lifts the larynx superiorly and tilts it posteriorly. This may improve swallowing but there have been no reports of dramatic improvement with the use of this technique. The one procedure that should be routinely performed to assist deglutition is fixation of the vocal cord in the midline if part of the arytenoid cartilage has been included in the supraglottic resection. With the removal of the entire arytenoid cartilage, the posterior glottic area is incompetent during adduction of the vocal cords, and aspiration will consistently result if the vocal cord is not fixed in the midline or reconstructed.

**Airway Obstruction.** Of all the partial laryngeal procedures, supraglottic laryngectomy with preservation of the arytenoid cartilage generally results in the least amount of changes in voice. Since the vocal cords are undisturbed in a standard supraglottic laryngectomy, the speech is usually excellent.

### Glottic Carcinoma

Carcinomas of the glottic region are the most common type of laryngeal carcinoma (50 to 70 per cent of cases). Symptoms appear early, since these lesions involve interference with voice production by the true vocal cord, which leads to earlier diagnosis. Occurrence rates according to staging are T<sub>1</sub>, 50 to 65 per cent; T<sub>2</sub>, 15 to 25 per cent; T<sub>3</sub>, 15 to 20 per cent; and T<sub>4</sub>, about 5 per cent. Usually these lesions are well differentiated and slow growing and extend in predictable ways. They occur most commonly on the anterior half of the true vocal cord. The margins of the true vocal cord are devoid of deep lymphatics; therefore, early tumors in this area are well localized, highly curable, and have virtually no incidence of regional metastasis. These tumors first invade Reinke's space, a potential space between the vocal ligament and the subepithelial layer of the margin of the true vocal cord. These lesions can extend anteriorly or posteriorly to the commissures and the opposite true vocal cord. As they infiltrate deeply, they may involve the vocalis muscle and the vocal ligament and extend to the ventricle and supraglottic airway or inferiorly into the subglottis. Both of these routes produce T<sub>2</sub> lesions. Posteriorly, a glottic tumor involving the vocal process may spread along the medial aspect of the arytenoid cartilage, involving the cricoarytenoid joint and escaping into the lateral paraglottic tissue. If there is normal vocal cord mobility, a superficial lesion is suggested. Deeper invasion of the paraglottic space or intrinsic laryngeal muscles produces impaired mobility.

T<sub>3</sub> lesions are defined by fixation of the vocal cord. This occurs by various mechanisms. The most common one is replacement of the thyroarytenoid muscle by tumor. It is not uncommon for larger lesions that are associated with vocal cord fixation to invade the thyroid cartilage. Invasion of the cricoarytenoid joint may also produce vocal cord fixation. The mobility of the true vocal cords is important to document because this implies deeper invasion with worse prognosis and implies different treatment from that for those lesions in which the vocal cords remain mobile. Once the tumor enters the paraglottic space, it is allowed to spread superiorly into the supraglottic area, as well as inferiorly to the subglottic area, and an easy access is afforded to the cricothyroid membrane, allowing escape of the tumor from the confines of the larynx. Tumors of the paraglottic space are in close proximity to the medial surface of the thyroid cartilage, allowing for invasion of this structure. When there is invasion of the laryngeal framework, the ossified portions of the cartilage

present the least resistance to destruction by the tumor. Tumors that have invaded the laryngeal cartilage or have escaped from the confines of the larynx are staged as T<sub>4</sub>.

**Transglottic Tumors.** Although transglottic lesions are not a separate tumor classification, this term is used frequently by clinicians. Transglottic tumors by definition involve the paraglottic space and therefore are associated with a high incidence of laryngeal cartilage invasion, extralaryngeal spread and regional cervical metastasis. Although transglottic tumors may sometimes be visualized and diagnosed from their surface appearance and from limitation of motion or loss of motion of the true vocal cords, in some cases tumors may be transglottic and not have that appearance on surface examination. Paraglottic space invasion may not be obvious by either direct laryngoscopy or CT examination, although this technique is helpful. Errors in diagnosing deep invasion may occur especially in earlier lesions. This had been documented by comparing staging with histopathologic examination.

**Subglottic Tumors.** Primary subglottic tumors are rare, composing about 1 to 5 per cent of laryngeal malignancies. Many of these lesions are large at the time of initial diagnosis because they remain clinically silent until vocal change is produced secondary to either vocal cord fixation or impending airway obstruction. More than 80 per cent are T<sub>3</sub> or T<sub>4</sub> tumors at the time of initial diagnosis, with less than 20 per cent being T<sub>1</sub> or T<sub>2</sub>. Although primary subglottic tumors are rare, extension of glottic tumors into the subglottic area is not unusual. Subglottic tumors are associated with a high incidence of vocal cord fixation because of invasion of the thyroarytenoid muscle as well as cartilage invasion. The lymphatics of the subglottic area drain into the cricothyroid region and from there they spread into the paratracheal nodes. The incidence of nodal invasion is high, and therefore treatment planning should include the primary and regional lymphatic drainage areas.

**Regional Node Metastasis.** The true vocal cord has few lymphatic pathways, especially from the superficial mucosa. With deeper invasion, especially of the paraglottic space, lymphatic spread occurs through the cricothyroid membrane area into the paratracheal nodes, and with superior extension of the tumor into the paraglottic space, lymphatic drainage may be through the thyrohyoid membrane and into the upper cervical nodes. The overall incidence of the node metastasis associated with glottic tumors is less than 10 per cent. The vast majority of metastasis occurs in T<sub>3</sub> and T<sub>4</sub> lesions, which would be expected from their paraglottic space involvement. The metastatic rate increases if the tumor invades the anterior commissure, the vocal process, or the arytenoid cartilage, or if it extends subglottically.

**Treatment of Glottic Tumors.** Accurate mapping and staging of glottic lesions is important in order to decide on correct therapy. The vocal cord mobility is probably the single most important factor. Other treatment planning factors include tumor involvement of the anterior commissure, arytenoid cartilage, and subglottic extension.

Carcinoma in situ or superficial intraepithelial carcinomas carry a significant risk of subsequent invasion developing and therefore should be treated. Both surgery and radiotherapy are effective. Surgical therapy can be performed by mucosal stripping using microlaryngeal techniques or with the CO<sub>2</sub> laser. Cordectomy may also be performed, either transorally with the laser or by laryngofissure. Cordectomy does result in worsening of the voice. Some of these patients have widespread disease with premalignant changes in multiple other sites within the larynx. Radiation therapy allows treatment of the entire laryngeal area,

therefore reducing the risk of subsequent malignant change of other premalignant lesions. Usually voice preservation is good, although not perfect. The disadvantages of surgery include the treatment of isolated areas within a larynx that may be diffusely involved with disease as well as postoperative scar formation and worsening of voice quality. The disadvantage of radiation therapy is the amount of time (4 to 6 weeks) required for therapy and the possible changes in the laryngeal mucosa, including edema that may be confusing as the patients are followed after treatment. Both therapies result in cure rates between 75 and 95 per cent. In patients with recurrent disease or disease that progresses to invasive carcinoma, salvage surgery can almost always be performed.

T<sub>1</sub> lesions have a high cure rate either with surgery or radiation, with 5-year cure rates ranging from 80 to 95 per cent. The high cure rates generally include surgical salvage for radiation failures, which account for about 5 to 10 per cent of these cases. Radiation usually involves about 6000 rad over a period of 6 weeks. The surgical techniques involve various forms of hemilaryngectomy with or without anterior commissure resections. Lesions that involve the arytenoid cartilage posteriorly carry a worse prognosis and also require more extensive techniques with somewhat worse voice quality.

The overall cure rates for T<sub>2</sub> lesions are in the range of 70 to 80 per cent. T<sub>2</sub> lesions in which vocal cord mobility is normal are similar to T<sub>1</sub> lesions, with cure rates in the 90 per cent range; however, in T<sub>2</sub> lesions with impaired vocal cord mobility, the cure rate with radiation decreases to the 70 per cent range. Thus, T<sub>2</sub> lesions with impaired vocal cord mobility are more like T<sub>3</sub> lesions. Surgical treatment with conservation surgery also produces the same range of percentages, with overall cure rates between 70 and 80 per cent. Conservation surgery is limited to those patients with subglottic extension less than 1 cm anteriorly and 4 mm posteriorly. If conservation cases are selected properly, the cure rates are equivalent to those in patients undergoing total laryngectomy for the same stage lesions.

T<sub>3</sub> lesions include vocal cord fixation, and radiation therapy is less effective. Cure rates with radiation range from 30 to 57 per cent. These data include those patients salvaged by total laryngectomy. Surgical therapy is curative in 50 to 80 per cent of them. Cervical metastasis is infrequent even in T<sub>3</sub> glottic carcinomas, but the rates increase with transglottic spread.

T<sub>4</sub> lesions are characterized by extralaryngeal spread of tumor, and radiation therapy produces lower rates of cure than does surgical therapy in these cases. As tumor volume increases, the cure rates for laryngeal cancers using radiation therapy decrease. Generally, radiation therapy is reserved for palliative treatment. Cure rates for radiation are in the range of 20 per cent, whereas surgical therapy results in rates of 35 to 57 per cent. At present, most of these patients are treated with combinations of total laryngectomy and postoperative radiation therapy.

**Subglottic Tumors.** These tumors are rare and at the time of diagnosis usually are large and commonly involve the cricothyroid space and cricoid cartilage; therefore, therapy usually consists of total laryngectomy. Rarely, hemilaryngectomy may be possible. Earlier cure rates ranged from 36 to 42 per cent; however, combined therapy with surgery and postoperative radiation or radiation alone for T<sub>1</sub> to T<sub>3</sub> lesions has been reported to produce a 70 per cent cure rate. T<sub>4</sub> lesions have a markedly lower cure rate. At the present time, most

T<sub>4</sub> tumors should be treated with total laryngectomy, including removal of extralaryngeal soft tissue and appropriate surgical therapy to the paratracheal lymph nodes followed by postoperative radiation therapy.

Tumors that are primary subglottic ones and those that are subglottic secondary to glottic or supraglottic lesions have a higher incidence of stomal recurrence following total laryngectomy. This seems to be increased in those patients with preoperative airway obstruction requiring a tracheostomy preoperatively. In these cases, emergency laryngectomy may be a consideration.

**Stomal Recurrences.** In cases of tumor recurring at the stoma following total laryngectomy the prognosis is poor. Wide resection of the stoma and mediastinum has resulted in generally poor results. Recently, a control rate of 45 per cent was reported for stage I and stage II lesions - those limited to the superior stoma. In stage III and stage IV, with involvement of the inferior stoma and mediastinum, the control rate was 9 per cent.

**Surgical Therapy of Malignant Neoplasms of the Glottic Area.** Surgical therapy of the glottic area of the larynx can be divided into conservation techniques and total laryngectomy. Conservation techniques strive to maintain the laryngeal functions of respiration, deglutition, and voice production. These techniques are based on correct staging of the tumor and our knowledge of tumor behavior as related to the histologic type and the various barriers of the larynx. Conservation laryngeal surgery finds its greatest application in the management of glottic carcinoma. In addition to eliminating the need for total laryngectomy, conservation surgery also represents an alternative to primary radiotherapy, which provides diminished local control with some advanced vocal cord lesions.

In order for patients to be selected for partial laryngectomies, accurate mapping and defining of the exact extent of the lesion is critical. This is usually performed under general anesthesia at the time of direct laryngoscopy. Multiple biopsies may be performed in order to determine the exact extent of the lesion. Vocal cord mobility should be assessed by direct palpation at the time of direct laryngoscopy as well as by office examination. CT is frequently helpful, especially in determining paraglottic involvement, subglottic extension, and cartilage invasion.

With more advanced conservation techniques, patients should be in reasonably good health, especially their cardiac and pulmonary status, as some of these patients have prolonged healing with problems of dysphagia and some aspiration. In patients whose medical status is questionable, total laryngectomy will usually produce a shortened postoperative course, although obviously this involves the loss of voice.

### **T<sub>1</sub> Lesions**

**Removal by Laryngoscopy.** Carcinoma in situ and superficial carcinomas may be removed by direct laryngoscopy and vocal cord stripping. Laser excision may also be performed for this stage lesion. High control rates are achieved in properly selected cases. With use of the laser, appropriate protection should be performed, including use of saline in the cuff of the endotracheal tube as well as subglottic packing.

**Technique.** Under general anesthesia, using microlaryngoscopy technique, the free edge of the true vocal cord is grasped just posterior to the anterior commissure with a microlaryngeal forceps. The mucosa is then stripped by pulling the forceps posteriorly back to the vocal process. This should produce one strip of intact mucosa, which gives the pathologist an adequate specimen for examination. If other areas of the vocal cord are involved with suspicious lesions, they should be removed. If there is a diagnosis of carcinoma in situ or superficial cancer, regular follow-up examinations are performed, and patients are strongly encouraged to discontinue smoking. Microlaryngoscopy and stripping are repeated in 3 months. If the follow-up strippings are normal, the patient may be followed at regular intervals, and repeat strippings may be necessary in the future depending upon the results of the laryngeal examination. If repeated strippings continue to be abnormal, radiation therapy usually is given. In some cases, cordectomy or hemilaryngectomy may be recommended, depending on the individual patient.

**Laryngofissure and Cordectomy.** This technique was more commonly used in the past, with cure rates in the range of 80 to 95 per cent; however, if this technique is used on more advanced lesions, the cure decrease. At the present time, hemilaryngectomy has generally replaced cordectomy in the surgical management of glottic carcinoma because it provides wider margins of resection and patients have a stronger voice than do patients who undergo laryngofissure.

**Hemilaryngectomy.** This technique removes the ipsilateral thyroid lamina, the false vocal cord ventricle, and the involved true vocal cord. It is generally used for those lesions that extend from the anterior commissure to the vocal process. The resection may be modified to include lesions that extend across the anterior commissure to involve one third or more of the contralateral true vocal cord, tumors that have spread posterior to the vocal process, and tumors that extend subglottically no more than 10 mm anteriorly or 5 mm posteriorly. Surgery is useful in improving local control in those lesions that extent to the anterior commissure or posteriorly to or beyond the vocal process. In some cases, hemilaryngectomy may be used following radiation therapy; however, the vocal cords need to be mobile. Cure rates of 77 to 87 per cent following hemilaryngectomy have been reported. Contraindications to hemilaryngectomy include extension across the ventricle onto the false vocal cord and thyroid cartilage invasion. Impaired vocal cord mobility is a relative contraindication. Impaired vocal cord mobility is a relative contraindication. Recurrences after hemilaryngectomy generally are in the subglottic area.

**Surgical Technique.** Direct laryngoscopy is performed under general anesthesia immediately prior to the resection. This confirms the extent of tumor noted at a previous laryngoscopy. A tracheostomy is performed, and general anesthesia is maintained through an endotracheal tube. A collar incision is extended bilaterally from the tracheostomy incision back to the external jugular vein. A skin flap including the platysma is elevated to the level of the hyoid bone bilaterally. The strap muscles are separated in the midline, exposing the larynx. The perichondrium of the thyroid cartilage is incised in the midline and elevated to the posterior margin of the thyroid cartilage. The perichondrium is also elevated 1 to 2 mm on the contralateral side. The thyroid cartilage is cut with an oscillating saw in the midline or in a contralateral paramedian position, depending on tumor location. The posterior cut is made approximately 0.5 cm from the posterior border of the cartilage. The cricothyroid membrane is exposed by resecting the soft tissues over it, including the Delphian lymph



nodes. A transverse incision is made in the cricothyroid membrane on the superior surface of the cricoid cartilage. The patient is paralyzed and, using a headlight, single hooks, and a small clamp, the vocal cords are separated and the lesion is visualized. A knife is passed between the vocal cords anteriorly to sever the anterior commissure. The incision is extended superiorly to separate the false vocal cords up to the petiole of the epiglottis.

After the larynx is opened, the lesion is visualized, and mucosal cuts are outlined along the upper border of the cricoid extending posteriorly. The superior margin is across the free superior edge of the false vocal cord. Usually these cuts are completed by using a Mayo scissors on the inferior incision first. This is extended posteriorly and an adequate margin is taken. The superior cut is then performed and the margins are joined posteriorly and the lesion is excised. Care must be taken not to remove the elevated perichondrial flap with the resection. Posteriorly the cut is usually made with right-angled scissors, and the superior laryngeal vessels are clamped, divided, and ligated. If a small portion of the opposite vocal cord has been included in the resection, the remainder of that vocal cord is reattached anteriorly to the inner thyroid perichondrium with an absorbable small suture. The epiglottis is attached to the hyoid bone by suturing the petiole anteriorly with a heavy mattress suture. The larynx is closed by reapproximating the perichondrium and strap muscle. A drain is placed and the skin flaps are sutured.

Patients are usually able to undergo decannulation within a week. The size of the tracheotomy tube is decreased and is ultimately plugged. If the patients tolerate this for 24 hours, the tracheotomy tube is removed. After the tracheostoma is closed, oral feedings are reinstated. Prior to this time, tube feedings have been given. Usually these patients do well with swallowing, since the arytenoid cartilage has not been resected.

**Arytenoid Cartilage Extension.** Posterior extension of vocal cord carcinoma to the arytenoid area alters the biologic behavior and worsens the prognosis. Tumor in this area may extend to the cricoid cartilage and interarytenoid muscle and may involve the cricoarytenoid joint and thyroarytenoid muscle. Further extension will lead to pharyngeal involvement. Rates of cure for lesions extending to the arytenoid cartilage that are treated with partial laryngectomy range from 74 to 90 per cent.

An extended frontolateral hemilaryngectomy is indicated for lesions that involve the anterior portion of the arytenoid cartilage. This technique is contraindicated if there is extension to the aryepiglottic fold and posterior surface of the arytenoid cartilage and involvement of the interarytenoid muscles or the cricoarytenoid joint, or both. This technique also should not be used for tumors with greater than 1 cm of subglottic extension or when fixation of the vocal cord is present. In this technique, the resection continues posteriorly along the true vocal cord to include the arytenoid cartilage. Curved right-angle or heavy scissors are used for the arytenoid cartilage resection. The specimen is pulled anteriorly, and heavy scissors are used to encompass the arytenoid cartilage.

The area of the resected arytenoid cartilage must be reconstructed to obtain glottic closure posteriorly and to prevent postoperative aspiration. Reconstruction of the arytenoid area includes replacement with free or pedicled muscle, tendon, fat, perichondrium, or cartilage grafts, and epiglottis. Another technique is the use of a cartilage graft that is cut from the remaining posterior portion of thyroid lamina and left pedicled on the inferior

constrictor muscle. This is rotated and fixed to the cricoid cartilage and covered with a pyriform sinus mucosal flap.

**Anterior Commissure Lesions.** Primary lesions of the anterior commissure are rare, the majority of tumors of this area representing spread from vocal cord lesions. Lesions of the anterior commissure tend to invade cartilage because of the close proximity of mucosa to the cartilage. There is a higher rate of extralaryngeal extension of anterior commissure lesions because of the access to the cricothyroid membrane. Cure rates for radiation or surgery are about the same - in the 80 to 85 per cent range; however, it has been reported that anterior commissure involvement may increase the failure rate with radiotherapy, and some radiotherapists consider this an indication for surgery.

The anterior commissure resection involves bilateral paramedian sagittal thyroid cartilage cuts with the resection of the anterior portion of the thyroid cartilage and the anterior segments of both vocal cords. Placement of a keel in this area is mandatory to prevent anterior commissure webbing. The perichondrium of the thyroid cartilage is incised in the midline and elevated bilaterally. Vertical thyroid cartilage cuts are made with an oscillating saw 1 cm from the midline. The cuts are performed perpendicular to the cartilage. The cricothyroid membrane is incised along the upper border of the cricoid cartilage, and the incision is carried forward to the thyroid cartilage cut on the side of lesser involvement. After the cartilage is retracted, the true and false vocal cords are divided under direct vision, and the larynx is opened. A subperichondrial dissection is performed, the mucosa is incised on the contralateral side, and the surgical specimen is removed.

In order to prevent anterior webbing and stenosis, a polymeric silicone (Silastic) keel is placed anteriorly, which extends posteriorly between the vocal processes. It is kept in position by heavy nylon sutures brought through the remaining thyroid cartilage and tied over buttons on the external surface of the skin. The keel is left in place 4 to 6 weeks and is removed endoscopically. The patient then undergoes decannulation.

**Bilateral Vocal Cord Lesions.** Large bilateral glottic tumors involving the anterior commissure in both vocal cords may involve resection of extended portions of the thyroid alae to reduce the incidence of local recurrence. Portions of the laryngeal cartilage must be removed to decrease local recurrences because of vocalis muscle invasion. The anteroposterior diameter of the larynx may be reconstructed by using either the posterior borders of the thyroid cartilage as described by Biller and Lawson or the epiglottis as described by Tucker and colleagues.

**Near-total vertical Hemilaryngectomy with Thyroid Cartilage Transposition Reconstruction.** In this technique, a stepped vertical incision is made in the midline to form two transverse skin flaps. The larynx is exposed, and without elevation of the perichondrium, bilateral vertical thyroid cartilage cuts are made 1 cm anterior to the posterior border of the thyroid lamina. An incision in the cricothyroid membrane on the upper border of the cricoid cartilage is carried posteriorly in a subglottic direction to the level of the vocal process on the less involved side. This is extended superiorly, transecting the true and false vocal cords and aryepiglottic folds. The thyrohyoid membrane is divided at the upper border of the thyroid cartilage, and the larynx is rotated to the opposite side. A posterior cut is made through the vocal process, body of the arytenoid cartilage, or cricoarytenoid joint, depending on the extent

of the tumor, and the specimen is removed. The petiole of the epiglottis is sutured anteriorly to the perihyoid tissue. The posterior segments of the thyroid alae are mobilized, leaving the attachment of the inferior constrictor muscles. These segments are then rotated forward 90° and are wired into position to the cricoid cartilage. The segments may be shortened if they are too long. If the arytenoid cartilage has been resected, a cartilage fragment is wired to the cricoid cartilage. The mobilized skin flaps cover the transposed cartilages and are sutured to the mucosa of the residual posterior portion of the larynx. The skin incisions are closed and a tracheostomy tube is placed. The patient is fed by nasogastric tube for a week followed by oral feedings. The laryngostome is closed when there is healing of the suture line, lack of aspiration, and an adequate airway on occlusion of the opening with gauze. This usually occurs in 3 to 6 weeks.

At the time of final closure, an incision is made around the laryngostome and the skin is undermined medially and rotated in to form the inner layer of the closure. The outer portion of the defect is closed by rotation of a cervical flap. The patient usually undergoes decannulation in about a week. This technique has not been used in large series and is contraindicated in patients who have had radiation therapy. In the few patients in whom this technique has been used, good results have been obtained.

**Near-total Vertical Hemilaryngectomy with Epiglottic Flap Reconstruction.** This surgery is indicated in advanced glottic cancers that involve both vocal cords from one vocal process around to and including a portion of the arytenoid cartilage on the more involved side. The patient must have one arytenoid cartilage that is free of tumor and functional. This resection is contraindicated in lesions that extend more than 10 mm anteriorly or 5 mm posteriorly in a subglottic direction.

The resection is the same as described earlier. The arytenoid cartilage must be preserved on the less involved side. The reconstruction consists of grasping the epiglottis at the petiole with a tenaculum and dissecting the soft tissues off the anterior surface, including the mucosa over its lingual aspect. The hyoepiglottic and glossoepiglottic ligaments must be divided. The epiglottis is mobilized inferiorly and attached to the upper borders of the cricoid cartilage with nonabsorbable sutures. The perichondrial flaps are closed over the epiglottis. The strap muscles are closed at the midline as in the standard hemilaryngectomy.

Good results have been reported; however, in patients who have the thyroid lamina resected back to the vocal process, a foreshortened larynx may result. This technique is perhaps best used when more of the thyroid lamina is left intact. The epiglottis has a natural angle that pulls down and reconstructs the anterior portion of the larynx nicely. Postoperative radiation therapy may be given in these cases.

## **T<sub>2</sub> Lesions**

**Subglottic Extension.** Involvement of the subglottic area worsens the prognosis. The survival rate in patients having unilateral vocal cord lesions involving the anterior commissure and having less than 10 mm of subglottic extension is higher (90 per cent) than in those with extension greater than 10 mm (50 per cent).

If the subglottic extension is greater than 1 cm anteriorly, this places the tumor at the upper border of the cricoid cartilage. It is necessary to make a transverse cut through the anterior portion of the cricoid cartilage in order to include the upper anterior half of the cricoid cartilage and cricothyroid membrane with the hemilaryngectomy specimen. Extension of the vocal cord carcinoma subglottically more than 10 mm anteriorly and 5 mm posteriorly results in involvement of the cricothyroid membrane and cricoid cartilage. Involvement of these areas worsens the prognosis.

Most tumors that extend subglottically in the cricoid area are treated with total laryngectomy. However, Biller and Som have reported a method of reconstruction that permits partial laryngectomy in selected cases. The contraindications to this procedure are (1) irradiation failure, (2) vocal cord fixation, and (3) tumors in which a 6-mm margin cannot be obtained.

In this technique, the larynx is entered in the midline as in the standard hemilaryngectomy. The extent of the subglottic tumor is assessed, and the inferior border of the cricoid cartilage is determined. A margin 6 to 7 mm from the tumor is necessary for this surgery. The inferior and posterior mucosal cuts are made in the subglottic and interarytenoid areas. The interarytenoid muscle is divided, and the cricoid cartilage cut is performed laterally and posteriorly. The specimen is removed. The remaining posterior segment of the thyroid lamina is then mobilized and left attached to the inferior constrictor muscle. This pedicled cartilage is trimmed, rotated, and stabilized in position to replace the resected cricoid cartilage. Additional bulk in the arytenoid area may be obtained by fat, muscle, or omohyoid tendon. The grafted area is covered by a mucosal flap from the pyriform fossa.

**Transglottic Lesions.** Superior extension of a glottic carcinoma over the ventricle and onto the false vocal cord allows invasion of the paraglottic space and provides access to the extensive lymphatic network of the supraglottic larynx. Involvement of the pre-epiglottic space and regional lymph node metastasis increase significantly. Conservation procedures for transglottic lesions are usually accompanied by a high rate of failure. Impaired mobility and fixation of the vocal cord decrease the cure rates. Total laryngectomy is generally reserved for salvage of irradiation failures.

**T<sub>3</sub> Lesions.** These lesions are defined by fixation of the vocal cord. This indicates an advanced glottic tumor that has infiltrated the deep structures of the larynx. With vocal cord fixation, most laryngologists feel that surgery is superior to radiotherapy for control of the tumor. Cure rates range from 50 to 70 per cent. The treatment most commonly recommended is total laryngectomy with neck dissection if palpable lymphadenopathy is present. Postoperative radiation therapy may be indicated, depending on the extent of the tumor and the regional lymph nodes in each individual case. In a few series of carefully selected cases, partial laryngectomy has been possible with some degree of success; however, it is generally not recommended for fixed vocal cord lesions.

**Near-total Laryngectomy.** This is a form of extended partial laryngectomy as indicated for carcinomatous fixation of one vocal cord. This fixation may develop by extension through the paraglottic space from the pyriform fossa or the supraglottis or may arise from a primary tumor of the vocal cord. In this procedure, most of the larynx is resected except for a portion of the cricoid cartilage and an area over the uninvolved arytenoid

cartilage. This procedure developed as surgeons became aware that in some cases a total laryngectomy excised more of the larynx than was necessary to cure the cancer. The near-total laryngectomy differs from the other partial procedures in that although it preserves the voice, it does require a permanent tracheostoma. The voice is preserved by creating a tracheopharyngeal speaking shunt in the area of the remaining arytenoid cartilage.

This procedure is contraindicated if there is involvement of the postcricoid or interarytenoid regions. It should not be performed if there are obscure tumor margins, especially in postradiation disease or if the surgeon cannot be sure of the healing capability of the preserved laryngeal remnant with its arytenoid cartilage and overlying mucosa. This procedure should be considered in treating cancers that are too small to require total laryngectomy but are improperly located or too large to perform partial or conservation laryngeal surgery without unacceptable sequelae. Whole laryngeal sections have demonstrated that in some cases in which total laryngectomy was performed, the tumor could have been resected by a near-total laryngectomy. Even in patients in whom it is technically feasible to do near-total laryngectomy, other factors such as previous radiation, infection, age, general health, compliance, and reliability must qualify the decision to perform this more extensive conservation procedure.

**Technique.** At the time of direct laryngoscopy, the interarytenoid and postcricoid regions, the contralateral arytenoid cartilage, and the ventricle must be clear of tumor. Following mobilization of the larynx, as in a standard total laryngectomy, a laryngeal cartilage wedge is resected from the underlying perichondrium of the uninvolved side. The uninvolved ventricle is entered and the incision is extended superiorly across the vallecula, retaining the body of the hyoid bone with the specimen. The incision is directed inferiorly on the less involved side, and an appropriate area of the true vocal cord is transected, usually near the midline. This is extended through the anterior cricoid arch to the first tracheal ring.

The resection extends onto the undersurface of the first tracheal ring toward the tumor-involved side. The cricoid cartilage is sectioned in the posterior midline, and the anterior incision is continued subglottically in a lateral direction to join the midline posterior cricoid cartilage cut. The superior incision in the vallecula is extended down inferiorly and laterally into the hypopharynx on the tumor-involved side, taking appropriate margins and joining this to the postcricoid incision and removing the specimen.

A small posterolateral remnant of cricoid cartilage is left on the side not involved by tumor. The laryngeal remnant includes the posterior border of the thyroid cartilage as well as a small piece of cricoid cartilage deep to the inferior cornu of the thyroid cartilage. This should be preserved to prevent injury to the recurrent laryngeal nerve. A strip of mucosa remains in the arytenoid area joining the trachea below and the pharynx above. The mucosal strip is tubed over a No. 14 French catheter using 3-0 chromic catgut. This creates a vocal shunt. The pharynx is closed with 2-0 chromic catgut in a manner similar to that for a total laryngectomy closure. The strap muscles are sewn across the upper portion of the tube to reach the suprahyoid muscular remnants. The tracheostoma is created in a standard fashion.

Pearson reported 14 cases performed for glottic and subglottic lesions with a mean follow-up of 22 months. No local recurrences were seen in this series. Several patients experienced wound disruption postoperatively, but they were successfully treated. Near-total

laryngectomy does not replace total removal of the larynx, but it decreases the indications for this surgery and extended partial glottic operation.

### **T<sub>4</sub> Lesions**

**Total Laryngectomy.** These lesions, which involve thyroid cartilage or have extended extralaryngeally, require total laryngectomy. There is a higher incidence of cervical metastasis (clinical, 39 to 59 per cent; occult, 20 per cent). Cure rates are in the 50 per cent range, with rates decreasing to 20 to 40 per cent if there are lymph nodes involved with tumor.

Candidates for total laryngectomy are the following: (1) patients with advanced glottic carcinomas having vocal cord fixation, interarytenoid involvement, cartilage invasion, or extralaryngeal extension; (2) patients with intermediate tumors with normal vocal cord mobility but with a degree of subglottic extension beyond the limits of conservation surgery; (3) patients with small lesions that have crossed the ventricle to involve the false vocal cord and become transglottic; (4) patients who fail to respond to partial laryngectomy and radiotherapy because of residual or recurrent tumor or who are disease free but have serious therapeutic complications (chronic aspiration and chondritis).

**Technique.** A low collar incision is performed with superior extensions if a neck dissection is included. Following tracheostomy and skin and platysmal flap elevation, the strap muscles are divided 2 to 3 cm above the suprasternal notch attachments. If a neck dissection has been performed, the specimen is left pedicled on the lateral aspect of the thyroid and cricoid cartilages. The part of the gland that is to be retained is dissected from the trachea and cricoid cartilage and is mobilized laterally. The omohyoid muscle is divided, the portion of the thyroid gland to be included in the specimen is mobilized, and the inferior thyroid vessels are clamped and ligated. The inferior constrictor muscle is transected along the posterior border of the thyroid cartilage. The superior thyroid artery pedicle is clamped and ligated. The superior cornu of the thyroid cartilage is mobilized and separated from the underlying pyriform fossa mucosa to preserve this mucosa for closure if it is not involved with tumor. The superior laryngeal vascular pedicle is divided and ligated, and the same procedures are performed on the opposite side.

The suprahyoid muscles are transected off the superior aspect of the hyoid bone. The pharynx is entered through the vallecula if the lingual surface of the epiglottis is tumor free, otherwise entry is made through the contralateral pyriform fossa. The epiglottis is pulled with a tenaculum anteriorly, and the dissection proceeds inferiorly along the lateral aspects of the epiglottis and anterior margin of the lateral pharyngeal wall, preserving as much of the pyriform fossa as possible. The mucosa is incised across the lower border of the cricoid cartilage, and dissection is carried out on the posterior cricoid cartilage, separating the esophagus from the laryngeal specimen. The proximal trachea is separated from the esophagus, and the trachea is transected at the level of the second or third tracheal ring.

The pharynx is closed with continuous or interrupted sutures. A tracheostoma is created by excision of a circle of skin from the upper and lower skin flaps and by anchoring the trachea to the cut margins with interrupted sutures. Suction drains are placed and the incisions are closed in layers. Nasogastric tube feeding continues for 7 days if there has been no previous radiotherapy and for 10 to 14 days following radiation therapy. After this, oral

feedings are instituted.

**Complications of Total Laryngectomy.** Complications include infection, wound breakdown, fistula formation, and stenosis. The incidence of complications is markedly increased following previous radiation therapy. Small pharyngocutaneous fistulas frequently close spontaneously with local wound care, but larger fistulas may require closure with pedicled flaps. Stenosis of the pharyngeal lumen should be prevented with adequate initial surgical technique, particularly if attention is devoted to preservation of mucosa. If a significant portion of the pharyngeal mucosa is excised in conjunction with a total laryngectomy, some type of flap reconstruction will avoid stenosis. If stenosis does occur, serial dilatations may be required, allowing a normal diet. Stricture of the tracheostoma may occur but can be corrected by surgical procedures.

### **Unusual Laryngeal Malignancies**

The tumors discussed in the following paragraphs account for only 5 to 10 per cent of all laryngeal malignancies. As stated at the beginning of this chapter, the vast majority of malignancies of the larynx are squamous cell carcinoma (90 to 95 per cent).

#### **Verrucous Carcinoma**

An uncommon but distinct variety of squamous carcinoma, verrucous carcinoma accounts for 1 to 2 per cent of all laryngeal neoplasms. It appears most commonly in the oral cavity and larynx, but similar lesions have also been described in the nasal passages and esophagus. Verrucous carcinoma is a slow-growing, locally invasive tumor that, unlike the usual squamous carcinoma, does not metastasize either to local lymph nodes or to distant sites.

Considerable difficulty may be experienced in establishing the correct diagnosis. To the laryngologist, the tumor is a pale, bulky exophytic lesion projecting from the mucosal surface, often with a broad base. It is clearly demarcated from the adjacent mucosa and has the clinical appearance of a fungating, often papillomatous, malignant neoplasm. In contrast, on the biopsy specimen the pathologist sees keratosis, acanthosis, and an exuberant hyperplastic papillomatous appearance, but it is totally lacking in the cytologic atypia necessary for a malignant diagnosis. Microscopically, verrucous carcinoma has an irregular surface with papillary fronds, and the surface is usually heavily keratinized. This presents a somewhat white, warty clinical appearance.

It is common for multiple biopsies to be performed before the clinician, convinced of the malignant nature of the lesion, can persuade the pathologist that this benign-appearing lesion actually represents verrucous carcinoma. It is usually quite helpful if the pathologist comes to the operating room and actually visualizes the primary lesion within the larynx at the time of direct laryngoscopy. It is helpful if biopsy specimens are taken that also include the margins.

Verrucous carcinoma, despite its deceptively benign microscopic appearance, may grow very large and may extensively infiltrate and destroy adjacent tissues, whether they be soft tissues, bone, or cartilage. Enlargement of the draining lymph nodes is commonly seen

with verrucous carcinoma, but it is invariably due to benign inflammatory hyperplasia secondary to the inflammatory reaction of the lesion.

There has been considerable controversy regarding the examples of so-called anaplastic transformations of verrucous carcinoma following radiation therapy. This incidence has been reported to be less than 10 per cent. Whether transformation occurs is debatable; some pathologists feel that within the primary tumor in these cases, there may be isolated areas of the more standard squamous cell carcinoma. This is still a debatable point; however, most institutions believe that surgical therapy, if possible, should be the primary modality. Some institutions have reported good results with radiation therapy. Generally, the small or localized tumor should be treated by local excision or partial laryngectomy. Surgery is usually effective, depending on the size of the lesion. The recurrence rate following surgery is less than 10 per cent; however, with larger lesions, total laryngectomy may be required, and considering all of the patients with verrucous carcinoma roughly 25 per cent require total laryngectomy sometime during the course of their disease.

### **Spindle Cell Carcinoma - Pseudosarcoma Carcinoma**

Spindle cell carcinoma is an unusual malignancy that appears to be the combined product of a simultaneous squamous cell malignancy and sarcomatous degeneration. Most pathologists feel that this tumor is primarily an epidermoid carcinoma with a pseudosarcomatous stroma. In the larynx, about 80 per cent of these tumors are glottic and about 66 per cent are large polypoid masses on a relatively small stalk. The carcinomatous element is typically located at the base of the stalk of the polyp.

Most recent series have recommended treating these unusual tumors like similarly staged squamous cell carcinomas. Some investigators have reported neck and distant metastasis, usually of the squamous component, but sometimes of the spindle cell component and occasionally of both components. Overall, it is felt that these tumors carry a somewhat worse prognosis than similarly staged squamous cell carcinomas.

### **Malignant Glandular Tumors of the Larynx**

There are numerous collections of seromucinous glands of the minor salivary gland type within the supraglottic and subglottic areas of the larynx. Tumors arising in these structures are uncommon but are morphologically similar to those arising in the minor salivary glands at other sites.

Most glandular tumors of the larynx are malignant, the most common being adenocarcinoma, adenoid cystic carcinoma, and mucoepidermoid carcinoma, with rare examples of acinic cell carcinoma. These tumors compose less than 1 per cent of all laryngeal malignancies.

Usually these tumors are large, bulky lesions arising from the supraglottis. They have a very poor prognosis, with about half of patients experiencing regional metastasis, and despite radical therapy, nearly all patients die of widespread pulmonary and hepatic metastasis within 2 years. Most cases are treated with total laryngectomy and neck dissection. Radiotherapy is not considered to be effective; however, postoperative radiation therapy may



be given in an attempt to decrease recurrence rates.

Adenoid cystic carcinomas rarely occur within the larynx, but when they do, they have the same prognosis as in other sites. Most patients eventually succumb to the tumor within 10 years or more after the diagnosis. Most of these tumors are large and advanced at the time of presentation. Metastasis eventually develops in more than half of these patients.

### **Carcinoid and Oat Cell Carcinomas of the Larynx**

Laryngeal carcinoid and oat cell tumors are considered to be neuroendocrine malignancies. Electron microscopy reveals neurosecretory granules. Carcinoid tumors are extremely rare, with only a few cases reported. Usually they are in the subglottic area. Cervical metastasis is common and occurs in most patients. These patients are usually treated with surgery or combination therapy. The number of cases is so low that long-term results are not known.

Oat cell carcinoma is more common, although it is still rare. These tumors are at the malignant end of the spectrum of neuroendocrine tumors. They are very aggressive, similar to oat cell pulmonary tumors. The lesions usually arise in the aryepiglottic fold region and subglottis. About half of the patients have cervical adenopathy at the time of diagnosis, and distant metastasis is not unusual. Results of therapy have been uniformly poor, with most patients having succumbed to widespread metastasis within a few months of diagnosis, despite aggressive therapy.

### **Malignant Neoplasms of Neural Origin**

**Laryngeal Paragangliomas.** These tumors arise from paired superior and inferior paraganglia located within the soft tissues of the larynx. The superior pair are located adjacent to the superior margin of the thyroid cartilage in close association with the superior laryngeal nerve. The inferior pair have been described between the inferior horn of the thyroid cartilage and the cricoid cartilage. About 30 case reports have been described in the literature with virtually all of them apparently arising from the superior pair. Usually these lesions present as a small, smooth, mucosa-covered, red, and painful mass located on the aryepiglottic fold. A striking clinical feature is the presence of pain on swallowing referred to the ipsilateral ear and resolved by biopsy or removal of the lesion. Because these lesions are very vascular, significant hemorrhage may accompany a biopsy procedure.

Most reported cases have pursued a benign clinical course and have been successfully treated by local excision or partial laryngectomy procedures; however, a significant number of these tumors have occurred locally, and a small number have been reported to metastasize and even kill their hosts. Histologic features of malignancy are usually not evident even in those tumors that eventually metastasize.

### **Vascular Tumors of the Larynx**

Hemangiopericytomas rarely occur in the larynx. Most occur in the supraglottis. Metastatic spread is rare, and many can be resected by partial laryngectomy.

## **Malignant Tumors Arising From Lymphoreticular Tissue**

Lesions arising from lymphoreticular tissue include non-Hodgkin's lymphoma, mycosis fungoides, plasmacytoma, and malignant histiocytoma. The treatment is based on the treatment regimen for other sites in the body according to staging. Usually local irradiation is the treatment modality for non-Hodgkin's lymphomas, although occasionally laryngectomy has been required. Local control is usually good.

Plasmacytomas have occurred most frequently in the supraglottis. These lesions are usually treated with local excision followed by radiation therapy. More widespread disease is commonly treated with radiation therapy and chemotherapy.

Malignant fibrous histiocytoma is a rare lesion, most often occurring in elderly men. Long-term control has been achieved in the majority of patients. The usual treatment is surgical excision, with radiation and chemotherapy reserved for advanced or recurrent lesions.

## **Malignant Neoplasms of the Supporting Tissue**

**Cartilaginous Tumors of the Larynx.** These lesions, both benign and malignant, have been discussed earlier in this chapter in the section of benign lesions of the larynx.

**Bony Tumors of the Larynx.** These lesions are extremely rare, with only a few instances of primary osteosarcoma being recorded in the literature. The usual outcome is pulmonary metastasis and a rapid demise within a few months.

Laryngeal fibrosarcomas are quite unusual. Most occur in men older than 50 years of age and originate on the vocal cord or anterior commissure. Well-differentiated examples make up the majority of cases and have a 50 per cent 5-year survival rate. In contrast, poorly differentiated examples frequently metastasize, and only about 5 per cent of patients survive 5 years.

**Muscular Tumors of the Larynx.** Rhabdomyosarcoma has been reported in only a few cases as a primary tumor of the larynx. One third of these tumors occur in children and most occur in males. These tumors are usually bulky and often polypoid. They may arise from any area of the larynx. Almost all reported cases are of the embryonal histologic type. These tumors usually are radiosensitive and susceptible to chemotherapy. Individualized combination therapy is usually recommended. Surgery may be recommended in selected cases.

## **Metastatic Carcinoma to the Larynx**

When a patient presents with an unusual neoplasm involving the larynx, particularly an adenocarcinoma, the possibility that the neoplasm represents a metastasis should be considered. In many instances, such patients will have documented evidence of a primary tumor elsewhere, but occasionally the laryngeal metastasis may be the presenting complaint. Renal cell carcinoma has been the most frequently reported site of the primary tumor, but examples of breast, ovarian, lung, nasopharyngeal, colon, prostate gland, and cutaneous melanoma have also been reported.

## **Thyroid Carcinoma Involving the Larynx**

Thyroid carcinoma may occasionally invade the larynx with involvement of the airway. Occasionally, such a tumor may make its initial presentation in the upper airway. It is speculated that such tumors may actually arise in the larynx and upper trachea from thyroid rests located in the submucosa overlying the cricoid and upper tracheal rings. Such thyroid rests are said to occur in 1 to 2 per cent of the population.