Chapter 115: Conservation Surgery of the Larynx

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Preservation of function is a prime consideration in all aspects of head and neck surgery. Conservation surgery of the larynx deals specifically with the goal of complete cancer excision while maintaining respiration, deglutition, and voice production. These results can be accomplished in the larynx by combining information on tumor behavior with knowledge of the unique compartments and barriers in the larynx.

The spectrum of conservation surgery is great, extending from microsurgical removal of superficial cancers of the true vocal cords to the more radical subtotal laryngectomy and partial laryngopharyngectomy. Approximately 50% to 70% of patients with cancers of the larynx have lesions amenable to conservation procedures (Schechter, 1983c; Tucker, 1977).

History of Conservation Surgery of the Larynx

Recognition of laryngeal cancer as an entity can be found in the writings of Aretaeus and Galens, AD 100 to 200. The concept of conservation surgery is not new (Silver, 1981). In 1778 the French surgeon Pellatan opened a patient's larynx to remove a piece of impacted meat, thus introducing the concept of surgically entering the larynx for treatment. In 1851 an American surgeon, Gurdon Buck, performed the first laryngofissure for intrinsic cancer. This advance was followed in 1863 by a laryngofissure for carcinoma of the larynx, performed by H. B. Sands of New York. Billroth performed the first vertical hemilaryngectomy in 1878, but during the next quarter-century confusion existed over the distinction between laryngofissure and vertical hemilaryngectomy. During that time, immediate and long-term survival rates of these procedures were low.

The beginning of the twentieth century witnessed a clearer distinction between vertical hemilaryngectomy and laryngofissure. Themistokles Gluck led the work in this area (1903). Gluck developed the true vertical hemilaryngectomy, but the popularity of this procedure was still low because it was staged and the incidence of recurrence was high.

World War II marked a turning point in the development of the vertical hemilaryngectomy (Clerf, 194). It became a single-stage procedure, and early reconstructive refinements were introduced (Norris, 1958). Increased knowledge of tumor behavior improved survival.

In the past 20 years the hemilaryngectomy has been extended, and now as much as 75% of the larynx may be resected and reconstructed. More recent refinements in reconstruction have focused on improving voice, respiration, and deglutition.

Supraglottic laryngectomy had an inauspicious beginning in the hands of Astley Cooper. Reportedly, in the first part of the nineteenth century he removed a large epiglottis tumor with finger dissection (Alberti, 1975). Over the next 100 years others used more sophisticated approaches. The combined effects of improved techniques, increased knowledge of tumor behavior, and advances in overall patient care after World War II produced acceptable survival and functional results. Professor Justo M. Alonso, of Montevideo,

Uruguay, was a pioneer who devoted his professional life to the development of techniques for resection of supraglottic tumors (Alonso and Jackson, 1952). His publications provided a foundation for Som, Ogura, and Bocca, who refined the procedure and extended it for larger tumors.

Concervation Surgery Versus Radiotherapy

During the developing years of conservation surgery, radiotherapy was in a primitive state. Today, however, with the variety of radiation sources and sophisticated simulation techniques, many observers believe that the majority of limited lesions are best treated with radiotherapy. Published results from the major irradiation oncology centers in the USA are impressive (Dickens et al, 1983; Million and Cassisi, 1981; Wang, 1983). Survival figures are comparable to those achieved with surgery, and the added benefit is better preservation of function.

This situation, however, is less straightforward than it appears (Schechter, 1984; Thawley and Ogura, 1979). Radiotherapy requires well-trained therapists, expensive equipment, and prolonged patent contact. Many patients do not have access to the few irradiation oncology centers that can produce the most successful results.

Of the 10.000 to 12.000 patients whose laryngeal cancers are diagnosed each year in the USA, some are clearly irradiation candidates, whereas others are candidates for a conservation surgery approach (Lawson and Som, 1975). The patients in the "gray zone" are those whom the otolaryngologist - head and neck surgeon must evaluate carefully, using his or her skills as a total physician. The following questions should be asked in deciding whether to use radiotherapy or conservation surgery:

1. Is the patient's lesion amenable to the proposed primary therapy?

2. Is the patient a good medical candidate for the proposed therapy?

3. Is the patient able to afford the proposed treatment and prepared for its effects?

4. Does the patient have any biases, based on previous experience, towrd the proposed therapy?

5. Is the therapist or surgeon skillful and experienced enough to produce the results predicted to the patient?

As with all therapeutic challenges in medicine, the physician is ultimately faced with making a choice and must do this with the help of the patient. He or she must react in a responsible fashion and not use a "cookbook" method of determining treatment. Each patient must be evaluated individually, and the treatment plan should be based on personal and medical factors, gross and microscopic pathologic findings, and expertise of the available therapists.

Basic Concepts

The unique embryology, compartmentalization of the larynx, and growth pattern of laryngeal cancer are the foundation for the principles of conservation surgery of the larynx (Silver, 1981). The larynx develops from three branchial arches. Supraglottic structures are derived primarily from the fourth arch, with the superior aspect related to the third arch. The glottis, cricoid cartilage, and subglottic areas arise from the sixth arch. This multiple-arch derivation results in horizontal segmentation of the laryngeal structures. Vertical segmentation exists as well because each half is paired from the respective arches.

The horizontal and vertical segmentation is significant because it provides intralaryngeal and extralaryngeal separation of the lymphatic drainage (Fig. 115-1). Supraglottic structures drain to the superior deep cervical lymph nodes, and glottic and subglottic structures drain to the juguloomohyoid and inferior deep cervical lymph nodes. The apex of the piriform fossa (its most inferior portion) is on the same plane as the glottis and drains to the juguloomohyoid and inferior deep cervical lymph nodes. Surface lymphatic vessels of the mucosa freely connect between the sides, but little connection exists between the lymphatic drainage of the glottic and supraglottic structures. The deeper submucosal lymphatic vessels remain in compartments according to the vertical and horizontal segmentation mentioned previously.

The glottic region is relatively free of lymphatics. This is particularly true in the membranous true vocal cords within the mucosa and Reinke's space. Lateral to the vocal ligament and arytenoid, the muscular compartments are more vascular and contain significant numbers of lymphatic channels. The concentration of lymphatic vessels increases toward the posterior one third, around the arytenoids and the interarytenoid space.

The anterior commissure must be considered separately (Bagatella and Bignardi, 1983). There is no internal perichondrium of the thyroid cartilage at this point, and the submucosa is closely applied to the cartilage (Fig. 115-2). Anterior commissure cancers readily extend to the cartilage and inferiorly to the cricothyroid membrane. Here, the soft tissues and overlying Delphian lymph node may be involved.

The significant anterior relationship of the supraglottic structures is the preepiglottic space (Fig. 115-3). This is bounded by the upper half of the thyroid cartilage, the thyrohyoid membrane, the thyroepiglottic ligament in the base of the vallecula, the infrahyoid portion of the epiglottis, and the thyroepiglottic ligament inferiorly. This space contains fibrofatty tissue and is rich in lymphatic vessels.

The most common malignant tumor of the larynx, epidermoid carcinoma, grows slowly in known patterns. In the majority of cases the tumor is moderately to well differentiated and has clearly defined margins of growth. This, along with the distinct compartmentalization of the larynx mentioned previously, permits "millimeter surgery". This concept is seen most clearly with epiglottic cancers. Supraglottic laryngectomy may be performed even with tumor extending to within 3 to 4 mm of the anterior commissure and ventricle. Glottic cancers can be resected with only 2 to 3 mm of anterior or posterior margin on either side. Exceptions to this are when the tumor's growth pattern shows infiltrating margins or when multicentric disease is present (Bauer et al, 1975).

Patient Evaluation and Selection

Patient evaluation and selection have two aspects (Leonard and Litton, 1969). The first involves the lesion and whether or not it qualifies for a conservation surgical procedure. The second relates to the general qualification of the patient for conservation surgery. The two evaluations are carried out simultaneously.

Evaluation of the laryngeal lesion starts with the initial examination. At this time observations are made for vocal cord mobility, pooling of secretions, aspiration, presence or absence of lymph nodes, and general dynamics of the lesion. A radiologic evaluation follows this evaluation.

In the past two decades, radiologists have taken the laryngeal evaluation through several stages, including soft tissue radiographs and laminograms, positive-contrast laryngography, polytomography, and xeroradiography. Each stage added a new dimension to the evaluation, but computed tomography (CT), CT scanning, and magnetic resonance imaging (MRI) have now replaced these earlier attempts at tumor definition. Enhanced high-resolution CT scans and/or MRI scans of the larynx and neck are recommended in all cases before endoscopy.

Medical evaluation

Patients with suspected cancer of the larynx should have a thorough medical evaluation before direct endoscopy and definitive planning for treatment. An internist who is familiar with the problems of conservation surgery and has a strong backgroung in pulmonary medicine is an essential member of the team. The surgeon should be an expert in the peculiarities of patients and their medical diseases as they relate to the treatment of head and neck cancer.

Three general disease categories most affect the treatment of patients being considered for conservation surgery: metabolic, cardiac, and pulmonary. Many of these patients have nutritional disorders and are alcoholics. Nutritional assessment is an essential part of the initial evaluation, and definitive treatment should be delayed until deficits are corrected. Improvement in liver function is an important part of reversal of nutritional problems and may play a vital role in the postoperative healing and function of patients who have conservation surgery, as has been shown in patients undergoing reconstruction with flaps, grafts, and stomach tissue (Schechter, 1983a; Schechter et al, 1982).

The patients' cardiac status is evaluated from the aspect of general anesthesia and any planned endoscopy, but consideration is also given to the stresses of prolonged surgery and the specific demands of conservation surgery.

Pulmonary function evaluation must relate specifically to conservation surgery (Murray, 1976). The guidelines are not well defined. Flow loop studies are conducted in addition to standard static and dynamic function tests to determine whether upper airway obstruction is affecting the situation. Patients with pulmonary function less than 50% of predicted normal should not be considered for conservation surgery of the larynx. Those in the borderline are of 50% to 65% of predicted normal may be considered if they have

historical indications of better function. Reviewing daily work and leisure habits with the patient and family is essential in these cases. Ultimately the practical "stair test", mentioned in the personal teachings of Ogura, should be used. This involves walking a patient down a hallway and up a flight of stairs at a slow but steady pace and without stopping. The patient who stops or becomes breathless is a poor candidate for conservation surgery of the larynx.

The patient's age should not be considered a factor until the overall evaluation is completed. Conservation surgery of the larynx can be successful in elderly patients; their physiologic and psychologic functions are the important factors, not their chronologic age (Tucker, 1977).

Speech therapists are an important part of the rehabilitation team. Special training in swallowing therapy is essential in working with conservation surgery patients. The speech therapist should review the barium swallow result preoperatively to determine whether a special swallowing study is necessary for delineating preexisting swallowing problems. Long-standing articulation problems may play a major role in posttreatment fluency and discimination (Rizer et al, 1984). Postoperative voice recordings and overall assessment of speech, voice, and swallowing functions are useful to rehabilitation. Special strategies are necessary to rehabilitate patients who have had hemiglottic or supraglottic laryngectomies. Involvement of the speech therapist also indicates to the patient that the surgeon is concerned about voice, communication, and swallowing needs.

Radiographic evaluation

A chest radiograph and barium swallow are necessary parts of the evaluation to rule out other primary lesions or metastases. The bariums swallow may also detect preexisting problems with deglutition at the upper and lower esophageal sphincters, primary esophageal motor disorders, and hiatal hernias with reflux. The presence of any of these conditions preoperatively must be accounted for in the postoperative rehabilitation period. This is important information in determining the eligibility of patients for conservation surgery of the larynx because of the marked alterations in deglutition this surgery produces (Flores et al, 1982).

During direct endoscopy the patient must have general anesthesia with total paralysis. This state enables the endoscopist to manipulate the laryngeal structures and accurately map the lesion. A complete examination of the laryngopharynx and postcricoid area is conducted initially with an easily manipulated instrument such as the Holinger anterior commissure laryngoscope. Microlaryngoscopy is then performed with a large operating laryngoscope, such as the Dedo or Jako. This magnification allows close evaluation of the mucosa for evidence of multifocal disease and more exact margins. Biopsy samples of the primary and suspicious areas should be taken at the leading edges. Small or superficial lesions limited to the true vocal cords should be stripped completely, because this may become part of the primary therapy plan if pathologic analysis indicates complete removal.

Panenedoscopy (laryngoscopy, esophagoscopy, and bronchoscopy) is not necessary in all cases. It is certainly not required when the patient has a small intrinsic laryngeal lesion and results of the barium swallow and chest radiographs are negative. Piriform fossa lesions, however, should be evaluated by laryngoscopy and flexible fiberoptic esophagoscopy to

esnure that a second primary or "skip area" is not present. Likewise, any evidence of pulmonary involvement should be investigated with flexible fiberoptic bronchoscopy and washings submitted for bacteriologic and cytologic examination.

Conservation Surgery of the Glottal Region

The most common cancer of the larynx involves the glottis and is associated with hoarseness as an early symptom. Increased public awareness of cancer and its symptoms has resulted in the management of a greater percentage of early cancers of the glottis.

Cancer of the glottis is the most curable of the laryngeal cancers. It is also the most salvageable when initial treatment fails. This, of course, depends on careful follow-up observation.

Membranous true vocal cord

Vocal cord stripping

The ealiest cancers of the true vocal cord are carcinoma in situ and microinvasive carcinoma. These usually involve the membranous portion of the cord. They may coexist with areas of keratosis, keratosis with atypia, and gross invasive carcinoma. Thus the surgeon must approach the biopsy of these lesions prepared to make a thorough microlaryngoscopic evaluation and to perform complete vocal cord stripping (Bailey, 1980; Miller, 1970; Schechter, 1978; Stutsman and McGavran, 1971). Evaluation by a competent pathologist is essential when the surgeon is dealing with very early and superficial lesions.

The technique for complete vocal cord stripping involves a sequential approach to the three surfaces of the cord. Initially the free edge of the cord is grasped 1 mm posterior to the anterior commissure with an upbiting microlaryngeal forceps. The forceps is then rotated 180 degrees on its axis away from the cord. This produces a clean cut in the mucosa and prevents inadvertent stripping of the anterior commissure. The stripped mucosa is then separated from the underlying vocal ligament by pulling the forceps cephalad or pushing it wodn into the subglottic area. The ease with which the mucosa is pulled away from the ligament may indicate whether invasion is present. The stripping is carried back to the vocal process.

A laryngeal microsuction is then placed on the ventricular surface of the cord, lateral to the vocal ligament. When it is pushed down on the body of the cord, the free edge rolls up toward the examiner, exposing the mucosa on the unfersurface for a similar stripping process. The ventricular surface of the cord is stripped with a straight forceps, grasping the mucosa anteriorly and then sweeping posteriorly. Vocal cords that have had previous stripping, laser treatment, or radiotherapy are not stripped easily and may require a piecemeal approach.

The strippings should be laid on a filter paper or pinned to a tongue blade and slowly immersed in fixation to prevent them from rolling up. This results in accurate sectioning within the paraffin block.

Once the diagnosis of carcinoma in situ or superficial cancer is established, the patient must be counseled. This includes informing the family of the significance of the findings, setting up regular visits for examination, and initiating aggressive steps to help the patient stop smoking.

Flexible fiberoptic or rigid fiberoptic laryngoscopy is performed monthly as part of the standard head and neck follow-up program. Any indication of thickening of mucosa or redevelopment of keratosis should be checked with repeat microlaryngoscopy and stripping. Videostroboscopy may be helpful in determining subtle changes in the cord as early keratosis, or recurrent superficial cancer, develops. Redevelopment of superficial cancer after two strippings is an indication for referral to radiotherapy for treatment. The use of lacer cordectomy, laryngofissure and cordectomy, or standard hemilaryngectomy as an alternative to radiotherapy depends on the patient's individual circumstances.

Surgical technique

Grossly invasive epidermoid carcinoma of the membranous true vocal cords that is treated surgically requires complete excision of the vocalis muscle. When cord movement is good and the lesion is limited to the midportion of the membranous vocal cord, peroral cordectomy with suspension techniques and the laser may be used (Shapshay et al, 1990). Laryngofissure with cordectomy allows more complete removal of the vocal muscle and the internal perichondrium (Daly and Kwok, 1975; Desanto et al, 1977; Lerous-Robert, 1975). These are good approaches from an oncologic standpoint if the lateral extent of resection is adequate. This is difficult to determine through the peroral route. Development of an adequate pseudocord by means of laryngofissure or laser cordectomy is unpredictable.

The standard hemilaryngectomy allows complete resection under controlled conditions (Mohr et al, 1983; Olsen and DeSanto, 1990; Silver, 1981), and one of several techniques may be used to encourage pseudocord development. The patient is placed under general anesthesia with deep muscle paralysis (Fig. 115-4). A collar incision extending to the external jugular veins bilaterally is developed, tracheotomy is performed, and anesthesia is maintained through an endotracheal tube in the tracheotomy site. The neck flap is elevated to a point above the hyoid bone. Direct palpation of the paralaryngeal and deep cervical lymph node areas is carried out, and lymph nodes suspected of involvement are removed for frozen section evaluation. A self-retaining retractor is positioned to hold the neck flaps in place while the strap muscles are separated in the midline from the level of the hyoid bone down to the thyroid gland. A midline incision is then made in the thyroid cartilage perichondrium and is extended laterally on the side of the lesion along the superior and inferior borders of the thyroid cartilage. The perichondrium is initially elevated from the cartilage by blunt dissection using a "peanut". The remaining elevation is carried back to the posterior border of the thyrid cartilage with a Freer or Cottle elevator. The perichondrium is then sutured to the overlying sternothyroid muscle with 4-0 plain catgut sutures to prevent separation from the overlying muscle. The thyroid cartilage is cut in the midline or in a contralatetral paramedian position, depending on tumor location. The posterior cut is made approximately 0.5 cm from the posterior border of the cartilage. A transverse incision is made in the the cricothyroid membrane, and the mucosa in the midline is held apart with single hooks. Using a headlight and a Kelly clamp, which is placed in the interarytenoid space, the surgeon separates the cords. A small knife blade is passed between the cords and drawn forward and upward to

sever the anterior commissure and separate the false vocal cords. The midline cut is drawn up to the petiole of the epiglottis.

Once the larynx is opened completely, the lesion is visualized and the remaining mucosal incisions are outlined with electrocautery. The inferior margin must be at least 1 cm below the free margin of the cord to encompass the vocal muscle and is usually greater to provide a tumor margin. The posterior margins should be 3 to 4 mm posterior to the tumor and may be across the vocal process. The superior margin is above the free edge of the false vocal cord. These cuts are completed, starting with the inferior margin. Heavy curved Mayo scissors are used, and the cut is extended back to the planned posterior line of resection. A similar cut is made along the superior border of the thyroid cartilage, extending approximately two thirds of the way back to the posterior margin. The cut is not completed at this time to prevent premature severing of the superior laryngeal neurovascular pedicle. A right-angle scissors are used to make the posterior margin cut, starting inferiorly. This cut leaves the specimen attached by the neurovascular pedicle, which then may be dissected out, ligated with suture, and severed.

General hemostasis is then achieved with clamps and cautery in the muscle bed posteriorly, and a suction cautery is used along the mucosal edges. The petiole is drawn upward to prevent the epiglottic from healing into the resectin bed at the level of the glottis. This is accomplished by passing a 2-0 chromic suture on a large, curved needle down through the dense fibrous tissue under the hyoid bone in the midline, through the petiole, and then back up through the petiole and out the same area under the hyoid bone. Once this suture is tied, the petiole is elevated up toward the hyoid bone. The strap muscles are reapproximated, using absorbable suture with the external perichondrium patch opposite the remaining true vocal cord. Because of the absence of cartilage, the perichondrium-muscle combination collapses inward, forming a pseudocord. Other techniques of pseudocord formation may be used, including the bipedicled muscle flap laryngoplasty, free muscle implant, and hemi-epiglottis reconstruction. These are discussed later in the chapter. The wound is then irrigated, drained, and closed in a routine fashion, and a tracheotomy tube is placed.

In most cases the cannula can be removed in 3 to 5 days. Oral feedings may then be started as outlined later in this chapter in the section on oral rehabilitation.

Arytenoid, anterior commissure, and contralateral cord involvement

Extensions of the standard hemilaryngectomy are necessary when the tumor involves adjacent areas (Biller et al, 1971). Each extension requires a small change in the resection technique. However, a specific reconstructive effort to enhance voice production and prevent aspiration must accompany this change.

Arytenoid

Tumor at the arytenoid is not an absolute contraindication to hemilaryngectomy (Biller and Som, 1977; Sessions, 1980; Som, 1975). A good tumor margin is possible if the involvement is limited to the vocal process and anterior half of the arytenoid body. If the entire body is involved or vocal cord fixation exists, the surgeon must assume that tumor is in the lateral muscle areas, which are rich in lymphatic channels. This situation makes

developing an accurate deep tumor margin less likely (Kirchner and Som, 1981b; Lesinski et al, 1976).

Surgical technique. Removal of the arytenoid during hemilaryngectomy is accomplished by extending the inferior cut along the superior border of the cricoid cartilage to the cricoarytenoid joint. Here the vocal process alone, the anterior half of the body, or the entire arytenoid may be removed. If the body of the arytenoid must be taken, in whole or part, a generous amount of lateral muscle should be included to ensure removal of tumor that might have extended along the lateral muscular planes.

Reconstruction. Removal of the vocal process usually does not require extra reconstructive effort other than the attempt to improve voice by laryngoplasty. Partial or complete removal of the arytenoid body, however, does necessitate reconstruction to prevent aspiration.

Several methods are available for reconstructing the arytenoid area, and they all improve pseudocord formation anteriorly as well. The bipedicled muscle flap has been extensively investigated (Bailey, 1975). It provides varying amounts of well-vascularized tissue that can be used to fill in the arytenoid defect, and it helps develop a good anterior pseudocord. When this technique is used, the external thyroid perichondrium is elevated, severed from the posterior thyroid lamina, and sutured to the undersurface of the sternothyroid muscle (Fig. 115-5). At least two thirds of the thyroid cartilage and lamina must be retained to hold the bipedicled flap within the lumen. If an arytenoid defect exists, suturing of the posterior border of the bipedicled muscle flap into the arytenoid bed is advisable to ensure that the muscle bulk is where it is needed.

Other methods for arytenoid replacement include free and pedicled muscle insertion, omohyoid musculoosseous insertion, and posterior thyroid cartilage-inferior constrictor muscle laryngoplasty (Biller and Lucente, 1979; Blaugrund and Kurland, 1975; Dedo, 1975; Park et al, 1982; Quinn, 1975).

Anterior commissure

Involvement of the anterior commissure, as a primary site of tumor or as an extension from a primary true cord lesion, necessitates removal of the central thyroid cartilage and cricothyroid membrane (Bailey, 1971; Blitzer et al, 1980; Kirchner and Som, 1975). This is known as a frontal or frontolateral hemilaryngectomy. It results in loss of anterior support as well as decreased anteroposterior diameter of the laryngeal lumen. The larger and deeper larynx in men can tolerate this loss more easily than the small, broad larynx in women. In either sex it is recommended that attempts be made to reconstitute this anterior angle and maintain the anteroposterior diameter.

Reconstruction. Efforts to reconstruct the anterior commissure have been based on use of cartilage and bone grafts, skin or mucosal grafts, skin flaps, keels, and stents. These approaches have limited success and require multiple procedures. However, the epiglottic reconstruction technique (Fig. 115-6) offers many advantages because it has a single stage, produces a mucosa-lined lumen, and provides excellent support (Schechter, 1983b; Thawley, 1983; Tucker et al, 1979). It may be used for defects ranging from single-cord excision,

requiring only half of the epiglottic, to near-total or subtotal laryngectomy. In the latter case the entire epiglottis is used and only a contralateral arytenoid remains after resection.

Postoperative alimentation

Alimentation may be a problem after extended hemilaryngectomy. Not feeding the patient until the tracheotomy tube is removed is preferable. This may mean waiting 10 to 14 days. When this length of time is involved, cervical esophagostomy, or percutaneous esophagogastrostomy (PEG), is recommended in preference to insertion of the standard nasogastric tube. Either of these methods allows a more deliberate and less hurried approach to oral rehabilitation. The cervical esophagostomy can be placed by the head and neck surgeon at the time of the primary surgery. The PEG can likewise be placed at the time of primary surgery or as part of the preoperative staging endoscopy. With the feeding tube in place, oral rehabilitation can be delayed and the patient sent home for more complete overall recovery. This is a good philosophy to follow for almost all patients who have undergone extensive conservative surgery.

Results

Complications

The complication rate for conservation surgery procedures in the glottal region depends on the extent of surgery (Yonkers, 1983). When dealing with superficial lesions, the surgeon finds voice changes with varying degrees of hoarseness the rule (Moore, 1975). Aggressive bilateral vocal cord stripping or laser therapy may result in anterior web formation. This is preventable if aggressive stripping and laser work are limited to the membranous cord and the anterior commissure is protected. Scarring of Reinke's space, with resulting poor mobility and atrophic overlying mucosa, is a normal sequela of aggressive stripping and laser therapy.

Hemilaryngectomy complications include wound infection, fistula formation, laryngeal granulations, stenosis, glottic incompetence, aspiration, and chronic pneumonia. The incidence of glottic incompetence and aspiration varies with the extent of arytenoid resection and the success of reconstruction (Di Santis et al, 1983; Padovan and Oreskovic, 1975; Schoenrock et al, 1972; Sessions et al, 1975; Ward et al, 1977). In the more aggressive or extended hemilaryngectomy procedures, a thin line exists between glottic incompetence and glottic stenosis. The patient may have to choose between a good voice and the ability to breathe through the larynx. No choice exists when glottic incompetence with aspiration is present. Although as many as 20% of patients have some degree of aspiration after hemilaryngectomy, it is usually mild and is not a major problem after the first 6 to 9 months.

Secondary reconstruction, using cartilage or muscle implants, may successfully correct glottic incompetence, but often cartilage resorption and muscle atrophy make these techniques temporary answers to the problem. Synthetic fluorine-containing resin (Teflon) injection into the inadequate pseudocord is usually unsuccessful because excessive scar tissue is present. Recent evidence indicates that collagen II may provide enhancement of the pseudocord with repeated injections (Ford and Bless, 1986). Completion laryngectomy is necessary when these efforts fail.

Prognosis

Cure rates based on the tumor, node, metastasis (TNM) classification are difficult to report and to compare because of changes in the system over the past 10 to 15 years (Ogura et al, 1975b; Skolnik et al, 1975). The inclusion of carcinoma in situ as a separate classification has improved the system, but the broad range within the T1 classification still leads to confusion. Only exact descriptions of the locations and degree of invasion permit accurate comparisons of treatment.

The reported survival results for carcinoma of the glottis, treated by conservation surgery techniques, depend on the extent of tumor and location in the glottal region. Lesions of the membranous true vocal cord have the best prognosis, whereas those of the arytenoid body and anterior commissure are less favorable. Superficial cancers and carcinoma in situ that are amenable to treatment by aggressive stripping, and are therefore limited to the membranous cord, may be cured in more than 90% of cases (Bailey, 1980; Miller, 1970). Failures usually occur in patients who have poor follow-up observation, multifocal disease, continued heavy smoking, or extensive invasion of Reinke's space.

T1 lesions of the vocal cord, treated by hemilaryngectomy, have a better than 90% 3- to 5-year cure rate. Patients with lesions of the true vocal cord that involve the anterior commissure or arytenoid and that require extended hemilaryngectomy are reported to have 5-year cure rates of 70% to 85%. Fixation of the cord, T3 classification, is associated with a cure rate in the 40% to 60% range. Lesions confined to the anterior commissurre requiring frontal hemilaryngectomy resection are associated with a 70% to 75% cure rate.

Salvage treatment may be successful when initial attempts at conservatin surgery have failred (Myers and Ogura, 1979). Radiotherapy or hemilaryngectomy should result in cures in more than 90% of patients with recurrent superficial or grossly invasive lesions of the membranous cord. In patientss whose cancer recurs after hemilaryngectomy or after any of the extended procedures, total laryngectomy (conversion laryngectomy) may still hold the overall cure rate in the 80% range. Radiotherapy may be attempted in patients with total laryngectomy used for salvage (Lee et al, 1980).

Conservation Surgery of the Supraglottic Larynx

Carcinoma of the supraglottic structures produces vague symptoms that are hard for both the patient and general physician to interpret. Therefore, these lesions are often diagnosed later in the course of disease. The patients complain of pain on swallowing, fullness in the throat, and pain referred to the ear. Hoarseness, or a muffled voice, occurs after significant tumor progression.

The supraglottic structures do not present immediate barriers to tumor invasion from the mucosa, as is seen in the glottal region (Kirchner and Som, 1971a; McDonald et al, 1976). The surgeon must assume that the preepiglottic space has been invaded by cancers of the epiglottis, particularly those occurring at a level below the hyoid bone. If any question exists concerning the preepiglottic space, fine needle aspiration (FNA) may be used during endoscopy or transcutaneously. Suprahyoid epiglottic cancers may extend through to the lingual surface only, but cancers of the false vocal cord and arytenoids usually involve the

deep soft tissues, muscle, and glands. Because little compartmentalization exists within the supraglottis, limited resection of parts of the region is not advised.

This discussion is limited to cancers of the laryngeal surface of the epiglottis. Involvement of only the suprahyoid epiglottis is uncommon. When it does occur, epiglottectomy through an anterior transhyoid approach may be used. Very small lesions of the epiglottic tip may be removed by suspension laryngoscopy and laser, but bleeding may be a significant problem. Most epiglottic cancers are large and bulky and require supraglottic laryngectomy for removal.

Surgical technique

The standard supraglottic laryngectomy (subtotal supraglottic laryngectomy, horizontal hemilaryngectomy, or supraglottic hemilaryngectomy) is performed after the laryngeal and paralaryngeal regions are exposed (Schechter, 1973; Som, 1959) (Fig. 115-7). A wide collar incision may be used, but neck dissection is commonly performed, and lateral incisions, such as the half-H or apron flap, are necessary.

Once the larynx is exposed, incisions are made in the strap muscles at the superior border of the thyroid cartilage. The perichondrium of the thyroid cartilage is then incised along its superior border. It is elevated by blunt dissection with a "peanut" and sharp dissection with a Freer elevator. Cartilage incisions are outlined with a marking pen. These incisions extend laterally from a point halfway between the deepest recesses of the superior and inferior thyroid notches, which marks the anterior commissure attachment. In the smaller larynx of a woman this point should be 1 mm above the midpoint. The size and location of the lesion determine the lateral directions of the cartilage incisions, which should be at least at the level of the true vocal cords. In youngers patients the cartilage cuts may be carried out with a large knife blade, but an oscillating saw is necessary in older patients with ossified cartilage.

The hyoid bone is skeletonized on the side of the lesion and transected across the lesser horn on the contralateral side. If no gross invasion of the preepiglottic space is present, the body of the hyoid may be saved by dissecting under the periosteum and leaving it with the attached omohyoid, hyoglossus, and geniohyoid muscles. This will act as a good point for anchoring the inferior thyroid cartilage remnant and maintaining the hyomandibular complex for deglutition. The ipsilateral piriform fossa is then exposed by cutting through the inferior constrictor muscle up to the hyoid bone. The hypopharynx is entered, and the base of tongue is retracted superiorly. This exposes the epiglottis, which is grasped with a tenaculum. Appropriate scissor cuts are made into the aryepiglottic folds anterir to the arytenoids. At this point the patient must be completely paralyzed, and head-light illumination is desirable. If the aryepiglottic fold or arytenoid is involved, the mucosal incisions must be modified accordingly. The incisions are then extended down into the ventrices just above the true vocal cords, and the intrinsic laryngeal and extrinsic cartilage cuts are connected by incising the intervening tissues. Anteriorly, care must be taken to prevent detaching the anterior commissure from the thyroid cartilage.

Cricopharyngeal myotomy is accomplished by placing the surgeon's finger through the sphincter and cutting through the muscle over it. A number 18 feeding tube is then placed through the pharyngotomy into the esophagus as a guide, and a cervical esophagostomy is performed. The feeding tube is directed up from the esophagostomy site through the strap muscles to ensure interposition of muscle between the tube and the carotid artery. Care must be taken to prevent injury to the recurrent laryngeal nerve.

The pharyngotomy is then closed by interrupted non-absorbable sutures. Placing a pursestring suture at each end of the pharyngotomy opening is sometimes beneficial. The intervening sutures are placed from a point 1 cm proximal to the lingual mucosa down through the previously elevated perichondrium of the thyroid cartilage. All of the sutures are placed before they are tied. Tying is made easier by flexing the patient's head to relieve suture line tension. A second layer of muscle closure may be attempted. The wound is drained and closed in a routine fashion.

Postoperatively the patient is encouraged to maintain a flexed head position for 2 weeks. This is facilitated by placing a small, firm pillow or rolled sheet under the occiput.

Tube feedings are usually started on the second postoperative day. The decannulation procedure is performed between the seventh and tenth postoperative days. Although many surgeons attempt oral feedings at this point, my policy is to send the patient home receiving esophagostomy feedings after decannulation and to start the oral rehabilitation routine when the patient returns for follow-up examination. This schedule is less traumatic to the patient and has been far more successful than forcing the issue in the hospital immediately after surgery and decannulation.

Arytenoid involvement

Epiglottic lesions that extend to the arytenoid are treated by including arytenoidectomy with the supraglottic laryngectomy (Ogura et al, 1975a). This is accomplished by incising the interarytenoid mucosa and muscle down to the superior border of the cricoid cartilage. The incisions are then extended laterally through the cricoarytenoid joint on the involved side and then anteriorly and superiorly across the vocal process. The remainder of the supraglottic laryngectomy is carried out as previously outlined. The transected vocal cord is reconstructed by suturing the vocal process to the cricoid cartilage in the midline with a slowly absorbed suture (Ogura and Thawley, 1978). The goal is to provide a fixed cord against which the mobile cord may close. The patient must have good pulmonary reserve to be rehabilitated after this intricate reconstruction.

Results

Complications

Complications occur in approximately 10% of supraglottic laryngectomies. Wound infections or fistulas are reported in 2%, airway obstruction in 2.5%, aspiration in 4%, and pneumonia in 1.5%. Aspiration and pneumonia are more often associated with the rehabilitation phase (Flores et al, 1982; Klein et al, 1977), and the incidence is probably higher than reported in association with surgical series.

Chronic aspiration must be investigated by barium swallow with cinefluoroscopy and by direct endoscopy. Glottic insufficiency may be corrected with synthetic fluorine-containing resin (Teflon) injection or cartilage implantation. Failure of the larynx to elevate toward the tongue base is one of the most common causes of aspiration. Attempts to prevent this by suspension at the time of surgery (Calcaterra, 1976; Goode, 1976) and to correct it after surgery are not always successful. Preoperative or postoperative radiotherapy may aggravate the problem. Conversion laryngectomy is sometimes necessary.

After supraglottic laryngectomy the voice is usually good, and only a minor increase in the fundamental frequency is noted. Occasionally hoarseness results from chronic edema of the true vocal cords. This problem is probably caused by decreased lymph drainage resulting from radiotherapy or neck dissection.

Prognosis

Because these are T1 and T2 lesions, the probability of survival after conservation surgery for supraglottic cancer is generally good (Bocca et al, 1983; De Santo et al, 1977; Ogura et al, 1975c). Patients with lesions not associated with lymph node metastasis have a 75% to 80% 3- to 5-year survival rate, which drops to 60% with lymph node metastasis. Overall failure is greater in the neck than at the primary site. When local recurrence occurs, conversion laryngectomy is indicated.

Extended Supraglottic Laryngectomy

The basic supraglottic laryngectomy may be extended for the less common and aggressive cancers of the vallecula, aryepiglottic fold, and piriform fossa (Ogura et al, 1975d). These lesions are more lethal because they occur in areas where compartmentalization is not present and are more deeply invasive than their surface presentation would indicate. Therefore, they must be removed with abundant margins, including the surrounding supraglottic structures.

The criteria for qualification of patients for extended supraglottic laryngectomy are more rigid. These procedures are associated with a greater incidence of wound problems and postoperative aspiration. Generally, performing them in younger patients who are in good nutritional condition and who have near-normal pulmonary function is preferred.

Vallecula and tongue base

Cancers of the vallecula and adjacent tongue base are resected by including this area with a standard supraglottic laryngectomy. The superior line of resection must be made across the tongue after all other incisions are completed. This margin should be at least 2 cm anterior to the palpable edge of the tumor. Making this determination is often difficult because of the nodular character of the tongue base and because cancers in this area infiltrate deeply. The limit of resection that will allow a functional tongue is at the circumvallate papillae.

Resection of the aryepiglottic fold requires that the supraglottic laryngectomy be extended to include complete arytenoidectomy, as described previously, and the upper half of the piriform fossa (Ogura et al, 1975d). The latter requires that the ipsilateral cartilage cut extend from the midpoint inferiorly toward the cricothyroid articulation.

Piriform fossa

Primary cancer of the piriform fossa usually is manifested late in the course as an advanced lesion (Eisbach and Krause, 1977; Kirchner and Owen, 1977). When the cancer is discovered early, the endoscopic evaluation is critical in determining whether partial laryngectomy can be used (Ogura et al, 1980). Important features of the radiologic evaluation also need emphasis.

Demonstrating the inferior extent of a bulky lesion of the piriform fossa is difficult radiographically, and a false impression of greater involvement may be obtained. This results from the inability to coat the inferior surface of the lesion adequately with contrast material. A high-resolution CT scan or MRI may be helpful in demonstrating involvement of the inferior extent of the piriform fossa or apex. In addition, the surgeon must look for ipsilateral subglottic edema, which indicates lymphatic involvement of the inferior piriform fossa.

The anterior commissure laryngoscope is best suited for evaluation of the piriform fossa apex. It should be inserted into the postcricoid area via the contralateral piriform fossa, rotated to the side of the lesion, and slowly withdrawn. The spatulalike anterior surface helps raise the lesion and demonstrate the apex. If at least a 2-cm margin from the gross lesion can be achieved by cutting through the piriform apex, a conservation approach may be used (Fig. 115-8).

The conservation surgery procedure for piriform fossa cancer is called partial laryngopharyngectomy. This is actually a supraglottic laryngectomy extended to include the ipsilateral arytenoid and the entire piriform fossa. Midline fixation of the vocal cord remnant is essential, and the pharyngotomy opening, which is larger than in a supraglottic laryngectomy, must be closed with a vertical and a horizontal limb.

The supracricoid laryngectomy with cricohyoidoepiglottopexy may be used in selected cases of inferior supraglottic carcinomas with or without true vocal cord involvement (Laccourreye et al, 1990a). This same technique may be employed for epidermoid carcinomas of the true vocal cord that extend superiorly toward the epiglottis and false vocal cords (Laccourreye et al, 1990b).

Results

Complications

Complications, such as fistulas and infection, occur more often with extended supraglottic laryngectomies and partial laryngopharyngectomies than with the standard supraglottic laryngectomies. These may result from the greater amount of hypopharyngeal tissue that is resected. A planned fistula is recommended when there has been previous irradiation. Decannulation is often delayed by increased intralaryngeal edema. This is

particularly true when a surgically fixed vocal cord remnant exists.

Long-term complications related to deglutition and aspiration also occur more frequently in these patients than in those who have had supraglottic laryngectomies. They result from the marked alterations in the anatomy of the piriform fossa and postcricoid area. Examples of this are obliteration of the piriform fossa, decreased laryngeal mobility, cricopharyngeal stenosis, and inadequate vocal cord fixation. Some of these may be managed with dilations and with the passage of time. Glottic insufficiency should be treated by an attempt at repeat fixation of the cord in the midline or cartilage implantation. Synthetic fluorine-containing resin (Telfon) paste injection rarely helps.

Prognosis

In patients with limited superior hypopharyngeal lesions (T1 or T2) who are treated by conservation surgery with ipsilateral neck dissection and planned radiotherapy, the 5-year survival may be as high as 60%. Recurrent disease in this group of patients usually requires aggressive surgery, such as pharyngolaryngoesophagectomy, for salvage.

Oral Rehabilitation Procedures

The success of oral rehabilitation after conservation surgery of the larynx depends on the amount of tissue removed and the overall condition of the patient. The lesion determines the extent of resection. Each patient has a different response to the surgery and recovers at his or her own pace. Therefore, starting oral rehabilitation at a predetermined time in every patient is not good policy.

Removal of the patient's tracheotomy tube before oral rehabilitation begins is important, and the time this occurs depends on when the laryngeal airway is open. Closure of the tracheotomy tube site allows the development of adequate subglottic pressure and upward migration of the larynx during deglutition, both of which help prevent aspiration.

As mentioned previously, I believe that all of the complicated conservation surgery procedures, such as extended hemilaryngectomy, supraglottic laryngectomy, and partial laryngopharyngectomy, should include feeding esophagostomies or placemenet of a PEG. Postoperatively, these patients are given plain water followed by skim milk and then commercial tube feeding formulas as soon as they show evidence of gastrointestinal function. This usually occurs on the second or third postoperative day. They are discharged from the hospital 24 to 48 hours after successful removal of the tracheotomy tube. An occasional patient is discharged with the tracheotomy tube in place.

The first follow-up visit occurs 1 to 2 weeks after discharge from the hospital, which is usually approximately 1 month after surgery. At this time instructions for oral rehabilitation are given to the patient and family. The patient is allowed to try ice cream, iced carbonated beverage, and cold juice. The presence of the surgeon and nurse during the first attempts gives the patient some security.

The complete list of foods to be tried initially is discussed with the patient and family and includes beverages and semi-solid foods with extremes of temperature, taste, and texture. These foods, which take advantage of the remaining special and general sensory innervation of the patient's oral cavity and pharynx, include cold carbonated beverages, hot coffee or tea with sugar, cold coarse applesauce, hot puréed soup, ice cream, and cold custard. Forceful swallowing of normal mouthfuls of each is encouraged. The patient is discouraged from nibbling or using a straw and concentrates on the food or combination of foods that is best tolerated.

To guard against dehydration, intravenous fluid supplementation is continued for hemilaryngectomy patients in the hospital during the first 2 days of oral rehabilitation. Patients who have feeding esophagostomies and are at home are encouraged to keep water intake through the tube at a normal level and to supplement calories as needed. All patients are advanced to a soft diet according to their individual progress. The esophagostomy tube or PEG is removed after the patient demonstrates complete independence from tube feedings and when any planned postoperative radiotherapy is completed.

Neck Dissection and Conservation Surgery of the Larynx

The basic concepts of neck dissection are covered in Chapter 91. Application of these concepts to conservation surgical procedures of the larynx is based entirely on the known incidence of gross and microscopic lymph node involvement for the lesion under consideration. Neck dissection is rarely indicated for a lesion of the glottal region because the incidence of cervical metastasis is less than 5%.

Supraglottic lesions that are classified as T1 and T2 are associated with an incidence of cervical metastasis up to 50%. About half of these are occult. Ipsilateral neck dissection is recommended as part of the surgical treatment in association with supraglottic resections, except for patients with very small T1 suprahyoid lesions. The presence or absence of microscopic cervical metastasis is important in prognostication and in planning of subsequent radiotherapy to the neck bed and contralateral side.

Superior hypopharyngeal cancers are associated with a high incidence, 70%, of cervical metastasis, even when the primary lesion is small. Neck dissection is always recommended in these cases.

Radiotherapy and Conservation Surgery of the Larynx

Conservation surgery may be used in selected patients who have had primary radiotherapy and who have recurrence (Burns et al, 1979; Nichols et al, 1980; Sorenson et al, 1980). These patients must be chosen carefully. It is advisable to limit this approach to patients who have had accurate mapping of their lesions before radiotherapy, close follow-up observation, and early diagnosis of recurrence. Wound-healing problems and difficulties with oral rehabilitation must be expected when conservation procedures are performed on patients who have had a full course of radiotherapy.

Radiotherapy when conservation surgery has failed should be limited to patients who have positive findings on gross examination of the margins or who have early local recurrence (Lee et al, 1980). Recurrence in the operative site, however, is often camouflaged by the altered anatomy. The diagnosis is occasionally made after extensive infiltration of the remaining larynx and surrounding structures has occurred. Full-course radiotherapy to a laryngeal remnant with recurrent cancer often results in considerable edema, dysphagia, and airway obstruction. Therefore, in the cases of extensive and insidious recurrence or those with marked edema after radiotherapy, the preferred treatment is conversion laryngectomy.

Planned radiotherapy, in association with conservation surgery of the larynx, has been given a great deal of attention over the years. It is not considered in the treatment of cases of the glottal region. It is advocated by some for patients who have had supraglottic laryngectomy (Spaulding et al, 1989), but whether or not it decreases the incidence of local recurrence is controversial. Good evidence shows that planned postoperative therapy decreases the incidence of cervical metastasis and neck recurrence in larger supraglottic and superior hypopharyngeal lesions (Eisbach and Krause, 1977; Vandenbrouch, 1977).

Summary

Patients with laryngeal cancers limited to specific sites within the larynx may be treated with partial or conservation laryngectomy. The unique developmental anatomy of the larynx results in segmentation of the lymphatic structures and containment of early cancers. Careful evaluation of the patient and the lesion is necessary to determine eligibility for conservation surgery. Guidelines have been developed for performing partial resections of small lesions in most parts of the larynx. Specific reconstructive maneuvers are necessary to correct the resultant structural defects. The overall prognosis and functional results are good.