– CONSERVATION LARYNGEAL SURGERY

Chapter 46 – Endoscopic Laser Excision of Laryngeal Carcinoma

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Approximately 12,000 new cases of carcinoma of the larynx are discovered each year in the United States.[1] Slightly more than half originate on the true vocal cords (TVCs), and nearly all of the remainder originate in the supraglottis, with very few originating in the subglottis. Cancers arising in the supraglottis demonstrate a biologic behavior that is probably due to variability in embryologic development and lymphatic supply[2,3] and are therefore discussed in a different chapter.

Cancer of the glottis is nearly always squamous cell carcinoma (SCC) resulting from exposure to environmental carcinogens. Almost all patients with laryngeal cancer have a history of tobacco exposure. The causative relationship of tobacco use, particularly cigarette smoking, has been demonstrated clinically and has not been in serious dispute since the mid-1950s. Other probable causative factors include alcohol use, dietary factors, possibly exposure to petroleum products, and genetic predisposition. Chronic gastroesophageal reflux disease has been implicated by some authors.[4] Human papillomavirus (HPV) viral DNA has been found in a minority of laryngeal cancers. Interestingly, DNA analysis demonstrates that viral DNA is not as commonly incorporated into the host DNA in laryngeal cancer as it is in other HPV-related cancer, thus suggesting that HPV may be a “passenger” or function as a cofactor in carcinogenesis.[5]

SCC of the glottic larynx is a common malignancy of the head and neck in the United States and is one of the most curable cancers that head and neck oncologists treat. With the fortuitous development of early symptoms such as hoarseness, hemoptysis, or respiratory complaints, carcinoma of the glottis can be identified at a more curable stage. Another feature of the anatomy of the glottis is the paucity of lymphatic drainage relative to other laryngeal sites, which results in a low incidence of cervical metastasis. Studies by McGavran and colleagues[6] and Kirchner[2,7] have provided an anatomic explanation for local spread and for the very rare metastasis of isolated glottic SCC to the cervical nodal basin as compared with supraglottic and subglottic cancer. For these reasons, early carcinoma of the glottis (as well as selected, more advanced tumors) can often be treated with local surgical techniques performed mainly through the endoscope.[8–10]

PATIENT SELECTION

Microsurgical resection is ideally suited for unilateral (T1a) cancer because the uninvolved vocal fold does not sustain radiation damage and the involved vocal fold can be surgically rehabilitated. Glottic reconstruction can be accomplished through a combination of endoscopic injection medialization with fat or transcervical implant medialization, or both. Graded narrow-margin endoscopic microsurgical resection has the same cure rate as wider-margin resection[11]; however, the surgeon must be skilled in the approach. Involvement of the anterior commissure or vocal process of the arytenoid by T1 glottic cancer is not a contraindication to microlaryngoscopic resection.[12,13]

Staging

Staging of carcinoma of the glottis (Table 46-1) is accomplished by clinical assessment of tumor size, extent of local tissue infiltration, and nodal disease. Tis refers to carcinoma in situ that has not extended through the basement membrane of the epithelium. Infiltrating carcinoma involving the TVCs but without impaired mobility or extension above or below the level of the glottis is staged as T1. Microinvasion is common and constitutes a lesion in the spectrum between carcinoma in situ and true invasive carcinoma. Tumors that extend above or below the level of the TVCs and in which vocal cord mobility is not impaired are staged as T2 tumors. This stage includes tumors that extend only minimally to the subglottis at the anterior commissure and those with more extensive, but superficial supraglottic or subglottic extension. Cancer that invades the muscle of the TVC and results in fixation is staged as T3, and cancer that invades the laryngeal framework is staged T4. Although staging correlates well with patient survival and the feasibility of voice preservation, before the advent of modern imaging the error rate in clinical staging was nearly a third when compared with pathologic staging. Recent improvements in diagnostic imaging have reduced this error rate significantly, but the variable pattern of laryngeal cartilage ossification can lead to overstaging if based on loss of ossification. Understaging can be common if careful direct laryngoscopy is not performed with angled rigid endoscopes.[1] Indeed, for early glottic lesions, endoscopic excision at the time of staging laryngoscopy is often feasible and advantageous for the patient.

Table 46-1 -- AMERICAN JOINT COMMISSION FOR CANCER 2002 STAGING FOR GLOTTIC CARCINOMA OF THE LARYNX

T1	Limited to normal vocal fold mobility
T1a	Limited to one vocal fold
T1b	Involves both vocal folds
T2a	Extends to the supraglottis and/or subglottis
T2b	Impaired vocal cord mobility
T3	Vocal cord fixation Invades the paraglottic or preepiglottic space Erosion of the inner cortex of thyroid cartilage
T4a	Invades cricoid/thyroid cartilage Extralaryngeal extension (e.g., trachea, tongue, strap muscles, thyroid, or esophagus)
T4b	Invades the prevertebral space Encases the carotid artery Invades mediastinal structures

Early glottic carcinoma, specifically, stage I or II, can be treated by endoscopic excision, radiation therapy, or open partial laryngectomy.[14] Over the past 2 decades this topic has received intensive interest, and controversies have often focused on techniques and outcomes with the use of endoscopic excision versus radiation therapy. This chapter discusses the philosophy, techniques, and outcomes of resection via the endoscopic approach to early glottic carcinoma. Optimization through appropriate instrumentation, staging, and technical details is critical for achieving favorable postoperative oncologic and vocal outcomes. The reader must remember that more than 90% of T1 lesions and approximately 75% of T2 lesions are curable, and therefore adherence to the principles described later is important to achieve these outcomes. In many centers, patients are successfully treated with external beam radiation therapy or an open surgical technique; however, only the former option is briefly discussed in this chapter.

PREOPERATIVE PLANNING

Radiation Therapy

Radiation therapy alone, properly administered in doses of 66 to 70 Gy, will cure 80% to 90% of patients with T1 cancer of the TVC.[15] With surgical salvage, the overall cure rate in some studies approaches 95%.[16] Radiation therapy is most effective for small lesions involving the midportion of the membranous vocal cord and is ideally suited for bilateral glottic disease, especially if the anterior commissure tendon is not invaded by cancer. Its effectiveness diminishes with involvement of the anterior commissure, vocal process, and arytenoid and in those with bulky lesions or some limitation of vocal cord mobility. Control rates for T2 cancer with radiation therapy alone are not as high, although with surgical salvage an overall 5-year survival rate of approximately 90% is achieved.[8] Treatment of premalignant vocal fold epithelium with radiation therapy is generally unsound management because the patient undergoes a single-use cancer treatment when cancer is not present, thereby “burning a bridge” for future management. In most cases, irradiating young patients (<45 years) is unwise because they are at great risk for metachronous primary cancer.

Nevertheless, radiation therapy represents the standard therapy for these early lesions in many centers because it preserves a high-quality voice in most patients without compromising the chance for cure. Six weeks of daily therapy is required, and the success of this modality is highly dependent on the skill of the radiotherapy team. The edema and histologic sequelae of radiation therapy impair both visual and histologic examination in the post-treatment period. Biopsy carries with it the risk of precipitating chondritis, hence the admonition to avoid biopsy of an irradiated larynx. Unfortunately, this policy can result in delayed diagnosis of recurrent disease and lessen the likelihood of successful salvage. In addition, the small radiation ports used for carcinoma of the vocal cord complicate application of radiation therapy to the cervical lymphatics because of field-matching difficulties if it is required later for subsequent cancer of the head and neck. The lack of histologic confirmation of disease status is a major shortcoming of the use of radiation therapy as primary treatment because the most useful prognostic factors in current clinical practice are obtained through pathologic analysis. Clinically and histologically correlated studies suggest that errors in staging based on clinical criteria are commonplace and may explain the failure of radiation therapy to control “limited” disease. For these and other reasons, many centers treat selected patients with T1 and T2 carcinoma of the TVCs with laser excision and obtain approximately similar voice results.[14,16,17]

Premalignant Glottic Lesions

Leukoplakia of the TVCs is commonly encountered in a population of smokers (Fig. 46-1). Biopsy of these lesions may reveal histologic changes ranging from mild dysplasia to true invasive carcinoma. The level of risk of these premalignant lesions developing into a malignancy is unknown. The difficulty inherent in differentiating benign lesions from early carcinoma mandates biopsy of the lesion or preferably complete excision.

Figure 46-1 Premalignant (dysplastic) lesions of the true vocal folds are commonly encountered in the population at risk for squamous cell carcinoma of the larynx. Biopsy of these lesions may reveal histologic changes ranging from mild dysplasia to verrucous or invasive squamous cell carcinoma.
(Courtesy of Dr. Robert Buckmire.)

Carcinoma in situ requires removal of the epithelial layer only; thus, the proper plane of dissection is within the superficial lamina propria. Certainly, underappreciated microinvasive tumors do occur, so adequate margins should take this possibility into account. Great care should be taken to not expose the vocal ligament because doing so will remove the gelatinous superficial lamina propria (Fig. 46-2). The postoperative voice result is directly related to preservation of as much of this pliable, gelatinous lamina propria as possible to enable maximal vibratory activity of flexible re-epithelialized overlying tissue. The patient is endotracheally intubated, preferably with a metal laser-proof endotracheal tube (Fig. 46-3A), and draped in accordance with laser safety techniques (see Figure 46-3B); the appropriate instrumentation is arranged conveniently on a side table (see Fig. 46-3C).

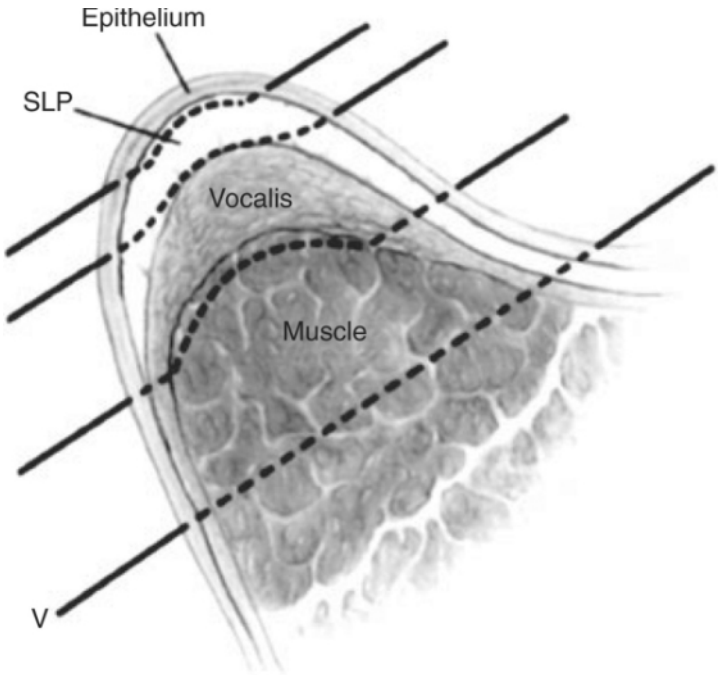

Figure 46-2 Vocal fold layers showing potential planes of dissection: epithelium, superficial lamina propria (SLP), vocalis ligament, and thyroarytenoid (vocalis) muscle (V).

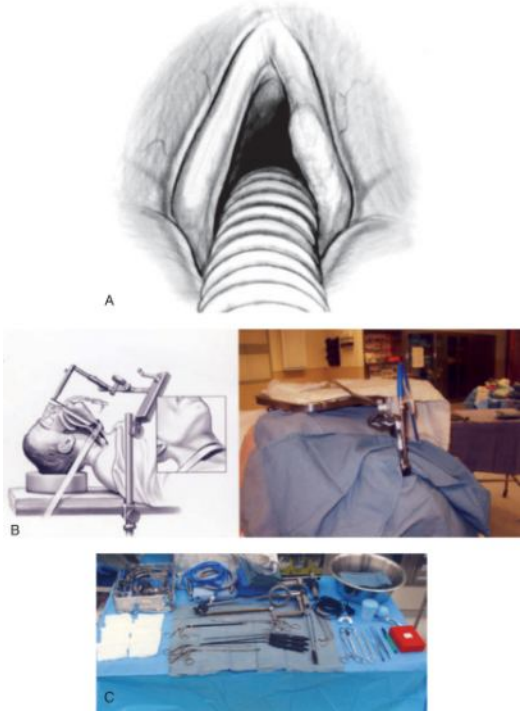

Figure 46-3 **A,** A small laser-safe endotracheal tube is used to permit adequate visualization and surgical access to the anterior and posterior tumor margins. **B,** Boston University suspension gallows and anterior cricoid pressure *(left)* and Loewy suspension apparatus *(right)*. The patient is draped and suspended for microlaryngoscopy with laser-safe materials and soaked wet towels. Flexion-extension is generally used for optimal exposure of the anterior laryngeal anatomy. Suspension with the Loewy suspension apparatus on a Mayo stand may be used. Suspension with a Boston Gallows is favored by others because it is attached to the operative table and moves with the patient *(left diagram)*. **C,** Rigid endoscopes and laryngeal instruments are arranged on the side table for appropriate endoscopic visualization and manipulation of the tumor. Bivalve and anterior commissure laryngoscopes may alternatively be used for optimal exposure as the tumor and its location permit. *(B and C, Courtesy of Guy Petruzzelli, MD, PhD.)*

The specimen should be removed en bloc if possible and properly labeled so that margins may be assessed by the pathologist. If the specimen is removed piecemeal, additional margins of the surgical field may be taken with microcup forceps to verify complete removal. Some surgeons do not advocate sending margins. Our approach is to send margins for permanent pathologic evaluation only in cases in which more extensive cancer is present because frozen section analysis is not sensitive enough for clinical decision making.

Patients are instructed to maintain voice rest for 7 to 10 days. If the margins are negative on permanent histopathology, patients can be assigned to routine surveillance for recurrence or progression every 4 to 6 weeks for the first year and then at 2- to 3-month intervals during the second year. Antireflux medication is given postoperatively for up to 1 month.

Verrucous Carcinoma

Verrucous carcinoma, a histologic variant of SCC, deserves specific discussion because it has a biologic behavior that is different from that of invasive SCC. Formerly it was thought that all these cancers occurred secondary to HPV, although recent investigation suggests that the prevalence of HPV in verrucous carcinoma is no higher than that in other laryngeal cancers. Grossly, the tumor resembles a hyperkeratotic papilloma, and histologic examination reveals papillomatous growth. Histologic demonstration of true invasion is difficult, and occasionally the surgeon must elect to completely excise the lesion to ensure a diagnosis. Deep invasion and regional metastases are rare, so local excision is often feasible despite extremely bulky disease that would appear to suggest the need for more radical surgery. Pillsbury and Kirchner[18] demonstrated an overall 30% rate of incorrect histologic staging when compared with pathologic staging for cancer of the glottis, but the only patients in their series who were overstaged were two with verrucous carcinoma.

Radiation therapy does not appear to be very effective in the management of verrucous carcinoma, and some reports suggest that its use may result in the development of more aggressive forms of malignancy. Surgical excision offers the best chance of control. Endoscopic excision is often feasible, but more advanced cases may require open excision with partial or total laryngectomy.

Early Glottic Squamous Cell Carcinoma

Small invasive lesions on the membranous portion of the TVCs impair the vibrating characteristic of the vocal fold and result in hoarseness. Hence, early diagnosis of carcinoma is possible, provided that this hoarseness leads to an examination of the larynx. Patients may therefore initially be found to have carcinoma in situ or early invasive cancer. These patients are curable by any of several modalities, and treatment choices are dictated by expected voice quality and expediency rather than the probability of cure. However, hoarseness may go unnoticed in other patients with preexisting voice abnormalities secondary to scarring and gastroesophageal reflux, thereby resulting in delayed diagnosis. Patients often have advanced cancer at initial evaluation because of delay in seeking medical care or delay in referral by their primary practitioners despite widespread public awareness. Delay as a result of either patient factors, such as denial and inattention to personal health, or health care personnel who fail to fully evaluate patients with voice disorders is common. The multitude of benign conditions commonly associated with hoarseness, as well as lack of pain or constitutional symptoms, results in complacency on the part of the patient or physician.

The most important factor leading to early diagnosis is recognition of an abnormal voice and subsequent performance of office laryngoscopy. Further improvement in the control rate of vocal cord carcinoma will require earlier recognition of the need for laryngoscopy. The American Academy of Otolaryngology–Head and Neck Surgery Foundation has established a web-based educational program for primary care providers to assist in these educational efforts, of which hoarseness is one module (www.entlink.net/education/cool, accessed April 15, 2005). The use of imaging (usually computed tomography [CT] or coregistered positron emission tomography [PET]-CT) for laryngeal carcinoma is determined by the judgment of the treating surgeon, and suggested indications are listed in Table 46-2.

Table 46-2 -- INDICATIONS FOR IMAGING OF GLOTTIC CARCINOMA

Severe hoarseness
Limited vocal cord mobility
Significant involvement of the anterior commissure
Transglottic involvement
Cervical lymphadenopathy

The goal of endoscopic management of an isolated T1 lesion of the musculomembranous vocal fold is eradication of the cancer with maximal preservation of the normal glottic substructure (see Fig. 46-2). This approach optimizes the postoperative voice without compromising oncologic cure and consists of four components: (1) dissection just under the basement membrane with minimal disturbance of the superficial lamina propria for atypical epithelium, (2) dissection in the deeper aspect of the superficial lamina propria for microinvasive cancer (as suggested via the infusion technique),[19] (3) dissection between the vocal ligament and the vocalis muscle for lesions that are attached to the ligament but not through it, and (4) dissection within the vocalis muscle for lesions penetrating the vocal ligament and vocalis muscle. This approach can be further fine-tuned by performing partial resection of any of the layered microstructure. The specimen is always oriented for whole-mount histologic analysis, and frozen section margin assessment is used selectively to verify complete excision.

Relative contraindications to endoscopic excision of laryngeal carcinoma are listed in Table 46-3. The surgeon must be guided by previous experience and the ability to manage each tumor individually based on location, extent of disease, and ability to expose the tumor for oncologic resection.

Table 46-3 -- CONTRAINDICATIONS TO ENDOSCOPIC RESECTION OF LARYNGEAL CARCINOMA

Subglottic extension (≥5 mm)
Postcricoid extension
Invasion of the iriform sinus
Cartilage invasion

Vocal fold fixation (relative)
Arytenoid extension (relative)
Involvement of the base of the tongue

SURGICAL TECHNIQUE

Most cancers involving the membranous TVC that do not extend onto the arytenoid, into the ventricle, or to the anterior commissure are easily managed by microlaryngoscopy and laser excision (Fig. 46-4). Patients must be selected carefully by accurate preoperative evaluation with an emphasis on vocal fold mobility. In selected patients, excision may be feasible at the time of initial biopsy. The extent of cancer involvement may be found to exceed that appreciated in the outpatient setting; therefore, patients must be counseled that further therapy, either irradiation or partial laryngectomy, may be necessary after pathologic evaluation.

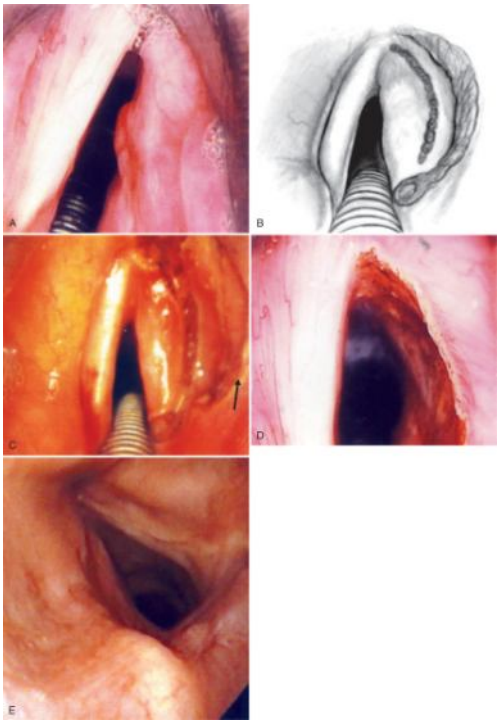

Figure 46-4 **A,** T1,N0,M0 squamous cell carcinoma of the right vocal fold. **B** and **C,** The CO_2 laser is used for spot marking and incision of the lateral margins of resection. Also evident is a previous vestibulotomy *(arrow)*, which was accomplished by excising the right false vocal fold for lateral exposure and future postoperative outpatient tumor surveillance. **D,** Resected tumor bed. **E,** Healed right neocord several months after resection. The contralateral vibratory epithelium is retained for apposition to the stiff resection site, which medializes fully for adequate vocal function.

The CO_2 laser is the instrument of choice in most centers. This laser is directed through an articulated arm attached to an operating microscope. The CO_2 laser has a wavelength of approximately 10,000 nm and is absorbed by water. The impact of the laser vaporizes the cells and allows precise excision of tissue via a micromanipulator attached to an aiming mirror. A low-wattage helium-neon aiming beam is used for directing the beam because the CO_2 laser beam itself is invisible. A typical spot size is 0.3 to 1 mm in diameter with a power output of 3 to 10 W, depending on spot size. Other centers may elect to use the yttrium-aluminum-garnet (YAG) or potassium titanyl phosphate (KTP) laser. These lasers are preferentially absorbed by red pigment, and hence they have somewhat improved hemostatic capability over the CO_2 instrument. The KTP laser beam can be delivered either by a micromanipulator connected to the microscope or by hand-held flexible fibers. Laryngoscopes are available that permit simultaneous suctioning of smoke and laser plume with beam delivery.

Transoral laser excision for Tis, microinvasive disease and T1, and selected T2 carcinoma of the larynx is an acceptable modality and can be performed with minimal morbidity. The postoperative voice can be as good as that achieved after curative radiotherapy; however, endoscopic excision can be performed in one sitting and provides pathologic staging of the disease process. Most surgeons maintain that optimal outcomes from laser excision result when the tumor is confined to the membranous cord. Steiner and others, however, report excellent results with laser excision of larger tumors, even when the tumor involves the arytenoid, extends into the ventricle, or crosses the anterior commissure.[20] The author's experience has generally been consistent with these extended indications in appropriately selected patients. Here, frozen section margin control may be necessary to ensure removal of disease. Postoperatively, close follow-up is required, often including a planned “second-look” endoscopic evaluation on an outpatient basis. Excision is particularly warranted for early cancer in which radiation therapy seems to be excessive treatment. Use of the laser attached to the operating microscope has greatly facilitated this procedure.

General Procedure

Fundamental to any laryngologic procedure is the ability to adequately visualize and expose the involved sites of the larynx. A wide variety of laryngoscopes that allow binocular exposure are available, as well as bimanual instrumentation. The evolution of suspension microlaryngoscopy is predicated on the ability to use both hands under high-power magnification. We currently use a Jako-Dedo type V laryngoscope with a fulcrum-type Loewy suspension apparatus (see Fig. 46-3).

The patient should be fitted with a dental guard after any necessary extractions are performed. Patients thought to have normal intubating anatomy are given a muscle relaxant to allow easier visualization of the glottis. Paramount to safe and effective management of the airway is clear and open communication between the otolaryngologist and anesthetist before and during the procedure. Although these health professionals “share” the airway, in most situations the otolaryngologist will be more adept at obtaining adequate airway exposure and navigating distorted laryngeal anatomy. Rigid laryngoscopes must be prepared and available with a second suction in these situations. Because patency of the airway is not usually a concern, many head and neck surgeons perform the first evaluation and intubation before disruption of the baseline appearance of the tumor by standard anesthetic induction procedures.

Positioning

Laser safety is not to be overlooked despite the prevalence of laser use in modern endoscopic practice. The patient's eyes, face, and chest are protected with soaked gauze and towels (see Fig. 46-3B). Despite the use of a laser-resistant endotracheal tube, moistened cotton pledgets are used to protect the glottis and subglottis from stray laser strikes. Familiarity with safe use of the laser instrument and an action plan in the event of airway fire are paramount to responsible application of this technique. An apneic technique can be used during times of laser activity, or the oxygen content delivered by the anesthetist should be decreased below 30% to prevent an airway fire from oxygen leaking around the cuff. An airway fire should be handled by immediate extubation, removal of supplemental oxygen, application of saline into the airway, and reintubation of the patient.

Preoperative preparation of the operating suite with identifying signs, protective eyewear for all personnel, and appropriate smoke evacuation equipment is mandatory. Viral DNA has been recovered from laser plume; therefore, it is prudent to wear appropriate high-filtration “laser masks” to avoid potential inhalation of virulent viral material. Confirmation of correct alignment of the aiming and treatment beams is necessary and should be done before each procedure. Typically, such confirmation is achieved by testing the beam on a moistened wooden tongue blade.

Endotracheal tubes used for general anesthesia must be fireproof. Various nonflammable tubes are available; however, recent investigation has suggested that a metal endotracheal tube is the safest and preferable to coated “laser-safe” tubes. These coated tubes can still be ignited if subjected for a sufficient period to enough energy to penetrate the lining.

The patient is typically intubated in the supine position with the head in the “flexion-flexion” position. This can be performed by the surgeon or by an anesthesiologist familiar with laryngologic procedures. With the laser-safe endotracheal tube in place, the patient and endoscope are then suspended in a “flexion-extension” position by a suspension gallows system such as the Boston University Gallows or a more standard fulcrum-type device with a Mayo stand (see Fig. 46-3). The true vector suspension technique with the patient in cervical flexion and atlanto-occipital extension is reported to give the best visualization of the anterior commissure. An operating binocular microscope is introduced for visualization of the glottis, usually with a 400-mm lens and 10× to 40× magnification. Tape may be applied to the anterior aspect of the neck and table to provide any necessary counterforce for complete glottic exposure. It should be noted that digital pressure, though useful for cursory evaluation, may fluctuate throughout the procedure. Often a 45- or 70-degree telescope is useful in evaluating the undersurface of the vocal folds and possible subglottic extension. Use of a rigid telescope takes advantage of magnification and enables photodocumentation for the medical record and teaching purposes. For assessment of a lesion in the posterior aspect of the larynx, apneic evaluation of the glottis may be required because the endotracheal tube obscures this view. Special endoscopes, some that enable simultaneous ventilation, are also available for this purpose.

After general anesthesia is induced, the endotracheal tube is inserted and secured. Before excising the tumor, the patient should undergo formal endoscopy, including examination of the piriform sinuses, supraglottis, and esophagus. The laryngoscope is inserted and suspended. The patient's eyes are protected by moistened eye pads, and moistened towels are placed around the field to preclude the danger of laser burns secondary to reflected or stray laser impact. The binocular operating microscope with a 400-mm objective lens is positioned with the attached laser. After careful examination and palpation of the cancer, moistened neural felt patties are placed in the subglottic air space to absorb and protect the tracheal lining and endotracheal tube cuff from laser "overshoot."

It is imperative that the surgical exposure include visualization of the entire extent of the tumor; however, the endoscope might have to be repositioned several times to achieve such visualization. Some lesions may need surgical facilitation of the exposure. We advocate removal of the false vocal fold in nearly all endoscopic glottic SCC resections, a technique known as laser vestibulotomy (see Fig. 46-4B, arrow). This maneuver provides improved visualization for endoscopic resection and enhances follow-up surveillance. In addition, access to the paraglottic and subglottic space is provided by this technique if extended tumor removal is required (Fig. 46-5).

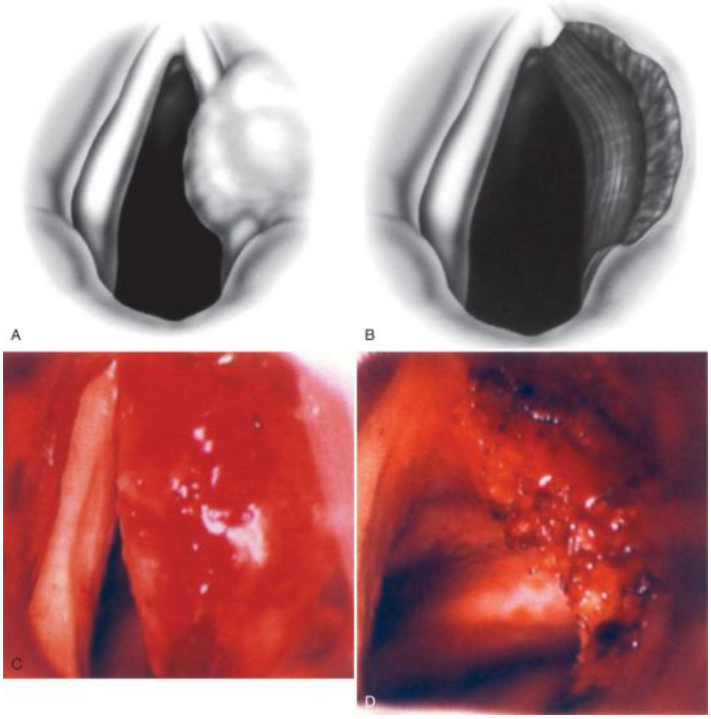

Figure 46-5 **A** and **C,** Schematic and operative images depicting a T2N0N0 glottic squamous cell carcinoma involving the entire right true vocal fold and inferior surface of the right false vocal fold. Laryngeal mobility was retained except for minor impairment because of tumor bulk. **B** and **D,** Postexcision tumor bed. Frozen section margins may be sent at this point to determine the extent of tumor control. The anterior commissure is not involved.

Larger T2 lesions (Fig. 46-6) involving the true and false vocal folds or the epiglottis (even T3 tumors with early preepiglottic space involvement, Fig. 46-7) can be managed by an experienced endoscopic surgeon.[21]

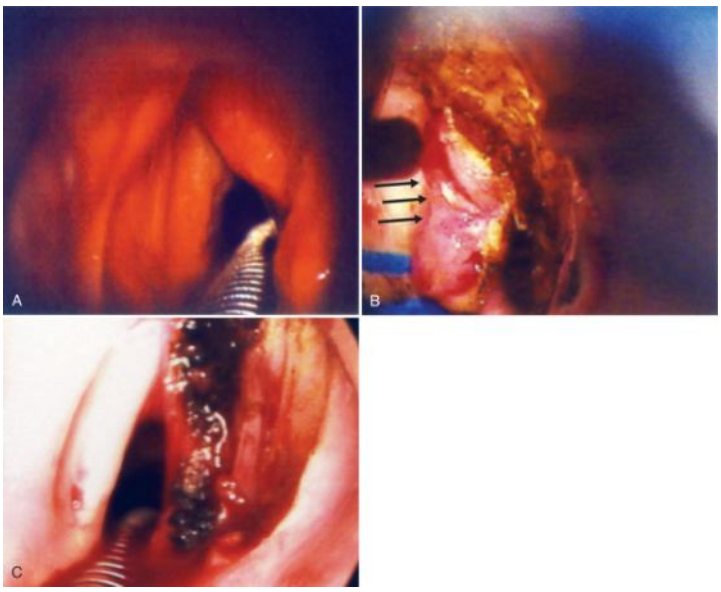

Figure 46-6 **A,** Bulky T2 transglottic squamous cell carcinoma involving the false vocal fold and extending inferiorly to the true vocal fold and posteriorly to the mucosa of the ipsilateral arytenoid. **B,** Tumor is bisected superiorly *(arrow)* to determine depth and to improve manipulation and exposure. Vocal fold mobility was impaired but involvement of the cricoarytenoid joint was not present (**C**).

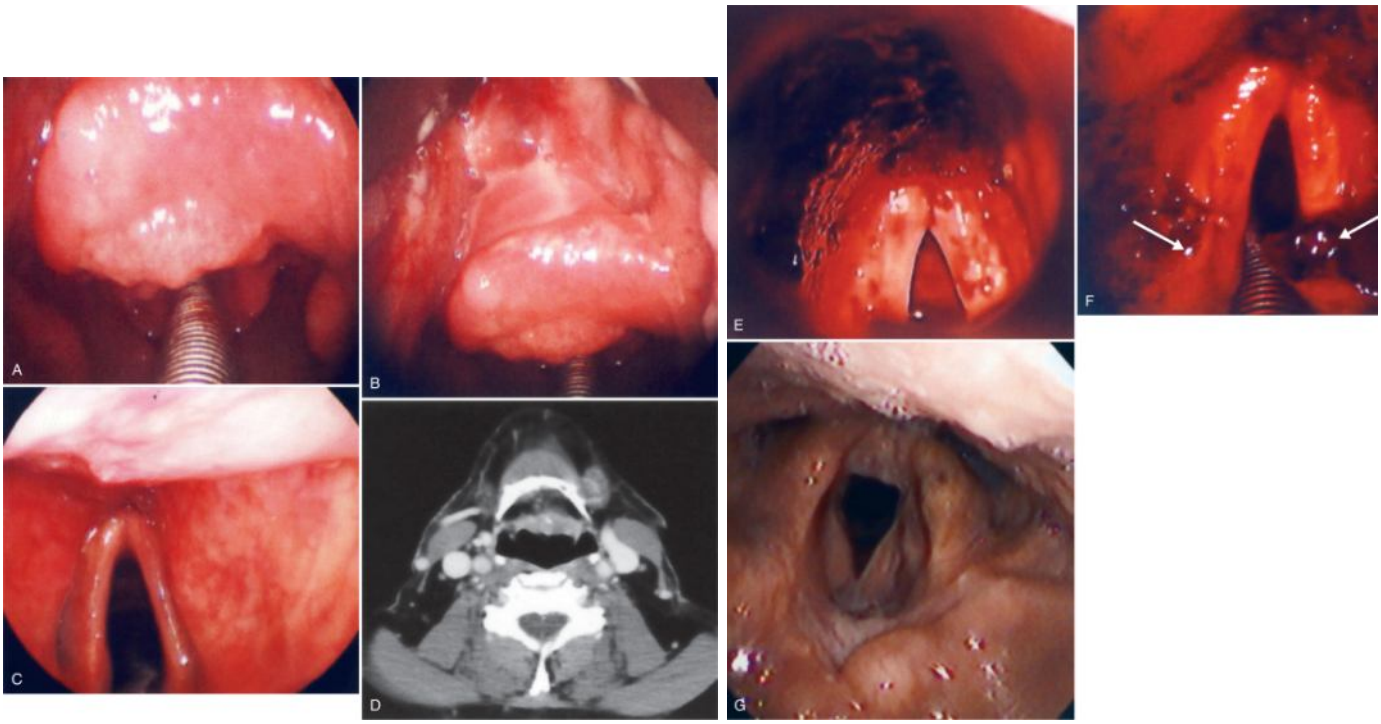

Figure 46-7 **A** to **C,** T3,N0,M0 supraglottic squamous cell carcinoma involving the laryngeal surface of the epiglottis above the petiole with cartilage invasion and early preepiglottic space invasion. Superior tumor excision (tumor bisected) was perform staged fashion to permit visualization of the inferior, immediately supraglottic tumor extent. **D,** Computed tomography scan indicating early preepiglottic space involvement of tumor. **E** and **F,** Final excision of the inferior and lateral tumor margin is perform adequate visualization. The *arrows* indicate the aryepiglottic fold (superior to the arytenoid cartilage) as posterior margins. The specimen is marked and oriented with direct communication between the surgeon and pathologist. Frozen or permanent sectio margins may be obtained for additional tumor control as needed. **G,** Postoperative result at 3 months.

Operative Technique

The procedure proceeds with the CO_2 laser on 5- to 6-W continuous or super-pulse energy with a 0.27-mm spot size. Super-pulse settings consisting of 0.6 second on and 0.2 second off may dissipate heat energy while providing enhanced "burst" laser-cutting action. The false vocal fold is resected en bloc from the infrapetiole region anteriorly and brought posteriorly to the level of the vocal process of the arytenoids (see Fig. 46-4B, arrow). It is important to properly orient and label this specimen so that histologic analysis can refute or confirm the presence of malignancy, particularly its undersurface. The CO_2 laser is especially useful in performing vestibulotomy because it provides concomitant cutting and hemostasis. Significant bleeding may be encountered during this maneuver but can be controlled with a defocused laser beam. If a laser is unavailable or ineffective at obtaining hemostasis, direct pressure with pledgets soaked in epinephrine (1:100,000) or suction cautery on low setting (10 to 15 mV) will usually suffice. One should confirm that a higher concentration of epinephrine (such as 1:1000) is not inadvertently used in the operating room. Microflap technique with cold instruments may be used for superficial lesions with excellent results. This technique involves preservation of the superficial lamina propria, results in quicker healing, and provides better voice results.

At this point the entire vocal fold should be visible, including the confluence at the anterior commissure. Subepithelial injection of a saline-epinephrine mixture or a 1:10,000 dilution of epinephrine alone via a 27-gauge Brüning or butterfly needle will help determine invasion beyond the superficial lamina propria into deeper structures such as the vocal ligament or thyroarytenoid muscle. Besides its diagnostic utility, the subepithelial fluid provides a heat sink to protect surrounding tissue from laser-generated heat and may also aid in dissection in the appropriate layer. Before any dissection is begun, the margins of resection should be determined and spot-marked with a CO_2 laser (see Fig. 46-4B). Gentle medial traction is achieved with microcup forceps, and the dissection is preferably carried out in a lateral-to-medial (and posterior-to-anterior) direction because this provides reliable identification and visualization of the planes of dissection.

The laser is set on single pulse, and the margins of the planned excision are marked. The tumor is excised with a continuous- or repeating-pulse mode. It is not necessary to remove the lesion in one piece. In fact, Steiner and associates have demonstrated that bisection of the tumor permits assessment of the deep planes and helps ensure complete excision, particularly in larger lesions.[16] It is crucial to avoid tears or fragmentation of the specimen to maintain registration between the excised specimen and the surgical bed. Correct orientation is necessary to permit accurate frozen section analysis of the margins. Hemostasis can be achieved by electrocautery either through a suction cautery unit or via the defocused laser beam.

Intraoperative frozen sections may be useful to ensure complete tumor removal. Close cooperation and communication between the surgeon and pathologist are necessary to ensure correct orientation of the specimen and margins. The margins of excision can be very small (<2 mm) but require careful orientation of the specimen. It is usually best if the pathologist can come into the operating room and observe the procedure through the monitor or the side arm of the microscope to assist in orienting the specimen. Identification of one end of the resected specimen with a small suture is helpful for avoiding later confusion.

Additional resections are performed as required to obtain adequate tumor margins. Care must be taken to ensure that re-excisions are correctly oriented and removed from the appropriate area of the specimen bed. After hemostasis is accomplished, the microscope and laryngoscope are removed from the field, and the patient is awakened and extubated and may be discharged as soon as the airway is adequate. Aspiration is rarely a difficulty, although it can occur subclinically, and voice rest may be used for 1 week.

Care must be taken to ensure that adequate tissue has been removed. Flexible bronchoscopy with washings may be indicated as well. If final permanent pathologic evaluation reveals tumor at the margins of resection, repeat laser excision should be performed. If negative margins cannot be obtained, the patient should undergo either radiotherapy or open surgical excision (i.e., vertical or horizontal partial laryngectomy).

Cancer originating from or involving the supraglottis is treated with similar approaches and instrumentation. A variety of rigid endoscopes must be available to permit adequate exposure of these structures. As shown in Figures 46-6 and 46-7, excision of cancer of the epiglottis, aryepiglottic fold, and false vocal fold is possible with direct access to the paraglottic and preepiglottic spaces. Treatment of the neck, which is at greater risk for nodal metastasis with supraglottic cancer,[22] can be incorporated into the endoscopic procedure or, more commonly, staged once the pathologic results of excision of the primary cancer have been obtained.

POSTOPERATIVE MANAGEMENT

Postoperatively, the patient is treated for laryngopharyngeal reflux for up to 8 weeks as necessary. Antibiotics or analgesics (or both) are prescribed selectively according to surgeon and patient preference and the extent of the surgery. Complete voice rest with head elevation is advised for 1 week and modified voice use for 2 weeks. A vaporizer at the bedside at home is valuable for patient comfort. Preoperative and postoperative appointments with a speech pathologist are scheduled for objective voice assessment and discussion of vocal hygiene. Formal voice therapy is initiated as needed.

COMPLICATIONS

Hemorrhage

Bleeding that requires intervention is extremely rare after endoscopic resection of early glottic cancer because vessels of a significant diameter are seldom encountered except during larger resections. If persistent hemoptysis develops, fiberoptic laryngos-copy should be performed. Based on this examination and the character of the bleeding, the patient can be brought back to the operating room if necessary. Hemostasis should be achieved with microscopic control and can be accomplished with the laser or a microelectrocautery.

Airway Obstruction

As indicated earlier, postoperative airway obstruction is unusual because careful intraoperative assessment and appropriate intervention are the tools for airway safety. If a patient has been left intubated in the initial postoperative period, extubation should be done in a controlled environment such that the laryngologist can observe and re-establish the airway in a prepared organized fashion.

Granuloma Formation

Granuloma formation usually occurs in patients who have acid reflux and can arise anywhere in the glottal surgical field. These lesions probably develop in a de-epithelialized area from the glottic

trauma that results from talking and coughing in an environment of glottic mucositis secondary to reflux. All char should be removed at the end of the laser resection to avoid the formation of "charcoal granuloma."[23] Persistent hoarseness after the procedure should alert the surgeon to this possibility, which must be accompanied by microsurgical excision of the granuloma.

Scarring

Scar formation in residual vocal fold soft tissue is an inevitable outcome of excision of glottic cancer. This scarring may result in excessive stiffness of the oscillatory capability of the vocal fold. It typically occurs when the surgical field for cancer excision is wider than oncologically necessary to encompass the lesion. Excessive trauma to normal vocal fold tissue is obviated by carefully assessing the three-dimensional characteristics of the lesion and selecting appropriate instrumentation for the excision, especially when tangential dissection in only part of the subepithelial layer is required to perform an adequate excision.

Excessive Hoarseness and Dysphonia

Patients may have a variety of vocal complaints that relate not only to the acoustic quality of the voice but also to vocal efficiency, that is, the effort or "work of phonation." Voice change is inevitable after resecting glottic cancer. If an exophytic lesion is present on the medial surface, the voice may even be directly improved after excision.

The greatest difficulties with regard to postoperative hoarseness relate to inappropriate expectations by the surgeon or patient of the unavoidable voice deterioration that sometimes occurs. Precise preoperative assessment of the lesion and the patient's phonation characteristics will minimize this problem. Stroboscopic evaluation is very valuable for assessing the vibration characteristics of nonmalignant vocal fold epithelium. At times, voice therapy can enhance vocal quality by teaching the patient more effective strategies to overcome the compromised oscillation characteristics of the glottal valve. In some cases, medializing a postresection excavated neocord by means of an external thyroplasty can enhance glottal efficiency. A stiff leaking glottal valve that requires extremely high subglottic pressure to induce entrained oscillation can be reconstructed so that glottal closure and oscillation are dramatically improved.

PEARLS

- Endoscopic microsurgical resection for treating laryngeal cancer consists of a series of graded excisions in which the cancer margins are accommodated precisely to the three-dimensional characteristics of the tumor.
- A primary oncologic goal is to narrow the cancer-free margin and decrease patient morbidity while not altering the cure rate.
- Subepithelial infusion of saline or local anesthetic in T1 cancer may allow preservation of the entire vocal ligament and vocalis muscle, as well as part of the deep portion of the superficial lamina propria.
- Whenever possible, cancer resections should be performed en bloc. At times, especially with T2 and T3 lesions, serial resections of deep tissues must be done with frozen sections or repeat ("second-look") procedures to control for adequate margins.
- Postoperative swallowing function may be worse in patients treated by laser excision after radiation therapy.

PITFALLS

- A small amount of extra glottic tissue that is excised with the deep margin can have a profound effect on vocal outcome while not necessarily improving the cure rate.
- Failure to observe all aspects of laser safety may result in significant injury to or death of the patient or treating individuals.
- Poor patient selection, such as those with compromised pulmonary function, will result in compromised postoperative swallowing and aspiration, thus negating the oncologic outcome.
- Laser excision of cancers previously treated with radiation therapy may lead to difficulty obtaining negative margins because of submucosal spread and radiation-induced changes in the mucosa that preclude narrow-margin surgery.
- Persistent hoarseness after the procedure should alert the surgeon to the possibility of a "charcoal granuloma" formed as a result of retained, cauterized tissue, which must be treated by microsurgical excision of the granuloma.