Surgical Approach to Organ Preservation in the Treatment of Cancer of the Larynx

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Nonsurgical approaches to preservation of the larynx in the treatment of laryngeal carcinoma include either radiation alone or chemotherapy and radiation in combination. In light of the common use of total laryngectomy,

Introduction

It is important that the clinician counseling a patient about alternative approaches for preserving the larynx in the treatment of laryngeal cancer not only focus on the role of nonsurgical approaches but also explain the role of surgical approaches for organ preservation. Currently, a broad spectrum of surgical procedures are available for preserving the larynx in the setting of laryngeal carcinoma. The only way a clinician can appropriately counsel a patient with laryngeal cancer about treatment options is to gain a thorough understanding of both the surgical and nonsurgical alternatives.

In an era when patients have ready access to the medical literature via the Internet, it is even more important for clinicians to be prepared for educated questions, and to have a thorough understanding of the options that may benefit their patients. After a discussion of fundamental concepts, including the differences between surgical and nonsurgical organ-preservation approaches, this article will review the oncologic and functional outcomes associated with specific surgical approaches.

Speech and Swallowing Without a Permanent Tracheostomy

To begin with, we must ask what "saving the voice box" means. The basic function of a normal larynx is to allow for effective swallowing without aspiration. Almost all animals have some type of valve or sphincter that separates the alimentary tract from the respiratory tract, and like all other animals, we use the larynx to facilitate swallowing. If the larynx is not functioning adequately, then symptoms of dysphagia may become evident, and aspiration of food or saliva into the trachea may occur.

The second function of the larynx is in respiration. The larynx opens and closes spontaneously to allow for appropriate respiration. Naturally, we also use our larynx for communication. In that regard, the larynx functions as the generator of a tone. As air passes over the vocal cords or folds, they vibrate, thereby generating a tone. The true test of a treatment’s efficacy as a "laryngeal-preservation approach," however, is whether, the patient is still able to speak and eat without a permanent tracheostomy at the point when no local recurrence is expected (about 2 years or so for most treatments).

Side Effects of Laryngectomy

The issue of a permanent tracheostomy is particularly important because the main cause of a decline in quality of life associated with total laryngectomy is the permanent stoma.[1] In fact, after total laryngectomy most patients are able to speak by using either an electrolarynx (an electronic tone generator), via esophageal speech, or with a voice prosthesis inserted into a tracheoesophageal fistula. All these methods of voice rehabilitation stem from the fact that what really needs to be replaced when the larynx is removed is a tone generator.

When the larynx is removed, the pharyngeal mucosa collapses on itself and can be made to vibrate as air passes over it. This can be accomplished by esophageal speech, for which the patient is taught...
to swallow air and expel it past the pharyngeal mucosa in a controlled fashion, causing the pharyngeal mucosa to vibrate and, in turn, to generate a tone. Today, speech is rehabilitated more commonly with a voice prosthesis that is inserted via a tracheoesophageal fistula. With a voice prosthesis, air can be forced from the trachea into the esophagus and pharynx via a small plastic one-way valve that prevents liquid and food from passing from the pharynx back into the trachea.[2]

Nonetheless, patients frequently have the misconception that the main problem with total laryngectomy is that they will not be able to speak postoperatively. Consultation with a qualified speech pathologist can help a patient understand that almost all the chronic side effects of total laryngectomy are related to the stoma and that the loss of the ability to speak is not, in fact, the major problem. Stoma-related side effects include (1) a diminished sense of smell and therefore taste, because the patient can no longer breathe through the nose and mouth but instead must breathe through the tracheostoma; (2) difficulty in swallowing, related to changes in the pharyngeal anatomy; (3) the emotional and cosmetic effects of both losing an organ and living with a permanent tracheostoma; and (4) other lesser complaints.[3,4]

Risk of Treatment Failure

Why stress the issues related to total laryngectomy in an article about using surgery to save the larynx? A myth shared by many patients and clinicians is that choosing either a surgical or nonsurgical organ-preservation strategy means that the patient will avoid total laryngectomy and, therefore, does not need to be "disturbed" by any mention of this radical procedure. In fact, every organ-preservation treatment regimen, surgical and nonsurgical, is associated with some risk of local failure. Regardless of how high the reported local control rate of a particular treatment regimen may be, the patient must always be counseled about the possible need for total laryngectomy in case the primary treatment modality fails.

Obviously, if we are dealing with a very small T1 glottic carcinoma for which all treatment regimens offer a high probability of laryngeal preservation, the issues related to total laryngectomy in the event of failure may be mentioned but do not have to be stressed. Common sense dictates that a reported 5% local failure rate is low enough that most patients will never have to deal with the problems associated with a recurrence of the cancer. Nonetheless, patients in whom local treatment fails may become angry if they had previously been counseled that local failure never occurs or is so infrequent that they need not worry about it. A 5% rate of failure is not equivalent to a 0% failure rate. It is wise to advise patients that even though only a small percentage of patients with small T1 cancer may fail treatment, those who do fail after radiation therapy usually require total laryngectomy.[5]

If the approach being recommended for a T2 glottic carcinoma is nonsurgical, then the clinician counseling the patient is obliged to discuss total laryngectomy in greater detail. Given the higher local failure rate, for example, following radiation therapy in patients with T2 lesions, there is approximately a 30% risk that patients so treated will ultimately need a total laryngectomy.[6]

The issue of counseling patients about the impact of total laryngectomy becomes even more critical when treating a larger cancer such as a T3 glottic carcinoma with radiation or a chemoradiation approach such as the Veterans Affairs (VA) protocol.[7] In the VA protocol, induction chemotherapy is followed by radiation therapy in patients with a 50% response at the primary site and by total laryngectomy with radiation therapy in patients with less than a 50% response. The critical point to stress to patients who will be receiving the VA protocol is that they are at significant risk (36%) of needing a total laryngectomy following either induction chemotherapy or definitive treatment.

For the VA protocol to be successful from a survival standpoint, patients must be followed very closely by a clinician who is competent at detecting a local recurrence. Discovering a local recurrence early may be a difficult proposition, even for an experienced clinician, because of the inflammatory changes and scarring that develop after irradiation of the larynx.[8]

In summary, surgical salvage is an important aspect of organ-preservation approaches, with total laryngectomy being the most common salvage procedure. Prior to organ-preservation treatment, a speech pathologist should be consulted to counsel high-risk patients about the functional impact of
total laryngectomy in the event it becomes necessary.

Organ-Preservation Surgery of the Larynx: Toward a New Paradigm

The goal of organ-preservation surgery is to remove enough of the larynx to allow for local control of the cancer, while preserving enough of the larynx to allow for speech and swallowing without a permanent tracheostomy. The open surgical approach, in which the skin is incised and the larynx is opened to remove the cancer, is known as conservation laryngeal surgery. In the late 19th century and most of the 20th century, vertical partial laryngectomy was the dominant technique in conservation laryngeal surgery, and then, as today, it was used for the treatment of selected glottic carcinomas.[9]

In 1947, the supraglottic partial laryngectomy was introduced for the treatment of selected supraglottic carcinomas.[10] When vertical partial laryngectomies and supraglottic partial laryngectomies were performed in patients with selected (mostly early) carcinomas, the local control rate as well as attainment of speech and swallowing without a permanent tracheostomy was high.[11,12] The problem with an approach limited to the use of a vertical partial laryngectomy or supraglottic partial laryngectomy was that a large number of patients with laryngeal cancers were not candidates for these procedures. The remaining surgical options were either the near-total or total laryngectomy—both of which require a permanent tracheostoma.[13]

In response to this situation, some surgeons tried to expand the indication for vertical partial laryngectomy and supraglottic partial laryngectomy with so-called extended procedures. The problem with these approaches, however, was that extended vertical partial and extended supraglottic partial laryngectomies tended to be reported in small numbers, and the functional outcome and local control rates were variable.[14-17] In addition, these procedures were reported with a plethora of difficult-to-reproduce laryngeal reconstructions.[18] A resident or fellow in training might have been exposed to few, if any, extended vertical partial and extended supraglottic partial laryngectomies, making it difficult for them to use these procedures in practice.

Thus, from a practical standpoint, the surgical management of laryngeal carcinoma in the United States included vertical partial laryngectomy and supraglottic partial laryngectomy for smaller lesions, with total laryngectomy reserved for larger lesions. Although this strategy led to a high local control rate, it also resulted in a large number of patients requiring a total laryngectomy and, hence, a permanent tracheostoma.

The VA Protocol

In response to the limitations associated with the conservation surgical approach to avoid a permanent tracheostoma in patients with higher-stage tumors, nonsurgical organ-preservation protocols using novel combinations of radiation and chemotherapy were developed. One such approach, the VA protocol resulted in laryngeal preservation in 64% of patients, without a decrease in survival when compared to total laryngectomy with postoperative radiation therapy.[7] Despite the obviously superior outcome in terms of laryngeal preservation compared to total laryngectomy, many patients (36%) still lost their larynges.

In addition, another prospective randomized European trial recently evaluated the VA protocol and found that for T3 laryngeal carcinoma, survival was significantly superior in the total laryngectomy and postoperative radiation therapy arm (84%) vs the chemotherapy and radiation arm (69%).[19] Although there were some weaknesses in the design of this European trial, a particular strength, compared to the original VA trial, was that it enrolled only patients with T3 cancer; the original VA protocol included patients with all T stages.

Further Developments in Strategy

Beginning in the late 1950s, another strategy to decrease the need for a permanent stoma evolved in some European countries.[20] This involved the introduction of a novel surgical approach known as the supraccricoid partial laryngectomy.[21,22] The version of supraccricoid partial laryngectomy...
used for selected glottic carcinomas results in resection of both true cords, both false cords, the bilateral paraglottic spaces, and the entire thyroid cartilage. The reconstruction is performed by suturing the cricoid to the epiglottis and hyoid and, hence, the unusual eponym cricothyroidoepiglottopexy. The version of the procedure used for selected supraglottic carcinomas involves the resection of all the tissue resected in the supracricoid partial laryngectomy with cricothyroidoepiglottopexy plus the whole preepiglottic space and epiglottis. Reconstruction in this case is accomplished by suturing the cricoid to the hyoid; hence, the name cricothyroidopexy.

These procedures were reported in large European series over the past 30 years and have demonstrated reproducibly excellent local control and functional outcome for selected cases of laryngeal carcinoma.[21-24] The addition of supracricoid partial laryngectomies to the surgical armamentarium has broadened the head and neck surgeon’s ability to treat a wider array of laryngeal carcinomas with surgery aimed at preserving the function of the larynx.[25]

The second important development over the past 2 decades, both in the United States and abroad, was the endoscopic resection of laryngeal carcinoma. This is achieved with either the laser or standard endoscopic excision. These endoscopic approaches have clearly been shown to produce high local control rates for early lesions. In addition, for selected lesions, the voice outcome following endoscopic resection has been shown to be equivalent to that achieved with radiation therapy.[26]

Endoscopic resection as well as open conservation laryngeal surgical approaches can be considered subsets of organ-preservation surgery for laryngeal cancer. Adopting an organ-preserving surgical approach requires not only a change in perspective, but also an understanding of five critical principles.

**Principle 1: Nonsurgical vs Surgical Organ-Preservation Strategies**

The first concept is that there are both surgical and nonsurgical approaches to organ preservation, and that each has a role in the management of laryngeal cancer. If we are resecting a large portion of the larynx, how can this possibly be considered organ preservation? Doesn’t the treatment have to result in a "normal" larynx to be considered organ preservation? In a word, no. Once it is clear that the larynx is cancerous, it can no longer be called normal. The presence of a cancer, particularly a large cancer, can result in destruction of normal tissue and permanent scarring that affects all aspects of laryngeal function, even after successful nonsurgical organ-preservation therapy with radiation or chemoradiation.[27] Furthermore, all treatments for laryngeal cancer have acute and chronic side effects, both in the larynx and the surrounding tissues.

A prevalent misconception in the literature is that radiation therapy is the preferred treatment modality for early laryngeal carcinoma because the resulting voice quality is superior to that following surgery. This idea likely stems from a time when the only surgical preservation options were procedures such as the vertical hemilaryngectomy for glottic carcinoma. With the advent of glottic and supraglottic endoscopic approaches, and selected open approaches such as the supraglottic laryngectomy, much or all of the vocal cords can be spared during surgery so that the voice after surgical resections is, in fact, either normal or equivalent to the voice after radiation therapy. This is not simply a personal opinion but has been clearly demonstrated in the literature.

Radiation alone, even for early glottic carcinoma, has an impact on the tissues of the larynx, leaving voice quality abnormal.[28] A number of studies support the finding that the voice after partial endoscopic cordectomy for early glottic cancer is equivalent to the voice after radiation therapy for similar lesions.[26,29] The voice after chemoradiation for advanced laryngeal cancer is also abnormal.[30]

**The Stoma and Quality of Life**

Quality-of-life studies indicate that it is the stoma and not the posttreatment voice quality that is the major determinant of quality of life.[1] If one treatment regimen has a much higher probability of achieving local control than another, then quality-of-life data indicate that the treatment associated with greater local control and hence a lower stoma rate secondary to laryngectomy should be the
approach of choice. An example of this situation would be the supracricoid partial laryngectomy for T2 glottic carcinoma. There is no debate that the voice after radiation therapy for T2 glottic carcinoma is superior to the voice after supracricoid partial laryngectomy. Nonetheless, because the local failure rate associated with radiation is so much higher, approximately 30% more patients with T2 glottic carcinoma will require a permanent stoma in the long term after salvage laryngectomy than will those who undergo a supracricoid partial laryngectomy as the primary treatment.

On the basis of initial voice quality, radiation is superior to supracricoid laryngectomy, but on the basis of avoiding total laryngectomy and a permanent tracheostoma, the supracricoid partial laryngectomy is a better approach. Clearly, there are patients who will opt for a treatment that results in better vocal function, even if the risk of requiring a total laryngectomy is greater or survival is decreased with the chosen treatment.[31] Although a physician with laryngeal cancer might also choose voice quality over local control when faced with this decision, the physician must not project his or her own preferences onto the patient. Rather, the physician’s role is to inform the patient of the side effects and local control rates associated with all treatments, both surgical and nonsurgical, and assist the patient in choosing the most acceptable option.

Clinicians who are counseling patients about treatment options, whether they are surgeons, medical oncologists, or radiation oncologists, must relate the safety rates and efficacy associated with each organ-preservation approach. Denigration of either the surgical or nonsurgical organ-preservation approaches will lead to inadequate counseling of patients about the outcomes following the various treatment options.

Tumor Staging in Laryngeal Carcinoma

One fundamental difference between the surgical and nonsurgical organ-preservation approaches is in the pretreatment work-up. In nonsurgical approaches such as radiation and chemoradiation, the focus of the pretreatment work-up is on staging, so that the prognosis can be predicted based on large series of patients reported in the literature. The surgeon contemplating an organ-preservation procedure, on the other hand, cannot use the staging system because it is not precise enough. The staging system for laryngeal cancer is based on gross extension of tumor and vocal cord mobility,[32] dividing all related cancers into four categories. Thus, while the nonsurgeon is more focused on the gross characteristics of the lesion such as tumor volume and degree of tumor differentiation, the organ-preservation surgeon is more concerned with the surface extent and depth of invasion of the cancer. This difference in perspective leads to distinct differences in pretreatment work-up.

Pretreatment Endoscopy and Laryngeal Mobility

The nonsurgeon typically uses indirect laryngoscopy to assess the gross findings in the larynx such as whether the tumor is exophytic or endophytic, the sites of involvement (eg, true cord, epiglottis), and vocal cord mobility. The purpose of assessing these gross findings is to stage the cancer. The organ-preservation surgeon uses pretreatment endoscopy indirectly, in the office, and directly under general anesthesia in the operating room, to map the surface extent of the carcinoma with millimeter accuracy.[33] Of course, it is also important for the organ-preservation surgeon to stage the patient, so that the local control rate associated with the chosen organ-preservation surgery technique can be compared with that of nonsurgical organ-preservation approaches or total laryngectomy.

The nonsurgeon assesses vocal cord mobility to stage the patient. The organ-preservation surgeon assesses both vocal cord and arytenoid mobility and uses knowledge gleaned from the anatomic literature to correlate vocal cord and arytenoid mobility with the depth of invasion of the lesion.

Pretreatment Radiology

The nonsurgeon uses x-rays to help stage the patient and to assess gross tumor characteristics such as tumor volume. A correlation between tumor volume and outcome after radiation therapy has been established.[34] Organ-preservation surgeons use magnetic resonance imaging (MRI) or computed tomography (CT) scans to confirm their clinical findings in terms of depth of invasion of
the cancer. In addition, these techniques are useful in assessing areas of cancer invasion that are difficult to evaluate clinically—for example, measuring moderate invasion of the preepiglottic space or early cartilaginous invasion, subglottic extent of the tumor, and extension of the carcinoma beyond the confines of the larynx.[35]

Radiographs can never be used in lieu of indirect laryngoscopy to stage laryngeal cancer. Although x-rays may be valuable for assessing some aspects of deep invasion, visualization of the larynx with laryngoscopy is far superior in assessing the extent of disease on the mucosal surface.[35] This becomes particularly important for clinicians who do not perform indirect laryngoscopies to look at the larynx themselves. It is critical not to upstage the lesion based on a radiologic evaluation without the benefit of a laryngoscopic assessment of the mucosal extent of the lesion.

Confirmation of Findings After Treatment

A distinct difference between the surgical and nonsurgical approaches for laryngeal preservation is in confirmation of the clinical exam findings. Nonsurgeons never actually remove the cancer; therefore, the clinical findings are never directly confirmed. Nonsurgeons confirm their clinical exam indirectly 2 to 5 years later, if local control is achieved. The organ-preservation surgeon confirms any physical findings within 2 to 5 weeks after surgery. If the preoperative findings are wrong, the surgeon may be unsuccessful or may have to convert to a total laryngectomy intraoperatively. Therefore, the key to surgical success is accurate preoperative assessment of the exact depth and extent of the cancer.

Principle 2: The Cricoarytenoid Unit

The cricoarytenoid unit includes one arytenoid cartilage, the cricoid, the ipsilateral superior and recurrent laryngeal nerves, and the ipsilateral cricoarytenoid musculature. Two significant issues concern the cricoarytenoid unit. The first is that this is the basic functional unit of the larynx; ie, speech and swallowing are possible without a permanent tracheostomy if the surgical approach spares at least one functional cricoarytenoid unit. This implies that neither vocal cord is needed to preserve laryngeal function. Thus, preservation of the vocal cords during surgery is unnecessary to retain the voice, but preservation of one or both vocal cords may improve voice quality.

The second significant point to bear in mind regarding the cricoarytenoid unit is the issue of arytenoid mobility. The tumor-staging system focuses only on vocal-cord mobility, not arytenoid mobility, but the organ-preservation surgeon must consider both. Indeed, both are important in allowing the clinician to assess the depth of invasion and the resectability of the cancer.

Whole-organ studies of larynges with laryngeal cancer reveal that fixation of the vocal cord indicates invasion of the thyroarytenoid muscle.[36] As long as the fixed vocal cord is associated with an ipsilateral arytenoid that is completely or partially mobile, the patient is still a candidate for organ-preservation surgery. When the arytenoid cartilage is fixed, either the cricoarytenoid joint or the cricoarytenoid musculature has been invaded by cancer, thus precluding the use of organ-preservation surgery.[37] A patient with a T3 glottic carcinoma, therefore, may still be a candidate for organ-preservation surgery if there is some arytenoid mobility.

Principle 3: The Spectrum of Laryngeal Carcinoma

Although the tumor-staging system is useful for predicting outcome following nonsurgical organ-preservation approaches, it has no value in predicting which patient may benefit from a particular organ-preservation technique. This is because the organ-preservation surgeon must accurately predict both the three-dimensional and surface extent of the cancer and then choose the surgical technique that removes adequate tissue to optimize local control. There is, in fact, a spectrum of lesions, from small to large, and a corresponding spectrum of surgical procedures that may be performed to preserve the larynx. Figure 1 and Figure 2 illustrate the organ-preservation surgery spectra for glottic and supraglottic carcinomas, respectively.

Schematic views of laryngeal carcinomas appear on the top line of each spectrum, from smallest on
the left to largest on the right. The box below each schematic allows for documentation of the vocal cord and arytenoid mobilities as well as invasion of specific laryngeal spaces or cartilages. The lower line shows the surgical techniques that are available for organ preservation, from smallest on the left to largest on the right. The procedures listed in these spectra are those that have been shown in the literature to be associated with consistently good functional outcome in terms of speech and swallowing without a tracheostomy. In addition, the local control rates for these procedures have been reported to be approximately 85% to 95%, depending on the extent of the cancer and the procedure performed.[91]

These spectra assist the clinician in documentation and in planning treatment. Every other schematic is blank, so that the clinician can put the lesion in question in the appropriate place in the spectrum. The surgeon can then determine what the appropriate surgical approach would be for lesions smaller and larger than the lesion being assessed. In some instances, there may be more than one acceptable organ-preservation surgical procedure, thus allowing for controversies in the literature and opinions of clinicians.

**Principle 4: The Resection of Normal Tissue to Maintain Postoperative Function**

A common misconception among both patients and physicians is that the more tissue that is removed during organ-preservation surgery, the poorer the postoperative function. The procedures that are included in the organ-preservation surgery spectra yield consistent functional outcomes, regardless of the extent of tissue resection. This means that these techniques have been widely reported in the literature by numerous surgeons and centers and that functional outcomes can be expected to be favorable in the long term.[92] The expected functional outcome associated with these procedures has been shown to be (1) temporary difficulty swallowing (in many cases, no difficulty swallowing), (2) some degree of postoperative hoarseness (in many cases, no permanent hoarseness), and (3) no permanent tracheostomy (in many cases, no temporary tracheostomy).

A fundamental principle of organ-preservation surgery, although contrary to common sense, is that it is reasonable to remove "normal" laryngeal tissues beyond what is considered an oncologic margin, in order to improve the postoperative functional outcome. For example, in a vertical partial laryngectomy, part of the thyroid cartilage may be resected so that a reconstruction can be done with an imbrication laryngoplasty to improve vocal function.[11] Another example is the supraglottic partial laryngectomy, during which an uninvolved false cord is removed because it has been shown that, if you spare it, the patient will have more dysphagia from the asymmetric reconstruction.[38] A third example is the supracricoid partial laryngectomy with cricothyoidoepliglottopexy, in which the uninvolved true vocal cord is removed to allow for a reconstruction that will yield consistently excellent functional results.[39]

**Principle 5: The Importance of Local Control**

Fundamental to any organ-preservation surgical approach is the achievement of local control. This relates to the concept that the primary goal of any organ-preservation approach, whether surgical or nonsurgical, should be to maximize the number of patients who will not require a permanent stoma. Quality-of-life studies have shown that neither the acute side effects of treatment (such as dysphagia) nor the permanent side effects (such as hoarseness) are lesser determinants of quality of life than a permanent stoma after the treatment of laryngeal cancer.[1] The organ-preservation approach accepts a permanent side effect such as hoarseness in all patients after a given procedure if the result will be a larger number of patients achieving local control and, therefore, no permanent stoma. Additionally, local failure following either surgical or nonsurgical organ-preservation approaches has been associated with a decrease in survival.[5,40,41]

**Organ-Preservation Surgical Techniques**

The organ-preservation surgical approaches can be divided into techniques used for supraglottic carcinomas and those used for glottic carcinomas. The remainder of this article will focus on oncologic and functional outcomes following specific organ-preservation surgical techniques.
Preoperative Clinical Assessment

The preoperative evaluation of all patients with laryngeal cancer must include an indirect laryngoscopy, either with a mirror or a fiberoptic or rigid optic laryngoscope. This will allow assessment of both the vocal cord and arytenoid mobilities. In addition, all patients must be examined with direct laryngoscopy under general anesthesia in order to determine the full extent of the cancer and to decide whether the patient is a candidate for organ-preservation surgery.

Although many surgeons choose not to perform the full spectrum of organ-preservation surgery in their practice, there are many head and neck surgeons with a particular expertise and interest in organ-preservation surgery throughout the United States. Even if a surgeon does not choose to perform organ-preservation surgery, he or she should be skilled in performing a diagnostic work-up of patients to assess whether they are indeed candidates for such a procedure (and to suggest the option when appropriate).

The roles of bronchoscopy and esophagoscopy remain controversial.[33] The neck and primary site should be evaluated with an MRI or CT scan. Patients with carcinoma in situ or T1 glottic carcinoma do not require a neck scan. In the absence of symptoms, the metastatic work-up should be limited to a chest x-ray; chest, abdomen, and bone scans are not helpful in these diseases, may delay treatment, and create unnecessary anxiety.

Carcinomas Arising at the Glottic Level

Endoscopic Approaches: The endoscopic approach to glottic cancer is performed transorally, without a tracheostomy, using laryngoscopes and other specialized equipment. Although carcinoma in situ may be treated surgically or with radiation therapy with high success rates, surgery generally plays a primary role in very early disease.[42-45] Radiation therapy is reserved for patients who have multiple recurrences after repeated surgical resections, contraindications to general anesthesia, or extensive carcinoma in situ throughout the larynx precluding adequate surgical excision.[46]

Whether endoscopic organ-preservation surgery is appropriate for a particular T1 glottic carcinoma patient is a matter for clinical judgment. There is a wide spectrum of T1 glottic carcinoma, ranging from a minute mid-vocal cord cancer (no more than a few millimeters in size) to a sizable cancer extending up to a centimeter into the subglottic region and involving the whole length of both vocal cords. Cragle et al noted that the local control rates for early glottic carcinoma were equivalent for surgery and radiation therapy, that voice quality after laser resection was as good as after radiotherapy, and that the cost of laser cordectomy was much lower.[29] The morbidity associated with endoscopic excision is very low, with the chronic side effect being some degree of hoarseness, correlated directly to the extent of the primary lesion.[47]

A reasonable approach is to recommend endoscopic excision when the surgeon predicts that the voice outcome will be comparable with radiation therapy. This is generally the case when the endoscopic excision can be limited to mucosal excision for microinvasive cancers, or when the primary lesion is small enough to allow for a partial rather than a total endoscopic cordectomy. Endoscopic resection for T2 carcinomas remains controversial. German investigators led by Eckel recommended that endoscopic resections should not be attempted for T3 glottic carcinomas.[48]

Vertical Partial Laryngectomy: Procedures in this category result in the resection of one or both vocal cords via a vertical transection of the thyroid cartilage. A temporary tracheostomy is indicated. The role of vertical partial laryngectomy has been limited on the one hand by the advent of endoscopic approaches, and on the other by supraccricoid partial laryngectomy with cricothyoidopepiglottopexy.[49] Types of vertical partial laryngectomy include the open laryngofissure and cordectomy, the vertical hemilaryngectomy, and the epiglottic laryngoplasty.

The reported local control rates for vertical hemilaryngectomy in selected T1 glottic carcinomas ranged from 89% to 100%.[11,50-54] Although local control rates are very high, open procedures such as these, requiring a temporary tracheostomy, are not warranted if an endoscopic procedure
can be performed. The local control rate for T2 glottic carcinoma with vertical partial laryngectomy is much more variable, with the local failure rate ranging from 4% to 26%.\textsuperscript{11,51-53,55-58} An option that offers more consistent local control for T2 glottic carcinoma is the supracricoid partial laryngectomy with cricohyoidoepiglottopexy.

The expected functional outcome after vertical partial laryngectomy includes some degree of hoarseness, the extent of which depends on the type of reconstruction. An excellent reconstruction is the imbrication laryngoplasty, which allows for soft-tissue reconstruction using the adjacent false vocal fold.\textsuperscript{59}

**Supracricoid Partial Laryngectomy With Cricohyoidoepiglottopexy:** The supracricoid partial laryngectomy with cricohyoidoepiglottopexy results in resection of both true and false cords and the entire thyroid cartilage. The reconstruction is accomplished by suturing the cricoid to the epiglottis and hyoid; hence, the name cricohyoidoepiglottopexy.

This procedure is used primarily for selected T2 and T3 glottic carcinomas. The 5-year local control rate after supracricoid partial laryngectomy with cricohyoidoepiglottopexy for 62 patients with invasion of the anterior commissure classified as T1b or T2 lesions was 98.2% (61/62).\textsuperscript{60} Among 67 patients with T2 lesions (31 with impaired motion of the true vocal cord, and 36 without impaired motion), the 5-year local control rate was 95.5% (64/67).\textsuperscript{61} In 20 patients with T3 glottic carcinoma with vocal cord fixation, the 5-year actuarial local control rate was 90%.\textsuperscript{62} In a group of 112 previously untreated patients with impaired motion (T2 = 90) or fixation (T3 = 22) of the true vocal cord, Chevalier et al\textsuperscript{63} reported an estimated 5-year actuarial local control of 94.6%.

The expected functional outcome is temporary difficulty swallowing, a temporary tracheostomy, and permanent hoarseness. Long-term dysphagia is rare, with the time to removal of a temporary nasogastric tube ranging from 9 to 50 days.\textsuperscript{22,64-69} Studies of voice quality after supracricoid partial laryngectomy with cricohyoidoepiglottopexy have shown that, at 6 months, the phrase grouping and number of words per minute are similar to that of normal speakers, while the fundamental frequency is lower and wider than normal, suggesting voice instability.\textsuperscript{70}

A recent quality-of-life study compared speech, swallowing, and general health status in patients who had undergone supracricoid partial laryngectomy with cricohyoidoepiglottopexy to outcome after a total laryngectomy with voice prosthesis. The investigators found the supracricoid laryngectomy to be superior to total laryngectomy in all parameters.\textsuperscript{71}

**Carcinomas Arising at the Supraglottic Level**

**Endoscopic Approaches:** As with glottic cancers, endoscopic approaches to organ-preservation surgery for supraglottic cancers are performed transorally with specialized laryngoscopes, typically without a tracheostomy. Numerous centers have reported excellent oncologic and functional outcome following endoscopic supraglottic partial laryngectomy. In Utah, Davis and Hayes\textsuperscript{72} found that among 24 patients treated with laser resection for T2 or microscopic T3 tumors (treated with postoperative radiotherapy), only one had a local recurrence.

In one German center, Eckel and Thumfart\textsuperscript{48} reported on 15 patients without local recurrences. Zeitels et al, in Boston, reported on a large series of patients who underwent laser resections without postoperative radiation therapy (including 22 patients with mostly T1 cancers of the supraglottis and hypopharynx) with no local recurrences.\textsuperscript{73} Steiner et al found the 5-year local control rate among 48 patients with early supraglottic carcinoma managed by laser resection was 100% for T1 disease and 89% for T2 disease.\textsuperscript{74}

The local failure rate following laser resection of T3 and T4 cancers has been reported to be much higher. In 1992, Eckel and Thumfart recommended that laser excision not be used to treat T3 supraglottic carcinomas.\textsuperscript{48} This point of view was not shared by Steiner et al, who advocated the use of laser resection for T3 supraglottic carcinoma.\textsuperscript{75}

In summary, laser supraglottic laryngectomy has been shown by numerous surgeons to be a reliable technique for selected T1 and T2 supraglottic carcinomas, whereas laser resection for T3 carcinomas...
remains controversial. There is no reported role for laser "debulking" followed by radiation therapy.

The functional outcome following laser supraglottic laryngectomy has the advantage of not requiring a tracheostomy in most cases, and temporary dysphagia in the vast majority of patients. Voice quality is excellent after this procedure because the vocal cords are not resected.

**Supraglottic Partial Laryngectomy:** The supraglottic partial laryngectomy results in excision of the epiglottis, both false cords, and the upper half of the thyroid cartilage. Extended versions of this procedure involve resection of either the tongue base or an arytenoid and pyriform sinus. As with vertical partial laryngectomy, the indications for open supraglottic partial laryngectomy have been diminished by the introduction of endoscopic approaches on the lower end of the spectrum and the supracricoid partial laryngectomy with cricohyoidopexy on the larger end. Reported local failure rates following supraglottic laryngectomy for T1 carcinoma range from 0% to 10%, and for T2 carcinoma, from 0% to 15%. Therefore, the supraglottic partial laryngectomy can be said to be a reliable oncologic technique for the management of selected T1 and T2 supraglottic carcinomas.

There is much greater variability in local control for T3 and T4 supraglottic carcinomas. Local failure rates for T3 supraglottic carcinomas range from 0% to 75%, and for T4 carcinomas, from 0% to 67%. The best local control rate for T3 supraglottic carcinomas was reported by Lee et al, who combined supraglottic laryngectomy with postoperative radiation therapy for intermediate stage tumors, to yield a local control rate of 100%. Nonetheless, given the variability in oncologic outcome when supraglottic laryngectomy is performed for T3 and T4 carcinomas, this procedure should be used with great caution in these cases. Of note, extension of carcinoma to the glottic level, extension of carcinoma to the ventricle, or impaired or fixed mobility of the vocal cord are contraindications to supraglottic partial laryngectomy.

The expected functional outcome following standard supraglottic laryngectomy includes excellent voice and swallowing with a temporary tracheostomy. In one study of this surgical approach, 87% of patients had normal to mild breathiness, while 67% had mild or no evidence of hoarseness. This makes sense because the vocal cords are not removed in this procedure. While functional outcomes in terms of swallowing and decannulation of tracheostomy have been reported to be excellent following standard supraglottic laryngectomy, the incidence of impaired swallowing is higher following extended supraglottic laryngectomy.

**Supracricoid Partial Laryngectomy With Cricohyoidopexy:** The resection used in this technique results in removal of both true and false cords as well as the entire epiglottis and thyroid cartilage. Reconstruction is accomplished by suturing the cricoid to the hyoid; hence, the name cricohyoidopexy. Supraglottic carcinomas with glottic level invasion either via the ventricle or anterior commissure, impaired vocal cord mobility, preepiglottic space invasion, or limited thyroid cartilage invasion will frequently be resectable with supracricoid partial laryngectomy with cricohyoidopexy.

In 1990, Laccourreye et al noted no local failures among 68 patients who underwent supracricoid partial laryngectomy with cricohyoidopexy (T1 = 1, T2 = 40, T3 = 26, T4 = 1). Among 19 patients who underwent supracricoid partial laryngectomy with cricohyoidopexy for supraglottic carcinomas involving the preepiglottic space, the local failure rate was 5.6% (1/19) with a minimum of 5 years’ follow-up. Chevalier et al reported on a series of 61 patients with supraglottic carcinoma managed by supracricoid partial laryngectomy with cricohyoidopexy with a 3.3% (2/61) local failure rate. Vincentiis et al, reporting on an Italian series of supraglottic and transglottic carcinomas, noted a local failure rate of 6% (6/98, including 2 T1b, 69 T2, 25 T3, and 2 T4 tumors) after supracricoid partial laryngectomy with cricohyoidopexy.

This procedure is the most extensive organ-preservation surgical technique, particularly when one arytenoid is resected. Nonetheless, the expected functional outcome following supracricoid partial laryngectomy with cricohyoidopexy is temporary dysphagia, a temporary tracheostomy, and permanent hoarseness. Difficulty swallowing is more common when one arytenoid is resected. An analysis of voice following supracricoid partial laryngectomy with cricohyoidopexy revealed a normal average fundamental frequency, while there was significantly less efficient jitter, shimmer,
and maximum phonation time.[84] These findings are consistent with the long-term qualitative finding of hoarseness.

Organ-Preservation Surgery Following Radiation Failure

It is important to advise patients at the time of the primary treatment that those who fail nonsurgical organ-preservation regimens involving radiation or chemoradiation can rarely undergo organ-preservation surgery subsequently.[85,86] This is so even for patients with T1 lesions.[5] Part of the problem is late detection of the recurrence, which can often be masked by edema, erythema, or changes in vocal cord or arytenoid mobility secondary to treatment and scarring.[8]

Nonetheless, some lesions are still amenable to organ-preservation surgery after radiation or chemoradiation failure. Therefore, if a patient was a candidate for organ-preservation surgery prior to nonsurgical organ preservation and that patient fails primary treatment, then he or she should be assessed again for organ-preservation surgery. Although very few of these patients will be candidates for organ-preservation surgery, the literature supports that they are likely to do well from both an oncologic and functional perspective. Among patients who were candidates for a vertical hemilaryngectomy prior to radiation, and who failed without enlargement of the cancer, the local control rate is estimated to be approximately 80% following salvage vertical hemilaryngectomy.[87]

According to Sorenson et al, the use of supraglottic partial laryngectomy in the postradiation setting resulted in both poor oncologic and functional outcome.[88] Shaw stated that supraglottic partial laryngectomy should be contraindicated in the postradiation setting unless (1) the recurrence is located anteriorly, (2) the primary tumor is small, and (3) the cancer never involved the vocal cord level.[89] An alternative for lesions that recur after radiation therapy and are too large for either vertical partial laryngectomy or supraglottic partial laryngectomy is the supracricoid partial laryngectomy with either cricohyoidoepiglottopexy or cricohyoidopexy.[90]

Summary

In summary, there are both surgical and nonsurgical approaches to organ preservation for laryngeal cancer. Over the past decade, there has been a renaissance in surgical approaches to organ preservation. A search of the online databases by the name of any surgical organ-preservation technique reveals that there are head and neck surgeons throughout the United States with experience in the gamut of endoscopic or open surgical approaches. The addition of endoscopic techniques on one end of the spectrum and supracricoid partial laryngectomies on the other has broadened the scope of organ-preservation surgery techniques. When the appropriate technique is chosen, the oncologic outcome can be expected to be excellent. The expected functional outcome is the ability to speak and swallow without a permanent tracheostomy.

The tumor-staging system has no value in deciding which organ-preservation surgical technique should be used for a particular lesion. The pretreatment work-up for organ-preservation surgery requires a more precise evaluation of the three-dimensional and surface extent of the cancer than the staging system allows. Nonetheless, most patients with T1 and T2 tumors, many with T3 disease, and very few with T4 carcinomas are candidates for organ-preservation surgery. Clinicians who are counseling patients about alternatives to organ preservation should understand all of the available surgical and nonsurgical options.

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