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Introduction

Voice-sparing treatment options for early glottic carcinoma include endoscopic surgical excision, thyrotomy with cordectomy, hemilaryngectomy, vertical partial laryngectomy with laryngoplasty, supracricoid partial laryngectomy, and radiation therapy. Similarly, for supraglottic lesions, endoscopic resection, open supraglottic laryngectomy, and radiation therapy are treatment options. Supracricoid partial laryngectomy, supraglottic laryngectomy, and radiation therapy have been reviewed at length in prior grand rounds presentations, and will not be examined in depth here.

Conservation laryngeal surgery refers to any procedure that maintains physiologic speech and swallow function without the need for a permanent tracheostoma. The goal in conservation laryngeal surgery is to preserve maximum laryngeal function without compromising the cure rate. In other words, complete removal of all malignant disease should be achieved while preserving the 4 basic functions of the larynx: deglutition, respiration, phonation, and airway protection.

Regardless of the specific conservation laryngeal procedure, a few key principles must be respected according to Tufano. First, one must be able to confidently predict the extent of tumor, for it is the extent of tumor, and NOT the T-stage, that determines eligibility for organ preservation surgery. Involvement of the cricoarytenoid joint is a contraindication to any organ preservation surgery. Furthermore, it is vitally important to assess subglottic extent at the time of endoscopy.

Second, the cricoarytenoid unit, and not the true vocal cord (TVC), is the basic functional unit of the larynx; it is the cricoarytenoid unit that makes conservation laryngeal surgery possible. As long as one cricoarytenoid unit can be preserved, the patient is a potential candidate for organ preservation laryngeal surgery.

Third, resection of normal tissue in organ preservation surgery is necessary to achieve consistent functional outcomes.

Fourth, it is impossible to know the extent of submucosal tumor involvement preoperatively. For this reason, even the most confident surgeon must consent his or her patient for a total laryngectomy in addition to the intended procedure.

Anatomy

Lymphatic drainage of the larynx is sparse anteriorly and at the level of the glottis. The lymphatic drainage is richer in the supraglottic and subglottic regions, as well as the posterior ½ of the larynx. Lesions above the level of the true vocal cords drain superiorly, while glottic and subglottic lesions drain inferiorly.

Laryngeal cancer arises from the TVCs approximately 75% of the time. Three fibroelastic membranes serve as the major barriers to the spread of cancer from (and to) the glottic region: the conus elasticus inferiorly, the quadrangular membrane laterally, and the thyrohyoid membrane superiorly. *Broyles' Tendon* is the insertion of the vocalis tendon into the thyroid cartilage in the area of the anterior commissure. This is significant because thyroid cartilage perichondrium is deficient in this area, making it a weak point for the spread of malignancy into the thyroid cartilage and on to the extralaryngeal soft tissues of the neck.

The cricoarytenoid unit consists of the arytenoid cartilage, cricoid cartilage, associated musculature, and the superior laryngeal nerve and recurrent laryngeal nerve for that unit. Of note, a cricoarytenoid unit may retain its function despite compromise of the vocal process or superior aspect of the arytenoid, as long as the body of the arytenoid is preserved.

Pathophysiology of Laryngeal Cancer

Limitation of true vocal cord mobility correlates with a worsening prognosis, especially if the lesion displays an invasive pattern of growth rather than an exophytic or verrucous one.

Kirchner described two types of carcinomatous involvement of the anterior commissure: early lesions that are not invasive and confined to the level of the glottis, and those lesions that invade aggressively and spread superiorly to involve the base of the epiglottis. The latter tend to advance within the cancellous framework of the thyroid cartilage deep to normal appearing soft tissue and imply a poorer prognosis.

Approximately ¼ of early glottic cancer extends to the anterior commissure. Approximately 1/5 of early glottic cancer extends 5 mm or more below the level of the true vocal cords. Likewise, 1/5 extends to involve the supraglottic region.

Early glottic cancer infrequently metastasizes, and when it does, it is almost always to the ipsilateral neck. Lesions limited to the true vocal cords (e.g., T1 and T2) demonstrate a 5% incidence of cervical metastasis, while this figure jumps to 30-40% for T3 lesions.

Approximately 95% of glottic neoplasms are squamous cell carcinoma. Tumor spread is usually superficial and well visualized. Skip lesions, like those seen in the hypopharynx, are rare.

Supraglottic squamous cell carcinoma is a different disease process from its glottic counterpart. Supraglottic carcinoma exhibits a much higher incidence of occult nodal metastasis and frank nodal metastasis at presentation. Furthermore, 19% of survivors will develop a second respiratory tract primary within 5 years.

Supraglottic lesions tend to take a long time to spread to the glottis and paraglottic space. However, epiglottic carcinoma demonstrates a predilection for preepiglottic space involvement. When preepiglottic and paraglottic space involvement occurs, it usually involves a broad, pushing front with a pseudocapsule. This pseudocapsule likely arises from the epiglottic perichondrium and the quadrangular membrane.

Early suprahoid epiglottic lesions are unique in that they rarely invade the preepiglottic space and rarely result in cervical metastasis *unless* there is occult tongue base involvement.

Special Cases of Glottic Carcinoma

Carcinoma in Situ (CIS)

Approximately 1/6 of CIS eventually progresses to invasive carcinoma when treatment is limited to a single excisional biopsy. Radiation therapy is a treatment option, but more failures are associated with radiation as opposed to surgical management in CIS. The classic teaching involves microsuspension laryngoscopy with stripping of the involved TVC epithelium to ensure adequate margins and facilitate histopathologic analysis (to rule out microinvasive carcinoma). A closely monitored program of followup is indicated (e.g., every 2-3 months for 5 years).

Microinvasive Carcinoma

In this case, cancer cells pass through the epithelial basement membrane but do not invade the vocalis muscle. Appropriate treatment entails either a slightly deeper plane of dissection (i.e., taking partial thickness vocalis muscle/ligament with the specimen) or serial epithelial excision Q2-3 months until 2 consecutive specimens without tumor cells are noted. The major difference between microinvasive carcinoma and CIS is that microinvasive carcinoma has metastatic potential, whereas CIS does not.

Verrucous Carcinoma

These lesions are characterized by a rough, shaggy surface with rounded, pushing margins. These lesions do not metastasize. Compared to other types of SCCA, these tumors are relatively radioresistant. The treatment of choice is endoscopic resection for smaller lesions, and partial laryngectomy for larger lesions.

Endoscopic Management of Glottic Lesions

For CIS, T1a, and T1b glottic carcinoma, there are essentially three treatment options: conservation surgery, radiation therapy, and microendoscopic CO2 laser excision. The cure rates for all three of these options are approximately equal.

Regardless of treatment modality (laser excision versus XRT), local control is approximately 94% for T1a lesions, 71% for T1b lesions, and 83% for T2 lesions. This indicates that anterior commissure involvement (e.g., T1b lesions) portends a worse prognosis for laryngeal conservation regardless of treatment modality. In the US, vertical partial laryngectomy is favored over the laser or XRT for T2 lesions involving the anterior commissure or arytenoid. Tumor features that predict a poor response to XRT and favor use of the laser include increased tumor bulk and overexpression of P53. One tumor factor that predicts a poor result with laser excision is a history of previous XRT.

There are essentially 3 minimally invasive surgical treatment options for early glottic cancer: cold instrumentation, powered instrumentation, and transoral laser excision.

Strong and Jako in 1972 introduced CO2 laser excision for the treatment of laryngeal disease. The advantages they noted were precise control, minimal bleeding, and the absence of post-operative edema.

Preoperatively, all patients should undergo a thorough physical examination, including flexible laryngoscopy and videostroboscopy. It is vitally important to assess for the presence or absence of a mucosal wave, which implies the absence or presence of involvement of the vocalis muscle. However, injection of 1:10,000 epinephrine pre-excision has proven more reliable than videostrobe at determining the presence of invasion of the vocal ligament. In addition, *any* impairment of vibratory patterns of the TVC suggests that a submucosal cordectomy, alone, will not be adequate. Gallo is even more aggressive. She recommends a complete cordectomy for involvement of the anterior commissure, any lesion that infiltrates into the vocal fold, and tumor size >0.7 mm.

Manual pressure applied by an assistant or silk tape over the neck is often useful to improve visualization, especially at the anterior commissure. Microcups should be used to grasp the lesion, and tension applied. The excision should then be performed with solitary laser bursts. Once the cordectomy specimen has been excised, it should be oriented and then sent to surgical pathology for frozen section. If a positive margin is noted, the resection can be extended until healthy margins are obtained. Currently a “safe” margin for CIS or T1 lesions is considered 2-5 mm of surrounding healthy tissue.

Exclusion criteria should be stricter for endoscopic resection of glottic lesions as compared to open conservation laryngeal surgery. Exclusion criteria include deep involvement or fixation of tumor at the anterior commissure, vocal process involvement, involvement of the ventricle (some debate), and subglottic extension (some debate). In the area of the anterior commissure, resection must include thyroid cartilage because of the absence of perichondrium in this region. In addition, endoscopic resection is only appropriate when close followup is possible and appropriate adjuvant therapy is provided when indicated.

Many authors also regard impaired TVC mobility as a contraindication to use of the laser; in a series by Steiner, 11 patients with T2b lesions who received laser excision and post-op XRT had a 5-year disease free survival of 67%. However, the University of Utah introduced a technique that may significantly improve outcomes for T2b lesions. In their series of 11 patients with T2b lesions, they improved the 5-year disease free survival rate to 91% by performing

excision of the ipsilateral aryepiglottic fold and hemiepiglottis before excising the glottic specimen. This had the effect of “uncapping” the posterolateral paraglottic space and allowing full exposure of the medial wall of the pyriform sinus and thyroid cartilage from above. This is merely an extension of the concept that adequate visualization of the tumor during endoscopic excision is vital.

In Moreau’s study of 124 patients with glottic lesions, granuloma formation at the anterior commissure was a common occurrence. These granulomas tended to last for several months before spontaneous resolution. Other complications, which were few, included laryngeal hemorrhage, pneumothorax, aspiration pneumonia, subcutaneous air, and prelaryngeal abscess. In addition, several webs resulted from anterior commissure resection; these were treated with repeat endoscopic procedures.

Most European authors advocate the CO₂ laser equivalent of vocal cord “stripping” for CIS and microinvasive carcinoma. For CIS, a submucosal cordectomy is advocated; the plane of dissection is the superficial layer of the lamina propria. For microinvasive carcinoma, a subligamental or transmuscular cordectomy is advocated; the plane of dissection is either between the vocal ligament and the vocalis muscle, or through the vocalis muscle (the key point being that at least some vocalis muscle is left intact throughout the full thickness of the cord). They grant this may result in “overtreatment” of many lesions, but this results in excellent oncologic results while maintaining good voice outcomes. In addition, CIS can be very difficult to distinguish from microinvasive carcinoma, especially based upon a small biopsy of mucosal tissue. (Of note, immunohistological staining for Epidermal Growth Factor receptors can help in distinguishing moderate from severe dysplasia.) Most American authors feel that cold instrumentation, alone, is adequate for a plane of dissection superficial to the vocal ligament. The CO₂ laser should be used for any transmuscular dissection.

Cordectomies performed in a submucosal or transmuscular plane can be performed safely as a day surgery procedure. Outcomes have been excellent following these procedures. In Damm’s series of 29 patients, local control was achieved in 86% of patients following the first endoscopic procedure; 3 of the 4 patients with recurrence were treated successfully with 1 additional laser procedure, while the other required 4 additional endoscopic procedures. No one required an open procedure for control. In Gallo’s series of 156 laser cordectomy patients with Tcis-T1b lesions, local control was 100% with laser alone at 3 years for CIS. For T1A lesions, 6% experienced local recurrence; all were treated with either XRT or subtotal laryngectomy (no total laryngectomies were required). For T1b lesions, only 9% experienced local recurrence; again, no one required a total laryngectomy for salvage. Flint’s review of the literature suggested a local control rate of 40-100% for glottic Tcis-T2 lesions using the laser.

More extensive procedures should be followed by at least 24-hour observation for airway and swallow safety.

Powered instrumentation deserves mention, though its use in the endoscopic management of laryngeal neoplasms is limited. Flint recommends setting the microdebrider to oscillate at 500 RPM for mucosal lesions on or near the TVC, or 3,000 RPM for larger lesions. The 3.5 mm round window laryngeal blade should be used for superficial lesions, while the 4 mm tricut blade

is better for larger lesions. A tissue trap should be used to catch the specimen, which may then be processed and evaluated as a tissue block.

Advantages of powered instrumentation as compared to the laser include improved access to the anterior commissure and subglottis, and elimination of the risk of surgical fire/thermal injury. However, disadvantages include no margin control, and the specimen cannot be oriented. This, of course, is a major drawback. The microdebrider is excellent for the treatment of benign laryngeal lesions. In the setting of malignancy, powered instrumentation may be most useful in terms of “debulking” large, exophytic laryngeal lesions prior to excision with margin control, or to temporarily improve a patient’s airway and avoid tracheotomy prior to more definitive treatment.

Endoscopic Management of Supraglottic Lesions

Unlike glottic carcinoma, surgery is *usually* favored in the treatment of supraglottic squamous cell carcinoma unless patient factors preclude surgery.

The major contraindications to *any* form of supraglottic laryngectomy include

- 1) Involvement at the glottic level (Kirchner demonstrated that extension into the infrapetiole/anterior commissure region frequently results in thyroid cartilage invasion)
- 2) Invasion of the cricoid or thyroid cartilage
- 3) Involvement of the tongue base to within 1 cm of the circumvallate papillae.

Vaughan first described the CO2 laser for use in supraglottic squamous cell carcinoma in 1978. Since that time, application of the laser to supraglottic cancer has gained wide acceptance in Europe, but not so in the United States. Some reasons for this may be that the endoscopic approach involves an entirely different treatment paradigm with which most American surgeons are not familiar. In addition, larger lesions are technically more difficult to resect with the laser. And, finally, there has been a proliferation of non-surgical organ preservation protocols in our country.

The key to use of the laser in the supraglottic region is optimizing exposure. A bigger area of exposure is required than for glottal surgery. Steiner started to use a bivalved laryngopharyngoscope in the 1980’s. Zeitels later modified this while maintaining the bivalved design to develop the presently popular supraglottiscope.

Positioning works hand-in-hand with the scope to maximize exposure. The Boyce-Jackson position is optimal: extension occurs at the occipitoatlantic joint with the neck flexed on the chest.

Transoral laser resection is most successful when supraglottic lesions are selected for small size and endoscopic accessibility. The supraglottic lesions most amenable to laser resection are those that rest perpendicular to the distal lumen of the supraglottiscope and therefore minimize tangential cutting. These include

- 1) Suprahyoid epiglottic lesions

- 2) Lesions of the aryepiglottic fold
- 3) Lesions of the false vocal fold

Lesions of the infrahyoid epiglottis and upper FVC are more difficult to resect.

Following resection of the specimen, margin analysis is best accomplished by sending the entire specimen for evaluation. Decisions regarding radiation therapy and management of the necks should be based on the pathology of the primary lesion. Fears that this may result in undesirable treatment delay of the necks should be alleviated by the fact that laser resection can be performed as an excisional biopsy at the time of staging endoscopy.

In Zeitels series of 19 patients with T1 and T2N0 supraglottic lesions limited to sites 1-3 above, none of them failed in the neck, no patient required artificial airway intervention, and most patients returned to a normal diet within several days.

Larger lesions in N0 patients are better served post-excision by full-course XRT to the primary and bilateral necks, and this represents a more aggressive form of treatment than XRT alone, particularly in those patients who may not be good candidates for open surgery. Even in these cases, clear margins are usually obtained at the time of laser excision because of the tendency of supraglottic carcinoma to develop a pseudocapsule. In Zeitels series of 23 patients with T2 or T3N0 lesions treated with laser excision and XRT, 16/23 had clear margins at the primary site; none of these patients failed locally. However, of the 7 patients without clear margins, 4 experienced local failure requiring salvage total laryngectomy, and another failed in the neck. In general, completely excising the primary lesion prior to XRT is thought to result in a 20-35% treatment advantage over XRT alone. Though Steiner has used single-modality endoscopic treatment for T2 and T3 lesions, most surgeons advocate post-operative XRT because it is extremely difficult to guarantee comprehensive excision of the preepiglottic and paraglottic space.

Complications related to the use of the CO2 laser in the supraglottis are exceptionally rare. The epiglottis is thought to be a vestigial organ in humans, so swallowing should not be significantly compromised without it. Laryngeal protection is impaired for several days to 6 weeks depending on the extent of laser resection. Patients with a normal preoperative swallow do not experience permanent swallowing deficits with laser resection. Preexisting swallowing impairment such as may be seen in stroke or previous head and neck surgery is a relative contraindication to *any* partial laryngeal resection. In short, some, but not the majority of patients, may require temporary feeding tubes. This is so when using the laser because the superior laryngeal nerves are not disturbed proximal to the larynx, laryngeal elevation is not impaired by a tracheotomy or disturbance of the suprahyoid musculature, and healing by secondary fibrosis and epithelialization results in a favorable cicatrization that produces a new supraglottic valve.

Of note, patients who are poor candidates for supraglottic laryngectomy because of pulmonary status are still good candidates for transoral resection. In Zeitels' study, none of the patients predicted as poor candidates for open supraglottic laryngectomy developed post-operative pulmonary complications.

Hospitalization is usually required for 1-3 days postoperatively. Close involvement with a speech pathologist is very important.

All of this being said, open supraglottic laryngectomy remains the standard surgical management for early supraglottic carcinoma.

Vertical Partial Laryngectomy (VPL)

Prior to conservation laryngeal surgery, the primary tumor must be carefully mapped at the time of endoscopy, and it is a good idea to perform a direct laryngoscopy at the time of operation as well, particularly if more than a week has passed since the original endoscopy. Cricoarytenoid joint involvement is a contraindication to any organ preservation surgery; this may be assessed even before direct laryngoscopy by having the patient cough during flexible nasolaryngoscopy. Alternatively, one may palpate the arytenoids at the time of direct laryngoscopy to check for mobility. The difference between a fixed TVC secondary to paraglottic space involvement and a fixed TVC secondary to cricoarytenoid joint involvement can mean the difference between organ preservation and tracheostoma dependence. In addition, subglottic extension should be assessed carefully at the time of endoscopy. This is best accomplished via apneic technique using 0 and 30-degree rigid endoscopes. Other very important features to note during endoscopy are the tumor's proximity to the AC and arytenoid, and involvement of the ventricle/undersurface of the false vocal cord.

There are five generally accepted contraindications to VPL:

- 1) A fixed true vocal cord
- 2) Involvement of the posterior commissure
- 3) Invasion of bilateral arytenoids
- 4) Bulky transglottic lesions
- 5) Thyroid cartilage invasion

The upper limits of tumors amenable to VPL include

- 1) Up to 5 mm of contralateral TVC involvement
- 2) Up to 15 mm of subglottic extension anteriorly
- 3) Up to 5 mm of subglottic extension posteriorly
- 4) Lesions extending up to the free edge of the false vocal cord superiorly.

Vocal cord fixation (i.e., apparent T3 lesions) suggests the lesion is unsuitable for VPL. 75% of the time, lesions resulting in a fixed vocal cord will extend through the thyroid or cricoid cartilage and involve cartilage beyond the extent of visible tumor.

With respect to patient selection, cardiopulmonary status is an important factor. Aging and chronic obstructive pulmonary disease increase the risk of postoperative atelectasis and pneumonia. The value of preoperative Pulmonary Function Testing (PFTs) is controversial. Some authors recommend the routine use of PFTs. An FEV1 of less than 50-60% of expected for the patient's age suggests a high risk of pulmonary-associated complications following conservation surgery. However, in 1988, Chow and colleagues demonstrated that a patient's

ability to walk up two flights of stairs is a better predictor of post-operative complications than PFTs. In addition, a chronic and inefficient cough, and purulent sputum bode poorly for the patient's ability to tolerate organ preservation surgery.

All patients should be evaluated preoperatively by a speech therapist. The patient must also be aware of the need for a temporary feeding tube and tracheostomy.

A tracheotomy is required when performing a VPL, and an armored endotracheal tube is placed. An apron incision is then made, and a superior flap elevated in the subplatysmal plane to allow exposure up to the level of the hyoid bone. Care must be taken to avoid injury to the superior laryngeal nerves. After elevation of the flap, cervical lymph nodes should be examined; suspicious nodes should be sent for frozen section. The strap muscles are then divided in the midline. An ipsilateral thyroid lobectomy should be performed if there is >5-10 mm of subglottic involvement. The external thyroid perichondrium is then divided in the midline and along the superior and inferior margins of the thyroid alae. The perichondrium is then elevated to a point parallel with the superior and inferior thyroid cornua. The thyroid cartilage is then divided in the midline, or slightly off midline on the less involved side, with an oscillating saw. The cricothyroid membrane is then cut vertically (or in a transverse direction) and a hemostat is inserted to allow the surgeon to examine the subglottic area directly using a headlight. The internal perichondrium is then elevated off of the deep surface of the thyroid alae. Tufano advocates routinely resecting at least a portion of thyroid cartilage at the glottic level in continuity with the specimen. The tumor is then excised under direct vision with a cuff of normal tissue. The inferior line of excision should extend along the superior margin of the cricoid cartilage. Excessive resection of the epiglottis should be avoided to prevent aspiration. Surgical margins are sent for frozen section analysis.

Several options exist for the reconstruction of the surgical defect. With an intact ipsilateral thyroid lamina, these include a skin graft, buccal mucosa, and false vocal cord advancement. When all or part of the ipsilateral thyroid lamina is removed, these include a composite septal cartilage/perichondrial free graft, and an inferiorly and laterally rotated epiglottis. In either case, a bipediced strap muscle flap is an excellent option; one must anticipate approximately 30% muscle atrophy when inseting the flap. The sternohyoid, sternothyroid, and thyrohyoid muscles may be used and transposed deep to the remaining thyroid ala; the preserved external perichondrium is then used to line the laryngeal lumen.

The resection specimen should include the lower ½ of the FVC and all of the TVC (including the arytenoid when necessary). A VPL may be extended to include the entire endolaryngeal circumference except for 1 arytenoid unit and the posterior commissure. In such a case, reconstruction would require bilateral bipediced muscle flaps. If both sides of the endolarynx undergo excision or reconstruction, then an anterior commissure keel should be used during the healing phase (at least 3 weeks) prior to removal. The keel can be fashioned with anterior limbs that can be tacked down to the soft tissues of the neck with suture.

If the anterior commissure is involved, a central segment of thyroid cartilage may be isolated and removed en bloc with the specimen. In such a case, two longitudinal paramedian incisions would be required when opening the thyroid cartilage rather than a single median thyrotomy. Two major options exist for reconstruction of the anterior commissure: first, the

epiglottic petiole may be dissected free and pulled inferiorly into the surgical defect and sutured into place; second, bilateral omohyoid muscle flaps may be used to reconstruct the defect. If the epiglottis is not required for closure, Osguthorpe advocates tacking the petiole to the hyoid in the midline to minimize epiglottic retroversion.

Yet another variant of VPL is imbrication laryngectomy. In this procedure, a through and through excision of a horizontal segment of larynx is performed in continuity with the specimen. The caudal and cephalic portions of the cut thyroid ala are then brought together and overlapped, and the endolaryngeal mucosa is approximated over the cartilage. Thus, the cartilaginous support and soft tissue planes of the larynx are preserved, with the FVC essentially acting as the neocord.

Drains should be placed in the neck intraoperatively. Oral feeds should begin by the end of the first post-operative week. Decannulation should be performed at 1 to 2 weeks postoperatively. Patients can usually resume functional phonation by approximately 4 weeks postoperatively.

VPL is indicated for T1 or T2 glottic lesions with or without supraglottic extension. At our institution, XRT has been the mainstay as initial therapy for T1 and T2 glottic lesions. However, patients with T1 lesions extending to the anterior commissure demonstrate longer survival and fewer total laryngectomies for salvage when VPL is used rather than XRT as initial therapy. In addition, obese patients with early glottic cancer demonstrate high complication and failure rates following primary XRT. Other factors favoring VPL as opposed to XRT include

- 1) Radioresistant tumors (such as verrucous carcinoma)
- 2) Salivary gland malignancies
- 3) Benign laryngeal tumors
- 4) Patients deemed unreliable for 6 weeks of XRT
- 5) Young patients (due to the theoretical increased risk of late radiation-induced sarcoma)
- 6) Neck nodes >2 cm in size favors primary surgery for both neck and primary.

Furthermore, VPL is considered a safe option in selected cases of tumor recurrence following XRT. Criteria for this include

- 1) The lesion must be limited to one TVC (anterior commissure involvement is acceptable)
- 2) The body of the arytenoid must be free of tumor
- 3) Subglottic extension must be <5-10 mm
- 4) The TVC must be mobile
- 5) Thyroid cartilage must NOT be invaded
- 6) The entire area of pre-XRT tumor involvement must be encompassed in the resection
- 7) The lesion must extend no higher than the lateral wall of the ventricle

The overall 5-year local control rate for VPL is 89-100%. Local control is worse when the AC is involved. The most common site of recurrence for a primary involving the AC is in the subglottis. For T2 lesions, failure rates typically exceed 14%. For T3 lesions, failure rates are highly variable, but typically exceed 30%, likely because most versions of VPL do not fully address the paraglottic space or cricoarytenoid joint. VPL is best suited for T1 lesions without

AC involvement, and should be used with caution in the setting of extensive T2 lesions *or* AC involvement. VPL is best avoided for T3 lesions. When comparing VPL to XRT, outcomes are essentially the same *except* for T2b lesions, in which case 5-year disease free survival is 64-76% for XRT vs. 73-90% for VPL.

Foremost, early complications following VPL include those complications typically associated with tracheotomy (e.g., tube occlusion, hemorrhage, tracheocutaneous fistula, etc.). Infection, including wound infection and chondritis, is also a possibility. Aspiration and dysphonia are common difficulties following VPL, but these should not persist beyond 3 postoperative weeks.

Late complications include aspiration, chondritis, laryngeal stenosis, severe hoarseness, granulation tissue, and tumor recurrence. Two common causes of local failure include an inability to recognize the inferior margin of the tumor (essential during direct laryngoscopy), and missing spread of cancer outward through the cricothyroid membrane. Granulation and webs may be treated with the CO2 laser and the temporary placement of a keel at the AC. Delayed decannulation can occur in up to 5% of patients; again, the CO2 laser may be helpful. However, when laryngeal stenosis occurs, local recurrence must be ruled out. Aspiration may be managed with injection laryngoplasty. This is best performed within the first 6-8 postoperative weeks.

Voice

Voice is a major factor in comparing treatment modalities with very similar rates of local control. Ultimate voice preservation is slightly more successful following primary treatment with conservation laryngeal surgery than it is following primary XRT (97% vs. 90% local control; Bron 2001). Factors with the biggest impact on voice following XRT are a history of prior TVC “stripping” and smoking after treatment.

In conservation surgery for glottic lesions, the presence of even a minimal mucosal wave through a lesion noted preoperatively strongly suggests that the lesion is superficial and amenable to microflap or superficial laser excision with a high probability of attaining normal or near normal speech after healing. This fact emphasizes the importance of a pre-treatment videostrobe.

Critical factors in maximizing postoperative voice, particularly in the setting of CIS or microinvasive carcinoma, are limiting the amount of mucosa resected, restoring and maintaining a straight vocal fold edge, and preserving the vocal ligament. To achieve these three aims while still taking adequate surgical margins is actually best achieved using cold microsurgical techniques. However, in Mahieu’s series, 12 of 16 patients with CIS or microinvasive carcinoma had a “normal” voice following CO2 laser excision, and 11 of 16 had a normal post-op videostrobe. This demonstrates that excellent voice outcomes may be achieved using the laser as well.

Following XRT, Stoicheff showed that most patients demonstrate a gradual improvement in voice that plateaus at approximately 4 months post-XRT in >80% of patients, while some patients took up to 2 years to achieve their maximal voice improvement. Lehman demonstrated that, following XRT for glottic carcinoma, videostrobe demonstrated that all patients had

reduced or absent mucosal waves bilaterally, and 50% showed irregular glottic closure. Radiation results in fibrosis and decreased mass of the vocal folds. In summary, the literature regarding XRT and voice suggests that most patients are pleased with their voices following XRT, and voice tends to improve gradually following XRT, but the post-irradiation voice is not perfect, and many patients experience persistent vocal problems substantiated by objective data.

Immediately following laser excision for glottic lesions, the voice tends to be breathy and rough. Healing of the TVCs progresses from granulation tissue to the formation of scar tissue with overlying mucosal cover. Recent data suggests that the mucosal wave will be preserved approximately 33% of the time.

In the 5 major studies comparing voice following laser cordectomy to voice following XRT, 3 of 5 showed no significant difference. 2 of 5 showed that the post-irradiated voice was better. Subjective comparisons between the 2 modalities are generally equivalent. The more vocalis muscle resected, the worse the voice.

Total cordectomy results in moderate to severe breathy dysphonia with decreased volume, decreased maximum phonation time, and increased vocal fatigue. Videostrobe demonstrates a severely reduced or absent mucosal wave and incomplete glottic closure. In this setting, the surgical voice is generally thought to be inferior to the post-XRT voice.

With respect to quality of voice following VPL, preservation of functional arytenoid units is the key. Following VPL with strap muscle flap reconstruction, Hirano demonstrated the patients had a rough, breathy, and strained voice with decreased maximum phonation time, increased airflow, and a decreased ability to vary pitch and volume. 80% demonstrated incomplete glottic closure and >50% demonstrated supraglottic hyperfunction. The major finding was the unpredictability of voice results following VPL; post-operative voice varied widely. To date, there have been no studies comparing VPL to XRT with respect to voice.

Discussion

Open conservation laryngeal surgery is associated with a local recurrence rate of approximately 5%. Open procedures are thought to result in slightly higher rates of local control, but these procedures typically require tracheotomy. Following radiation therapy, the recurrence rate of early glottic cancer is higher: from 10% for T1 lesions up to 30% for T2b lesions. When comparing primary surgery to XRT, the treatment of recurrence following XRT is much less satisfactory and frequently requires a total laryngectomy. The primary advantage of laser excision is the curability of recurrence following treatment. Eckel, Steiner, and Rudert all reported adjusted survival rates of 100% for T1 to T3 glottic lesions following laser excision. In Moreau's series of 160 total patients with laryngeal lesions, *none* required a total laryngectomy for salvage.

Other advantages of laser excision include decreased cost (approximately ¼ to ½ the cost of XRT), decreased morbidity (patients are more likely to eat sooner, complain of less pain, and *rarely* require a tracheotomy), good voice as long as anterior commissure is not involved, increased ease of detecting recurrent disease, and laser excision does not preclude further treatment. Importantly, a wide range of treatment options remains in the event of recurrence.

Carcinoma in Situ is a particularly appropriate indication for endoscopic excision, since radiation therapy demonstrates a significantly higher incidence of local recurrence. The ultimate laryngeal preservation rate is 7-fold greater for laser excision than it is for radiation therapy, and 12-fold greater than it is for conventional vocal cord stripping.

When comparing open conservation surgery to XRT, the advantages of XRT are generally thought to include superior voice quality, no in-house stay, and no surgical complications. The disadvantages of XRT are thought to be 6-7 weeks missed from work, and radiation-associated complications (chondritis 1%, stenosis 2%, obstructing edema 2%, radiation-induced malignancy).

The advantages of open surgery are thought to be histologic tumor margin control, improved ability to assess for cervical metastasis, return to work within 4 weeks, and a better chance of salvage with total laryngectomy. The disadvantages include surgical complications and the possibility of a "poor" voice.

Staffieri performed a meta-analysis comparing open supraglottic laryngectomy to XRT (n=15,000). He found that 5-year disease free survival was 75% following surgery and 64% following primary XRT.

According to DeSanto, the major problem with supraglottic cancer is cervical metastasis, which is not addressed by use of the CO2 laser. Open supraglottic laryngectomy offers the possibility of a single modality of treatment of both the primary site and the necks. Steiner typically does his neck dissections later, at the time of a second endoscopic look at the primary site. Obviously, it would be preferable to perform neck dissections at the time of treatment of the primary lesion. Thus, the ideal candidate for laser resection in the setting of supraglottic cancer is a patient with a small, superficial lesion of the suprahoid epiglottis and N0 necks (i.e., a patient who does not require neck dissections).

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