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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.

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. 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 suprahyoid 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.

Background on Lasers

Laser is an acronym for *l*ight *a*mplification by the *s*timulated *e*mission of *r*adiation. Einstein postulated the theoretical foundation of laser action, stimulated emission of radiation, in 1917. Einstein postulated that the spontaneous emission of electromagnetic radiation from an atomic transition has an enhanced rate in the presence of similar electromagnetic radiation. Maiman built the first laser in 1960. With synthetic ruby crystals, this laser produced electromagnetic radiation at a wavelength of 0.69 µm in the visible range of the spectrum. Although the laser energy produced by Maiman's ruby laser lasted less than 1 ms, it paved the way for explosive development and widespread application of this technology.

Two important advances allowed the laser to be useful in otolaryngology: (1) in 1965, the carbon dioxide (co_2) laser was developed, and (2) in 1968, Polanyi developed the articulated arm to deliver the infrared radiation from the co_2 laser to remote targets. He combined his talents with Jako and used the articulated arm and the co_2 laser in laryngeal surgery. Simpson and Polanyi described the series of experiments and new instrumentation that made this work possible.

A laser is an electro-optical device that emits organized light (rather than the random-pattern light emitted from a light bulb) in a very narrow intense beam by a process of optical feedback and amplification.

Electrons can change their orbits, thereby changing the energy state of the atom. During excitation, an electron can make the transition from a low-energy level to a higher energy level. Excitation that comes from the electron interacting with light (a photon) is termed *absorption*. The atom always seeks its lowest energy level (i.e., the ground state). Therefore, the electron will spontaneously drop from the high-energy level back to the lowest energy level in a very short time (typically 10^{-8} sec). As the electron spontaneously drops from the higher energy level to the lower energy level, the atom must give up the energy difference. The atom emits the extra energy as a photon of light in a process termed the *spontaneous emission of radiation.*

All laser devices have an optical resonating chamber (cavity) with two mirrors. The space between these mirrors is filled with an active medium, such as Ar, Nd:YAG, or co_2. An external energy source (e.g., an electric current) excites the active medium within the optical cavity. This excitation causes many atoms of the active medium to be raised to a higher energy state. A population inversion occurs when more than half of the atoms in the resonating chamber have reached a particular excited state. Spontaneous emission is taking place in all directions. Light (photons) emitted in the direction of the long axis of the laser is retained within the optical cavity by multiple reflections off of the precisely aligned mirrors. One mirror is completely reflective, and the other is partially transmissive. Stimulated emission occurs when a photon interacts with an excited atom in the optical cavity. This yields pairs of identical photons that are of equal wavelength, frequency, and energy and are in phase with each other. This process occurs at an increasing rate with each passage of the photons through the active medium.

With most surgical lasers, the physician can control three variables: (1) power (measured in watts); (2) spot size (measured in millimeters); and (3) exposure time (measured in seconds).

Of power, spot size, and exposure time, power is the least useful variable and may be kept constant with widely varying effects, depending on the spot size and the duration of exposure. For example, the relationship between power and depth of tissue injury becomes logarithmic when the power and exposure time are kept constant and the spot size is varied.

Irradiance is a more useful measure of the intensity of the beam at the focal spot than power is because it considers the surface area of the focal spot. Specifically, irradiance is expressed (in W/cm^2) as: Irradiance = Power in the focal spot/Area of the focal spot.

Power and spot size are considered together, and a combination is selected to produce the appropriate irradiance. If the exposure time is kept constant, the relationship between irradiance and depth of injury is linear as the spot size is varied. Irradiance is the most important operating parameter of a surgical laser at a given wavelength. Therefore, surgeons should calculate the appropriate irradiance for each procedure to be performed. These calculations allow the surgeon to control, in a predictable manner, the tissue effects when changing from one focal length to another (e.g., from 400 mm for microlaryngeal surgery to 125 mm for hand-held surgery). Irradiance varies directly with power and inversely with surface area. This relationship of surface area to beam diameter is important when evaluating the power density because the larger the surface area, the lower the irradiance; conversely, the smaller the surface area, the higher the irradiance.

Depth of focus is realized when a camera is focused. With a camera, a range of objects is in focus, which can be set without carefully measuring the distance between the object and the lens. The preceding equations show that a long focal length lens leads to a large beam waist, which also translates as a large depth of focus.

The size of the laser beam on the tissue (spot size) can therefore be varied in two ways: (1) because the minimum beam diameter of the focal spot increases directly with increasing the focal length of the laser focusing lens, the surgeon can change the focal length of the lens to obtain a particular beam diameter. As the focal length decreases, a corresponding decrease occurs in the size of the focal spot. Also, the smaller the spot size is for any given power output, the greater the corresponding power density. (2) The surgeon can also vary the spot size by working in or out of focus. The minimum beam diameter and highest power concentration occur at the focal plane, where much of the precise cutting and vaporization is carried out. As the distance from the focal plane increases, the laser beam diverges or becomes unfocused. The cross-sectional area of the spot increases and thus lowers the power density for a given output. The size of the focal spot depends on the focal length of the laser lens and whether the surgeon is working in or out of focus.

The surgeon can vary the amount of energy delivered to the target tissue by varying the exposure time. Fluence refers to the amount of time (measured in seconds) that a laser beam irradiates a unit area of tissue at a constant irradiance. Fluence is a measure, then, of the total amount of laser energy per unit area of exposed target tissue. Fluence varies directly with the length of the exposure time, which can be varied by working in the pulsed mode (duration, 0.05–0.5 sec) or in the continuous mode.

When electromagnetic energy (incident radiation) interacts with tissue, the tissue reflects, absorbs, transmits, and scatters portions of the light. The surgical interaction of this radiant energy with tissue is caused only by that portion of light that is absorbed (i.e., the incident radiation minus the sum of the reflected and transmitted portions).

The actual tissue effects produced by the radiant energy of a laser vary with the laser's wavelength. Each type of laser exhibits different characteristic biologic effects on tissue and is therefore useful for different applications. However, certain similarities exist regarding the nature of laser light interaction with biologic tissue. The lasers used in medicine and surgery today can be ultraviolet, meaning the interactions are a complex mixture of heating and photodissociation of chemical bonds. The more commonly used lasers emit light in the visible or the infrared region of the electromagnetic spectrum, and their primary form of interaction with biologic tissue leads to heating. Therefore, if the radiant energy of a laser is to exert its effect on the target tissue, it must be absorbed by the target tissue and converted to heat. Scattering tends to spread the laser energy over a larger surface area of tissue, but it limits the penetration depth. The shorter the wavelength of light, the more it is scattered by the tissue. If the radiant energy is reflected from or transmitted through the tissue, no effect will occur. To select the most appropriate laser system for a particular application, the surgeon should thoroughly understand these characteristics regarding the interaction of laser light with biologic tissue

co_2 lasers produce light with a wavelength of 10.6 μm in the infrared (invisible) range of the electromagnetic spectrum. A second, built-in, coaxial helium-neon laser is necessary because its red light indicates the site where the invisible co_2 laser beam will impact the target tissue. Thus, this laser acts as an aiming beam for the invisible co_2 laser beam. The radiant energy produced by the co_2 laser is strongly absorbed by pure, homogeneous water and by all biologic tissues high in water content. The extinction length of this wavelength is about 0.03 mm in water and in soft tissue. Reflection and scattering are negligible. Because absorption of the radiant energy produced by the co_2 laser is independent of tissue color and because the thermal effects produced by this wavelength on adjacent nontarget tissues are minimal, the co_2 laser has become extremely versatile in otolaryngology.

With current technology, light from the co_2 laser cannot be transmitted through existing flexible fiberoptic endoscopes, although research and development of a suitable flexible fiber for transmission of this wavelength is being carried out internationally. At present, the radiant energy of this laser is transmitted from the optical resonating chamber to the target tissue via a series of mirrors through an articulating arm to the target tissue. The co_2 laser can be used free-hand for macroscopic surgery, attached to the operating microscope for microscopic surgery, and adapted to an endoscopic coupler for bronchoscopic surgery. This latter application requires rigid nonfiberoptic bronchoscopes. Pattern generators coupled with a micromanipulator on the operating microscope have also been introduced to help with the surgical precision in laryngology.

Laser Safety

The laser is a precise but potentially dangerous surgical instrument that must be used with caution. Although distinct advantages are associated with the use of laser surgery in the management of certain benign and malignant diseases of the upper aerodigestive tract, these advantages must be weighed against the risks of complications. Because of these risks, the surgeon must first determine if the laser offers an advantage over conventional surgical techniques. For the surgeon to use good judgment in the selection and use of lasers in practice, prior experience in laser surgery is necessary. Hospitals that offer laser surgery should appoint a laser safety officer and set up a laser safety committee consisting of the laser safety officer, physicians using the laser, anesthesiologists, operating room nurses, a hospital administrator, and a biomedical engineer. The purpose of this committee is to develop policies and procedures for the safe use of lasers within the hospital

Several structures of the eye are at risk. The area of injury usually depends on which structure absorbs the most radiant energy per volume of tissue. Depending on the wavelength, corneal or retinal burns, or both, are possible from acute exposure to the laser beam. The possibility for corneal or lenticular opacities (cataracts) or retinal injury exists after chronic exposure to excessive levels of laser radiation. Retinal effects occur when the laser emission wavelength occurs in the visible and near-infrared range of the electromagnetic spectrum (0.4–1.4 μm). To reduce the risk of ocular damage during cases involving the laser, certain precautions should be followed. Protecting the eyes of the patient, surgeon, and other operating room personnel must be addressed. The actual protective device will vary according to the wavelength of the laser used. A sign should be placed outside the operating room door warning all persons entering the room to wear protective glasses because the laser is in use. In addition, extra glasses for the specific wavelength in use should be placed on a table immediately outside the room. The doors to the operating room should remain closed during laser use.

Patients undergoing co_2 laser surgery of the upper aerodigestive tract should have a double layer of saline-moistened eye pads placed over the eyes. All operating room personnel should wear protective eyeglasses with side protectors. Regular eyeglasses or contact lenses protect only the areas covered by the lens and do not provide protection from possible entry of the laser beam from the side. When working with the operating microscope and the co_2 laser, the surgeon need not wear protective glasses. The optics of the microscope provide the necessary protection. When working with the Nd:YAG laser, all operating room personnel (and the patient) must wear wavelength-specific protective eyeglasses that are usually blue-green. Although the beam direction and point of impact may appear to be confined within the endoscope, inadvertent deflection of the beam may occur because of a faulty contact, a break in the fiber, or accidental disconnection between the fiber and endoscope. Special wavelength-specific filters are available for flexible and rigid bronchoscopes. When these filters are in place, the surgeon need not wear protective eyeglasses.

When working with the Ar, KTP, or dye lasers, all personnel in the operating room, including the patient, should again wear wavelength-specific protective eyeglasses that are usually amber. When undergoing photocoagulation for selected cutaneous vascular lesions of the face, the patient usually wears protective metal eye shields rather than protective eyeglasses. Similar precautions are necessary for the visible and near-infrared wavelength lasers. The major difference is the type of eye protection that is worn.

The patient's exposed skin and mucous membranes outside the surgical field should be protected by a double layer of saline-saturated surgical towels, surgical sponges, or lap pads. When microlaryngeal laser surgery is being performed, the beam might partially reflect off the proximal rim of the laryngoscope rather than go down it. Thus, saline-saturated surgical towels completely drape the patient's face. Only the proximal lumen of the laryngoscope is exposed. Great care must be exercised to keep the wet draping from drying out. It should occasionally be moistened during the procedure. Teeth in the operative field also need to be protected. Saline-saturated Telfa, surgical sponges, or specially constructed metal dental impression trays can be used. Meticulous attention is paid to the protective draping procedures at the beginning of the surgery. The same attention should be paid to the continued protection of the skin and teeth during the surgical procedure.

Two separate suction setups should be available for all laser cases in the upper aerodigestive tract. One provides for adequate smoke and steam evacuation from the operative field; whereas the second is connected to the surgical suction tip for the aspiration of blood and mucus from the operative wound. When performing laser surgery with a closed anesthetic system, the surgeon should use constant suctioning to remove laser-induced smoke from the operating room. This helps to prevent inhalation by the patient, surgeon, and operating room personnel. When the anesthetic system is open or has jet ventilation systems, suctioning should be intermittent to maintain the forced inspiratory oxygen at a safe level. Laryngoscopes, bronchoscopes, operating platforms, mirrors, and anterior commissure and ventricle retractors with built-in smoke-evacuating channels facilitate the evacuation of smoke from the operative field.

Complications

Aside from a few minor eye injuries from a laser beam exposure, most serious accidental injuries related to laser use can be traced to the ignition of surgical drapes and airway tubes.[41] Because the anesthesiologist is also concerned with the airway and because potent oxidizing gases pass through the airway in close approximation to the path of the laser beam, it is necessary to develop a team approach to the anesthetic management of the patient undergoing laser surgery of the upper aerodigestive tract. It is recommended that anesthesiologists involved with laser surgery cases attend a didactic session devoted to this subject. Finally, the operating room staff must be educated with regard to laser surgery. Attendance at an inservice workshop with exposure to clinical laser biophysics and the basic workings of the laser, as well as hands-on orientation should be the minimal requirement for nurses to participate in laser surgery.

One of the most devastating complications of laser surgery of the aerodigestive tract is endotracheal tube ignition and resulting injury to the laryngotracheal mucosa. At present, a nonflammable, universally accepted endotracheal tube for all types of laser surgery of the upper aerodigestive tract does not exist. The traditional polyvinyl endotracheal tube should not be used, either wrapped or unwrapped. It offers the least resistance to penetration by the laser beam of all the endotracheal tubes that have been tested, fire-breakdown products are toxic, and tissue destruction associated with combustion of this tube is the most severe. Endotracheal tubes for laser surgery that are wavelength specific are now available from several manufacturers and should be used at all times unless jet ventilation techniques are used.

Protection of the endotracheal tube from direct or reflected laser beam irradiation is of primary importance. If the laser beam strikes an unprotected endotracheal tube carrying oxygen, ignition of the tube could result in a catastrophic, intraluminal, blowtorch-type endotracheal tube fire. Protection should also be provided for the cuff of the endotracheal tube. Methylene blue-colored saline should be used to inflate the cuff. Saline-saturated cottonoids are then placed above the cuff in the subglottic larynx to further protect the cuff. These cottonoids require frequent moistening during the procedure. If the cuff deflates from an errant hit by the laser beam, the already saturated cottonoids turn blue to warn the surgeon of impending danger. The tube should then be removed and replaced with a new one. Use of the microlaryngeal operating platform offers further protection against potential danger. Inserted into the subglottic larynx above the level of the packed cottonoids, this unique instrument serves as a back stop to protect the cottonoids, endotracheal tube, and cuff from any direct or reflected laser beam irradiation.

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 cicatrisation that produces a new supraglottic valve.

In Moreau’s study 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.

The transoral management of squamous cell carcinoma of the larynx using the co_2 laser is an obvious extension of the application of this surgical instrument. The advantages of precision, increased hemostasis, and decreased intraoperative edema allow the surgeon to perform exquisitely accurate and relatively bloodless endoscopic surgery of the larynx.

A comprehensive report on the results of TLM was given by Steiner and his colleagues at the European Federation of Oto-Rhino-Laryngological Societies (EUFOS) in Budapest. His reports were based on 606 patients treated from 1979 to 1986 in Erlangen-Nurnberg or 1986 to 1993 in Göttingen. The last Erlangen entry was in January 1994, and the last Göttingen entry was in December 1995. The only exclusions were patients with simultaneous second primary cancers, thus not treatable for cure. Of the patients, 360 had early glottic cancer, 43 had early supraglottic disease, 147 had late glottic carcinoma, and 56 had late supraglottic cancer. The T distributions were pT_{is}; 45 patients, pT_1; 228 patients, pT_2; 231 patients, pT3; 69 patients and pT4; 33. As might be expected, the T_{is} and T_{1a} cases did extremely well and will receive no further comment.

Combining the pTis to pT2a patients, there were 35 recurrent cancers amongst 360 TLMs. Of these 35 recurrences, 5 occurred more than 5 years after initial treatment (thus possibly were second primaries).

Of the 35 patients, 27 were salvaged by functional surgery, mainly by transoral laser micro-re-resection. Eight patients proceeded to laryngectomy. Of the 360 (0.5%), 2 died from the glottic cancer. Six developed neck metastases, 3 with their primary controlled and 3 with recurrent cancer at the primary site. During the course of their follow-up, 23 patients (6.4%) developed second primaries, and 16 (5%) died of their second primary. The commonest cause of death in the whole group was intercurrent disease—64 patients (17.5%). The 5-year Kaplan-Meier survivals were 87% for the "very early" glottic group and 83% for the "early" cases. TLM preserved voice in 352 of the 360 patients (98%), and was judged to be of satisfactory quality in 90%. One patient bled. No one needed a tracheotomy.

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.

Moreau performed a retrospective study of 160 patients treated from 1988 to 1996 to determine if laser endoscopic microsurgery is a reliable and appropriate approach in the treatment of laryngeal cancers. Glottic tumors were treated with either type I, type II, or type III cordectomy, with or without conservation of an inferior muscular band, and extended if necessary to all or part of the contralateral cord. For supraglottic cancers, an excision limited to a part of the vestibule, a trans-preepiglottic resection, or a radical supraglottic resection was carried out. They found that corrected actuarial survival at 5 years was 97% for the 98 infiltrative glottic tumors and 100% for the 18 infiltrative supraglottic and 27 in situ carcinomas. No local recurrences were noted, in either the group of 118 infiltrating cancers (in whom two precancerous lesions were treated with a further laser excision), or in the 27 in situ carcinomas. Local control was thus 100%. One patient died of his cancer, with lung metastases after neck recurrence. He concluded that, like Steiner and Rudert, his series demonstrated the oncologic validity of this surgical approach to the treatment of unadvanced glottic tumors.

Gallo et al performed a retrospective study of 151 patients treated from April 1982 to June to define when laser resection of early-stage glottic carcinoma is indicated and to compare the results obtained by laser surgery with other therapeutic options. Glottic tumors were treated with type III, type IV, and type Va cordectomies according to the classification of endoscopic cordectomies proposed by the European Laryngological Society in 2000.

They found that all patients with carcinoma in situ Tis were free of disease with local control rate at 3 years of 100%; 2 died of other causes without evidence of local recurrence with an overall survival rate at 3 years of 83.2%. Of the 117 patients with stage T1a cancer, 110 are free of disease at 3 years with local control rate of 94%; 4 patients died of other causes without evidence of local recurrence with an overall survival rate of 96.5%. Of the 22 patients with stage T1b cancer, 20 are free of disease at 3 years with a local control rate of 91%; 1 patient died of other causes without evidence of local recurrence with an overall survival rate at 3 years of 95.4%. They concluded that endoscopic laser surgery is an efficacious and cost-effective treatment for early stage glottic cancer.

Gallo et al also noted that the removal of 2 to 5 mm of healthy tissue surrounding the neoplastic lesion is the suggested measurements in the current literature. They stated that a dilemma arises when treating a tumor of the vocal cord, which extends to (T1a) or involves (T1b) the anterior commissure. Under these circumstances, the removal of the anterior commissure, together with a variable portion of the contralateral vocal cord, can be helpful in obtaining safety margins. Therefore, they recommended that the transmuscular cordectomy (type III) is indicated in cases of small superficial tumors of the mobile vocal fold (T1a); the total cordectomy (type IV) is indicated in cases of T1a cancer with extension to the anterior commissure, and/or when the tumor involves the vocal fold in an infiltrative pattern and/or when the tumor size is more than 0.7 mm; the extended cordectomy encompassing the contralateral vocal fold (type Va) is indicated in cases of T1b cancer involving the anterior commissure or in horseshoe lesions.

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.

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.

Ambrosch stated that comparing the results of different treatments for early laryngeal carcinoma one may conclude that laser microsurgery is the method of choice for treatment of these tumors based on oncologic, functional, and economic considerations. The published results, however, indicate that approximately 70–80% of patients with pT2b and pT3 glottic carcinomas remain free of local tumor recurrence, with minimal morbidity and a functioning larynx. The results of laser microsurgery in patients with moderately advanced supraglottic cancer are comparable to those of open supraglottic laryngectomy with regard to local control and survival rates. They are better than the results published for primary radiotherapy with regard to local control and survival, and they are superior with respect to organ preservation.

Jones et al investigated were 488 patients with T1-2, N0 squamous cell carcinoma of the larynx. Four hundred nineteen patients were treated by irradiation, and 69 were treated with surgery. Most surgical patients were treated earlier in the series, whereas radiotherapy later became the treatment of choice. The primary outcome measures were recurrence at the primary site, recurrence in the neck, and tumor-specific survival. The secondary outcome measure was speech and voice quality. Surgery included horizontal or vertical partial laryngectomy and various minor procedures on the glottis, including cordectomy. Over a 30-year period, radiotherapy was administered to a dose of 60-66 Gy given over 30-33 daily fractions.

They found that surgery tended to be performed early on in the series and radiotherapy thereafter. Surgery was more likely to be carried out for supraglottic disease. These differences apart, the radiotherapy and surgery groups of patients were well matched. The 5-year tumor-specific survival for those treated by irradiation was 87% and for surgery it was 77% ($p = .1022$). Glottic cancer and T1 disease were associated with high 5-year survivals: 90% and 91%, respectively. Supraglottic site and T2 disease both had a poorer prognoses: 79% and 69%, respectively. The differences for both sets of data were significant. There was no significant difference in primary site recurrence rates for the two treatment modalities, but regional recurrence was higher in the surgery group. Further analysis demonstrated that this was not a function of surgery per se but rather of the unit's policy toward the N0 neck at the time surgery was carried out. Regarding speech and voice quality, radiotherapy was far superior to surgery. All patients in the radiotherapy group but only 3 of 10 in the surgery group were judged to have a good or normal voice ($p = .0017$). They concluded that both surgery and irradiation are equally effective at treating early laryngeal carcinoma. Speech and voice were highly significantly better in patients treated by irradiation than in those treated by surgery.

Conclusions

Microendoscopic laser surgery provides an excellent alternative to radiotherapy in the treatment of early-stage glottic cancer. Since its introduction by Strong and Jako in 1972, CO_2 laser has found wide acceptance in the treatment of laryngeal diseases. The advantages of laser resection include minimal bleeding, precise control of resection, and the absence of postoperative edema. Cure rates of patients with early-stage glottic carcinoma treated with CO_2 laser are equal to those achieved with radiation therapy. Nevertheless, the role and the indications of this technique in the treatment of early-stage glottic cancer has not been defined accurately and remains controversial.

Discussion

Discussant's Remarks by Charles Vaughan, M.D.:

I am impressed and pleased and ask that you pass on to Camysha Wright, MD, my congratulations for a job well done. It was an excellent discussion of published literature. Perhaps some further experience might also be of interest . It is unpublished because there is no way to describe it in "scientific" terms, the problem being that of field cancerization, a common phenomenon in the glottis. As a "for instance", a heavy equipment operator who worked in his enclosed cab and continuously smoked, was referred following failed xrt for T1 scca RTVF. This was easily managed with the CO2 laser; however in a few months he had a lesion on the opposite fold, again, easily managed, only later to show a new lesion on the right fold, a few mm anterior to the first. Well, to make short, over the next 12 years we managed 13 such "early" cancers arising in his "sick mucosa". During this time he continued to smoke- and to talk and to eat normally. He died of lung cancer.

How do you determine cure rates when dealing with both synchronous and metachronous cancers? The above story is extreme, but the problem is common. Our experience at VAMC Boston is a metachronous rate of 5%/year! and the question becomes this: is a further appearance of cancer new disease or old? And how can it be reported? I have been at this since the late 1960's and still can't figure it out. (And this might also give you pause when you read reports of cure rates by others). My experience also includes meticulous histologic evaluation of every excised specimen, jointly with the pathologist, and this has led me to the conclusion that a widely applied carcinogen (tobacco) has wide affect. All exposed mucosa become sick, and given time develops cancer. Unfortunately, we have no cure for this. Yes, we can remove the dangerously atypical cells, and the laser does this nicely, but attempting more than this does not improve things. It only creates morbidity.

So this is the advantage of the laser/microscope combo: because the field is dry and magnified, the surgeon (with experience) can actually SEE cancerous tissue; and only it need be removed. (if all the cancer is removed, what is the advantage of a 5mm margin? Or any margin)

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