CHAPTER ONE HUNDRED AND NINE

Transoral Laser Microresection of Advanced Laryngeal Tumors

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Key Points

- Transoral laser microsurgery (TLM) permits both small and large laryngeal tumors to be resected. The limits of resectability are based on access and functional consequences and not on extent or T stage.
- Piecemeal resection of cancer permits precise tumor mapping and may improve local control over traditional "en bloc" resections. It further permits larger tumors to be removed through endoscopes that could otherwise not accommodate the physical volume.
- TLM offers numerous functional advantages including fewer tracheostomies, no fistulas, earlier swallowing, and sensation.
- TLM can replace traditional conservation laryngeal operations.
- TLM can fit well into multimodality therapy strategies.

Terms and Definitions

Transoral laser microsurgery (TLM) is a surgical treatment strategy for primary cancers of the mouth, pharynx, and larynx. In TLM, the instrument of excision is a carbon dioxide (CO_2) laser beam, an operating microscope imparts the perspective, and the natural passageways of the upper aerodigestive system provide the access.

Two features distinguish TLM from open surgery[1]: healing is allowed to occur by secondary intention[2] and the tumor block can be subdivided into manageable units by the laser (in situ).

TLM is clearly a conservation strategy, but it is not a reconstructive one. "Piecemeal" removal is a distinguishing feature of TLM—and a key source of controversy. Tumor transection endows important diagnostic dimensions to TLM, and magnification exploits the difference in visual appearance between normal tissue and cancer.

Safe TLM requires two conditions: adequate exposure through the mouth and a tangible specimen.

TLM is an excision, not vaporization. A specimen is the basis of meaningful frozen section margins. Individual specimens may be small, but, in aggregate, the resected tissue volume parallels that of an open operation.

In many ways, TLM is a misleading name. Transoral laser microsurgery is not totally transoral—open surgery is still required for nodes in the neck. TLM is not entirely laser, either—it depends on endoscopic cautery, vascular clipping, and occasionally blunt and sharp dissection. Finally, TLM is not exclusively surgical—radiotherapy may be offered (for neck indications, but never to finesse margins).

The aim of TLM is to improve cure and function through patient selection and technical excellence. The goal is the cure rate of open surgery and the functional promise of a tissue-conserving treatment like radiotherapy, all of this with less morbidity, at lower cost.

"Advanced" (as in "advanced laryngeal tumors") is a confusing term. In the context of laser surgery, it once meant any tumor larger than T1a glottic. In traditional discussions, it used to mean cancer with a fixed cord. The staging system suggests a different connotation—positive neck nodes. What is clear is that laryngeal cancer is not one disease. It is many different diseases. And unless we digress and clarify the descriptors of the different laryngeal cancers, all discussions of treatment are ambiguous. The answer to the question, "Does an advanced case qualify for TLM?" is "It depends. What do you mean by advanced?" Let's look at the classifications.

Is it cancer? Laser surgery manages everything along the histologic spectrum, but this chapter only relates to the worst actor, invasive squamous cell carcinoma. The Ljubljana taxonomy[3] is probably the closest thing we have to an internationally accepted classification of epithelial hyperplastic laryngeal lesions (EHLL). For the most benign, "simple hyperplasia," acanthosis predominates. "Abnormal hyperplasia" is next, and basal proliferation is the hallmark. "Atypical hyperplasia" features dysplasia and atypia. Fourth is carcinoma in situ (CIS), cytologic neoplasia on an intact basement membrane. All these can be laser resected, but TLM is a higher strategy for a higher challenge, group five, neoplasia with subepithelial penetration (i.e., invasive squamous cell cancer).

Is it TLM? An excellent classification for laser cordectomies has been developed by the European Laryngological Society.[4] It names five types: subepithelial, subligamental, transmuscular, total, and extended cordectomy. The first three are elegant one-piece excisional biopsies, and a laser may be used on them. TLM (and the strategy of depth determination) comes into play for the last two.

What site? Before "multidisciplinary" committees imposed a theoretic anatomic classification (glottic, supraglottic, and subglottic) on laryngeal cancer, surgeons included clinical behavior in the sorting system. For 50 years, laryngeal cancer was "intrinsic" or "extrinsic."[5] Intrinsic was "interior region" cancer, primarily glottic in origin, and slow growing, and its nodes were generally late.[6] TLM treats most of these, but not all. Extrinsic cancer was more supraglottic, originating around the laryngeal opening or its pharyngeal surface. It had a higher rate of metastases and was more lethal. TLM treats the local disease, but not the metastases.

Now the official categories are glottic, supraglottic, and subglottic, whereas "transglottic" is used to describe tumors that span the ventricle. However, in the anterior larynx, glottic and subglottic cancers behave similarly.[7] Subglottic cancer often turns out to be glottic, with descent. The height of the glottis is controversial (5 mm high, 10 mm high), or excluded posteriorly (sparing the posterior commissure). None of the sites is off limits to TLM.

In discussing local extent, clinicians often reduce their spoken references to "early" and "advanced" laryngeal cancer, the traditional dividing line being vocal cord motion. In these terms, TLM is primarily an "early" cancer treatment, as opposed to the "advanced" group.

The tumor, node, metastasis (TNM) staging system[8] uses T_X, T_{is}, T_1 (a and b in the glottis), T_2, T_3, T_{4a}, and T_{4b} to define a local tumor, expanding 3 regions to 18 "extents." And this is just for the local disease (T). Nodes multiply the possibilities by 7. Metastases multiply the possibilities by 3, for more than 300 possibilities. Some are suitable for TLM. Some are not. No one knows where we should place the dividing line, or where "advanced" should start (or end). The staging system does encourage a summary format, stage 1, stage 2, stage 3, and stage 4, but the neck dominates this classification. If the neck is positive, everything is stage 3 or 4 (advanced), even if the primary is miniscule.

The staging of laryngeal cancer is not linked to any particular therapy and has significant limitations. TNM staging leaves out historic factors (age, previous treatments, habits, work, duration of and number of symptoms, literacy, religious beliefs, distance from treatment facility, etc.) and leaves out comorbidities. Both symptom severity scores and comorbidity scales have been shown to improve the accuracy of TLM.[9] TNM also ignores complex patient factors (e.g., exophytic vs. endophytic, keratinized vs. ulcerated, stridor, obesity vs. cachexia, forced expiratory volume, ejection fraction, hemoglobin, protein levels, blood sugar, liver function tests). These and other limitations of TNM staging pose challenges to the treating physician.

This leaves the doctor with the problem of how to interpret the term "advanced" in the context of TLM. It makes little sense to link advanced to a higher TNM stage (3 or 4) if patients with T_1 and T_2 local cancers will be included (all that is required to make a T2 cancer "stage 3" is for someone to feel a node in the neck). For example, the 2002 American Joint Committee on Cancer (AJCC) TNM staging of larynx cancer states that stage III includes T_1, T_2, or T_3 N_1(or T_3 N_0), where N_1 is a single node smaller than 3 cm. The AJCC also lists stage IVA to include T_1, T_2, T_3, or T_{4a} N_2 (or T_{4a} N_1 or N_2), where N_{2a} is a node between 3 and 6 cm in size, on the same side; N_{2b} is multiple nodes smaller than 6 cm, on the same side; and N_{2c} is bilateral or contralateral nodes smaller than 6 cm in size.

This chapter is primarily about the treatment of the local diseases by TLM. Therefore we need to classify local diseases and to help distinguish those for whom TLM is an option and those for whom it is not.

Five Types of Local Laryngeal Cancer

From the surgeon's standpoint, local laryngeal cancer comes in five different "flavors," each one more damaging (to function) and more difficult to cure. Severity relates to what stock local excision would be required for complete removal. What would that impose on the patient, in terms of voice, swallow, and nasal breathing? This does not indicate the treatment is surgery. It does ensure that the appropriate local option for surgery is identified, especially to the patient, when the selection among various modalities is made. Each flavor can thus be defined by one of five classic excisions, which ascend in severity from laryngoscopic biopsy to total laryngectomy. Each excision removes a customary block, from one nodule to the whole larynx and its coverings, and each has a formal technique. We have a published record for each of local control rates from 98% to 80%. The expected functional outcome ranges from normal voice, swallow, and breathing down to tracheoesophageal puncture (TEP) voice and stomal breathing. Each of these five categories can be named as follows: very early, early, intermediate, advanced, and very advanced.

1. Very Early
   Exophytic midcordal T_{1a} carcinoma. Encompassed by transoral excisional biopsy removal. Includes one-piece subepithelial cordectomy (stripping), subligamental[4] partial cordectomy, and midcordal transmuscular cordectomy.

2. Early
   Two subtypes, glottic and supraglottic.
   a. Early Glottic
      T_{1a}, T_{1b}, and T_{2a} true cord carcinoma whose formal external excision would be a vertical partial laryngectomy,[10,11] or hemilaryngectomy.[12,13] The European Laryngological Society's total cordectomy and extended cordectomy[10] concepts probably fit here.
   b. Early Supraglottic
      T1 supraglottic carcinoma fitting within a supraglottic laryngectomy block.[1,14,15]

3. Intermediate
   Laryngeal cancer that fits within a supracricoid partial laryngectomy block.[16,17] Thus T_2 glottic carcinoma (T_2 by spread to the supraglottis), T_3 glottic (T_3 by thyroid cartilage erosion from the anterior commissure—mobility is preserved), T_2 supraglottic (T_2 by descent to involve the vocal cords), or T_3 supraglottic cancer (if T_3 by involvement of the preepiglottic space PES).[18-20]

4. Advanced
   T_3 glottic carcinoma (T_3 by unilateral cord fixation and invasion of the paraglottic space or the thyroid ala) is the prototype because it is lateralized and fits within a near-total laryngectomy.[21] Lateralized invasive T_{2b} glottic carcinoma qualifies if the T_{2b} is by impaired mobility of one vocal cord. Also, advanced glottic carcinoma includes T_2 supraglottic carcinoma, where T_2 means involvement of the vallecula or the medial pyriform wall, and T_3 supraglottic carcinoma, where T_3 means unilateral cord fixation with invasion of the paraglottic space or the thyroid ala.

5. Very Advanced
   Bilateral anterior T_3 glottic carcinoma invading both ventricles, bilateral posterior T_3 supraglottic cancer invading the postcricoid region, or T_{4a} glottic or supraglottic carcinoma, which means the cancer has invaded into adjacent structures outside the larynx—the strap muscles, the thyroid gland, the tongue beyond the immediate base, the trachea, or the esophagus. The minimum excision these cancers would require is at least a wide field total laryngectomy (T_{4b} is incurable by surgery). T_{4b} means gross distant extension. But this is virtually unheard of in cancers with no prior treatment. Examples include direct extension into the prevertebral space or the mediastinal structures or encasing the carotid.

Now we can examine TLM in the context of the clinical severity of the local disease. Others can judge the use and validity of the approximate term *locally advanced.*

Acronyms

CHEP Cricohyoidoepiglottopexy.[22] Reconstruction for supracricoid partial laryngectomy (SCPL).

CHP Cricohyoidopexy.[23,24] Reconstruction for SCPL.

HSL Horizontal supraglottic laryngectomy.

NTL Near-total laryngectomy.[25,26] Frontoanterior VPL with epiglottoplasty, SCPL, and NTL have at various times all been called *subtotal laryngectomies.*[27-30]

PES Preepiglottic space.

SCPL Supracricoid partial laryngectomy. Frontoanterior VPL with epiglottoplasty, SCPL, and NTL have at various times all been called *subtotal laryngectomies.*[27-29]

TLM Transoral laser microsurgery.

TEP Tracheoesophageal puncture, tracheoesophageal prosthesis.[31,32]

VPL Vertical partial laryngectomy. Includes the vertical frontoanterior and frontolateral[10,11,33,34] partial laryngectomies, and hemilaryngectomy.

Laser Surgery and Transoral Laser Microsurgery in the Treatment of Early, Intermediate, and Advanced Cancers

Laser surgery is not new in larynx cancer. Davis and colleagues[35]; Jako and colleagues[36]; Strong[37]; and Vaughan and assessites[38] all treated selected tumors during the 1970s and early 1980s.

Through the 1980s and 1990s, Motta and others[39] and Steiner[40,41] pioneered a new concept: tumor transection in situ. Consider the implications. If infiltrative cancer could be safely resected in pieces, tumor depth could be determined in situ. Incremental resection would become possible—as in Mohs' chemosurgery.[42] (Mohs treated cancer successfully in more sites than just the skin.) One could "follow the tumor" (i.e., custom tailor the excision to each individual patient). If tumors could be subdivided into manageable subunits, early, intermediate, and even some advanced laryngeal cancers might be candidates.

Of course, transoral cordectomy provided outstanding results long before the laser was added. Suspension[43-46] and the microscope were the keys, not a laser. What the laser added was questionable—costs for new equipment, time to set up, regulations in the operating room, thermal injury hazards, maintenance issues, anesthesia issues, more suction, filters, retraining requirements, and new credentialing. And what the laser gave up was considerable—the tactile feedback of cold steel microinstruments, the ability to cut around corners, the plume-free operating site, the char-free pathology specimen, operating room space, an unencumbered microscope, and the precision of a cut path versus a vaporization path.

But in the 1980s and 1990s, a sustained experience of endoscopic laser surgery for larger than T_{1a} glottic cancers was growing in Germany.[40,41,47-51] This raised additional questions among traditionalists. They had concerns about exposure, hemostasis, reconstruction, margins, and wound healing. The greatest concern, however, was tumor transection. Steiner cut right through laryngeal cancer—in situ—through a laryngoscope! The claimed advantage was visualization and confirmation of tumor depth. How did the skeptics respond? First, they were asked to compromise access and work through smoke with an endoscope, with no convincing evidence this was meaningful. Then they were asked to give up orientation and violate the principle of en bloc resection—with no laboratory evidence this was safe!

Other concerns fueled the discussion. After a laser supraglottic resection, there was no reconstruction! Open supraglottic laryngectomy always led to aspiration if one failed to repair the gap between the glottic unit and the tongue base.[15,52,53] After laser SCPL, there was no cricohyoidopexy. Yet this was essential in open SCPL.[19,24] There were so many additional issues a laser did not address (e.g., bleeders over 2 mm, ossified cartilage, neck nodes).

Furthermore, the obvious problems of access were troubling. Big tongues, small mandibles, capped teeth, mild trismus, and other challenges all lay in waiting, even for the most resourceful of operators. Very early midcordal T_{1a} carcinomas may have been fine. But early cancers would require greater exposure, intermediates more, and so on. Some would be too big to extract through an endoscope. A growing plethora of "laser laryngoscopes" raised suspicion that the problem of access remained unsolved.

Another challenge would be quality control from the pathology department. In cancer operations, negative margins are compulsory. If laser specimens were vaporized, the pathologist would have no margins to read. If they were excised with a laser, margins would at best be charred. If they were excised in several pieces, positive margins would be meaningless!

In North American practices, these considerations delayed TLM. This occurred despite much of the pioneering work originating in North America—the entire organ serial section studies from New Haven,[54] Philadelphia,[55] and Toronto[56,57]; the development of the CO_2 laser itself at American Optical Corporation by Strong[58] and associates in 1965; and the pioneering clinical laryngology of Strong[37]; Jako,[36] Vaughan,[38] Davis,[35] and Ossoff[59] and their coworkers; and Shapshay.[60] But the German centers were leaders in the collaborative development of all the ancillary laryngologic instrumentation needed to capitalize on the technique. They pushed their experience well beyond the concerns recited earlier, tracked their results, and continue to report on their experience.[41]

In 1996 the authors of this chapter began to study this body of work more closely, and subsequently we took numerous steps to incorporate TLM into our practices. This effort provided new perspectives on laryngeal cancer management and the initial selection of therapy. Now we seek to share what we have learned.

Theoretic Basis of Transoral Laser Microsurgery

TLM does violate a time-honored dictum of surgical oncology—en bloc resection. A typical glottic or supraglottic cancer (above T_1) is likely to be extracted in three to six separate pieces!

En bloc has always been a prudent tactic to avoid unseen physical dispersion of viable malignant cells in a wound. When a scalpel penetrates cancer, the cells exposed will be alive. Viable cancer cells may adhere to the blade. Nothing prevents the surgeon from inadvertently transferring unseen cancer to an adjacent site in the wound. If unseen cell transplantation does occur during open surgery, and then we close the wound, how could tumor not recur? In open traditional surgery, this is why we isolate cancer in an unbroken package of normal surrounding tissue—to prevent contact between cancer and a scalpel or a scissor. This way, maybe we can avoid transplanting living malignant cells from the cancer back into the patient.

Rethinking this chain of events in laser microresections raises a new question. What would be the apparatus of physical transplantation? Cancer cells do not adhere to a beam of light. There is no physical carrier to transplant the tumor. Then again, grasping forceps and the suction cautery tips are used in TLM. They could do it. But assuming no tearing of the specimen, how would exposed cancer cells be viable? Cells revealed by laser energy are thermocoagulated, not viable. Finally, in the TLM paradigm, we do not close the wound. An unseen cancer cell falls on a thin layer of coagulum, not a healthy tissue surface. This layer is gradually sloughed, not incubated.

These are theoretic reasons we postulate that laser surgery permits local cancer ablation without en bloc resection. Is there any laboratory or clinical data? Werner and colleagues showed (for CO_2 laser incisions) that the lymphatic vessels of the wound margin are sealed immediately, and lymphatic vessels remain sealed for about 10 days after laser surgery.[61] And we also have 20 years of European clinical data.[62-65] Steiner and colleagues[41,64-67] have been performing TLM since the early 1980s. He and his colleagues have observed a low local recurrence rate (2% to 10%), a high survival rate, and a low rate of complications.[66,67] They have not seen an increase in late neck or distant metastases during follow-up of more than 10 years. The incidence of cure by TLM is the same as the best results reported for open conservation surgery. Put another way, open surgery follows the principle of block resection but produces no more local cures than TLM! TLM allows laser tumor subdivision, but local failure occurs with the same low incidence as in traditional open conservation surgery.

If tumor transection can be safely accomplished (it is not automatic, care is still important), we have an attractive new technique to determine the depth of cancer invasion before we commit to the plane of excision. If we misjudge and cleave too close to the tumor, this is just another form of tumor transection. We can extend the excision, incrementally. All we have lost is some time.

If tumors can be divided in situ, the tumor itself ceases to be a factor in obstructing our vision. Complete removal always requires that we expose the entire mucosal margin of the tumor. Now we can achieve that goal in a mosaic of views, unrestricted by the bulk of the disease.

If tumors can be extracted in pieces, the internal diameter of the laryngoscope does not set the limit on how large a tumor we can resect. The limit becomes the exposure for each step and our disciplined attention to specimen orientation. Mohs[42] transected cancers in situ successfully, and his attention to orientation was uncompromising.

Later in this chapter we summarize our TLM results, as well as those of others.[67] We have documented a low incidence of failure at the primary site and also reported the ultimate causes of death. Our conclusion is that ultraradical treatment of the primary is not justifiable in a disease for which the main causes of death are advanced neck recurrences, distant metastases, second primaries, and serious general diseases. In modern times, quality of life is increasingly salient. In related diseases like hypopharyngeal cancer (TLM treats pyriform cancer, too[68]), 5-year survival rates have stood between 15% and 30% for decades. Aggressive combined therapy (chemotherapy, radiotherapy, and radical surgery) have not improved the poor prognosis. Again, if we can effect local control with conservation laser surgery, the argument in favor of radical ablation clearly declines.

Transoral Laser Microsurgery Compared with Open Conservation Surgery

Open operations approach intralaryngeal carcinoma from its "blind side." The surgeon cannot see the primary cancer until he or she has opened the neck, divided the fascia, separated the strap muscles, opened the framework, and penetrated the lumen at a critical point, determined by the local anatomy. Once exposed, field margins are oozy, not laser cut. Structures within the field relocate with the surgery, instead of maintaining a fixed position. The tumor margins are diminutive, not magnified, and the headlamp is illuminated, not microscope superilluminated. For safety and reproducibility, open operations closely replicate a named excision block, chosen without the benefit of intraoperative depth information. For example, supraglottic laryngectomy removes the superstructures above the cords, which produces a predictable wound, requires a characteristic reconstruction, and can be repeated for numerous supraglottic cancer patients, despite the fact each has unique anatomy, distinctive preoperative findings, and slightly different tumor characteristics. Because the neck will be opened, the timing of a node dissection is determined. The neck dissection is continuous with the primary wound, so steps must be taken to prevent a fistula. Because the framework is elevated to the tongue base and both swell, airway safety demands a temporary tracheotomy. Supraglottic laryngectomy supports the principle of en bloc resection, but this was necessitated by the scalpel, not the cancer. It assists teaching, but for gross anatomy, not for the microanatomy and micropathology. Open supraglottic laryngectomy provides the access needed for reconstruction, but the open surgery necessitated the reconstruction.

By approaching laryngeal carcinoma through the mouth, TLM requires no disassembly for access. The laryngeal framework continues to support the airway. A tracheotomy is usually superfluous in a supraglottic TLM. The strap muscles retain their swallowing contribution. Through the endoscope, the operator confronts the authentic primary right from the beginning of the resection, with no disassembly of the patient just to reach the cancer. The laryngoscope stabilizes the field. The magnification and brilliant illumination unveil important subtleties (e.g., dysplasia at a margin). With no disturbance of the neck, and no connection of a neck wound with a laryngeal wound, pharyngocutaneous fistulae disappear from the list of potential complications.

During TLM, diagnosis continues.[69] Wherever the local tumor extends, the microscope and the laser try to follow. Magnified tissue appearances acquire new significance. Some tumors change the vascular patterns in the mucosa. Deeper in, invasive cancer tends to appear pale and dysmorphic. Tissues give up subtle information about their consistency as they are retracted. Cancer is stiff or soft (soft can progress to friability and bleeding). Beyond the tumor, the expected microarchitecture is striated muscle, fat, seromucinous glands, fibrous perichondrium, (ossified) cartilage, or bone. Fat looks yellow and lobulated; mucous glands are pale and lobulated but more noticeably vascular. Muscle is striated. Fibrous tissue is white and dry. Ossified cartilage and bone carbonize to a dominoes-like appearance. The undersurface of the strap muscles is loose and areolar.

TLM is a natural ally of combined treatment. Once the tumor is out, the locoregional microvasculature is still undisturbed—the best milieu for postoperative radiotherapy. And complete three-dimensional resection under the microscope has minimized the chances of a positive margin.

During the weeks after TLM, the endolaryngeal wound heals by secondary intention (in many ways similar to a tonsil bed). The framework resists stenosis because it remains intact. The thermal damage from laser resection is superficial (after electrocautery, it is deeper). No local flaps are mobilized or transposed, so there is no chance to bury residual tumor. "Second look" endoscopies become a meaningful way to revisit the primary site.

Months later, persistent granulation may signal the need for endoscopic removal, to improve voice. Follow-up laryngoscopy also allows the removal of small, ossified cartilage sequestra, which sometimes develop after laser resection has been carried down to the framework. Reepithelialization seems to forecast recovery but does not completely eliminate all risk of recurrence. Not even a negative second look excludes later recurrence. An overhanging anterior glottic scar may hide an unsuspected nubbin of residual tumor—still a salvageable circumstance, by simple laser resection, if discovered in time by this tactic. Before recommending TLM, discuss the willingness of the patient to return for a "second look."

Instrumentation and Techniques of Transoral Laser Microsurgery

Instruments

We use a floor-model CO_2 laser console that can generate an output beam of 1 to 50 W or a hand-held hollow CO_2 fiber (Omni-Guide). The latter device permits some cutting at angles. Two modes, pulsed and continuous, are possible. Pulsed mode produces the fastest vaporization and the least adjacent thermal injury—the least char, hence the best clear recognition of the texture at the cut surface. But any vessel larger than an arteriole will bleed, and the bleeding must be arrested with electrocautery. Pulsed mode at low power (2-3 W) is ideal for glottic mucosa. One can maintain control over the cut (working slowly), avoid collateral heat (especially unintended thermal injury to the anterior commissure), and also avoid a "hole" of unintended depth (by pausing). For most normal laryngeal incisions, we use continuous mode at around 6 W of power. This setting provides excellent hemostasis but not enough char to upset the pathologists. Most mucosa bleeds too much in pulsed mode. Continuous mode results in a little more coagulation (about 50 to 100 μm).

The overall spectrum of power in laryngeal work is wide—1 W (focused, pulsed mode, for fine cutting of cordal mucosa), to 20 W (defocused, continuous mode, to vaporize friable semi necrotic centers inside bulky cancer, one of the few justifications for vaporization).

Besides mode and power, four more variables influence the effect:

- Speed: How quickly one moves the beam. Thermal transmission takes some time.
- Focus: Defocus the beam to create a superficial cautery effect but turn up the power, especially for broad forward advancement. Defocusing reduces the density of the power.
- Target tissue: Normal tissue (moist, not running wet) cuts best. Wet tissue (fluid is visible) cuts slowly, with a lot of thermal artifact from the boiling that has to take place first.

- Bleeding: Flowing blood stops laser surgery cold. It has to be ended (with electrocautery) before the excision can continue. Bleeding tissue just takes refuge under an expanding black char ball. Paradoxically, a beam set for the least char may impose the greatest char, by requiring the use of electrocautery.

An articulated arm brings the laser beam to the microscope body. From here we direct it with the joystick on a Sharplan Acuspot 712 micromanipulator. The frame of the micromanipulator bears a gimbaled half-silvered mirror through which we see the target and with which we manipulate the laser beam. The narrowness of the micromanipulator frame is important. Anything wider than the microscope body will conflict with the introduction of instruments (22 to 23 cm long). Unimpeded maneuvering and hemostasis at the primary site demand a clear path alongside the microscope for the grasping forceps and suction cautery tubes.

If the hollow Omni-Guide CO_2 fiber is preferred, the micromanipulator can be removed from the microscope granting greater visibility and increasing the working space. The company can provide both straight and angled introducing fiber carriers. Occasionally we use both the micromanipulator (for precise tremor-free work) and the fiber.

The CO_2 cutting beam is invisible, at 10,600 nm (far infrared). The wavelength of visible light is 400 nm (violet) to 700 nm (red). The surgeon observes a red spot on the target produced by an integral red Helium Neon (HeNe) beam at 632.8 nm (visible red). A video camera is mounted on the microscope as in otologic microsurgery. A monitor displays the operative field, so the operating room nurses can anticipate and assist.

More than anything else, laser microresection requires sophisticated skills in direct laryngoscopy. Much of this is experience, but part of it is an understanding of the laryngoscopes. Narrow tubular endoscopes (i.e., narrow side-to-side) overcome difficult exposure best. The tongue is incompressible (a fluid) and confined by the arch of the mandible. It can only be distorted. Wherever the scope contacts the tongue, it employs strong pressure and deforms it such that a straight path to the anterior commissure results. The narrower an endoscope, the more it can sink into the tongue, and the more the tongue can squeeze around the sides.

A narrow vertically oval instrument like the Hollinger anterior commissure laryngoscope is the optimal tool to overcome difficult anterior visualization. But a narrow monocular laryngoscope is too narrow to accommodate the side-by-side dual optical pathways of an operating microscope. A Dedo anterior commissure laryngoscope overcomes this limitation. It provides just barely enough width to accommodate a microscope. The Zeitels Endocraft laryngoscope[70] maintains this advantage and adds a useful tip enhancement for glottic work—less bevel. A blunt tip is better for holding aside the false cords. Regular tips actually cover the anterior commissure by the time the rest of the barrel reaches distal enough to lateralize the false cords. Zeitels' scope also features proximal slots along the sides to improve access for the instruments. Special modifications load both the Dedo and the Zeitels instruments with extra light and need extra suctions carriers. Laser plume is the most troublesome limitation to clear vision during TLM, so the optimum allocation of suctions is important.

Storz and colleagues[66,67] have developed a specific assortment of laryngoscopes for TLM. Their standard adult laser laryngoscope (8661 CN) has a dome-shaped cross-section, a lip at the tip (anterior commissure), and an unobtrusive suction channel incorporated into the upper wall of the blade and the handle. For larger tumors, distending laryngoscopes are the best. Two we have considered indispensable are the Weerda distending operating laryngoscope (8588 L) and the Weerda/Rudert distending supraglottiscope (8588 E). These instruments are wider, independently adjustable, and fitted with great suction tubes. The upper blade features flare at the side to help hold the tongue out of the way. The lower blade mounts on a strong left proximal C arch (8588 L) or a strong ring (8588 E) to provide minimal encroachment on instrument access.

The best vallecular laryngoscope is probably the Lindholm instrument (8587 A). The essential laser laryngoscopes for difficult access and subglottic access are the Steiner models. These are long and thin. The "half dome" subglottiscope (8661 DN) sinks into a large tongue the best, and the suction channel is incorporated into the handle. The flat-bodied subglottiscope (8661 E) gets past prominent incisor teeth the best, and a separate suction can be clipped.

We protect the incisors by fashioning a custom splint of heated Aquaplast (PS-1685), a thermoplastic substance that sets to a hard stable cap and diffuses the pressure over five or six teeth (WFR/Aquaplast Corp., Wyckoff, N.J.). Sometimes we provide external counterpressure to the larynx with a band of tape across the table to provide downward pressure to the larynx.

You can never have too much suction for plume evacuation—suction tubes on the laryngoscopes, suction tubes on the grasping instruments, suction in the insulated cautery, and plain dedicated suction tubes. Support each one with a separate suction line. Then add special suction tubes for blood. We prefer plain suction tubes for cleanup and gentle tissue manipulation and insulated suction-cautery tubes for flowing blood (two of each). Insulated (model 8606) suction cauteries come in various diameters—the insulation is necessary to prevent them from sparking out to the endoscope. Prevent suction trauma (and worse, sticking to a friable specimen and tearing it) with a small relief hole in the tubing or at the sucker tip. We recommend at least three separate suction lines per case.

Larger vessels sometimes require something more targeted than suction cautery. Insulated model 8663 alligator forceps will pick up a small bleeder around a corner for electrocoagulation. Control the lateral vascular pedicles coming into the supraglottis with insulated MicroFrance CE 0459 bipolar cautery-forceps (specify 22.5-cm length). Place titanium clips on named arteries such as the superior laryngeal and the anterior cricothyroid arteries. Delayed secondary hemorrhage would be a formidable complication in a patient with no tracheotomy. Stop this problem before it arises by using laryngeal vascular clip applicators (model 8665 works well).

Bouchayer fenestrated forceps (8662 R or L) are excellent grasping instruments for small cordal specimens. But to secure the grip we need on the larger specimens we manipulate in TLM, normal laryngeal microinstruments are too delicate. Saw-tooth grasping forceps meet the need. Use one (model 8662 EL, FL, GL, or HL) to maintain a stable grip on tumor subunits. Use two to advance by double grasping. The L denotes a suction channel.

Controlled resection is only as certain as the stability we create for the micromanipulator. A rock-steady microscope stand, like a Universal S3, serves our Zeiss OPMI 111 well. Reduce the wrist and finger movements you transmit to the system with adjustable armrest stabilizers on a pneumatic chair (like the Möller-Wedel Combisit E). Adjust the microscope and the patient to a comfortable position for you (as in otologic microsurgery) instead of the other way around.

During TLM, operating laryngoscopes require frequent redirection. This is why a rack-and-pinion chest table (like the Storz Göttingen model) is worthwhile. It permits efficient breakdown and redirection of the suspension system, which affords the operator the opportunity to quickly re-establish a different stable vantage point several times per case. Coupled with table-height and tilt adjustment (controlled from the head end of the table too), the operator can repeatedly re-establish the optimal line of sight.

Techniques

To enhance endoscopic exposure of the anterior commissure, one can laser-transect the ventricular bands (i.e., the inferior free margin of the false cord or upper lip of the ventricle) from their anterior anchorage on the framework of the larynx. But this diminishes the contribution undisturbed false cord tissues might have made to voice (exposure of the anterior commissure for lasering presupposes that the anterior glottic contribution to voice will be lost).

Do not rely completely on the pathologist. Study the mucosal margin around the tumor yourself. The operator enjoys the advantage over the pathologist when it comes to dodging a falsely negative margin reading. The pathologist will only see some of the margin—a rolled edge, with its telltale vascular network empty and collapsed. The surgeon gets to view the living margin under brilliant illumination, extended by traction, and further described by its vascular patterning.

Once beneath the mucosa, follow the cancer in an orderly way. Use your knowledge of cross-sectional anatomy. Use the telescopes to inspect beyond the tumor. Use the power of laser surgery to resect one piece at a time and maintain constant orientation. Replace finger palpation with instrument palpation. Pull the tumor into the field with grasping forceps. Finish an area before changing the tension and exposure in favor of another.

For laryngeal cancers that we choose to remove in sections, the plan of TLM is to complete each subresection a block (or view) at a time. Use transection at the edge of the field to find the healthy tissue plane and deliver all the cancer that will be taken in that established view. Tumor transection defines the plane of separation from the rest of the cancer. Consider marking it with ink. This surface will be the plane we need to place within the next view we "capture," to maintain a continuous resection. Like a Rubik's cube, as each new tumor subcomponent is delivered, an adjacent component becomes more accessible.

As each subunit is resected, three obligations are paramount:

1. Maintain continuous orientation to the cancer. Recognize what has been completed and what next to expose. Know what remains to be done.

2. Orient the resected specimen for the pathologist. The deep margin is the margin of interest, not the margin released from the rest of the tumor, which is known to be cancerous. It usually remains unmarked or bears the specific color we use to designate tumor transection surfaces.

3. Ink the deep surface margins and the peripheral margins, which are expected to be negative, with the previously agreed on study color (usually blue).

Any time TLM is applied to intermediate or advanced cancer, some patients will present with significant disease in the subglottic larynx. This can be a challenging location for exposure. Among the most helpful ploys are a small endotracheal tube, proper choice of the endoscopes, top-to-bottom sequencing of the resection, and special positioning of the larynx. Tip the larynx up by elevating the thyroid cartilage with the laryngoscope blade and depress the cricoid with cross-table taping. Most patients with subglottic cancer have glottic cancer. Excise the glottic component first and exposure is automatically improved for the subglottic disease. When cancer descends to the inferior margin of the thyroid cartilage, include the cartilage margin itself in the resection. It is possible to encounter (and recognize) the Delphian node when laser resections extend forward through the lower margin of the thyroid cartilage. Resection with the cricothyroid soft tissues provides an opportune method to identify an important mode of extralaryngeal nodal spread, a finding that usually calls for further treatment of the nodes in the neck.[70] Laser resection and histopathologic study of the Delphian node should probably be a routine part of any significant subglottic resection.

TLM is not just a simple combination of already familiar techniques. It forces us to reconsider the detailed anatomy of the larynx—to learn it "inside out." Otolaryngologists introducing TLM into their practice should watch someone do it. Take a course. Be prepared to train an assistant and a scrub nurse too. If facilities permit, fresh frozen cadaver dissection has merit. Some of the goals would be to distinguish the greater horn of the hyoid versus the upper edge and cornu of thyroid cartilage, the preepiglottic fat versus the glands around the ventricle, the distribution of the superior laryngeal artery and its main branches,[26] the form and attachments of the conus elasticus, and other parts of the neck.

If you biopsy a cancer at a separate sitting, use this opportunity to evaluate your preparedness and equipment for TLM. Determine whether your exposure will be adequate. When it comes to making the transition from study and observation to practice and application, start with small cancers and edentulous patients, the easiest to expose. Then work your way up.

Pathology Issues

TLM tends to be a "one-surgeon" operation. But it is by no means a one-doctor operation. An interested, enthusiastic, and involved frozen-section pathologist is an essential partner. Multiple specimen blocks require mutual understanding and clear communication. The step-section technique works nicely for a single block (like a T1a glottic specimen). It is not appropriate for the usual multiblock TLM case.[2]

When a tumor has been subdivided in situ, as already noted in this chapter, not all raw borders are margins. We have outlined one way to ink the margin in question on the specimen (Davidson Marking System). Another is to cut separate margin specimens from the wound. You may be surprised at how easily a specimen becomes disoriented. Orientation is often lost by the time the specimen reaches the lips! If you want the pathologist to work from the primary specimen itself, ink the margin in situ before the specimen is detached. In complex resections, ink the site of detachment, too, so that the subsequent readings will be easier to track. If you prefer, cut specific separate margin specimens from the wound. Then all the pathologist has to do is evaluate the entire submitted specimen. Is it yes or no? Is tumor present or not? The surgeon's responsibility is to avoid three errors—errors of sampling, errors of communication, and errors of identification. Sampling is the art of providing a dead specimen and getting the pathologist to tell you what will happen with the adjacent living tissue still present in the patient. Communication means providing the pathologist with key information, like whether the patient was irradiated before. Identification means keeping track of the sites of the sources of the biopsies. Use hemo clips, maps, lists, and inks of different colors. Number the specimens and link them to a map or a color. Make sure you and the cytopathologist share the same site names.

Transoral Laser Microsurgery in Relation to Each of the Five Clinical Categories of Laryngeal Cancer

Very Early Laryngeal Cancer

Very early laryngeal cancers provide a good initiation to laser laryngology, but the laser is just a "stand-in" for microforceps and cautery with little tangible advantage. Expert laryngologists commonly cure midcordal T1a glottic lesions by transoral laser excision. But all they perform is a simple excisional biopsy. Suspension microlaryngoscopy is a key asset. But the secret to the high cure rate in "very early" cancer is patient selection, skillful laryngoscopic exposure, careful en bloc excision, and negative margins. The advantage lies not with a laser, but with the nature of the disease. Very early glottic cancers are an exceptional neoplasm, being small, localized, and off the anterior commissure. No new principles were really required and no old principles were really challenged.

Early Laryngeal Cancer

"Early" laryngeal cancer comprises two groups, loosely similar to previously untreated T1B and T2A glottic cancer and previously untreated T1 supraglottic cancer: (1) glottic cases falling within the purview of an open vertical partial laryngectomy and (2) supraglottic cases falling within the boundaries of a supraglottic laryngectomy.

Transoral laser microresection clearly meets or exceeds expectations in early laryngeal cancer:

- The cure rate matches the open operations (vertical partials and supraglottics) while the morbidity and functional losses decline.[67]

- TLM does not require a temporary tracheotomy to treat early cancer. Hospital time contracts to 3 days[72] and costs fall.[73]

- Radiotherapy may outperform open VPL for voice in early glottic cancer, but only if cure is obtained. TLM provides the same high cure rate of VPL, but a better voice than VPL.[74] The major advantages of TLM relate to the efficiency of cure (obtained with only one treatment) and speed of completion (treatment is finished at the same direct laryngoscopy and biopsy the patient would require to start radiation treatment).

- Radiotherapy may surpass open supraglottic laryngectomy (HSL) in resisting aspiration (but it loses on cure and efficiency). TLM preserves better swallowing[75] than HSL and, unlike radiotherapy, requires no diminution of lubrication or taste.

- Over a lifetime, up to 25% of laryngeal cancer patients develop a second cancer.[76] Half involve the upper aerodigestive system. Patients who opted for TLM retain every possible option for the second cancer (including radiotherapy and laser surgery). Patients who accepted radiotherapy—and even prevailed—have narrowed their de facto future options to surgery in an irradiated field.

The conduct of TLM in early laryngeal cancer proceeds as follows. Intubate for general anesthesia with a small laser-approved endotracheal tube. (To minimize trauma, consider doing it yourself.) Our tubes have two balloons filled with water. Set up the laser for parfocal operation, for the smallest microspot (0.25 mm), and for continuous mode. Ask for 3 W power if you are a beginning laser surgeon, more as you learn to work faster. Establish the initial laryngoscopic exposure and the video image. Protect the face with a wet towel.

For early glottic cancer, use the laser, retract with suction, and outline the tumor margins. Then subdivide the lesion into a "middle plus anterior" and a "posterior" subunit.[66] Identify the depth of infiltration into the thyroarytenoid muscle and the extent onto the arytenoid. Laser-resect the posterior block. Resuspend the laryngoscope and transect the remaining tumor between the "middle" and "anterior" block. Laser-resect the middle block so that all that remains is the front. Reconfirm the depth by frozen section. Finally, reposition the laryngoscope and resect the anterior block. Traction with Bouchayer forceps works well to clarify the resection line at the anterior commissure.

In anterior commissure cancer, the voice is usually bad due to the disease. Voice after TLM for anterior commissure cancer is usually no worse.[72] However, the mechanism is different. Extensive resection of anterior commissure/anterior glottic cancers changes the glottis to a keyhole shape. It also bares the inner aspect of the thyroid cartilage. Healing on the inner aspect of cartilage will produce thin mucosa on a solid base, cartilage or fibrous scar with tethered restriction points. Thus we obtain stiffness. And stiffness produces hoarseness. Also, the intact thyroid cartilage will brace open the defect to produce an anterior glottic gap. And a gap produces breathiness.

In some cases, breathiness can be reduced with phonosurgery (e.g., cartilage implantation[77]) to reduce the anterior glottic gap. The correction of hoarseness caused by stiffness awaits future advances. The principal strategy now is the intelligent preservation of uninvolved tissues and the avoidance of unnecessary desiccation of the normal tissues left behind (TLM preserves glandular elements better than radiotherapy).

For early supraglottic cancer (confined to the supraglottis—the glottis and both arytenoids are free), split the suprahyoid epiglottis[78,79] vertically in the midline (even if this transects cancer crossing the midline). Identify the hyoid bone. Cut the vallecula and expose more hyoid to each side. Pass down the thyrohyoid membrane and clearly identify the upper margin of the thyroid cartilage. Plan to capture the bilateral supraglottic vascular pedicles with insulated grasping forceps or the bipolar cautery forceps. In most cases, it is prudent to clip (with two or three hemoclips) the internal branch of the superior laryngeal artery. Resect suprahyoid tissues before infrahyoid tissues, in planned subsections, proximal to distal. Above the plane of the thyroid alar margin, you will not harm the glottis. Below this plane, improve your access and vision by having resected all of the suprahyoid tissues on both sides. When resecting the false cords, take advantage of the angled suction protectors (model 8596) to shield the vocal cords. Insert the "baffle" into the ventricle or above the anterior commissure. In every supraglottic case, the surgeon should work to resect all of the preepiglottic space.

Intermediate Laryngeal Cancer

Earlier we defined "intermediate" laryngeal cancer to be one that would require SCPL to be encompassed by an open operation. Most "intermediate" glottic or supraglottic cancers can be treated by laser microresection, open SCPL, or radiation with surgical salvage. The problem with radiation and salvage is that intermediate cancers that fail radiotherapy are not cured by conservation operations. SCPL has a better record of local control,[24,80] but patient selection and surgical execution require tremendous sophistication. SCPL pushes function to the limit—it is probably the most extensive open resection one can do and still restore swallowing and an internalized airway (i.e., the tracheotomy is temporary).

Experience refutes the allegation that TLM cannot encompass intermediate cancers. When an anterior commissure lesion is too big for a vertical partial (but too mobile for a near total or total laryngectomy),[72] TLM provides a logical resection. TLM clearly rivals open SCPL for functional results. The morbidity is more than we see after TLM for early cancer, but clearly less than we expect after open SCPL for intermediate cancer.[81] Case selection may be more forgiving than it is for open SCPL because of the intraoperative diagnostic advantage of TLM.

Full exposure of intermediate cancer is only slightly more difficult than for early cancer. The larger challenge is continuity and orientation. Start with early cases to master exposure. Then progress to intermediate cases and the greater manipulative and directional tests they offer. Intermediate anterior glottic cancers typically involve the thyroid cartilage but spare the arytenoids. Of course, anterior laryngeal resections can include large pieces of the thyroid cartilage and the subglottis. Ossified framework can be devitalized with heat and outlined for endoscopic resection with Jackson laryngeal scissors (Pilling).

If motion on one side of the anterior glottis is at all impaired (T2b), look for extraconical cancer during TLM. And bear in mind that once external to the conus, the tumor descends to escape outside the larynx (through the cricothyroid triangle).[82] Borders of the cricothyroid triangle are the inferior margin of the thyroid cartilage, the lateral edge of the cricothyroid ligament, and the medial border of the cricothyroid muscle. An "intermediate" cancer found to extend outside the larynx can be managed by TLM. However, early in one's experience it might be better to open the neck and permit the formal resection of, say, a near-total laryngectomy, which includes strap muscles and the thyroid isthmus and lobe.[83] The price is the permanent stoma that accompanies NTL, but this is better than recurrent cancer.

TLM can also treat T_2 supraglottic cancers if the reason for "T_2" is invasion of the glottis or the medial pyriform wall. Once, a total laryngectomy was rationalized in these cases (by the notion that the tumor exceeded the limits of a supraglottic laryngectomy). That was why SCPL was a real advance. When TLM is feasible for T_2 supraglottic cancer, TLM becomes the next advance. Note that the patient undergoing TLM for intermediate cancer reaps the additional benefit of continuing diagnosis. Under brilliant magnification and stable exposure, little extensions of unexpected cancer[84] are likely to be recognized and removed. So are erythroplasia and keratosis, future sites of origin of the next cancer. When TLM cannot be done for intermediate cancer, the attempt to perform a laser excision may demonstrate why transoral laser and open SCPL are both unsafe (in that patient).

Intermediate TLM risks glottic stenosis. The maximum safe preservation of intralaryngeal mucosa and cricoid cartilage resists it. Preemptive suppression of reflux with antacid medical regimens also makes sense. If you anticipate losing an arytenoid at TLM, do a tracheotomy at the time of the laser surgery. Take advantage of the view (no endotracheal tube) and protect (to the degree possible) the patient against initial aspiration with a cuff.

TLM may generate the most logical resection for intermediate cancer, but the wound is still left to granulate and contract by itself. Open SCPL calls for a strong cricohyoidopexy.[85] The return of swallowing after TLM implies cricoarytenoid elevation is accomplished by other means. Perhaps this is preservation of the strap muscles—no suprahyoid dissection, no circumhyoid suturing.

The risk of a fistula after TLM for intermediate laryngeal cancer is nil because the neck dissection never connects to the primary site.

Advanced Laryngeal Cancer

"Advanced" laryngeal cancers are glottic, supraglottic, transglottic, aryepiglottic, or even medial pyriform cancers distinguished by two fundamental features: (1) permeation of the paraglottic space (therefore advanced cancers impair the motion on one side) and (2) a clearly lateralized disposition (advanced cancers seem to permeate the "hemilarynx").

The block to encompass such a cancer corresponds to a near-total laryngectomy.[83] NTL is a complete supraglottic laryngectomy plus an extended hemilaryngectomy, combined to include all of one paraglottic space and all of its contiguous neighbors (i.e., thyroid lobe and isthmus, hemicricoid, arytenoids, pyriform, anterior commissure and subglottis). However, much contralateral anterior glottis is necessary to encompass the cancer. Patients undergoing NTL retain a lung-powered voice—a prosthesis-free tracheopharyngeal fistula voice—but their stoma is permanent.

What saves these patients from being classified as "very advanced" are the following characteristics.

1. Most of the subglottic mucosa within the cricoid, certainly all of it on the "good" side, is free of cancer.
2. The contralateral ventricle is clear of cancer.
3. The contralateral vocal cord is only involved in the superficial mucosa and the most anterior glottic musculature.
4. The posterior commissure and postcricoid regions are completely clear.

To recognize patients with "advanced" laryngeal cancer, we have to be able to identify and exclude the "very advanced" cancers, for which near-total laryngectomy would not be safe. "Very advanced" means the only dependable ablative option is total laryngectomy and the preferred voice strategy is TEP. Typical "very advanced" laryngeal cancers are midline and bilateral, not lateralized. For example:

1. Massive "horseshoe" glottic/subglottic cancers (both ventricles and both muscular vocal cords are cancerous).
2. Significant subglottic cancers (generally involve the cricoid bilaterally and often present with airway obstruction).
3. Posterior commissure/postcricoid cancers (both arytenoid complexes are involved).

Near-total laryngectomy is the most logical open "block" for advanced cancers. But NTL requires a specialized lateral laryngotomy. The challenge is to enter the lumen without encountering cancer and without compromising the future speaking shunt. In many candidates, it would be easier to outline the block from within the lumen of the larynx. And the laser would be the ideal tool. More subglottic mucosa could be saved (which improves the tapered capacity of the inferior shunt—the tracheocricoid entry into the speaking shunt). More interarytenoid soft tissue could be saved (which contributes to the shunt's voicing and valving capacities). Occasionally, it might be recognized that both arytenoids were actually clear. That is, the cancer was "intermediate," not "advanced," and a logical laser supracricoid operation could be performed. This would confer an important advantage for the patient—no permanent tracheotomy.

Generally, we find "advanced" cases cannot be treated by TLM because reconstruction is required. The value of TLM lies not in complete excision, but in prereleasing the crucial tissue that really needs to be excised—this can define whether the cancer actually rises to the level of a near-total laryngectomy. Prerelease occurs with visible direction from familiar endolaryngeal landmarks, and it avoids the cancer itself. Then the surgeon can perform open delivery through the neck. No concerns about the site of entry, where the true margins lie, or where unseen submucosal cancer might extend. Perhaps the pharyngeal augmentation flap (to be turned down from the ipsilateral side to participate in the shunt[83]) can be precut with the laser as well. Voice shunt reconstruction would then be a simplified assembly with precut margins, no mucosal bleeding, and the least chance of cautery damage to the nerve supply or the muscular components of the shunt. The exception is when both arytenoids and cricoarytenoid joints—or at least the posterior half of the arytenoids can be preserved. In this situation, complete tumor excision is possible via TLM, generally with acceptable functional consequences (Figs. 109-1 through 109-3).

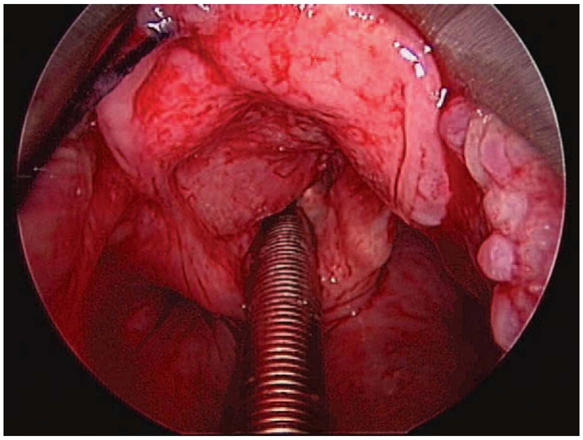

Figure 109-1. Preoperative T_4 transglottic squamous cell carcinoma (cartilage penetration).

Very Advanced Laryngeal Cancer

TLM has no apparent application in the "very advanced" category of laryngeal cancer. The exception might be the emergency treatment of neglected cancer with airway obstruction.[86]

Total Laser Microresection and Neck Dissection

The neck nodes are treated by open surgery or postoperative radiotherapy. We can carry out a neck dissection at the same sitting as TLM on the primary, but laser endoscopic surgery cancels the argument to perform a node dissection now because "the neck is already violated" (to access the primary). A better time might be weeks later. One unproven hypothesis suggests later is better because the micrometastases "in transit" at the time of the TLM will have had time to lodge in the nodes. A more practical reason would be to wait until a patient with serious comorbidities has recovered from the primary resection, or until after an elderly patient has regained swallowing after a laser supraglottic laryngectomy, or until after we know exactly what the pathologist has to say about the invasive nature of the primary cancer. Because a "second look" is possible after TLM, this might be a suitable time to operate on the deferred neck. With respect to the patient with a very low tolerance for complications, we have already mentioned that staging the primary and the neck surgery at separate sittings reduces the chance of a pharyngocutaneous fistula to zero.

Total Laser Microresection and Radiotherapy

TLM undoubtedly works best as a primary treatment. But surgeons who can offer TLM are not always consulted when the initial therapy is being selected. About half of our anterior commissure patients had already received previous treatment by the time we were called on to consider laser surgery.[72] Therefore surgeons will be confronted with patients who seek TLM for radio recurrent disease.

Prior radiotherapy complicates the planning of TLM and increases the morbidity attributable to delayed wound healing. It diminishes the accuracy of clinical judgment and the specificity of preoperative imaging. Radio recurrent cancer is often submucosal and sometimes discontinuous.[87] These factors complicate the decision to even attempt TLM. If TLM is undertaken, magnification does help disclose atypical patterns of spread. But magnification comes with its own danger—the temptation to cut normal-looking margins too close.

In our anterior commissure series,[72] 5 of 16 patients with intermediate laryngeal cancers received postoperative radiotherapy. The

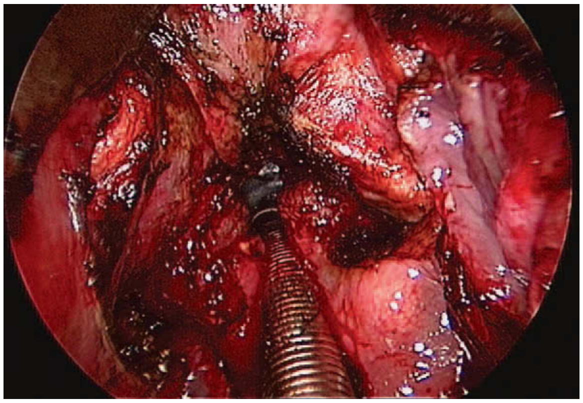

Figure 109-2. Extensive TLM resection removing left and anterior thyroid cartilage, both true vocal cords, supraglottic structures and preepiglottic space, and some strap muscle, but preserving cricoid ring and both posterior arytenoids.

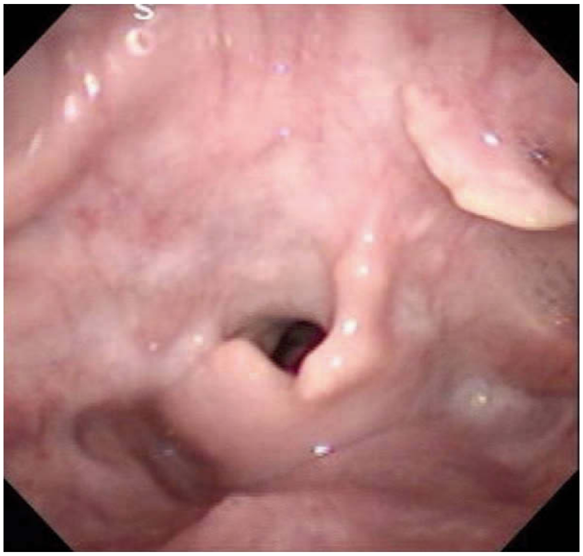

Figure 109-3. One year post-transoral laser microresection (and radiotherapy). Feeding tube has been removed and there was no tracheostomy.

indication was suspected disease in the neck, never a positive margin at the primary site. A positive margin at the laser site is an indication for further surgery, not radiotherapy.

TLM gives us a way to remove the primary without first disturbing the neck. After TLM, postoperative radiation faces the novel circumstance that no one has first disturbed the microcirculation with an open operation. Maybe the obligation to include the primary site in the radiotherapy fields is more questionable after TLM, when margins were clear and radiotherapy is being given for neck indications. TLM patients tend to heal as quickly as patients with open surgery. But more importantly, the risk of a complication (necrosis, a fistula, an infection in the neck) is diminished. Therefore TLM may be a more logical choice for the excisional component of combined therapy. Indicated radiotherapy will not likely be delayed by the prior performance of a TLM.

Complications of Transoral Laser Microresection

The complications of stray laser light include unwanted burns. Tiny pinpoint burns to normal laryngeal or pharyngeal mucosa are not rare, as the beam can easily pop the endotracheal cuff. Burns to facial skin, or worse, to the eyes or the airway are extremely rare but potentially devastating. We use small, wet precut toweling strips to cover fields beyond the target site, and angled suction protectors shield the cords. Cover the face and eyes of the patient with wet toweling after you position the laryngoscope. The microscope itself will save the operator's eyes from harm, but all other personnel need protective eyewear in the operating suite. Give the laser pedal to the surgeon (only) and the cautery pedal to the assistant (only). Control the concentration of oxygen in the airway (below 30% FiO_2), and use a double-cuffed laser endotracheal tube with saline in each cuff to maintain the seal confining the oxygen to the distal trachea.

Prolonged endoscopic displacement of the tongue causes obvious, sometimes severe, lingual contusion, swelling, and subsequent dysphagia, with or without long-term lingual dysesthesia. Chipped or loosened teeth follow difficult intubations or forceful endoscopic suspension in the dentulous patient. Sponges used to protect mucosa easily drift out of sight to be left behind when an endoscope is repositioned. Arteries can bleed voluminously into the wound in the larynx, particularly in the patient recently taking platelet inhibitors. All of these complications threaten the airway—with swelling, foreign bodies, or blood.

Many patients undergoing TLM require no tracheotomy. However, every consideration should be given to one in the intermediate and advanced cases where the role of a tracheotomy may be different. Here are some potential indications:

- To bypass expected edema from prolonged pressure on the tongue base in a lengthy case with difficult exposure.
- To bypass the specter of serious hemorrhage in the supraglottic region in the absence of airway protection.
- To avoid the impediment to exposure an endotracheal tube can pose, especially in the subglottis.
- To allow cuffed resistance to laryngotracheal aspiration in a patient with susceptible lungs.

Sudden secondary bleeding—without a tracheotomy—is probably the most dangerous risk.[88] The best treatment is avoidance: never trust the cautery to provide sustained control of a named artery (like the superior laryngeal), clip named arteries, and never trust the standard mouth guards to protect the teeth. Also, cover the upper incisors with thermosetting plastic and cool it with ice water. We use the small square of double-folded Aquaplast, the same material used to fashion rhinoplasty splints. As much as possible, the surgeon should pick up the tempo of the TLM to avoid prolonged tongue pressure. Do not be slowed down by inadequate plume suction, a weak laser beam, or a medium power beam weakened by defocusing. Learn to adjust the power and focus to the optimal settings for pace. Lengthy surgery risks tissue stasis and deep vein thromboembolism. Consider timed repositioning and apply antiembolism devices to all but the "very early" cases.

TLM imposes obvious limitations on reconstruction, but, in practice, the fact that the wound must heal by secondary intention is usually an advantage. The surface we will eventually be following in the office will be recovered by indigenous mucosa, not a skin graft, regional flap, or irradiated mucosa. This should improve our ability to monitor for local recurrence. Secondary intention healing involves contraction and granulation tissue, of course, but the preserved laryngeal framework does a surprisingly good job resisting contraction and stenosis is not common. Beware the patient with reflux. Reflux slows healing, which encourages fibrous stenosis. Be prepared to give proton-pump inhibiting medications on minimal evidence. Leaving the wound unreconstructed may yield two additional benefits: free cancer cells (if any) will fall on a slightly more inhospitable surface than the one we "bury" by reconstruction in open operations; and, at a future date, not having buried that surface, we preserve the possibility of a second chance through the discovery of persistent cancer at a "second look."

Whenever the inner surface of the cartilage is exposed by TLM, a sizeable granuloma is almost inevitable. Small osseocartilaginous sequestrae will perpetuate a granuloma until they are removed. At the anterior commissure, extensive resection leads to a rounded open anterior glottic defect. The opening produces breathiness. The walls consist of thin new mucosa, directly applied to the cartilage. The stiffness begets hoarseness. Prevention involves the optimal preservation of laryngeal mucosa,[89] plus the recognition and removal of any cartilage that undergoes laser thermal devitalization. Treatment of the breathiness draws on one's phonosurgical experience.[77] The stiffness is so far resistant to intervention.

TLM incurs new expenses. The institution incurs new costs, for training and equipment, and increased demands are made on the cytotechnicians and frozen-section pathologists. Some patients require a "second look" laryngoscopy (a few patients require more than one "second look"). Other patients will seek phonosurgical procedures (Fig. 109-4A and B). Some patients will receive postoperative radiotherapy (but their indications will be the same as in open surgery, so this cannot be considered an extra cost). TLM requires more travel for some patients because of its limited availability in the United States (although travel for radiotherapy is also common, and the time required away is considerably longer). Despite these extra costs, TLM reduces costs considerably.[72,73] Unfortunately, in practice, many patients do not receive TLM until after they have already incurred the expense of a previous therapy (that has failed). If TLM gains broader acceptance as an initial option, the potential for expense reduction may further improve.

TLM is a more difficult skill to transfer to the residents than is open surgery. The subtleties of orientation defer the assignment of part to the resident, part to the consultant. TLM tends to be a one-person, start-to-finish operation. There is not the usual sharing of duties possible with open surgery or the formal laboratory experience familiar to ear surgeons who prepared themselves on the temporal bone. TLM requires new judgment from laryngeal surgeons with respect to case selection and more advanced skills in laryngeal endoscopy because of the challenges of proper exposure. There are additional procedures to master including second-look direct laryngoscopies, new phonosurgical procedures, and the artful management of the complications noted earlier.

Contraindications to Transoral Laser Microresection

Extensive tumor spread to the neck (e.g., great vessels, esophagus, thyroid gland) is an absolute contraindication to TLM. So is inability to expose (with caveats if the upper teeth are the only impediment). The patient might consider the extraction of (carious) teeth, especially if it might save an open approach and a separate dental charge. Radiotherapists advise patients who have cancer to have pretreatment extractions. Preparation would include receiving patient consent and the taking of a dental impression.

TLM should not be advised for unresectable cancer, advanced cancer needing reconstruction, patients with functional disorders after extensive partial resections (like severe persistent aspiration or secondary stenosis), or the patient with overwhelming comorbidities. TLM is not very successful in any palliative role. It will usually prove unhelpful at the primary site in a patient with an N_3 neck or distant metastasis. A fixed (not impaired) cord is a relative contraindication to TLM, as is recurrent cancer in an irradiated "bed."

TLM has the potential to attract more patients with unrealistic expectations (e.g., those with advanced or very advanced laryngeal cancer after chemoradiation failure) or patients with major systemic comorbidities hoping to avoid a needed open operation for cancers that are advanced or very advanced. Sometimes a patient seeking TLM has built up too much faith in "the laser myth" while denying the realities of his or her predicament. TLM cannot repair tissues or functions already lost to cancer, radiotherapy, or previous surgery. It cannot restore tissues currently compromised by cancer. TLM cannot bring back lubrication, it will not reverse soft tissue or chondro-osseous necrosis, and it does not improve edema or painful soft tissue induration after radiotherapy.

Results of Transoral Laser Microresection

After an open operation or radiotherapy, laryngeal cancer reappearing at the original site is properly designated as "local persistence" or "recurrence." Local recurrence is disease that reappears after the initial treatment program has been completed. In TLM a "second look" is often a planned second phase of treatment. The discovery of residual cancer

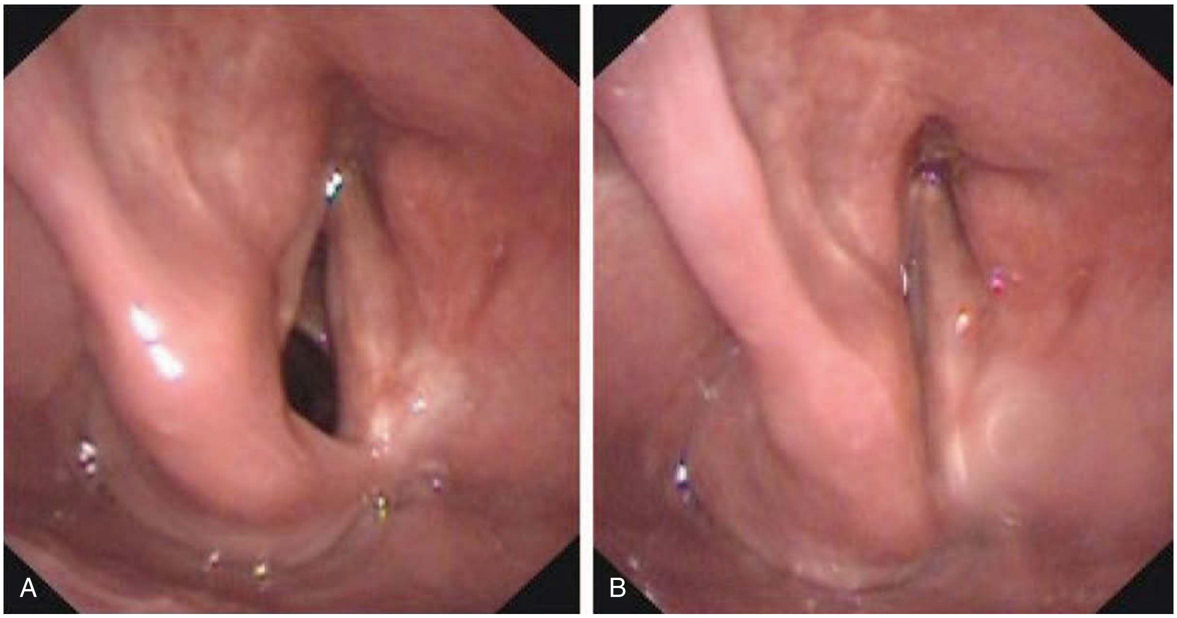

Figure 109-4. **A,** Open view of post-transoral laser microresection larynx for T_3 (fixed R true vocal cord requiring removal of right arytenoid) after open phonosurgical reconstruction (Gortex). **B,** Closed view. Patient does not use a feeding tube.

amenable to cure by laser resection at the time of the second look should not be listed as "local persistence" or "recurrence." These are diagnoses one would logically withhold until after a second-look strategy has been completed (or after one has been refused). This convention would be similar to the standard for chemotherapy, where persistent cancer at the primary site is not considered a failure if only the first cycle has been given.

In our recent publication on TLM for advanced laryngeal cancer the results of 117 patients were presented. These results were compared with the chemotherapy and concurrent radiotherapy and the radiotherapy-only arms of the RTOG 91-11 study.[90] The overall and T stages were similar with fewer T2s in the TLM group (8% vs. 12%). In the TLM series, at 2 years the percentage of patients with an intact larynx after treatment was 92%. The 2-year local control and locoregional control rates were 82% and 77%, respectively. The 2-year disease-free and overall survival rates were 68% and 75%, respectively. The 5-year Kaplan-Meier estimates were local control, 74%; locoregional control, 68%; disease-free survival, 58%; and overall survival, 55%. Most patients in our series did not receive adjuvant radiotherapy. These results compare favorably with those published in the RTOG 91-11 trial.[91] We concluded that TLM with or without adjuvant radiotherapy is a valid treatment for select advanced staged laryngeal cancers.

Göttingen Group Results

After first observing TLM by Wolfgang Steiner and Petra Ambrosch in 1996, and later by Heinrich Rudert in Kiel, Germany, the authors attempted to emulate these techniques in their own practices. Around that time, 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. Because many North American laryngologists remain unfamiliar with this important presentation and, because our own combined experience in more than 900 TLM patients seems congruent with this original work, we have tried to summarize Steiner's data here.

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 patients. As might be expected, the T_{is} and T_{1a} cases did extremely well and will receive no further comment.

Attempting to reclassify all of Steiner's glottic cases as "very early" (pT_{is} or pT_{1a} for 236 patients) and "early" (pT_{1b} pT_{2a} for 124 patients), there were 18 recurrences (15%) in the 124 "early" cases. Among the 26 pT_{1b} glottic cancer patients, 5 local tumors recurred. Of the 98 patients with pT_{2a} glottic cancers, 13 experienced recurrences. Combining the very early and early patients, there were 35 recurrent cancers among 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 microreresection. Eight patients proceeded to laryngectomy. Of the 360 (0.5%), 2 died from the glottic cancer. Six developed neck metastases, three with their primary controlled and three 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.

Steiner reported 43 previously untreated patients with supraglottic cancers. Of these, 18 (42%) underwent TLM to the primary only. Of the 43 patients, 23 (53%) also had open surgery on their neck. Two (5%) received postoperative radiotherapy. Again, trying to apply our clinical definitions to Steiner's supraglottic cases, we judged none to be "very early," 10 to be "early," and 33 to be "intermediate." Only four (9.5%) developed a local recurrence (or second primary) within 5 years, and three of these were salvaged by functional operations (one open supraglottic laryngectomy and two transoral laser reresections). No patients lost their larynx. Five (12%) died from their supraglottic cancer—one who refused treatment of a local recurrence, one who was never controlled in the neck, and three with distant metastases. In addition, five (11.3%) developed second primaries, two (5%) ultimately fatal. Six supraglottic patients (14%) died of intercurrent disease, while in one patient the cause of death was unknown. As in the glottic cancer patients, intercurrent disease placed ahead of laryngeal cancer as a cause of death. The 5-year Kaplan-Meier overall survival was 73%.

Of the 43 patients undergoing laser supraglottic resection, 36 (84%) required a feeding tube. One received a tracheotomy at the time of the laser surgery, and one needed a tracheotomy postoperatively. Two patients with dyspnea (5%) required assistance, including one of the temporary tracheotomies. The other was managed by lasering. Two with aspiration required treatment, one by tracheotomy to allow a cuffed tube and the other by conservative means. Two patients (5%) had bleeding, and one of these had to be returned to surgery for cautery under general anesthesia.

TLM was used for glottic cancer staged T_{2b} and above in 147 patients in Steiner's report. There were 93 pT_{2b} glottic cancers, 40 pT_3, and 14 pT_4. Using our clinical classification, this was about 93 early or intermediate and 54 intermediate or advanced. Ninety (61%) were TNM stage 2, 38 (26%) stage 3, and 19 (13%) stage 4. Ninety-five (65%) of the 147 glottic patients received laser treatment of the primary (only). Thirty-two (22%) were treated with TLM at the primary site plus open surgery in the neck. Four more (3%) underwent TLM and radiotherapy. Eight (5%) had laser microresection, neck surgery, and postoperative radiotherapy. All in all, 40 patients (27% of the "T_{2b} and above" glottic cancer patients) underwent neck dissections, mainly selective dissections of levels 2 and 3. Twenty patients (14%) received radiotherapy after surgery.

Among the 147 patients treated by TLM for early/intermediate/advanced glottic cancer, there were 45 local recurrences (including possible second primaries). The 5-year Kaplan-Meier survival overall was 59%. During 40 months, the recurrence rates broken out by clinical stage ran as follows: 28 of the 93 patients with early and intermediate glottic cancer and 17 of the 54 intermediate to advanced. Seven patients developed neck metastases in addition to their recurrence at the primary site. One grew nodal disease without a primary recurrence. Three (2%) patients acquired distant metastases.

In the entire 147 patients undergoing TLM for T_{1b} early or T_2 intermediate or T_3 advanced glottic cancer, 45 developed local recurrences. In 21, this led to a total laryngectomy, 8 of whom also received postoperative radiotherapy. Four patients received open vertical partial laryngectomies. Ten were salvaged by TLM, and six more were salvaged by TLM and radiotherapy. Four of the patients who developed local recurrences received palliative care only. Thirteen of the 93 early/intermediate cases and 12 of the 54 patients with intermediate/advanced cancer died from their glottic disease. Thus 25 of the 147 patients (17%) with larger tumors died. Only 11 of the 25 died of local/locoregional recurrence. One died from regional recurrence alone, and 13 died from distant metastases. The number of second primaries was 14 (9.5%), with only 1 in the head and neck. Ten patients (7%) died of a second primary and 29 (20%) died of intercurrent disease. Once again, intercurrent disease beat glottic cancer treated by TLM as the cause of death in these patients.

Steiner's report to EUFOS included 56 patients with higher TNM stage supraglottic cancer. One had pT_1 local disease, 7 had pT_2, 29 had pT_3, and 19 had pT_4. Therefore 48 of 56 patients had pT_3 or pT_4 supraglottic cancer. Eight (14%) underwent only TLM. One (2%) had TLM and radiotherapy. Of the 56 supraglottic TLM patients, 47 (84%) also received neck surgery, mainly of selective dissection of levels II and III. Twenty six (46%) had neck surgery only; 21 (37.5%) had postoperative radiotherapy as well. In the whole group of 56 patients with higher-stage supraglottic cancer, 22 (39%) had radiotherapy after surgery. Of the 56, 11 (19.5%) developed local recurrences (or second primaries). Eleven patients developed neck metastases, five with their primary controlled and six with recurrence at the primary site (locoregional recurrence). Of these, three also developed distant metastases.

No local recurrence was salvaged with an open partial laryngectomy. Three were salvaged with radiotherapy and six patients required a total laryngectomy. Two also received postoperative radiotherapy. Two patients with recurrence received palliative treatment only. The overall 5-year Kaplan-Meier survival for these patients with higher-stage supraglottic cancer (where the primary was treated by TLM) was 50%.

In Steiner's 1996 series, 48 patients had pT_3 or pT_4 supraglottic cancers. Complications in this group included three patients with early stenosis. One was lasered. Two required a permanent tracheostomy. Five patients suffered significant aspiration, leading to total laryngectomy in three. One responded to a temporary cuffed tracheotomy, and one accepted a gastrostomy tube. Four patients experienced bleeding that required endoscopic coagulation under general anesthesia.

In the pT_3/pT_4 supraglottic cancer group, 11 recurrences (or second primaries) (23%) appeared. Six patients with recurrence (12.5%) were laryngectomized (two with postoperative radiotherapy). Nine second primaries (16%) arose, four in the head and neck. Of these patients, seven (12.5%) died from their second primary. Six patients (11%) died of intercurrent disease. Of the 13 (23%) patients who died from supraglottic cancer, 4 died from local recurrence, 5 of regional recurrence, and 4 from distant metastasis. Notice that if TLM failed locally in pT_3 or pT_4 supraglottic cancer, half the patients required a laryngectomy (6 of 11 or 55%). And again, intercurrent disease and second primary cancers combined to cause death as often as locally advanced supraglottic cancer treated primarily with TLM.

For interested readers, Steiner also reported his TLM results for pyriform cancer to EUFOS.[68] Of 103 previously untreated patients with hypopharyngeal cancer, mainly pyriform, 63 patients had pT_2 cancers and 14 had pT_3. Sixty percent had proven neck disease. Steiner excluded patients with simultaneous second primaries, very advanced neck disease (N3), or distant metastases (i.e., not treatable for cure). All patients underwent TLM, but 75% also had neck surgery and 50% had postoperative radiotherapy. Of these 103 patients, 93 were controlled locally—there were only 10 local recurrences during a 44-month mean follow-up period. The 5-year Kaplan-Meier survivals mirrored supraglottic cancer (69.2% for combined stage I and II, 52.5% for stage III and IV), validating Krishaber's classic differentiation of "intrinsic" versus "extrinsic" disease. More laser surgery, open surgery, and radiotherapy were used to address failure. Eighteen patients (17%) died from pyriform cancer. Nearly as common (as causes of death) were intercurrent disease (16, or 15%) and second primaries (13 deaths among 16 second primaries or 13% of the total group).

Conclusions

TLM is not cancer surgery through a keyhole. In fact, it has oncologic advantages. The diagnostic component supports accurate verification of the tumor extent. The patient receives not the largest resection, but the most logical resection. The strategy of "follow the tumor" reduces the risk of undertreatment. Tissues adjacent to the resection site do not require dissection, which ensures preservation of the local microcirculation—the optimum precondition for adjuvant radiotherapy. And TLM leaves behind an open resection site—no chance to bury residual cancer cells, and all the better in follow-up.

TLM offers meaningful functional advantages—fewer tracheotomies, no fistulae, less disfigurement, less pain (nurse's observations), earlier swallowing, and a lower risk of overtreatment. It also carries certain socioeconomic advantages—reduced treatment costs from the shorter length of stay and the low rate of retreatment (for local control). TLM is a repeatable treatment (radiotherapy is not). And TLM anticipates the real problem of second primaries. After TLM, all treatment options remain.

Some things have changed with the introduction of TLM and some have not (e.g., time spent in the operating room—it takes us just as long to perform a transoral resection as an open one). More time is spent on the resection and the frozen sections, while less time is spent on open approaches and closures. The indications for and performance of neck dissection remain the same. The only variation is the greater opportunity to stage the neck. The indications for adjunctive radiotherapy remain the same, and, of course, so does the need for expert anesthesia and skilled postoperative care.

In the United States, opinions once held that TLM should never be done because it contravened oncologic principles—transected cancer, burned specimen margins, and replaced brilliant reconstructive techniques with healing by secondary intention. Now TLM is receiving more and more attention. Block excision can be seen as just a tactic to spill no viable cancer in the wound, and TLM as a strategy that supports this goal, but with a different tactic. It turns out that pathologists can read laser microresection specimens well. There are more specimens to study, and the surface coagulation is only several cells deep—less than what electrocoagulation will sometimes produce in an open surgery specimen. Secondary intention healing is no longer seen as a disadvantage because TLM selects patients for whom secondary intention healing provides excellent results.

Of course, not all change is progress. Predictions that laser surgery would (or should) produce miracles because laser technology was new, easier, faster, and bloodless were clearly exaggerations. TLM is a demanding endoscopic intervention and a complex resection, with no savings in time and its own special set of challenges. Bleeding does occur, and it can stop the laser in its tracks. Cautery and hemoclips remain entirely necessary. Laser surgery does require us to invest in new equipment and accept new safety regulations. Laboratory evidence of oncologic efficacy still lags, but it may be a bit late for animal evidence, given the excellent cure rates reported in actual human application.[66,67,78] Detailed documentation of quality-of-life outcomes is starting to become available. The TNM system retains its due respect as a reporting system, but we feel we have better concepts to guide initial treatment selection. Some will claim long-term multi-institutional cooperative trials have supported other modalities in the United States[92,93] and not TLM, but our own experience suggests that properly selected patients with advanced lesions can be managed by TLM with equal or superior rates of control and function. TLM does not rule out chemotherapy or radiation whenever they can add to the outcome. Radiotherapy cannot be used until a direct laryngoscopy and biopsy have been done, and this is usually a perfect opportunity for laser microresection.

Cartilage involvement and subglottic extension were once thought to constitute contraindications to TLM, but this turns out not to be so. Margins are not unobtainable just because the thyroid cartilage is involved. Laser microresection of the arytenoid was predicted to cause inevitable intolerable aspiration, but, again, this proves to be an overstatement. Subglottic resection is challenging, but now special techniques and special endoscopes[70,94] are available to overcome the limits on exposure.

TLM is eminently suited to the treatment of laryngeal cancer because squamous carcinoma starts in the epithelium and the epithelium is accessible through the mouth. The tumor needs to be accessible to endoscopy, but it does not need to be completely exposed in a single field of view. The cancer will need to be completely resected, with negative margins, but it will not need to be removed in one single piece. The resection site will need to have the time and conditions to heal by secondary intention and the support to resist stenosis—but it will not require primary closure. T stage in and of itself does not rule out TLM as worthy of consideration. In a series of laryngeal cancers involving the anterior commissure,[72] transoral laser excision was valid in selected carcinomas staged pT_2b, and a small number of pT_3 and pT_4 anterior commissure cancers were also treated successfully. This led to our focused study on advanced laryngeal cancer.[91]

In patients with very early laryngeal cancer, suspension microlaryngoscopies and laser excisional biopsies might best be considered "beginners TLM." When possible, it avoids 6 weeks of radiotherapy.

In early glottic cancer, TLM virtually replaces conventional VPL and hemilaryngectomy in our practice. We have experienced the same for early supraglottic cancer. TLM basically puts conventional HSL out of business. (The minimum prerequisite is at least one mobile arytenoid cartilage.)

TLM challenges supracricoid laryngectomy, and it replaces partial laryngeo-pharyngectomy (Ogura's "PLP"[71]). Laryngeal cancer extension outside the framework contraindicates TLM, but in cases of doubt this decision can be made during treatment because endoscopic surgery can always be converted to open surgery. The need for reconstruction is considered a relative contraindication to TLM. But the vertical closures familiar in HSL and SCPL have not proven necessary in patients treated by TLM.

TLM now also has a role to play in advanced laryngeal cancers, but the arytenoid complex must be preserved bilaterally in part or in total to resist aspiration.

TLM has no role in very advanced laryngeal cancer, except possible palliative relief of airway obstruction until definitive open laryngectomy.

Transoral laser microsurgery is clearly one of the important treatment options for squamous cell cancer of the larynx. Advantage is taken of the operating microscope, laser micromanipulators and the new CO_2 fiber, and advanced laryngoscopic instrumentation to provide the most logical tumor resection, the least loss of normal tissue, and the best opportunity to follow tumor extension beyond what was visible in the office and to the scanners. With fewer tracheotomies, shorter hospitalizations, and no limitation on additional treatment, laser resection seems to combine the promise of the "light scalpel" with endoscopic advances and the realities of laryngeal cancer. For many patients, transoral laser microresection can provide the optimum combination of cure and quality of life.

Appendix on the Clinical Classification Used in This Chapter

"Early" and "advanced" were ancient designations intended to differentiate whether the cord was fixed. Fixation meant advanced, which meant total laryngectomy. Early glottic cancer had two operations: resection via direct laryngoscopy or laryngofissure and cordectomy. Early meant a low volume of cancer and a reasonable prospect of cure by radiotherapy. Advanced meant radiation usually failed, and surgery would usually be required. But sometimes radiotherapy worked and avoided a total laryngectomy.

Some early cancers were so favorable that they could be cured by a biopsy. This could falsely inflate treatment results—irradiation after an excisional biopsy would invariably produce a "cure." Therefore this subgroup was given its own category, namely "very early."

Conservation surgeons recognized that some cases with a fixed cord could have less than a total laryngectomy. These types of cancers kept the name advanced, but those cancers that everyone agreed had no chance with anything less than a total laryngectomy came to be called "very advanced."

A clinical classification of local laryngeal cancer thus evolved. There were four categories, very early, early, advanced, and very advanced. Early could be handled by classic conservation operations like the vertical and horizontal partials. Advanced was defined as lateralized cancer pervading one paraglottic space and sparing enough mobile innervated glottic tissue on the contralateral side to make a voicing shunt. The cord was fixed, but advanced could be controlled by a near-total laryngectomy.

Naturally, some laryngeal cancers fell in between a supraglottic laryngectomy and a near-total laryngectomy. We called them "intermediate" (between early and advanced). As it happens, these cancers fit the supracricoid partial laryngectomy block quite nicely.

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