3 Fundamentals of Laryngeal Surgery: Approaches, Instrumentation, and Basic Microlaryngoscopic Techniques

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Core Messages

- Most laryngeal lesions are located in the mucosa or submucosal space, making them easily accessible to endoscopic surgery.
- Advantages of the endoscopic approach include the avoidance of skin incisions, division of the thyroid cartilage, and tracheotomy.
- Open laryngeal surgery is required for the cartilaginous structures of the larynx, if the position of the larynx is to be altered, or if the anatomical situation prevents adequate endoscopic visualization.
- Endolaryngeal surgery is done using Kleinsasser's microlaryngoscopy technique.
- CO_2 laser systems are frequently used for laryngeal surgery, particularly phonosurgery, stenosis surgery, and resection of most laryngeal tumors.

Laryngeal endoscopy and surgery aims are a refined diagnosis of laryngeal, tracheal, and hypopharyngeal disease; improvement or restoration of laryngeal function (i.e., phonation, airway protection during deglutition, airway patency); and removal of neoplastic alterations of a benign or malignant nature. In recent years, transoral endoscopic surgery has seen enormous progress, whereas open surgery is now usually restricted to ablative or reconstructive surgery at the cartilaginous framework of the larynx.

3.1 Historical Background

Modern endoscopic laryngeal surgery traces its origins to the second half of the 19th century. Turck and Czermak of Vienna first used angled mirrors for clinical examination of the larynx in 1857, and 2 years later Stoerk used these mirrors for endolaryngeal cauterization of the larynx. As a result of these efforts, endolaryngeal surgery became more widely practiced, and techniques were advanced by McKenzie, Fränkel, Kirstein, Killian, and Jackson. Thus, the development of endolaryngeal surgery was contemporaneous with, but essentially separate from, that of open laryngeal surgery. The decisive breakthrough for endolaryngeal surgery as a universal approach for laryngeal operations occurred when Oskar Kleinsasser of Cologne, Germany, introduced microlaryngoscopy during the early 1960s [1]. This method provides access to most of the mucosal lesions of the larynx and a number of submucosal lesions. At the same time, it requires a specialized set of microinstruments that are controlled with both hands, requiring a high degree of manual skills.

The rich vascular supply of the tissues in the larynx, however, makes it difficult to carry out more extensive procedures, tending to cause troublesome bleeding from the cut tissues that obscures the operative field and makes precision microsurgery difficult or impossible. An early solution to this problem involved using monopolar electrocautery probes in endolaryngeal surgery to improve hemostasis during operations involving the relatively extensive division of submucosal tissues

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(e.g., cordectomy, arytenoidectomy). In light of the above situation, the introduction of laser systems into laryngeal surgery marks an important milestone in the development of this operative approach [2]. By coupling a CO_2 laser to the operating microscope and controlling the invisible treatment beam with a micromanipulator, guided by a visible-wavelength coaxial aiming beam, a relatively stationary, noncontact technique was achieved for dividing endolaryngeal tissues while simultaneously coagulating small blood vessels. This approach overcame several basic problems in endolaryngeal surgery: The laser beam does not obstruct the surgeon's view of the confined operating field, it provides adequate tissue hemostasis for greater visibility, and it facilitates the surgical dissection.

The obvious advantages of endolaryngeal laser surgery were not generally appreciated at first. A major objection was that laser incisions always caused thermal tissue damage (burns) and therefore did not meet the requirement of clean, atraumatic tissue division with margins that could be evaluated histologically. Over time, technical refinements eliminated most of these objections, and laser use not only made it easier to carry out known surgical procedures but also laid the foundation for developing new therapeutic concepts, especially in the field of oncological surgery. Remarkably, these concepts were not developed in the United States, where lasers were first used in laryngology. It was left to clinical pioneers in Europe to research, describe, apply, and publicize the clinical potential of endolaryngeal laser surgery. In addition, endoscopic laser surgery has led to a modification of numerous operative procedures for benign lesions of the larynx. Van Overbeek pioneered the CO_2 laser-assisted endoscopic treatment of Zenker's diverticulum. Carruth in the United Kingdom and Freche in France advocated the use of CO_2 laser for benign lesions and bilateral vocal fold immobility. These techniques are briefly reviewed in this chapter.

In France, Marc Bouchayer, one of the best phonosurgeons of his time, improved the cold steel instruments especially for microphonosurgery. The new lines developed more recently on the Unites States, such as the Sataloff's or Benninger's sets, are directly inspired from Bouchayer's tools.

Until Kleinsasser, endolaryngeal surgery was frequently performed as indirect laryngoscopy under general anaesthesia. Afterward, It was much less popular even it was still practiced mainly in Japan or Eastern European countries.

The development of the "chip tip fiberscope" including a camera in the distal tip and an operating channel, the recent financial incentives for office-based procedures, and new injectable substances and laser wavelength have induced a shift for procedures performed transcutaneously or transnasally. A good balance between these two approaches, however, has still not been found.

In the United States, the gap between endolaryngeal surgery and open laryngeal surgery is still evident; although head and neck surgeons in the United States are skilled in open laryngeal surgery, they often take a skeptical view toward endoscopic laryngeal surgery, which is the domain of "laryngologists." This "overdivision" into subspecialties helps explain the long delay in acceptance of endolaryngeal laser surgery in the United States.

3.2 Endolaryngeal Versus Extralaryngeal Approach to the Larynx

Most benign laryngeal lesions are located in the mucosa or submucosal space of the larynx, making them easily accessible to endoscopic inspection. Advantages of the endoscopic approach include avoidance of skin incisions, division of the thyroid cartilage, and tracheotomy. Therefore, it causes less surgical trauma and its related morbidity. As a consequence, open operations on the larynx are now considered obsolete unless surgery is required for the cartilaginous structures of the larynx, if the position of the larynx is to be altered, or if there are particular problems that prevent adequate endoscopic visualization of the anatomicical structures. In most cases, surgical resection of benign laryngeal pathology is the only reasonable therapeutic option in cases where treatment is warranted. Except for oncological surgery, which aims to remove diseased structures, laryngeal surgery is driven by functional considerations, aiming at improving voice, deglutition, or airway patency. If doubt exists as to the nature of a given lesion, it may be prudent to leave some of the pathology behind and resect it at a later time if it better preserves the functional integrity of the larynx.

3.3 Surgical Endoscopy

Direct laryngoscopy under general anesthesia is indicated for all laryngeal diseases in which the larynx cannot be examined in the conscious patient (children) or in which mirror laryngoscopy, telescopic laryngoscopy, or flexible endoscopy has revealed findings in the larynx, hypopharynx, or trachea that require further investigation. Suspension laryngoscopy uses an identical approach but fixes the laryngoscope by means of a chest support. The surgeon's hands are free for bimanual manipulation. It provides ideal access for many diagnostic and therapeutic procedures in the trachea, in which the laryngoscope can serve as a "sheath" for introduction of tracheoscopes and operating instruments (Fig. 3.1). Using an operating microscope additionally provides a three-dimensional view of the endolaryngeal anatomy. In addition to inspection of the mucosal surface with the operating microscope and introduction of rigid endoscopes, this technique allows selective excisional biopsies, even enabling the surgeon to take large samples if required. In additional, visual inspection can be supplemented by tactile examination (e.g., to assess the mobility of an ankylosed arytenoid cartilage). Currently, CO_2 laser can be used for excisional biopsies, completely resecting small mucosal lesions of indeterminate nature in a procedure that is both diagnostic and therapeutic.

3.4 Fundamentals of Endolaryngeal Surgery and Equipment

Endolaryngeal surgery is done using Kleinsasser's microlaryngoscopy technique. The patient is positioned in a supine position. A rigid laryngoscope of appropriate size is inserted through the oral cavity, and the oropharynx and held in place using a chest support. The use of an operating microscope allows three-dimensional visualization of the endolaryngeal structures and bimanual surgical handling of instruments inside the larynx. The basic setup is shown in Figure 3.2 [3, 4].

In Figure 3.2, red lines indicate the patient's head positioning. The operating table has been adjusted in a way that allows the surgeon to sit comfortably on an operating chair, with arms supported by armrests, footswitches for steering the operating microscope, laser, and electrocautery; a red line indicates the viewing axis from the microscope to the larynx. Proper positioning of the patient is usually achieved with the patient's neck in

Fig. 3.1. Basic setup for direct laryngoscopy. A rigid endoscope is used to visualize the anatomical structures of the larynx and trachea. Positioning of the head and body is indicated by *red lines*

Fig. 3.2. Basic setup for microlaryngoscopic surgery. *C*, chest support; *L*, laser arm; *M*, monitor; *A*, arm rest; *1*, foot switch for microscope; *2*, foot switch for laser; *3*, foot switch for electrocautery

flexion and the head in slight hyperextension (Fig. 3.3). Other important prerequisites are preoperative assessment of dental status, adequate mouth protection during the procedure to prevent dental injuries, and a trained, proficient surgeon. Suitable options for anesthesia–ventilation include general endotracheal anesthesia (using a laser-safe ventilation tube), jet ventilation, and mask ventilation with intermittent apnea. The necessary equipment includes an assortment of laryngoscopes and stands, an operating microscope, microinstruments, CO_2 laser, monopolar cautery probes, rigid telescopes, and suction. Some procedures also require implants and their corresponding application instruments (collagen, fat, cartilage, dispersed silicone) and photographic or video equipment. The essential problems in any minimally invasive procedure, regardless of whether it is in the abdominal cavity, knee joint, or larynx, are obtaining an adequate view of the operative field and the ability to use the necessary instruments at the surgical site. For laryngeal surgery, operating laryngoscopes are employed. Because no laryngoscope can satisfy all requirements, the laryngeal surgeon should have an assortment of models on hand. The most important are listed below.

Fig. 3.3. Kleinsasser laryngoscope. (Courtesy of Karl Storz Company, Tuttlingen, Germany)

- Kleinsasser laryngoscopes (sizes A–C, DN, J, JL) (Fig. 3.3) are still valid for microsurgery of benign laryngeal lesions. Recent modifications have been proposed by major companies for better exposition of the anterior commissure or for laser-assisted microsurgery. Laryngoscopes are now equipped with wall-integrated channels for smoke evacuation and a light guide. The inner part of the scopes should be ebonized or sandblasted to prevent laser beam reflection and to favor maximum dispersion of the beam.
- The Bouchayer laryngoscope remains a gold standard for cold steel microphonosurgery for many phonosurgeons, particularly in France.
- Bivalved laryngoscopes in various sizes (Rudert, Steiner, Weerda) are necessary for approaching the supraglottic larynx and the hypopharynx (Fig. 3.4).
- The Lindholm laryngoscope, when inserted into the vallecula epiglottica, affords an excellent view of supraglottic structures (ideally of the whole larynx) (Fig. 3.5).
- Diverticuloscope for endoscopic cricopharyngeal myotomy.
- Pediatric laryngoscopes (various models).

Optimal instrumentation is just as important when treating benign laryngeal lesions as it is for surgery of malignant tumors. It may be even more so inasmuch as tumor surgery is basically a destructive process whereas surgery for benign laryngeal lesions is often a tailoring procedure. The goal of this type of surgery is not just to remove abnormalities but rather to modify

Fig. 3.4. Bivalved laryngoscope. (Courtesy of Karl Storz Company, Tuttlingen, Germany)

Fig. 3.5. Lindholm laryngoscope. (Courtesy of Karl Storz Company, Tuttlingen, Germany)

and adapt (tailor) anatomical changes to allow optimum functional rehabilitation of the voice, swallowing, and respiration.

No single company provides the ideal tool box so far. Surgeons, according to their own practice, experience, and professional surroundings, may prefer one instrument to another. Moreover, many companies provide similar instruments. Personal relations with these companies and their local representatives have, de facto, a major influence.

These instruments were originally designed for cold steel microsurgery. Many of them have been adapted for laser-assisted surgery with a channel for smoke evacuation.

The microinstruments are usually 22 cm in length, and most are paired symmetrical sets with a right and a left directed working end. The basic box should have the instruments designed originally by Kleinsasser: thin, curved forceps that have serrated teeth and cup forceps for biopsies. The Bouchayer "heart-shaped" forceps are ideal for microsurgery of the vocal fold. The head of the forceps is directed 45° to the left or right sides and 45° to the top, allowing perfect, gentle holding of the vocal fold. Microscissors, sickle knives, flap elevators, straight or curved, are of course mandatory for cold steel surgery. Three to four suction tubes with various diameters are also necessary.

Monopolar electrocautery is also necessary for bleeding control. Electrocautery connected to a suction tube or a forceps is available and can be recommended. Many surgeons achieve coagulation simply by contact between a basic electrocautery blade and the suction tube or forceps.

Stronger, larger forceps are available for endoscopic cancer surgery when large specimens have to be handled. The table is completed with wet towels for protecting the patient's face in case of laser-assisted surgery, swabs soaked in epinephrine solution (1:100,000) for controlling oozing and for protecting the cuff of the ventilation tube in case of laser surgery, and a silicone tooth guard or folded gauze sponge for protecting the teeth.

Other instruments may be necessary according to the specific surgery, such as Brünings syringe or the Ford injection device for injecting fat, collagen, or other substances. These choices are also related to the surgeon's own preferences and experience. They are discussed in the following chapters.

3.5 Laser Systems Used for Endoscopic Surgery of Benign Laryngeal and Tracheal Lesions

The CO_2 laser is the undisputed workhorse of laser surgery in laryngology. Owing to its frequent use in tumor surgery, nowadays it is available in the ear/nose/throat

(ENT) departments of most large hospitals. Designed for surgery, its wavelength is 10,600 nm, with absorption by water inducing minor peripheral thermal effects in the surrounding tissues. CO_2 laser meets the requirements for use for most benign laryngeal lesions, particularly during phonosurgery, stenosis surgery, swallowing rehabilitation, and resection of most benign laryngeal tumors.

The initial CO_2 laser microwave was a continuous wave. At a given power, it provided continuous output. The continuous exposure resulted in much heating of collateral, nontarget tissue by conduction. To minimize the thermal effect; a pulsed mode was developed for the CO_2 laser (Sharpulse). The thermal reduction is even more important with Superpulse or Ultrapulse waves. SuperPulse and UltraPulse are pulsed waves with the high peak of power delivered in millisecond pulses or less. The resultant average pulse power, preset during programming, usually ranges between 1 and 10 W. The interpulse pause of approximately 1 ms, called thermal relaxing time, permits the tissue to cool. This significantly reduces the thermal effect and consequent coagulation of the area surrounding the impact. SuperPulse has higher peak power (400–500 W) than UltraPulse (200 W) but less energy because its delivering time is shorter (Fig. 3.1). This pulse energy determines tissue impact and must reach the necessary threshold for ablation. Energy below ablation threshold leads to stronger thermal impact. UltraPulse adjusts its pulse energy automatically such that it is always above ablation threshold. This is not the case with SuperPulse (Fig. 3.2). The SuperPulse is cone-shaped, which means that some part (the rising and falling parts) is below ablation threshold, which in turn means this part of the energy goes into tissue and heats it more. UltraPulse is rectangular. Hence, there may be slightly more thermal damage with SuperPulse than with UltraPulse.

In addition to the laser unit itself, accessories are available for optimal delivery of laser energy to the operative site.

In terms of laser light delivery from the laser arm to the target, currently available are the Acuspot micromanipulator and scanner. The micromanipulator, which is attached to the operating microscope and connected to the laser arm, yields the smallest possible beam diameter presently available (i.e., 250 μm for a focal length of 400 mm). This micromanipulator makes possible the accurate tissue incision and dissection required for phonosurgery. By means of a computer-guided system of rotating mirrors, the scanner allows the beam to sweep a given surface with extreme rapidity. This feature makes it a highly effective tool when macroscopic vaporization is required. A "shaving" effect a few microns deep is achieved during each beam sweep, with little in-depth thermal penetration. The usual shape chosen for the surface is the circle. This mode of laser use is suitable for selective, superficial removal of mucosal lesions in cases where histological examination is not required and the main aim is to achieve uniform tissue ablation with the least possible collateral injury. An example is the removal of papillomas or patchy areas of leukoplakia, which can be histologically confirmed prior to laser ablation. The result of this procedure is a superficial mucosal wound with no thermal alteration of the underlying tissue. This type of wound undergoes rapid secondary epithelialization and can heal with an excellent functional result.

The Acublade is a scanner software modification that allows the beam to travel across the target as a straight or curved incision line instead of "shaving" a given surface (Fig. 3.3). Various lengths (0.5–3.5 mm) and penetration depths (0.2–2.0 mm) are programmable. The operator can, at all times, modify the parameters proposed by the laser-controlling software. This incision line can be rotated to the left or right thanks to a driving belt articulated with the scanner. The belt is moved with a joystick-controlled electrical motor (Fig. 3.4a).

The software-calculated penetration depth is based on average absorption of the CO_2 laser by living soft tissues. Depending on the desired length and penetration, the software calculates the required power and pulse duration for the single pulse mode. The Acublade was designed for SuperPulse and continuous modes that can originate from the same optical cavity. The Acublade is now available with UltraPulse technology. The guiding system of the incision line is fully electronic and integrated in the scanner (Fig. 3.4b).

Incisions are sharper with UltraPulse, making the dissection more comfortable, mainly when approaching a major vocal fold structure, such as the vocal ligament. This difference in efficiency is of interest for delicate phonosurgery of the vocal fold in single-pulse mode, but it is not an advantage for other procedures, such as cordectomy, when the shooting is usually in continuous mode. On the other hand, there may be more coagulation along the incision line.

The differences between SuperPulse and UltraPulse when used with Acublade are only perceptible during surgery. The differences do not affect the postoperative period or the functional results. For the selection of suitable laser parameters (e.g., pulse shape and duration, power output), the reader is referred to selected publications and to Chapters 1, 2, and 6 of this volume.

When treating laryngeal hemangiomas, especially when they are large, the neodymium:yttrium aluminum garnet (Nd:YAG) laser or other fiber-guided lasers with good absorption in the red spectrum, such as potassium titanyl phosphate (KTP) and diode lasers, have the advantage of greater penetration depth in tissue than other lasers, producing deeper coagulation of the hemangioma. Nd:YAG laser emits at 1064 nm. Its frequency is doubled by passing the light through KTP to produce KTP laser, which then emits at 532 nm. The diode laser, made from arsenium and gallium, has a wavelength of 805 nm, which situates it between the CO_2 and Nd:YAG lasers. As a result, the tissue effects of the KTP and diode lasers are altogether different from those of the Nd:YAG laser, mainly regarding the thermal effects. It must be remembered that the thermal diffusion of Nd:YAG is more than 4 mm into the surrounding tissues.

When approached carefully, however, circumscribed hemangiomas can be successfully shrunken by coagulation or excised locally with the CO_2 laser.

Argon lasers can also be used to treat vascular neoplasms owing to the absorption of the light by the red blood pigment. A special laser treatment modality is photodynamic therapy (PDT) (tissue lasing following selective uptake of a photosensitizing agent). The efficacy of PDT has been documented for a number of benign, preneoplastic, and neoplastic mucosal lesions. However, the cost of the procedure and concerns about unpredictable mucosal scarring limit its application in the treatment of benign lesions of the larynx and trachea. PDT is more frequently used for palliative treatment of head and neck cancer no longer treatable by surgery, radiotherapy, and/or chemotherapy. Foscan is presently one of the most used photosensitizing agents.

New wavelengths such as those of thulium or holmium-YAG which are fiber-guided, are presently on trial and are promising for office-based surgery. A hollow fiber transmitting the CO_2 laser is also commercially available. So far only rough ablations or incisions are possible.

Pulse-dye laser (PDL), originally developed to treat skin conditions that involve blood vessels, such as birthmarks, have been used transnasally in the office for treating angiectatic polyps or Reinke's edema. Long-term results are pending.

3.6 Alternatives to Surgical Laser Use

Surgical lasers, particularly CO_2 laser, can be used in various ways to treat benign laryngeal and tracheal lesions.

- Tissue ablation (precise cutting with minimum coagulation for resecting abnormal tissue)
- Coagulation (of blood vessels or highly vascular neoplasms)
- Vaporization (of tissues, as for papilloma removal)
- Induction of photochemical processes (in photodynamic therapy)

Alternative techniques are available for all of these applications and are briefly described below.

3.6.1 Tissue Cutting

Tissue incision and cutting can be accomplished with sharp cutting instruments (knives, scissors)—the essential tools for selective tissue ablation in every surgical discipline. Special small knives and microscissors are available for traditional tissue ablation in the larynx and trachea, but these instruments require expert manual skill and rigorous practice. They are designed to have a long shaft that must be passed down the operating laryngoscope, making them less effective than the scalpels and scissors used during open operations. At the same time, the division of tissues with cutting instruments always involves capillaries and small arterial or venous vessels, leading to diffuse bleeding at the surgical site. Although blood loss in the larynx is not quantitatively significant in itself, the bleeding nevertheless obscures the operative field and makes it difficult to assess the progress of the operation. This type of bleeding is particularly troublesome in the situation of maximum precision microsurgery. Not infrequently, it prevents the surgical precision that is desired from a functional standpoint and prolongs the operating time. The bleeding and the associated obstacles created during the surgery can result in functional failures and persistent, undesired anatomical changes (scars, synechiae). On the other hand, "cold" instruments offer the significant advantage of precise cutting with no thermal damage to surrounding tissues. This makes it easier for the pathologist to evaluate the margins of the excised tissues and eliminates the deleterious effects of collateral thermal damage on wound healing. Moreover, the use of cutting microinstruments in laryngeal surgery does not require the elaborate technical precautions necessitated by laser use. In summary, there is no question that the ability of cold instruments to remove small lesions confined to the mucosa, especially with phonosurgery, is the equal of surgical lasers and is even superior to lasers in some situations. CO_2 laser should be used for phonosurgical ablation of mucosal lesions only by a highly skilled surgeon and only in settings where optimal technical facilities are available.

In addition to conventional instruments, powered instruments (microdebriders, shavers) for use in laryngeal and tracheal surgery have been described recently. These instruments have been widely used in paranasal sinus surgery. Basically, they consist of a motorized blade rotating in a sheath with suction at the tip. Tissue is excised superficially by the rotating blade and simultaneously aspirated out of the sheath. Those advocating this type of instrument for endolaryngeal surgery (especially papilloma removal) have noted that shaver systems require less time for tissue ablation and do not generate a smoke plume. This argument is worth mentioning because human papillomavirus (HPV) DNA has been identified in the plume produced during the CO_2 laser vaporization of respiratory tract papillomas. Its clinical significance is uncertain, however. The difficult healing of "tissue burns" caused by endolaryngeal laser surgery has been cited as another argument for the use of microdebriders. However, bleeding is possible, which can be a factor in the dissemination of HPV.

One fact should be emphasised at this point: Surgical lasers cause burns in the larynx and trachea only if the surgeon is using an outdated device or is not well trained in laser surgery. In other words, burns following laser surgery are the fault of the operator, not of the method. Modern, fully equipped CO_2 laser systems enable the surgeon to divide tissue with absolute precision with a focused beam, without causing clinically significant thermal damage to normal surrounding tissue. Thus, the concern voiced by many authors that lasers cause "burns" is based on observations either from the early days of laser surgery or improper laser use. When all facts are considered, the argument of thermal tissue damage and its implications for wound healing can no longer be taken seriously. Moreover, it is unclear whether motorized instruments used on the fine structures of the vocal cord mucosa pose an equal or even greater risk of inadvertent tissue damage than present-day laser technology. Let us consider an analogy with middle ear surgery: CO_2 lasers have gained an established place in stapes surgery, and today no ear surgeon would think of using shaver systems on the auditory ossicles. At the same time, microdebriders are probably an effective supplement to the surgical armamentarium for the rapid removal of large neoplasms that do not require further histological evaluation.

3.6.2 Coagulation

In addition to surgical lasers (CO_2, KTP, Nd:YAG), electrocautery probes are commonly used to coagulate blood vessels and tissues having a rich blood supply. Before the advent of surgical lasers, electrocautery probes were widely used in endolaryngeal surgery. They were used for cutting (e.g., arytenoidectomy), tissue ablation (suction–coagulation during papilloma removal), and selective cauterization of small blood vessels. Today, classic electrosurgery is more of an adjunct to endolaryngeal laser surgery than a competing modality. It is no longer considered an acceptable tool for most procedures because it causes far more extensive thermal damage and cauterization of specimen margins than the CO_2 laser and cannot be manipulated as precisely as the laser beam. When used as an adjunct to CO_2 laser, electrosurgery is indispensable in all major endolaryngeal procedures because CO_2 laser can only coagulate blood vessels no larger than 0.5 mm. It is unable to coagulate large bleeders, such as those encountered during an arytenoidectomy or endolaryngeal partial laryngectomy, even when applied in the continuous mode with a defocused beam. In these cases, the electrocautery probe is an essential adjunct to the laser for obtaining surgical hemostasis.

Electrosurgery as a stand-alone method has undergone technical refinements in recent years, and these improvements have eliminated some of the inherent disadvantages of electrosurgical procedures. For example, thermal tissue damage can be substantially reduced by irrigating the surgical site with water. Good clinical results have been achieved by applying a continuous stream of noble gas to the tissue to be coagulated (argon beamer, argon plasma coagulation). This technique permits optimum electrocoagulation of the tissue while preventing carbonization. It has become an accepted alternative to laser surgery, particularly for operations on the nose and paranasal sinuses. So far there has been little clinical experience with argon plasma coagulation in laryngeal surgery, but it is entirely conceivable that the method could be effective in treating vascular lesions located away from the vocal folds.

3.6.3 Vaporization

Aside from the argon plasma coagulation systems described above, there is no alternative to CO_2 laser for tissue vaporization.

3.6.4 Photodynamic Therapy

Laser systems have ideal technical properties for inducing desired photochemical reactions in tissue. PDT would not be possible without lasers. The question is which laser system is the most suitable. This question, just as that of choosing the best photosensitizing agent, is a topic of current research and is beyond the scope of this chapter.

3.7 Anesthesia, Perioperative Care, Adjunctive Medical Therapy

Laser surgery can be done under general endotracheal anesthesia and jet ventilation. Endotracheal intubation is generally preferred in operations where there is likely to be heavy bleeding (tumor resection, arytenoidectomy, laryngeal papillomatosis). Special laser-safe tubes should be used to protect against tube combustion and airway fires.

Because theses tubes are expensive, a number of techniques have been introduced to protect the standard tubes by wrapping them with a protective, nonflammable material. One of the earliest and most effective techniques involved wrapping a 12-mm (0.5 in.) aluminum tape (3M, #425) from the cuff to the proximal end of the tube, in a spiral motion. The entire length at risk of exposure, usually 10–12 cm, is covered for total protection. The wrapping starts at the distal end just proximal to the cuff. A tape cut at 60° allows the first spiral to be applied against the cuff. Each spiral overlaps the previous one by a few millimeters so no bare tube is exposed. At the same time, excessive overlapping is avoided as it makes the tube rigid and unyielding. Copper foil tape (Venture) can also be used. When removing the tube, caution must be taken to avoid injuring the vocal folds with the sharp edge of the aluminum foil.

The foil wrapped-tube is introduced orally because endonasal intubation is too traumatic. To permit swift withdrawal of the tube in case of fire, the proximal end of the tube is not taped to the perioral area contrary to customary anesthetic practice. It is usual to use comparatively small size tubes in microsurgery.

The accidental laser impact on the silver aluminum foil does not cause tube ignition. However, the reflective surface of the foil allows unintentional reflection of laser energy onto nontarget tissue, which may result in secondary "ghost burn." It is necessary for the anesthetist to ensure that the wrapping is adequate. It must be noted that handmade wrapping of the tube is no longer approved by the U.S. Food and Drug Administration (FDA).

Some manufacturers produce factory-wrapped tubes, such as Rüsch and Xomed, of much better quality. Merocel Laser-Guard is a self-adhesive silver foil covered with sponge. It increases the outer diameter of the tube by 2 mm. The sponge must be kept constantly saturated with physiological saline: the Laser-Guard ignites if too dry. Another method for protecting the tube is adhesive copper foil overwrapped with fabric that has to be kept saline-soaked (Laser-Trach).

Cuffs are filled with physiological saline tinted with methylene blue. If the beam perforates the cuff, the saline absorbs the laser, and the dye signals the perforation even if minimal. However, care must be taken to protect the cuff throughout surgery with saturated cotton swabs.

Jet ventilation is preferred during operations for airway stenosis and in many phonosurgical procedures as it provides a better view of the glottis and subglottis. Even extensive endolaryngeal procedures can almost always be done without a prior tracheotomy when surgical lasers are used.

The present authors have achieved good results with routine intravenous administration of 250 mg methylprednisolone before endolaryngeal procedures. Antibiotic prophylaxis (e.g., 3 g ampicillin–sulbactam or 600 mg clindamycin i.v.) is also given for more extensive procedures, especially those involving exposure of laryngeal cartilage. Patients generally require postoperative monitoring in an intensive care unit (ICU) following laser surgery for airway stenosis. For all other procedures, ICU monitoring is generally unnecessary from a surgical standpoint.

3.8 Office-Based Laryngeal Procedures

Office-based procedures will increase in the coming years, including biopsies, injections, and lesion removal. The major reasons office procedures are increasing in popularity are based on patient acceptance. When compared with a procedure that is performed under general anesthesia, an office-based procedure is considered less invasive by patients and physicians.

As the aging in developed countries continues, it is anticipated that the elderly and their need for better voice and swallow function will parallel the disease processes that are due to aging, such as presbyphonia and Parkinson's disease. The search by the patient for better function will drive additional procedures to the office. Office-based procedures that are safe and effective will have an increasing role. For most otolaryngologists, laryngeal biopsy or laryngeal injection is laborious, and the time it takes is not compensated adequately. If the surgeon could use the office setting, this would be a more efficient use of time and resources.

Office delivery of drugs, lasers, and instrumentation will improve. The use of chips in scope technology is superior enough that stroboscopy can be accomplished through a flexible laryngoscope. Such technology was not available until recently. A revisit of the procedures that were mastered many years ago is worth it in light of today's technology. Some of the factors for revival of procedures already well known and written about since the 19th century are economic, demographic, and technological.

Selecting appropriate patients should be mentioned first. It is better to err on the side of caution than to spend too much time with an anxiety-ridden patient only to have the procedure fail because of patient reluctance. In this regard, proper information on the procedure, its duration, and the patient's feelings after local anesthesia is helpful. The duration of local anesthetic application is around 15 minutes, and it cannot be hurried. The local anesthetic is applied topically by spray into the oropharynx and the hypopharynx. The topical medication that is used may be 10% lidocaine. It is important to spray during inhalation. This is done twice. If the patient coughs, it must be repeated. The patient is asked to hold his or her own tongue and sit forward in a chin-forward position. A cotton ball is used to paint the tonsils, vallecula, and piriform sinuses. When the cotton ball is inserted in the larynx, it occludes the airway partially. The patient is instructed to cough with the cotton ball in the larynx. This ensures better topical application.

A test palpation of the larynx can be done using a probe or the biopsy forceps. Tolerance to passive palpation should be confirmed before procedures that may require biopsy, laser beam delivery, or injection. For vasoconstriction of the nasal cavity, a decongestive spray is used. In some cases, a topical swab in the nose to obtain adequate decongestion is necessary to pass the scope. Being able to lay the patient flat is helpful if the patient feels faint.

3.9 Complications of Endoscopic Laser Surgery

A number of authors have described complications of endoscopic laser surgery in the larynx, trachea, and hypopharynx. These problems mostly involve combustion of ventilation tube materials and anesthetic gas mixtures during surgical laser use in the larynx. The surgeon should consider the possibility of these complications during each laser operation and take appropriate precautions. Combustion of tube materials can be avoided by the use of laser-safe tubes. Ignition of anesthetic gas mixtures during procedures using jet ventilation can be prevented by ventilating the patient with room air (rather than pure oxygen) and by operating in intermittent apnea. On the whole, such incidents can be safely avoided nowadays by selecting suitable materials, operating methods, and analgesic techniques. Reports of airway fires in the current literature must be viewed more as a result of poorly trained operating room personnel than as inherent risks of laser surgery.

Possible laser-associated complications are less important during endolaryngeal surgery than complications caused by the laryngoscope itself. In a study by one of the authors [5], 75% of 339 consecutive microlaryngoscopy patients were found to have small mucosal lesions of the lips, oral cavity, and oropharynx. These lesions caused significant complaints for some time but resolved without sequelae in a few days. Dental injuries occur in approximately 6% of all patients, but they predominantly affect patients who already have significant carious damage to the teeth, preexisting loose teeth, periodontal disease, or a fixed denture. Patients with healthy dentition did not sustain dental injuries in this study. The nature of the denture injuries ranged from simple loosening and enamel fractures to chipped teeth and complete dental displacement. No laser-associated complications were observed. Microlaryngoscopic procedures may be followed by transient functional impairment of the hypoglossal nerve and lingual nerve. By and large, this type of complication cannot be completely avoided during microlaryngoscopic surgery, but the range of complications is definitely more limited than with open laryngeal surgery. In summary, laser surgery of benign lesions of the larynx, pharynx, and trachea can be considered a minimally invasive surgical approach with a low risk of complications.

3.9.1 Tips and Pearls to Avoid Complications

- Preoperative examination of patient's dental situation allows risk assessment with regard to dental injuries during microlaryngoscopic surgery.
- Different positions of the patient's head should be tried in cases of difficult laryngeal exposure.
- Comprehensive surgical equipment, including a variety of laryngoscopes, CO_2 laser, electrocautery, microscope and rigid endoscopes (0°, 30°, 70°) should be available during laryngeal surgery.
- Endolaryngeal exposition of glottic and subglottic structures is best when jet ventilation is used in place of ventilation tubes.
- Special laser-safe tubes should be used to protect against tube combustion and airway fires.
- Intraoperative administration of 250 mg of methylprednisolone avoids laryngeal edema.

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