Glottic Airway Stenosis

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9

Core Messages

- The larynx forms the narrowest part of the central respiratory tract. As a result, anatomical or neurogenic changes can easily lead to clinically significant airway narrowing.
- Glottic airway stenosis most frequently arises from bilateral vocal cord immobility caused by recurrent laryngeal nerve injury.
- Previous surgery, mostly thyroid surgery, is the most common cause of laryngeal nerve paralysis.
- The diagnostic protocol includes detailed history-taking, inspection, palpation, zoom laryngoscopy and/or transnasal flexible laryngoscopy, thyroid gland workup, stroboscopy, microlaryngoscopy, pharyngoesophagoscopy, tracheobronchoscopy, and suspension laryngoscopy with tactile assessment of arytenoid cartilage mobility. Ultrasonography of the neck, video-fluoroscopy, magnetic resonance imaging studies of the brain, computed tomography scans of the thorax and lateral skull base, and specific laboratory tests should be performed when needed. The flow–volume curve, peak expiratory flow (PEF), peak inspiratory flow (PIF), and total airway resistance are the standard function tests for diagnosing central airway obstruction. PEF and PIF seem to be the best suitable follow-up parameters to assess airway mechanics before and after surgical procedures.
- A variety of endoscopic procedures are available for treatment. The most important ones are arytenoidectomy, cordectomy, posterior cordectomy, temporary lateral fixation of the vocal cord, and definitive lateralization of the vocal.

9.1 Anatomical Background

Because of its dual functions in preventing aspiration and producing speech, the larynx must be able to close the airway temporarily during deglutition. Disturbances of this physiological process can lead to permanent narrowing of the airway lumen. Inflammatory swelling, scarring, movement disorders of the vocal cords, and tumor masses can narrow or obstruct the airway. The larynx forms the narrowest part of the central respiratory tract. As a result, anatomical or neurogenic changes can easily lead to clinically significant airway narrowing. The relative narrowness of the respiratory tract at this level is based on the physiological function of the larynx as a safety valve between the upper respiratory and alimentary tracts. In adults, the airway lumen at the level of the trachea is 300–500 mm^2, the subglottic airway measures approximately 200–300 mm^2. and the glottic airway (with abducted vocal cords) 150–200 mm^2. With bilateral vocal cord paralysis, the glottic airway is reduced to 30–60 mm^2, measuring only some 20–30% of the glottic airway in healthy individuals (Fig. 9.1) [1, 2].

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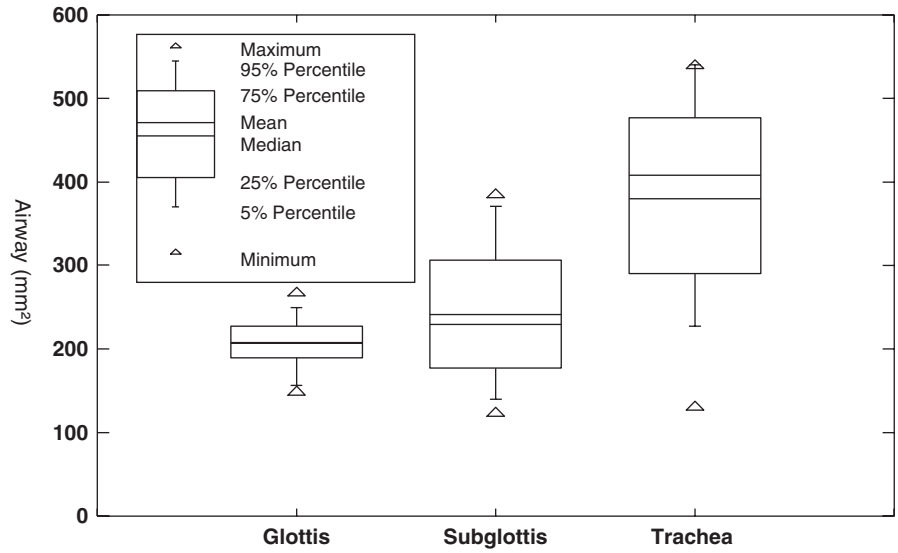

Fig. 9.1. Dimensions of the human central airway in adults (Adapted from Eckel and Sittel [1], with permission)

9.2 Classification

Glottic airway stenosis most frequently arises from bilateral vocal cord immobility caused by recurrent laryngeal nerve injury. Paralysis of the vagus nerve or, more commonly, of the inferior laryngeal nerve most frequently occurs after surgical procedures in the neck (especially in the thyroid gland) and upper mediastinum. It may also be caused by malignant tumors invading the larynx, hypopharynx, esophagus, thyroid, or tracheobronchial tree and other malignant neoplasms in the lower neck or upper mediastinum. Neurogenic laryngeal stenosis may also develop during the course of viral inflammation or as a result of central nervous system processes (cerebral or skull-base tumors, injuries, surgical procedures on the lateral skull base). The recognition of concomitant superior laryngeal nerve paralysis on one side is important because it may be relevant for planning surgical measures (especially arytenoidectomy) that could result in increased aspiration [3].

Previous surgery, mostly thyroid surgery, is the most common cause of laryngeal nerve paralysis (Table 9.1). Revision thyroidectomy bears a particularly high risk for inferior and superior laryngeal nerve trauma. The rate of immediate postoperative unilateral recurrent laryngeal nerve paresis following primary thyroid surgery for benign disease is approximately 2–7%; the rate of permanent paralysis has been reported to be 0.5–4.0%. During revision surgery and operations for malignant conditions of the thyroid gland, unilateral recurrent laryngeal nerve paresis occurs in some 10–20% of all interventions. Bilateral vocal fold paralysis is obviously seen far less frequently. Surgery of the cervical spine via an anterior approach and surgery of the larynx, pharynx, cervical esophagus, upper mediastinum, and carotid artery surgery can typically result in laryngeal nerve or even vagus nerve injury. Other conditions causing laryngeal nerve palsies include the following.

- Lesions of the brain stem
- Neurovascular disorders (stroke) and other central nervous system disorders
- Demyelinating disorders of the peripheral nervous system (Guillain-Barré syndrome)
- Lateral skull base lesions (trauma, tumor)
- Sequel of skull base surgery
- Cervical spine injury or surgery
- Degenerative motor unit disorders (e.g., amyotrophic lateral sclerosis)
- Infectious diseases of the affected nerves
- Neurotoxins (e.g., lead)
- Primary neurogenic tumors (e.g., schwannoma)
- Malignant tumors of the thyroid, larynx, pharynx, trachea, esophagus, bronchus, thymus, neck, and mediastinum
- Traumatic lesions of the neck
- Aortic aneurysm

Bilateral recurrent nerve paralysis frequently leads to functional glottic stenosis, with the vocal folds in a fixed paramedian position. The predominant symptom

Table 9.1. Etiology of bilateral vocal cord immobility in 218 patients

	Bilateral vocal cord paralysis	Bilateral arytenoid cartilage fixation	Total
Previous surgery	**154 (82.8%)**	**1 (3.1%)**	**155 (71.1%)**
Thyroid surgery (revision surgery)	141 (75.8%)	0	141 (91.0%)
Thyroid surgery (primary intervention)	4 (2.2%)	0	4 (2.6%)
Esophageal surgery	4 (2.2%)	0	4 (2.6%)
Other surgery	5 (2.7%)	1 (100%)	6 (3.8%)
Long-term intubation (> 24 hours)	**0**	**22 (68.8%)**	**22 (10.1%)**
Malignant tumors	**16 (8.6%)**	**0**	**16 (7.3%)**
Esophageal carcinoma	9 (56.2%)	0	9 (56.2)
Bronchogenic carcinoma	4 (25.0%)	0	4 (25.0%)
Other	3 (18.8%)	0	3 (18.8%)
Short term intubation	**5 (2.7%)**	**3 (9.4%)**	**8 (3.7%)**
Neurogenic	**7 (3.8%)**	**0**	**7 (3.2%)**
Wegener's granulomatosis	**0**	**3 (9.4%)**	**3 (1.4%)**
Rheumatoid arthritis	**0**	**2 (6.2%)**	**2 (0.9%)**
Caustic ingestion	**0**	**1 (3.1%)**	**1 (0.5%)**
Other/unknown	**4 (2.2%)**	**0**	**4 (1.8%)**
Total	**186 (100%)**	**32 (100%)**	**218 (100%)**

Modified from Eckel et al. [3], with permission

is airway compromise. It ranges from unnoticeable to mild dyspnea to inspiratory stridor and respiratory distress, even without physical effort. Acute airway obstruction resulting from bilateral vocal fold immobility (e.g., following thyroidectomy) frequently requires immediate surgical or medical intervention (e.g., tracheotomy) to maintain an adequate airway and prevent acute asphyxiation or pulmonary consequences of chronic central airway obstruction. In contrast to unilateral vocal cord paralysis, voice quality is not the primary concern in these patients. Voice quality is usually only mildly affected (if just the recurrent laryngeal nerves are involved). For idiopathic palsies, a less than 50% rate of partial and complete recovery can be expected [4].

Congenital malformations, including aerodynamically relevant synechiae of the ligamentous glottis and laryngeal atresia, are rare.

Inflammatory laryngeal stenosis is rare in adults (exceptions: epiglottitis and glottic stenosis due to severe Reinke's edema) but is a frequent and dreaded condition in children [5]. Acute infections of the larynx and trachea are particularly ominous in children owing to the small size of their airways [6]. Swelling of the mucosa or an accumulation of tracheal secretions can cause considerably greater obstruction of the anatomically smaller airways than that in adult patients. Acute obstructive airway inflammation in children is seen in a heterogeneous group of infectious diseases with a common presentation marked by a typical barking cough (croup), inspiratory stridor, hoarseness, and airway obstruction. Generally, these cases are managed by endoscopy, endolaryngeal intubation, or tracheotomy, specific high-dose antibiotic therapy, or intensive care of the affected child. Further surgical measures are not required.

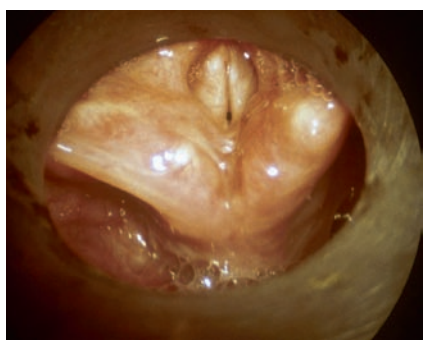

Fig. 9.2. Arytenoid cartilage fixation. Both arytenoid cartilages are fixed and cannot be abducted passively during microlaryngoscopy

The most common laryngeal injuries, which generally resolve spontaneously, are caused by intubation. Long-term intubation can cause permanent trauma-related changes in the larynx, particularly interarytenoid synechiae and arytenoid cartilage fixation (Fig. 9.2–9.4). With the latter condition, the arytenoid cartilage is fixed

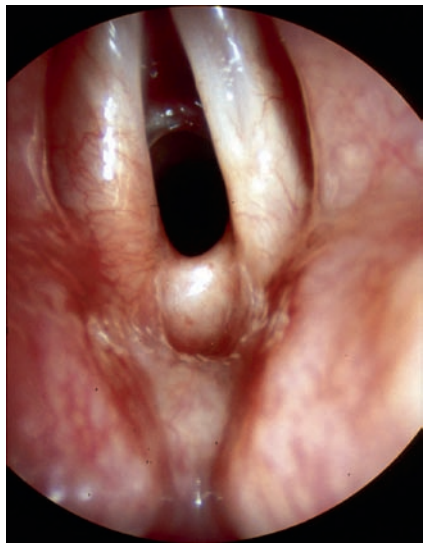

Fig. 9.3. Interarytenoid scarring following long-term intubation, causing paramedian immobility of the vocal cords

Fig. 9.4. Posterior synechia following intubation, causing paramedian immobility of the vocal cords

in the cricoarytenoid joint, causing vocal cord immobility. Some of these cases are clinically indistinguishable from recurrent nerve paralysis, but the correct diagnosis is suggested by the history, passive mobility of the arytenoid cartilage during microlaryngoscopic examination under anesthesia, and electromyography to record summation action potentials from the muscle groups supplied by the inferior laryngeal nerve [4, 7]. In patients with bilateral immobility of the vocal cords, bilateral recurrent laryngeal nerve paralysis is usually suspected, but various causes of arytenoid cartilage fixation may produce a clinical image that is indiscernible from recurrent laryngeal nerve paralysis during routine office laryngoscopy or videostroboscopy. Impaired movement of the cricoarytenoid cartilage with immobility of the vocal cord and airway obstruction may occur as a consequence of disorders of the cricoarytenoid articulation, interarytenoid fibrous adhesion, or both. Immobility of the cricoarytenoid joint may arise from arytenoid cartilage dislocation during laryngotracheal intubation and consequent ankylosis, arthritis, or tumorous infiltration of laryngeal or hypopharyngeal carcinoma. Interarytenoid fibrous adhesion most commonly results from prolonged or traumatic endotracheal intubation. The tube causes a decubitus with chondritis and consequent scar tissue formation involving the arytenoid cartilages and the interarytenoid area resulting in severe impairment of both cricoarytenoid joints' motility and laryngeal stenosis. Table 9.1 gives the frequency of various etiological factors in recurrent nerve paralysis and arytenoid cartilage fixation.

Benign or malignant tumours (laryngeal or tracheal carcinoma, esophageal carcinoma invading the cervical trachea, central bronchial carcinoma, locally advanced thyroid carcinoma, malignant tumours of the upper mediastinum) occasionally lead to malignant central airway stenosis. This type of stenosis may be caused by extrinsic airway compression, tumor invasion of the tracheal wall with subsequent malacia, or intraluminal tumor growth in the trachea and larynx. Tumor infiltration of the recurrent nerve with subsequent vocal cord paralysis in a paramedian position can also lead to functional airway stenosis. In all of these situations, endolaryngeal surgery with CO_2 laser (or occasionally Nd:YAG laser for larger tumor masses) provides an excellent tool for airway recanalization. The enlarged airway can be maintained in the intermediate term by implanting stents in the carina, thoracic trachea, and cervical trachea as far as the laryngotracheal junction [8, 9].

9.3 Diagnostic Procedures and Preoperative Assessment

In most patients presenting with glottic airway stenosis, the underlying condition is obvious from the patient's

history (e.g., recurrent laryngeal nerve paresis following thyroidectomy). In patients with unclear etiology of the underlying condition, a complete diagnostic workup is compulsory. The diagnostic protocol for these patients includes detailed history taking (particularly regarding previous surgery), inspection, palpation, zoom laryngoscopy and/or transnasal flexible laryngoscopy, thyroid gland workup, stroboscopy, microlaryngoscopy, pharyngoesophagoscopy, tracheobronchoscopy, and suspension laryngoscopy with tactile assessment of arytenoid cartilage mobility. Ultrasonography of the neck, video-fluoroscopy, magnetic resonance imaging (MRI) studies of the brain, computed tomography (CT) scans of the thorax and lateral skull base, and specific laboratory tests should be conducted if needed [7]. Pulmonary function tests should be obtained to clarify the resulting airway compromise. The flow-volume curve, peak expiratory flow (PEF), peak inspiratory flow (PIF), and total airway resistance are the standard function tests for diagnosing central airway obstruction. Among all conventional lung function values, PEF and to a certain degree PIF seem to be the most suitable follow-up parameters to assess airway mechanics before and after surgical/endoscopic procedures [10–13].

Upper airway stenosis involving surface areas of no more than 50 mm^2 can be overcome using adequate respiratory compensation, but any narrowing beyond this limit results in hypoventilation, inappropriate oxygen uptake, and retention of CO_2. Experimental evidence indicates that laryngotracheal obstruction within a critical range of < 50 mm^2 surface area compromises respiratory efforts enough to be of clinical importance [12–14]. Glottic stenosis alters the flow–volume curve by causing increased airway resistance, turbulence (at high flow rates), and a decrease in luminal cross section. Unlike an anatomically fixed cicatricial stenosis of the subglottis or trachea, the airway stenosis associated with bilateral recurrent nerve paralysis is characterized by passive abduction of the vocal cords during expiration and adduction (medialization) of the cords through a suction effect (Bernoulli) during inspiration. This produces a characteristic curve with extreme inspiratory flattening, often accompanied by an essentially normal expiratory pattern.

Voice analysis should be done prior to airway-restoring surgery. Laryngeal electromyography may be helpful for assessing the prognosis in patients with vocal cord paresis.

9.4 Indications for Surgery

Surgical correction is not appropriate for every central airway stenosis. The need for surgery depends in part on whether the stenosis is acute or chronic, the resulting adaptation of the respiratory muscles to the increased central airway resistance (conditioning), and especially the degree to which the respiratory compromise restricts normal levels of physical activity. Studies by the author indicate that an inspiratory resistance of more than 2.5 kPa × s/L is a good empirical cutoff point for selecting patients who require surgical correction [12–14]. Ultimately, however, the decision to operate depends on the level of physical exertion at which the patient can still compensate for the stenosis through increased respiration.

Acute bilateral recurrent nerve paralysis generally presents as severe inspiratory airway obstruction with inspiratory stridor. Occasionally, tracheotomy is required to overcome airway distress.

Once the acute respiratory compromise caused by bilateral recurrent nerve paralysis of recent onset has been overcome, most patients can breathe well at rest and during mild physical exertion. High-dose intravenous steroids are used during the early phase of this disorder. Once the patient has adjusted to the glottic narrowing, mild physical training should be encouraged to adapt the thoracic muscles to overcome increase inspiratory airway resistance. Upper airway stenosis involving surface areas of no more than 50 mm^2 can be overcome using adequate respiratory compensation, but any narrowing beyond this limit results in hypoventilation, inappropriate oxygen uptake, and retention of CO_2.

Conservative treatment for airway improvement in bilateral vocal cord paralysis includes the following.

- Nasotracheal intubation for acute airway distress due to bilateral vocal cord paralysis is not recommended, or only for a very short term so long as the patient is in an institution where immediate reversible lateralization can be performed after extubation in the operating theater and introducing jet-anesthesia for glottis-dilating surgery.
- High-dose intravenous steroids and nonsteroidal antiphlogistics.
- Antiviral or antibiotic agents if an infection is suspected.
- Mild physical training once the patient has adjusted to the glottic narrowing.

The indication for glottis-expanding surgery is mainly based on the following conditions.

- Inspiratory stridor at rest and/or inspiratory resistance of more than 2.5 kPa × s/L
- A lack of exercise tolerance
- Potential risk to the patient from sporadic respiratory inflammations (flu-like infections) that may cause swelling of the already-tight glottis

So long as the degree of respiratory compromise is acceptable to the patient at rest and during mild exercise, it is reasonable to wait for approximately 9 months after the onset of paralysis to watch for spontaneous recovery of nerve function.

Occasionally, the prognosis of recurrent nerve paralysis can be based on the clinical situation, as in the case of a thyroidectomy for thyroid carcinoma in which a recurrent nerve had to be deliberately sacrificed. It is rarely possible, however, to make such a confident prognosis based on clinical status alone. Electromyography is useful for making a prognostic assessment, although it cannot be done with certainty in patients with neurapraxic paralysis [4, 15, 16]. A confident prognosis can be made only by waiting and watching for the return of normal vocal cord mobility over a period of 6–9 (up to 12) months. It should be noted that in patients with bilateral paralysis the prognosis may be different for each of the affected sides. It is not unusual for the paralysis on one side to regress over time whereas that on the opposite side persists indefinitely. Once the acute respiratory compromise caused by bilateral recurrent nerve paralysis of recent onset has been overcome by adaptation of the respiratory muscles, most patients can breathe well at rest and during mild physical exertion.

Bilateral recurrent nerve paralysis must be differentiated mainly from arytenoid cartilage fixation (rare cases may also involve paralysis on one side and cartilage fixation on the other) [3]. Ankylosis of the arytenoid cartilage or fibrosis of the connective tissue capsule of the cricoarytenoid joint most commonly develops as a result of previous intubation. Therefore, it is difficult to differentiate cartilage fixation (ankylosis) from paralysis based on the history alone. Accordingly, arytenoid cartilage fixation or posttraumatic fibrosis of the joint capsule should be considered in each patient who presents with limited vocal cord motion and a prior history of intubation. Mechanical restriction of joint motion can be differentiated from paralysis by means of laryngeal electromyography and also by testing the passive mobility of the arytenoid cartilage during microlaryngoscopic examination of the larynx under general anesthesia. It is important to distinguish between paralysis and ankylosis because treatment options are not the same for these two disorders.

Apart from paralysis or arytenoid cartilage fixation, glottic stenoses are occasionally caused by congenital malformations (webs), synechiae (postoperative or postinflammatory), or tumors. Synechiae can be divided by laser surgery. In patients with synechiae of the anterior commissure, the intervention should include insertion of a keel and, if necessary, a free mucosal graft, but even then the vocal results are usually unsatisfactory.

9.5 Surgical Procedures

Whereas extralaryngeal surgical procedures (lateral fixation with its numerous variants) were once the standard treatment for bilateral vocal cord paralysis, endoscopic techniques have advanced considerably since the advent of endolaryngeal laser surgery. Today, endoscopic procedures have largely replaced open laryngeal surgery in the treatment of this disorder.

- Arytenoidectomy [15, 17–19] is highly effective for expanding the airway if the surgeon can completely remove the arytenoid cartilage and completely divide the conus elasticus as far as the cricoid cartilage. Even partial arytenoidectomy is believed to provide satisfactory airway enlargement. The disadvantages of this technique include frequent transient aspiration, the risk of cricoid chondritis and necrosis in patients who have previously had radiation to the neck, scarring, and granuloma formation.
- Cordectomy [17] is as effective as arytenoidectomy for airway restoration. However the resected vocal cord is eventually replaced by scar tissue, similarly to that seen after cordectomy performed for removal of vocal cord carcinoma. There is no risk of aspiration with this procedure, but the voice may more severely deteriorate compared to that after arytenoidectomy.
- The procedure is carried out with a surgical CO_2 laser coupled to an operating microscope with a 400-mm objective lens. The laser is set to an output power of 4 W in the continuous beam delivery mode at a spot size of approximately 0.8 mm^2. Patients are usually intubated transorally for surgery. Following transsection of the vocal process of the arytenoid cartilage, the vocal ligament, vocalis muscle, and much of the

lateral thyroarytenoid muscle are resected. The most anterior portion of the vocal cord, however, is not included in the resection, as its removal would contribute little to the desired airway enlargement.

- Posterior cordectomy [20, 21], in which the vocal cord is divided in the area of the vocal process of the arytenoid cartilage combined with division of the conus elasticus, is considered by many laryngologists to be the best compromise between expanding the airway and preserving voice quality (Fig. 9.5a, b).
- Temporary lateral fixation of the vocal cord as described by Lichtenberger [15, 22–24] is the only potentially reversible procedure for glottic airway enlargement (Fig. 9.6a–e). It is indicated if the vocal

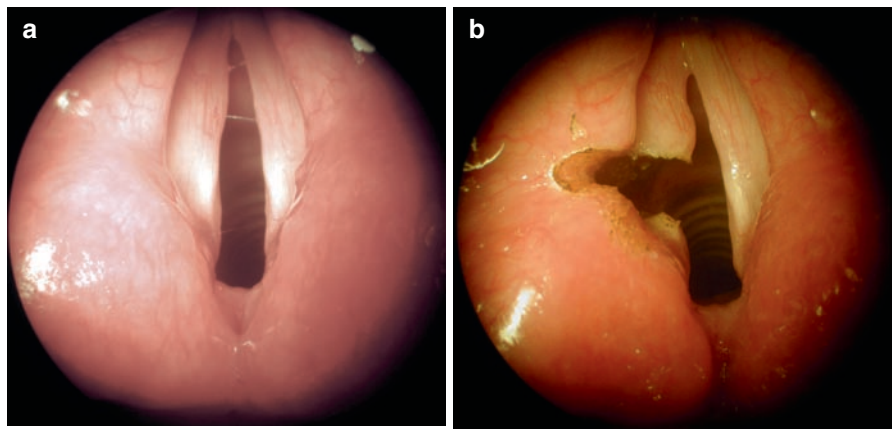

Fig. 9.5. Bilateral vocal cord paralysis. View during microlaryngoscopy before (**a**) and after (**b**) posterior cordectomy

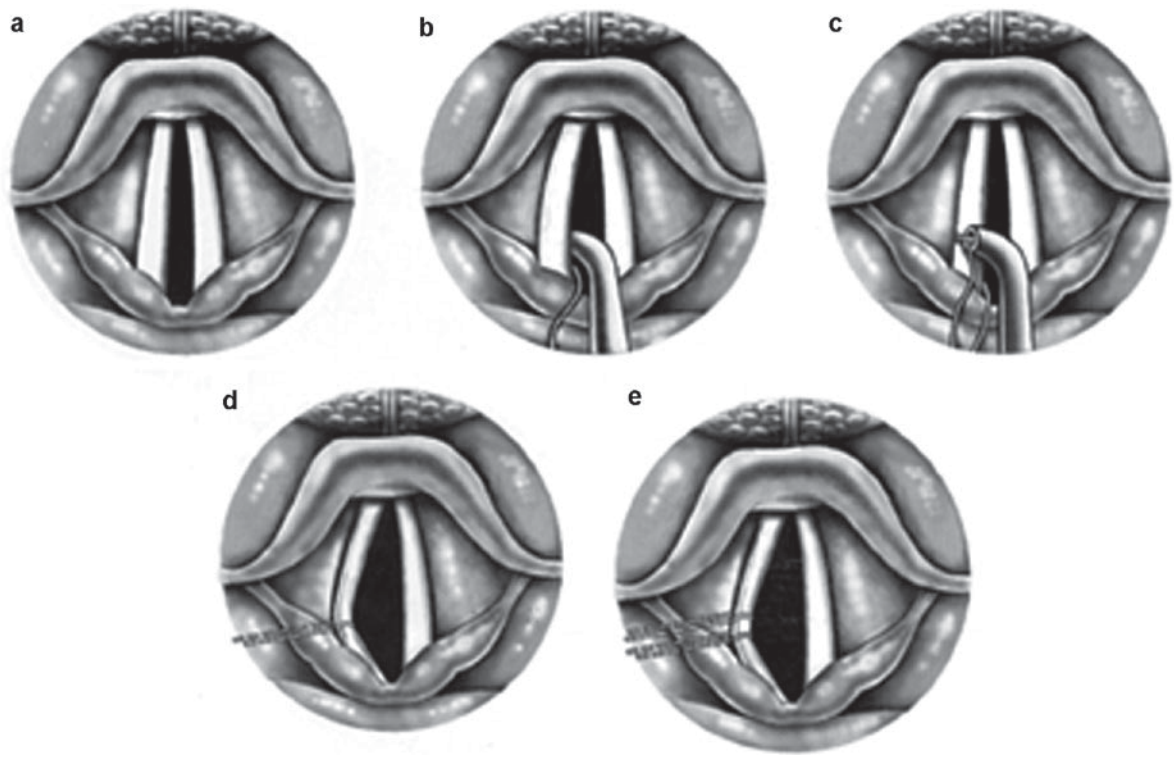

Fig. 9.6. Temporary lateral fixation of the vocal cord as described by Lichtenberger. (**a**) Paralyzed vocal cords. (**b**) One end of the lateral fixation suture was pushed through the larynx below the posterior third of the vocal cord. (**c**) The other end of the lateral fixation suture was pushed through the larynx above the posterior third of the vocal cord. (**d**) The ends of the fixation suture were pulled and knotted over a small silicone sheet placed on the thyroid cartilage or on the sternohyoid muscle. (**e**) The second lateral fixation suture was placed in a similar fashion 1–2 mm anterior to the first suture

cords are in a paramedian position, functional recovery of at least one vocal cord is anticipated, and there is no scar formation in the lumen of the larynx. It can be performed correctly only with jet anesthesia or apnea. Once recurrent nerve function has recovered, the endoscopically performed lateral fixation of the vocal cord can be reversed.

- To achieve laterofixation of one vocal cord, fixation sutures are placed through the larynx with the help of the endoextralaryngeal needle carrier. The skin is cut in the same line as the previous incision for thyroidectomy. Only the skin and platysma flap are identified and retracted. The laryngoscope is then introduced. The paralyzed vocal cords are brought into the field of vision (Fig. 9.6a). One end of the lateral fixation suture is pushed through the larynx below the posterior third of the vocal cord (Fig. 9.6b). A similar stitch is made, this time above the posterior third of the vocal cord (Fig. 9.6c). The ends of the fixation suture are pulled and knotted over a small silicone sheet placed on the thyroid cartilage or on the sternohyoid muscles (Fig. 9.6d). Formerly, we used the silicone sheet only if the sternohyoid muscle had been damaged during thyroid surgery. The second lateral fixation suture is placed in a similar fashion 1–2 mm anterior to the first suture (Fig. 9.6e). The knotted suture over the sternohyoid muscle is then left subcutaneously, and the wound is closed. As a surgical alternative, the assistant surgeon can make an approximately 10 mm long incision between the two ends of the thread, which were pushed through the larynx and neck skin; then, both ends are pulled back under the skin and tied above the prelaryngeal muscles. Finally, the skin incision is closed with sutures. The patients are discharged from the hospital within a few days when it is thought that the airway is stable.
- Definitive lateralization of the vocal cord as described by Lichtenberger (partial laser arytenoidectomy with submucosal cordectomy covering the defect with the spared mucosa of the arytenoid and vocal cord using endoextralaryngeal suture technique) [22, 24–26] (Fig. 9.7a–f). This operation is indicated if the vocal cords are in a paramedian position and there is no chance for recovery. This operation also can be performed without tracheostomy with Jet ventilation during surgery. A triangular incision is made laryngoscopically under microscopic magnification with a microscalpel and scissors or with laser. The incision begins a few millimeters in front of the vocal process and extends posteriorly over the vocal process 1.0–1.5 mm from the edge of the vocal cord to the area above the arytenoid cartilage. Another incision is made from the vocal process to the muscular process of the arytenoid. The two incisions are then connected with a transverse incision at the height of the muscular process (Fig. 9.7a). The arytenoid cartilage is dissected and removed, usually only partially. A submucous cordectomy is performed on the thyroarytenoid muscle as previously described, again sparing the mucous membrane (Fig. 9.7b). The suture then is fixed again in the neck as described for the previous procedure (Fig. 9.7c–f).

As a rule, modern endoscopic laser operations to expand the glottis are considered reliable techniques for airway restoration. Generally, they can be performed without a temporary tracheotomy, making them easier for patients to tolerate. However, any surgical widening of the glottis trades voice for airway. Therefore, a compromise must be found between retaining voice quality and restoring an adequate airway. These considerations should be discussed with the patient preoperatively to weigh the physical activity needs of the patient against anticipated voice deterioration and strive for a compromise that is best for the individual situation, although the phonatory outcome of a glottis-expanding operation cannot be predicted accurately.

Additional sites of stenosis are more frequently identified in patients with glottic stenosis due to arytenoid cartilage fixation. Although stenosis due to recurrent laryngeal nerve paralysis can be managed endoscopically without a preliminary tracheotomy, patients with arytenoid cartilage fixation frequently require total arytenoidectomy or open surgery with a temporary tracheotomy [3, 27].

9.6 Postoperative Care

Extubation is usually performed 30–60 minutes after the end of the intervention, and patients are observed for 4–24 hours in an intensive or intermediate care unit after extubation. Patients are usually kept in hospital for 3–5 days after surgery. With procedures exposing the cartilaginous structures of the larynx, preoperative antibiotic prophylaxis is indicated to prevent wound infection. Antibiotics should be given 30 minutes before surgery.

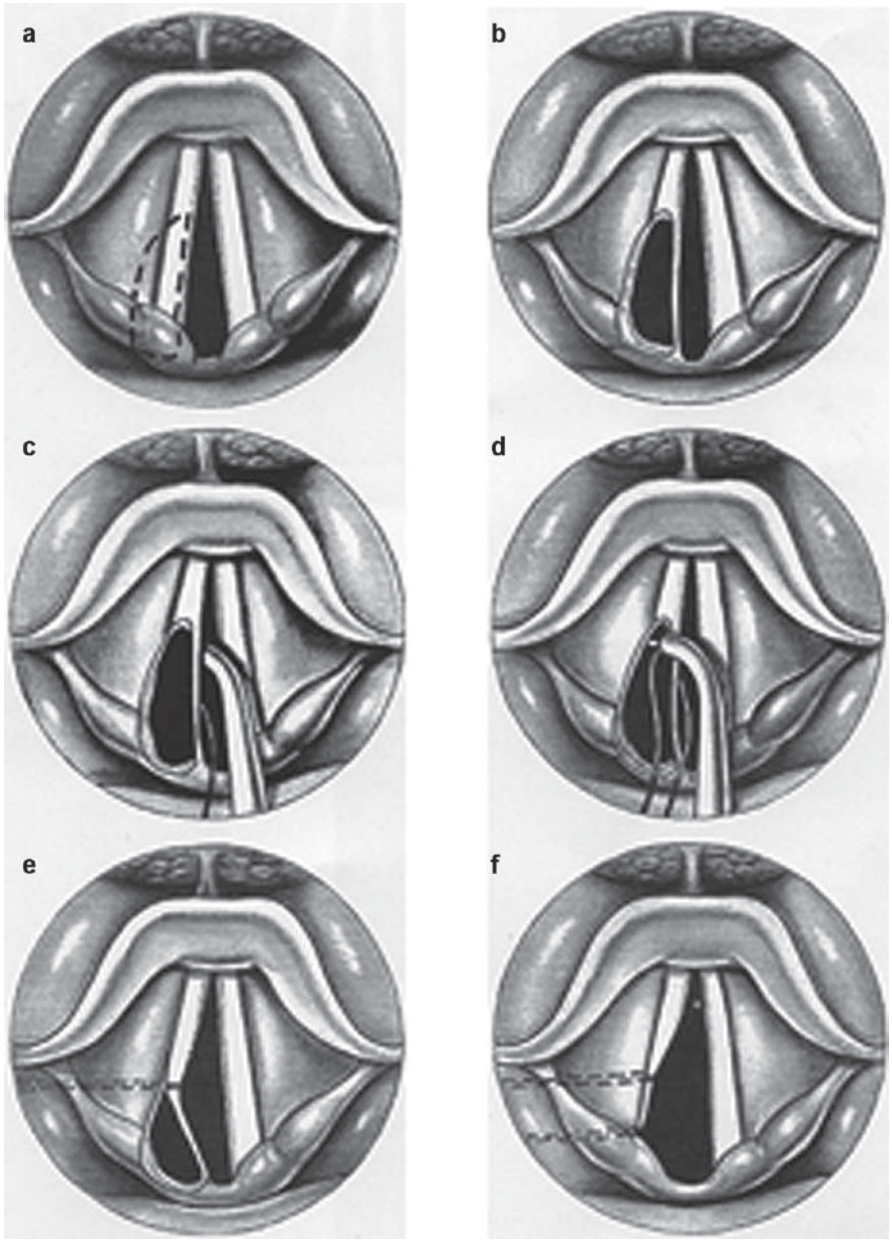

Fig. 9.7. Definitive vocal cord lateralization as described by Lichtenberger. (**a**) Triangular incision using CO_2 laser with microscopic magnification. (**b**) The arytenoid cartilage and the medial and lateral thyroarytenoid muscles were removed endoscopically, preserving the medial mucous membrane part of the vocal cord. (**c**) One end of the thread was pushed through the larynx with the help of the needle carrier below the posterior third of the residual vocal cord. (**d**) The other end of the thread was pushed through the larynx above the posterior third of the residual vocal cord. (**e**) The ends of the thread were pulled. (**f**) The ends of both threads were pulled

The agents of choice are first- or second-generation cephalosporins, a combination of penicillins and penicillinase inhibitors, or clindamycin. The efficacy of steroids is a controversial issue. High steroid doses (e.g., 250 mg methylprednisolone) during the immediate postoperative period have a number of beneficial effects, most notably the prevention of surgery-related tissue swelling and reduced surgical trauma. Occasionally, steroids are given for a prolonged period after surgery to prevent new connective tissue formation and undesired

new scarring. It is the authors' opinion, however, that this therapy is of uncertain benefit. Delaying or reducing new connective tissue formation ultimately means a delay in wound healing. The authors do not routinely prescribe steroids during the initial days after surgical correction of airway stenoses. Recently, several reports have been published on the local application of mitomycin C for the prevention and treatment of undesired scarring of the larynx and trachea. Mitomycin C is an antibiotic first isolated from *Streptomyces caespitosus* in 1958. It inhibits DNA synthesis due to alkylation and is a potent inhibitor of connective tissue formation. Mitomycin C is an effective antineoplastic cytostatic drug that is used systemically and locally for the treatment of carcinoma at various sites. High local concentrations and low plasma levels are achieved following local application. In laryngology, the use of this agent has been described following endoscopic laser treatment of airway stenosis and after open operations to reduce granuloma and scar formation but with very different effects [28].

9.6.1 Tips and Pearls to Avoid Complications

- Before a final decision is made regarding the type of surgery for the individual patient, a comprehensive endoscopic evaluation of the airway, including tracheobronchoscopy with flexible endoscopes, should be undertaken.
- Temporary tracheotomy can usually be avoided in patients undergoing endoscopic airway surgery for glottic stenosis. However, all patients must be informed that tracheotomy may become necessary during or shortly after surgery.
- Patients should receive 250 mg of methylprednisolone prior to surgery and during the first days thereafter. Antibiotic prophylaxis is recommended.
- Patients should be extubated immediately after surgery and need to be monitored at an intermediate care or intensive care unit for one night.
- In patients with a history of previous radiotherapy to the neck, there is considerable risk for chondritis, chondronecrosis, and severe laryngeal edema.
- The endoextralaryngeal needle carrier is mandatory for temporary end definitive endoscopic laterofixation.

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