Chapter

33 Laryngotracheal Reconstruction Surgery

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A six-year-old female, born at 26 weeks' gestation, presents for an aero-digestive evaluation (bronchoscopy, laryngoscopy, esophagoscopy) as part of her presurgical evaluation prior to laryngotracheal reconstruction (LTR).

At present, she is tracheostomy-dependent due to severe, grade 3 subglottic stenosis.

Medications include: albuterol by nebulizer and ranitidine.

She has a 4.0 uncuffed tracheostomy tube in place with a heat and moisture exchanger (HME).

What Are the Most Common Indications for Which Laryngotracheal Reconstruction (LTR) Is Performed?

An LTR is performed in cases of acquired or congenital subglottic stenosis.

What Is Subglottic Stenosis (SGS)?

Subglottic stenosis is narrowing of the airway between the lower border of the cricoid cartilage and extending up to below the vocal folds (Figure 33.1).

The most rigid and unyielding part of the airway is the cricoid cartilage.

What Are the Causes of Acquired SGS?

Trauma to the subglottis is the primary cause of acquired subglottic stenosis (SGS), most commonly resulting from prolonged or traumatic endotracheal intubation.

Prolonged intubation or intubation with an oversized tube or overinflated endotracheal cuff increases the risk of developing SGS, especially in the presence of underlying congenital anomalies.

Risk of developing SGS is increased in the presence of inflammatory conditions, such as persistent gastroesophageal reflux.

The incidence of SGS in intubated neonates is reported to be 0–2% although most neonates can tolerate long periods of intubation without injury to the subglottis (in stark contrast to adults).

What Are the Causes of Congenital SGS?

Congenital subglottic stenosis is a rare birth defect due to incomplete recanalization of the laryngotracheal tube during gestation and is frequently associated with other congenital head and neck lesions and syndromes including: 22q11 deletion, Down syndrome, and CHARGE syndrome.

What Are the Symptoms and Signs of SGS?

Signs of SGS include "noisy breathing" or stridor, respiratory distress, history of recurrent croup, and exercise intolerance. Stridor in SGS is biphasic because of fixed narrowing of the extra-thoracic airway. This is in contrast to inspiratory stridor, characteristic of supraglottic pathology, and expiratory stridor, characteristic of intrathoracic pathology.

What Is the Myer–Cotton Grading Scale for Determination of Severity of SGS?

The stenosis is based on age-appropriate airway size and degree of narrowing.

Mild stenoses (grades 1 and 2) are usually managed nonoperatively, whereas more severe stenoses (grades 3 and 4) often require surgical intervention (Figure 33.2).

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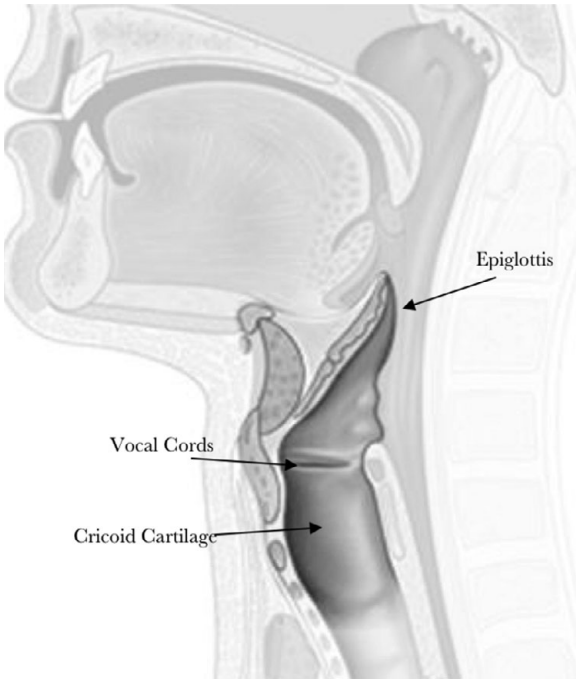

Figure 33.1 Schematic demonstrating the relationship between the vocal cords and cricoid cartilage

How Is the Airway Size Determined?

The airway is sized during suspension laryngoscopy. Under direct vision, the otolaryngologist places an uncuffed endotracheal tube through the vocal cords. A leak test is performed during which the insufflation is maintained at increasing pressures (e.g. 5, 10, 15 c H_2O) until a leak is visible under direct vision. The outer diameter of the uncuffed endotracheal tube determines the airway size. The largest tube that can be placed with an air leak less than 20 cm of water is recorded for staging.

What Is the Work-Up for SGS and Presurgical Planning?

A detailed history and physical exam is performed along with an assessment of voice quality.

A neck radiograph may demonstrate subglottic narrowing or masses (secondary stenosis which requires alternative treatment) and a CT scan may show complete tracheal rings (Figure 33.3).

Feeding abnormalities are evaluated and if there is suspicion of aspiration, a swallow evaluation is performed by a speech pathologist.

A comprehensive aero-digestive evaluation is performed during presurgical work up and planning.

The decision regarding whether or not to perform tracheal reconstruction is based on the degree of stenosis, the associated symptoms, and on the comorbidities. Children with a high risk for aspiration, severe tracheomalacia, or need for chronic ventilatory support are not good surgical candidates.

Preoperative diagnosis and treatment of conditions causing laryngeal inflammation, such as gastroesophageal reflux, eosinophilic esophagitis (EOE) or infection, is crucial as laryngeal inflammation affords a greater procedural failure rate.

During the evaluation, the otolaryngologist performs direct laryngoscopy and bronchoscopy to evaluate the degree of stenosis, as described above. A gastroenterologist performs an upper endoscopy with biopsy to screen for signs of inflammation suggestive of gastric reflux or EOE. Finally, a pulmonologist evaluates the lung status with flexible bronchoscopy and bronchial alveolar lavage.

The patient is considered suitable for airway surgery when the stenosis has matured (grade of stenosis is stable over time), there is no active inflammation, and ventilatory support is not needed.

What Is the Treatment for Mild SGS (Grade 1 and 2)?

Some cases of mild stenosis may be observed without intervention. Symptomatic but mild cases may need endoscopic treatment. A sickle knife can be used to divide thin tracheal webs. The stenosis is then dilated with a balloon. Lasers and micro-debriders are also sometimes used to remove scar tissue. Serial dilations, repeated at one- to three-week intervals, may be necessary. Children with thin, web-like, and soft stenosis consisting of immature scar tissue are likely to respond well to balloon dilation. Patients with mature, firm scars or cartilaginous narrowing are less likely to improve with conservative interventions.

What Is the Treatment for Severe Cases of SGS (Grade 3 and 4)?

Most patients with severe subglottic stenosis require a tracheostomy as the proximal airway is too narrow to accommodate the required flow. Speech therapy is often not tolerated as the airway doesn't provide sufficient flow to allow for the use of speaking valves or intermittent

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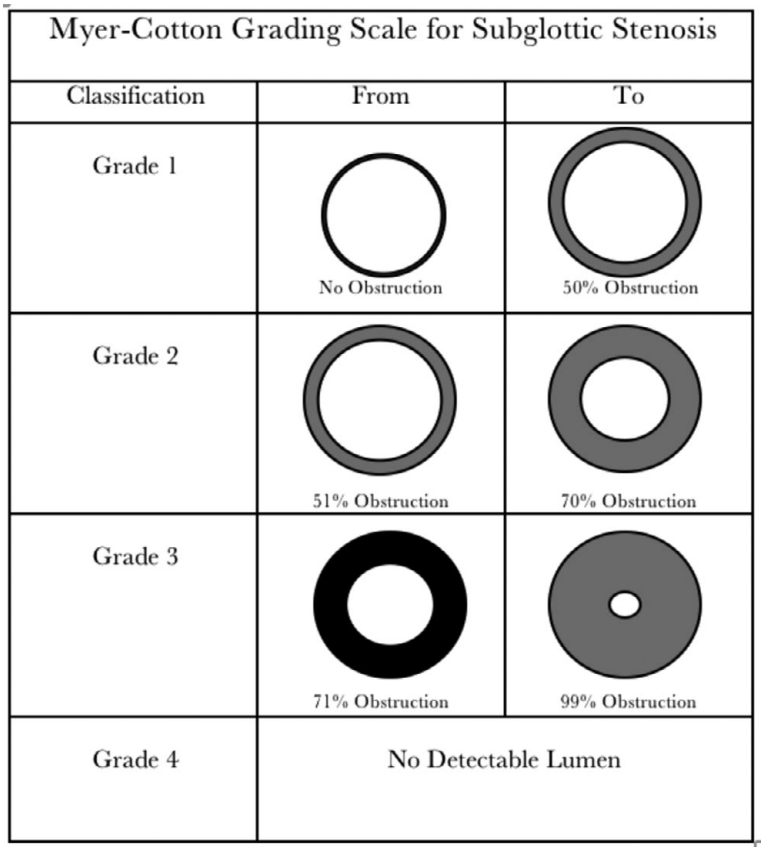

Figure 33.2 Myer–Cotton grading system for degree of subglottic stenosis

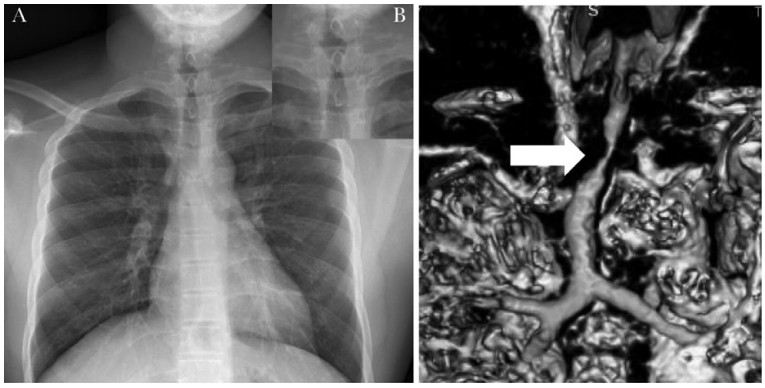

Figure 33.3 Radiographic appearance of severe tracheal narrowing by chest X-ray (A) with enlargement (B) (left) and CT 3D reconstruction of severe tracheal narrowing (white arrow) (right)

capping. Open surgical repair is often required to repair the stenosis and allow for tracheostomy decannulation. Decannulation rates after LTR are near 90%.

Laryngotracheal reconstruction can be performed as either a single or dual staged procedure. In both cases, a graft, usually costal cartilage, is inserted into the anterior and sometimes posterior tracheal wall to increase the diameter (Figure 33.4). In the single stage procedure, the tracheostomy tube is removed at the time of surgery. The patient remains intubated and sedated in the ICU for about seven days, then returns to the operating room for extubation. Another direct laryngoscopy and bronchoscopy are performed two weeks following the LTR procedure.

In the dual-staged procedure, the tracheostomy remains throughout the procedure and decannulation

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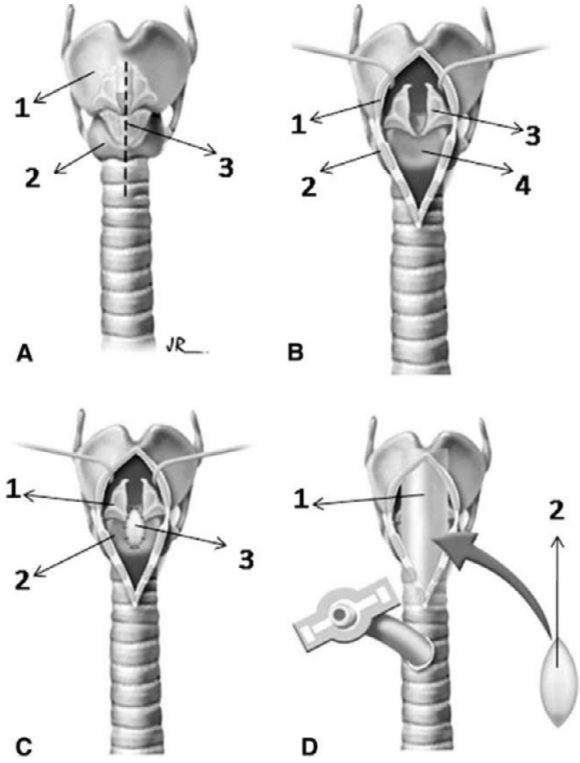

Figure 33.4 Schematic demonstrating the steps of standard laryngotracheal reconstruction. (A) Laryngotracheal anterior exposure: (1) thyroid cartilage; (2) cricoid cartilage; (3) incision site to perform anterior laryngeal split. (B) Airway exposure after anterior laryngeal split: (1) and (2) thyroid and cricoid cartilages split and retracted respectively; (3) arytenoids; (4) posterior cricoid plate, exposed and ready to be split. (C) Posterior larynx grafting and posterior cricoid split: (1) arytenoids; (2) posterior cricoid plate already opened; (3) rib cartilage graft filing posterior groove. (D) Laryngeal stent and anterior grafting: (1) solid stent inside the airway; (2) rib cartilage graft prepared to fill the anterior defect. Reproduced with permissions from Terra RM, et al., *J Thorac Cardiovasc Surg* 2009;137(4):818-23. Copyright © 2009 The American Association for Thoracic Surgery. Published by Mosby, Inc. All rights reserved

occurs at a later date after the airway size has been assessed for adequate patency. Double-stage repair may be advisable in cases of difficult intubation, poor pulmonary function, and those patients with prior failed reconstructions or sedation issues.

What Are Contraindications to LTR Surgery?

Contraindications to decannulation and surgery include: severe tracheomalacia, uncontrolled gastric reflux, asthma, active eosinophilic esophagitis, and tracheostomy tube dependence due to chronic pulmonary disease or neurologic impairment resulting in recurrent aspiration.

What Are the Major Anesthetic Considerations for Laryngotracheal Reconstruction?

Preoperative planning and close communication with the surgeon throughout the procedure are extremely important. To gain better surgical access to the neck, the tracheostomy tube is replaced by the surgeon with either a sterile wire-reinforced tube or an oral RAE tube that has been cut down by the surgeon to fit into the trachea. A Murphy eye may also need to be cut into the distal end of the altered RAE tube to limit the risk of tube obstruction. The stomal tube may need to be replaced by a nasal endotracheal tube after the airway is opened and the posterior graft is placed.

In single-stage procedures, without tracheostomy, an uncuffed nasal endotracheal tube is sutured in place by the surgeon. Sometimes balloon dilation of the airway is needed prior to intubation.

Total intravenous anesthesia is most commonly performed for maintenance with infusions being continued postoperatively to assure adequate sedations for airway protection.

Commonly used postoperative infusions at Texas Children's Hospital include: fentanyl (1–2 mcg/kg/hour), dexmedetomidine (0.3–1 mcg/kg/hour), and rocuronium (8–12 mcg/kg/minute).

Ketamine and/or midazolam infusions may be added in patients with a history of difficult sedation.

Complications from airway surgery can occur both intraoperatively or postoperatively. Intraoperative risks include tube dislodgement or obstruction, pneumothorax, and bleeding.

What Are the Postoperative Considerations with Regard to Ventilation and Sedation?

Postoperative sedation risks and benefits should be weighed. A limited period of sedation and immobilization may lower the risk of ventilator-acquired pneumonia, pressure ulcers, neuropathy and myopathy, as well as narcotic or benzodiazepine withdrawal. Sedation should eliminate anxiety and awareness in the initial postoperative period as well as decrease the risk of accidental extubation and manipulation of the

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surgical site. Often, the neck is kept in flexion to reduce tension on the airway anastomosis. The surgeon may elect to suture the endotracheal tube to the chest. Prolonged neck flexion results in significant neck spasms and may warrant scheduled diazepam during this period.

Paralysis with rocuronium, usually limited to the initial postoperative period (<24 hours), is administered to reduce the risk of airway granulation tissue formation resulting from mechanical sheer trauma (inadequately sedated patient resulting in friction from the tracheal tube with the surgical site). If neuromuscular blockade (NMB) is continued longer than 24 hours, NMB "holidays" should be incorporated in order to avoid patient muscle weakness.

Following a single-stage procedure with planned decannulation, the patient typically remains intubated in the PICU for one to three days after anterior grafting and five to seven days after anterior and/or posterior grafting.

Early postoperative complications also include wound infection, dehiscence, and graft dislodgement or displacement for both single- and double-stage reconstruction.

Extubation, along with direct laryngoscopy and bronchoscopy, is performed in the operating room. In the six- to twelve-hour period prior to going to the operating room, sedation protocols are converted to a propofol infusion at 50–100 mcg/kg/minute. Sedation boluses may be given, however, medications with long half-lives following continuous infusion should be stopped in the hours prior to the procedure. It is crucial that the patient not be overly sedated during extubation as this may contribute to failed extubation attempts. Steroids should be given prior to the operating room.

In the OR, the patient can be extubated to BiPAP or CPAP, although positive pressure may increase the risk of air leak and the development of subcutaneous air, pneumothorax, or pneumomediastinum.

Suggested Reading

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