Operative Techniques in Otolaryngology (2005) 16, 171-179

ELSEVIER

Operative Techniques in

Otolaryngology

The subglottis and trachea

Michael J. Rutter, BHB, MBChB, FRACS

From the Division of Pediatric Otolaryngology/Head & Neck Surgery, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio.

KEYWORDS
Subglottic cysts;
Subglottic stenosis;
Tracheomalacia;
Complete tracheal rings;
Vascular compression

While the symptoms of laryngeal and tracheal pathology, including stridor and retractions, are most noticeable in the awake child, sleep disordered breathing is a frequently associated finding. The evaluation and management of common laryngeal and tracheal anomalies are discussed, including operative and postoperative management.

Subglottic and tracheal pathology may be subdivided into disorders associated with fixed stenosis, compression, or dynamic collapse. The classic triad of symptoms in the awake child with subglottic narrowing consists of stridor, retractions, and exercise intolerance. Meanwhile, dynamic tracheal compromise may present with wheezing, cough, and even dying spells if severe. In infants, failure to thrive may be an issue. Although this group of disorders is best recognized for the symptoms seen while awake, all may contribute to sleep disturbed breathing in a child.

This article specifically addresses subglottic cysts, subglottic stenosis, tracheomalacia, complete tracheal rings, and vascular compression of the trachea. These causes of pediatric airway compromise do not primarily present with sleep disturbance as the primary complaint, but rather sleep disturbance may be a component of their presentation. The symptoms of subglottic and tracheal pathology seen during sleep include stridor and retractions, and may also include restlessness, apnea, carbon dioxide retention, and mucus clearance issues. The treatment of these disorders often requires a team approach, and collaboration may include pulmonology, gastroenterology, anesthesia, and cardiothoracic surgery.

Subglottic cysts

Subglottic cysts are a consequence of intubation of the premature infant, even when the period of intubation is brief (Table 1). The presentation is classically weeks or months after discharge from the neonatal unit, usually with the insidious onset of retractions and biphasic stridor. When severe, there may be associated cyanosis, apnea, and failure to thrive. The cysts are often multiple, and because of the insidious nature of their progression, are usually much more impressive on endoscopy than the symptoms would suggest. Subglottic cysts may be quite superficial and thin walled, or may be deeply submucosal, and, as such, may be confused with a subglottic hemangioma. In 10% to 20% of cases, there is some degree of associated subglottic stenosis.

Preoperative evaluation

Preoperative evaluation requires both evaluation of the child and of the airway. In the premature infant, bronchopulmonary dysplasia is commonly associated and can further compromise the child's respiratory function. Transnasal flexible laryngoscopy at the bedside in the awake child may occasionally suggest the diagnosis but primarily serves to exclude other pathology, such as laryngomalacia or vocal cord paralysis. Definitive diagnosis requires rigid endoscopy, which confirms the presence of a cyst or cysts in the subglottic space. These cysts may be markedly occluding the airway but are soft and easily permit passage of an endotracheal tube or bronchoscope. The subglottic space should be evaluated for associated subglottic stenosis, and the rest of the airway should be inspected to exclude other pathology.

Surgical procedure

Small incidental cysts may be observed, but usually cysts are large, compromising the airway, and requiring

Address reprint requests and correspondence: Michael J. Rutter, BHB, MBChB, FRACS, Division of Pediatric Otolaryngology/Head & Neck Surgery, Cincinnati Children's Hospital Medical Center, ML 2018, 3333 Burnet Avenue, Cincinnati, OH 45229-3039.
E-mail address: mike.rutter@cchmc.org.

1043-1810/$ -see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1016/j.otot.2005.09.006

Table 1 Subglottic cysts

Indications	Symptomatic subglottic airway compromise
Contraindications	Subglottic stenosis (a relative contraindication)
Special instruments	Bugbee monopolar electrocautery
Tips and pearls	Endoscopic cyst marsupialization is an effective treatment Cyst recurrence is common

intervention. In most cases, cyst marsupialization is effective, although differing tools are available to achieve the same result. Carbon dioxide laser ablation, microlaryngeal instruments, and the Bugbee electrocautery, which is a conveniently available urologic monopolar diathermy insulated wire that can pass down a ventilating bronchoscope, are all effective (Figure 1). Access may be with a ventilating bronchoscope or suspension laryngoscopy, using an infant subglottiscope. If there are bilateral cysts, care should be taken not to cause undue trauma or thermal damage on both sides of the subglottis. In cases with multiple cysts, it may be better to remove the larger cysts and return in the future to ablate the remaining cysts, rather than risk inducing a subglottic stenosis by attempting removal of all cysts present at 1 sitting.[1]

Complications

Postoperative edema of the subglottis is common and most troublesome if there is also associated subglottic stenosis. Occasionally, the subglottic stenosis is severe enough to warrant laryngotracheal reconstruction, in which case, the cysts may be marsupialized directly at that time.

Postoperative care

Postoperative treatment should include provision of steroids (dexamethasone, 0.5 mg/kg, as a single dose). Consideration should also be given to postoperative overnight intubation for treatment of subglottic edema.

Long-term follow-up

Cyst recurrence, or the appearance of other subglottic cysts, is so common as to be the expectation. Follow-up bronchoscopy is recommended to marsupialize further cysts if present. This procedure should be performed at 4- to 6-week intervals until no cysts remain. It is very unusual for cysts to require removal on more than 4 occasions.

Subglottic stenosis

Congenital subglottic stenosis is the third most common cause of congenital stridor in infants, after laryngomalacia and vocal cord paralysis (Table 2). However, acquired subglottic stenosis, usually as a consequence of prolonged intubation of the neonate, is far more common. Subglottic stenosis may present with failure of extubation, tracheotomy dependency, or stridor. Children requiring prolonged intubation frequently have other coexistent conditions, such as prematurity, chromosomal anomalies, or other congenital anomalies, and these need evaluation in concert with assessment of the airway.

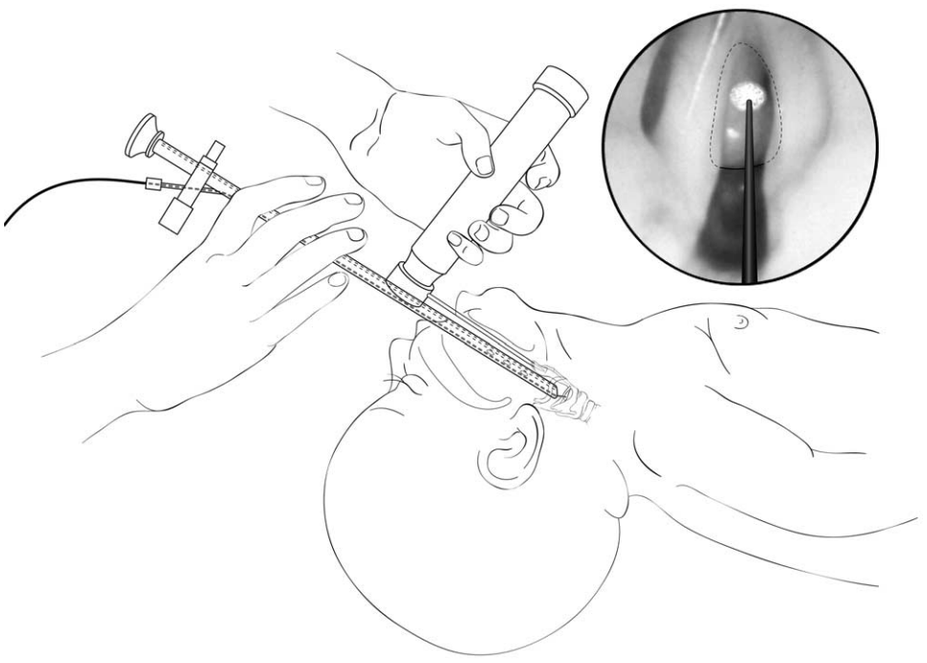

Figure 1 Bugbee electrocautery of a subglottic cyst through a ventilating bronchoscope.

Table 2 Subglottic stenosis

Indications	Grade 2, 3, or 4 subglottic stenosis
Contraindications	Aspiration, ventilator dependency, progressive neuromuscular disorders, an "active" larynx
Special instruments	Doyne dissector (for rib harvest)
Tips and pearls	Endoscopic evaluation of the airway after graft placement will confirm adequate graft placement before wound closure Eosinophilic esophagitis is a relatively recently recognized and potently negative influence on the outcome of laryngotracheal reconstruction

Preoperative evaluation

The first aspect of airway evaluation in a child with subglottic stenosis is the impact of the stenosis on the child. Is the child intubated and unable to be extubated? Is the child tracheotomy dependent? Does the child have stridor with exertion? In a child with subglottic stenosis but few or no symptoms, intervention may be delayed or even not required. Assessment of voice and sleep disturbance is also indicated at this time. The child's airway should also be assessed, including the grade, length, and maturity of the stenosis, and whether other airway pathology coexists. Rigid bronchoscopy with formal sizing of the airway remains the gold standard, although flexible bronchoscopy may provide complementary information. Assessment with the child spontaneously ventilating is desirable to assess the dynamics of the airway. The third aspect of the assessment is aimed at optimizing the outcome of surgical reconstruction, if required. Evaluation for and treatment of gastroesophageal reflux disease, eosinophilic esophagitis, and methicillin-resistant *Staphylococcus aureus* colonization may all influence the outcome. Evaluation should also address whether it is appropriate to attempt decannulation. In children with a severe aspiration risk, ventilator dependency, or progressive neuromuscular disorders, decannulation may not be desirable.

Surgical procedure

The surgical correction of subglottic stenosis may be endoscopic, for mild stenosis, or open. Open reconstruction may be resection surgery (cricotracheal resection), or expansion surgery, including the anterior cricoid split, and laryngotracheal reconstruction (cartilage grafting of the anterior cricoid, posterior cartilage, or anterior/posterior cartilage grafting). The workhorse graft material is costal cartilage, which is abundant, easily harvested, and easily carved. Surgery may be single staged, with the child intubated for a few days postoperatively, or double staged, with a stent placed above the tracheostomy tube to stabilize the graft. A single-staged anterior costal cartilage graft is described in Figure 2.

The tracheotomy site is excised, with anesthesia maintained through an endotracheal tube placed through the stoma. Suprastomal skin flaps are raised up to the level of the hyoid proximally and clavicles distally. The straps are divided in the midline, the thyroid isthmus divided, and the anterior trachea exposed. This is then split from the stoma site, through the cricoid cartilage, and up to the lower third of the thyroid alar, with care being taken to stay in the midline, and below the level of the anterior commissure. The child is then nasally intubated, and the length and width of the anterior cricoid split measured. A chest incision is made, usually over the right sixth rib, with the incision being placed in the anticipated breast crease in girls. A segment of costal cartilage is harvested, preserving the inner perichondrium, while leaving the outer perichondrium attached to the graft. A Valsalva maneuver with water in the chest wound ensures that a pneumothorax is not present. The graft is then carved into a boat shape of the desired width and length, with an outer flange that will prevent prolapse of the graft into the airway. The perichondrium should face the airway. The graft is sutured into placed with interrupted 4.0-monofilament absorbable or nonabsorbable sutures placed in a mattress fashion. The wound is then closed in layers over a Penrose drain, and the child is extubated 1-5 days later. The airway should be reevaluated weekly by rigid bronchoscopy on 2 or 3 occasions postoperatively to ensure healing and an adequate airway.[2]

Complications

Intraoperative complications are usually airway related. The endotracheal tube may become displaced, or secretions in the distal airway may compromise ventilation, and recognition is the key to effective treatment. Pneumothorax may occur during harvest of costal cartilage, and, again, recognition is the key to treatment. Placement of a suction catheter through the pleural rent and then a purse-string pleural closure while the suction is removed during the Valsalva maneuver is effective for avoiding the need for a chest tube. Early postoperative complications include bleeding and infection, and also air leak from the repair site. As long as a Penrose drain remains in place, subcutaneous emphysema or pneumothorax can be avoided. Most air leaks spontaneously resolve, but avoidance of positive pressure ventilation or, alternatively, the use of a cuffed endotracheal tube will promote spontaneous closure. Single-stage procedures are associated with a variety of sedation and intensive care unit related issues, including extubation stridor caused by glottic edema. The late postoperative complication of most concern is restenosis, occurring in 10% of cases in most series.

Postoperative care

In single-stage procedures, most children younger than 3 years will require sedation, while many older than 3 years will tolerate minimal sedation, and may be able both to ambulate and eat while intubated. The main need for sedation is to prevent the risk of accidental extubation. In double-stage procedures, the suprastomal airway is occluded by a stent, and the tracheotomy tract has usually been revised, so tracheotomy care for the first several days until the

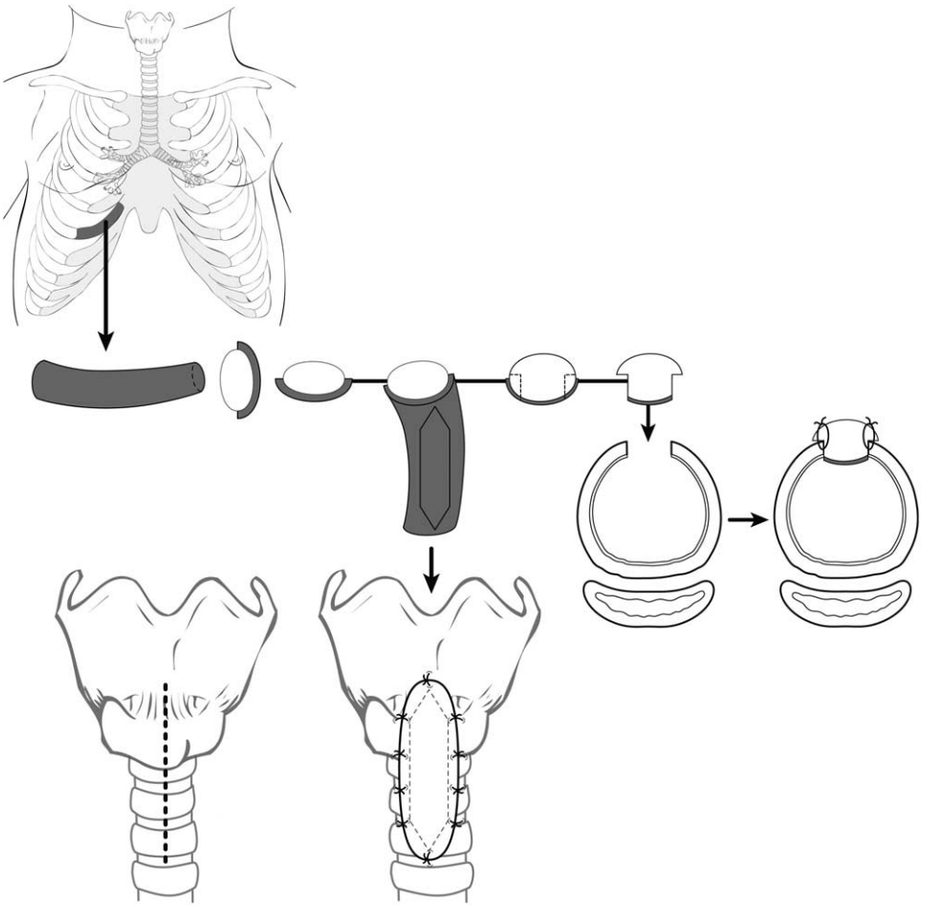

Figure 2 Harvest, carving, and placement of a costal cartilage graft to the anterior cricoid.

tracheotomy tract has established is critical. Rigid suprastomal stents must not overlap the tracheotomy site because the stent may obstruct the passage of the tracheotomy tube during tracheotomy tube changes. This is not a problem with soft Silastic (Dow Corning, Corp, Midland, MI) suprastomal stents.

Long-term follow-up

Regular interval endoscopy should be performed until there is definitive evidence of the reconstructed airway growing with the child, even if the intervals between endoscopies are 2 yearly. In 10% of cases, airway growth will not keep up with the growth of the child, and, eventually, symptoms of subglottic stenosis will necessitate re-intervention.

Tracheomalacia

Tracheomalacia is a dynamic collapse of the tracheal lumen, usually caused by an excessively wide posterior tracheal membrane and broad, flat tracheal rings (Table 3). It is commonly associated with tracheoesophageal fistulas, and posterior laryngeal clefts but may also be an isolated problem. Symptoms are of failure to extubate, expiratory wheeze, a honking cough, and nocturnal apnea. When severe, dying spells may occur. Although spontaneous resolution with time is expected in most cases, initial symptoms often worsen during the first 6 months of life. Treatment is expectant in mild-to-moderate cases, but, in severe cases, intervention is required. Although continuous positive airway pressure (CPAP) is effective and may be useful temporarily, it is not a long-term solution. The mainstay of treatment is tracheotomy, with the tip of the tracheotomy tube lying close to the carina to bypass the malacic segment. This process may require a special length tracheotomy tube. In children with associated bronchomalacia, ambulatory ventilation, CPAP, or bilevel positive airway pressure may

Table 3 Tracheomalacia

Indications	Isolated symptomatic thoracic tracheomalacia
Contraindications	Bronchomalacia or severe cervical tracheomalacia Absent thymus or an aorta already close to the sternum
Special instruments	Thorascopic instruments
Tips and pearls	Thymectomy is the key to adequate aortopexy Intraoperative bronchoscopy allows evaluation of the adequacy of the aortopexy and whether additional pexing sutures are required

be required. In isolated tracheomalacia, an alternative to tracheotomy is aortopexy.

Preoperative evaluation

Although airway fluoroscopy of the sleeping child may assist in diagnosis, the definitive diagnosis is made on bronchoscopy with a spontaneously ventilating child. Flexible bronchoscopy is superior to rigid bronchoscopy in the evaluation of dynamic tracheomalacia. Although tracheomalacia may appear severe on endoscopy, intervention is not mandated on the bronchoscopic appearance but, rather, on the symptoms of the child. A sleep study may assist in decision making in equivocal cases. If symptoms do warrant intervention, then imaging of the chest is indicated. Although magnetic resonance imaging provides excellent images, it is time consuming and frequently requires sedation of a child with an already compromised airway. Therefore, rapid acquisition computerized tomography (CT) with contrast is preferable, with emphasis not so much on the airway but on the proximity of the aorta to the sternum and the size of the thymus gland. The ideal candidate for aortopexy is a child with a large thymus separating the aorta from the sternum and in whom the maximally malacic segment of trachea is in the region of the aorta.

Surgical procedure

An aortopexy may be performed thorascopically or through a comparatively small, left-sided parasternal incision between the third and fourth ribs. The thymus is resected, and pexing sutures are then placed from the inner periosteum of the sternum to the aorta. Care is taken to minimize the dissection on the lateral and posterior aspects of the aorta, so that the attachments of the aorta to the trachea allow the trachea to be dragged forward with the aorta as it is pexed to the sternum. It is very useful for an assistant to pass a flexible endoscope down the endotracheal tube as the pexing sutures are tightened to visualize the effect on the trachea and decide if further pexing sutures are required. Once a satisfactory aortopexy has been completed, the wound is closed over a chest drain (Figure 3).[3]

Complications

Pneumothorax and hemothorax are risks, but the most significant risk is inadequate aortopexy, with resultant failure.

Postoperative care

Extubation may be immediately postoperatively, or the next day. Facemask CPAP or high-flow nasal cannula may assist with perioperative respiratory distress.

Long-term follow-up

Repeated bronchoscopy 4-6 weeks postoperatively should show improvement, but the true measure of success is resolution of clinical symptoms, even if the bronchoscopic appearance shows only small improvement, which is not infrequent.

Complete tracheal rings

Complete tracheal rings are a rare congenital anomaly but still the most common cause of congenital tracheal stenosis (Table 4). In more than 75% of cases, other congenital anomalies are also present, sometimes severe. The most common associations are cardiovascular anomalies, particularly the pulmonary artery sling. In most cases, presentation is around 4 months of age, as the infant outgrows its airway, and presents with increasing respiratory distress, stridor, apnea, and difficulty clearing secretions from the airway. Sleep disturbance, particularly apnea, may be a component of the presentation. In some cases, presentation may be late, with exercise intolerance. In 10% of children, intervention is not required, and, in a further 10% of children, intervention may be delayed.

Historically, complete tracheal rings carried a very high mortality and morbidity rate, and a number of different surgical procedures have been used to treat these children. The introduction of the slide tracheoplasty technique has markedly improved the outcome for these challenging children, and may be used with almost any variant of complete tracheal rings, including short segment stenosis, long segment stenosis, and even in children with an associated tracheal (pig) bronchus.

Preoperative evaluation

The evaluation of a child with complete tracheal rings is divided into evaluation of the airway and evaluation of the rest of the child. Airway evaluation commences with a simple high kilovolt airway view of the trachea to provide an impression of the extent and severity of the stenosis before bronchoscopic evaluation. Rigid bronchoscopy is the evaluation of choice but should be performed with extreme care because in 50% of children, the narrowest point of the airway approaches 2 mm in diameter. Therefore, only the smallest Hopkins rod-lens telescope (the Storz 27017 telescope [Karl Storz Endoscopy, Culver City, CA] that is provided with a 2.5-ventilating bronchoscope has an outer diameter of 1.9 mm) may be able to pass the maximally stenotic segment, which is usually close to the carina. It is noteworthy that the smallest endotracheal tube (2.0 mm) has an outer diameter of 2.9 mm and the smallest tracheotomy tube (Bivona 2.5 mm) has an outer diameter of 3.5 mm. In these children, it may not be possible to intubate or perform tracheotomy to bypass the stenotic segment of trachea, and, therefore, the airway of these children should be treated with the utmost respect.

When performing rigid bronchoscopy, tracheal secretions may compromise adequate evaluation, and rigid suctioning of the airway is contraindicated. This effect is because if suctioning or bronchoscopy causes any edema within the lumen of the stenotic segment, an already compromised airway may become a critical airway. Although intubation of the trachea above the stenotic segment may

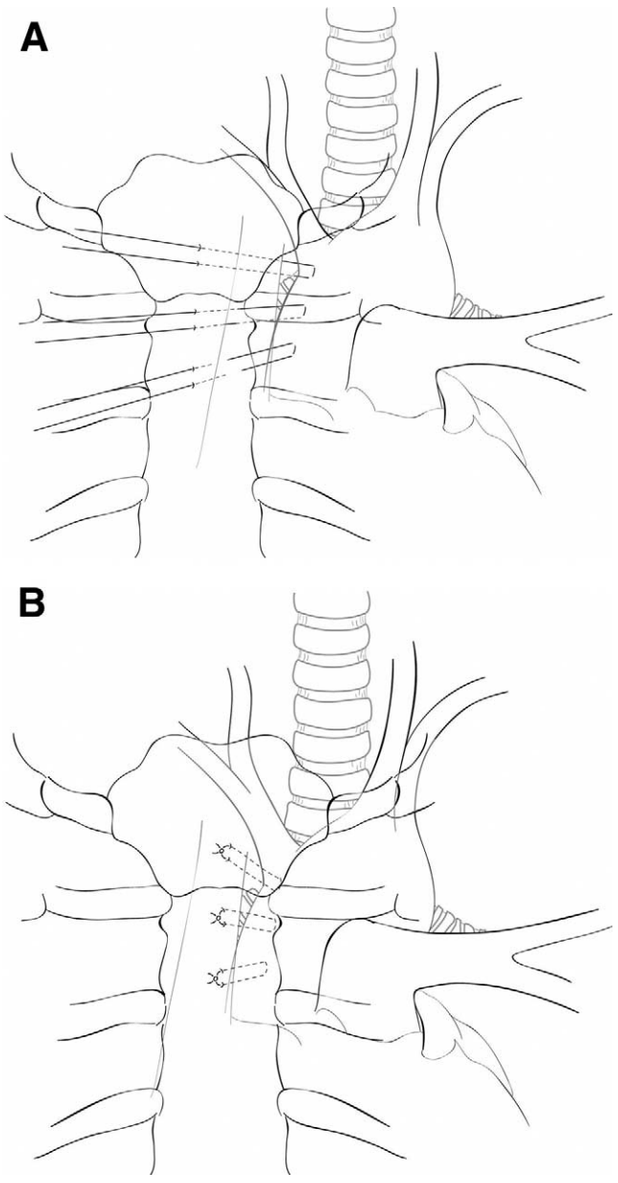

Figure 3 (A) Placement of pexing sutures from anterior aortic arch to sternum. (B) Suspension of aorta to sternum, dragging trachea (still attached to the posterior aorta) anteriorly.

allow ventilation, if this is still inadequate, then placing the child on extracorporeal membrane oxygenation may be the only alternative. Therefore, to minimize risk to the airway during endoscopic evaluation, initially, the trachea should be "intubated" with a 5/6F suction catheter to suction secretions from the airway, and a bolus of propofol (Diprivan; AstraZeneca International, London, UK) is then given intravenously to prevent the child gasping during the bronchoscopic assessment. During the 1-2 minutes of apnea provided by the propofol, the bronchoscopy is performed, ideally assessing the proximal and distal extent of the stenosis, the diameter of the airway, whether a tracheal bronchus is present, and whether bronchial stenosis also exists. In some cases, it may be better to recognize a stenosis and not adequately evaluate the more distal airway than try to place too large a telescope through the stenotic segment and risk compromising the airway.

Once the airway evaluation has been completed, the rest of the child should be evaluated. The most important aspect is evaluation of the intrathoracic and cardiac vasculature. A high-resolution contrast-enhanced CT of the chest will provide information not only about the airway, but also the great vessels, particularly evaluating for a pulmonary artery sling or aberrant superior vena cava. An echocardiogram will provide information about the cardiac anatomy. Although magnetic resonance imaging and magnetic resonance angiography provide excellent images, these are lengthy and noisy examinations, and may require sedation in a child with a compromised airway.

At this point, treatment decisions include whether the child requires imminent tracheoplasty, and if so, what is the best approach. In our institute, if the stenosis involves the distal third of the trachea, or if a coexistent cardiovascular anomaly also requires correction, then the surgery is performed on cardiopulmonary bypass through a median sternotomy. In our experience, 90% of cases are performed on cardiopulmonary bypass.

Surgical procedure

These children are challenging and complex, and care is optimized by a collaborative team approach. The child is initially bronchoscopically evaluated and then intubated with an age-appropriate endotracheal tube above the stenosis. The sternotomy is then performed, the trachea exposed, and the child placed on cardiopulmonary bypass. Any cardiovascular anomalies are repaired at this time. Flexible bronchoscopy is then performed through the endotracheal tube, and a 30-gauge needle is inserted into the trachea to estimate the proximal and distal extent of the stenosis. Measurements are taken of the length of stenosis and the trachea transected at the midpoint of the stenosis. The trachea is mobilized while attempting to preserve lateral vascular attachments, and care is taken not to damage the recurrent laryngeal nerves. The proximal segment of the trachea is then split posteriorly until normal trachealis is reached, and the distal segment of trachea is split anteriorly until the complete rings are all opened.

The transected edges of the trachea are trimmed, and the trachea is slid over itself (Figure 4). The anastomosis is then commenced from the proximal posterior aspect of the trachea, and a running double-armed 6-0 polydioxanone suture is used along both edges of the anastomosis until a single knot is placed anteriorly at the carina. It is prudent to

Table 4 Complete tracheal rings

Indications	Symptomatic tracheal stenosis
Contraindications	Asymptomatic or minimally symptomatic tracheal stenosis
Special instruments	Consideration of cardiopulmonary bypass
Tips and pearls	Postoperative intubation with a 3.5 or larger endotracheal tube permits pulmonary toilet with a flexible bronchoscope with a suction port

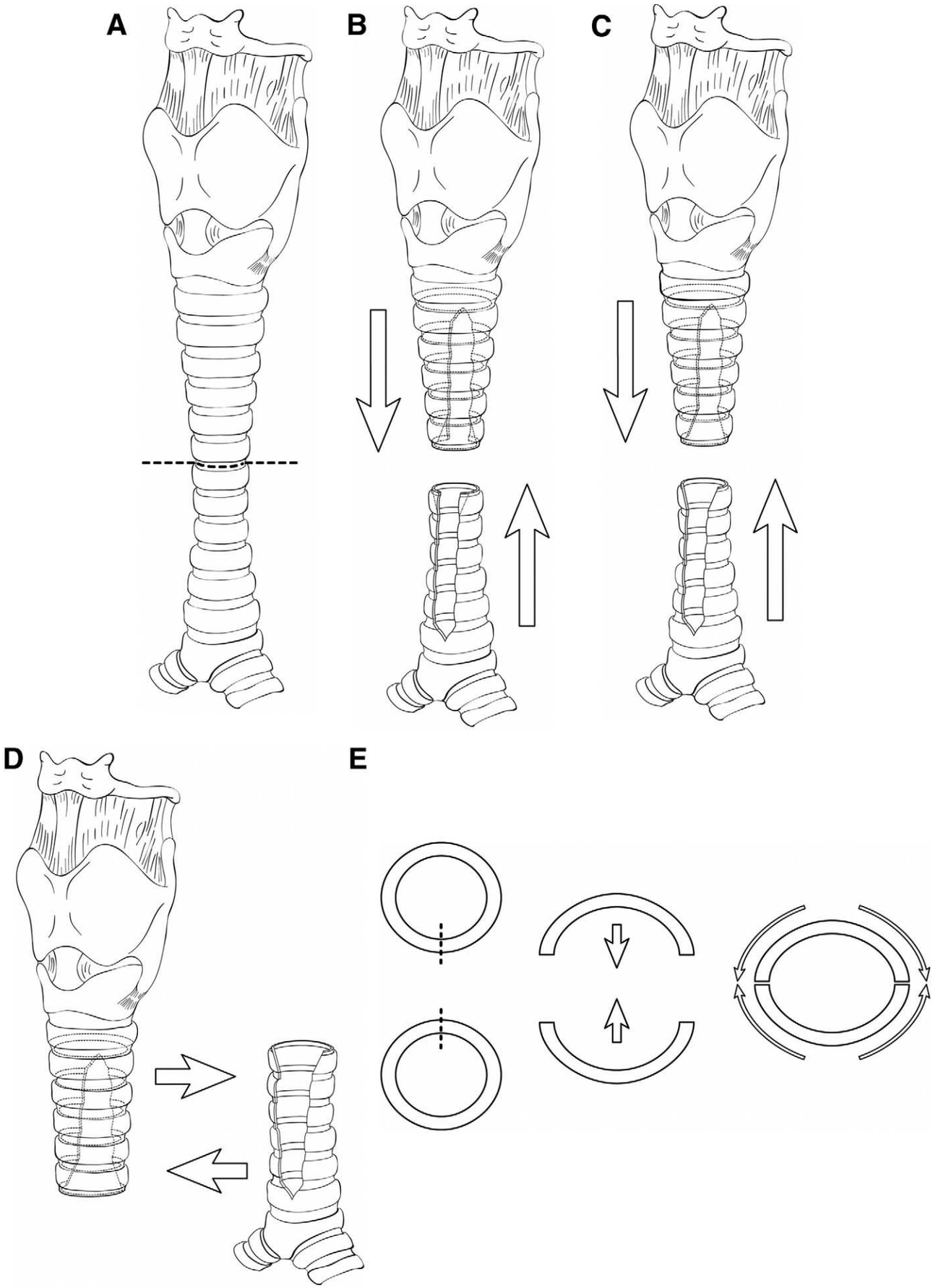

Figure 4 (A) Complete tracheal rings with proposed transection site of trachea at the midpoint of the segment of complete rings. (B) Trachea transected, proximal segment of rings split posteriorly, distal segment of rings split anteriorly, right angled corners at transaction site marked for trimming. (C) Corners trimmed, trachea ready to be slid over itself. (D) Trachea ready for anastomosis to commence. (E) Axial view of anastomosis.

perform flexible bronchoscopy at this point to ensure an adequate intraluminal repair, position the tip of the endotracheal tube in an appropriate position, and to suction any blood and debris out of the trachea and bronchi. The child is then taken off cardiopulmonary bypass, and the chest closed.[4]

Complications

The list of possible postoperative complications is long, but with the slide tracheoplasty technique, the 2 most frequent complications are transient unilateral recurrent nerve palsy and lateral bunching of the edges of the anastomosis (the "Figure 8" trachea). Both problems tend to self-correct during the postoperative weeks or months. Although, historically, the outcome was primarily mediated by the status of the child's trachea, increasingly, the long-term outcome is a reflection of the child's nontracheal pathology.

Postoperative care

The most frequent postoperative problem is with bronchial plugging with secretions and blood during the initial 24-48 hours. Flexible bronchoscopic toilet of the airway may be required during this period. Dependent on the child's cardiovascular status and other medical conditions, extubation is usually achieved in 24-48 hours. As with laryngotracheal reconstruction, 2-3 postoperative bronchoscopies may be required during the initial month postoperatively. During this period, vocal cord mobility should be confirmed.

Long-term follow-up

The expectation is that a good initial outcome will be followed by a good long-term outcome, but occasional interval bronchoscopy is recommended to confirm normal tracheal growth.

Vascular compression

Vascular compression of the airway presents with symptoms similar to those seen with tracheomalacia, and, indeed, segmental tracheomalacia may be a component of the pathology (Table 5). Symptoms classically deteriorate during the first few months of life and then may start improving. However, in many children, intervention is warranted at an early age. The most common and most benign form of vascular compression is an anterior indentation of the thoracic trachea by the innominate artery, and only in a minority of cases will intervention be required. The double aortic arch is a vascular ring that may bilaterally compress the trachea and esophagus, and usually requires division of the smaller of the 2 aortas, usually the left. A right-sided aorta may also compress the airway but infrequently requires intervention. The pulmonary artery sling requires division and reimplantation of the left pulmonary artery, and demands bronchoscopic evaluation to exclude complete tracheal rings. Compression of the main stem bronchi by the atria or the pulmonary arteries is usually secondary to abnormal intracardiac anatomy and may respond to cardiac repair. Rarely, a posterior aortopexy of the descending aorta may assist with isolated vascular compression of the left mainstem bronchus.

Table 5 Vascular compression

Indications	Symptomatic vascular compression of the airway
Contraindications	Mild symptomatology, even if endoscopic appearances are impressive
Special instruments	Arterial cross-clamping instruments
Tips and pearls	Pulmonary artery slings require bronchoscopic evaluation to exclude complete tracheal rings

In infants with vascular compression of the airway, tracheotomy or placement of expandable metal wire stents both carry the potential for erosion into the vessel, with potentially catastrophic hemorrhage into the airway. Because innominate artery compression is the most common form of vascular compression of the airway, this will be primarily discussed.

Preoperative evaluation

Bronchoscopic evaluation of the airway will establish the degree of airway compression, but symptoms drive the need for intervention. With innominate artery compression, if a pulse oximeter is placed on the left hand, and the bronchoscope is then used to apply anterior pressure to the trachea at the point of compression, the pulse will be lost to the left hand and return when the pressure is removed. Although the bronchoscopic appearance of the airway will often suggest the diagnosis, confirmation with imaging studies is also required, and contrast-enhanced CT of the chest is recommended. A barium swallow is also useful in assisting with the diagnosis of a double aortic arch (posterior filling defect in the esophagus) or a pulmonary artery sling (anterior filling defect in the esophagus).

Surgical procedure

Although aortopexy is an effective intervention for innominate artery compression, the alternative is reimplantation of the innominate artery, and this is described. Through a median sternotomy, the insertion of the innominate artery at the aorta is identified, and the innominate artery cross-clamped and divided. The aorta is repaired and then the innominate is reimplanted more proximally along the aortic arch, so that it no longer compresses the trachea (Figure 5). Removal of the thymus assists in decompression of the trachea.[5]

Complications

The most common complication is inadequate alleviation of the vascular compression. Anastomotic bleeding may also occur but will usually be minor in nature. Although anastomotic stenosis is described, it is rare and may be a late occurrence.

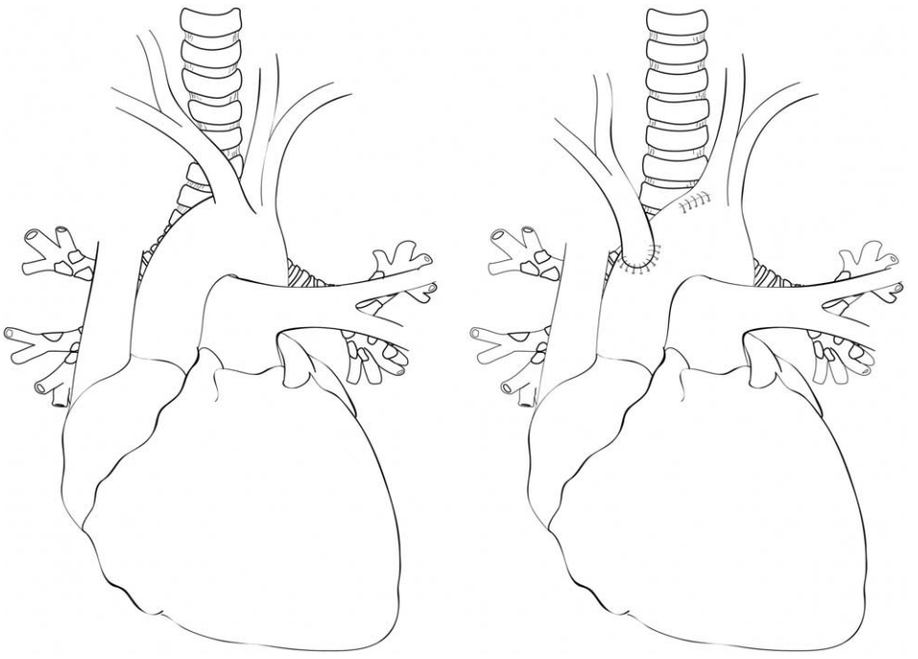

Figure 5 Reimplantation of the innominate artery more proximally on anterior ascending aortic arch.

While there is potential for a cerebrovascular accident, in practice, this is unlikely as long as the cross-clamp time is kept to a minimum. Care should be taken to avoid damage to the right recurrent laryngeal nerve, although this normally passes lateral to the operative area.

Postoperative care

Extubation may usually be achieved the same day or the following day.

Long-term follow-up

Follow-up bronchoscopic evaluation is recommended. If symptoms resolve initially, it is unlikely that late deterioration will occur, and, therefore, long-term bronchoscopic evaluation is not generally required.

References

1. Johnson LB, Rutter MJ, Shott SR, et al: Acquired subglottic cysts in preterm infants. J Otolaryngol 34:75-78, 2005
2. Cotton RT: Management of subglottic stenosis. Otolaryngol Clin North Am 33:111-130, 2000
3. Wright CD: Pediatric tracheal surgery. Chest Surg Clin N Am 13:305-314, 2003
4. Rutter M, Cotton R, Azizkhan R, et al: Slide tracheoplasty for the management of complete tracheal rings. J Pediatr Surg 38:928-934, 2003
5. Hawkins JA, Bailey WW, Clark SM: Innominate artery compression of the trachea. Treatment by reimplantation of the innominate artery. J Thorac Cardiovasc Surg 103:678-682, 1992