Refresher Course

Management of Laryngotracheal Stenosis in Children

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INTRODUCTION

Laryngotracheal stenosis has been a complicated problem for pediatric patients especially following prolonged intubation. The incidence of subglottic stenosis following prolonged intubation has been found to range between 1-8%.[1] Trauma, infection and reflux disease are major contributory factors causing deterioration of the fibrotic scar. Although not all the stenoses cause apparent airway compromises, the majority of the patients need tracheotomy to bypass the obstructed part. Watching and waiting allows the patient's larynx to grow and develop until the tracheotomy can be removed. But the patient and family have the burden to get through the tracheotomy care program with the risk of prolonged tracheotomy. Many therapeutic approaches have been created to overcome this tracheotomy-dependent disease with favorable outcome. However, the managing of severe and complicated stenosis has been still a challenging task for the surgeon and still sometimes achieves disappointing results.

Etiology and pathophysiology

In an adult, the narrowest part of the airway is at the level of vocal cords. In contrast, the subglottic airway is the narrowest part of the airway in children. The cricoid cartilage is the only point in the air passage which is circumferentially formed with a signet ring shape. The full-term infant and the pre-term infant with cricoid rings less than 4 mm and 3 mm in diameter respectively are diagnosed as subglottic stenoses. Every full-term infant should be able to be intubated with endotracheal tube No.3 (ID = 3mm) and air should leak around this tube at less than 30 cm of water pressure[1].

Subglottic stenosis (SGS) is classified as congenital or acquired (Table 1).[2] Various degrees of congenital SGS result from the interruption of the laryngeal recanalization process at a specific time during the prenatal period. The cricoid cartilage may be abnormal in shape or have a normal shape with a small size. A laryngeal cleft and a trapped first tracheal ring within the cricoid cartilage are associated with thickened cricoid lamina and submucosal fibrosis, resulting in significant subglottic stenosis. Trauma and infection at the subglottic area as a result of endotracheal intubation are the commonest causes of the acquired SGS. Acquired lesions are usually confined to soft tissue stenosis, sometimes with an ossified fragmented distorted cricoid cartilage. The size and material of endotracheal tube, the number of intubations and movement of the tube influence the degree of subglottic injury. Care must be taken to select the proper size and type of tube including restraining the child in order to minimize the trauma to subglottic area.

It has been shown that neonates tolerate prolonged intubation well because the laryngeal cartilages of the neonate are hypercellular with scant gel-like matrix that is found more commonly in more mature cartilage. For children beyond the neonate period, the longer period of intubation results in the greater potential of injury because of maturation of the laryngeal cartilage. Although it is controversial regarding the proper time for conversion from endotracheal intubation to tracheotomy, in order to avoid complications, a tracheotomy should be performed in those whose intubation is planned to exceed 10 to 14 days.[1]

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Table 1. Classification of subglottic stenosis

1. Cartilaginous stenosis (usually congenital)
    1.1 Cricoid cartilage deformity
        1.1.1 Normal shape, small size
        1.1.2 Abnormal shape
        1.1.3 Elliptical shape
        1.1.4 Flattened shape
        1.1.5 Laryngeal clefts
        1.1.6 Thickened cricoid
        1.1.7 Acquired lesions
            (fragmented, distorted cricoid, cricoid ossification)
    1.2 Trapped first tracheal ring

2. Soft tissue stenosis (usually acquired)
    2.1 Submucosal mucous gland hyperplasia
    2.2 Ductal cysts
    2.3 Submucosal fibrosis
    2.4 Granulation tissue

Studies have shown pressure necrosis in the tissue with a period of progression from mucosal edema to hemorrhage and ulceration, to frank necrosis. In severe injury, the underlying pericondrium is penetrated and followed by secondary infection resulting in necrosis of the cartilage. Finally, healing by secondary intention occurs which narrows the subglottic area with fibrotic tissue.A stenotic segment may extend to involve the glottis superiorly and the upper trachea inferiorly. So the term laryngotracheal stenosis is more correct and descriptive.

Gastroesophageal reflux (GER) has been proven to be a complicating factor that causes damage to the subglottic mucosa in animal models. The estimated incidence of GER in infant is 20%. Eighty–one percent of subglottic stenosis patients were found to have at least one positive test for GER, suggesting a significant association between GER and SGS.[3] Therefore, we should be concerned about GER and treat it before going on to reconstructive surgery.

Clinical presentation

1. Neonates who are intubated shortly after birth for complications of prematurity may repeatedly have unsuccessful extubations despite favorable weaning parameters.

2. Children with a mild to moderate degree of stenosis may be asymptomatic until an upper respiratory tract infection further narrows the subglottic airway. They present a history of recurrent croup with prolonged time to resolve and may continue despite increasing age.

3. Those with acquired stenosis will present signs and symptoms of upper airway obstruction after a history of previous intubation 1-4 weeks ago.

4. Children with significant congenital subglottic stenosis usually present within the first few weeks of life with signs and symptoms of upper airway obstruction.

Obstruction at subglottic level results in biphasic stridor with chest wall retraction. The voice may be normal if the glottic area is not involved. The child is usually small due to the loss of energy for respiration especially during feeding.

Investigations

A lateral soft tissue neck X- ray may provide information about the subglottic area. CT scan and MRI can demonstrate any abnormality that compresses the airway from the outside of tracheobroncheal tree but give less information concerning the site and extent of SGS than endoscopy does.

The mainstay of diagnosis and evaluation for laryngotracheal stenosis is rigid endoscopy with optical magnification achieved by a rigid Storz-Hopkins endoscope. Information obtained from endoscopy should include vocal cord movement, degree, framework, length and extension of the stenosis segment. It is recommended that a thorough upper aerodigestive tract examination is performed to rule out other associated airway problems.

Due to the significant association between SGS and GER, GER should be looked for and treated in order to avoid further damage to the subglottic area by the acid refluxed from stomach. There are many tests for GER such as gastric emptying scan, pH probe, barium swallowing, bronchoalveolar lavage for lipid laden macrophage and esophageal biopsy. As an otolaryngologist the last two tests can be done concurrently with the diagnostic endoscopic procedure.

Staging of stenosis

Cotton RT proposed this grading system in 1984 and it was historically used at Children's Hospital Medical Center in Cincinnati.

Grade I : Stenoses have subglottic narrowing of up to 70% of the lumen.

Grade II : Stenoses have 70-90% of the subglottic lumen obstructed.

Grade III : Stenoses have greater than 90% obstruction of the lumen.

Grade IV : Stenoses are totally obstructed.

Myer CM, et al.[4] revised their grading system based on endotracheal tube sizes in 1994. They used the outside diameter of the endotracheal tube that passed through the smallest point of the lumen to determine the percentage of airway obstruction by comparing to the expected age-appropriate endotracheal tube size. They presented a conversion tube size to the new grading scale.

Grade I : Up to 50% obstruction.

Grade II : From 51% to 70% obstruction.

Grade III : Above 70% obstruction with any detectable lumen.

Grade IV : No detectable lumen.

Although this grading system is simple, practical and easy for measuring and comparing the stenotic lesion, Laryngotracheal stenosis should be described in every aspect according to the American Society of Pediatric Otolaryngologists (ASPO) Agreement in 1988.[4] ASPO proposed the FLECS system which revealed the data of function, Lumen, extent, consistency and site of laryngotracheal stenosis. This standard data collection would provide a useful information for staging, planning and comparing the results of different treatment modalities. However it may be too cumbersome to be used routinely.

Treatment

There is no standard treatment plan for every patient. Each case should be considered individually depending on the type, site and degree of stenosis, age, weight and general medical condition of the patient. Mild cases can be treated without tracheotomy. Forty-four percent of the congenital SGS required tracheotomy comparing to 97% of the acquired type.[5] After the tracheotomy, there are two general philosophies for the management of SGS, conservation and surgical intervention. The conservative approach of "wait and see" for mild congenital SGS has been used successfully with a high rate of decannulation. Normal growth enlarges the airway sufficiently without surgical intervention. In the acquired type, the stenosis is more severe and complicated and surgical intervention should be considered. The surgeon should remember that contributory factors such as infection, GER, should be treated before consideration of any surgical intervention. Only mature stenosis can be surgically treated because the final degree of active fibrosis and inflammation is settled. A period of 3 months may be spent for the scar to mature.[6] If there has been evidence of perichondritis with significant cartilage loss, it is essential to wait for at least 6 months to 1 year before attempting an open operation.[7]

There are many reasons for hastening decannulation with surgical intervention in stead of watchful waiting. Fearon B and Cotton RT [8] reported in 1974 of 24% mortality rate in the subglottic stenosis patients during wait and see period. Today there is a good postoperative tracheotomy care program and the mortality rate has been reduced to 0-5%.[9,10] However this program needs a lot of intensive family training including the constant physical and psychosocial burden of caring for a child with a tracheotomy. Children with tracheotomy require adjustments in the home environment as well as special supervision at school. Although there is controversy about the effect of tracheotomy on the development of language skills, early creation of an airway allows the child to develop normal speech and language and easier integration into the social aspects of childhood. The risks and benefits of both conservative and surgical approaches should be discussed with the patient and family.

Endoscopic methods of treatment

It may be useful to use endoscopic dilation for mild soft stenotic web or scar. Judicious dilation in the early stages of the inflammatory process aids in the establishment of a lumen which is easier to reconstruct than complete stenosis, but it seems illogical to expect to be able to dilate a circumferential scar surrounded by a ring of cartilage considerably thickened by perichondritis.[6] It should be remembered that too great a dilation of the immature scar causes further trauma that may finally result in a more fibrotic scar.

The CO_2, argon, and KTP lasers are currently the most commonly used endoscopic tools. The energy of laser should be applied only to the affected site and controlled to limit the zone of tissue injury. Improper use of the laser commonly causes unwanted injuries to soft tissue and cartilage, worsening the stenosis.

The following abnormalities of the airway are associated with high failure rate when treated with the laser.

1. Circumferential scar extending more than 1 cm.
2. Lesion with active infectious process.
3. Loss of cartilaginous framework.
4. Exposed cartilage or perichondrium.
5. Advanced and severe cases of SGS.

Airway reconstruction

Open surgical reconstruction should be considered in severe and complicated stenosis which is beyond the capability of the endoscopic method. The airway reconstruction technique can be classified broadly as split, augmentation and resection. Expansions and augmentations with cartilage grafts have been the work horse of the reconstructive technique with a success rate ranging from 76-97%.[11-15] However, severe stenosis may need more than one operation with prolonged stenting resulting in delay or failure of decannulation. Cricotracheal resection with reanastomosis would be a good choice especially in severe, discrete or collapsing stenotic segments. Stenting is an adjuvant measure that is used for a variable length of time depending on the instability of the larynx after surgical reconstruction. Not all reconstructions need a stent.

Five steps involved with airway reconstruction are:-

1. Complete evaluation of the airway.
2. Expansion of the subglottic lumen with preservation of laryngeal function.
3. Stabilization of the expanded laryngeal framework.
4. The period required for healing of the operative site.
5. Decannulation, the goal of laryngeal reconstruction.

Grade I lesions rarely need open surgical reconstruction and usually are handled well by an endoscopic technique. Grade II lesions may be managed by either endoscopic or open reconstruction. Grade III and IV lesions usually require an open procedure to establish an adequate airway.

Contraindications include contraindications to general anesthesia, situations in which a patient will require a tracheotomy despite an adequate laryngotracheal airway (e.g., severe neuromuscular problems, chronic aspiration or airway obstruction above reconstructed site), and severe GER that requires antireflux surgery before airway surgery.

Anterior cricoid split

Cotton RT, et al.[16] proposed this technique in 1980 as an alternative method for tracheotomy in premature neonates who had not been able to be extubated after prolonged intubation with a success rate of 75%. In a later report of Cotton RT[17], he extended the age of the patients who successfully underwent this procedure to up to 28 months. A single vertical incision is made through the anterior cartilaginous ring of the cricoid and through the mucosa to expose the endotracheal tube. This incision is extended superiorly and inferiorly to a variable length of thyroid cartilage and upper two tracheal rings (Figure 1). This procedure permits distraction of the cricoid ring after incision up to 3 mm. Polypropylene monofilament traction sutures are placed in the cricoid cartilage in a paramedian position. The endotracheal tube is changed to appropriate site for the age of the infant in order to act as a stent and prevent the subglottic lumen from becoming obliterated with edema secondary to the mucosal damage already established. The soft tissues are closed loosely over a drain, with traction sutures. The endotracheal tube is left in place for 7 to 14 days. Steroids are initiated 24 hours before the planned extubation and are continued up to 5 days after extubation. Racemic epinephrine treatments, humidification, and chest physiotherapy are all appropriate to maintain the infant during the initial 72 hours after extubation. If the extubation fails, the infant should undergo endoscopy for examination, removal of granulation tissue and suction of inspissated secretions. Repeated intubation with an endotracheal tube one-half size smaller than the previous one for an additional 72 hours, with continued administration of steroids, may permit successful extubation. Repeated failure will need tracheotomy.

Criteria for performing an anterior cricoid split are :-

1. Extubation failure on at least two occasions secondary to subglottic laryngeal pathology.
2. Weight greater than 1,500 gm.
3. No ventilator support for at least 10 days before repair.
4. Supplemental oxygen requirement less than 30%.
5. No congestive heart failure for 1 months before repair.
6. No acute respiratory tract infection.
7. No antihypertensive medication for 10 days before.

It is important to stress that this operation should be considered only in young children whose subglottic pathology is secondary to immediate endotracheal damage. Extensive glottic pathology, cartilage exposure, severe perichondritis and mature subglottic stenosis are not advised to receive this procedure. The long-term follow up, the cricoid cartilage still grows in a U shape and there is no evidence of cartilaginous irregularity of collapse. Animal data as well as data from follow up of patients suggest that operating on the thyroid and cricoid cartilage of infant primates or puppies does not interfere with the growth potential.

Laryngo-tracheoplasty

Evan JNG, et al.[18] reported this technique in 1974. The operation is carried out in two stages six weeks apart. The larynx is opened anteriorly in the midline from the thyroid notch to the cricothyroid membrane. Then a castellated incision is fashioned through the cricoid cartilage and involved tracheal rings. Submucosal dissection and removal of the scar tissue is made using scissors designed for micro-surgery. As much laryngeal mucosa as possible is saved to line the stenotic segment. If the cricoid is abnormally thick, cartilage may be pared or cored from its internal surface to increase the lumen. An internal stent consisting of a "Swiss-roll" of silastic sheeting is inserted and the cartilaginous laryngeal and tracheal pegs are sutured in their displaced position (Figure 2). The silastic roll is secured by a transfixion suture which is brought out over the strap muscles and buried subcutaneously. The silastic roll is removed endoscopically 6 weeks later.

The disadvantage of this technique is that a lot of raw surface along the incision needs to heal by secondary intention and granulation tissue is always found at this site. The stent has to be in place for longer than the augmented cartilage graft technique because of the instability of the reconstructed larynx and the large bare area needs fibrous tissue to fill in. In severe cases which do not have enough cartila-

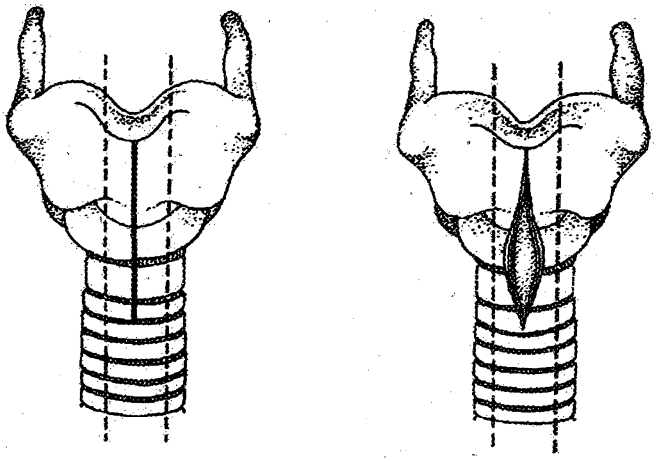


Figure 1. Anterior cricoid is split from the midpoint of thyroid cartilage down to the upper tracheal rings. The incision goes through mucosa to expose the endotracheal tube.

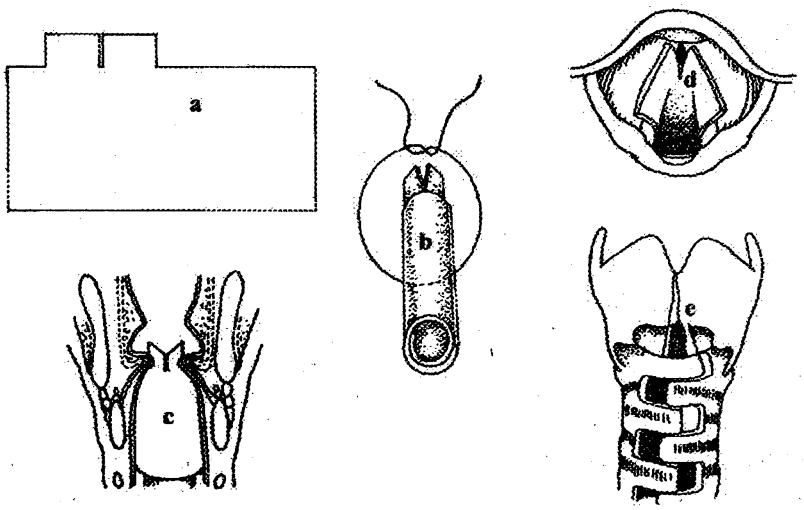


Figure 2. Laryngo-tracheoplasty as described by Evans JNG. The incision is carried in a step-wise fashion through the cricoid and the upper tracheal rings. A piece of silástic sheet is cut in rectangular shape leaving 2 small flanges on the upper border (a). The silastic sheet is curled upon itself like a "Swiss roll" and inserted to the reconstructed larynx as a stent (b), (c). The cartilaginous interdigitations are distracted and sutured in their new positions (e). The Swiss-roll is held in position by a transfixion suture in the position that the flange projects through the glottis (d).

ginous framework left, this technique will be unsuccessful.

Augmentation laryngotracheal reconstruction

When distraction of the laryngeal framework must be greater than 3 mm, the secondary intention healing by soft tissue fibrosis of this large area results in collapse and obstruction of the newly created lumen. Fearon B and Cotton RT[19] in 1972 reported an experimental surgical technique by using the thyrochondral trap door flap augmenting the split cricoid in monkeys. Pathological specimens showed the graft to be in good position and firmly attached at either end. Furthermore, the internal diameter of the cricoid lumen was significantly larger. Their progress report[8] in 1974 demonstrated successful operation in 2 patients. Cotton RT[6] reported in 1978 using autogenous costal cartilage graft to stabilize the expanded laryngeal framework with 90% success rate in 11 children. There have been many reports using different kinds of autogenous graft such as auricular cartilage, hyoid-muscular flap, etc. Lusk RP, et al.[14] used auricular cartilage from cymba conchae combining with a holding suture at both sites of the split cricoid to strap muscles or sternocleidomastoid muscles. They reported an 83% success rate over 23 patients with easy taking and minimal deformity of donor site compared to the costal cartilage graft. Because of the limits of the length of auricular cartilage, they did not recommend this technique for severe or long-segment stenosis. The stenosis should be short enough to allow a single auricular cartilage graft to span its length. However, costal cartilage is most commonly used because of its size and rigidity. The larynx may be augmented in the midline anteriorly, posteriorly or both. Lateral division of the cricoid is also possible to gain maximal expansion of the laryngeal framework. These cuts are made at 3 and 9 o'clock (Figure 3). No attempt is made to remove the scar, since doing so will produce a raw intraluminal surface.

The fifth costal cartilage is taken with intact perichondrium on the lateral surface. The deep surface perichondrium must be left intact to the chest wall to protect against pneumothorax (Figure 4). The anterior graft is considerably larger and thicker than the graft placed posteriorly. The perichondrium site of the graft must be positioned intraluminally. The strap muscles are the source of nutrient to the graft so adequate contact of both structures has to be maintained. The anterior graft is elliptic and secured with mattress sutures of 4-0 polypropylene monofilament, keeping the sutures extraluminal. Wide flanges are designed to prevent prolapse of the graft into the airway. The posterior graft must be in midline and sutured into place with 4-0 absorbable sutures with a small cutting needle.

A stent is placed to support the newly created lumen and cartilage graft for a period of 4-8 weeks. A Cotton-Lorenz stent made from medical-grade teflon is commonly used because it is biocompatible with human laryngeal tissue and does not cause irritation or granulation. It may be placed independently or as a complex with tracheotomy depending on the extent of the stenosis. After removal of the stent, the reconstructed larynx should be examined and a plan made for decannulation if the operation is successful.

Stent

Laryngeal stents often are required in laryngotracheal reconstruction to provide stability to the newly reconstructed airway, to minimize the shearing forces between opposing laryngeal structures, to force distraction of cartilaginous segments and to maintain mucosal grafts. The stable anterior cartilage graft augmentation may not need stenting.

The duration of stenting will vary depending on the purpose. A period of 3 to 6 months is required when the larynx has been divided and the distracted segments must be fixed by fibrosis to maintain the distraction. Cartilage grafting generally requires 4 to 8 weeks of stenting to allow enough intrinsic structural support to develop between the graft and the native laryngeal cartilage. Stenting of mucosal grafts requires 3 to 5 days of support.

There are many types of stent such as the Cotton-Lorenz rigid teflon stent, the Alboulker stent, Silastic roll, Montgomery T-tubes and nasotracheal tube. The superior end of the stent should be positioned above the false vocal cords and below the top of the arytenoid cartilages. The length of the

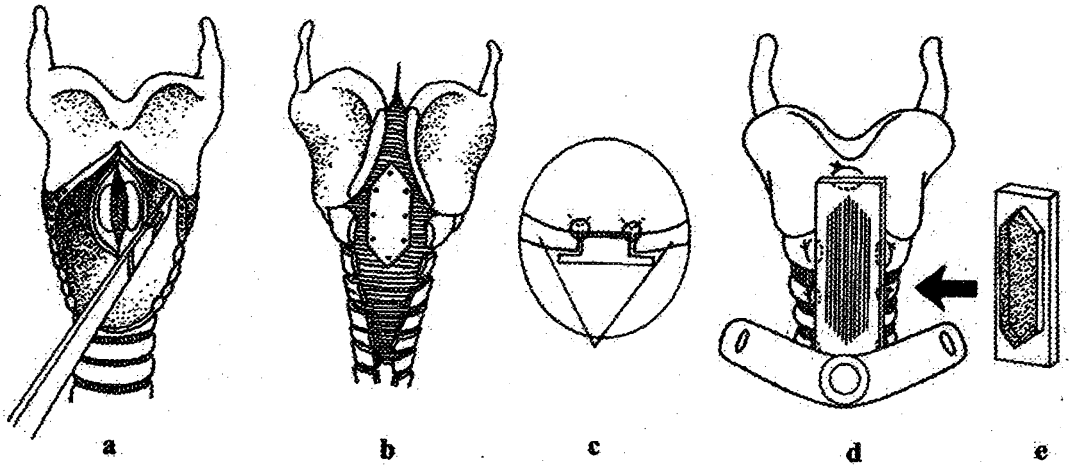


Figure 3. Midline laryngofissure allows visualization of the endolarynx. The cricoid plate may be also divided posteriorly and laterally at 3 and 9 o'clock (a). The larynx can be augmented anteriorly, posteriorly, or both (b), (d). The cartilage graft is sculptured in an elliptical shape placing the perichondrium side intraluminally (e). Wide flanges are created to prevent prolapse of the graft through the reconstructed lumen (c).

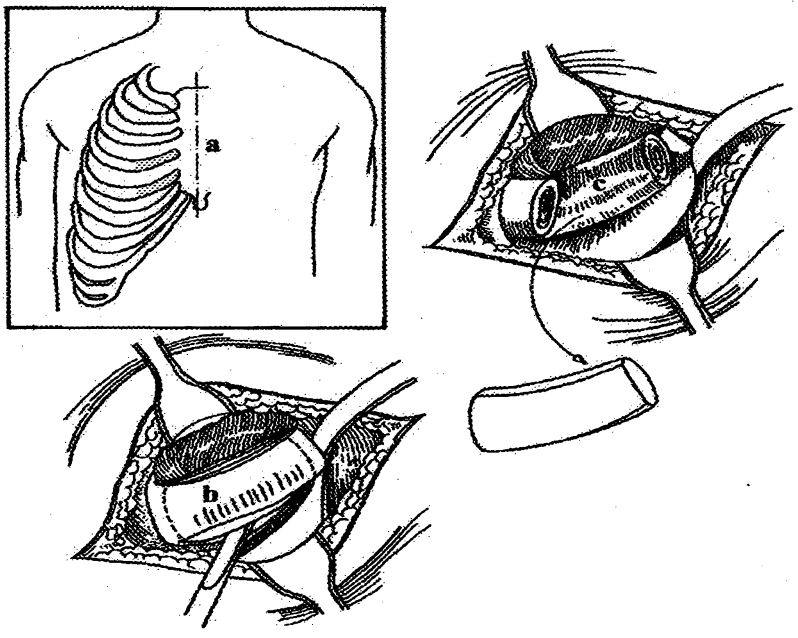


Figure 4. Harvesting a cartilage graft. The incision is made over the 4th - 5th costal cartilage (a). The outer perichondrium is preserved and attached to the harvested cartilage (b). The costal cartilage is dissected posteriorly in the subperichondrial plane, leaving the inner perichondrium in situ, in order to avoid penetration into the pleural space (c).

airway to be stented inferiorly depends on the underlying abnormality. It may be just superior to the tracheostoma or including the stomal area.

Single-stage laryngotracheal reconstruction (SSLTR)

This technique was first described in 1988 by Presscott CAJ.[20] In order to avoid tracheotomy and complications from a long-term stent, the third to the fifth steps of airway reconstruction are combined together. The larynx may be augmented anteriorly, posteriorly, or both with costal cartilage grafts. Tracheostoma is closed at the same time of the reconstruction. A nasotracheal tube is used as a stent and removed 7 to 14 days after surgery. This type of reconstruction, like an anterior cricoid split, should be done only in a center where postoperative airway intensive care is available.

Lusk RP, et al.[15] reported a 95% success rate and proposed the principles apply to SSLTR that

1. The surgeon must feel confident the cartilage graft is secure and will not prolapse or shift.
2. The entire length of the stenotic segment must be reconstructed.
3. The stoma and any suprastomal granulation tissue should be removed at the time of the procedure.
4. Placement of an endotracheal tube allows time for the initial healing of the graft and provides access for ventilation.
5. The sutures should not extend into the lumen of the trachea.
6. Because of possible air leak, the neck incision should never be fully closed.
7. The timing of the extubation is based primarily on clinical judgement of how successful the primary repair has been. A low-pressure air leak is an encouraging sign that favors successful extubation.

Postoperative period is the most important part of SSLTR. Most of the surgeons prefer to use neuromuscular blocking agent (NMB) to paralyze the patients in addition to sedative and analgesic agents.[5,3,20-22] Bauman NM, et al.[21] reported that using intermittent NMB lessened the degree of atelectasis and muscle weakness comparing to using continuous NMB. Cotton RT, et al.[13] and Rothschild MA, et al.[23] used titrated sedation and analgesia in patients younger than 3 years to prevent agitation and accidental self extubation, thus avoiding paralysis. He reported a 86% success rate in 104 patients and only 1 accidental self-extubation without mortality. The decision to use sedation with or without an NMB drug and the exact method of administration of NMB drug depend on characteristics of individual patient, as well as on the expertise and experience of the anesthesia/critical care team.[3] Using an NMB drug may avoid potentially catastrophic early extubation and decrease the shearing force at newly created subglottic lumen, but it may result in the problem of atelectasis and post-extubation neuromuscular weakness especially when combined with corticosteroid. Yellon RF, et al.[3] reported that the use of prophylactic antimicrobial agents (clindamycin plus anti-pseudomonal antimicrobials) during intubation after SSLTR significantly decreased perioperative infection complication.

Complications of atelectasis, opioid withdrawal symptom, wound infection, weakness, pneumonia and cortical blindness due to transient hypoxia from accidental intubation were reported in laryngotracheal reconstruction.[3,6,22]

Resection

It must be admitted that the success rate of augmentation laryngotracheal reconstruction in severe SGS (grade III –IV) has been disappointing. Severe stenosis may need more than one open operation with prolonged stenting, resulting in delay or even failure of decannulation. Surgeons have to modify their approach and resection of the stenosed segment may be a good choice to overcome this stubborn stenosis. A short-segment of the cervical trachea may be resected easily with primary anastomosis. But in subglottic stenosis, it is very difficult to perform the procedure due to the small size of the larynx and possible injury to the recurrent laryngeal nerve. In spite of many reports of successful partial cricotracheal resection with primary anastomosis in adult, there is concern about the pattern of growth and development of the resected laryngotracheal complex in pediatric patient.

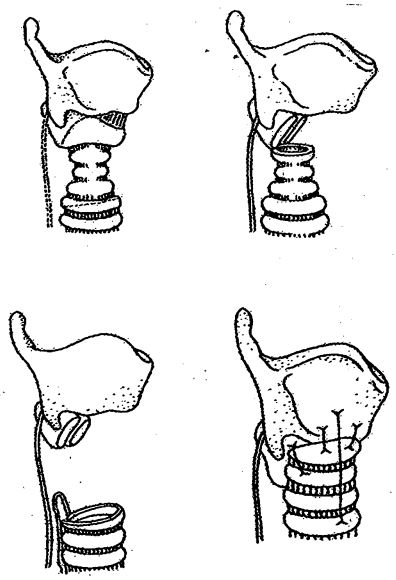


Figure 5. Diagram of partial cricotracheal resection with reanastomosis.

Monnier P, et al.[24] reported the Lausanne experience of 31 cases of partial cricotracheal resection (PCTR) with long-term follow up from 1978-1996. They showed a high decannulation rate of 97% without fatalities. Fourteen patients who were followed for more than five years reached adulthood with normal growth of the larynx and the trachea. The report from Cincinnati also showed the same results.[25,26]

Surgical resection of the cricoid is performed in a subperichondrial plane using a vertical anterior midline incision of the cricoid perichondrium. Lateral border of the resection margin is limited to just anterior to the cricothyroid joint in order to avoid recurrent laryngeal nerve injury. The superior resection line starts at the inferior border of the thyroid cartilage while the inferior border includes all the stenotic segments of the upper trachea (Figure 5). After the resection is complete, the posterior cricoid plate is exposed. If there is a thickening from submucosal fibrosis, a submucoperichondrial resection of the fibrotic scar could be done and a diamond burr may be useful for thinning the posterior cricoid plate. This allows the healthy upper tracheal ring to adapt itself to the narrower subglottic space. The resected cricoid can sometimes be used recycled as a cartilage graft augmenting anteriorly or posteriorly. Postoperative care is still the most important part leading to decannulation. PCTR may be performed as a single stage or two stages procedure as the expansion technique depending on the extent of the stenosis, condition of the patient, surgeon preference and facilities of the institution.

Conclusion

Knowledge of the pathophysiology and techniques of surgical reconstruction make surgeons able to treat laryngotracheal stenosis. Successful treatment requires a multidisciplinary approach including thorough endoscopic examination, assessment of the patients' general medical condition, expertise in surgical technique, intensive postoperative care under supervision by an anesthesiologist, and proper respiratory physical therapy program after decannulation. It is of the utmost importance to prevent, not to treat, laryngotracheal stenosis from endotracheal intubation. Great care must be taken in children who need prolonged intubation in order to minimize the contributory factors of laryngotracheal stenosis and convert to tracheotomy at the proper time.

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