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Introduction

Subglottis Stenosis is a disease that has seen considerable decline in its incidence over the last several decades. Improved intubation and ventilator techniques have significantly aided in decreasing the trauma to the subglottic region and have been pivotal in decreasing the disease process. Despite these improvements in subglottic stenosis rates, prolonged intubation, caustic ingestion, infections, thermal inhalation and autoimmune disease continue to play a role.

Also changing over the last several decades is the introduction of endoscopic techniques that have been used to treat more mild forms of disease. In this discussion we will focus on the treatment of patients with advanced or recurrent disease.

Background and History

With any disease process it is appropriate to begin with definitions. Subglottic stenosis is defined as narrowing of the airway below the true vocal cords and this can be either congenital or acquired. The subglottis is described as being 10mm inferior to the anterior commissure and 5mm inferior to the posterior commissure since the glottis itself is tilted. Normal lumen diameter in an infant is described at 4.5mm to 5mm in diameter with less than 4mm in a full term infant being considered stenotic and less than 3.5mm in a premature infant being considered stenotic (1).

The subglottis is the most susceptible area to be injured for several reasons. The first is that in infants and children it is already the narrowest part of the airway. The second is that its structure is composed of a complete cartilaginous ring as opposed to the trachea which is muscular posteriorly. Third the mucosa is lined by pseudostratified columnar epithelium which is very fragile and easily disrupted.

Despite breathing being the most important thing involving any trauma algorithm, the larynx has several other functions as well. It is important for protection against aspiration while swallowing as well as coughing when aspirated material is introduced. It is important for phonation and communication as we all know. Finally it is important for maintaining PEEP and being able to perform a valsalva. This last function is important when a patient goes to pick up a heavy object or strain. Without the valsalva it is very difficult to perform this task.

The anatomy of the larynx is much different between adults and children and should be discussed. The larynx is proportionally larger in children, it is positioned higher in the neck, and as stated earlier, the narrowest portion is the subglottis. In the adult the smallest portion is the glottis. As for positioning, in pediatric patients the larynx is at the second cervical vertebrae however in adults it rests at the sixth cervical vertebrae. Finally normal laryngeal function is even more important in the pediatric population because their epiglottis is more floppy than that of adults leading to increased risk of aspiration.

Embryologically the larynx is derived from the 4th and 5th branchial arches. It develops as an outgrowth from the primitive pharynx. A laryngotracheal opening occurs between the two arches and three masses form: hypobranchial eminence and the paired arytenoid masses. The hypobranchial eminence develops into the epiglottis and the arytenoid masses become the arytenoids. Once these masses have formed, recanalization occurs between the trachea and pharynx and if incomplete can lead to atresia, stenosis or web formation. As a side note, the arytenoid masses are separated by an interarytenoid notch which creates a cleft if it does not obliterate. This can lead to multiply recurrent bouts of aspiration pneumonia and should be looked for in any airway evaluation (2).

The most important thing to think about when dealing with a child who has airway issues or breathing difficulties is Poiseuille's Equation stating that resistance to airflow is inversely proportional to the radius quadrupled. Therefore in children who already have a small airway, a significant increase in the work of breathing can occur with just 1mm of edema or stenosis. Therefore we must be much more cautious in children given their smaller airway size.

$$\text{Resistance} = (n \times L) / r^4$$

Epidemiology, Characteristics of Disease and History

As stated earlier, there are two main causes of subglottic stenosis, congenital and acquired. Congenital subglottic stenosis represents only about 5% of all cases of subglottic stenosis. This occurs due to inadequate recanalization of the laryngeal lumen in the 3rd month of gestation. It can be further sub classified as being either membranous or cartilaginous.

The membranous form tends to be more circumferential and is not really related to an inflammatory cause. It is generally thought to be due to hyperplastic mucous glands and fibrous tissue hypertrophy. It often occurs about 2-3mm below the true vocal cords but can extend superiorly to involve the glottis. The cartilaginous form however, tends to grow in a more anterior to posterior direction leaving a small posterior opening present. This is therefore more variable and commonly involves the cricoid cartilage region only.

Acquired subglottic stenosis, however, represents about 95% of all cases and 90% of these cases are due to intubation trauma. Other causes include blunt trauma, smoke inhalation, caustic lye ingestion, chronic infections (TB, syphilis, leprosy, typhoid fever, etc.), chronic inflammatory diseases (sarcoid, lupus, Wegener's, GERD, and rheumatoid arthritis), and finally laryngeal neoplasms.

The incidence of subglottic stenosis following intubation has been reported anywhere from 0.9% to 8.3%, but again this is a vast improvement from the 1960's and 1970's where the incidence was around 12-20%. Low birth weight and children with RDS still have abysmal numbers compared to the regular pediatric population with rates up to 44%. Factors leading to subglottic stenosis secondary to intubation include: number of intubations, the size of the tube, the duration of intubation, and pressure

necrosis of the cuff. In 1985 Whited showed that the rate of stenosis increased dramatically as the number of days intubated increased (3).

2-5 days →0-2% stenosis
5-10 days →4-5% stenosis
>10 days →12-14% stenosis

Pathophysiology

Congenital subglottic stenosis occurrence is relatively straightforward, with failure of the laryngeal lumen to recanalize during the 3rd month of gestation, however acquired is generally due to the easily repeatable phrase, “necrosis, fibrosis, stenosis.” It all starts with tissue injury which leads to edema, ulceration, and necrosis of the tissue. This injury to the mucosa leads to mucociliary stasis instead of clearance with secondary infection and perichondritis ensuing. Once infection and perichondritis set in, granulation tissue, proliferation, and scarring occur leading to laryngeal dysfunction and increased susceptibility to injury. This increased susceptibility eventually also leads to addition tissue injury, thus propagating the cycle. Ultimately this laryngeal dysfunction leads to airway, voice, and feeding abnormalities that must be addressed.

Workup

When obtaining a history on these patients it is important to discuss things such as birth history, prematurity status, previous intubation history, feeding/voice/breathing difficulties, symptoms of reflux, recent infections, autoimmune diseases, and other systemic symptoms to suggest chronic inflammatory conditions.

Initial presenting signs and symptoms of subglottic stenosis generally begin with airway complaints such as biphasic stridor, dyspnea, air hunger and retractions if the obstruction is bad enough. Voice complaints include an abnormal cry, hoarseness, and aphonia especially if there is concurrent glottis stenosis. Finally dysphagia and recurrent aspiration pneumonia can be the presenting complaint. Patients with acquired subglottic stenosis generally present within 2-4 weeks of the initial insult or trauma, however if the stenosis is only mild, they may not present until they have a second insult such as an upper respiratory tract infection or additional intubation for further surgery.

Noisy breathing is one topic that should be covered at this point because it is important to be able to differentiate “noisy breathing” or “stridor” consults based on when the stridor is heard. Speaking in generalities, inspiratory stridor is due to an obstruction in the supraglottis or glottis, expiratory stridor is due to tracheal or distal stenosis, and biphasic stridor is due to subglottis stenosis. These simple tips will help you triage consults and narrow your diagnosis.

Once a proper history and physical exam has been performed flexible nasopharyngolaryngoscopy can be performed to help identify the area of obstruction causing the noisy breathing. The nose can be evaluated for signs of pyriform aperture stenosis or choanal atresia. The supraglottis can be evaluated for laryngomalacia. The glottis can have clefts/webs/atresia/masses and can also show asymmetry of vocal cord dysfunction. Finally the immediate subglottis can be identified and you may pick up subglottic masses or a stenosis if the lesion is not too far distal.

Radiologic evaluation has been shown to be useful in certain situations. Especially in a child, a high voltage plain film can easily show the region of airway stenosis, is relatively quick and is very cost effective in children. CT and MRI are both very helpful with regards to surgical planning. They give excellent detail regarding the length and severity of the lumen obstruction, but are pretty difficult to

perform in children given the need for sedation and for the patient to sit still. Ultrasound has become a very useful bedside tool to quickly identify the lumen diameter and length of stenosis, however these are very operator dependent.

In 2006 Carretta et al. compared preoperative CT findings with intraoperative rigid endoscopy finding. They found that although CT scan is good, rigid endoscopy is better at characterizing the extent of stenosis as well as better visualization of the vocal cords, thus confirming it as the gold standard form of evaluation (4). During rigid endoscopy there are several things that are important to keep in mind and document in order to maximize your understanding of the disease process.

1. Outer diameter of the largest ET tube or bronchoscope that can be passed.
2. Location and length of stenosis
3. Reflux changes
4. Other airway abnormalities
5. Minimize damage to normal tissue

Keeping these 5 things in mind will be helpful when planning further treatment and it is of the utmost importance to prevent damage to surround normal mucosa because any additional insult may worsen the stenosis to a point where more aggressive means of therapy are warranted.

Aside from the above stated tests, several other ancillary tests can and should also be performed prior to therapy when specific causes of stenosis are suspected. Lab tests including PPD, RPR, C-ANCA, ANA and other rheumatologic testing can be helpful. Reflux diagnosis is really important especially when treating these patients postoperatively. Therefore knowing the severity of reflux with a 24 hour PH dual probe test is helpful. EGD with biopsy can be performed for suspected esophagitis. Modified barium swallow and functional endoscopic evaluation of swallowing are both important to have a baseline to compare postoperative function. Finally PFT's can be used to follow postoperative improvement in variable extra thoracic obstruction.

Reflux is a big issue that is believed to play a significant role not only in the progression and failure of treatment for subglottic stenosis, but also as the inciting continued insult leading the way for the formation of the disease. In 1991 Koufman showed that 73% of patients with subglottic stenosis had abnormal pH probe results and that 67% of these patients had abnormal upper pH probe results (5). Walner in 1998 looked at 74 pediatric patients and found that patients with subglottic stenosis had a 3 fold higher incidence of reflux compared to the general population (6). Speculation as to which came first or if there was direct correlation was not performed however the general consensus has evolved so that nearly all patients with stenosis are treated for reflux to prevent recurrence or progression (7).

Grading

Once you have performed a full workup and a rigid endoscopy has been performed to fully characterize the lesion it is important to stage the lesion. There are 3 grading systems available. The first is the Cotton-Meyer grading scale and this one is the most commonly quoted however it does not take into account the length of the obstruction. The scale can be found below.

- Grade I – 0-50% narrowing
- Grade II – 51-70% narrowing
- Grade III – 71-99% narrowing
- Grade IV – Complete obstruction with no lumen

The grading system by Lano was described in 1998 and is based solely on the number of subsites involved in the stenosis (8). Subsites include the glottis, subglottis, and trachea. It does not take into account length or diameter of stenosis. The scale can be found below.

- Grade I – one subsite involved
- Grade II – two subsites involved
- Grade III – three subsites involved

The third and final grading system was described by McCaffrey in 1992 (9). His grading system was based on subsites and the length of stenosis but not on lumen diameter. Again the subsites include glottis, subglottis, and trachea. Below is a description of his grading system.

- Grade I: Confined to the subglottis or trachea and less than 1cm
- Grade II: Isolated to the subglottis and greater than 1cm
- Grade III: Subglottic and tracheal lesions not involving the glottis
- Grade IV: Glottic involvement

Lano compared these three grading systems by reviewing 41 cases of LTR in adults. He classified patient lesions with all three grading systems and found an overall 80% decannulation rate. Surgical outcome was significantly correlated with the Lano and McCaffrey grading system, but not with the Cotton-Myer system. The best predictor of surgical outcome, however, was obtained by multiplying the value from the Lano and the Cotton-Myer systems. This was believed to be due to the fact that subsite and circumference were both included in the severity of lesion suggesting more of a 3D model (8).

Ultimately the key to grading a stenotic region is more for counseling purposes because a good surgeon is going to characterize all parts of the lesion including circumference, subsite and length to optimize options for each individual patient.

Management

The goals of treatment for subglottic stenosis are three fold and should include the following:

1. Produce an adequate airway
2. Preserve a competent larynx
3. Produce an acceptable voice

Each of these goals are important however the goals are a stepwise fashion that should be assessed only after the previous one is achieved. I liken this relationship to that of head and neck cancer where cancer extirpation is the most important goal but closely following include function and then cosmesis.

Tracheotomy and Anterior Cricoid Split

In the 1900's most subglottic stenosis was secondary to infection and was treated primarily with tracheotomy. In the 1950's and 1960's there was a significant increase in the incidence of subglottic stenosis due to intubation practices and tracheotomy remained the standard of treatment. Tracheotomy related mortality was high. In the 1980's however Cotton described the anterior cricoid split as an alternative to tracheotomy. Over the last 15-20 years additional techniques have been described including laryngotracheal reconstruction using single stage techniques, and most recently endoscopic techniques have emerged as viable options for initial treatment of mild disease.

As stated previously maintaining an adequate airway is the most important thing when taking care of patients with subglottic stenosis. Tracheotomy therefore remains the mainstay of initial treatment and decannulation is only performed once adequate airway has been recreated. It is important to use the smallest tube that permits ventilation as well as air leak for phonation if possible. Tracheotomy is usually just temporary but it is important to consider removing suprastomal granulation tissue prior to decannulation.

Although this discussion is primarily about advance surgery, endoscopic techniques are important for initial low grade management. Dilation and scar excision with either cold knife or laser have been most commonly used. Adjuvant therapy with steroid injection or topical mitomycin C therapy has also been popularized recently. Endoscopic therapy is mainly reserved for grade I or II stenosis and many times can prevent the need for tracheotomy in non-emergent cases. Although endoscopic techniques are good initial options, a study by Herrington in 2006 showed that 70% of patients require repeated procedures to maintain adequate airway (10). Therefore it is important to counsel patients that although they airway is patent they likely will need revision surgery.

In 1980 Cotton described the anterior cricoid split as an alternative to tracheotomy (11). The procedure involves exposing the anterior cricoid ring and dividing it with the first two tracheal rings. The neck is then closed with an endotracheal tube in place to act as a stent for healing. The patient is then left in the ICU intubated for 7-14 days. In order for patients to be good candidate for this procedure Cotton documented a very strict set of criteria.

1. Extubation failure on 2 or more occasions
2. Weight greater than 1500g
3. No assisted ventilation required for 10 days prior to the procedure
4. Oxygen requirement less than 30%
5. No signs of CHF for over 1 month
6. No signs of acute URI
7. No antihypertensive medications for over 10 days

Cotton described this procedure as being best for mild anterior narrowing

External Expansion Surgery

Because anterior cricoid split is generally reserved for anterior obstruction only grade III and IV stenosis requires more aggressive surgical management. This is in the form of external expansion surgery and it combines splitting of the cricoid with cartilage grafting and stents. Success rates, defined by decannulation, have been reported around 90%, and it is important to perform these procedures at the youngest age possible in order to allow improved speech and language development.

Anterior laryngofissure with cartilage grafting is the first option for expansion. It is indicated for stenosis that is mainly anterior or associated with collapse of the anterior cartilaginous wall. The approach is essentially the same as that of the anterior cricoid split however a cartilage graft is placed into the laryngofissure to expand the stenotic segment. This can be extended to include division of the thyroid cartilage and larynx as well if necessary, however meticulous re-approximation of the vocal cords is vital to maintaining an adequate voice. The perichondrium of the cartilage graft is placed on the lumen side of the airway in order to aid in re-epithelialization as well as act as a barrier to infection. The sutures used are placed through only the cartilage so as not to disrupt the perichondrium or mucosa, and an external flange of cartilage is often utilized to prevent prolapse of the cartilage into the airway (modified boat graft). Prolapse has been described despite the use of sutures.

Expansion surgery requiring posterior cricoid division and grafting is reserved for more severe cases and almost always requires division of the thyroid cartilage (laryngofissure) in order to gain access to the posterior cricoid ring. This operation is reserved for patients with posterior subglottic or glottic stenosis, circumferential stenosis, and cricoid deformities. Again it is important to avoid complete laryngofissure to avoid damage to the anterior commissure. Many advocate for stenting up to 3-6 months for posterior grafts and some do not place sutures because they rely on grafts to aid in healing.

Overall decannulation success rates have been described at 86-100% with grafting techniques (13-15). Younis actually broke success rates down by site and showed that anterior grafting success rates were 100%, anterior plus posterior grafting success rates were only 83%, and revision case success rates were 70% in their series (14). This stands to show that as the amount of stenosis and complication of the procedure increases, success rates fall as would be expected.

Over the past 10 years there has been considerable debate on whether patients should undergo single stage (SS-LTR) or double stage (DS-LTR) procedures. SS-LTR allows for immediate decannulation in the postoperative period. Patients are generally left intubated in the ICU for about 1 week postoperatively while the graft heals in place, and this can be performed in patients receiving anterior grafts, posterior grafts, or both. Patients generally have best results if they weigh greater than 4kg and are over 30wks old. DS-LTR is only different due to the use of long term stents. Patients are therefore not decannulated postoperatively however they also don't require a weeklong stay in the ICU under heavy paralysis and sedation. Stents are usually left in place for months.

Several authors have compared SS-LTR and DS-LTR. Saunders in 1999 reviewed his series of patients and found that patients undergoing DS-LTR has more severe stenosis (average grade 2.56) with previous laryngeal surgery whereas patients undergoing SS-LTR had less severe stenosis (average grade 2.14) with significantly better decannulation rates and significantly fewer postoperative procedures (12). In 2010, however, Smith looked at 71 patients, 22 SS-LTR with average grade of 2.1 and 62 DS-LTR with average grade of 2.9 (13). They showed that although operation specific decannulation rate was significantly better for SS-LTR (91% vs 68%), overall decannulation rate was not statistically significant (100% vs 93%).

From these two studies it is important to recognize that each case of laryngotracheal stenosis is different and that not all cases can be treated with a single stage procedure. Therefore it is up to the experienced surgeon to make a judgment call as to whether a patient will tolerate decannulation on a single stage or if multiple operations will be required.

Grafts and Stents

Cartilage grafts commonly used to expand the airway have generally relied on the costal cartilage as the workhorse for this disease. Rib grafts are abundant and you can generally harvest any size necessary. The fifth rib is the one most commonly harvested and the complication rate is low. The biggest things to watch out for are pneumothorax and hematoma formation. Other cartilage sources have been described such as auricular cartilage, thyroid alar cartilage and the hyoid bone, but again costal cartilage is the main player used.

Although cartilage grafts are sutured into place, stenting is very important to hold the grafts in place while they heal. Stents have been shown to counteract scar contractures and they hold grafts in place and improve success rates. The two most common stents used are Montgomery T tubes (silastic) and Albouker stents (Teflon). Endotracheal tubes are used as stents in the short term for SS-LTR cases. T tubes are generally reserved for adults because they have an increased risk of blockage in children. Some consider stents to be inert and therefore have a low risk of granulation tissue formation but many believe that any persistent foreign body in the airway will lead to at least some granulation tissue formation.

In 2006, Nouraei et al looked at the stent colonization in patients who had been stented after cartilage grafting. They found that colonization with either *staphylococcus aureus* or *pseudomonas aurigenosa* showed increased risk of granulation tissue formation (16). Duration of stent placement and polymicrobial colonization with normal oral flora did not correlate with granulation tissue formation. This is why postoperative antibiotic coverage is recommended against *staphylococcus aureus* or *pseudomonas aurigenosa* is recommended for 1 week postoperatively.

Cricotracheal Resection (CTR)

For cases that are completely resistant/recurrent despite other interventions or for severe grade IV stenosis cricotracheal reconstruction has become the mainstay of therapy. It was not always that way however. In 1953 Conley described the 1st CTR in adults however the procedure was not performed in children until 1978. CTR is best tolerated in patients with isolated tracheal/subglottic stenosis without involvement of the glottis, and is well tolerated in patients with grade III or IV stenosis.

The procedure begins with the same anterior approach as before, however a larger incision is made to accommodate the amount of dissection that will occur. Care is specifically taken to identify and preserve the recurrent laryngeal nerve bilaterally to provide the best chance of voice postoperatively. The actual resection begins anteriorly just beneath the inferior border of the thyroid cartilage. The incision is carried posterolaterally and in an inferior direction so that the posterior portion of the cricoid ring is left intact. At this point the party wall between the trachea and esophagus is entered and dissected inferiorly past the stenotic tracheal region. The stenotic region is then truncated and dissected free from the soft tissue inferiorly. Once freed inferiorly, the trachea is sutured to the remaining cricoid and thyroid cartilages at many levels in order to hold the anastomosis in place.

In 2005, White et al look at risk factors for failures when performing CTR (17). Patients had either grade III or IV stenosis in 96% of the cases and they reported a 94% decannulation rate. They found that vocal cord paralysis postoperatively was the only finding that was statistically significant for preventing decannulation. Other factors such as Down Syndrome, tracheostomy tube present at the time of CTR, and use of chin to chest sutures to prevent strain on the anastomosis played no role. Interestingly eosinophilic esophagitis was significantly associated with poorer decannulation rates, however there were not enough patients with eosinophilic esophagitis to analyze appropriately.

Complications are not uncommon following CTR and Rutter et al described their complication rates in 2001 (18). They found that anastomotic webbing was found in almost all cases, similar to that of suprastomal granulation tissue with tracheostomy, and that it was usually asymptomatic. They found arytenoid prolapse in 45% of cases but only 40% were symptomatic requiring partial laser arytenoidectomy. Restenosis occurred in 20% of patients and 11% of their patients were tracheotomy dependent. Postoperative infection and recurrent nerve injury occurred in 5% of cases, and there were no reported cases of anastomotic dehiscence.

Just as decannulation rates are important to discuss, so are airway, voice and swallowing outcomes because these are again, the 3 functions we wish to preserve with surgery. Jacquet et al (2005) showed that 95% of patients were free of exertional dyspnea after CTR. In terms of voice 21% had no vocal abnormalities, 49% had mild dysphonia, and overall 70% showed postoperative improvement. Finally, 89% of patient showed postoperative improvement in swallowing (19). The key to remember here is that although airway and swallowing have very good success results, voicing continues to be an issue for many patients and it is important to counsel them that you will likely make the voice better but that it may not every be “normal.”

Studies have shown that the earlier the surgery the better the quality of life, decreased financial burden on families, improved long term speech and language development, and no chance of accidental death from tracheostomy plugging (20). In 2010 Ikonomidis et al performed a study looking at CTR in children weighing less than 10kg to see if earlier surgery was safe. He performed a retrospective review on 36 patients weighing less than 10kg (average 8.8kg, smallest 4.4kg) and compared this group to a similar group of children weighing greater than 10kg (65 patients). The majority of patients were between 1 and 2 years old however 11 patients were less than 1 year old. Decannulation rates in 27 patients treated with single stage vs double stage CTR was 100% vs 92% respectively. He found no statistical significance in decannulation or complication rates between the two groups suggesting that children less than 10kg are safe to undergo this procedure.

Postoperative Care

As expected with any specialized surgery, every surgeon has their own way of management postoperatively. A review article by Gupta in 2010, however, put forth some basic guidelines based on a literature review for postoperative care of patient undergoing airway reconstruction. Below is a summary of their recommendations (21).

1. ICU with specialized staff to care for patients
2. Nasotracheal intubation for 7-14 days
3. Sedation and paralysis is necessary but should be used as sparingly as possible.
4. Steroids should be started 12 hours before and continued for 5 days after decannulation.
5. A leak test should be performed prior to extubation to ensure adequate airway.
6. Precedex used during the tracheal extubation helps prevent complications and actually decreases the need for sedation.
7. Antibiotics should be given for 2 weeks if stenting is not performed and for months if stenting is performed.
8. All patients should receive anti-reflux therapy.
9. Enteral feeding should be initiated as soon as possible.
10. Chest physiotherapy and log rolling is important to prevent lung complications
11. You must have a high index of suspicion for nosocomial infections in order to prevent complications.

Conclusion

Subglottis stenosis is a common problem in patients stricken with prolonged intubation and each patient needs an appropriate workup with the most important part being a rigid endoscopy to characterize the lesion. Management is driven by grading and airway is always the most important thing to remember when managing these patients. Tracheotomy remains the mainstay of treatment for acute airway obstruction, however endoscopic techniques have recently helped prevent tracheotomy in non-emergent and low grade lesions. Grade III and refractory cases require some form of reconstruction with anterior and posterior grafting being most commonly used. Grade IV reconstruction requires cricotracheal reconstruction. Single and double stage procedures are both viable options however every patient is different and you must consider the lesion you are dealing with prior to categorically choosing a path for the patient.

Finally it is important to maximize speech and swallowing postoperatively. Although these are secondary goals they are just as important to the patient in terms of quality of life. Therefore early and prompt treatment of the disease to allow for appropriate development is key to a successful outcome.

Comments by Dr. Underbrink on presentation by Dr. Coughlin on Subglottic Stenosis

That was a very nice talk, Dr. Coughlin on the surgical management of advanced and recurrent subglottic stenosis . The boards always quiz you on Cotton-Meyer grading scale and that helps us decide on whether to use balloon dilation before entering on more definitive surgical interventions. The McCaffrey staging system is perhaps more important as the length of the stenosis tends to determine what kind of success you're going to have. If the length is longer than 2 centimeters, we're probably not going to be able to manage those children with dilation alone and open repair will be necessary.

Postoperative management is important in that you're going to have to keep these children sedated for seven to ten days before extubation, with physiotherapy directed to the prevention of atelectasis and pneumonitis. Sedation of adults need not be for as long a period, however.

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