Posterior cricoid split with costal cartilage augmentation for high subglottic stenosis

T. Pradhan · Sikka Kapil · A. Thakar

Abstract

Background Stenosis of the upper subglottis presents special problems. Its vicinity to the vocal folds leads to a high incidence of vocal fold fixation, and also precludes surgical treatment by cricotracheal resection and anastomosis

Objective To describe the experience with posterior cricoid split and insertion of free costal cartilage graft in the treatment of high subglottic stenosis and posterior commissure glottic stenosis.

Setting Tertiary care university hospital.

Methods Four cases with Grade III/ IV high subglottic stenosis/ posterior commissure glottic webbing recalcitrant to previous surgical therapy treated with posterior cricoid split and insertion of free costal cartilage graft by a laryngofissure approach. Temporary airway stenting for 4 months post surgery with a silicone T- Tube.

Results Successful restoration of the airway and decannulation in all 4 cases.

Conclusion Grade III or IV stenosis of the upper half of the subglottis is successfully treated in a high proportion of patients with posterior cricoid split and augmentation with costal cartilage free graft.

Keywords Cricoid Cartilage · Stenosis · Graft

Key messages Posterior Cricoid Split and costal cartilage augmentation is a reliable and effective method for treatment of cases with high subglottic and posterior glottic stenosis

Introduction

Significant grade III / IV stenosis of the upper 1/3 to 1/2 of the subglottis presents a difficult clinical problem. Similar stenosis of the trachea and the lower half of the subglottis are currently best managed by segmental excision of the scarred length and end to end anastomosis of the anatomically normal remnants (cricotracheal resection and anastomosis). Such a technique is however not applicable to situations wherein the stenosis extends to the superior subglottis. A circumferential resection here would necessarily involve part or all of the vocal folds, and necessarily impair phonation and risk life threatening aspiration.

The option of surgical excision of the scarred areas being unavailable in this situation, surgical procedures have therefore been restricted to techniques aiming at coring or restoration of lumen in the scarred segment. Techniques used range from laser vaporization of the scarred tissues combined with luminal stenting [1], to laryngotracheal reconstruction (LTR) with an anterior or posterior cricoid split and augmentation of the cricoid arch with an anterior costal cartilage graft [7–11]. The results employing laser surgery have been proved disappointing in cases of extensive subglottic stenosis [9]. The prognosis is especially poor for the subglottic stenosis with circumferential scarring, vertical scars with a depth of 1 cm or more and cases with arytenoid fixation [1, 9, 12].

In recent times we have applied the surgical option of Posterior Cricoid Split with costal cartilage interposition to four cases with high subglottic stenosis. Our experience with this operation in these four cases has been uniformly

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successful- even in cases which were previously recalcitrant to surgical treatment. The experience is reported here.

Methods

All four cases of high subglottic stenosis managed at our institution with posterior cricoid split and costal cartilage augmentation are reported. All were previously tracheostomised with the duration of tracheostomy ranging from 4 months to 8 years. Three of four cases had had previously unsuccessful attempts at surgical restoration of the airway with the number of such procedures ranging from one to four.

Pre-operative evaluation of the airway was by initial skiagram and CT scanning and by rigid endoscopy under anaesthetic. All cases had grade III to IV stenosis, in addition all had immobile vocal folds which were fixed in the median/ paramedian position. The fixation of vocal folds was consequent to scarring in the superior subglottis involving the conus elasticus, or from scarring in the glottic posterior commissure.

The previous treatments and the description of stenosis for each patient are summarized in Table 1. Other significant features of each case are briefly discussed in the following individual case descriptions. The surgical procedure is described in conjunction with case 1. The size of the costal cartilage graft used measured approximately 20mm X 10mm x 5mm (*length X breadth X thickness*) in adults and slightly less (15mm X 7mm X 4 mm) in the pediatric case (case 1). A silicon T-Tube was used to stent the lumen and to support the cartilage graft for 4 months in all cases.

Case 1 A girl child, when aged two (1998), suffered an accidental fall resulting in a strangulation injury to the neck. Respiratory distress ensued, leading to a tracheotomy at the local hospital. Subsequent evaluation led to a diagnosis of bilateral abductor palsy and repeated surgical operations were undertaken over the next few years, including procedures at our institution (Table 1). Endoscopic evaluation in 2004 indicated glottic and subglottic stenosis, with a thick posterior commissure web extending to the subglottis and a grade III pin-hole subglottic lumen.

Surgical Procedure The patient was taken up for posterior cricoid split with costal cartilage augmentation of the posterior cricoid lamina. Following a vertical laryngofissure through the thyroid cartilage, the posterior glottic web was divided by sharp dissection and the cut further deepened through the full thickness of the cricoid lamina. Incision of the cricoid lamina extended from just below the interarytenoid area to the lower end of the cricoid lamina. Special care was taken to ensure that the interarytenoid mucosa was preserved and also the postcricoid mucosa immediately posterior to the cricoid incision remained uninjured. The costal cartilage of the 5th rib was then harvested and fash-

ioned to size. The perichondrium on the cartilage was preserved, and the two lateral edges drilled so as to create wide vertical concave grooves on each side. The two edges of the sectioned cricoid lamina were then distracted and the costal cartilage graft wedged in in the space so created (Fig. 1). The lateral grooves created in the cartilage graft prevented antero-posterior displacement of the graft, and the graft was further fixed by passing two monocryl sutures from the graft to the distracted cricoid lamina. It was ensured that the inner, lumen facing, surface of the graft was lined with smooth perichondrium.

A silicon T- tube was inserted through the preformed tracheostoma with its upper end in the subglottis and glottis, so as to stent the lumen and to support the cartilage graft. The T- tube was kept for a period of 4 months.

Case 2 A 20 year old female suffered accidental strangulation in April 2003, leading on to respiratory distress and a tracheotomy at the local hospital. On subsequent referral to our institution, she was noted to have Grade IV stenosis extending from 3 mm below the vocal folds to the 2nd tracheal ring with both vocal cords fixed in the paramedian position.

At surgery, in April 2004, the superior two rings of the trachea were found to be deficient and replaced by fibrous tissue and the cricoid arch was thickened and distorted. Repair was undertaken by subglottic augmentation by anterior and posterior cricoid split and costal cartilage grafts (two separate cartilage grafts – one inserted in the split posterior

Fig. 1 Schematic diagram of posterior cricoid split and placement of cartilage graft.

- Laryngofissure with posterior cricoid split (left)
- Fashioned costal cartilage graft used for the procedure (middle)
- Graft interpositioned between the distracted ends of the posterior cricoid lamina showing the widened subglottis (right)

cricoid lamina, and another in the anterior cricoid arch), and also resection and anastomosis for the tracheal stenosis (resection of tracheal rings 1&2 and anastomosis of 3rd tracheal ring to the distracted portions of the cricoid lamina and arch).

Case 3 A 11 year old boy suffered accidental strangulation injury in 1997 resulting in laryngotracheal injury and a tracheotomy. Multiple operations since, both at the local hospital and at our institution proved unfruitful. By mid 2005 he had B/L fixation of the vocal cords with posterior commissure scarring and the right arytenoid over-riding and fixed to the left arytenoid, and a grade IV stenosis of the upper subglottis.

Access to the subglottic lumen was obtained by a laryngofissure. Surgical insult to the anterior cricoid arch was avoided as this had been previously reconstructed by an anterior cricoid split with costal cartilage augmentation, and so the laryngeal cartilage incision was limited to a vertical midline thyroid cartilage incision. The glottic chink was followed posteriorly to the posterior commissure and the scar tissue in the posterior commissure and the subglottis divided by sharp dissection. The cricoid lamina was then sectioned through its full thickness, and the costal cartilage graft wedged in.

Case 4 A 26 year old male suffered a road traffic accident resulting in comminuted fractures of the laryngeal cartilages. Following a tracheotomy and repair at the local hospital, on referral to our facility he was noted to have significant webbing at the glottis and upper subglottis and immobile vocal folds. Initial excision of the anterior web and keel placement proved unsuccessful, and the patient had a subsequent posterior cricoid split with costal cartilage graft insertion (Fig. 3).

Results

All 4 cases had a silicon T-tube stent after surgery for duration of 4 months. Following removal of the tube all cases demonstrated an adequate laryngeal airway and were decannulated (Table 1). Two cases (case 1 and case 3) had been tracheostomy dependent for significant periods of their childhood prior to decannulation. Over a follow up period ranging from 6 months to 2 years since decannulation, all continue to be free from respiratory obstruction.

Endoscopic evaluation indicated the subglottic airway to be normal/ near normal in all (Table 1; Fig. 2). Previously immobile vocal cords in 2 cases became mobile and these achieved good voicing. The vocal cords in 2 other cases remained immobile, but were adequately distracted in the posterior commissure to enable a wide posterior lumen (Table 1). The voice in these cases remained harsh and breathy.

No patient reported of aspiration and all can swallow normally.

Fig. 2 Post op subglottic lumen as viewed by retrograde endoscopy performed through the tracheostoma (case 1). The subglottis is visualized with a wide lumen and circumferential mucosal lining. The partly opened glottis is seen above the subglottis.

Fig. 3 Operative photograph of case 4 demonstrating anterior and posterior cricoid split and graft in place (arrow)

Discussion

A variety of surgical procedures are advocated for the surgical treatment of laryngo-tracheal stenosis, but the exact indications for each procedure are often not clearly defined. Most severe (Grade 3 and 4) stenosis of the trachea is associated with involvement of the cartilaginous framework, and for these, resection of the involved trachea with end-to-end anastomoses of the residual trachea is currently the standard of care [2,4]. The option of Resection-Anastomosis can also be extended to lower subglottic stenosis, wherein the lower cricoid lamina and the cricoid arch are included in the resection [3].

The upper half of the subglottis however, differs from the lower subglottis and the trachea as it is bordered by the undersurface of the vocal folds and the cricovocal membrane [2]. Scarring in this area may lead to fixation of the

Table 1 Clinical presentation and final outcome of individual cases

Sr.No	AgeSex	Mode of injury	Previous surgical procedures	Endoscopic findings	Outcome
1.	9 F	strangulation	1. Tracheotomy 2. Left partial cordectomy 3. Rt vocal fold suture lateralization 4. Rt arytenoidectomy 5. Laryngofissure glottic web excsn.	bilateral immobile vocal cords, posterior commissure & high subglottis scarring	Immobile vocal cords, glottic chink 5mm Adequate (near normal) subglottic lumen Decannulated, no aspiration
2.	20 F	strangulation	1. Tracheotomy	bilateral immobile vocal cords, Gd IV stenosis 3mm below vocal cords to 2nd tracheal ring*	Mobile vocal cords Adequate (normal) subglottic lumen Decannulated, no aspiration
3	19M	Strangulation	1. Tracheotomy 2. web excision 3. Laryngo-tracheal reconstruction (ant. cricoid split with costal cartilage graft)**	Bilateral immobile cords, post. commissure scarring, Gd IV stenosis upper subglottis.	Immobile vocal cords, glottic chink 6mm Adequate (near normal) subglottic lumen Decannulated, no aspiration
4	26M	Blunt injury (RTA)	1. Tracheotomy 2. Laryngofissure web excision with keel insertion	Bilateral immobile cords, Anterior/posterior glottic webbing extending to upper subglottis	Mobile vocal cords Adequate (near normal) subglottic lumen Decannulated, no aspiration

* Treated with combined anterior cricoid split and posterior cricoid split with anterior and posterior costal cartilage augmentation + resection of upper 2 tracheal rings and end-to-end anastomosis.

** The subsequent laryngofissure for posterior cricoid split was done through the thyroid cartilage without disturbing the previously placed anterior cricoid arch graft.

vocal folds, and indeed all patients in this report had immobile vocal folds. Surgical treatment of lesions in the high subglottis remains difficult, is often unsuccessful, and may be complicated by complications such as aspiration [2]. The surgical option of Resection Anastomoses is unavailable here as a resection would include a portion of the vocal fold and may thus lead to aspiration.

Resection of the cartilaginous framework not being a viable option, such lesions are therefore necessarily to be treated by augmentation and reinforcement of the existing cartilaginous framework. The surgical procedures of Anterior cricoid split with costal cartilage augmentation (laryngo-tracheal reconstruction), and of Posterior cricoid split with costal cartilage augmentation aim to restructure the distorted/ collapsed cricoid arch. Successful restoration of the subglottic airway by posterior cricoid split and costal cartilage augmentation has been well documented in the literature [2, 6].

Conventional otolaryngologic wisdom believed the cricoid cartilage – the only complete ring in the laryngo-tracheo-bronchial airway – to be a sacrosanct structure, surgical insult to which is to be avoided. Surgical injury to the cricoid as in a tracheotomy and cricothyroidotomy is believed to lead to airway stenosis [5]. Surgeons have therefore been reluctant to directly incise the cricoid – even in its repair. Full thickness division of the posterior cricoid

lamina and its augmentation by a costal cartilage free graft; goes against such conventional surgical wisdom in that the cricoid is surgically dissected and remodeled. Nevertheless, the procedure has now become firmly established. The literature includes several reports wherein posterior cricoid split and augmentation (with or without additional anterior cricoid augmentation) has been applied to the treatment of subglottic, glottic and combined glottic-subglottic stenosis with successful decannulation rates of greater than 90% have been reported [2,6-11]. We have found posterior cricoid split with rib augmentation to be remarkably efficacious in expanding the subglottic airway, and also to be free from complications over a follow up period ranging to two years. The procedure is technically simple to execute. In our practice it is now the procedure of choice for patients presenting with high subglottic stenosis.

Incision of the cricoid lamina is undertaken in the midline. The interposed cartilage graft serves to expand the cricoid lamina and subglottic lumen, and also to diverge the two arytenoids cartilages and widen the posterior commissure and interarytenoid distance. Concerns that this widening of the interarytenoid distance may predispose to aspiration have proven to be unfounded. The separation of the arytenoids has rather proved beneficial as it has prevented recurrent scarring and webbing of the posterior commissure. Infact in two cases (case 2 and 4), this has facilitated

return of arytenoid and vocal fold mobility that had been initially compromised by scar tissue.

Care is taken at surgery to preserve the perichondrium on the costal cartilage graft surface that is facing the subglottic lumen. The smooth perichondrium has been found to merge with the mucoperichondrium of the cricoid lamina and to contribute to formation of a mucosa lined lumen. No mucosal or skin graft was used in any of our cases.

Most of the previous literature on this procedure comes from quaternary referral pediatric centers, and pertains to children with either congenital subglottic stenosis, or acquired stenosis consequent to long term intubation [7–11, 13, 14]. The cases referred to in this report however have been young adults and adolescents with acquired stenosis consequent to accidental strangulation or blunt neck injury. Accidental strangulation is a frequent cause of laryngotracheal injury in our practice, as neck scarfs are part of traditional dress for both women and men in the local culture, and can get entangled in machinery or other mechanical devices.

In our current practice, stenosis of the inferior subglottis is treated by cricotracheal resection (resection of the cricoid arch and adjoining trachea if required) and anastomosis of the normal trachea to the thyroid cartilage anteriorly and cricoid lamina posteriorly. High subglottic stenosis is currently managed by posterior cricoid split with costal cartilage augmentation. Webbing of the posterior commissure leading to vocal cord fixation has also proved frustrating in the past, but is currently managed again by posterior cricoid split and costal cartilage augmentation. Insinuation of the cartilage graft serves to interpose non-scar tissue between the edges of the surgically divided posterior commissure scar, and thus prevents its recurrence. 2 of the 4 cases in this report regained vocal fold mobility following the procedure.

Inglis et al [13] have reported 10 cases of posterior cricoid split and rib cartilage grafting in children undertaken by a transoral microlaryngoscopic approach. The soft non-calcified pediatric cartilage is divided with a laser, the divided cricoid cartilage then distracted, and the cartilage graft placed endoscopically. In all probability, the coming years, would see further development of endoscopic techniques resulting from the ongoing development of lasers [13, 14], the advent of bioabsorbable expandable stents [15], and also the therapeutic application of growth factors and other inflammatory cytokines [16].

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