

Partial laryngotracheal resection and anastomosis, institutional 10 years' experience

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Objective

This study aimed to evaluate the results of partial laryngotracheal resection and anastomosis in the management of iatrogenic laryngotracheal stenosis.

Patients and methods

This retrospective analytical study was conducted on all patients who had been operated by means of partial laryngotracheal resection and anastomosis in our institute, from 2004 to 2014. The period of follow-up was at least 1 year. The total number of the patients included was 22.

Results

Successful decanulation was achieved in 20 (90.9%) cases. The number of complicated cases in our study (with one or more complication) was eight (36.3%). Two cases complained of dyspnea with documented restenosis of the trachea, and one case died from severe hemoptysis at 12 days postoperatively, most probably from trauma of the innominate. Two cases were complicated by surgical emphysema and one case was complicated by hematoma; all of them were managed successfully.

Conclusion

Partial laryngotracheal resection and anastomosis is a safe and reliable surgical method for the management of grade III and IV iatrogenic laryngotracheal stenosis. This technique achieves best results in male patients when the stenosis is short segment, and not involving the cricoid cartilage.

Keywords:

laryngotracheal stenosis, partial laryngotracheal resection and anastomosis, successful decanulation

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Introduction

Iatrogenic laryngotracheal stenosis can be caused by either cuff-induced ischemic damage to the trachea, stomal injury from a tracheostomy, or a combination of the two [1].

The incidence of postintubation laryngotracheal stenosis has been reported ranging from 10 to 19% [2,3].

According to the nature and severity of the condition, a variety of treatments exists. They range from endoscopic laser sessions with or without dilatation or stenting to laryngotracheal reconstruction with anterior, posterior, or combined costal cartilage grafts, to partial cricotracheal resection for the most severe grades of stenosis, and to extended partial cricotracheal resection for laryngotracheal stenosis [4].

Yamamoto *et al.* [5] performed a meta-analysis study to compare the results of different therapeutic procedures for acquired subglottic stenosis in adults. They reported that the success rate of the laryngotracheal

resection and anastomosis was 95%, the success rate of the laryngotracheal reconstruction with or without grafting was 76%, and the success rate of the endoscopic procedures ranged between 40 and 82% [5].

Tracheal resection and primary anastomosis remain the standard of care for the definitive treatment of tracheal stenosis. Despite being very effective, with success rates greater than 90%, complications are an issue [6].

Patients and methods

In this retrospective chart review, we obtained the clinical records of all patients ($N=22$) who underwent partial tracheal or laryngotracheal resection and anastomosis for subglottic, tracheal, or combined

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iatrogenic stenosis between 2004 and 2014. Ethical committee approved the study and a written formal consent was taken from all the patient. The period of follow-up ranged from 1 to 10 years.

All patients underwent a recorded preoperative flexible fiberoptic endoscopic examination to assess the grade and extent of the stenosis. The stenosis was graded according to the Myer and Cotton grading system [7] as follows: grade I: lesion causing less than 50% obstruction; grade II: lesion causing obstruction between 51 and 70%; grade III: lesion causing 71–99% obstruction; and grade IV: complete stenosis (Fig. 1).

All patients were evaluated using high-resolution spiral computed tomography scan in the axial plan, and then sagittal and coronal reformatting was obtained. This was performed for accurate determination of the location and length of the stenotic segment, especially in the sagittal view. Virtual computed tomography endoscopy was not performed in all cases.

Preoperative direct laryngotracheobronchoscopic evaluation under general anesthesia was carried out for all cases. The goals were to find out the nature (soft or hard), site (relative to vocal cords), degree (diameter of the airway), and the length of the stenotic segment.

The stenosis is classified as follows: pure tracheal stenosis and tracheal stenosis extending to the cricoid cartilage.

Surgical technique

The trachea is isolated by means of careful sharp dissection directly on the cartilage. A vertical incision is then made in the midline of the stenotic segment and extended inferiorly and superiorly until normal mucosa and an acceptable lumen caliber is achieved. Horizontal incisions are then made

superiorly and inferiorly at the margins of the stenotic segment. An endotracheal tube is then used to intubate the distal trachea through the neck. If the posterior trachea is uninvolved and the stenotic segment does not involve more than two or three tracheal rings, a wedge resection leaving the posterior tracheal wall intact can be performed.

Dissection is then completed around the stenotic segment to be resected. The dissection should be close to the tracheal wall to avoid injury to the recurrent laryngeal nerves.

The shoulder roll is then removed to allow the neck to move to a more flexed position. Mediastinal release was performed in all cases. If the repair still needed to be under tension, suprahyoid release was performed; if it was still not sufficient, infrahyoid release was also performed.

The posterior membranous trachea is closed first, using 3-0 Vicryl sutures (© ETHICON, INC 2008, Somerville, New Jersey, United States). Once all of the posterior sutures are placed. The cartilaginous trachea is closed using 2-0 Vicryl sutures.

In case of stenosis that extends to the larynx, resection of the anterior cricoid arch is performed with preservation of the upper part of the posterior lamina of the cricoid cartilage. Thyrotracheal anastomosis is accomplished using 2-0 Vicryl sutures. The raw area of the upper half of the posterior cricoid lamina can be covered by a membranous flap tailored from the distal trachea.

The anastomotic closure is then leak tested by flooding the field with saline solution and deflating the cuff on the endotracheal tube while ventilating the patient.

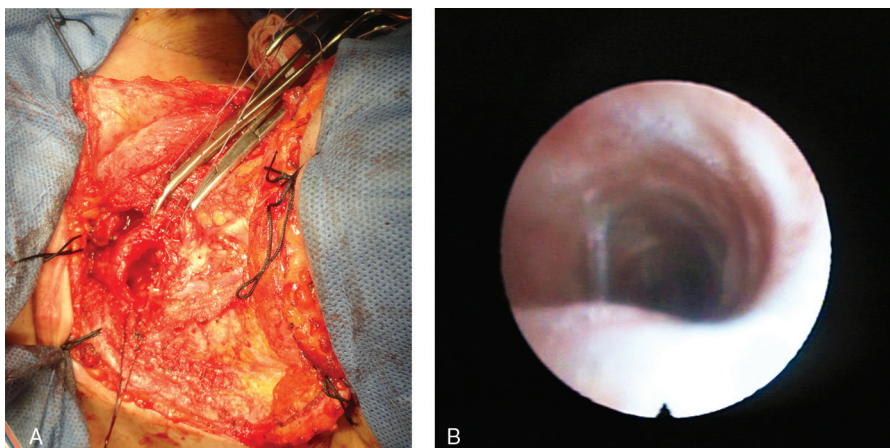
Repair of the two cut ends of the thyroid isthmus is achieved by using 3-0 Vicryl sutures in front of the anastomotic site (Figs 2 and 3).

Figure 1



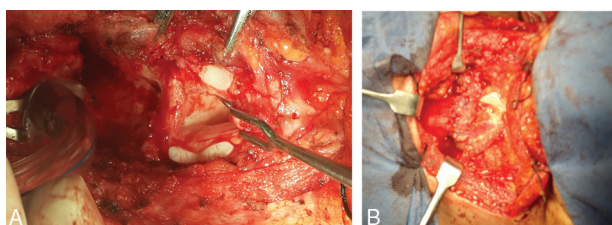
(a) Preoperative endoscopic view showing grade IV tracheal stenosis. (b) Endoscopic view of the same patient at 11 days postoperatively.

Figure 2



(a) Posterior suture line. (b) Anterior suture line and tension sutures.

Figure 3



(a) The proximal end was cut in the posterior cricoid lamina. (b) Posterior suture line and covering the upper part of the posterior cricoid lamina. (c) Thyrotracheal anastomosis.

A suction drain is used and positioned at the anastomosis. The wound is then closed in three layers. Patients are monitored in the ICU for 2–3 days with endotracheal tube (acting as a stent) on sedation.

Postoperative period and follow-up

Keep neck in flexed position for 2 weeks. Extubation is performed after 2–3 days, and then voice rest is advised for 3–5 days to minimize glottic pressure and subsequent airflow at the site of the anastomosis. Empiric antibiotic coverage was carried out for 5–7 days. Antiemetic drugs, pain medication, and soft diet may be started after extubation. Postoperative feeding tubes are rarely required unless extensive releasing maneuvers are performed. Suction drain removal is carried out on day 3 if there are no complications or evidence of air leak/crepitus. Skin sutures are removed at 1 week. Chin flexion suture is removed at 2 weeks.

Statistical analysis

Data were entered into a computer and then analyzed using Statistical Package for Social Sciences version 22.0 (IBM Corp., Armonk, NY, USA).

Categorical variables were summarized as number and percent in brackets, whereas age and length of tracheal cut part variables were summarized as mean \pm SD and analyzed using independent *t*-tests.

To determine factors associated with tracheal resection and anastomosis complications univariate logistic regression was used. Odds ratios and their 95% confidence interval (CI) were noted. Factors with the *P*-value of less than 0.05 were considered to have been statistically significant.

Results

There were 17 male and five female patients; their average age was 24.41 (range was 16–41) years. All cases were caused by prolonged intubation, mainly due to head trauma (18 cases), suicidal attack (three cases), and iatrogenic trauma (one case).

Seven (29.2%) patients had previous failed attempts for the treatment of stenosis in the form of one or more trials of endoscopic partial excision of the stenosis and granulation (if present) by means of laser and/or endoscopic dilatation using balloon.

All patients had a pre-existing tracheostomy at the time of surgery. All patients had bilateral mobile vocal folds. The total number of cases with grade III stenosis was 16 cases and the total number of cases with grade IV stenosis was six.

Stenosis was only found in the cervical trachea in 17 patients, whereas in five patients it was found in the cervical trachea and extending to the cricoid cartilage.

The estimated preoperative length of the stenotic segment ranged from 1.5 to 4 cm (mean=2.52±0.87 cm).

Mediastinal release was performed in all cases. Suprahyoid release was also performed in six cases. Suprahyoid and infrahyoid release was performed in one case (Table 1).

As regards surgical complications, we had two cases with complains of dyspnea with documented restenosis. Both cases had cricotracheal stenosis. One of these cases was successfully managed with tracheal dilatation 5 months after surgery. The other one was manifested also by tracheomalacia and distal airway collapse, and hence this case was recanulated with permanent tracheostomy tube. One case died from severe hemoptysis at 12 days postoperatively, most probably from trauma of the innominate. Two cases were complicated by surgical emphysema: the first case was relieved by means of conservative measures and reinsertion of the endotracheal tube in the ICU for 2 days. The other case that had cricotracheal stenosis was relieved through removal of one skin stitch and application of a drain, which was removed 3 days after insertion. One case developed hematoma 24 h after surgery (in the postoperative intubation period) and it was successfully managed in the operative theater through evacuation of the hematoma and ligation of the bleeding vessel. Moreover, there was another case that complained of persistent dysphagia after the surgery. It is worth mentioning that the cases that complicated by hematoma and dysphagia were also cases with cricotracheal stenosis.

Table 1 Demographic and clinical characteristics of patients enrolled in the study (n=22)

	n (%)
Sex	
Female	5 (22.7)
Male	17 (77.3)
Previous endoscopic trials	
No	15 (68.2)
Yes	7 (31.8)
Location	
In the trachea and cricoid cartilage	5 (22.7)
Only in the trachea	17 (77.3)
Grade	
III	15 (68.2)
IV	7 (31.8)
Additional release	15 (68.2)
Suprahyoid	6 (27.3)
Suprahyoid+infrahyoid	1 (4.5)
Age [mean±SD (range)]	24.41±6.88 (16–41)
Length [mean±SD (range)]	2.52±0.87 (1.5–4)

The number of successful cases in our study was 20 (90.9%) cases. Successful case was defined as a case that did not need recanulation during the follow-up period (≤12 months). The number of cases that developed one (or more) of the above mentioned complications in the follow-up period was eight (36.3%) cases (Tables 2 and 3).

Discussion

Laryngotracheal stenosis can involve either one or more of three anatomical sites, which are either the glottis, the subglottis, or the trachea [8]. In our study we excluded stenosis extending to the glottis because mobile vocal fold is essential before performing the resection and anastomosis. Moreover, we did not face cases with stenosis limited only to the subglottis, and hence we classified our patients to either patients with stenosis limited to the trachea or patients with stenosis involving the trachea and extending to the subglottis.

The high success rate and good functional results of single-staged laryngotracheal resection with primary end-to-end anastomosis make this an effective and reliable approach for the management of benign laryngotracheal stenosis [9].

Grade III or IV stenosis up to 4.5 cm is amenable for transcervical resection and primary anastomosis utilizing only transcervical tracheal mobilization procedures. These include neck flexion suprahyoid or infrahyoid release technique [10].

In our study, we achieved an overall success rate of 90.9%. The success rate in the previous studies ranged between 89 and 96.7% [11–17]. Thus, our results confirm the high efficiency of this operation in the management of tracheal stenosis.

The incidence of recurrent laryngeal nerve injury during surgery was reported to be 2.2 and 3.7% [18,19]. In our study there were no cases of

Table 2 Distribution of the complications

Complications	n (%)
Early complications	
Surgical emphysema	2 (9)
Hematoma	1 (4.5)
Vocal cord paralysis	0 (0)
Late complications	
Restenosis with dyspnea	2 (9)
Restenosis without dyspnea	1 (4.5)
Recanulation (failure)	1 (4.5)
Persistent dysphagia	1 (4.5)
Death (failure)	1 (4.5)

Table 3 Relation between other risk factors and the rate of postoperative complications

Variables	Noncomplicated [n (%)]	Complicated [n (%)]	OR	95% CI	P-value ^a
Sex					
Male	13 (76.5)	4 (23.5)	1	1.11–152.35	0.041 (S)
Female	1 (20.0)	4 (80.0)	13		
Previous endoscopy					
No	10 (66.7)	5 (33.3)	1	0.24–9.47	0.999 (NS)
Yes	4 (57.1)	3 (42.9)	1.5		
Location					
T	13 (76.5)	4 (23.5)	1	1.11–152.35	0.041 (S)
CT	1 (20.0)	4 (80.0)	13		
Grade					
III	10 (66.7)	5 (33.3)	1	0.24–9.47	0.99 (NS)
IV	4 (57.1)	3 (42.9)	1.5		
Length (mean±SD) (cm) ^a	2.11±0.63	3.25±0.76	8.88	1.56–50.44	0.014 (S)

CI, confidence interval; CT, trachea and cricoids; NS, nonsignificant; OR, odds ratio; S, significant; T, trachea only. ^aTwo-sided Fisher's exact *P* values.

postoperative Recurrent Laryngeal Nerve (RLN) paralysis; this may be due to the subperichondrial dissection of the resected segment.

The mortality rate after tracheal resections and reconstructions has been reported to be 2.4% [18]. In our study, one (4.5%) patient died on the 12th day after surgery due to sudden massive internal hemorrhage due to innominate vein rupture. In this patient the resected segment was long (six tracheal rings), and hence extensive mediastinal dissection was needed to gain a sufficient space for tensionless repair.

In the previous series, the rate of restenosis at the site of anastomosis varied from 5.3, 10.5, and 25% [20–22]. In our study, restenosis occurred in two (10%) cases, both of which were associated with involvement of the cricoid area.

Moreover, there was a significant relation ($P=0.041$) between the cricoid cartilage involvement and the rate of complication occurrence. We found that the odds of complication occurrence among cases with cricoid involvement was 13 times higher than that for pure tracheal stenosis, with 95% CI (1.11–152.35). These findings are consistent with other studies confirming that associated cricoid stenosis is the main risk factor for restenosis [18,21,23,24].

Considering sex, there was a significant relation ($P=0.041$) between sex and rate of complication occurrence; the odds of complication occurrence among female patients were 13 times higher than that for male patients, with 95% CI (1.11–152.35). This may be attributed to the difference between male and female patients as regards tracheal and laryngeal dimensions. This difference was documented in the

previous studies, but it was not a significant difference [24,25].

We found that the rate of complications increases with increasing of the length of the removed segment (odds ratio: 8.88; 95% CI: 1.56–50.44; $P=0.014$). Wright *et al.* [23]. in their study supported the positive relation between the length of the stenotic segment and the rate of failure. They found that resections of a segment from the trachea longer than 4 cm were associated with a dramatic rise in the rate of failure.

There was no significant difference between those who had undergone trial of endoscopic dilatation before resection and those who did not as regards morbidity/mortality. Some reports have shown worse outcome of Tracheal resection (TR)/Cricotracheal resection (CTR) after previous interventions, explained by expansion of scarring and damage to the cartilaginous skeleton [19,26]. This may be due to the limitation of the use of endoscopic procedures as a trial before performing the surgery in our center; we only use endoscopic dilatation and partial laser excision for the obstructing granulations.

In our study, we performed mediastinal release in all cases. Suprahyoid release was also performed in six cases. Suprahyoid and infrahyoid release was also performed in one case. There was no significant increase in morbidity in patients who underwent suprahyoid release in comparison with those who underwent tracheal release only. In three patients (out of six patients) who underwent suprahyoid release, it was noted that postoperative dysphagia improved in 2–4 weeks. The case that underwent

suprahyoid and infrahyoid laryngeal release developed persistent dysphagia. However, Peskind *et al.* [27] advocated the routine use of suprahyoid and infrahyoid laryngeal release to decrease tension at the level of the anastomotic suture line.

Considering the grade of the stenosis, there was no significant difference ($P=0.999$) between the complication rate in patients with grade III and patients with grade IV tracheal stenosis. Marques *et al.* [12] reported a significant positive association between the grades of stenosis preoperatively and the restenosis rate postoperatively. However, Negm *et al.* [24] found that this relation was nonsignificant. This is more theoretically accepted because restenosis is usually due to inadequate repair and usually not related to the state of the excised segment.

Conclusion

Partial laryngotracheal resection and anastomosis is a reliable surgical method for management of grade III and IV iatrogenic laryngotracheal stenosis. This technique achieves best results in male patients when the stenosis is short segment, and not involving the cricoid cartilage. The grade of stenosis and history of previous endoscopic surgeries do not affect the surgical outcomes.

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Conflicts of interest

There are no conflicts of interest.

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