

Thoracic

Tracheal Reconstruction: Initial Experience of Ain-shams University Hospital

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Objective : To review the cases of tracheal reconstruction done at ASUH.

Methods : From January 1997 through 2004, 23 patients underwent tracheal resections and reconstructions. 18 of these patients had received ventilatory assistance at a time. 2 patients had undergone a prior attempt of tracheal reconstruction, 3 patients had had laser treatment, and 2 patients used to have regular tracheal dilatation. 3 patients had tracheal tumors. Follow-up was obtained by direct patient contact and was obtained in all patients.

Results : have been classified as good, satisfactory, and death. The average length of follow-up was 3.2 years. We had two deaths. The results were good in 18 patients, and satisfactory in 3 patient

Conclusion : Tracheal reconstruction is feasible, reproductible with good results .

Post-intubation tracheal injuries remain the most common indication for tracheal resection and reconstruction, despite identification of the causes of these lesions and development of techniques for their avoidance. Tracheal tumors are also an important indication for reconstruction of the trachea. We report our experience of tracheal reconstruction in a consecutive series of 23 patients treated in the last 8 years.

Methods

From January 1997 to December 2004 a total of 23 patients underwent primary tracheal resection and reconstruction for different causes of tracheal stenosis or obstruction. They included 13 females and 10 males with an age range of 1 to 52 years -mean 25 years-(table1). Follow-up was obtained by direct patient contact and was obtained in all patients.

Age in years	No. of patients
10>	2
10-19	6
10-29	10
30-39	3
40-50	1
50<	1

Table 1. Age distribution

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The main cause of airway stenosis was intubation and mechanical ventilation (18 patients). 9 patients had trauma that necessitated ventilatory support for sometime, 7 patients who needed ventilatory support after other kinds of operation followed by respiratory failure (5 patients post neurosurgical operations, 1 post cardiac surgery, and one after stormy gastric stapling for morbid obesity). One patient received ventilatory support for suicide attempts; one patient was ventilated as a result of faulty ingestion of pesticide.

The remaining 5 patients did not have any history of mechanical ventilation. Three patients had tracheal tumors (Fig.1), one patient had pulmonary artery sling that was compressing the trachea just before its bifurcation, and in the last patient the cause of tracheal stenosis could not be identified (idiopathic).

The length of mechanical ventilation varied from 4 to 80 days with mean of 17 days. 14 patients had an existing tracheostomy when entered for tracheal reconstruction and it was used for the induction of anesthesia, 6 patients did not have tracheostomy and the other 3 patients had tracheostomy at a time but were intubated orally.

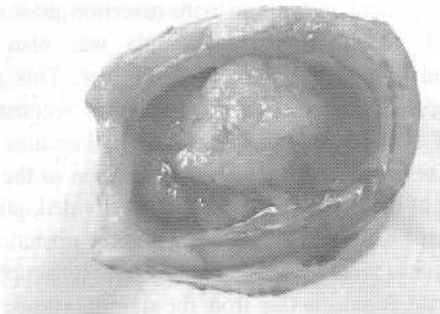


Fig.1. resected tracheal segment with adenoid cystic carcinoma.

18 patients had undergone prior attempts before referral. 8 patients had tracheostomy distal to the obstruction; one of them was done as an emergency procedure in the patient with idiopathic tracheal stenosis. 6 patients had tracheal dilatation once or more, 1 of them proceeded to reconstruction, 4 had tracheostomy followed by tracheal reconstruction, and the 6th had tracheostomy followed by its closure later with the insertion of a tracheal stent. This patient had a tracheoesophageal fistula (TOF) at a lower level. 2 patients had laser dilatation that was followed later by tracheostomy. 2 patients were referred to us with restenosis after unsuccessful tracheal reconstruction. The remaining 5 patients did not have any intervention before referral.

Although a careful preoperative endoscopic examination to assess the extent and the length of the stenotic segment and also the length of the normal airway remaining and the presence of active inflammatory process was our standard method of diagnosis, it was not always possible in all cases. In these cases we found that thin cuts CT (2mm) scan of the neck and the chest were very helpful and accurate to identify all the data about the lesion except the extent of inflammation. All patients underwent accurate laryngotracheal studies to determine the integrity of the vocal cords.

The lesions were located at the cervical level in 9 patients (39%), at the cervico-thoracic junction level in 11 patients (48%) and were intra-thoracic in 3 patients (13%). 4 patients had preoperative signs of tracheomalacia in the site of stenosis.

Operative Techniques

Surgical techniques have been detailed previously¹. The operative approach was through a cervical collar incision in 9 patients (39%), cervical with sternal split in 8 patients (35%), cervical with full median sternotomy in 3 patients (13%)—one patient with along narrow segment that needed laryngeal drop, one patient with additional tracheo-esophageal fistula, and one patient who had previous reconstruction—. Median sternotomy was employed in only in one patient (4%) who had pulmonary artery sling. 2 patients (8%) underwent repair via a high posterolateral thoracotomy.

Surgical procedures were circumferential tracheal resections with end to end anastomosis in all patients, one patient had laryngeal drop, and one patient had repair of tracheo-esophageal fistula.

The patients were placed in a supine position with a bag beneath the shoulders and the head hyper-extended except for the two patients who had right posterolateral thoracotomy.

The anesthetic techniques have been described². If the patient was tracheostomised; stomas are often used for intubation and the induction of anesthesia. If the patient did not have a stoma, a rigid bronchoscope was performed before intervention to assess the extent of the stenosis, to guide the intubation, or to dilate the stenotic segment with dilators and pediatric bronchoscopes with the patient under general anesthesia. In some cases the stenotic segment could segment could not be dilated and the endotracheal tube was positioned just above the stenotic segment. In another situation with an endobronchial tumor at the upper third of the trachea, a guide wire was passed by the side of the tumor with the help of the rigid bronchoscope then a size 3 endotracheal tube was passed along side the tumor over the guide wire.

The dissection is performed mainly on the anterior surface of the trachea and carefully on the lateral sides only in correspondence with the stenotic segment to avoid injury to the vascular supply and to the recurrent laryngeal nerves, which lie in the tracheo-esophageal groove. Then, the trachea is divided below the stenotic area, the ventilation is performed with a cross-field endotracheal tube, placed in the distal tracheal tract (fig.2), the original oro-tracheal tube is withdrawn by the anesthetist. The posterior surface of the trachea is also dissected then the two ends of the trachea are approximated together to make sure that the anastomosis will be without tension. During the anastomosis the ventilation is ensured from the cross-field tube. After the resection of the stenotic tract (Fig.3), the primary anastomosis is performed with four interrupted sutures of 4-0 polyglactin for the membranous part of the trachea. The cross-field endotracheal tube is then removed and these 4 sutures are tied with the knots outside the lumen while the head is maintained in the flexed position. An oral endotracheal tube is then passed by the anesthetist and guided by the surgeon in the lower segment of the trachea. Now about 8 to 14 interrupted sutures of 3-0 polyglactin are placed in the lateral and anterior aspects of the trachea (the cartilaginous part) and all the knots of the sutures are tied outside.

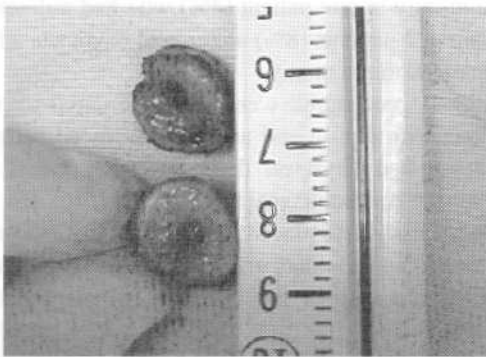


Fig.2. the lumen of the resected segment

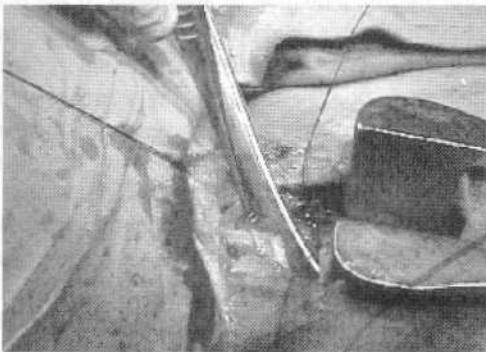


Fig.3. Ventilation across the surgical field

Anastomoses were covered with adjacent tissues, thyroid isthmus, cervical strap muscle, and other tissue including thymus and pericardial fat pad. Tissue was interposed, in general, between the trachea and innominate artery if the anastomosis was adjacent or if the artery had been previously dissected.

After the closure of the incision, a heavy suture is placed through the chin skin and the presternal skin: these sutures are tied with the neck in flexion to protect against sudden hyperextension. The patient is extubated in the operating room and is kept under observation for 24 to 48 hours in an intensive care unit.

In the one-year old patient with tracheal stenosis and pulmonary artery sling we used the cardiopulmonary bypass. We did not impose any myocardial ischemia, and the entire procedure was performed with a mild degree of hypothermia. The trachea was exposed between the superior vena cava and the aorta. We used 6-0 monofilament PDS polydioxanone for the anastomosis.

Cervical flexion is maintained with a suture from the submental crease of the chin to the presternal skin for 7 days after the operation. Laryngeal release described by Montgomery³ was needed in only one patient in whom 4.5 cm were resected.

In one patient, in addition to the resection anastomosis, repair of tracheo-esophageal fistula was also done. This kind of repair was reported before⁴. This patient was assessed with virtual bronchoscopy reconstructed from CT scan. In this patient the after resection of the stenotic segment and trans-field ventilation to the lower segment of the trachea, the fistula was divided, and both the anterior wall of the esophagus and the posterior wall of the trachea were closed separately with interrupted 3-0 polyglactin. A muscle flap from the sternomastoid muscle was interposed between the trachea and the esophagus. Eventually, tracheal reconstruction was performed.

Results

Follow-up was obtained by direct patient contact and was obtained in all patients. The results have been classified as good, satisfactory, and death. The results are described as good if the patient is functionally able to perform usual activities and if postoperative roentgenograms or bronchoscopic examinations show an anatomically good airway.

Results are considered satisfactory if the patients can perform normal activities but are stressed on exercise, if they have abnormalities such as a paralyzed vocal cord (totally or partially), or if significant narrowing is evident on either endoscopic or roentgenologic examination, even if the patient's level of activity does not clini-

cally evidence his. The average length of follow-up was 3.2 years . We had two deaths. The results were good in 18 patients, and satisfactory in 3 patients (table2).

Table 2. The overall results.

Good		Satisfactory		Death	
.No	%	.No	%	.No	%
18	79	3	13	2	9

The first mortality was the 1 year-old patient with pulmonary artery sling. He died in the first post operative day due to progressive hypoxemia. He had an intra operative event during the construction of the tracheal anastomosis where the aortic cannula was accidentally slipped. There was a major flooding of blood into the opened air way.

The second patient was a 52 year-old. She had gastric stapling for morbid obesity which was followed by abdominal complications. She was mechanically ventilated for 35 days without having a tracheostomy. In one and half month after extubation, she developed tracheal stenosis about 2 cm. above the carina. She had bronchoscopy and tracheal dilatation. She was explored via a right posterolateral thoracotomy and had tracheal resection with end to end anastomosis which went uneventful. She was weaned off mechanical ventilation with some difficulty on the 5th postoperative day. Her recovery was relatively slow but she was transferred to the room on her 9th postoperative day. She had a cerebral stroke on the 24th postoperative day, and died of the sequelae of the stroke on the 35th postoperative day.

3 patients had only satisfactory results. The first one was a 35 year-old male patient. He had post intubation tracheal stenosis which was treated with tracheostomy that was followed with tracheal reconstruction. He had post reconstruction tracheal restenosis then another tracheostomy was done below the level of repair. He was referred to us for redo surgery. The operation took about 8 hours due to the extensive inflammatory adhesions. He had post operative bilateral recurrent laryngeal nerve injury. He was mechanically ventilated for the first 14 hours postoperatively. He had laser cordotomy that improved his breathing pattern and he was discharged on the 16th postoperative day and was referred for speech therapy.

The second patient was a 23 year-old male patient. He also was referred for redo tracheal reconstruction after an unsuccessful repair. He had reconstruction that was complicated by bilateral recurrent laryngeal nerve injury. He also had laser cordotomy in the postoperative period. He had restenosis at the Anastomotic site which required repeated dilatation.

The third patient was a 26 year-old male. He had mechanical ventilation for 21 days after a motor car accident. He had tracheostomy after the closure of which he had tracheal stenosis. He had repeated tracheal dilatation. In one of these trials, he developed tracheo-esophageal fistula at a lower level than the stenotic segment. The tracheo-esophageal fistula was treated by insertion of a tracheal stent. The stent was dislodged and dropped in the right main bronchus closing the orifice of the right upper lobe bronchus. The patient was then referred to us for tracheal reconstruction and repair of the tracheo-esophageal fistula. He had successful reconstruction with repair of the tracheo-esophageal fistula and removal of the stent. This patient has evidence of tracheal restenosis not to the extent to necessitate intervention.

Prior Intervention

Results in patients who had prior tracheal are listed in table (3). In the 2 patients who had previous resection and reconstruction, the outcome was only satisfactory none of them had good result compared with 86% good results in the 21 patients who did not have prior tracheal reconstruction.

Table 3. Results in comparison to previous intervention

Previous Intervention	Total	Good Outcome		Satisfactory Outcome		Mortality	
	.No	.No	%	.No	%	.No	%
Tracheostomy	17	14	82	3	18	0	
Tracheal dilatation	6	4	66	1	17	1	17
Tracheal stent	1	0	-	1	100	0	-
Laser therapy	2	2	100	0	-	0	-
Tracheal reconstruction	2	0	-	2	100	0	-
No previous intervention	5	4	80	0	-	1	20

17 patients had tracheostomy before going to surgery. 14 of them (82%) had good outcome while 3 patients (18%) had only satisfactory outcome. In the remaining 6 patients who did not have tracheostomy, 4 patients (67%) were in the good outcome while 2 patients (33%) were in the mortality group. Although the mortality appear significantly higher in the second group, this is due to the small number of patients in this group as well as the causes of mortality were not directly related to the presence of tracheostomy. The other procedures of previous intervention included insertion of stents, previous laser therapy, and repeated tracheal dilatation. They did not seem to affect the results. None of the patients needed tracheostomy in the postoperative period.

Laryngeal Releases

One patient had a laryngeal release procedure to reduce tension on the anastomosis. The length of resection in this patient was 4.5 cm. This patient had a good outcome.

Repair Of Tracheo-esophageal Fistula

One patient underwent repair of a tracheo-esophageal fistula concomitantly with tracheal resection and reconstruction for stenosis. This patient had a satisfactory outcome.

Postoperative Reintubation

The need for reintubation after reconstruction indicated a problem. 8 patients (35%) needed postoperative intubation. Only 3 of them had good outcome. 3 patients had satisfactory outcome and the remaining 2 died in the postoperative period. Intubation was either done as failure to extubate the patients or was done on the operative day in all patients.

Complications

Complications are summarized in table (4)

Table 4. Recorded complications.

Recurrent L.N. injury	2
Wound infection	3
dehiscence	2
Restenosis	2
pneumothorax	1
Cerebral stroke	1

Recurrent Laryngeal Nerve Injury

Two patients had recurrent laryngeal nerve injury. Both had previous tracheal reconstruction and one of them had another tracheostomy below the level of restenosis. There was extensive fibrosis at the site of tracheal reconstruction which made it almost impossible to avoid injury of the nerve during the procedure. Both patients needed mechanical ventilation for less than 24 hours. Both had laser cordotomy in the postoperative period to increase the cross section of the air way at the level of the cords. One patient had dehiscence of a small portion of the anastomosis anteriorly. He required reexploration and primary closure with the support of a muscle flap. The other developed restenosis at the anastomotic site nine months postoperatively. It was dealt with by repeated tracheal dilatation.

Dehiscence

Anastomotic dehiscence occurred in 2 patients. One patient had dehiscence of a small portion of the anastomosis anteriorly. He required reexploration and primary closure with the support of a muscle flap. The second patient had minimal leak was successfully managed with drainage of the cervical wound and antibiotics.

Restenosis

Restenosis at the anastomotic site occurred in two of the patients. One patient had redo tracheal reconstruction which was complicated by bilateral recurrent laryngeal nerve palsy. He developed restenosis at the anastomotic site nine months postoperatively. It was dealt with by repeated tracheal dilatation. The other was the patient with the concomitant repair of the tracheo-esophageal fistula with the reconstruction. He did not need intervention due to the limited exercise performance he had.

Infection

Infectious complications developed in 3 patients. Two of them were minor infections were treated only with intravenous antibiotics and one required operative debridement and closure of the anterior wall of the trachea with the help of a muscle flap.

Other

One postoperative pneumothorax occurred and treated with an intercostals tube and one patient had cerebral stroke which resulted in the patient's death.

Discussion

The causes of postintubation stenosis have been well established⁵⁻⁶. Prevention is possible to a high degree by use of large volume, low pressure cuffs and careful management of tracheostomy tubes. However, the lesions continue to appear, most likely because of overinflation of nonelastic plastic cuffs and leverage on tracheostomy tubes. Tracheal tumors, although rare, are the second cause that leads to tracheal resection and reconstruction.

Conservative treatments in the form of repeated tracheal dilation, local and systemic steroids, cryosurgery, laser treatment, and prolonged or permanent stenting, have largely proved successful and without excessive complications only for highly selected lesions⁷⁻⁹.

Recent years have seen a prolific increase in use of the laser for management of cicatricial lesions of the airway¹⁰. However, experts in laser therapy agree that only thin web line strictures can be removed definitively

by laser treatment¹¹. Laser resection provides only temporary benefit in patients with larger circumferential lesions. Furthermore, repeated laser resection undoubtedly increases the extent of injury in some cases. Failure rates with laser treatment range from 23% to 43%¹². Segmental tracheal resection remains the preferred definitive treatment for postintubation stenosis.

The use of an endotracheal prosthesis could increase the length of stenosis and it is recommended avoiding this treatment in all patients who are candidates to receive surgical operations. It is believed that laser and endotracheal prosthesis should be used as a therapeutic option only in patients with absolute contraindications to surgery.

Regarding the surgical technique, we adopted the basic principles of tracheal reconstruction introduced by authors with large experience^{1,13-16}. These principles include avoidance of excessive anastomotic tension, maintenance of tracheal blood supply and meticulous dissection and anastomosis. We adopt interrupted absorbable sutures for anastomosis (3-0 or 4-0) in all patients.

In our series good or satisfactory results were obtained in 91% of all resections with a mortality rate of 9%. We believe that these good results are related to a careful selection of patients and to the strict adoption of technical details suggested by authors of huge experience in this field of surgery^{13,15}. We excluded the patients with involvement of the subglottic region. We also did not operate on patients in whom the preoperative assessment showed inflammation and edema at the border of stenotic segment. The presence of active inflammation and edema is one of the main reasons for recurrence. In fact, patients with severe inflammatory signs should be excluded from surgery and re-evaluated after a suitable period of observation, until the stenosis is stabilized. We also excluded the patients with apparent tracheomalacia¹⁷.

Our main complications and less satisfactory results were in patients who had undergone a prior failed reconstruction. Our early experience, the small number of the patients in this subgroup, and the extensive and complex nature of these prior procedures probably explain the unfavorable results in this small group. The lowered success rate in patients who had a failure of reconstruction before referral (0% good results versus 78%) confirms the intuitive conclusion that the first operation is most likely to succeed¹⁸.

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