Tracheal resection with end-to-end anastomosis for post-intubation cervical tracheal stenosis: study of 14 cases

R NANDAKUMAR, C JAGDISH, C B PRATHIBHA, C SHILPA, V SREENIVAS, A M BALASUBRAMANYA, R C NAYAR

Department of Otorhinolaryngology and Head and Neck Surgery, St John’s Medical College and Hospital, Bangalore, India

Abstract

Background and objectives: The incidence of acquired laryngeal stenosis is increasing. This retrospective study aimed to assess the long term results of circumferential resection with end-to-end tracheal anastomosis for isolated post-intubation stenosis of the cervical trachea, and to review the relevant literature.

Methods: Twelve male and two female patients (aged 16–30 years, mean age 24 years) treated between February 2003 and December 2008 were included. Hospital and office records were reviewed and relevant surgical details recorded.

Results: Indications for tracheal resection anastomosis were post-intubation stenosis (78.57 per cent) and trauma (21.42 per cent). One to five tracheal rings were resected (i.e. 1–2.5 cm of cervical trachea). Tracheal anastomosis was considered successful if the patient remained asymptomatic for 24 months of close follow up (involving regular flexible bronchoscopy and neck X-ray). The anastomotic success rate was 92.85 per cent.

Conclusion: Tracheal resection and end-to-end anastomosis is relatively safe and reliable for definitive treatment of benign tracheal stenosis in appropriate patients. Local application of mitomycin C prevents granulation and aids long term airway patency.

Key words: Tracheal Stenosis; Intubation, Endotracheal; Anastomosis, Surgical

Introduction

Laryngotracheal stenosis is becoming a common clinical challenge for otolaryngologists and head and neck surgeons, due to the increased incidence of acquired laryngeal stenosis. Acquired laryngeal stenosis in adults and children is usually a complication of prolonged intubation, or due to external trauma.1 Prolonged ventilation, together with advances in critical care medicine, cardiopulmonary surgery and neurosurgery, have resulted in an increased number of intubation-related laryngotracheal injuries.2 Within the trachea, trauma at the tracheostomy site, or around the cuff or tip of the ventilation tube, may result in granulation tissue formation. Following the onset of granuloma at the injury site, the reparative process may lead to the formation of fibrous tissue, with a compromised airway.3

Treatment options for tracheal stenosis include laser endoscopy, endoscopic dilatation, interposition grafting, tracheal stenting and tracheal resection. Each has its particular advantages and disadvantages. Endoscopic dilatation is usually performed as a temporary measure prior to definitive therapy. Restenosis may develop within days to weeks. Laser vaporisation and radial division of tracheal strictures have also been reported. Laser treatment is most successful for thin, web-like stenotic lesions (which are rare); in thicker lesions, laser treatment may worsen the severity of the lesion. Endoscopic dilatation and laser vapourisation are less successful in cases of stenosis that is circumferential, without cartilaginous support or longer than 1 cm.4 Tracheal stents have been used as an alternative or complement to surgery. Tracheotomy is another acceptable, life-long management option for tracheal stenosis patients who are poor surgical risks. Tracheal resection is well established as the definitive treatment for benign tracheal stenosis. Several series attest to its success in carefully selected patients.5–7

The current study aimed to assess the long term results of circumferential resection with end-to-end tracheal anastomosis, performed to treat isolated post-intubation stenosis of the cervical trachea. We focussed on the anastomotic success rate, morbidity and post-operative course. The study reviewed 14 cases of
tracheal resection with end-to-end anastomosis performed between February 2003 and December 2008.

Materials and methods
A retrospective review was conducted of 14 patients who had undergone circumferential tracheal resection with end-to-end anastomosis between February 2003 and December 2008. These patients comprised 12 males and two females aged between 16 and 30 years (mean age, 24 years).

We excluded from the study any patients who had undergone tracheal resection for tracheal or thyroid neoplasm, or who had true subglottic (cricoid) stenosis. Hospital and clinic records were reviewed for each patient. We recorded details of each patient’s clinical presentation, intubation and/or tracheostomy history, grade and length of stenosis, and surgical procedure (Table I). Follow-up information was obtained by direct patient contact and from clinic records. Follow-up data were obtained for all patients from 24 months to five years post-treatment. Treatment was considered successful if patients were asymptomatic for a minimum follow-up period of 24 months.

Pre-operatively, all patients underwent laryngotracheal studies to determine the extent of tracheal involvement, the integrity of the vocal folds, and the presence or absence of tracheomalacia. A careful pre-operative endoscopic examination of the larynx and trachea was undertaken, giving specific attention to the state of the tracheal mucosa in order to assess the presence of inflammation. The extent of involvement and amount of remaining trachea were measured using laryngotracheal tomography. All our patients were tracheostomised prior to definitive surgery.

The operative technique, previously described by Pearson et al. and Grillo et al., was carried out as follows.8,9

The patient was placed in a supine position with a shoulder roll beneath the shoulders and the head hyper-extended to bring the cervical trachea into prominence. Anaesthesia was obtained via a flexible endotracheal tube through the tracheotomy. A second orotracheal tube was placed with the tip just below the vocal folds, in readiness for ventilation after the anastomosis. A nasogastric feeding tube was inserted to aid the resection of the trachea from the oesophagus.

A collar incision was made at the level of the tracheotomy, including the stoma. Subplatysmal flaps were raised superiorly to the hyoid bone and inferiorly up to the manubrium. The strap muscles were separated in the midline and retracted laterally. The thyroid isthmus was divided and ligated wherever necessary.

The area of stenosis was identified. Dissection was performed close to the tracheal wall to prevent injury to the recurrent laryngeal nerve. Posteriorly, the stenotic segment was separated from the oesophagus by both blunt and sharp dissection. The trachea was excised above and below the stenotic segment. The line of transection of the trachea was sharp and neat circumferentially, without fraying of the mucous membrane or fragmenting of cartilage. Removal of the shoulder roll helped to bring the cut edges of the trachea close together.

For additional approximation, we preferred suprahyoid laryngeal release and blunt anterior mediastinal dissection. Suprathyroid release was carried out for five patients who required removal of more than four tracheal rings. This was done by identifying the hyoid bone and the suprahyoid muscles, which were then transected between the lesser cornu of the hyoid bone. The muscles and ligaments attached to the lesser cornu were also transected. This manoeuvre released the larynx, which was then pulled inferiorly without tension.

Local application of 1 mg/ml mitomycin C (an antineoplastic antibiotic with antiproliferative effects on fibroblasts) was applied to the resected ends of the trachea for three minutes, before commencing the anastomosis.

The anastomosis was performed with absorbable sutures (e.g. 3-0 Vicryl). The posterior trachea was anastomosed first by placing submucosal sutures at the
Results
At the termination of the surgical procedure, all 14 patients could ventilate freely after extubation.

One patient required re-intubation on the sixth day after extubation, followed by a tracheostomy on the eighth day, due to acute ascending viral transverse myelitis.

In another patient, we encountered right carotid artery bleeding, which was controlled successfully. This patient also developed an iatrogenic right vocal fold paralysis.

Nasogastric feeding was commenced in 14 patients within 24 hours post-operatively. Oral intake was tolerated well by the 10th post-operative day. The length of hospitalisation ranged from 22 to 30 days, with a mean stay of 24 days. No post-operative dysphagia or respiratory difficulty was encountered over two years’ follow up. The follow-up period ranged from two to four years.

The anastomosis success rate was seen in 13 (92.85 per cent) out of 14 patients.

Discussion
Treatment options for tracheal stenosis include laser endoscopy, endoscopic dilatation, interposition grafting, tracheal stenting and tracheal resection. Each has its particular advantages and disadvantages. Therefore, careful pre-operative evaluation of tracheal resection candidates is essential. Factors such as a previous failed resection, higher level of stenosis, and stenosis involving more than 50 per cent of the tracheal length have been observed to negatively influence surgical outcomes. Tracheal stenting is usually considered to be a better option for patients who are poor candidates for tracheal resection, due to previous conditions or comorbidity which increases their surgical risk.

Tracheal resection is well established as the definitive treatment for benign tracheal stenosis. Several series attest to its success in carefully selected patients. In our series of 14 patients who underwent resection and anastomosis, we achieved a success rate of 92.85 per cent.

Experimental data have emphasised the fact that the primary requirement for successful end-to-end tracheal anastomosis is the creation of a tension-free anastomosis line. According to Montgomery, tension should not exceed 1000 g at the suture line. Numerous mobilisation techniques have been used to gain tracheal length, including pretracheal and peritracheal dissection, suprahypoid release, and anterior mediastinal dissection. Extreme neck flexion, aided by a chin-to-chest suture, also contributes to a tension-free anastomosis.

In our series, resection varied from one to five tracheal rings, resulting in resection of 1 to 2.5 cm of the cervical trachea (there are approximately two tracheal rings per centimetre of trachea). A laryngeal release procedure was performed in five cases at our centre. Revision end-to-end tracheal resection was not required in our series, which achieved an overall success rate of 92.85 per cent.

Our results suggest that a tracheal defect of 2 cm or less can be successfully managed by primary anastomosis alone, without release techniques.

In our series, resection varied from one to five tracheal rings, resulting in resection of 1 to 2.5 cm of the cervical trachea (there are approximately two tracheal rings per centimetre of trachea). A laryngeal release procedure was performed in five cases at our centre. Revision end-to-end tracheal resection was not required in our series, which achieved an overall success rate of 92.85 per cent.

Our results suggest that a tracheal defect of 2 cm or less can be successfully managed by primary anastomosis alone, without release techniques. This conclusion is in agreement with the cadaver study of Laccourreye and Bessede, who noted that after resection of three to six tracheal rings, the intertracheal ring ligament elasticity allowed for tracheal end-to-end anastomosis without any adjunctive measures other than mediastinal tracheal dissection and wide, blunt cervical dissection between the sternohyoid and thyrohyoid-sternothyroid muscles.

Granulation tissue at the anastomotic site is the most common complication, and is more common with the use of non-absorbable sutures. Grillo et al. noted that significantly fewer patients developed granulation tissue at the site of tracheal anastomosis after the suture material was changed from Tevdek to Vicryl. Placing the anastomotic sutures through healthy...
tissue extramucosally, along with application of mitomycin C at the anastomotic site, also decreases the likelihood of granulation tissue development. Mitomycin C is an antineoplastic antibiotic with antiproliferative effects on fibroblasts, via inhibition of DNA synthesis (it leads to cross-linkage of strands of the double helix, inhibiting DNA replication). It can cause fibroblast arrest without sacrificing re-epithelialisation.\(^\text{16,17}\) Local application of mitomycin C to treat tracheal granulations has been documented.\(^\text{18}\) Our results suggest that local application of mitomycin C can be used to prevent tracheal granulations.

All our patients were extubated immediately after the surgical procedure. The timing of extubation has been a subject of debate. Several authors support leaving the tracheal tube in situ to allow air-tight intubation for 24 to 48 hours, to allow air-tight closure prior to the introduction of positive intratracheal pressure.\(^\text{7}\) In our opinion, maintaining an endotracheal tube presents a risk of injury to the anastomosis or a different segment of the trachea. Therefore, in our department extubation was always performed in the operating theatre. In agreement with Grillo et al., we successfully performed immediate extubation in all our patients.\(^\text{5}\)

- In this study, 14 patients with cervical tracheal stenosis underwent successful circumferential resection and end-to-end tracheal anastomosis
- Five patients underwent suprathyroid release due to resection of more than four tracheal rings; this gained tracheal length and thus reduced anastomosis tension
- Mitomycin C was applied at the anastomosis site to prevent granulation tissue formation
- Tracheal resection and anastomosis is a relatively safe, reliable procedure for benign cervical tracheal stenosis in appropriate patients

Potential post-operative complications following tracheal end-to-end anastomosis include airway obstruction, infection of the operated region, innominate artery rupture and dysphagia.\(^\text{7}\) None of these complications were noted in our series, except transient dysphagia lasting for up to 10 days. Iatrogenic complications included unilateral vocal fold paralysis in one patient.

**Conclusion**

Tracheal resection with end-to-end anastomosis is a relatively safe and reliable procedure for the definitive treatment of benign tracheal stenosis in appropriately selected patients. In our series, we had a 92.85 per cent anastomotic success rate, and no deaths occurred as a result of the procedure.

We conclude that tracheal resection with end-to-end anastomosis achieves wound healing by primary intention, and has a low complication rate and high success rate. In patients in whom one to four tracheal rings are resected, our findings suggest that end-to-end tracheal anastomosis does not require the systematic use of adjunctive measures to release tension at the level of the suture line. In our series, local application of mitomycin C prevented the development of granulations and resulted in long term airway patency.

**References**

8. Pearson FG, Cooper JD, Nelems JM, Van Nostrand AW. Primary tracheal anastomosis after resection of the cricoïd cartilage with preservation of the recurrent laryngeal nerves. *J Thorac Cardiovasc Surg* 1975;70:806–16

Address for correspondence:
Dr R Nandakumar,
Assistant Professor,
Department of Otolaryngology Head and Neck Surgery,
St John’s Medical College Hospital,
Koramangala,
Bangalore 560 034, India
E-mail: nandakumarrajan@yahoo.com

Dr R Nandakumar takes responsibility for the integrity of the content of the paper

Competing interests: None declared