ORIGINAL ARTICLE

TRACHEAL SURGERY - A 10-YEAR CENTER EXPERIENCE

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Abstract

Background: *Tracheal surgery is a specialized field in which many disciplines work jointly due to the variety of indications and the extended topography. The main indications for surgery include inflammatory (generally post-intubation), congenital or post-traumatic stenoses, benign or malignant neoplasms and tracheal lacerations, whether iatrogenic or traumatic. The purpose of this study is to review the management of one institution's approach to a wide variety of tracheal lesions over the last 10 years.*

Methods: *We retrospectively analyzed data of all subjects submitted to tracheal surgery in our center, between January 1, 2014 and December 31, 2023. The preoperative and postoperative data were retrospectively evaluated through the consultation of the clinical files and the computer registry system.*

Results: *We included 24 patients, mean age of 53 years (min 19; max 87), 54% being female. The most frequent indication for surgery was post-intubation tracheal stenosis (16, 67%) followed by tracheal laceration (6, 25%) and pleomorphic adenoma of the trachea (2, 8%). The mean operative time was 148 minutes (min: 80; max. 205). The mean tracheal length resected was 2,14 cm (min: 1; max: 3,2). Postoperative complications included: vocal cord paralysis (2, 8%), surgical wound site infection (2, 8%), anastomotic dehiscence (1, 4%) and mediastinitis (1, 4%). Re-stenosis occurred in 1 patient who was treated with prosthesis placement via bronchoscopy and 1 patient required definitive tracheostomy due to vocal cord paresis. Median chin stitch duration and median length of stay was 10 and 15 days, respectively. In-hospital mortality was 8% (2 cases). Overall mortality during mean follow-up time (51 months) was 8% (2 cases).*

Conclusions: *Tracheal surgery seems a valid and safe technique in selected patients and can be performed safely with low morbidity and mortality, according to our center results.*

Keywords: *tracheal surgery, tracheal stenosis, post-intubation stenosis, tracheal laceration*

INTRODUCTION

Tracheal surgery is a specialised field in which many disciplines work jointly due to the variety of indications and the extended topography. Despite reports of the first tracheal surgery performed by Belsey in 1950, it remains as one of the most challenging procedures among thoracic surgeons [1]. This is mainly due to the peculiar anatomy of the trachea, particularly its location both in the neck and mediastinum, length, structural rigidity and blood supply [2]. Tracheal resection and reconstruction is considered a relatively safe procedure if performed by an experienced surgeon. The overall success rate described in the literature is over 90%[3, 4].

The main indications for surgery include inflammatory (generally post-intubation), congenital or post-traumatic stenoses, benign or malignant neoplasms and tracheal lacerations, whether iatrogenic or traumatic [3, 5-7].

The vast majority of tracheal resections are performed for post-intubation lesions. After prolonged mechanical ventilation, either by intubation or tracheostomy, stenosis may occur due to pressure-induced ischemic injury of the tracheal wall caused by the endotracheal tubes with subsequent aberrant scarring process determining a stricture of the airway lumen. [3, 7-9]

Segmental resection and end-to-end anastomosis is currently the treatment of choice in a broad spectrum of tracheal stenoses. Main alternative therapy to surgery is represented by interventional pulmonology procedures, such

as mechanical dilatation, laser ablation and stenting but benefits are generally temporary and repeated treatments are often required. [2, 3, 5, 7, 10]

The purpose of this study is to review the management of one institution's approach to a wide variety of tracheal lesions over the last 10 years.

METHODS

We conducted a single-center and retrospective study including all consecutive subjects submitted to tracheal surgery in our center, between January 1, 2014 and December 31, 2023. The preoperative, surgical and immediate postoperative data were retrospectively evaluated by accessing clinical files and the computer registry system. Patients' records were analyzed up until the time of data collection in July 2024.

Preoperative information included personal demographic characteristics (age and gender) and surgical indication. Intraoperative variables included operative time and tracheal length resected. Additionally, postoperative information comprised chin stitch duration, length of stay, postoperative complications, recurrence and mortality during follow-up time.

Statistical analysis was performed using IBM–SPSS Statistics version 27.0 (IBM, United States of America).

RESULTS

We included 24 patients, mean age of 53 years (min 19; max 87), 54% being female. The most frequent indication for surgery was post-intubation tracheal stenosis (16, 67%) followed by tracheal laceration (6, 25%) and pleomorphic adenoma of the trachea (2, 8%). The mean operative time was 148 minutes (min: 80; max. 205). The mean tracheal length resected was 2,14 cm (min: 1; max: 3,2). Postoperative complications included: vocal cord paralysis (2, 8%), surgical wound site infection (2, 8%), anastomotic dehiscence (1, 4%) and mediastinitis (1, 4%). Re-stenosis occurred in 1 patient who was treated with prosthesis placement via bronchoscopy. One patient required definitive tracheostomy due to vocal cord paresis. Median chin stitch duration and median length of stay was 10 and 15 days, respectively. In-hospital mortality was 8% (2 cases). Overall mortality during mean follow-up time (51 months) was 8% (2 cases).

DISCUSSION

The most frequent indication for tracheal surgery in this cohort was post-intubation tracheal stenosis (67%), reflecting the well-known possible complication of prolonged mechanical ventilation. This high percentage aligns with existing literature where post-intubation stenosis remains a leading cause of tracheal surgery. The second most common indication was tracheal laceration (25%), a severe but less frequent trauma-related condition, often caused by iatrogenic injury during procedures such as intubation or endoscopy. The relatively rare occurrence of pleomorphic adenoma of the trachea (8%) as an indication highlights the low incidence of tracheal tumors requiring surgical intervention. In our practice, patients diagnosed with tracheal stenosis grade >II (Myer-cotton classification of stenosis) in which endoscopic treatment has failed, are referred for evaluation by thoracic surgery.

The mean operative time of 148 minutes suggests that these are technically challenging procedures, likely reflecting the complexity of tracheal anatomy and the need for precise resection and reconstruction.

Regarding the surgical approach, the technique usually used is cervicotomy, with or without extension to partial or total sternotomy. In this cohort, in two cases (8%) it was necessary to extend the cervicotomy to partial sternotomy. All remaining cases were performed via cervicotomy alone. Concerning ventilation, cross-table ventilation is usually performed. In this series, the use of cardiopulmonary bypass or jet ventilation was never necessary. After the portion of the trachea that will be removed is resected, an end-to-end anastomosis is performed using a continuous suture for the posterior surface and a simple interrupted suture for the anterior surface. All patients were extubated in the operating room to promote spontaneous breathing as early as possible and avoid the application of positive pressure to the suture of the tracheal anastomosis.

The maximal length of diseased trachea that can be resected has always been a crucial issue. In this cohort, an average of 2,14 cm of the tracheal lenght was resected, which is in accordance with previous studies regarding the maximum size of trachea that can be removed [3, 5]. There is a delicate balance between the removal of the pathological segment while maintaining sufficient structural stability and preventing excessive tension at the anastomosis site. Increasing technical experience in this field has proved that it is possible to resect with end-to-end anastomosis up to 50% of the length of the trachea in the adult. Patient's young age, elasticity of the tracheal wall and the absence of previous treatment may positively influence the potential extent of the resection. There can be no absolute guidelines to limits of resection in an individual patient, but prudence dictates that patients undergoing resections longer than 4 cm should be considered for a tracheal release procedure [4, 7]. In our center, in cases where the need for a large tracheal resection (>4cm) is anticipated, patients are referred to a high-volume international center and so no release procedures were applied in this cohort.

Tracheal surgery is challenging and associated with high morbidity due to high complication rates (up to 40%), even in the largest series [4, 9]. Due to its rigidity, short length and close proximity to neurovascular structures, tracheal resection can cause serious complications.

The incidence of vocal cord paralysis (8%) is notable and indicates the potential for recurrent laryngeal nerve injury during tracheal surgery. Given the proximity of this nerve to the trachea, particularly in cases involving extensive resection or manipulation, this complication is not unexpected but can

have significant functional implications for patients. It remains unclear if the cause of hoarseness is laryngeal oedema, inflammation, transient vocal cord paresis, or true nerve injury. True injury to the recurrent laryngeal nerve is rare and described in 2% [9]. To avoid damage of recurrent laryngeal nerve and devascularisation of the trachea, it is essential to keep the dissection close to the trachea and to avoid extended paratracheal lymph node dissection in malignancies.

Surgical wound infection (8%) and anastomotic dehiscence (4%) are also key complications, as infections and wound integrity issues can jeopardize airway stability and healing.

In the literature, the incidence of anastomotic dehiscence ranges between 1% and 6%, which is in line with our results [4]. The incidence of these complications is affected by various factors such as the suture, blood supply of the two ends of the trachea, and the anastomosis site's tension. In order to avoid damage of recurrent laryngeal nerve and devascularisation of the trachea, it is essential to keep the dissection close to the trachea and to avoid extended paratracheal lymph node dissection in malignancies. Additionally, dissection of the pretracheal plane should routinely be performed to enhance the mobility of the trachea. However, the key to avoiding anastomotic complications is preventing anastomotic tension and, whenever this is a concern, to consider liberal use of release manoeuvres. As previously mentioned, safe resection length is considered highly individual and varies with age, neck length, previous treatment, and body habitus. In this cohort, we observed a case of anastomotic dehiscence in the early postoperative period that was surgically corrected with re-anastomosis via total sternotomy. In this case, no release manoeuvres were adopted in either of the surgeries as patient was young, with a tracheal resection measuring 2.5 cm in length and without significant risk factors. The post-surgical result was favorable and there were no sequelae.

Of particular concern is the single case of mediastinitis (4%), a rare but life-threatening complication, highlighting the critical need for vigilant postoperative monitoring, especially in cases where surgery has taken place in a post-traumatic context, where patient's preoperative condition may usually be poorer compared to patients admitted for elective procedures, as was the case with this patient.

Re-stenosis occurred in only one patient, treated successfully with prosthesis placement. The surgical indication for this patient was idiopathic stenosis. Formation of granulation tissue is described between 1% and 18% in the literature. [4] One of the hypotheses described for the development of this complication is some degree of anastomotic separation, allowing ingrowth of granulation tissue. Endoscopic procedures can play a crucial role after resection in the management of complicated patients, thus limiting the need for redo surgery. Fortunately, healing mostly occurs spontaneously in minor degrees.

Finally, one patient required a definitive tracheostomy due to vocal cord paresis, potentially related to a more extensive dissection. Despite the three complications previously described, the long-term functional outcomes were generally favorable for the majority of patients.

The median duration of chin stitch placement (10 days) and the median hospital stay of 15 days underline the intensive postoperative care required in these patients. Besides sufficient mobilization of the larynx and the trachea during surgery, postoperative anteflexion of the neck is a widely applied manoeuvre to decrease the tension on the anastomosis. Various techniques have been described to secure collar anteflexion, including orthosis, halovests and neck collars [11]. The most commonly used method is the chin stitch, which reaches from the submental crease to the presternal skin helping to reduce tension at the anastomotic site, a key factor in preventing dehiscence. Its main purpose is to remind the patient to avoid hyperextension of the neck [12]. Due to this, all our patients were on chin chest suture postoperatively until bronchoscopy is performed for anastomosis assessment which usually takes place between the 5th and the 7th postoperative day, according to the availability of the Bronchology department.

The extended hospital stay is likely driven by the need for careful airway monitoring, management of complications, and rehabilitation, particularly in cases involving vocal cord dysfunction or wound infection.

The in-hospital mortality of 8% (2 cases) is relatively high, reflecting the complexity and risks associated with major airway surgery. It should be noted that both cases of mortality occurred in patients undergoing surgery to correct iatrogenic tracheal laceration, that is, in an urgent context. One of the patients developed postoperative mediastinitis with subsequent sepsis that led to death. The other patient ended up dying during the natural course of the underlying disease that led to intubation that resulted in the iatrogenic laceration of the trachea.

This figure aligns with other reports where high-risk patients or those undergoing extensive resections face substantial perioperative risks.

Importantly, the overall mortality during a mean follow-up period of 51 months was also 8% (2 cases), suggesting that the majority of patients achieve good long-term survival after successful surgery. However, this does not necessarily equate to complete recovery, as seen with the need for prostheses and tracheostomy in some patients, reflecting ongoing airway and functional challenges for a minority.

CONCLUSION

These results illustrate the delicate balance between successful airway reconstruction and the potential for serious complications in tracheal surgery. Despite the relatively high complication and mortality rates, the long-term survival and overall low re-stenosis rate suggest that, with careful patient selection and skilled surgical technique, most patients can expect favorable outcomes. However, vigilance for complications such as vocal cord paralysis, infection and dehiscence is essential, and some patients may require additional interventions postoperatively.

REFERENCES

1. Grillo, H.C., The history of tracheal surgery. Chest Surg Clin N Am, 2003. 13(2): p. 175-89.
2. Balasubbiah, N., et al., Tracheal resection and reconstruction: A 3-year case series of 14 patients. Med J Malaysia, 2022. 77(5): p. 622-627.
3. Siciliani, A., E.A. Rendina, and M. Ibrahim, State of the art in tracheal surgery: a brief literature review. Multidiscip Respir Med, 2018. 13: p. 34.
4. Ferreirinha, J., et al., Postoperative outcome of tracheal resection in benign and malignant tracheal stenosis. Swiss Med Wkly, 2020. 150: p. w20383.
5. D'Andrilli, A., E.A. Rendina, and F. Venuta, Tracheal surgery. Monaldi Arch Chest Dis, 2010. 73(3): p. 105-15.
6. Evermann, M., et al., Cervical Repair of Iatrogenic Tracheobronchial Injury by Tracheal T-Incision. Ann Thorac Surg, 2022. 114(5): p. 1863-1870.
7. Ziaian, B., et al., The effect of suture techniques on the outcome of tracheal reconstruction: An observational study and review of literature. Surgeon, 2023. 21(2): p. e89-e96.
8. Rea, F., et al., Benign tracheal and laryngotracheal stenosis: surgical treatment and results. Eur J Cardiothorac Surg, 2002. 22(3): p. 352-6.
9. Bibas, B.J., et al., Predictors for postoperative complications after tracheal resection. Ann Thorac Surg, 2014. 98(1): p. 277-82.
10. D'Andrilli, A., F. Venuta, and E.A. Rendina, Subglottic tracheal stenosis. J Thorac Dis, 2016. 8(Suppl 2): p. S140-7.
11. Mutrie, C.J., et al., Cervical tracheal resection: new lessons learned. Ann Thorac Surg, 2011. 91(4): p. 1101-6; discussion 1106.
12. Allen, M.S., Surgery of the Trachea. Korean J Thorac Cardiovasc Surg, 2015. 48(4): p. 231-7.