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*Research Article*

# Tracheal Resection Anastomosis: A Retrospective Analysis of 33 Cases

**Abdullah Al Shammari**,[1,2] **Ghadi Askar**,[1] **Talal Al Masri**,[1] **Mohamed Shoukri**,[3] **Mohammed Ishaq**,[2] **Waleed Saleh**[1,2]

[1]College of Medicine, Alfaisal University, Riyadh, Saudi Arabia
[2]Department of Thoracic Surgery, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia
[3]Department of Epidemiology and Biostatistics, Schulich School of Medicine and Dentistry, University of Western Ontario, Canada

Address correspondence to Abdullah Al Shammari (aalshammari@alfaisal.edu).

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## ABSTRACT

**Introduction:** Laryngotracheal stenosis (LS) is most commonly caused by iatrogenic injury, namely, tracheal intubation. The goal of treatment is the maintenance of a patent airway, which is mostly achieved by surgical intervention. Our objective was to study the effect of perioperative variables on tracheal resection anastomosis (TRA)/cricotracheal resection anastomosis (CTRA) surgical outcomes by identifying statistically significant factors associated with postoperative complications and failure of surgery, i.e., restenosis. **Methods:** Data from the medical records of 33 patients who underwent TRA/CTRA was analyzed by univariate and multivariate logistic regression. The data included perioperative variables such as the etiology of stenosis, comorbidities, and postoperative or long-term complications. **Results:** The study included nine females and 24 males, and most (29, 87.88%) were intubated prior to surgery. Nineteen patients (57.57%) developed one or more postoperative complications, including, but not limited to, surgical site infection and hematoma. Of all patients, six (18.18%) developed long-term restenosis. Multiple factors were significantly associated with the development of postoperative complications. Univariate analysis revealed the following factors as statistically significant: age ($p = 0.05$), diabetes ($p = 0.00001$), hypertension ($p = 0.00001$), and myocardial infarction ($p = 0.03$). Multivariate analysis showed that age ($p = 0.046$) and myocardial infarction ($p = 0.00001$) were independent factors. The study had an overall survival of 97%. **Conclusion:** TRA/CTRA is a complex surgical procedure, and its outcomes can be affected by many factors. More studies with bigger sample sizes are needed to better understand contributing factors and to confirm the already established associations.

**Keywords:** intubation, thoracic surgery, acquired subglottic stenosis, acquired laryngeal stenosis, surgical anastomosis, tracheal stenosis

## INTRODUCTION

Laryngotracheal stenosis (LS) refers to acquired or congenital conditions of reduced airway caliber at the level of the larynx or trachea. Acquired cases are caused by scar tissue formation due to prolonged intubation, history of tracheostomy, primary or secondary neoplastic processes, infections, trauma, and autoimmune disorders or idiopathic causes.[1,2] Clinical presentation can be acute or chronic dyspnea that initially manifests on exertion and then progresses to dyspnea at rest. Moreover, the presence of acute dyspnea indicates up to 75% narrowing of the airway. Other symptoms include cough, stridor, and hemoptysis in neoplastic etiologies.[3–5]

The primary management goal consists of maintaining a patent airway while avoiding the use of any indwelling appliances. Additional goals include preserving the patient's voice and swallowing. Surgical treatment remains the gold standard for achieving the above-desired outcomes.[1] Surgery can be divided into endoscopic and open approaches; the latter are generally preferred in cases of severe stenosis, tracheomalacia, cartilage loss, or stenosis greater than 1 cm in length.[6]

Although the most common indication for open surgery is related to prolonged intubation, malignancy as an indication is not uncommon.[7] Tracheal invasion from thyroid cancers occurs in 4–23% of patients, of whom, 0.5–1.5% have tracheal wall involvement with protrusion of the tumor into the lumen.[8] Tracheal sleeve resection with end-to-end anastomosis is the treatment of choice for thyroid cancers infiltrating the tracheal wall since it accomplishes locoregional tumor control and an overall 5-year survival rate of more than 80%.[9–16]

Various studies have investigated the potential significance of perioperative factors on the success of tracheal resection anastomosis (TRA)/cricotracheal resection anastomosis (CTRA). Some factors were associated with the development of anastomotic complications, such as the presence of comorbidities, previous tracheal resection, and the length of the resected segment.[17] In one study, preoperative tracheostomy, age older than 70, as well as cardiovascular and pulmonary comorbidities, significantly affected the incidence of major complications such as acute myocardial infarction and pulmonary embolism.[24]

This report presents the retrospective analysis of 33 medical records of patients who underwent primary TRA/CTRA. The objective of this work was to evaluate the effect of multiple perioperative variables, such as resection length, etiology, comorbidities, and previous relevant surgeries, as potential predictors of postoperative and long-term complications.

## MATERIALS AND METHODS

This retrospective analysis was performed at King Faisal Specialist Hospital and Research Center, Riyadh. The institutional review board approved this study and waived the need for informed consent. The electronic medical records of 33 patients between January 2000 and August 2016 were reviewed. Inclusion criteria included (1) Patients admitted to the Cardiothoracic Surgery Department of our hospital and (2) tracheal or cricotracheal resection and anastomosis due to traumatic injury or malignancy. The only exclusion criterion was patients with incomplete records. Potential prognostic factors were collected from all medical records.

Preoperative workup consisted of radiological and bronchoscopic evaluations. CT scans of the neck and chest and flexible bronchoscopy were performed to determine the level of stenosis and its severity. In addition, all patients with malignant lesions underwent a positron emission tomography (PET) scan to examine the degree of invasion of the trachea and the potential involvement of other tissues or the presence of metastases.

Airway resection and anastomosis was carried out following the procedure description published by Grillo et al.[19] Patients were positioned in a supine position with neck hyperextension, supporting the shoulder with a shoulder roll and the head over a head ring. After subcutaneous plane was dissected, the platysma and strap muscles were separated vertically in the midline to expose the anterior surface of the trachea. The pretracheal fascia were incised, and the trachea was dissected close to the lateral margin to preserve the recurrent laryngeal nerves and vasculature until the trachea was exposed and then mobilized. Diseased segments were dissected with or without cricoid cartilage or mucosa. The anastomosis was performed using a continuous Vicryl 4-0, Vicryl 3-0, 3-0 Maxon, 4-0 Maxon, PDS 3-0, PDS 4-0, or Monocryl 3-0 suture for the membranous part and interrupted Vicryl 3-0, PDS 3-0, or 3-0 Maxon sutures for the anterior cartilaginous part. The guardian chin suture was used conservatively according to the surgeon's preference. All patients were approached cervically, except for one patient who underwent a thoracotomy approach intraoperatively because of adhesions and difficult approach. All patients were extubated successfully in the operating room and moved to the ICU. Follow-up appointments with the thoracic surgery clinic were scheduled for all patients 2 weeks after discharge.

Complications were categorized as either postoperative if they occurred before discharge (within 1 week from the surgery), or long term if they were discovered on subsequent follow-ups. The postoperative group contained infection, hematoma, lung effusion, subcutaneous emphysema, upper airway obstruction, and restenosis. Long term, on the other hand, comprised restenosis as the only complication.

SPSS version 25 was used to analyze the data. Univariate and multivariate logistic regression models were used to identify the possible predictors of outcome (independent variables) and their effect on the development of the following outcomes (dependent variables): postoperative or long-term complications.

## RESULTS

The study included 33 patients, nine females and 24 males, with ages ranging between 13 and 70 years. Descriptive data of our patients, including their demographics and perioperative variables, are shown in Table 1.

The underlying etiology was either postintubation injury (Group A, 29 patients) or neoplastic lesions (Group B, six patients). Of the latter, adenoid cystic carcinoma was the most common (three patients), followed by papillary thyroid carcinoma (two patients), and finally, mucoepidermoid carcinoma (one patient). Two patients with adenoid cystic carcinoma had presurgical intubation; therefore, they were included in both groups because the cause of tracheal stenosis could not be exclusively attributed to one of the two factors (adenoid cystic carcinoma vs intubation injury). Twenty of the patients underwent TRA, whereas 13 patients underwent CTRA and were labeled as having a subglottic

**Table 1.** Demographics and perioperative variables of 33 patients

| Parameter | Value |
|---|---|
| Sex, *n* (%) | |
| Male | 24 (72.73) |
| Female | 9 (27.27) |
| Age, mean ± SD, y | 29.4 ± 15.7 |
| Comorbidities, *n* (%) | |
| Obesity | 1 (3.03) |
| Diabetes mellitus | 6 (18.18) |
| Hypertension | 4 (12.12) |
| Ischemic heart disease | 2 (6.06) |
| COPD | 1 (3.03) |
| Myocardial Infarction | 1 (3.03) |
| Obstructive sleep apnea | 1 (3.03) |
| Bronchial asthma | 1 (3.03) |
| Atrial fibrillation | 1 (3.03) |
| Hypoventilation syndrome | 1 (3.03) |
| Histopathology (Group A), *n* (%) | |
| Fibrosis | 26 (78.79) |
| Chronic inflammation | 1 (3.03) |
| Histopathology (Group B), *n* (%) | |
| Adenoid cystic carcinoma | 3 (9.09) |
| Papillary thyroid carcinoma | 2 (6.06) |
| Mucoepidermoid carcinoma | 1 (3.03) |
| Surgical resection length, *n* (%) | |
| < 2 cm | 2 (6.25) |
| 2–4 cm | 29 (87.87) |
| > 4 cm | 2 (6.25) |
| Surgical approach, *n* (%) | |
| Cervical | 32 (96.97) |
| Thoracotomy | 1 (3.03) |
| Surgical resection, *n* (%) | |
| Subglottic | 2 (6.06) |
| Upper tracheal | 13 (39.39) |
| Subglottic + upper tracheal | 11 (33.33) |
| Midtracheal | 4 (12.12) |
| Lower tracheal | 3 (9.09) |
| ICU stay, mean ± SD, days | 1.2 ± 0.7 |
| Intubation before surgery, *n* (%)[a] | 29 (87.88) |
| Living status, *n* (%) | |
| Alive | 32 (96.97) |
| Deceased | 1 (3.03) |
| Follow-up, *n* (%) | 21 (26.50) |

[a]This variable was not applicable for four patients.

surgical resection (as seen in Supplemental Table S1, available online).

Nineteen patients (57.57%) developed one or more postoperative complications. Out of those 19, 11 (57.89%) had some degree of lung atelectasis that resolved spontaneously. One patient had a surgical site infection and was treated with antibiotics, and another patient suffered a mild neck hematoma that was treated conservatively by discontinuing his anticoagulant medications. Moreover, one patient developed subcutaneous emphysema that resolved simultaneously. Anastomotic leak was investigated and ruled out by chest x-ray in patients who developed subcutaneous emphysema and infection. Granulation tissue was removed by bronchoscopy and bronchoalveolar lavage in one patient who developed an upper airway obstruction on the fourth day postoperatively. This patient was discharged in good health, maintaining a saturation of 96% on room air and stable hemodynamics. Lastly, one patient with previous myocardial infarction and diabetes developed restenosis 25 days after surgery and required bronchoscopy and dilatation. The patient could not be operated on again and was managed conservatively because a long segment was already resected. This patient continued to have restenosis regardless of management and thus was counted to have a long-term complication. Six patients developed restenosis as a long-term complication, which was considered an indicator of our surgical outcome. Three of these patients had subglottic plus upper tracheal stenosis, one had upper tracheal stenosis, and two had lower tracheal stenosis. All resected segments ranged between 2 and 4 centimeters. Restenosis was managed in those patients by rigid bronchoscopy and dilatation one or multiple times to alleviate symptoms of stridor and difficulty breathing.

The median follow-up duration was 12 months, with a range of 0–96 months. A case of recurrent adenoid cystic carcinoma in a 33-year-old woman was the only mortality for this series; the patient died years after surgery from a nonthoracic etiology. The overall survival was 97%.

For postoperative complications, univariate analysis was used to screen for potential risk factors. Surgical resection ($p = 0.04$), age greater than 37 years ($p = 0.0001$), myocardial infarction ($p = 0.01$), intubation ($p = 0.03$), metastasis ($p = 0.02$), and histopathology ($p = 0.01$) were found to be significant. Furthermore, multivariate analysis identified age ($p = 0.04$) and myocardial infarction ($p = 0.00001$) as significant independent factors for developing postoperative complications. As for long-term complications, univariate analysis identified age >37 ($p = 0.053$), diabetes ($p = 0.00001$), hypertension ($p = 0.00001$), and myocardial infarction ($p = 0.03$) as significant factors. The multivariate logistic regression model that was applied to these variables could not be carried out due to the multicollinearity of the variables.

## DISCUSSION

In this report, we present a case series of 33 patients with LS surgically managed at King Faisal Specialist Hospital and Research Center in Riyadh, Saudi Arabia. In addition to presenting details about the clinical and surgical findings of the patients, we evaluated the effect of etiology, comorbidities, previous relevant surgeries, and other perioperative variables as potential predictors of postoperative and long-term complications.

LS is a rare and serious complication of prolonged tracheal intubation, neoplastic lesions, infections, trauma, or autoimmune diseases. LS is not easy to manage, and an ineffective approach in management may lead to the loss of one or more tracheal functions, namely respiration, prevention of aspiration, and phonation.

The ideal surgical management approach for LS, as the current literature suggests and as widely practiced by clinicians, is TRA/CTRA.

Restenosis, our main surgical outcome, is a feared long-term complication of TRA/CTRA and is believed to be the product of tension and ischemia at the anastomotic site, subclinical anastomotic separation, or a combination of both. Possibly, this could be due to the leftover diseased trachea at the time of operation or is more likely due to low-grade ischemia at the anastomotic site.[20,21] Restenosis due to granulation tissue formation is seen as a common complication in patients with postintubation tracheal stenosis who undergo TRA/CTRA, as observed postoperatively in one patient in our series. Bronchoscopy and alveolar lavage were done, and the patient is currently asymptomatic. In this study, we have shown that the rate of restenosis as a long-term complication is about 18.2% (six patients). Wright et al,[22] however, reported a lower incidence of restenosis (4%). In our study, a higher incidence of restenosis could be attributed to confounding factors such as the underlying disease processes that lead to LS; it should be taken into consideration that our center is a referral tertiary care hospital and that our records included a high flow of oncology patients. The choice of suture material and location of the sutures may also have been contributing factors. Also, since the number of patients who present with LS at our hospital is inherently low, the higher incidence rate of restenosis might have been enhanced through statistical effect modification. With regard to the management of restenosis, either rigid bronchoscopies or a pneumatic balloon dilator may be used to dilate the site of anastomosis. If dilations are required more often than every 3–6 months, reoperation must be considered.[21] A T-tube may also be used as a short-term solution in patients who will have re-TRA/CTRA and as a permanent solution in those patients who are not eligible for re-TRA/CTRA, mainly due to insufficient residual trachea. One study in 2014 by Stock et al[23] suggested that hyperbaric therapy with 100% oxygen (HBO), when administered at pressures greater than 1 atm, might enhance wound healing after tracheal resection. However, further investigations are needed to delineate the exact oxygen concentration, pressure, and duration of HBO therapy. Although rare, the complications from oxygen toxicity also need to be carefully weighed when using HBO to minimize short- and long-term complications of TRA/CTRA.

Diseases affecting the vasculature, such as diabetes and vasculitis, are known to prevent effective wound healing. When present in patients undergoing TRA/CTRA, diabetes and vasculitis can negatively affect the outcome of the procedure, resulting in increased long-term complications, as shown in our study.

Diabetes is well known for impairing microcirculation and slowing wound healing. Our study identified diabetes as an important comorbidity associated with long-term complications such as restenosis ($p = 0.00001$). This was in line with previous studies published in the literature.[17,22,24] Piazza et al,[18] however, did not that find diabetes played a major role in terms of the complications rate. In one of his studies, Wright et al[22] pointed out that the increased complication rate with diabetes may be a result of impairment of an already compromised collateral watershed circulation at the site of anastomosis, and tension might be expected to put this area at further risk. Leftover diseased trachea and an impaired and already compromised microcirculation at the anastomotic site may be contributing factors to poor healing and resultant restenosis. Hence, diabetes must be considered when stratifying risk in patients. Some studies have shown that adjunctive HBO treatment was found effective in reducing ulcer wound area in diabetic foot disease.[25–27] The authors concur that adjunctive HBO therapy may be beneficial for diabetic patients undergoing TRA/CTRA. However, this requires further delineation through randomized clinical trials.

Age greater than 37 years, hypertension, and myocardial infarction were found to be associated with postoperative and long-term complications in our study. Piazza et al, Fiz et al, and Hentze et al[18,28,29] identified age and pulmonary or cardiovascular conditions to be associated with major postoperative complications and poor outcome. Their findings could explain the immediate postoperative restenosis reported in one of our patients who suffered a myocardial infarction that required a prolonged ICU admission prior to surgery. It is unclear, however, as to how hypertension in a patient could be associated with tracheal restenosis at the molecular level. Further investigations and larger studies are needed.

Some of the postoperative complications encountered in this study can be explained by confounding factors that reflected on the outcome. All cases of atelectasis were likely attributed to shallow breathing after surgery, which was later supported by the fact that patients improved spontaneously with the commencement of breathing exercises. Finally, we believe that the neck hematoma that developed in one patient was attributed to anticoagulation therapy as it resolved upon discontinuing the medications.

We acknowledge that our study has some limitations, including, but not limited to, the small sample size and its retrospective design. Also, the fact that we are a referral center could imply a certain degree of selection bias. We believe, however, that this bias was minimized because the patients in our cohort were extremely similar in their clinical profiles and the management approaches used in their treatment. Larger multicenter prospective studies of this kind are required to better understand the potential contributing factors and to consolidate the already observed associations of comorbidities with short- and long-term complications of TRA/CTRA.

## CONCLUSION

TRA/CTRA is an effective and reliable surgical procedure in the management of LS. Despite the success stories of TRA/CTRA, all surgical resection-anastomosis procedures involving the airway should be dealt with as major operative procedures, especially in patients with comorbid conditions such as diabetes and hypertension. Therefore, risk stratification is paramount in such patients to maximize surgical outcomes and patient quality of life. Furthermore, novel adjuvant therapies such as HBO that may help in wound healing, especially in patients with impaired microcirculation, and treatments that aim at minimizing short- and long-term complications must be explored further.

## Supplemental Material

Supplemental material is available online with the article.

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