The selection of individualized surgical schemes for laryngotracheal stenosis and effect analysis

Ting Wu¹, Yong Chen², Shuangba He¹, Jie Meng¹, Yaqun Liu¹, Xiaoguang Li¹, and Qingxiang Zhang¹

¹Southeast University
²Binhai County People’s Hospital

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Abstract

Objective: To explore the optimization and effect analysis of laryngotracheal stenosis surgery planning based on the Myer and Cotton grade, disease course, control of the primary disease, and the general condition of the body under the influence of various factors. Methods: A retrospective analysis was performed for 32 patients with acquired laryngotracheal stenosis who received surgical treatment from October 2015 to December 2021. Results: Surgical procedures included sleeve resection and end to end anastomosis (n = 16), partial circumferential tracheal resection (n = 2), tracheal granulation (scar) resection using a CO₂ laser (n = 2), and T-tube insertion (n = 12). Successful decannulation was achieved in 31 patients (96.9%). Post-operative complications comprised: Subcutaneous emphysema (n = 25), subcutaneous infection (n = 6), anastomotic restenosis (n = 4), and anterior cervical tracheal fistula (n = 4). Conclusion: Considering multiple factors, the optimization of the surgical plan according to the degree of stenosis, the disease course, control of the primary disease, and the patient’s general condition was an important guarantee to improve the curative effect of laryngotracheal stenosis.

Introduction

Laryngotracheal stenosis (LTS), which is defined as a partial or complete cicatricial narrowing of the endolarynx and trachea (1), is rarely seen in the clinic, but can lead to dyspnea and even asphyxia, which seriously endanger the physical and mental health of patients. Tracheal intubation is the direct cause of 90% of acquired benign LTS in adults, and the duration of intubation is the most important factor affecting its development (2, 3). Moreover, LTS can be secondary to tracheotomy, infection, trauma, chemical irritation, or radiation-induced cartilage necrosis after radiotherapy. Preoperative evaluation of these risk factors helps to improve surgical efficacy.

Clinically, we found that there are marked differences in the degree of stenosis, the disease course, control of the primary disease, and the general condition of each patient with LTS. Under the influence of these factors, choosing and optimizing treatment is an important clinical challenge. In this retrospective study, we report our experience of operation scheme design for LTS. The major goal of operation scheme design is to improve the efficacy of surgery for LTS.

Materials and methods

Patients

This study involved a retrospective analysis of patients who underwent LTS surgery between October 2015 and December 2021 at the Department of Otorhinolaryngology, Head and Neck Surgery, Nanjing Tongren Hospital. Thirty-two patients were included in the study, comprising 21 males (66%) and 11 females (34%). Among the patients with LTS, the most common etiological factor was prolonged tracheal intubation in the
intensive care unit, because of trauma (in 1 patient (3%)) and respiratory tract infection (in 1 patient (3%)) (Table 1).

**Pre-operative evaluation**

Electronic laryngoscope, laryngotracheal and lung computed tomography (CT), and three-dimensional reconstruction of the airway were performed before surgery to determine the degree and location of stenosis and the involvement of laryngotracheal cartilage, especially the cricoid cartilage. Stenosis was graded in accordance with the Myer and Cotton grading scale. This system classifies stenosis severity on the basis of airway obstruction, as follows: grade I = 0–50% obstruction; grade II = 50–70% obstruction; grade III = 70–99% obstruction; and IV = complete obstruction (4).

**Surgical plan design**

Design principles: 1) Patients with good general condition, cured or stable primary disease, disease duration of more than 3 months, stenosis mainly involving the cervical trachea, and a stenosis length of less than 4.0 cm should be treated using sleeve resection and end to end anastomosis. 2) For patients with narrowing involving the trachea cricoid cartilage (subglottic), a history of more than 3 months, narrow local scarring, primary disease, and a stable and mature general situation, then line ring partial nephrectomy revascularization of the airway should be used. 3) If the stenosis was located above the tracheostomy and was relatively limited, had less than 1/2 circumferential granulation or scarring was explored during operation, then CO\textsubscript{2} laser tracheal granulation or scar resection was used; 4) T-tube placement should be performed for patients with advanced age, poor general condition, or uncontrolled primary disease, who are unable to be weaned or blocked because of airway stenosis, and the length of airway stenosis was greater than 4.0 cm or more than 1/2 circumferential granulation or scarring.

**Sleeve resection and end to end anastomosis**

The end-to-end anastomosis of sleeve resection is relatively traumatic; therefore, it should be selected only if the patient’s general condition allows it. Herein, we found that for defects larger than 4 cm, the tension of cervical tracheal anastomosis can be effectively reduced by releasing the thyrohyoid muscle and the superior horn of the thyroid cartilage, moving the laryngeal body downward as a whole, and combining it with neck flexion. Sleeve resection and end-to-end anastomosis can be safely and effectively used to treat advanced LTS and large laryngotracheal defects (Figure 1).

**Partial circumferential tracheal resection**

By preserving the integrity of the bilateral cricothyroid joints, we could effectively protect the recurrent laryngeal nerve at the larynx, and maintain the normal anatomical position relationship between the cricoid cartilage plate and the thyroid cartilage plate. An annular supporting effect of the cricoid cartilage on the airway is formed, which is of significant to maintain the patency of the whole upper airway after surgery (Figure 2).

**T-tube insertion**

We used the "cloth method" to lead the upper branch from the stoma through the supporting laryngoscope from the mouth, which acted as a "guide wire" to smoothly guide the upper branch into the upper airway and simplify the surgical process (Figure 3).

**Follow-up and postoperative efficacy evaluation**

Postoperative follow-up was carried out for 11–48 months (average = 16.2 ± 17.3 months). At 1 year after surgery, electronic laryngoscopy and three-dimensional reconstruction of the neck CT scan were used to evaluate the airway status of the patients, and surgical efficacy was evaluated combined with the subjective feeling of patients. Cure was defined as removal of the tracheal tube or T-tube after surgery, the ability to perform normal physical activities, and imaging or electronic laryngoscopy (or bronchoscopy) showing that
the anatomical airway was normal. Effective: the tracheal tube or T-tube was removed after surgery, the patient could perform daily activities, but had difficulty breathing after exercise, or the electronic laryngoscope (or bronchoscopy) or imaging examination showed tracheal stenosis. Ineffective: The tracheotomy needed to be retained or the T-tube could not be removed. The short and long-term complications after surgery were observed and recorded.

Results

The surgical procedures carried out included sleeve resection and end to end anastomosis (n = 16), partial circumferential tracheal resection (n = 2), tracheal granulation (scar) resection using a CO\textsubscript{2} laser (n = 2), and T-tube insertion (n = 12). End to end anastomosis, partial circumferential tracheal resection, and tracheal granulation (scar) resection using a CO\textsubscript{2} laser restored airway function in the patients. At 1 year post-surgery 19 patients were cured and 1 patient had effective surgery, giving an effective rate of 100% (20/20). At 6–12 months after T-tube placement, 11 patients were successfully extubated, 7 were cured, 2 received effective treatment, and in 3 cases, treatment was ineffective, giving an effective rate of 75%. Two of the three ineffective cases underwent sleeve resection and end to end anastomosis to achieve successful extubation, and were judged to be cured after 1 year of follow-up. The other patient refused extubation and survived after blockage. For this follow-up period, the total cure rate was 87.5% (28/32), the effective rate was 9.4% (3/32), and the ineffective rate was 3.1% (1/32), with a total decannulation rate of 96.9%.

The most common postoperative complication was subcutaneous emphysema (78% (25/32)); however, no serious mediastinal emphysema and pneumothorax occurred. Different degrees of granulated tissue grew around the neck wound in the T-tube placement group after surgery, which improved or disappeared after 6–9 months. For four patients in the T tube placement group, extubation was carried out after tracheal fistula, with anterior portion colostomy mouth closed surgery being used to cure the line. No major bleeding or perioperative death occurred in either group (Table 2).

Discussion

At present, there are still serious challenges in the treatment of LTS, especially for patients with severe stenosis. With the improvement in surgical techniques and medical materials, there are more options for the treatment of LTS. Moreover, one treatment is not suitable for all types of LTS (5). Considering the complex conditions, choosing a reasonable treatment is vital.

The overall cure rate of LTS surgery is 82.5–86.7% (6). The total extubation rate of this group of patients reached 96.9%, and a relatively satisfactory treatment effect for patients with different conditions of LTS was achieved. We believe that the optimization of the surgical procedure should mainly consider the Myer-Cotton stage, the disease course, control of the primary disease, and the patient’s general condition, which includes two aspects: 1) Overall analysis and understanding the patient’s condition. Different underlying primary diseases might affect the curative effect of LTS surgery (7). In this group of 32 patients, 24 cases underwent tracheal intubation or tracheotomy because of acute abdominal and respiratory failure, representing the main primary causes in this group of patients. This might be due to high abdominal pressure, long-term bed rest, and the influence of gastric tube, leading to severe reflux. Gastroesophageal reflux, which is a risk factor for a low extubation rate, has been confirmed as an important factor causing a high incidence of tracheal granulation after tracheotomy (8, 9). When the acute abdomen is not stable, high abdominal pressure and gastroesophageal reflux are not recovered (9), and it is not appropriate to choose relatively radical open surgery, which would negatively affect efficacy. 2) Accurate assessment of local airway. Even if the resection of the stenosed airway has good efficacy (10), if the stenosed segment is too long, it is not suitable for sleeve resection and end-to-end anastomosis. By contrast, if the airway stenosis is limited and does not exceed half of the circumferential airway, scar or granulation resection can be performed directly, while extensive airway resection or the unnecessary placement of the T-tube can be avoided as much as possible, resulting in a decreased need for perioperative anesthesia and care. Therefore, in addition to the requirements of the surgical techniques, the treatment plan for LTS needs to be selected based on the overall condition of the patient and the local situation of their airway (8).
In addition, for each treatment method, only a correct understanding of its advantages, disadvantages, and applicable conditions, and accurate implementation during surgery, can ensure its efficacy. The end-to-end anastomosis of sleeve resection is relatively traumatic; therefore, it should be selected under based the patient’s general condition. Airway reconstruction after partial cricotracheal resection is a more complicated procedure, involving the treatment of cricoid cartilage and the protection of the recurrent laryngeal nerve, as well as the airway width and anastomotic tension (11). It is very important to determine the length of the upper and lower branches of the T-tube during T-tube implantation [7], and to avoid postoperative dysphagia, the upper branch should not be too long. If there is no stenosis at the lower end, the lower branch can be retained for 2 cm; however, it cannot be extended at will to prevent the long artificial airway from affecting the sputum excretion function of the patient.

In conclusion, considering the etiological factors, and based on the premise of ensuring the accurate implementation of each surgical method, the optimization of surgical planning according to the degree of stenosis, the disease course, primary disease control, and the patient’s general condition is an important guarantee to improve the efficacy of laryngotracheal stenosis surgery. There are some limitations to this study. The inclusion of several surgical methods would affect the homogeneity of the data, and thus, a comparison of efficacy among the groups could not be performed. In addition, in this group, no patients received balloon dilatation and extended partial cricotracheal resection, thus future studies should include such cases.

References

**Figure legends**

Table 1: Etiological factors affecting laryngotracheal stenosis surgery

Table 2: Postoperative complications of laryngotracheal stenosis surgery

Figure 1:
A: The 4 cm long stenotic segment was dissected longitudinally. B: The descending larynx was treated so that the larynx could be lowered by one vertebral height, which was about 2 cm.

Figure 2:
A: The anterior cervical soft tissue was separated to expose the narrow segment of the airway, cricochondromalacia and scarring were observed, and the lower edge of the thyroid cartilage was ladder-like. B: Schematic diagram of the plane and extent of airway truncation. C: The stenotic airway was removed.

Figure 3:
A: Before surgery, necrotic cartilage was seen at the tracheostomy site with surrounding granulation leading to tracheal lumen stenosis. B: After T-tube placement, an artificial airway was established. C: Three months after extubation, the airway was patent.

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