Different results of tracheoplasty for various tracheal diseases

Ming-Ho Wu

Department of Surgery, Tainan Municipal Hospital, Show Chwan Medical Care Corporation, Tainan, Taiwan

Abstract

Background: Tracheoplasty is a challenging surgical procedure for treating tracheal diseases. Preserving the voice and achieving normal breaths are considered favorable results. This article reports the mid-term results of tracheoplasty.

Materials and Methods: From July 1988 to June 2018, a total of 91 adults with various tracheal diseases who underwent tracheoplasty were enrolled in this study. Tracheal diseases were divided into two categories. Category 1 was not related to neoplasm and included posttracheostomy or postintubation tracheal stenosis, caustic tracheal stricture, tuberculous tracheal stenosis, and congenital tracheal stenosis. Category 2 was related to neoplasm and included tracheal neoplasm and tracheal invasion by thyroid cancer or esophageal cancer. The surgical procedures mainly involved segmental resection of the trachea, telescopic anastomosis following a middle split of thyroid-cricoid cartilage, spiral tracheoplasty, and slide tracheoplasty.

Results: One hospital death (1.1%) occurred. Favorable results of tracheoplasty were 81.3% (74/91). The failure rate of tracheoplasty was higher in Category 1 (24.2%, 15/62) than Category 2 (3.6%, 1/28). The subglottic involvement also induced a higher failure rate of tracheoplasty (35.3%, 6/17 vs. 13.7%, 10/73). However, the multivariate logistic regression model demonstrated that the category of tracheal disease and subglottis involvement did not statistically significant induce surgical failure of tracheoplasty. Sixteen (17.6%) patients had surgical failure resulted from anastomotic leaks, regrowth of granulation, or subglottic involvement.

Conclusions: Carefully evaluating the tracheal lesions and selecting the appropriate surgical procedure can yield favorable results of tracheoplasty.

Keywords: Tracheal disease, tracheal resection, tracheal stenosis, tracheoplasty

INTRODUCTION

Although tracheal stents, balloon dilatation, photodynamic therapy, and neodymium yttrium aluminum garnet laser have been used to manage various types of tracheal diseases,[1-4] tracheal resection and primary anastomosis are still recommended to treat tracheal lesions of some etiologies.[5-9] As a senior thoracic surgeon, I have 40-year experience of tracheal surgery. Data of the last 30 years are available for sharing my personal experience. To evaluate the outcome of tracheoplasty, the medical records, surgical methods, and mid-term results of tracheoplasty from the past 30 years were reviewed.

Address for correspondence: Dr. Ming-Ho Wu, Department of Surgery, Tainan Municipal Hospital, Show Chwan Medical Care Corporation, No. 670 Chunh-Te Rd., Tainan 701, Taiwan.
E-mail: m2201@mail.ncku.edu.tw
Received: 06-Nov-2018, Revised: 25-Dec-2018, Accepted: 14-Oct-2019, Published: 19-Feb-2020

For reprints contact: reprints@medknow.com

How to cite this article: Wu MH. Different results of tracheoplasty for various tracheal diseases. Formos J Surg 2020;53:14-9.
PATIENTS AND METHODS

From July 1988 to June 2018, 91 adults with various tracheal diseases underwent tracheoplasty. In the same period, 16 pediatric patients also underwent tracheoplasty and another 29 patients with advanced diseases directly underwent laryngotracheal resection with permanent tracheostomy. All procedures were performed by the author. The algorithm for the management of adult tracheal diseases is shown in Figure 1. The present study focused on the tracheoplasty of 91 adults (46 men and 45 women) ranging in age from 18 to 81 years (average, 50.5 years). Tracheal diseases were divided into two categories. Category 1 was not related to neoplasm and included posttracheostomy or postintubation tracheal stenosis, caustic tracheal stricture, tuberculous tracheal stenosis, and congenital tracheal stenosis. Of 63 patients in Category 1, the associated diseases were cerebrovascular accident in 24 (38.1%), caustic injury in 9 (14.3%), tuberculosis in 8 (12.7%), head injury in 8 (12.7%), multiple injuries in 4 (6.3%), drug intoxication in 3 (4.8%), and others of 7 (11.1%). Category 2 was related to neoplasm and included tracheal neoplasm, tracheal invasion by thyroid cancer, and tracheal invasion by esophageal cancer. In these eight esophageal cancer patients, four had severe airway obstruction, three had intraoperative findings of tracheal invasion, and the other one had tracheo-oesophageal fistula. Tracheal neoplasms included adenoid cystic carcinoma of 3, and each one of squamous cell carcinoma, squamous papilloma, chondroma, and glomus tumor.

Preoperative evaluation

Computed tomographic (CT) images of the chest were obtained to define the length of the tracheal lesion and to assess the nature of the disease or extent of the tumors. The location of tracheal lesions was also identified, such as the neck, cervicothoracic junction, or intrathorax. Flexible bronchoscopy and three-dimensional imaging of the trachea were performed to evaluate the extent of the tracheal lesions. Rigid bronchoscopy was also used preoperatively for detection and dilatation in patients with posttracheostomy and postintubation tracheal stenosis.

Airway management and anesthesia

Close cooperation between anesthesiologists and surgeons is essential to maintain a patent airway perioperatively. Anesthesia was induced using inhalation anesthetics and sedatives, whereas muscle relaxants were excluded. The endotracheal tube was selected to cope with airway narrowing. In dyspneic patients under local anesthesia, a tracheal opening was made beyond the lesion. Typically, a 5-mm nonkinking endotracheal tube is used through this opening for tracheal surgery. At anastomosis, we exchanged this nonkinking tube for a 7.5-mm endotracheal tube. The endotracheal tube was removed in the operating room or on postoperative day 2 or 3.

Choice of surgical procedures

The following surgical procedures were selected based on the tracheal disease being treated [Figure 2].

- Segmental resection of the trachea followed by end-to-end anastomosis: This surgical technique is appropriate for tracheal resection of less than half of the total tracheal length and is commonly used in patients with a granulomatous narrowing and neoplasm occupying most of the tracheal circumference.
- Telescopic anastomosis following a middle split of thyroid-cricoid cartilage: Since 2011, in the surgical treatment of subglottic stenosis, I have performed telescopic anastomosis following a middle split of thyroid-cricoid cartilage [Figure 3].
- Spiral tracheoplasty: Since 2008, I have used this technique to treat tangential tracheal lesions located at the cervicothoracic junction [Figure 4].
- Slide tracheoplasty: This technique has been commonly used to correct tracheal stenosis presented with normal tracheal mucosa, particularly in the surgical management of patients with congenital tracheal stenosis.

Surgical considerations

Collar incision, either alone or combined with partial sternotomy, is typically performed to treat tracheal diseases in the neck and at the cervicothoracic junction. Complete
sternalotomy or right thoracotomy was performed for lesions at the middle or distal thoracic trachea. To treat combined stenosis of the trachea and right or left main bronchus, a trans-pericardial approach was employed. Mobilization of the trachea was performed using the procedures of laryngeal and intrathoracic release. A simple tying of the first knot usually ensures that a tracheal anastomosis would be tension free. To prevent postoperative kinking of the esophagus, typically 1.5–2 cm of both tracheal ends is separated from the esophagus before tracheal anastomosis. An interrupted monofilament absorbable suture 1-0 or 2-0 (Maxon, Davis and Geck, Wayne, NJ, USA) is preferred for tracheal anastomosis. Anteflexion of the neck was maintained using a suture when a tracheal resection of >2 cm was performed.

**Associated surgical procedures**

A total of 35 patients required associated surgical procedures to be conducted in addition to tracheoplasty. Thirteen patients with thyroid cancer invasion underwent total thyroidectomy either previously (n = 1) or simultaneously with tracheoplasty (n = 12). Of nine patients with caustic stricture, seven underwent esophageal reconstruction previously or simultaneously. Seven patients with tracheal invasion by esophageal cancer underwent esophagectomy and esophageal reconstruction simultaneously. Of eight patients with tracheal tuberculosis, two underwent sleeve resection of the right main bronchus and one patient underwent sleeve resection of the left main bronchus simultaneous with tracheoplasty.

**Postoperative management**

Following each operation, bronchoscopy was performed through the endotracheal tube for tracheal toilet. More frequent bronchoscopic examinations were required when the patient's cough was ineffective or when a hypoventilated lung was evident. Oral intake was typically allowed on postoperative day 3. Neck anteflexion was maintained using the chin temporarily sutured to the chest for 1 week postoperatively. In tuberculous patients, anti-tuberculous drugs were administered for at least 6 months.

**Management of anastomotic leaks or restenosis**

We closely monitored wound drainage in the 91 patients. Anastomotic leaks could be detected if air or sputum was evacuated through the Penrose drain. Re-anastomosis was performed when mild leaks occurred. Tracheostomy or insertion of a tracheal T-tube or tracheal stent was considered if severe anastomotic leaks or restenosis occurred.

**Assessment of surgical results**

This study evaluated only the mid-term results of tracheoplasty and not oncological results. The follow-up period was 2 months to 10 years, with an average of 3 years. The surgical mid-term results were recognized as good if the voice was preserved and normal breaths were achieved or as a failure if the patient required tracheostomy or a tracheal T-tube or stent insertion.

**Statistical analysis**

The study variables were summarized using descriptive statistics. Continuous variables were presented as mean...
and standard error and were compared using the Student’s t-test. Categorical variables were presented as frequency counts, and intergroup correlations were performed using the Chi-square test. $P < 0.05$ was considered statistically significant. Statistical analysis was performed using the Statistical analysis was performed using SPSS Statistics (version 22, IBM Corp., Armonk, NY, USA).

**Ethical approval**
The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the institute. Informed written consent was obtained from all patients prior to their enrollment in this study.

**RESULTS**

In patients with tracheal stenosis, the mean length of the tracheal resection was 3 cm (range: 1.5–6.5 cm). Three patients required re-anastomosis. Results of tracheoplasty are shown in Table 1. A 24-year-old girl with postintubation tracheal stenosis died of brain infarction on postoperative day 19. Of these two category diseases, gender and age of these patients were similar ($P = 0.605$ and $P = 0.126$, respectively).

Favorable results of tracheoplasty were 81.3% (74/91). According to the univariate analysis, the failure rate of tracheoplasty was higher in Category 1 (24.2%, 15/62) than Category 2 (3.6%, 1/28) ($P = 0.042$, odds ratio [OR]: 8.662, 95% confidence interval [CI]: 1.08–68.89). The subglottic involvement also induced higher failure rate of tracheoplasty (35.3%, 6/17 vs. 13.7%, 10/73) ($P = 0.043$, OR: 3.44, 95% CI: 1.04–11.38). However, the multivariate logistic regression

---

**Table 1: Tracheoplasties of 91 adults with various tracheal diseases**

| Type of tracheal disease          | n   | Sex (male:female) | $P^*$ | Age        | $P^{**}$ | Hospital stay | $P^{**}$ | Success: failure | $P^*$ |
|----------------------------------|-----|------------------|-------|------------|----------|---------------|----------|-----------------|-------|
| Not related to neoplasm          | 63  | 31:32            | 0.605 | 48.7±2.2   | 0.126    | 21.1±3.9      | 0.051    | 47:15           | 0.013 |
| Posttracheostomy                 | 23  | 16:7             | 0.37  | 45.8±4.2   | 0.228    | 22.4±3.4      | 0.176    | 17:6            |       |
| Postintubation                   | 20* | 10:10            |       | 39.3±5.1   | 0.163    | 16.8±3.2      | 0.163    | 16:3            |       |
| Caustic stricture                | 9   | 3:6              |       | 47.8±4.0   | 0.198    | 15.0±8.5      | 0.63     | 6:3             |       |
| Tuberculosis                     | 8   | 2:6              | 1.24  | 52.0±6.7   | 0.704    | 35.2±9.0      | 0.62     | 6:2             |       |
| Congenital                       | 3   | 0:3              |       | 36.5±7.5   | 0.67     | 17.0±1.0      | 0.50     | 2:1             |       |
| Related to neoplasm              | 28  | 15:13            |       | 54.4±2.6   | 0.042    | 11.6±1.3      | 0.271    | 27:1            |       |
| Thyroid cancer                   | 13  | 4:9              |       | 54.9±4.2   | 0.042    | 10.6±2.0      | 0.121    | 12:1            |       |
| Esophageal cancer                | 8   | 8:0              |       | 59.5±3.8   | 0.424    | 14.8±4.2      | 0.80     | 8:0             |       |
| Tracheal neoplasm                | 7   | 3:4              | 1.24  | 47.6±6.9   | 0.694    | 8.5±1.5       | 0.70     | 7:0             |       |
| Total                            | 91  | 46:45            |       | 50.5±1.7   | 0.051    | 19.0±3.3      | 0.746    | 74:16           |       |

*One hospital death, *$P$ was based on the Chi-square test, **$P$ based on the Student’s t-test

---

**Table 2: Univariable and multivariable analyses to identify significant factors for surgical failure of tracheoplasty**

| Variables                        | Univariable analysis | Multivariable analysis |
|----------------------------------|----------------------|------------------------|
|                                  | OR  | 95% CI | $P$ | Adjusted OR | 95% CI | $P$ |
| Sex                              |     |        |     |             |       |     |
| Female                           | 1.00| 0.56-1.71 | 0.010 | 1.00 | 0.56-1.71 | 0.010 |
| Male                             | 0.38|        | 0.037 | 1.00 | 0.037 | 1.00 |
| Age                              |     |        |     |             |       |     |
| $<55$                            | 1.00| 0.42-3.67 | 0.944 | 1.00 | 0.42-3.67 | 0.944 |
| $\geq55$                         | 1.24|        | 1.71 | 1.00 | 1.71 | 1.00 |
| Category of tracheal disease     |     |        |     |             |       |     |
| Neoplasm related                 | 1.00| 1.08-68.89 | 0.042 | 1.00 | 1.08-68.89 | 0.042 |
| Not neoplasm related             | 8.62|        | 8.33 | 8.62 | 8.33 | 8.62 |
| Subglottis involvement           |     |        |     |             |       |     |
| No                               | 1.00| 1.04-11.38 | 0.043 | 1.00 | 1.04-11.38 | 0.043 |
| Yes                              | 3.44|        | 1.36 | 3.44 | 1.36 | 3.44 |
| Comorbidity                      |     |        |     |             |       |     |
| Yes                              | 0.63| 0.21-1.86 | 0.399 | 1.00 | 0.18-2.58 | 0.565 |
| No                               | 0.63|        | 0.67 | 0.63 | 0.67 | 0.63 |

OR: Odds ratio, CI: Confidence interval
model demonstrated that the category of tracheal disease \((P = 0.064, \text{OR} = 8.62, 95\% \text{CI}: 0.88–83.33)\) and subglottis involvement \((P = 0.094, \text{OR}: 3.06, 95\% \text{CI}: 0.82–11.36)\) did not statistically significant induce surgical failure of tracheoplasty [Table 2]. Four (4.4%) patients had restenosis. A total of 16 failed cases of tracheoplasty required that a tracheal T-tube \((n = 13)\) or stent \((n = 1)\) be inserted or required tracheostomy \((n = 2)\). Of these 16 patients, 15 (93.8%) belonged to Category 1. The causes of surgical failure and managements are listed in Table 3. They were typically severe anastomotic leaks, regrowth of granulation, subglottic involvement, and comorbidities. There was no tumor recurrence of the airway in the Category-2 patients.

**DISCUSSION**

Tracheal diseases should be carefully evaluated.\(^{[8]}\) Primary anastomosis of the trachea is typically considered after resection of the diseased tissue. If tension at the anastomotic site exists, the anastomosis may tear and separate, causing scar tissue to form and stenosis to occur. Tracheal mobilization, tension-relieving sutures, and head–neck immobilization are usually conducted to prevent anastomotic leaks.\(^{[10-12]}\) Posttracheostomy and postintubation tracheal stenosis remain the common conditions requiring tracheoplasty.\(^{[5,7]}\) Surgery for subglottic stenosis usually involves risk of injury to the vocal cords and recurrent laryngeal nerves. Some studies have developed different surgical techniques for managing subglottic stenosis.\(^{[13-17]}\) Early in my practice, restenosis of the subglottis occurred frequently. To solve this problem, I developed a novel technique involving a telescopic anastomosis following middle split of thyroid-cricoid cartilage. A nongraft surgical procedure is not affected by graft necrosis or displacement and usually yields favorable results.\(^{[18]}\) In the present series, only five of twenty patients with subglottic stenosis underwent this new surgical technique, but we hope more patients will derive benefits from it in future. Compared with cricoid–tracheal resection, this procedure can preserve the cricoid cartilage and surrounding tissue to ensure a firm and secure laryngotracheal anastomosis and less injury to the recurrent laryngeal nerves. In the surgical treatment of tuberculous tracheal stenosis, we administered anti-tuberculous drugs for at least 6 months after the operation to prevent the recurrence of tuberculosis. Congenital tracheal stenosis is commonly caused by vascular anomalies, of which complete vascular rings are the most often encountered. Innominate arterial compression, pulmonary arterial sling, and miscellaneous anomalies may also occur. Angiograms or CT is used to confirm the diagnosis of pulmonary arterial sling. A pulmonary arterial sling is a rare anomaly, and the respiratory distress usually appears in the neonatal period. In this presenting series of 91 adults, only one patient with pulmonary arterial sling was encountered. Slide tracheoplasty is suitable for tracheal stenosis with healthy mucosa. This surgical technique is performed by dividing the stenosis at midpoint, incising the proximal and distal narrowed segments vertically on the opposite anterior and posterior surfaces, and sliding these together.\(^{[19]}\) The stenotic segment is shortened by half, the circumference is doubled, and the lumen becomes cross section. In the early period of this series, esophageal cancer with tracheal invasion was aggressively resected but has now shifted to neoadjuvant chemotherapy. I first reported spiral tracheoplasty in 2009. This surgical technique is a suitable alternative when a tracheal tangential lesion is at the cervicothoracic junction.\(^{[20]}\) Segmental resection is commonly performed in patients with noncongenital tracheal stenosis or tumor circumferential involvement.

**Table 3: Causes and management of 16 failed tracheoplasties**

| Case | Age | Sex | Type | Associated disease | Subglottis* | Cause of failure | Management |
|------|-----|-----|------|-------------------|------------|-----------------|------------|
| 1    | 20  | Male| Postracheostomy | Multiple injuries | v          | Restenosis 7 years later | T-tube    |
| 2    | 71  | Male| Postracheostomy | COPD, jejunal perforation | v          | Ineffective cough | T-tube    |
| 3    | 44  | Female| Postintubation | Drug intoxication | v          | Anastomotic disruption | T-tube    |
| 4    | 69  | Female| Postintubation | CVA | v          | Ineffective cough | T-tube    |
| 5    | 24  | Female| Caustic | Esophageal stricture | v          | Restenosis | T-tube    |
| 6    | 58  | Female| Caustic | Esophageal stricture | v          | Restenosis | T-tube    |
| 7    | 58  | Male| Caustic | Esophageal stricture | v          | Ineffective cough | T-tube    |
| 8    | 78  | Male| Tuberculosis | DM | v          | Anastomotic leaks | T-tube    |
| 9    | 65  | Female| Thyroid cancer | DM | v          | Anastomotic leaks | T-tube    |
| 10   | 16  | Female| Postracheostomy | Tracheoinnominate fistula | -          | Anastomotic leaks | Tracheostomy |
| 11   | 29  | Male| Postracheostomy | Head injury | -          | Anastomotic leaks | T-tube    |
| 12   | 34  | Male| Postracheostomy | Head injury | -          | Respiratory distress | T-tube    |
| 13   | 81  | Female| Postracheostomy | CVA | -          | Ineffective cough | T-tube    |
| 14   | 63  | Female| Postintubation | CVA, DM | -          | Neck wound infection | Tracheostomy |
| 15   | 44  | Female| Tuberculosis | Pulmonary tuberculosis | -          | Restenosis | T-tube    |
| 16   | 44  | Female| Congenital | Tracheal malacia | -          | Tracheal malacia | Tracheal stent |

*Tracheal disease involved the subglottis. CVA: Cerebrovascular accident, COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus
of the trachea. A tracheostomy should be avoided when the patient intends to undergo tracheoplasty. Suitable candidates for resection of tracheal lesions have been young patients with localized middle or lower tracheal lesion, patients who offer good performance, and who are cooperative. Contraindications for the resection of tracheal stenosis are major associated diseases as well as patients who are bedridden, unconscious, emaciated, elderly, uncooperative, and have long-segment strictures. Resecting a long-segment trachea >3 cm is a challenge because a greater number of anastomotic complications will occur in longer resections. In the series, I never used extracorporeal membrane oxygenation during tracheal reconstruction. Considering the better results of Category 2, two reasons should be mentioned. The first one: failures of tracheoplasty in Category 1 are usually attributed to the long-segment damage of tracheal mucosa and cartilage, nonhealthy tissue at the subglottis, or comorbidities. The second one, the Category 2 did not include the patients whose tumor involving the vocal cords. Based on my experiences, tracheal surgery is a safe procedure for patients who are carefully selected for the procedure.

CONCLUSIONS

Careful evaluation and correct procedure can yield favorable results when performing tracheoplasty. Our study showed that tracheal diseases related to neoplasm presented more favorable mid-term results with tracheoplasty because these patients were highly selected.

Acknowledgment

The author would like to thank Prof. Chung-Yi Li for correcting statistical analysis.

Limitations

Because of a single surgeon’s experience of tracheoplasty, this study has the limitation of patient number and lacks long-term oncologic survival data.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Nashef SA, Dromer C, Velly JF, Labrousse L, Couraud L. Expanding wire stents in benign tracheobronchial disease: Indications and complications. Ann Thorac Surg 1992;54:937–40.
2. McLaughlin JS Jr, Hawley PC, Brown DG, Kakos GS, Williams TE Jr. Effect of light dose on the photodynamic destruction of endobronchial tumors. Ann Thorac Surg 1992;54:705–11.
3. McDougall JC, Cortese DA. Neodymium-YAG laser therapy of malignant airway obstruction. A preliminary report. Mayo Clin Proc 1983;58:35–9.
4. Neville WE, Bolanowski JP, Kotia GG. Clinical experience with the silicone tracheal prosthesis. J Thorac Cardiovasc Surg 1990;99:604–12.
5. Mungu SD, Egryssy K, Laxmanan B, Doblarc G, Ortiz-Comino R, Hogarth DK. Central airway obstruction: Benign strictures, tracheobronchomalacia, and malignancy-related obstruction. Chest 2016;150:426–41.
6. Naeff AP. Extensive tracheal resection and tracheobronchial reconstruction. Ann Thorac Surg 1969;8:391–401.
7. Grillo HC, Bendixon HH, Gephart T. Resection of the carina and lower trachea. Ann Surg 1963;158:889–93.
8. Grillo HC, Donahue DM, Mathisen DJ, Wain JC, Wright CD. Postintubation tracheal stenosis. Treatment and results. J Thorac Cardiovasc Surg 1995;109:486–92.
9. Pearson FG, Andrews MJ. Detection and management of tracheal stenosis following cuffed tube tracheostomy. Ann Thorac Surg 1971;12:359–74.
10. Auchincloss HG, Wright CD. Complications after tracheal resection and reconstruction: Prevention and treatment. J Thorac Dis 2016;8:160–7.
11. Mohsen T, Abou Zeid A, Abdelfattah I, Mosleh M, Adel W, Helal A. Outcome after long-segment tracheal resection: Study of 52 cases. Eur J Cardiothorac Surg 2018;53:1186–91.
12. Sachs ME, Conley J, Rabuzzi DD. Intralaryngeal release for tracheal anastomosis. Ann Otol Rhinol Laryngol 1983;92:482–4.
13. Richardson MA, Inglis AF Jr. A comparison of anterior cricoid split with and without costal cartilage graft for acquired subglottic stenosis. Int J Pediatr Otorhinolaryngol 1991;22:187–93.
14. Zalzal GH. Treatment of laryngotracheal stenosis with anterior and posterior cartilage grafts. A report of 41 children. Arch Otolaryngol Head Neck Surg 1993;119:82–6.
15. Cotton RT, Morigellit A, Myer CM 3rd. Four-quadrant cricoid cartilage division in laryngotracheal reconstruction. Arch Otolaryngol Head Neck Surg 1992;118:1023–7.
16. Gerber ME, Modl VK, Ward RE, Gower VM, Thomsen J. Endoscopic posterior cricoid split and costal cartilage graft placement in children. Otolaryngol Head Neck Surg 2013;148:494–502.
17. Boseley ME, Hartnick CJ. Pediatric partial cricotracheal resection: A new technique for the posterior cricoid anastomosis. Otolaryngol Head Neck Surg 2006;135:318–22.
18. Wu MH, Wu HY. Sequential correction of caustic stenosis of trachea and esophageal orifice. Clin Case Rep 2016;2:484–5.
19. Tsang V, Murday A, Gillie C, Goldstraw P. Slide tracheoplasty for congenital funnel-shaped tracheal stenosis. Ann Thorac Surg 1989;48:632–5.
20. Wu MH. Spiral tracheoplasty after tangential resection of trachea. Ann Thorac Surg 2009;88:2042–3.