



Resection and reconstruction via median sternotomy incision for tracheal tumors

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Background: The tracheal tumor is a rare disease with low incidence in the upper airway. Surgical resection and reconstruction are effective and radical treatments for such conditions, but the approaches vary depending on the tumor location. The current report tends to illustrate the clinical practice and advantage of the median sternotomy approach for treating tracheal tumors.

Methods: We summarized and demonstrated four cases of tracheal tumors patients who received tracheal resection and reconstruction via median sternotomy approach in our institute. Their clinical data and surgical procedures were also described. The follow-up would be carried on to monitor their prognosis after the operations.

Results: Two patients with lower tracheal tumors involving carina received sternotomies, one with the tumor in cervical, thoracic junction, and the other one with thyroid carcinoma involving and extending to the thoracic trachea received half-sternotomies. The surgical procedures were completed smoothly with ideal surgical vision and sufficient operative space. Case 1 and 2 patients underwent tracheal-bronchial end-to-side anastomosis, while the other two patients received end-to-end anastomosis. The thymus and mediastinal tissue were used as the anastomotic buttress. They were discharged no more than 2 weeks after operations. Case 4 was suffered from aspiratory pneumonia and experienced prolonged intensive care unit (ICU) stay and antibiotic use. No other severe complications were recorded in other cases. No anastomotic dehiscence was observed in the postoperative bronchoscopy.

Conclusions: Tracheal resection and reconstruction via sternotomy or half-sternotomy is a practical approach for intrathoracic tracheal lesions. It facilitates a satisfying field and anastomosis procedure. The reported cases had ideal surgical outcomes. Although it is convenient in some specific cases, further studies are warranted for its safety and efficacy.

Keywords: Sternotomy; surgery; tracheal tumor; anastomosis; case series

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Introduction

The tracheal tumor is a rare disease that accounts for only 2% of malignancies in the upper airway (1,2). Resection and reconstruction is a radical surgical treatment for tracheal malignancy, stenosis, fistula, etc. (3,4). The operational approach can vary depending on the tumor location, the length of the involved segment, and the necessity of release maneuver. The previous studies reported that right thoracotomy or video-assisted thoracoscopy surgery (VATS) provided decent effects and less invasiveness (5-7). However, these approaches might have poor exposure and limited operational space in the carinal and left main bronchial lesions (7). In terms of the thoracic trachea or those located at the junction, median sternotomy or half-sternotomy with collar incision are generally chosen.

It is reported that the median sternotomy and half-sternotomy carry a higher morbidity rate to the patients compared to the thoracotomy or VATS approaches, but these approaches have their indispensable advantages (8,9). Although the preference varies widely across different surgical teams and institutes, it has essential advantages in some specific cases. The median sternotomy approach would be selected in some specific cases, which offers ideal surgical visualization and operational spaces. We report 4 cases of trachea tumors who underwent tracheal resection and reconstruction with sternotomy or half-sternotomy approaches to describe the utility of these approaches and demonstrate their advantages in these patients. Meanwhile, we also intend to provide some surgical techniques and details, which we consider are crucial for higher successful rate and lower complications rate to those who are planning to apply such approach in tracheal resection and reconstruction. We present the following article in accordance with the AME Case Series reporting checklist (available at <https://tldr.amegroups.com/article/view/10.21037/tldr-22-177/rc>).

Methods

Patients

The patients underwent operations in the Department of Thoracic Surgery in the First Affiliated Hospital of Guangzhou Medical University from 2019 to 2021.

Patient 1

A 69-year-old male presented with irritative cough, dyspnea on excursion (DOE), and concomitant respiratory excretion

came to the out-patient for diagnosis and treatment. The chest computed tomography (CT) scan showed longitudinal 3.5 cm irregular mass locating in the left wall of the lower trachea 2.5 cm above the carina. Positron emission tomography (PET)/CT scan indicated either regional lymph node or distance metastasis was negative (*Figure 1A*). Considering the tumor was located in the left tracheal wall and involved the right and anterior wall, the resected length would be relatively long (>4 cm). Therefore, we chose median sternotomy as the operation approach, since it provided better surgical vision and favored complete mobilization of the trachea to minimize the anastomotic tension. A 4.5 cm-length involved tracheal segment was resected. An end-to-end anastomosis was performed between the distal right main bronchus (RMB) and the lower tracheal stump. While an end-to-side anastomosis was conducted between the lateral tracheal wall and the left main bronchus (LMB). The pathological result indicated epithelial-myoeipithelial carcinoma (*Table 1*).

Patient 2

A 26-year-old female presented with DOE, shortness of breath (SOB), irritative productive cough with bloody sputum for 2 months. The chest CT scan showed an oval neoplasm (4 cm) locating in the lower trachea involving the carina and the orifice of LMB (*Figure 1B*). The tumor was lobulated with an unclear margin and rough surface under the bronchoscopy. The lower trachea and the LMB were mostly occluded. For the sake of operational safety and stability, the venous-artery extracorporeal membrane oxygenation (V-A ECMO) was set up via femoral vein and superior vena cava (SVC) to the ascending aorta (AA) after the sternotomy. The vessels were then mobilized, the lower trachea, RMB, and LMB were clearly exposed, showing no significant outward invasions. The bilateral hilar tissue, pericardium and inferior pulmonary ligaments were thoroughly dissected and divided after opening the mediastinal pleura. Owing to the V-A ECMO, her lung was not ventilated, and the preload of her heart was decreasing which provided the surgeon a better visualization and operation space. The involved segment of the trachea, carina, and proximal LMB was resected with microscopical negative margin. The carina was reconstructed by RMB to trachea end-to-end anastomosis and LMB to trachea end-to-side anastomosis. The anastomosis was buttressed with the thymus. Bilateral chest tubes were placed in her thoracic cavities after the operation (*Table 1*).

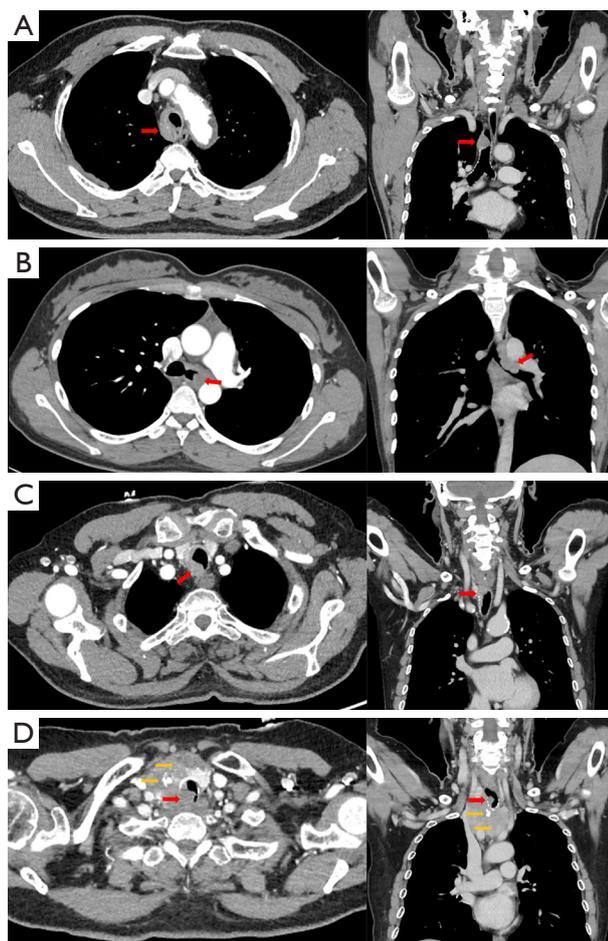


Figure 1 The pre-operative CT scan images of the patients. (A) The coronal and transverse section images of Case 1 showed an irregular mass located in the lower trachea involving the right lateral and posterior tracheal wall (red arrow: tracheal tumor). (B) The coronal and transverse section images of Case 2 showed a tumor involved lower trachea and LMB occluding most of the bronchial lumen (red arrow: tracheal tumor). (C) The coronal and transverse section images of Case 3 showed a tumor located in the junction of cervical and thoracic trachea involving the right lateral wall (red arrow: tracheal tumor). (D) The coronal and transverse section images of Case 4 showed a huge thyroid carcinoma with irregular shape and multiple calcifications invading into the trachea occluding most of the lumen (red arrow: tracheal tumor; yellow arrow: thyroid carcinoma). CT, computed tomography; LMB, left main bronchus.

Patient 3

A 62-year-old male presented with irritative productive cough and DOE for 3 months. The chest CT and bronchoscopy

revealed a 3.8 cm broccoli-shape tumor longitudinally involving the posterior wall of the thoracic trachea with the proximal margin 1.2 cm below the vocal cord and the distal margin 6.0 cm above the carina (Figure 1C). The preoperative pathological result showed squamous cell carcinoma after bronchoscopic biopsy. Considering the tumor was located in the cervical, and thoracic trachea junction, a half-sternotomy (sternal notch to Louis's angle) approach was performed. The thoracic trachea was exposed entirely and mobilized after dissecting the brachiocephalic artery, left carotid artery, left carotid vein, and brachiocephalic vein. A 4.5 cm length of the tracheal segment was resected, including tumor and at least 1 cartilage ring from the margin (Table 1).

Patient 4

A 72-year-old female presented with gradually cervical swelling, DOE, paroxysmal hemoptysis, and hoarseness for 3 months. The cervical and thoracic CT scan showed bilateral thyroid gland neoplasm involving the trachea extending into the thoracic cavity (Figure 1D). The bronchoscopy indicated that the invaded tumor partially obstructed the trachea lumen, roughly lobulated without a clear margin, and bled after contact. Since the cancer was from the thyroid gland and extended to the post-sternal area, a cervical collar incision with half-sternotomy was selected for thyroid gland resection, invaded trachea resection, and reconstruction. The thyroid tumor was fully exposed and completely resected after dissecting the platysma layer, bilateral sternocleidomastoid muscle, and strap muscles. The margins of the involved tracheal segment were determined by intraoperative bronchoscopy and resected. The tracheal reconstruction was performed using interrupted anastomosis with 3-0 and 4-0 Vicryl sutures. After the hemostasis and negative air-leak test, the strap muscles were used for anastomotic buttress (Table 1).

Surgical technique

An incision from the sternal notch to the xiphoid was made, and the subdermal tissue was dissected with the cautery till the sternum was exposed. In the half-sternotomy, the incision was from the sternal notch to the Louis's angle. The sternum was cut transversely in the second intercostal space. After sternotomy with the saw, the bone wax was applied to the edge of the sternum for hemostasis. The thymic and anterior mediastinal tissue was dissected and trimmed to flaps. Wet gauze was used to wrap the flap for the subsequent anastomotic buttress. After opening the

Table 1 The clinical features of the patients

Patient No.	Sex	Age	Tumor location	Involvement	Operation	Pathology
1	Male	69 years	Lower trachea	Thoracic trachea	Lower trachea partial resection + reconstruction (sternotomy)	EMC
2	Female	26 years	Lower trachea	Carina, LMB	ECMO-supported lower trachea, carina and LMB resection + reconstruction (sternotomy)	ACC
3	Male	62 years	Lower trachea	Cervical and thoracic trachea	Trachea resection and reconstruction (half-sternotomy)	SQ
4	Female	72 years	Thyroid gland	Cervical and thoracic trachea	Thyroidectomy + trachea resection and reconstruction (cervical collar incision with half-sternotomy)	TC

EMC, epithelial-myoepithelial carcinoma; LMB, left main bronchus; ECMO, extracorporeal membrane oxygenation; ACC, adenoid cystic carcinoma; SQ, squamous cell carcinoma; TC, thyroid carcinoma.

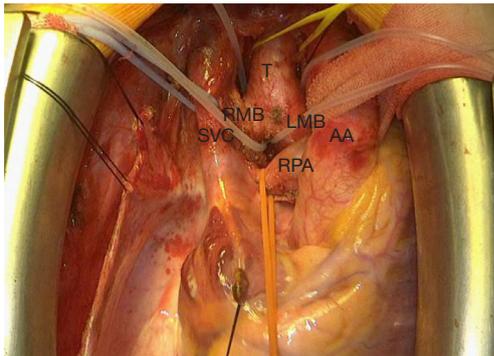


Figure 2 The anatomic structures of trachea and peritracheal organs in median sternotomy approach. T, trachea; RMB, right main bronchus; LMB, left main bronchus; SVC, superior vena cava; RPA, right pulmonary artery; AA, ascending aorta.

mediastinal pleura and pericardium, the thoracic trachea and the great vessels, including the brachiocephalic artery, the brachiocephalic vein, the SVC, and the aorta, were thoroughly dissected and suspended with a rubber band (*Figure 2*).

The proximal and distal resection margins were determined by intraoperative bronchoscopy. The tracheal lesion was resected with a scalpel and scissors, and the tracheal stumps were trimmed for anastomosis. Before reconstruction, the patients were repositioned with their necks flexing to facilitate tension-free anastomosis. The 2-0 Prolene suture was bilaterally placed on the wall of each stump. The membranous wall was firstly anastomosed with interrupted 4-0 Vicryl sutures. After tying up the 2-0 Prolene sutures, membranous wall was approximated and

the sutures were tied up subsequently. The cartilaginous wall of the trachea was reconstructed using interrupted 3-0 or 4-0 Vicryl sutures. Continuous suturing with 4-0 Prolene is also feasible and optional depending on the preference of the surgeons.

An air leak test (30 cmH₂O pressure) would be applied after reconstruction. The preserved thymic and mediastinal tissue flap was trimmed and buttressed the anastomosis. A chest tube was then placed in the surgical field for drainage. After complete hemostasis and pneumostasis, the sternum was closed with stainless steel wire, and the subdermal and the skin layers were closed successively. The patients were in a semi-recumbent position with their necks remaining flexion for 2–3 weeks postoperatively. Bronchoscopy was applied to them for aspiration and the anastomosis inspection.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the First Affiliated Hospital of Guangzhou Medical University (No. 2020K-43), and individual consent for this retrospective analysis and case series study was signed and collected from the patients. Their medical data and images would be demonstrated with their official permission.

Results

The mean operation time was 340 minutes ranging from 318 to 372 minutes. Their total blood loss was 140 mL on average without blood transfusion. They were discharged within 14 days after operations without significant short-term complications. They were suggested to receive cervical

and chest CT scan every 3 months and bronchoscopy every 6 months. There is no sign of local tumor recurrence or distant metastasis during the adjuvant therapy and follow-up process.

A total length of 4.5 cm involved tracheal segment was resected in Case 1. The distal RMB was anastomosed to the lower trachea. The lateral tracheal wall and the LMB were reconnected using end-to-side anastomosis. The pathological result indicated epithelial-myoeplithelial carcinoma. He was extubated in the postanesthesia care unit (PACU) and stayed in intensive care unit (ICU) for 3 days. He was then transferred to the general ward and eventually discharged on postoperative day (POD) 10. The bronchoscopy showed ideal healing in the anastomosis without any necrotic change 1 month after the operation. Case 2 was successfully detached from ECMO after the operation with stable hemodynamic status. After 5 days of mechanical ventilation in ICU, her hypercapnia was alleviated. She was extubated on POD 7 and transferred to the general ward on POD 8. The proximal segment of the LMB and the involved tracheal segment were resected and confirmed as adenoid cystic carcinoma. Her chest tubes were removed on POD 3 and 4. The bronchoscopy indicated no anastomotic dehiscence or necrosis on POD 3. Purulent secretion was noticed in the distal LMB, and the anastomosis was swelling. She was administered for higher grade of antibiotics (carbapenem) and albumin. The following bronchoscopy showed no purulence or other abnormalities. She was discharged on POD 12 without postoperative complications.

Case 3 underwent end-to-end tracheal reconstruction and was extubated in the PACU. He experienced a rapid recovery, only a 2-day ICU stay, and a 7-day total hospital stay. The pathological result of the tumor was squamous cell carcinoma. The postoperative bronchoscopy showed an unobstructed anastomosis without inflammation appearance or other abnormality. The platinum-based regimen was given to him for adjuvant chemotherapy. He was free from tumor recurrence or distant metastasis during the 1-year follow-up.

Case 4 was operated completely under non-intubated anesthesia, but she was intubated on POD 2 in the ICU because of aspiration and respiratory infection. The thyroid carcinoma invaded the trachea and the paratracheal tissue, which involved recurrent laryngeal nerve and parathyroid glands. As a result, her T3, T4, and the plasma calcium level were low, and her right vocal cord was paralyzed, which might lead to aspiration, hypoxemia, and hypercapnia.

The thyroid hormone, calcium, and carbapenem were administered. She was on ventilation and fasting with enteral nutrition via a gastrointestinal tube. She was extubated on POD 12 and eventually discharged on POD 16. The postoperative bronchoscopy on POD 14 showed immobility of the right vocal cord. The anastomosis was ideally healed without necrosis, ischemia, or dehiscence. No sign of local recurrence or residue was observed. Although she complains about hoarseness, no dyspnea, dysphagia, or choking is presented.

Discussion

There is limited evidence to standardize the surgical methods to treat tracheal tumors. A previous study reported customized incisions depending on the tumor location to facilitate the operation (10). The sternotomy provides adaptive approaches to the tumors in the lower thoracic trachea, carina, and LMB. Meanwhile, the tumors in the junction of the cervical and thoracic trachea could be easily accessed via half-sternotomy in addition to the cervical collar incision.

The right thoracotomy using VATS is usually selected for thoracic tracheal, carinal, and RMB resection and reconstruction. It provides an ideal vision of the right lateral wall of the thoracic trachea and the RMB. It is reported that it can be performed via uniportal thoracoscopy or robotic surgery (6,11). The significant advantage of this approach is minimal invasive favoring less pain and rapid recovery after the operation. However, the cases with tumors in the carina involving the left orifice or LMB are challenging to perform in this approach. The LMB locates posteriorly to the great vessels and inferiorly to the aortic arch. Once resected, the stump of the LMB would be hidden in the deep thoracic cavity leading to a challenging anastomosis (12,13). Additionally, the repair would be even more complicated if the air leak is observed. Compared to the right thoracotomy, the sternotomy favors the exposure and dissection of the lower trachea, carina, and main bronchi, providing ideal vision and space for the anastomosis. Besides, the air-leak test and repair would be less complicated.

To facilitate a tension-free anastomosis, the release maneuver is performed in some circumstances. Mathisen and his colleagues reported that tension was the major problem of anastomotic necrosis and restenosis (14). Therefore, the release maneuver is encouraged in various patients, including extended segment resection, massive adhesion, and excessive tumor involvement, etc. The right

hilar release, right pericardium release, and right inferior pulmonary ligament dissection could be conducted via right thoracotomy. However, the mediastinal left hilar, left pericardium, and left inferior pulmonary ligament dissection are impossible to complete, easily performed via sternotomy (14). Case 2 we reported is a typical example to demonstrate the superiority of the sternotomy approach. Her bilateral mediastinal pleura, hilar, pericardium tissue, and inferior pulmonary ligaments were thoroughly dissected. Therefore, her anastomosis was smoothly conducted without extensive tension, which was beneficial to her postoperative recovery.

Although the anastomotic buttress is reported to have no special effect than those without bronchial anastomosis, it is proved to be crucial in tracheal and carinal reconstruction. Vascularized tissue is reported to be an effective material for anastomotic buttress (15,16). In the right thoracotomy approach, the surgical field is relatively limited, leading to the insufficient option of buttress material. On the other hand, various choices for buttress can be selected in the sternotomy approach, including thymus, mediastinal tissue, pectoralis major, and even omental flap. However, acquiring the omental flap needs to abdominal operation. The bilateral thymus and mediastinal tissue are easier to access and are more currently used.

Except for Case 4, which had aspiration leading to prolonged ICU stay and antibiotics, the other three had ideal recoveries without postoperative complications. The nonsteroidal anti-inflammatory drugs (NASID) with an additional low dose of oxycodone were administered postoperatively, sufficient to cover their pain. It indicated the pain would not become intensive in the sternotomy approach and would not hinder the patients' recovery.

Conclusions

The sternotomy approach showed its feasibility and advantage in the lower thoracic tracheal tumor cases despite the cosmetic issue. It provides a satisfying surgical exposure and space for operation. Also, pulmonary release maneuvers and buttress can be conducted efficiently via such a method, which favors the tension-free and blood supply of the anastomosis. The further studies are warranted to verify the safety and efficacy of such approach.

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Footnote

Reporting Checklist: The authors have completed the AME Case Series reporting checklist. Available at <https://tldr.amegroups.com/article/view/10.21037/tldr-22-177/rc>

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://tldr.amegroups.com/article/view/10.21037/tldr-22-177/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the First Affiliated Hospital of Guangzhou Medical University (No. 2020K-43), and individual consent for this retrospective analysis and case series study was signed and collected from the patients. Their medical data and images would be demonstrated with their official permission.

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