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CASE REPORT

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ECMO-assisted bilateral uniportal thoracoscopic carinal resection and reconstruction: a case report

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Abstract

Background Carinal resection and reconstruction are complex surgical procedures often necessitated by tumors or other pathologies involving the tracheobronchial junction. Traditional approaches to these surgeries are highly invasive. The advent of uniportal video-assisted thoracoscopic surgery (VATS) along with the integration of extracorporeal membrane oxygenation (ECMO) offer potential advantages in reducing surgical trauma and improving outcomes.

Case presentation A 42-year-old female patient was admitted to the hospital with the chief complaint of "chest tightness for 20 days". Enhanced chest CT revealed a soft tissue shadow on the tracheal bifurcation wall, protruding into the left main bronchus opening. After multidisciplinary discussions and the exclusion of surgical contraindications, we performed ECMO-assisted uniportal VATS carinal resection and reconstruction for the patient. The patient's postoperative course was uneventful, and she was discharged on postoperative day 4 with satisfactory respiratory function and no major complications.

Conclusions This case demonstrates the feasibility and potential benefits of combining ECMO support with uniportal VATS for complex carinal surgeries. The approach minimizes surgical trauma, ensures stable intraoperative conditions, and may enhance postoperative recovery. Further studies are warranted to validate these findings and establish standardized protocols for such advanced surgical techniques.

Keywords VATS, Carinal reconstruction, ECMO, Tracheal tumor, Case report

Background

The procedure of carinal resection and reconstruction for tracheal tumors is considered highly complex and has traditionally been conducted through open thoracotomy due to the unique anatomical features involved [1].

Uniportal thoracoscopic surgery has gained considerable attention due to its advantages of minimal invasiveness and rapid recovery. However, surgeries involving airway reconstruction often entail significant blood loss and prolonged mechanical ventilation support, which can compromise the safety and feasibility of the procedure. Extracorporeal membrane oxygenation (ECMO),

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as an effective cardiopulmonary support technique, can provide essential oxygenation and ventilation during surgery, thereby reducing the risk of postoperative complications [2, 3].

Given this background, this case report aims to describe a patient with a primary tracheal tumor who underwent ECMO-assisted uniportal VATS carinal reconstruction. The objective is to offer valuable clinical insights for healthcare professionals and to enhance the understanding of the potential applications of this innovative surgical technique in the treatment of complex tracheal tumors.

Case presentation

A 42-year-old female was admitted to the hospital with a 20-day history of cough with sputum and chest tightness. The patient had no known comorbidity or history of smoking. The timeline illustrates her medical treatment process (Fig. 1). Bronchoscopy showed a smooth neoplasm obstructing the opening of the left main bronchus at the carina. Bronchoscopic ablation therapy was subsequently performed, with pathological analysis confirming adenoid cystic carcinoma (Fig. 2A, B). Further evaluation of the patient's systemic condition via PET-CT imaging revealed no evidence of metastasis in other anatomical sites.

Upon admission to our hospital, the patient underwent an enhanced CT examination, which revealed a soft tissue shadow on the tracheal wall at the carina, protruding into the opening of the left main bronchus, with mild stenosis of the lumen (Fig. 2C, D). The enhancement demonstrated mild to moderate intensity. Additionally, enlarged lymph nodes were observed in station 7, displaying heterogeneous enhancement. The pulmonary function test indicated an FEV1 of 2.15 L (85% of the predicted value) and an FEV1/FVC ratio of 66% (80% of the predicted value). To enhance understanding of the tumor's precise location, a three-dimensional reconstruction of the lesion was performed using the patient's CT findings. Following a comprehensive evaluation of preoperative assessments to rule out potential surgical contraindications and after engaging in multidisciplinary consultations, the decision was made to proceed with ECMO-assisted single-port thoracoscopic carina tumor resection and airway reconstruction. The patient provided informed consent for this therapeutic approach.

In the operating room, the patient was positioned supine and administered intravenous general anesthesia. With consent from family members, V-V-ECMO (with cannulation in the femoral vein and internal jugular vein) was initiated at the bedside to support oxygenation, maintaining a steady flow rate of approximately 4.5 L/min. Intraoperative blood loss was estimated at 10 ml. Due to tumor infiltration into the left main bronchus, it was necessary to extend the resection area. The proposed surgical approach involved initial access to the chest from the left side to meticulously dissect the surrounding tissues of the left main bronchus and free the left hilum, followed by entry from the right side to complete the resection and reconstruction of the carina.

Following the positioning of the patient in the right lateral decubitus position, an operating port of approximately 4–5 cm was established at the 5th intercostal space in the left mid-axillary line, and a wound protector was placed. Upon entry into the thoracic cavity, an ultrasonic scalpel was utilized to dissect and clear the lymph nodes of stations 4L and 7, followed by dissection of the tissues surrounding the left main bronchus. Subsequently, the left main bronchus was freed and confirmed to be adequately mobilized. The thoracic cavity was irrigated, a closed drainage tube was inserted, and the chest was sutured closed.

The patient was subsequently repositioned from the right lateral to the left lateral decubitus position, and a 4 cm operating port was established at the 5th intercostal space in the right mid-axillary line. Initially, the azygos vein was transected using a linear stapler. Subsequently, the right vagus nerve was dissected and suspended with sutures. Utilizing an ultrasonic scalpel, the trachea and right main bronchus were mobilized, and the lymph nodes of stations 2R and 4R were excised. Following this, sequential transection of the right main bronchus,

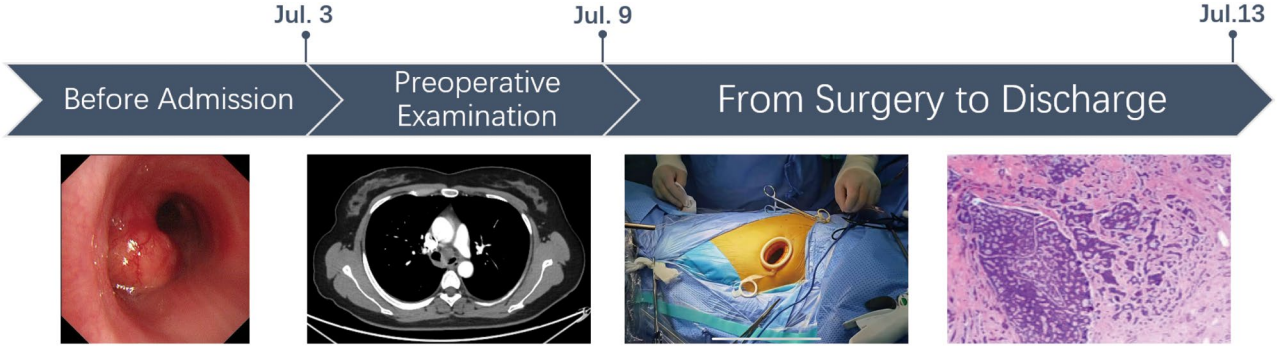

Fig. 1 A concise timeline of the medical treatment process

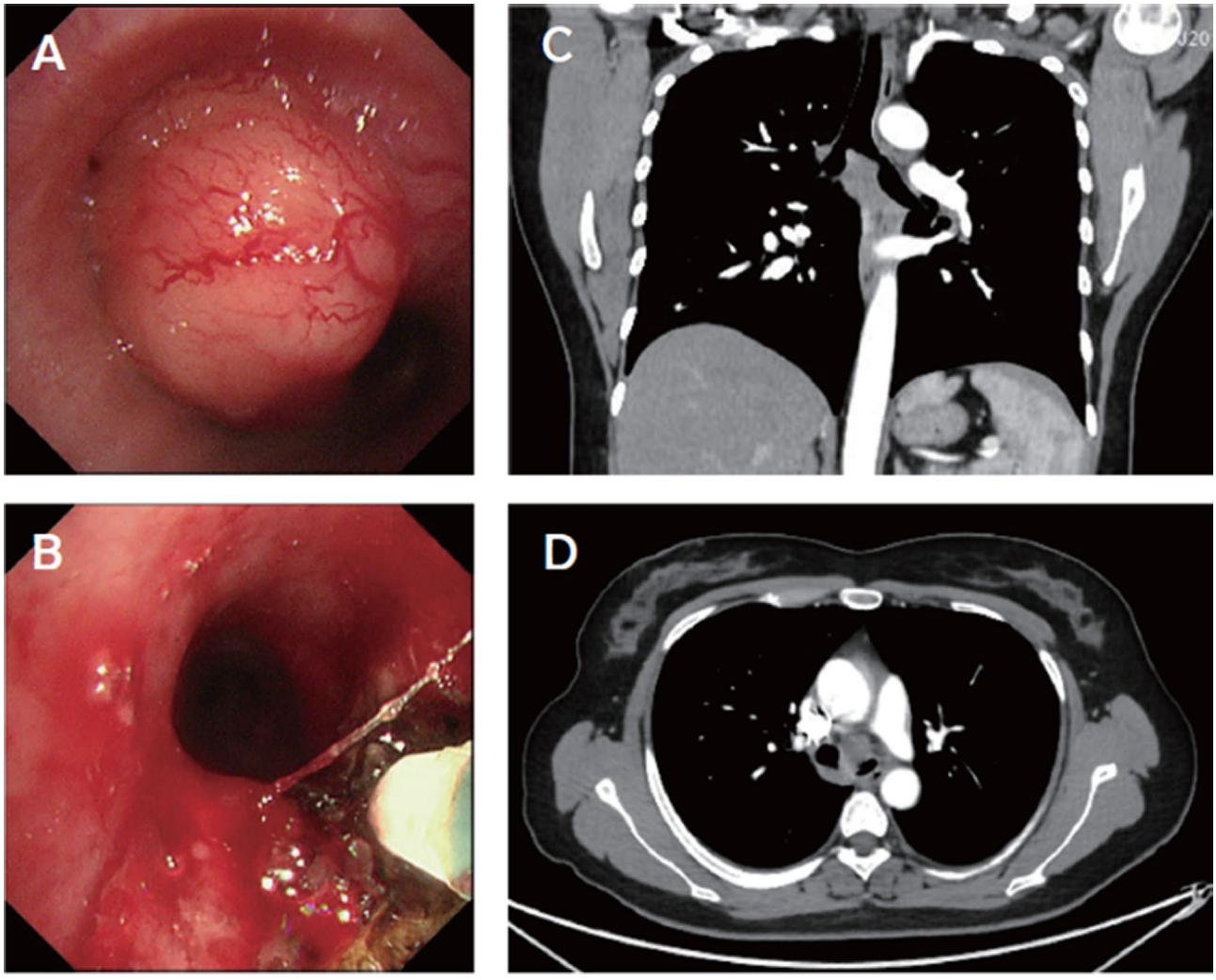

Fig. 2 Preoperative examination. Bronchoscopy revealed a smooth neoplasm at the carina, which was subsequently treated with ablation therapy(**A**, **B**); Enhanced CT scan before surgery showed the tumor(**C**, **D**)

trachea, and left main bronchus was performed, facilitating complete resection of the tumor and extraction of the specimen.

Rapid frozen pathology results indicated that the tracheal margin was suspiciously involved by the tumor. After resecting part of the trachea again, an end-to-end anastomosis of the left main bronchus and lower end of the trachea was performed using 3–0 Prolene sutures. The endotracheal tube was positioned superior to the anastomosis, and a water test (25 cm of H_2O) revealed no air leak. An aperture of approximately 1 cm in diameter was created in the lower trachea, approximately 2 cm proximal to the anastomosis. Utilizing 3–0 Prolene sutures, an end-to-side anastomosis was executed between the right main bronchus opening and the lower tracheal aperture.

After completing the sutures, a water test demonstrated satisfactory lung expansion with no air leak. Following meticulous hemostasis, a closed drainage tube was inserted at the 5th intercostal space in the right midaxillary line, and the thoracic cavity was subsequently closed. The entire duration of the surgery was approximately 5 h. The total blood loss during the operation was approximately 100 mL, and no blood transfusion was necessary (Fig. 3).

Postoperatively, the patient was transferred to the Anesthesia Intensive Care Unit (AICU), and the ECMO was removed three hours later. The postoperative pathological results showed that there was no metastatic carcinoma in the lymph nodes. The patient was subsequently relocated to the general ward on postoperative day two. CT imaging revealed a patent trachea with an intact anastomosis, absence of anastomotic leak, stenosis, or other abnormalities, as well as no evidence of pneumothorax or pleural effusion (Fig. 4). After the removal of the thoracic drainage tube on the third day after the

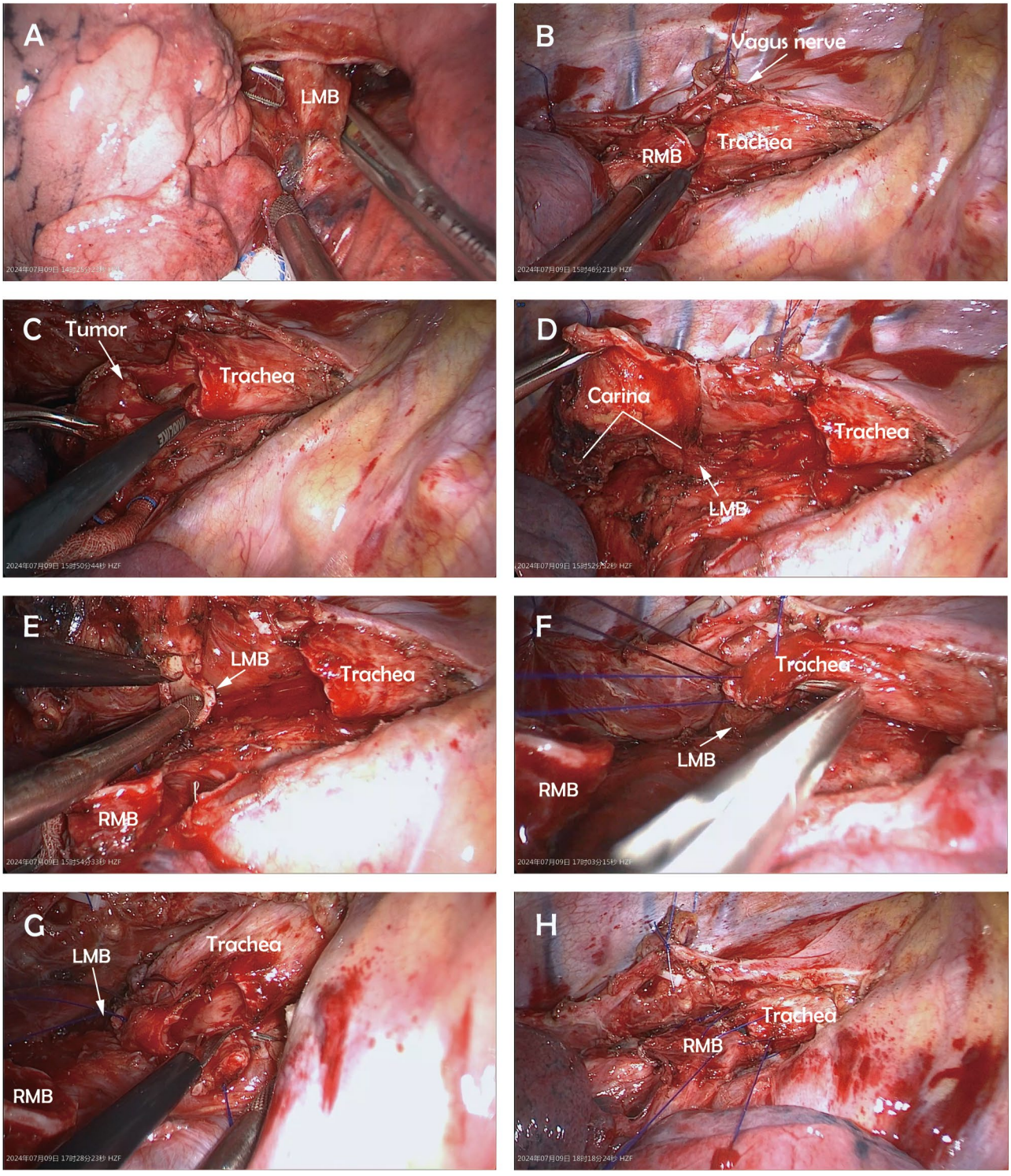

Fig. 3 Key surgery steps: Release the left main bronchus(**A**); Use sutures to suspend and protect the vagus nerve, and dissect the right main bronchus(**B**); After disconnecting the distal end of the trachea, the tumor was exposed(**C**, **D**); Dissect the left main bronchus(**E**); Perform end-to-end anastomosis of the trachea and left main bronchus(**F**); Create an opening approximately 2 cm from the anastomosis site in the lower segment of the trachea, with a diameter of about 1 cm(**G**); Perform end-to-side anastomosis of the right main bronchus and trachea(**H**). LMB, left main bronchus; RMB, right main bronchus

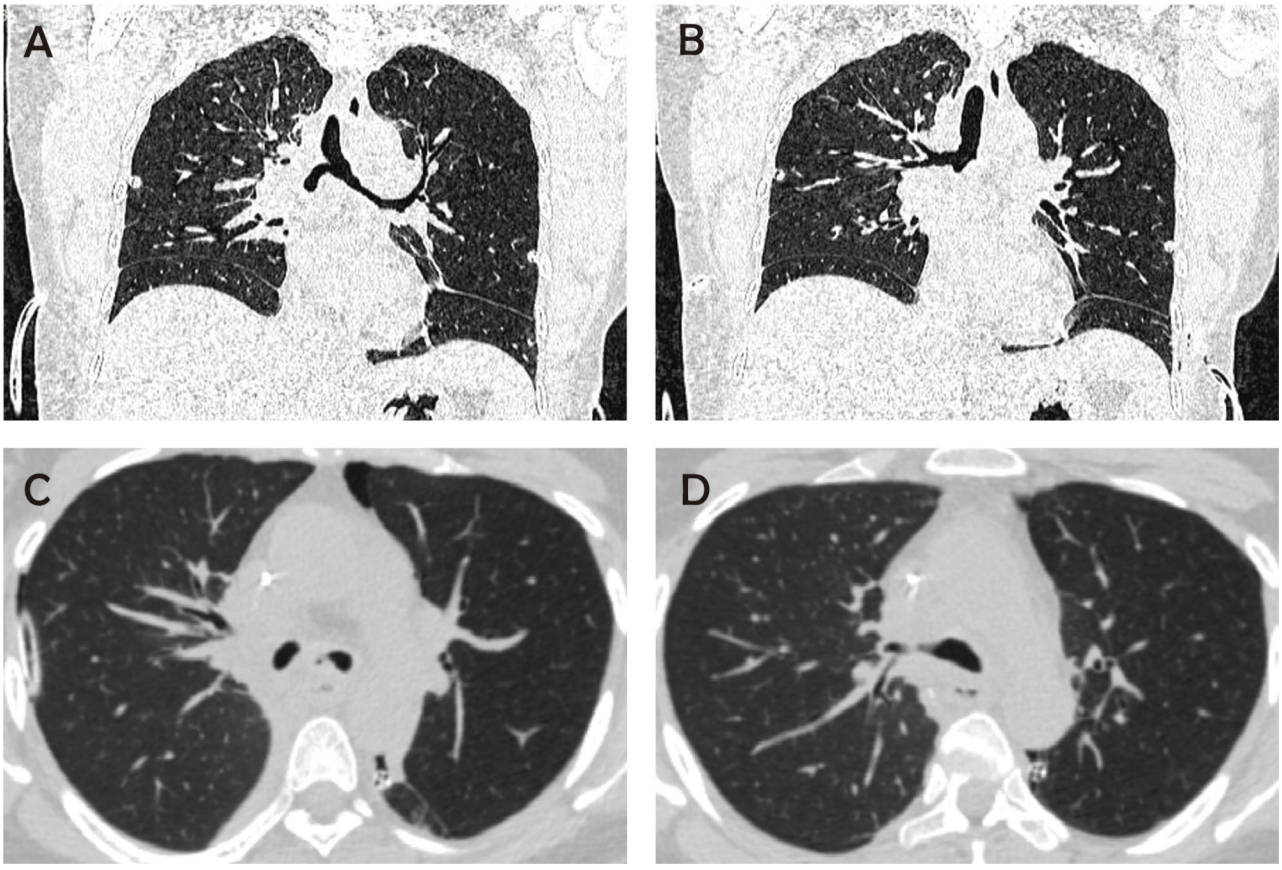

Fig. 4 Postoperative CT scan shows that the airway between the trachea and left main bronchus is clear and intact(**A**, **C**), and the airway between the trachea and right main bronchus is also clear and intact(**B**, **D**)

operation, we continued to observe the patient's condition and found that the patient was recovering well without any complications or abnormal situations. The patient's pain was effectively controlled, and the patient was able to breathe and move independently, and the diet and sleep also returned to normal. The patient was discharged on the fourth day after the operation. One month later, the patient returned to our hospital for a follow-up examination, and the CT scan showed no significant abnormalities.

Discussion and conclusions

Primary tracheal tumors are an uncommon form of malignant neoplasm, constituting less than 1% of all malignant tumors [1]. Squamous cell carcinoma and adenoid cystic carcinoma are the predominant histological subtypes [4]. Patients commonly exhibit nonspecific symptoms such as cough and wheezing, with the severity correlating with tumor size and location. Due to their potentially lethal nature, prompt diagnosis and treatment are crucial for enhancing patient outcomes.

In the realm of treatment strategies, surgical resection continues to be the favored approach for addressing localized tracheal tumors. Research indicates that individuals with non-metastatic primary tracheal tumors who undergo surgical intervention exhibit superior long-term survival outcomes to those receiving only conservative treatment [5]. However, the intricate anatomical characteristics of the carina region present significant challenges for surgical procedures. In recent years, advancements in thoracoscopic technology have provided new possibilities for minimally invasive surgery. VATS has been shown to offer notable benefits over traditional open thoracotomy, including decreased postoperative pain, faster recovery times, and reduced chest drainage volume [6].

Recent literature has reported an increasing number of cases of carinal resection and reconstruction performed under thoracoscopy, confirming the feasibility of minimally invasive surgery in treating carinal tumors [7]. Specifically, the utilization of the single-port thoracoscopic technique represents an advancement in minimally invasive surgery, but it also demands more from the operating surgeons. In addition to surgical techniques, maintaining intraoperative oxygenation for patients is also crucial. Non-intubated surgery has the advantages of avoiding complications related to endotracheal intubation and preserving the patient's physiological function

of spontaneous breathing [8]. However, when it comes to complex carinal surgeries, non-intubated surgery may face the risks of difficult airway management and unstable oxygenation, especially when the operation time is long or unexpected situations occur. Alternatively, ECMO can be employed. One of the benefits of ECMO is its ability to offer consistent oxygenation and carbon dioxide elimination over prolonged durations, rendering it particularly well-suited for intricate thoracic surgeries of extended duration and for individuals with compromised pulmonary function. Additionally, ECMO can not only provide intraoperative support but also be maintained in the postoperative period to enhance the stability of the patient's respiratory function, thereby reducing the likelihood of complications such as Acute Respiratory Distress Syndrome (ARDS). Nonetheless, ECMO technology is associated with potential risks of complications, including bleeding, infection, and thrombosis. Mitigation of these risks requires a thorough evaluation and treatment by a skilled multidisciplinary team. Prior research has demonstrated the successful utilization of ECMO support for tracheal tumor resection and carinal reconstruction, affirming its safety and feasibility [9]. Similarly, our initial observations support the reliability and efficacy of this technology [10]. Overall, in certain specific patient groups, if the patient has relatively good cardiopulmonary function and the lesion is relatively simple, non-intubated surgery may be a viable option. For those patients with complex conditions and in need of a higher level of support, our ECMO-assisted surgery technology has more advantages. Future research can further explore how to select the most appropriate surgical method according to the specific situation of patients, so as to improve the overall treatment effect of tracheal/airway surgeries.

It is important to acknowledge that the routine histopathological results after the operation showed a positive tracheal margin. During the operation, we did not further resect the trachea to achieve an R0 margin because excessive resection might severely affect the patient's respiratory function and increase the risk of complications. The goal of achieving an R0 margin and preserving as much of the trachea as possible appears to be conflicting objectives. Striking a balance between complete resection to prevent recurrence and avoiding excessive removal to maintain respiratory function is challenging. Further research is essential to establish standardized surgical guidelines that optimize both oncological and functional outcomes in such cases. While research has indicated that a positive margin may not have a significant impact on survival rates [11], it is evident that patients with positive margins are at a heightened risk for recurrence. Therefore, we recommend that the patient come back to our hospital for regular reexaminations as planned and receive radiotherapy in the follow-up [12].

The utilization of single-port thoracoscopic surgery with ECMO support for carinal resection and reconstruction represents a novel surgical technique with notable safety benefits and reduced surgical trauma. However, it necessitates a thorough evaluation of the patient's overall health status and should be conducted by a skilled medical team to avoid potential harm to the patient.

In conclusion, this study presents a case report detailing the successful carinal resection and reconstruction achieved through single-port thoracoscopic surgery with the assistance of ECMO. This novel surgical technique not only underscores the significance of ECMO in complex thoracic procedures but also offers new insights and resources for managing similar complex cases in future clinical practice.

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Author contributions
Yu Qi, Bin Wu and Yinliang Sheng collaboratively completed the surgery in this case. Zhenyang Geng completed the first draft of the paper. Yiming Xu and Xueyuan Fan compiled the clinical data. Ping Yuan and Feng Li completed the proofreading of the article. All authors reviewed the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

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Not applicable.

Consent for publication
All the authors are consent for publication.

Competing interests
The authors declare no competing interests.

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