Journal of Cardiothoracic Surgery

CASE REPORT

Open Access

Surgical treatment of delayed partial bronchial rupture under venovenous extracorporeal membrane oxygenation support: a case report

Li Zhenghan[2†], Chen Yuan[3†] and Luo Yuan[1*]

Abstract

Background Chest trauma may precipitate a spectrum of injuries, among which tracheal laceration represents an uncommon but critical sequela. The occurrence of tracheal laceration could significantly impair respiratory and cardiovascular homeostasis, thereby posing a life-threatening risk to the patient. Expeditious surgical intervention is paramount for therapeutic management, and in certain instances, the administration of venovenous extracorporeal membrane oxygenation (VV ECMO) may be necessitated to support the patient's respiratory function.

Case presentation This case report discusses the surgical management of a delayed partial bronchial rupture following thoracic trauma, supported by VV ECMO. The patient, who sustained multiple rib fractures, hemopneumothorax, and scapular fractures due to a motor vehicle accident, developed progressive dyspnea one month post-trauma. Imaging revealed right lung atelectasis and pleural effusion, necessitating emergency surgery. VV ECMO was used to stabilize oxygenation, allowing for successful right main bronchus resection and anastomosis. Intraoperative bronchoscopy played a crucial role in identifying the rupture site and ensuring effective anastomosis. The patient recovered well, with no significant complications at follow-up.

Conclusions This case highlights the importance of timely surgical intervention in bronchial rupture, the utility of VV ECMO for respiratory support, and the role of bronchoscopy in managing airway injuries. It underscores that delayed bronchial rupture, though rare, requires prompt recognition and treatment to prevent life-threatening complications.

Keywords Bronchial rupture, Venovenous extracorporeal membrane oxygenation, Bronchoscopy, Thoracic trauma, Surgical treatment

[†]Li Zhenghan and Chen Yuan contributed equally to this work.

*Correspondence:
Luo Yuan
luoyuan1724@163.com
[1]Department of Cardiothoracic Surgery, Chongqing Key Laboratory of Emergency Medicine, Chongqing University Central Hospital, Chongqing Emergency Medical Center, The Fourth People's Hospital of Chongqing, No. 1 Health Road, Yuzhong District, Chongqing 400014, China
[2]Department of Intensive Care Unit, Chongqing Key Laboratory of Emergency Medicine, Chongqing University Central Hospital, Chongqing Emergency Medical Center, The Fourth People's Hospital of Chongqing, Chongqing 400014, China
[3]Physical Examination Center, Chongqing Key Laboratory of Emergency Medicine, Chongqing University Central Hospital, Chongqing Emergency Medical Center, Fourth People's Hospital of Chongqing, Chongqing 400014, China

Introduction

Thoracic trauma could lead to various injuries, with tracheal rupture being a relatively rare but serious complication [1]. Once tracheal rupture occurs, it could compromise respiratory and circulatory stability, endangering the patient's life. Emergency surgical intervention is crucial for management, and some patients may require venovenous extracorporeal membrane oxygenation (VV ECMO) support due to hypoxemia to maintain adequate oxygenation during surgery [2, 3]. This case report describes a rare instance of delayed tracheal rupture following chest trauma, successfully treated with surgery and VV ECMO support, providing valuable reference for clinical practice.

Case presentation

A 55-year-old female patient with no history of diabetes, hypertension, or coronary artery disease presented following a motor vehicle accident one month prior, which caused multiple rib fractures, hemopneumothorax, and scapular fractures. She initially underwent emergency surgery, including bilateral rib fracture reduction and fixation (L4-7, R6-7) and repair of a left lung lingular laceration, and was discharged two weeks later. However, five days before the current admission, she developed progressive dyspnea of unclear etiology and was admitted to a local hospital. Chest CT revealed right lung atelectasis, and the patient was intubated and placed on mechanical ventilation. She was subsequently transferred to our hospital for further management.On admission, physical examination revealed a collapsed right chest wall, reduced respiratory movement on the right side, and diminished breath sounds over the right lung. Chest CT showed increased density in the right lung, atelectasis, right-sided pleural effusion with blood, and left-sided pleural effusion with partial expansion defect (Fig. 1). The patient was on mechanical ventilation with 100% oxygen, and arterial blood gas analysis indicated a PaO_2 of 67 mmHg, $PaCO_2$ of 34 mmHg, and oxygen saturation of 88%. Despite this, no mediastinal emphysema was observed. Due to the inability to maintain oxygen saturation despite mechanical ventilation, a right main bronchus rupture was suspected, necessitating emergency surgery.

Under ultrasound guidance, ECMO cannulas were inserted into the right femoral vein and right internal jugular vein for VV ECMO support. Following ECMO initiation, oxygen saturation increased to 100%. The patient was anesthetized, and a right-sided intercostal incision was made at the sixth rib space. Intraoperatively, extensive adhesions were found between the right lung and chest wall. After careful dissection, the right main bronchus was exposed. The innominate vein was found to be densely adherent to the bronchus and was clamped and divided. The right main bronchus was dissected free, and a bronchoscope was inserted to identify the site of obstruction approximately 1 cm from the carina. The bronchus was incised, revealing granulation tissue filling the lumen (Fig. 2). The obstructed segment was resected, and the bronchus was anastomosed with 3 – 0 Prolene sutures. Post-anastomosis bronchoscopy confirmed a complete and non-stenotic anastomosis. Extensive sputum suction and lavage of all lung segments were performed. After confirming no air leaks, hemostasis was achieved, a chest drain was placed, and the chest was closed in layers. The patient was extubated and weaned off ECMO, with stable vital signs and oxygen saturation of 100% on 60% oxygen supplementation.

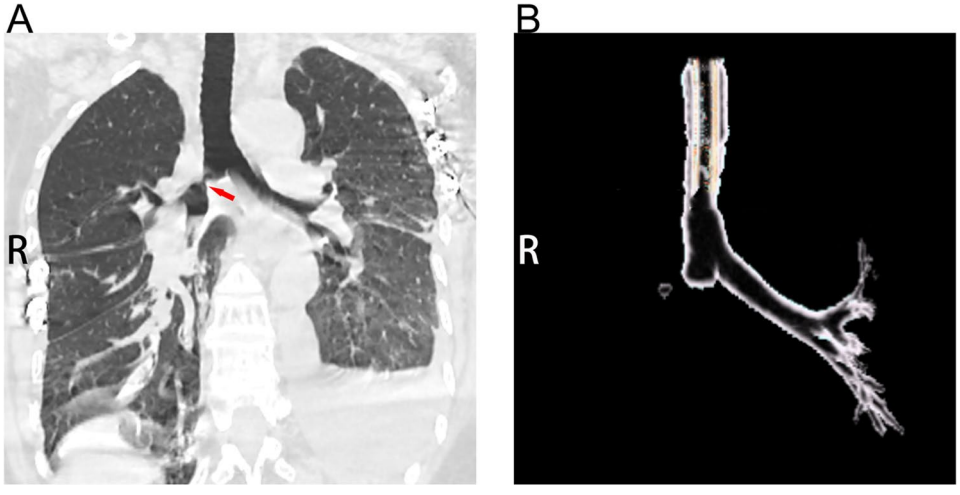

Fig. 1 Coronal CT scan and 3D reconstruction of tracheobronchial anatomy. (**A**) Coronal chest CT demonstrating significant pathological changes. The red arrow indicates a suspected tracheal lesion near the carina. The right lung (R) shows signs of collapse or atelectasis. (**B**) 3D reconstruction of the tracheobronchial tree highlighting the structural anatomy. The right bronchus (R) is not visualized, suggesting a possible rupture, consistent with the findings on the CT scan

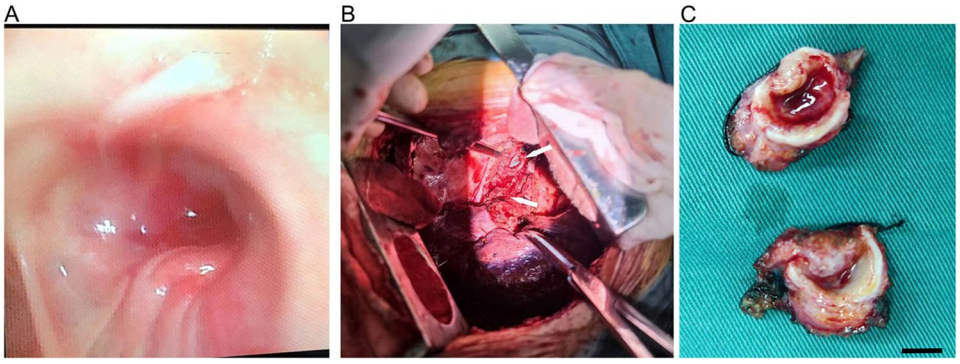

Fig. 2 Intraoperative findings and gross pathology of the tracheobronchial lesion. (**A**) Intraoperative bronchoscopy showing the tracheal lesion with visible mucosal irregularities and narrowing, consistent with the suspected rupture. (**B**) Surgical field during the resection of the tracheal lesion, with white arrows indicating the location of the rupture. Careful dissection was performed to free and resect the affected area, followed by bronchial anastomosis. (**C**) Gross specimens of the resected tracheal segments, demonstrating severe damage and disruption of the tracheal wall, further supporting the diagnosis of tracheal rupture. The scale bar represents 1 cm

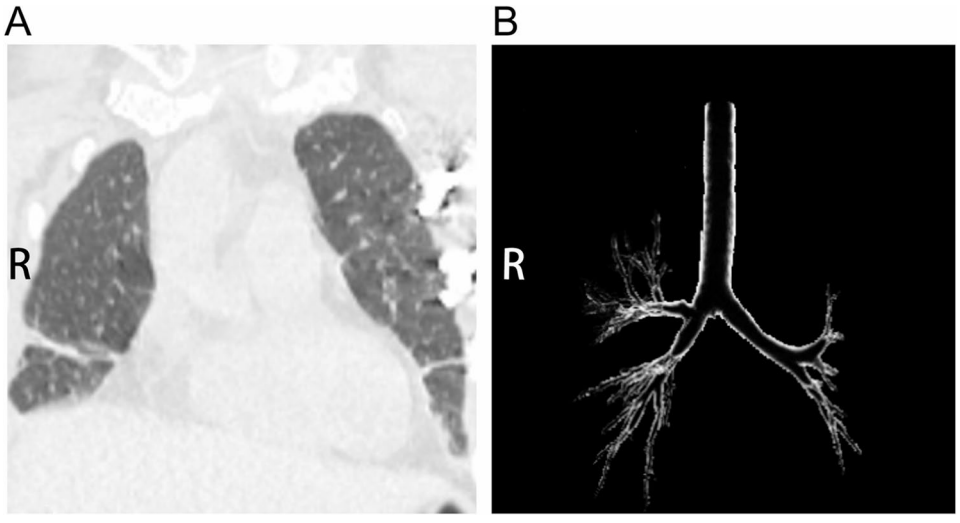

Fig. 3 Postoperative CT findings and 3D reconstruction of the tracheobronchial tree. (**A**) Postoperative coronal chest CT showing resolution of the previously noted right lung atelectasis (R). The tracheobronchial anatomy appears restored, with no evidence of residual obstruction or rupture. (**B**) 3D reconstruction of the tracheobronchial tree illustrating the restored continuity and patency of the airway. The previously absent right bronchus (R) is now fully visualized, indicating successful surgical repair and anastomosis

The patient was transferred to the ward with a tracheostomy, continued mechanical ventilation, and received prophylactic antibiotics, fluid resuscitation, and analgesia. The extubation was removed 17 h postoperatively, and respiratory care was intensified to promote coughing and sputum clearance to prevent pulmonary infection. Postoperative chest CT revealed linear and increased density shadows in both lungs, suggestive of resolving pulmonary contusion, and high-density shadows in the right hilum. Multiple rib fractures with postfixation changes were also noted. On postoperative day 8, the patient's vital signs were stable, with slightly coarse breath sounds and no significant rales or rhonchi, leading to discharge. A follow-up chest CT one month after discharge showed minimal pleural effusion, pleural thickening, adhesions, multiple rib fractures, and postfixation changes, with no other abnormalities (Fig. 3).

Discussion

Sudden chest compression leading to tracheal rupture is a complex biomechanical event [4]. Abrupt chest compression decreases the anteroposterior diameter of the thoracic cage while increasing the transverse diameter, pushing the lungs posteriorly and laterally. This creates significant tension near the carina, which may lead to tracheal rupture. The rapid closure of the glottis during such events could also cause a sudden increase in intrabronchial pressure. Larger bronchi, particularly the main bronchi, have relatively thinner walls and may exceed their elastic limits, resulting in rupture. Additionally, rapid deceleration during high-speed impacts can

generate shear forces that act on fixed points of the trachea, such as the cricoid cartilage and the carina, causing tears or fractures. The left main bronchus is more protected by surrounding structures compared to the right, making right-sided injuries more common in blunt trauma [5]. In this case, the patient sustained chest trauma from a motor vehicle accident, causing sudden chest compression and high-speed deceleration, which likely injured the right main bronchus without complete rupture. During recovery, abnormal proliferative repair could have increased internal bronchial pressure, leading to delayed rupture. Several studies have reported that delayed bronchial rupture following chest trauma could have an acute onset and be life-threatening if not treated promptly [2].

Given the patient's compromised lung function, right lung atelectasis following bronchial rupture, and low oxygen saturation despite ventilator support, the patient's functional reserve of the left lung was likely poor. Since bronchial anastomosis requires one-lung ventilation, it is challenging to ensure adequate oxygenation if the healthy lung is not functioning optimally [6]. Delayed bronchial rupture is often complicated by other chest injuries and adhesions at the site of injury, adding to the difficulty of surgical manipulation and prolonging surgery time [7]. Therefore, intraoperative ECMO support was necessary to ensure respiratory and circulatory stability. In this case, VV ECMO was selected due to stable circulation and isolated respiratory dysfunction. Once initiated, ECMO support rapidly improved oxygen saturation, providing a stable platform for surgery. In thoracic surgery, VV ECMO provides effective gas exchange support, ensuring adequate oxygenation and CO_2 clearance during thoracic surgeries [8]. However, its use also comes with notable downsides. The requirement for anticoagulation increases the risk of bleeding, particularly in patients with coagulopathies or those undergoing complex procedures. Additionally, VV ECMO does not address the underlying lung pathology, often serving as a temporary solution that could delay necessary treatment. Prolonged use may lead to complications such as cannula-related infections, thrombosis, and mechanical failure. Moreover, extended ECMO support may exacerbate systemic inflammation, contributing to multiorgan dysfunction. Therefore, while VV ECMO is a crucial tool in managing respiratory failure during thoracic surgery, careful monitoring and management of potential risks are essential for optimal outcomes.

Proper management of abnormal proliferation following chest trauma requires accurate identification of anatomical structures and removal of abnormal tissue while avoiding vital structures like blood vessels [9]. Intraoperative bronchoscopy is a reliable tool to assist in locating bronchial rupture sites and confirming anastomosis [10]. In this case, the bronchoscope's illumination light was used to identify the rupture, aiding anastomosis. Post-anastomosis, the bronchoscope facilitated assessment of anastomosis and lung segment lavage, helping to prevent postoperative infection.

Conclusions

Bronchial rupture following chest trauma is a rare but serious complication that can endanger patients' lives if untreated, particularly when delayed rupture occurs, as it is often overlooked. Timely surgical intervention is essential when bronchial rupture leads to atelectasis. When lung function is compromised and circulation remains stable, VV ECMO support should be considered for surgical treatment. Intraoperative bronchoscopy aids in localizing the injury, assessing anastomosis, and performing lung segment lavage to prevent infection. In this case, the patient achieved a favorable prognosis and satisfactory outcomes with timely and effective treatment.

Author contributions

L.Z.H, C.Y. and L.Y. conceived the study and collected the data. L.Z.H and L.Y.participated in drafting the initial draft. All authors read and approved the final version of the manuscript.

Funding

The authors declare that no financial support was received for the research.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval

Written informed consent was obtained from the participant/patient(s) for the publication of this case report.

Competing interests

The authors declare no competing interests.

Received: 11 October 2024 / Accepted: 7 February 2025
Published online: 15 February 2025

References

1. Fuentes-Martín Á, Disdier Vicente C, Cilleruelo-Ramos Á. Complete bronchial rupture due to blunt chest trauma. Pulmonology. 2023;29(2):176–7.
2. van Roozendaal LM, van Gool MH, Sprooten RTM, et al. Surgical treatment of bronchial rupture in blunt chest trauma: a review of literature. J Thorac Dis. 2018;10(9):5576–83.
3. Wang FY, Fang B, Yu ZH, et al. Severe thoracic trauma caused left pneumonectomy complicated by right traumatic wet lung, reversed by extracorporeal membrane oxygenation support-a case report. BMC Pulm Med. 2019;19(1):30.
4. Dogrul BN, Kiliccalan I, Asci ES, Peker SC. Blunt trauma related chest wall and pulmonary injuries: an overview. Chin J Traumatol. 2020;23(3):125–38.
5. Antonescu I, Mani VR, Agarwal S. Traumatic injuries to the trachea and bronchi: a narrative review. Mediastinum. 2022;25:6:22.
6. Jamal Eddine H, Abu Arab W, AlSaleh A, et al. Complex bronchial ruptures in blunt thoracic trauma: management and outcome. Indian J Thorac Cardiovasc Surg. 2021;37(3):311–5.

7. Li Y, Wang G, Wu C, et al. Experience of diagnosis and treatment of traumatic bronchial rupture in children in a single clinical center. Pediatr Surg Int. 2020;36(9):1019–25.
8. Voltolini L, Salvicchi A, Gonfiotti A, et al. Veno-venous extra-corporeal membrane oxygenation in complex tracheobronchial resection. J Thorac Dis. 2024;16(2):1279–88.
9. Dogrul BN, Kiliccalan I, Asci ES, et al. Blunt trauma related chest wall and pulmonary injuries: an overview. Chin J Traumatol. 2020;23(3):125–38.
10. Gómez-Hernández MT, Forcada C, Rivas C, et al. Techniques for intraoperative identification and confirmation of segmental bronchus in minimally invasive segmentectomy. Video-assist Thorac Surg. 2024;9:25.

Publisher's note