Extracorporeal membrane oxygenation as a support for emergency bronchial reconstruction in a traumatic patient with severe hypoxaemia

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Abstract
Extracorporeal membrane oxygenation (ECMO) is an extracorporeal life support technique to provide cardiac and/or respiratory assistance to patients. ECMO has been demonstrated to be beneficial for the life support of selected traumatic individuals. However, the application of arteriovenous ECMO as an intraoperative support strategy in emergency operations has rarely been described. The presented case involves a 31-year old male who sustained a right bronchial rupture and other multiple injuries in a car accident. His right main bronchus was sewn completely closed during the first operation in a local hospital, and he developed refractory hypoxaemia and haemodynamic instability. Although general anaesthesia was not applicable, arteriovenous ECMO was applied as a support to perform the second operation to reconstruct successfully his right main bronchus. As a result, he recovered from this injury.

Keywords: Extracorporeal membrane oxygenation • Operation • Trauma

INTRODUCTION
Extracorporeal membrane oxygenation (ECMO) is an extracorporeal life support technique that provides cardiac and/or respiratory support to patients. ECMO has been demonstrated to be beneficial to traumatic individuals who have suffered respiratory failure after trauma [1]. In surgery, ECMO is mainly used as a bridge to delayed surgical management [2]. However, the application of ECMO as an intraoperative support strategy in emergency operations has rarely been described [3–5]. This report presents the case of successful emergency reconstruction of a previously sewn right main bronchus (RMB) by conducting arteriovenous ECMO as a support for an adult traumatic patient with severe hypoxaemia.

CASE REPORT
A 31-year old male in respiratory distress was first referred to a nearby local hospital after he was involved in a severe car accident. Primary survey and imaging studies indicated a right-sided haemothorax, bilateral pulmonary contusions, brain contusion, minor subdural haematoma and subarachnoid haemorrhage, multiple rib fractures, a right femur fracture and multiple soft tissue contusions. Intercostal chest drainage was administered, but a large air leak persisted and the right lung was not re-expanded. Bronchoscopy demonstrated a longitudinal, helical tear in the RMB. Posterolateral thoracotomy was immediately performed to repair the RMB. However, postoperative chest radiography indicated complete right-sided pulmonary consolidation (Fig. 1A). The patient developed fever and progressive hypoxaemia on postoperative day (POD) 2, although mechanical ventilation support was provided through a tracheostomy tube.

The patient was transferred to our hospital on POD 5 to undergo further therapy. Bedside bronchoscopy revealed that the RMB was completely occluded. The axillary temperature was 38.5°C, and the white blood cell count was 21.82 × 10⁹/l. Despite mechanical ventilation with 100% FiO₂ using a pressure control ventilator support at 15 mmHg positive end-expiratory pressure, the arterial oxygen saturation was maintained at <60%. His haemodynamic condition was simultaneously unstable and manifest as tachycardia and blood pressure decrease. Hence, it was necessary to reconstruct the RMB to save him from severe ventilation/perfusion mismatch and obstructive pneumonia. However, general anaesthesia could hardly stabilize the patient for surgery because of severe hypoxaemia and unstable haemodynamics. Therefore, the anaesthetists initiated arteriovenous ECMO, which was applied by left-sided femoro-femoral cannulation.

Low-dose heparin was administered to maintain an active coagulation time between 160 and 180 s. A stepwise increase in ECMO output (from 2.0 to 4.3 l/min) was performed and a double-lumen endotracheal tube was substituted to perform isolated mechanical ventilation. The arterial oxygen saturation of the patient was improved after ECMO was initiated and stably maintained at ~90%. Posterolateral thoracotomy through the former incision was performed. The right lung was found to be completely consolidated and congested. A longitudinal, helical tear in the RMB was extended from its origin to bifurcation. The lumen of the RMB was...
completely sewn closed and one side of the right pulmonary artery was sewn to the bronchus. The right pulmonary trunk and the interlobar artery were dissected and temporarily blocked using a Satinsky clamp and a bulldog clamp, respectively. The sewn side was successfully detached and the artery was repaired using a running 4-0 Prolene suture. The needle holes bled slightly due to heparinization and the bleeding was controlled via compression using a warm saline-moistened gauze. After conducting vascular repair for \( \approx 10 \) min, we successfully performed a sleeve bronchial reconstruction of the RMB between its origin and bifurcation (Fig. 1B and C) and initiated bilateral lung ventilation. The right lung re-expanded and arterial oxygen saturation was gradually improved to 100% with 50% FiO\(_2\). After we closed the chest, orthopaedists performed closed reduction and external stent fixation on the fractured femur. The patient was successfully weaned from ECMO after he was provided support for \( \approx 450 \) min. He was then transferred to an intensive care unit for further therapy.

Pneumonia caused by *Stenotrophomonas maltophilia* complicated postoperative recovery. Sensitive antibiotics were administered, and measures against pulmonary contusions were implemented. On POD 12, he was successfully weaned from the ventilator. He received surgery on the right femur on POD 34. Imaging studies were performed to monitor and record his rehabilitation (Fig. 1D–F). He was then discharged on POD 51.

**DISCUSSION**

A few case reports have presented the successful application of ECMO in emergency repair of traumatic injury to the central airway [3–5]. However, the situation was more complicated in our case. The RMB of this patient had been sutured completely closed during the first operation. Suffering from complete right pulmonary consolidation, left pulmonary contusions and subsequent pulmonary infection, the patient further experienced refractory hypoxaemia and haemodynamic compromise, although strong antimicrobial therapy and mechanical ventilation support were administered. Given that the obstructed and consolidated right lung was not only the main cause of ventilation/perfusion mismatch, but also the main source of infection, we found that bronchial reconstruction was the final treatment option to conserve the patient’s right pulmonary function. This procedure was also the preferred treatment to rescue him from refractory obstructive pneumonia and respiratory failure by relieving bronchial obstruction when all the other regular therapies failed and death seemed inevitable. With the ability to provide lung-sparing oxygenation and circulatory stabilization, arteriovenous ECMO, along with antimicrobial therapy, could be applied to stabilize the patient for a while before he was subjected to surgery. However, the right lung could have been further damaged if occlusion was relieved at a later time. Therefore, we chose to perform the operation without delay and applied arteriovenous ECMO as a support instead of as a bridge to a delayed surgery. The use of venovenous ECMO would have been possible if the patient had not suffered from haemodynamic compromise. Given his stable condition after bronchial reconstruction was performed and bilateral lung ventilation was initiated, we decided to wean the patient from ECMO promptly to save him from prolonged ECMO support and its associated risks. Hence, surgical procedures and weaning from ECMO were successful.
This case demonstrated that ECMO could be applied not only as a bridge for a delayed surgery, but also as a support during an emergency operation.

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REFERENCES