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CASE REPORT

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Pulmonary lobectomy in two multitrauma patients under extracorporeal circulation placed preoperatively in an intensive care unit: A case report

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Abstract

The clinical course of our two patients highlights the feasibility of using venovenous extracorporeal membrane oxygenation (ECMO) with heparin for multitraumatic patients needing thoracic surgery. Further research is required to determine if surgery can be performed with totally heparin-free vv-ECMO. All ICU teams should become familiar with this technique.

KEYWORDS

coagulation, extracorporeal membrane oxygenation, extracorporeal support, multitrauma, pulmonary lobectomy

1 | INTRODUCTION

Posttraumatic pulmonary contusions are frequently present in traumatic patients admitted to intensive care units. These manifestations quickly tend to acute respiratory distress syndrome (ARDS) resulting from abcedation or pneumonia. In this kind of pathology, involvement of thoracic surgeons is sometimes needed to resect a part of the lung and a complete lobectomy may be performed. When the two lungs are breached and conventional ventilation fails to maintain oxygenation, thoracic surgery can be difficult because of hypoxemia. A solution to improve the oxygenation of the patient and to facilitate the surgeon's work is to perform the surgery under extracorporeal membrane oxygenation (ECMO). There are two types of ECMO: venovenous (vv) or venoarterial (va). This report only refers to vv-ECMO because of the need for oxygenation support, not hemodynamic support. The vv-ECMO is widely used in university hospitals, rarely in peripheral hospitals. We report our experience using vv-ECMO in two multitraumatic patients requiring pulmonary lobectomy to resect a pulmonary abscess. We also describe our approach of systemic anticoagulation. A number of heparin-free ECMO approaches are described in the literature but not yet for multitraumatic patients because of the risk of inducing internal bleeding if systemic anticoagulation is given.

2 | CASE REPORT

The first patient was a 51-year-old male without any health problems. He suffered multiple trauma after a motorcycle accident. The first computerized tomodensitometry (CT) scan and X-ray (Figure 1) made at his admission showed a right pneumothorax, the break of the first six right ribs, a right pulmonary contusion, and a hematoma of the right adrenal gland. The patient was directly taken to the operating room to put a thoracic drain in the right lung base and was then admitted to the intensive care unit (ICU), intubated, and sedated. There was no need to perform surgery on the adrenal gland hematoma. The CT scan and the X-ray performed the day

FIGURE 1 CT scan of the thorax on the third day of admission for patient 1. It shows the poor evolution of the two lungs

after his admission showed that his condition had worsened with an increase in the right pulmonary condensation and the appearance of condensations in the inferior lobe of the left lung. The different bronchial fibroscopies performed to treat atelectasis were positive for *Pseudomonas Aeruginosa,* and the patient later developed sepsis linked to an abcedation in the right lung. The thoracic CT scan made on the third day of admission also showed deterioration of the pulmonary state. Without improvement in the situation of the arterial gas saturation or in the patient's hemodynamics, in a multidisciplinary discussion between the ICU doctors, the anesthetists, and the thoracic surgeon, it was decided to perform a pulmonary lobectomy on the right inferior lobe (perhaps with the middle lobe). The parameters of ventilation showed a PaO2/FiO2 ratio of 55 while using neuromuscular blockers and leaving a permissive hypercapnia. Because of the poor lung function, it was decided to place a venovenous ECMO machine while in the ICU with the consent of the patient's wife. ECMO was thus recommended for acute respiratory distress syndrome (ARDS), lung contusions, the hypoxemic situation, and for facilitation of the surgeon's movements during surgery. The patient's Respiratory Extracorporeal Membrane Oxygenation Survival Prediction (RESP) score was 2.[1] The ECMO machine was placed while in the patient's room the day before the operation using fluoroscopy and the Seldinger technique. The first cannula was placed in the right internal jugular vein (21 Fr, Maquet, Germany) and the second in the right femoral vein (21 Fr, Maquet, Germany) both under ultrasonic control. The patient was heparinized with 5000 UI of heparin and then connected with the ECMO machine, Maquet Cardiohelp®. The ECMO machine settings were as follows: blood flow

TABLE 1 Arterial blood gases for the first patient: before, during, and after one-lung ventilation

	Pre-ECMO	During surgery (OLV)	Post-ECMO
pH	7.41	7.34	7.41
pO2 (mm Hg)	85	72	61
pCO2 (mm Hg)	52	59	52
SaO2 (%)	96	72	91
PaO2/FiO2 ratio	121	72	122

Note: This table shows a bad PaO2/FiO2 ratio during the OLV with a balanced pH thanks to the ECMO.

was set at the rate of 3 L/min, FiO2 was set at 50% (with the lowest acceptable SaO2 at 90% or PaO2 60 mm Hg), and volume control was set at 450 mL × 15/min with FiO2 50%. The patient's oxygenation improved after the introduction of vv-ECMO (Table 1). The surgery was performed the day after without incident. The patient was weaned from the ECMO machine four days later, and no complications were reported. He left the ICU seven days after surgery.

The second patient was a 23-year-old man without a medical history who fell from a height of three meters and suffered from a bilateral pulmonary contusion, a suffocating right pneumothorax that was drained in the emergency room, a spleen contusion, a liver contusion, an occipital condyle injury, fractures of the transverse process of the L1 to L4 vertebra, and an ischemia of basal ganglia. There was no need for emergency surgery for all the injuries, and the patient was only hemodynamically monitored in the intensive care unit. The patient rapidly developed a right pneumonia and a bilateral pleural effusion, which was drained with chest drains (Figure 2). The different bronchial fibroscopies performed to treat the atelectasis were positive for *Serratia Marcescens*. On the 5th day of admission, we performed a CT scan that showed a deterioration of the right lung with traumatic pneumatocele and an increase in condensation in the left inferior lobe. The CT scan was repeated the day after because oxygenation was becoming increasingly difficult, even using neuromuscular blockers and permissive hypercapnia. The CT scan showed hepatization of the right middle lobe. It was then decided to perform a classic right inferior lobectomy to improve lung function. Unfortunately, the surgery was not performed because good oxygenation was not possible when excluding the right lung. It was then decided to place a venovenous ECMO machine in the ICU with the consent of the patient's family. The patient's RESP score was 4.[1] The ECMO machine was placed the day after in the patient's room using fluoroscopy and the Seldinger technique. One cannula was placed in the right internal jugular vein (21 Fr, Maquet, Germany), and the second cannula was placed in the right

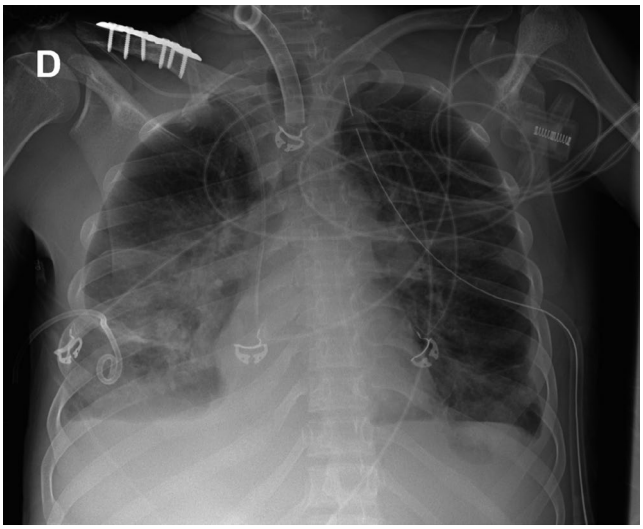

FIGURE 2 Chest X-ray the day before the placement of the vv-ECMO machine for patient 2. It shows the tracheostomy, right inferior pneumonia, and bilateral chest drains. The X-rays show opacities that may be caused by pneumonia or contusion

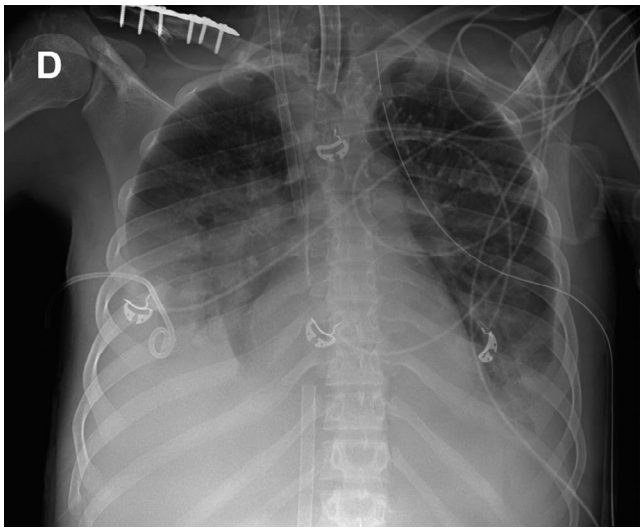

FIGURE 3 Chest X-ray for patient 2. It shows the jugular ECMO cannula and the femoral ECMO cannula

femoral vein (21 Fr, Maquet, Germany) (Figure 3). The Maquet Cardiohelp® machine was also used. The ECMO machine settings were as follows: blood flow set at the rate of 3.5 L/min, FiO2 set at 60% (with the lowest acceptable SaO2 at 90% or PaO2 60 mm Hg), and volume control was 350 mL × 13/min with FiO2 45%. The patient's oxygenation improved after the introduction of vv-ECMO (Table 2). The surgery was performed the day after with no incident, and the patient was weaned from the ECMO machine three days later, and no complications were reported. He left the ICU ten days after the surgery.

TABLE 2 Arterial blood gases for the second patient: before, during, and after one-lung ventilation

	Pre-ECMO	During surgery (OLV)	Post-ECMO
pH	7.53	7.4	7.49
pO2 (mm Hg)	56	72	87
pCO2 (mm Hg)	39	53	39
SaO2 (%)	92	94	97
PaO2/FiO2 ratio	124	72	248

Note: This table shows a better oxygenation after the surgery due to the pulmonary lobectomy (decreased dead space).

The use of ECMO with a multitraumatic patient is controversial due to the need for systemic anticoagulation because of the risk of inducing further internal bleeding. The risk of bleeding during thoracic surgery was also a major challenge. To address those problems, it was decided for the two patients to heparinize the circuit with a targeted activated clotting time (ACT) of 1.5 times the normal level and to stop the continuous heparin infusion six hours before the patients went to the operating room. The two patients were then far from fully heparinized during surgery. There were no bleeding complications reported.

3 | DISCUSSION

Trauma care has improved in the past 30 years, but the prevalence of respiratory and hemodynamic complications remains high. Extracorporeal membrane oxygenation (ECMO) support can be of further help to improve the outcome of trauma patients. Many venovenous ECMO applications are described in the literature for various indications: ARDS, pulmonary reduction surgery in chronic obstructive pulmonary disease (COPD) patients, and pulmonary tumor resection.[2] There is an organization called the Extracorporeal Life Support Organization (ELSO),[3] which states the indications for the different uses of ECMO. Our cases are not listed in the indications but are no longer contraindications. The ELSO also states the anticoagulation guidelines for use with ECMO.

Even if it is not the first indication, the application of vv-ECMO has been extended to traumatic patients in intensive care units for approximately the last ten years,[4,5] with the exclusion of patients with head injuries and thoracic injuries because of the risk of bleeding. Only one case report described the management of vv-ECMO without systemic anticoagulation in a multitraumatic patient suffering from lung and head injuries. Pulmonary contusion is a major challenge in multitrauma patients because it often leads to pneumonia and abscess formation, and it often compromises the oxygenation of the patient. Most cases reported concern the

use of venovenous ECMO in multitraumatic patients who develop ARDS because of a pulmonary contusion.[6,7] Even if lung resection is not the first-choice therapy to improve oxygenation, we sometimes need to perform pulmonary resection. Most of the time the surgery is performed with one-lung ventilation without incident but sometimes the contusion concerns both lungs, making the surgery impossible because of bad oxygenation. A way to fix this problem is to perform the surgery under venovenous ECMO. Because critical hypoxemia can occur rapidly during one-lung ventilation, we decided to install the ECMO machine preoperatively.[8] However, because of the risk of bleeding, the use of vv-ECMO on multitrauma patients to help perform surgery is still rare and is rarely reported in the literature. A recently published Taiwanese case-control study reported that trauma patients receiving ECMO support had an increased mortality rate and that they required further surgery during their hospitalization.[9]

The use of nonheparinized vv-ECMO in multitrauma patients suffering from ARDS is being developed[10,11] because the risk of bleeding remains challenging in trauma patients. The application of nonheparinized vv-ECMO to perform thoracic surgery has not yet been described. Anyway, this case report suggests that vv-ECMO therapy should not be avoided in severely injured patients needing thoracic surgery.

The cases reported in this publication concern the late phase of management of traumatic patients suffering from ARDS. The use of ECMO in the early phase should be kept in mind and has been described recently in the literature.[12] Although the clinical cases presented here may seem promising, it should be remembered that trauma patients receiving ECMO support and requiring additional surgery during their hospitalization have an increased mortality rate.[9]

Considering the different results reported in the literature and our own experience, we can reasonably assert that vv-ECMO can be safely used with multitraumatic patients requiring thoracic surgery. Unfortunately, the lack of references concerning the use of vv-ECMO and anticoagulation management (with or without heparin) does not allow a comprehensive recommendation at present. We recommend further analysis of the potential benefits of total heparin-free vv-ECMO preceding thoracic surgery in trauma care.

Finally, all ICU teams should become familiar with the vv-ECMO technique, and perhaps this technique will become the next continuous venovenous hemofiltration (CVVH) system of intensive care units.

4 | CONCLUSION

Venovenous ECMO can be of help in the performance of thoracic surgery in multitraumatic patients. We report two cases of vv-ECMO with heparin in multitraumatic patients who underwent pulmonary lobectomy with no bleeding incident, with heparin infusion stopped six hours before surgery. Further research is required to determine if surgery can be performed with totally heparin-free vv-ECMO.

CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTION

CF: involved in main work, data collection, and manuscript writing. MDK: involved in data collection, manuscript revision. OS: ICU physician and ECMO specialist, and revised the manuscript. FV: ICU physician and ECMO specialist, and revised the manuscript. DNS: ICU physician and involved in final revision.

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