

Veno-venous extracorporeal membrane oxygenation in a patient with severe acute respiratory failure – case report



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Abstract

Acute respiratory failure resistant to conventional pulmonary therapy often requires intensive medical care. In rare cases, ventilator therapy proves insufficient, and only the option of employing veno-venous extracorporeal membrane oxygenation (ECMO V-V) remains. The present article describes the case of a 23-year-old patient who experienced severe acute respiratory distress syndrome with associated multiple organ failure. The patient was admitted to the pulmonary ward of the Alfred Sokołowski Regional Pulmonary Hospital in Szczecin-Zdunowo with suspected pneumonia of unknown etiology. After the initial 5 days of diagnostics at the pulmonary ward, the patient required a further 97 days of hospital treatment and spent 63 days at the Intensive Care Unit. There, he underwent ECMO V-V therapy lasting 22 days, which resulted in the improvement of his arterial blood gas parameters and clinical condition.

Key words: ECMO, acute respiratory failure, pneumonia.

Introduction

Extracorporeal membrane oxygenation (ECMO) is often used in adult patients with severe respiratory failure in the course of pneumonia of various etiology. This technique provides the patient's blood with oxygen and reduces hypercapnia until the lung tissue's ability to perform efficient gas exchange is restored. Extracorporeal membrane oxygenation is indicated if the etiology of acute respiratory failure is reversible, which is not always known at the start of the therapy. The technique is complex and expensive; it requires

Streszczenie

Ostra niewydolność oddechowa, która nie poddaje się standardowemu leczeniu pulmonologicznemu, często wymaga intensywnej terapii oraz leczenia respiratorem. W rzadkich przypadkach respiratoroterapia bywa niewystarczająca i wtedy ostatnią możliwością pomocy choremu jest zastosowanie żyłno-żyłnej membranowej oksygenacji pozaustrojowej (*veno-venous extracorporeal membrane oxygenation* – ECMO V-V). W pracy opisano przypadek 23-letniego pacjenta przyjętego na oddział pulmonologiczny Specjalistycznego Szpitala im. Alfreda Sokołowskiego w Zdunowie z podejrzeniem zapalenia płuc o nieznannej etiologii, u którego wystąpił ciężki ostry zespół niewydolności oddechowej z towarzyszącą niewydolnością wielonarządową. Chory po wstępnej 5-dniowej diagnostyce na oddziale pulmonologicznym wymagał 97 dni pobytu w szpitalu, z czego 63 dni na oddziale intensywnej terapii, gdzie przez 22 doby stosowano ECMO V-V, uzyskując wyrównanie gazometryczne oraz poprawę stanu klinicznego.

Słowa kluczowe: ECMO, ostra niewydolność oddechowa, zapalenie płuc.

the involvement of a qualified team and is burdened with the possibility of a number of complications, such as kidney failure, bacterial pneumonia, sepsis, or serious bleeding. Mortality reaches almost 50% [1]. In this paper, we present a case of successful ECMO V-V treatment used in a 23-year-old patient with acute respiratory distress syndrome (ARDS).

Case study

The patient was admitted to the pulmonary ward with progressive dyspnea and increasing respiratory failure rais-

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ing the suspicion of pneumonia. His condition was gradually deteriorating. Radiological examination revealed extensive bilateral shadowing on the lower lung fields (Fig. 1). Further examinations revealed the following: oxygen saturation 75.6%, pH in blood gas analysis (BGA) 7.48, partial pressure of carbon dioxide (PaCO_2) 38.5 mmHg, partial pressure of oxygen (PaO_2) 41.9 mmHg, alanine aminotransferase 474 U/l, aspartate aminotransferase 266 U/l, lactate dehydrogenase 561 U/l. A treatment employing co-trimoxazole, ciprofloxacin, doxycycline, and rifampicin was implemented without achieving clinical improvement. On the 5th day of hospitalization, due to clinical and radiological progression, which presented as massive atelectasis of both lungs, left-sided pneumothorax, and mediastinal shift to the right (Fig. 2), the patient was transferred to the intensive care unit (ICU) with the diagnosis of severe acute respiratory failure. The patient required left pleural drainage, deep sedation (fentanyl, tramadol, midazolam, propofol), and ventilation with the following ventilation options: biphasic positive pressure, fraction of inspired oxygen (FiO_2) 0.5-0.8, positive end-expiratory pressure (PEEP) 32/14 cmH_2O , and pressure support (PS) 18 cmH_2O . An improvement was achieved in terms of oxygen pressure in the arterial blood (PaO_2 94 mmHg). Samples for microbiological analysis of the bronchial tree were collected, and treatment with vancomycin and fluconazole was implemented. The viral, fungal and bacterial analyses did not reveal any infection factors. Heart ultrasound examination showed normal cardiac structure, a dilated aorta, no valvular changes, and left ventricular ejection fraction (EF) of 70%. On the 10th day, the patient's respiratory function suddenly deteriorated – chest X-ray examination revealed an expansion of the inflammatory changes involving the lower and middle lobes of both lungs. On the 13th day, due to a deterioration in ventilation, a percutaneous tracheotomy was performed and FiO_2 was increased to 0.8-1.0. Subsequently, due to increasing concentrations of potassium (8.2 mmol/l) and creatinine (up to 1.7 mg/dl), renal replacement therapy was introduced. A dialysis cannula

was inserted into the right subclavian vein and continuous veno-venous hemofiltration was commenced. Due to the growing signs of severe respiratory failure and increasing multi-organ hypoxia, ECMO V-V was started on the 11th day of the patient's stay at the ICU. Under general anesthesia, cannulas were introduced into the right internal jugular vein (15 Fr) and the right femoral vein (20 Fr) using the Seldinger technique. Concurrently, heparin began to be administered in a continuous infusion of 2000-2800 units per hour, keeping the clotting time (activated clotting time – ACT) within the range of 130-148 seconds. Initially, the parameters of the ECMO oxygenator were set as follows: FiO_2 1.0, blood flow 4 l/min, speed of the centrifugal pump 3000/min, and gas flow 4 l/min. Ultimately, the required gas flow was set at 6-8 l/min. An improvement of the BGA parameters (pH: 7.35, PaO_2 : 108 mmHg, PaCO_2 : 54 mmHg) was achieved on the first day of the ECMO V-V therapy. Over the next two days, based on the normalization of serum potassium (3.9 mmol/l) and creatinine (0.8 mg/dl), a decision was made to terminate the dialysis. The ECMO therapy was continued with gas flow at 8 l/min and with 100% oxygen in the oxygenator, resulting in the achievement of a gradual improvement in terms of organ oxygenation as well as renal and hepatic function. The oxygen concentration of the ventilator was reduced in a stepwise manner, keeping constant FiO_2 0.5-0.6, PEEP 18 cmH_2O , PS 15 cmH_2O in assisted/controlled breathing. On the 23rd day, respiratory function deteriorated again. The performed X-ray examination revealed bilateral pneumothorax, mediastinal emphysema, and left-sided hemothorax 12 × 5 × 6 cm in size. This was treated with repeat thoracotomy and hematoma removal. The heparin treatment was terminated, and nadroparin was administered in a subcutaneous injection of 2 × 0.6 mg. Pathological examination of lung tissue samples showed active advanced interstitial and subpleural fibrosis, with signs of an interstitial inflammatory process dominated by eosinophil granulocytes, with bronchiolization of distal airspace. Again, microbiological tests failed to determine the etiology of



Fig. 1. Chest X-ray – extensive bilateral shadows on the lower lung fields



Fig. 2. Chest X-ray – massive atelectasis in both lungs, left-sided pneumothorax and mediastinal shift to the right

these changes. Periodically, norepinephrine infusion was required during drops in blood pressure. The patient received packed red blood cells, platelet-rich plasma, fresh frozen plasma, and cryoprecipitate. Moreover, blood coagulation factor VIIa was introduced, but failed to reduce the bleeding. The concentration levels of coagulation factors VII and IX were normal. On the 16th day of ECMO, the oxygenator had to be replaced due to clot accumulation. In the subsequent days, a slow improvement was observed in terms of respiratory function and chest X-ray results. On the 34th day, bleeding into the pleural cavities intensified (5500 ml per day), requiring surgical coagulation. In view of the inefficiency of the anticoagulation therapy and the increasing manifestation of oxygenator clotting, a decision was made to end the ECMO therapy after 22 days of its duration. The parameters of mechanical ventilation were established at: FiO_2 0.45, PEEP 34/10 cmH_2O , PS 24 cmH_2O ; blood oxygen saturation was maintained within the range of 90-96%, and satisfactory BGA parameters (pH: 7.49, PaO_2 : 102 mmHg, PaCO_2 : 41 mmHg) were noted. An improvement of the general condition was achieved, and normal coagulation function was restored (prothrombin time 10 s, Quick's index of 109%, INR 0.9, APTT 32 s). However, massive bleeding into the left pleural cavity persisted (9000 ml from the drains). The ventilator was set in proportional assist ventilation mode with oxygen concentration at FiO_2 0.3 and assistance at 50%. On the 68th day after admission, the bleeding stopped. After another two days, the ventilator was disconnected, and the tracheostomy was removed. The patient was breathing spontaneously with an oxygen mask at 2 liters per minute, with PaO_2 reaching from 60 to 80 mmHg. Despite persistent tachycardia of 100-120 per minute, right ventricular pressure was 40 mmHg, and the performed heart ultrasound confirmed good contractility of the cardiac ventricles with EF of 70%.



Fig. 3. Chest computed tomography – extensive bilateral ground-glass opacities in the lung fields and interstitial fibrosis

The patient was transferred to the Thoracic Surgery Ward in stable condition. Chest computed tomography showed adhesions on the left side, fluid and pneumothorax of 4 cm along with minor changes on the right side, as well as extensive bilateral ground-glass opacities in the lung fields and a reticular density giving the appearance of interstitial fibrosis (Fig. 3). Conservative treatment and rehabilitation were continued. On the 72nd day, due to increasing bleeding into the left pleural cavity (Fig. 4), the patient was qualified for left-sided thoracotomy, during which lung decortication, marginal lingula resection, and partial rib resection were performed in order to reduce the capacity of the pleural cavity. Throughout the period of hospitalization, the patient required the transfusion of 76 units of packed red blood cells, 9 units of platelets, 38 units of plasma, and 32 units of cryoprecipitate. After 96 days, the patient was discharged home in good general condition, with no fever, and with a recommendation to continue rehabilitation (Figs. 5 and 6).

Discussion

The main indications for the use of ECMO V-V in adults are: ARDS with oxygenation index ($\text{PaO}_2/\text{FiO}_2$) < 70 mmHg, asthmatic state, respiratory disorders due to sepsis, traumatic lung injury, and awaiting for a lung transplant. In many cases, ECMO is an effective therapy, and it offers a chance of survival to an increasing number of patients in whom conventional conservative treatment has failed. However, there are a number of contraindications to its use, including the irreversibility of the pulmonary changes, the existence of potential sources of bleeding preventing the use of heparin, and the lack of the patient's consent. Extracorporeal membrane oxygenation therapy is burdened with a number of complications associated with the patient's critical condition, technical complications including damage of the pump, drains and gauges, clotting in the cannulas, drains and oxygenator, damage of the heat exchangers, air bubbles in the drains, accidental decannulation, and, most importantly, bleeding. Therefore, ECMO



Fig. 4. Chest X-ray – left-sided massive hemothorax



Fig. 5. Chest X-ray before discharge

therapy is not only very difficult to conduct, but also very expensive. In the case described above, the therapeutic team decided to use ECMO V-V in a 23-year-old patient with severe ARDS, achieving a good therapeutic effect. The presented method is utilized in cases of respiratory failure not accompanied by a cardiac component [2]. Extracorporeal membrane oxygenation therapy is successful in the majority of patients, but the contraindications and risk involved require careful consideration [1, 2]. Thus, the indications are limited to conditions where mortality exceeds 80% without ECMO intervention [3]. The described patient exhibited complications typical for ECMO, such as renal failure requiring hemofiltration (occurring in 52% of cases), bleeding (33%), oxygenator dysfunction requiring oxygenator replacement (29%), venous thrombosis (10%), and gastrointestinal bleeding (7%) [1]. Bleeding and pneumothorax are the most common complications requiring surgical treatment in the course of ECMO. Thoracotomy due to complications is required by 3.2% of all patients undergoing ECMO; of these complications, 75% are hemorrhagic. Therefore, ECMO therapy should be performed in a thoracic surgery ICU in order to ensure the patient's safety in the event of bleeding [4]. Transporting a patient with ECMO equipment is extremely risky and logistically complicated [5]. Prevention of bleeding complications includes the administration of blood products such as red blood cell concentrates, platelet concentrates, plasma, and preparations of coagulation factors. There are reports of potentially beneficial effects of recombinant coagulation factor VIIa used for uncontrolled bleeding in patients treated with ECMO. The positive action focuses on stopping the bleeding without increasing the risk of ECMO clotting, but no conclusive results are available [6]. In the presented case, no clear effect of recombinant factor VIIa was observed. In order to prevent complications and monitor the patient's condition, regular cardiac ultrasound is required; it allows the physician to detect thromboembolisms or en-



Fig. 6. Chest X-ray 30 days after discharge

docarditis [7]. In the future, ECMO may provide a chance of survival to a much larger number of patients in the state of severe acute respiratory failure, provided that a reduction of ECMO complications is achieved, particularly with regard to bleeding.

Disclosure

Authors report no conflict of interest.

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