Silicosis-associated Severe Pneumonia Treated by Veno-veno-venous Extracorporeal Membrane Oxygenation: a Case Report

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Case Report

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Abstract

Background: Extracorporeal membrane oxygenation (ECMO) is an extracorporeal life support system (ECLS) for patients with severe cardiopulmonary failure, there are two basic patterns of veno-arterial (V-A) and veno-venous (V-V).

Case presentation: This paper mainly introduced a death case of modified ECMO Patterns which is veno-veno-venous ECMO in the treatment of silicosis with severe pneumonia and analyzed the cause of death after treatment with VV-V ECMO.

Conclusions: Although VV-V ECMO is recommended for patients with extremely poor oxygenation conditions, it still be difficult to improve the prognosis of patients with severe lung structural damage, and still has a long way to go.

Background

Extracorporeal membrane oxygenation (ECMO) leads the patient's blood from the body to the body and then pumped back after the gas exchange, which provides long cardiopulmonary support^[1]. Generally, there are two types of ECMO: Veno-arterial (V-A) ECMO is extracted from the venous system and injected into the arterial branch for patients with heart or cardiopulmonary failure; Veno-venous (V-V) ECMO is extracted from veins and injected into the venous system, which is suitable for patients with impaired lung function but good heart function. The principle of V-V ECMO is to drain the patient's hypoxic blood through a venous catheter, and then inject the oxygenated blood into the vena cava through the blood pump after oxygenation through gas exchange device combined with the discharge of carbon dioxide, to achieve the function of assisting or supporting human lungs^[1-2]. Veno-veno-venous (VV-V) ECMO is a derivative version of V-V ECMO, which can make the upper and lower venous blood of patients fully oxygenate so that the lungs can get sufficient rest, and improve the prognosis of patients. This is the first case to try VV-V ECMO treatment in Hunan, and it was administered in an awake state (wakeful ECMO).

Case Presentation

A 71-year-old male presented to the Emergency Department with coughing and sputum for one month and dyspnea for 10 days. He had no obvious cause to cough and sputum with white mucus sputum one month ago, no chest tightness, chest pain, dizziness, fatigue and discomfort, no night orthopnea and lower limb edema. He was self-administered take orally "cefoxime plus ambroxol tablets" for 3 days, the illness did not improve. Before 10 days, the patients had difficulty breathing and gradually progressed from climbing the building. The patient went to the emergency department of the local hospital on December 6th, 2020. At that time, the oxygen of the finger vein was 46% (without oxygen), and then he was directly admitted to the intensive care unit for treatment. The partial pressure of arterial blood gas carbon dioxide (PaCO₂) was 31mmHg (1mmHg = 0.133kPa) and the partial pressure of oxygen (PaO₂) was 50mmHg. He was treated with "non-invasive ventilator ventilation for 3 days and endotracheal

intubation ventilator assisted ventilation for 4 days", during which alveolar lavage was performed under fiber bronchoscope, "next-generation" sequencing technology (NGS) indicated positive results of *Streptococcus pneumoniae*, *Streptococcus intermediate*, *Streptococcus oral*, and *lepidycovirus*, and anti-infective treatment of "piperacillin-tazobactam + imipenem and cilastatin + moxifloxacin" was given, but the effect was not good. Blood and gas analysis was reviewed on December 12th showed pH 7.31, PaCO₂ 61mmHg, PaO₂ 61mmHg, lactic acid 2.72mmo1/L; Liver and kidney function: alanine transaminase 174.9U/L, ascorbic transaminase 221.7U/L, creatinine 149.7umol/L, urea nitrogen 15.23mmo1/L; Blood routine: WBC 16.46×10⁹/L, hemoglobin 130g/L, platelet 54×10⁹/L; C-reactive protein 120.44mg/L; Sputum culture showed *Naromonas* (no drug sensitivity results). Due to CO₂ retention and low PaO₂ were difficult to correct, the ECMO team of the intensive care department of our hospital was asked to conduct V-V ECMO support treatment for patient on December 13th, and then he with endotracheal intubation, ECMO tube, gastric tube, and the urinary tube was sent to our hospital at 17:00 on December 13th, 2020, to seek further advanced life support treatment and monitoring. He had Silicosis without systematic treatment for 16 years. He was on treatment for his type II diabetes mellitus and hypertension. Physical examination at admission: Body temperature: 36.8°C, Pulse: 93Times/min, Respiration: 21Times/min, Blood pressure: 115/67mmHg. Psychsanure, Rough breathing sounds in both lungs, lots of dry and wet rales can be heard, no pleural frictions. Heart rhythm, no noise. Abdominal flat soft, intestinal sound active. Urgent blood gas analysis after admission showed pH 7.34, PaCO₂ 46.1mmHg, PaO₂ 122mmHg, lactate 2.6mmol/L; Blood routine: WBC 6.84×10⁹/L, hemoglobin 95g/L, platelet: 61×10⁹/L, neutrophil percentage: 89.7%; C-reactive protein 248.53mg/L; Coagulation function: plasma antithrombin AT-51.1%, fibrinogen degradable substance 166.9ug/mL, fibrinogen concentration 1.15g/L, activated partial thromboplastin time 76.1 SEC; Liver and kidney function: aspartic aminotransferase 60U/L, alanine aminotransferase 59U/L, total bilirubin 20.8μmol/L, direct bilirubin 14.4μmol/L, urea 22.11mmol/L, creatinine 277μmol/L. Beside bed radiograph (Fig. 1A) showed bilateral lung infection with a small amount of pleural effusion on both sides. Admission diagnosis : 1. Severe pneumonia, ARDS 2. Sepsis, septic shock, acute liver damage, acute kidney injury 3. Silicosis stage II with infection 4. Hypertension grade, very high-risk group 5. Type 2 diabetes mellitus.

After admission, V-V ECMO life support treatment was continued (ECMO: Oxygen flow 4L/min, blood flow speed 3015RPM), endotracheal intubation assisted ventilation (CMV mode, peak airway pressure 32cmH₂O, ventilation per minute 8.2L/min, exhaled tidal volume 379ml, total respiratory rate was 27Times/min, the respiratory ratio was 1:3:1, blood oxygen saturation was 98%). The symptomatic support treatment of "piperacillin-tazobactam + ciprofloxacin + compound sulfamethoxazole" combined with anti-infection, cough and phlegm relieving, spasmolysis and antiasthmatic, sedation and analgesia, anticoagulation, enteral nutrition, transfusion of blood components. On December 14th, 2020, the patient was changed to VV-V ECMO mode, and the endotracheal intubation was successfully removed. The patient was replaced with high-flow oxygen inhalation, and the blood oxygen saturation of the patient could be maintained above 95%. On December 15th, the patient developed dyspnea and decreased blood oxygen saturation, and an urgent examination of blood gas showed PH 7.38, PaCO₂ 45mmHg, PaO₂ 58.2mmHg, lactic acid 1.6mmol/L, and oxygen saturation 88%. The symptoms were not significantly

improved after the treatment of more non-invasive ventilator-assisted ventilation. After the treatment of endotracheal intubation and invasive ventilator-assisted ventilation was performed again, the patient's oxygen in the finger vein could rise to 95%, and the blood gas condition was improved compared with the previous review. Two sputum cultures during the period indicated that multidrug-resistant *Acinetobacter baumannii* was sensitive to polymyxin. After the adjustment of antibiotics to "polymyxin + linezolid + ciprofloxacin", the infection indexes of the patient decreased significantly compared with before. On December 18th, review of calcitonin original, lactic acid from the previous rise, lung infection from the previous progress is shown in Fig. 1 (BC). After the intensive medical general consultation in our hospital, considering the possibility of secondary infection, finally, adjusted the anti-infection plan to "polymyxin + daptomycin + meropenem", review of infection index improved than before, bedside chest radiograph in pulmonary infection improved from the previous Fig. 1 (DE). On December 19th, the patient had a lot of sputum and was not easy to cough, and the effect of oral sputum suction was poor. Therefore, a tracheotomy was performed, and the oxygen saturation could be maintained above 95%. On December 23th, the airway was blocked by blood clots due to repeated oozing of blood in the airway, and the blood clots were cleared by a fiber bronchoscope beside the emergency room. The bronchi-ostomy kit was replaced, and the progressive decline of platelets and hemoglobin was monitored, D-dimer was increased, and APTT was prolonged. The anticoagulant regimen was adjusted and component blood transfusion was performed. Blood gas analysis on December 24th showed pH 7.19, PaCO₂ 41.5mmHg, PaO₂ 146mmHg, lactic acid 10.3mmol/L, Actual alkali surplus - 13.2mmol/L, actual hydrogen carbonate 13.9mmol/L. Quantitative detection of procalcitonin was 0.0053mg/L; C-reactive protein determination 151.16mg/L; Blood routine: leukocyte 22.38×10⁹/L, hemoglobin 90g/L, platelet 67×10⁹/L, Neutrophil percentage 83.2%; Coagulation function: fibrinogen degradable substance 121.8mg/L, D-dimer concentration 39.72mg/L, prothrombin time 14.4 SEC, prothrombin activity 58.2%, activated partial thromboplastin time 57.8 SEC. Beside bed chest radiograph (Fig. 1F) showed bilateral lung infection (the lesion of the right upper lung was slightly less than before, and the lesion of the left middle and lower lung was slightly worse than before), and a small amount of bilateral pleural effusion was slightly worse. Although repeatedly return etiology specimens and adjust the antibiotic solution, however, the patient's infection was further aggravated, and gradually showed less urine, renal impairment, fluid penetration, and drop in blood pressure. Although after full treatment, the patient's blood pressure is still difficult to maintain and the prognosis was extremely poor. We explained the patient's condition to the family in detail and signed for discharge on December 24th, 2020.

Discussion

ECMO is the treatment of last resort for critically ill patients, but its corresponding complications are numerous, which can be divided into two categories: mechanically-related complications and patient-related complications.

Mechanically-related complications include oxygenator dysfunction, circulatory pipe rupture, and pump failure, etc. Complications related to patients included hemorrhage, embolism, infection, renal

insufficiency, neurological complications, distal limb ischemia, cardiopulmonary complications, etc.^[1]. ECMO has two basic modes: V-A ECMO and V-V ECMO. The V-V ECMO is usually pumped through the vena cava (via the femoral vein or right internal jugular vein), and the blood is returned to the venous system after gas exchange through the membranous lung (via the femoral vein or internal jugular vein), or it can be achieved by inserting a double-lumen tube into the internal jugular vein. It is suitable for patients with impaired lung function but good heart function^[1-2]. The VV-V ECMO mode is a derivative of the V-V mode in which blood from the superior and inferior vena cava is drained out of the body (usually through the femoral vein and right internal jugular vein), oxygenated blood is injected through a blood pump and carbon dioxide is removed, then oxygenated blood is injected into the vena cava (the other femoral vein) using a catheter. While only part of the blood is fully oxygenated with the traditional V-V ECMO, VV-V ECMO can fully oxygenates the upper and lower venous blood of the patient, so the use of the VV-V ECMO is recommended for patients with extremely poor oxygenation conditions. If the patient's respiratory function is good, such as $SpO_2 > 96\%$, $PaO_2 > 80\%$, $PaCO_2 < 45\%$, clear consciousness, partner treatment, endotracheal intubation can be removed, and ECMO (awake ECMO) treatment can be carried out in the state of consciousness. Theoretically, this state is conducive to reducing the risk of infection and pulmonary complications of mechanical ventilation, conducive to nursing, reducing the occurrence of pressure ulcers, and to the normal balance of intestinal nutrition and intestinal flora^[2-4]. The patient in this case, had poor oxygenation under V-V ECMO and endotracheal intubation-assisted ventilation. To better solve the patient's respiratory needs, maximize lung rest, and improve oxygen saturation, VV-V ECMO treatment was tried for the first time, to restore lung function as far as possible. The blood gas analysis results of the patient under VV-V ECMO treatment were satisfactory and the oxygen saturation could be maintained, so the patient was treated with clear-headed ECMO treatment. The endotracheal intubation was removed early and the oxygen was inhaled at a high flow rate, to reduce the complications of mechanical ventilation. However, due to the poor control of pulmonary infection and the imbalance of volume management, the patient developed dyspnea and the low oxygen saturation could not be maintained. Endotracheal intubation or even tracheostomy as auxiliary ventilation, subsequent off-line can not be achieved, and the prognosis is poor. Although ECMO has a powerful cardiopulmonary replacement function, and the success rate of the rescue of many acute and critical patients has been significantly increased in clinical work, the patient in this case still had a poor prognosis with the support of wake VV-V ECMO, and finally died. The main reason was that the primary disease silicosis had irreversible damage to the lung parenchyma, combined with severe infection. Of course, the complications of ECMO treatment can not be ignored. The author will elaborate on the following three points: Firstly, the patient's lung parenchyma has irreversible structural lesions due to silicosis, and the lung function is difficult to recover. Silicosis is a pulmonary fibrosis disease, which is characterized by extensive nodular fibrosis of lung parenchyma caused by long-term inhalation of large amounts of silica dust^[5]. Pulmonary fibrosis restricts the ability of the lungs to ventilate and exchange air, and lung impairment increases with disease progression, even after the patient has left exposure. There is currently no effective treatment method, is given priority to with comprehensive treatment, such as anti-fibrosis, immunosuppressants, mesenchymal stem cell transplantation, alveolar lavage may help to improve the

quality of life and slow degradation^[5-6], the terminal stage can consider a lung transplant surgery, but in this case, considering the patient's age, basic diseases, and weak vital signs, lung transplant possibility is small. Therefore, the probability of pulmonary function recovery in patients is small and the prognosis is poor. Secondly, patients with high age, many basic diseases, poor immunity, and silicosis based on combined with severe infection, infection is difficult to control. Patients because of silicosis lung parenchyma progressive fibrosis, poor bronchial drainage and easy with microbial infection. When silicosis is complicated with pulmonary infection, it is recommended to perfect the sputum culture and drug sensitivity test when the patient is admitted to hospital, rationally use antibiotics according to the drug sensitivity results, and advocate the combination of drug use to prevent bacterial resistance^[7]. Lung infection improved with anti-infection therapy, and then secondary infection occurred with broad-spectrum antibiotics, pulmonary infection progress is difficult to control, not only difficult to recover lung function, ventilator dependence cannot be offline. Because of septic shock, a drop in blood pressure is difficult to maintain, the patient eventually gave up treatment and died. Thirdly, ECMO treatment has more and more serious complications, and the longer the use, the higher the complication rate. The patient in this case was already suffering from septic shock and renal dysfunction at admission. During ECMO assistance, there were inevitable redistribution of blood volume, the use of vasoconstrictive drugs, and various toxic metabolites in the body that aggravated renal damage. The invasive procedures and pipeline access of ECMO treatment increased the chance of blood infection. Poor infection control in subsequent patients may be associated with ECMO-related infections, which lead to septic shock and exacerbate renal failure. In short, pulmonary primary disease combined with infection and ECMO complications interacts with each other, acting on the body together and ultimately leading to multiple organ failure and death.

Conclusion

VV-V ECMO is recommended for patients with extremely poor oxygenation conditions, but it still be difficult to improve the prognosis of patients with severe lung structural damage, and still has a long way to go. Although the patient died in this case, VV-V ECMO is still an important trial, which provides reference experience for the development of VV-V ECMO treatment.

Abbreviations

ECMO: Extracorporeal membrane oxygenation

ECLS: Extracorporeal life support system

NGS: Next-generation sequencing technology

Declarations

Ethical Approval and Consent to participate

Not applicable.

Consent for publication

Written informed consent for publication of the clinical details and clinical images was obtained from the patient.

Availability of data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TX, XFS, ZLL and SPZ participated in the treatment of this patient and were involved in the development of the conclusions. TX wrote the first draft with assistance from XFS, ZLL and SPZ edited the final draft. All authors had read and approved the final manuscript.

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Figures

Figure 1

Lung zons of the X-ray during hospitalization A: After admission, infection in bilateral lung, a small amount of bilateral pleural effusion; B-C: During treatment, infection in bilateral lung with a small amount of bilateral pleural effusion became worse than before; D-E: After final adjustment of antibiotic treatment, infection in bilateral lung with a small amount of bilateral pleural effusion became smaller than before; F: Before discharge, a small amount of bilateral pleural effusion became worse than before.