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Successful treatment of COVID-19 using extracorporeal membrane oxygenation, a case report

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Abstract. – Since the end of 2019, COVID-19 has been prevalent in Wuhan, China, and has been rapidly spreading to mainland China. Currently, more than 80,000 people have been infected, of which over 10,000 were severely ill and had characteristics of dyspnea and hypoxemia about one week after onset. Severe patients had rapidly progressed to acute respiratory distress syndrome (ARDS), causing multiple organ failures and even death, with a mortality rate of nearly 4.3%. The treatment of severe COVID-19 patients has been rarely reported. This study reported a successful example of a severe COVID-19 patient with extracorporeal membrane oxygenation (ECMO) technology in our hospital. This experience revealed that the early application of ECMO can dramatically promote the recovery of severe COVID-19 patients.

Key Words:
Extracorporeal membrane oxygenation, COVID-19, Dyspnea, Hypoxemia, Acute respiratory distress syndrome.

Introduction

Pneumonia with the novel coronavirus infection has been reported in Wuhan, China, since early December 2019. With the rapid spread of the epidemic, this disease has also been found in other regions of China and overseas. The World Health Organization (WHO) recently termed this disease officially as coronavirus 2019 (COVID-19)[1]. The full-length sequencing of the virus genome was quickly identified after this disease broke out, which was named severe acute respiratory syndrome coronavirus (SARS-CoV-2)[2]. On that basis, the detection method of SARS-CoV-2 was developed with the fluorescence quantitative reverse transcription polymerase chain reaction (RT-PCR) technique[3]. Such an acute respiratory infectious disease has been included in the list of Class B infectious diseases stipulated in the Law of the People's Republic of China on Prevention and Control of Infectious Diseases; it is currently managed abiding by Class A infectious diseases. In accordance with the latest edition of the Ministry of Health's diagnosis and treatment guidelines, the clinical characteristics of COVID-19 are classified as severe type pneumonia if the patient has one of the following conditions: 1. Respiratory failure occurs, and mechanical ventilation is required; 2. Shock; 3. Patients with other organ failures should undergo intensive care unit (ICU) monitoring and treatment. The therapies of the most severe patients include intravenous antibiotics, oseltamivir administration, oxygen therapy, and mechanical ventilation[4]. Some patients need to have extracorporeal membrane oxygenation (ECMO) performed on them because of severe respiratory failure. Here, we reported a COVID-19 patient with successful ECMO treatment in our hospital.

Case Report

A 54-year-old man returned home from Wuhan city on January 19, 2020. He was admitted to Xinyang Central Hospital on January 26, 2020, with fever for 13 days as the main complaint. On January 13, 2020, the patient had a chill and fever under no obvious factors. His body temperature was 38.1°C and was not given any treatment. On January 23, 2020, the disease deteriorated; he had a body temperature of 39°C, myalgia, chest tightness, and chest pain. He took antipyretics, cephalosporins and visited us for poor conditions. His body temperature was 39.1°C and the moist rale could be heard in both lungs at admission. Blood routine examination showed 6.69x10^9/L white blood cells (WBC), 1.17x10^9/L lymphocyte (LYM), and liver function: aspartate

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aminotransferase (AST) 19 unit (U)/L, alanine aminotransferase (ALT) 12 U/L, lactate dehydrogenase (LDH) 206 U/L; renal function: blood urea nitrogen (BUN) 3.3 mmol/L, creatine kinase (CR) 76 mmol/L; inflammatory reaction markers: procalcitonin (PCT) 0.11 ng/ml, C-reaction protein (CRP) 54.86 mg/L; blood gas analysis: pH: 7.41, PO_2 91 mmHg, pCO_2 39 mmHg, fraction of inspired oxygen (FiO_2) 21%. Chest CT showed an infectious lesion of right lower lung and chronic inflammation of both lower lungs. After admission, throat swabs of patients were harvested and tested positive for SARS-CoV-2 nucleic acid by the fluorescence quantitative RT-PCR. This report was approved by the Ethics Committee of the Hospital. The patient signed the written informed consent.

Treatment

After the patient was admitted to our hospital, oxygen inhalation was immediately given by nasal catheter. Lopinavir/ritonavir, ribavirin, moxifloxacin, cefoperazone sulbactam, and methylprednisolone were injected into the veins. The patient's conditions became worse and chest tightness and shortness of breath occurred after activity, although the patient had these therapies. The monitored oxygen saturation decreased to 87% (oxygen inhalation 5 L/min). Blood gas analysis: PO_2 58 mmHg, PCO_2 39 mmHg, FIO_2 41%. On January 30, 2020, the patient underwent nasal high-flow oxygen therapy, and the oxygen saturation rose to nearly 95% (oxygen concentration 50%). On February 3, 2020, the patient's blood oxygen saturation declined again to 81% (oxygen concentration 100%), and mechanical ventilation was immediately performed by orotracheal intubation. After intubation, the patient's blood oxygen saturation remained difficult to maintain, with an oxygenation index of approximately 100 mmHg (ventilator conditions: PS 16 cm H_2O, PEEP 14 cm H_2O, FIO_2 100%). Examination of blood routine revealed WBC 14.1x10^9/L, LYM 0.37x10^9/L; chest X-ray showed more patchy shadows in both lungs than before (Figure 1A). Adjusted treatment regimen combined with Abidor antiviral therapy. At 14:00 on February 3, VV-ECMO rescue therapy was performed (Figures 1C and 1D). Under the guidance of B-ultrasound, the right femoral vein was inserted into the inflow cannula, the right jugular vein was inserted into the outflow cannula, the venous cannula was 21F, the arterial cannula was 17F, the depth of venous cannula was 42 centimeters (cm), and the depth of arterial cannula was 15 cm. During ECMO treatment, the patient also received deep sedation treatment, daily awakening and assessment of consciousness and brain function. At the same time, anticoagulant: heparin sodium was diluted to 50 ml with 1.25 WU during ECMO operation and pumped continuously. Coagulation function was reviewed every 3 hours, and partial thromboplastin time (APTT) was maintained for 50-60 seconds. The patient was complicated with unstable circulatory function in the early stage, while 50 ml of norepinephrine 4 mg saline was pumped to maintain systolic pressure between 100-120 mmHg. Norepinephrine gradually decreased until stopped during ECMO treatment. Blood gas analysis was performed every 4 hours, ECMO rotation speed was regulated to 2500-3000 rpm according to the patient's blood oxygen saturation and blood pressure level, blood flow was controlled to about 3.0-4.5 L/min, and PCO_2 was maintained at about 40 mmHg and SPO_2 at about 95%. ECMO oxygen concentration was given to 80% in the early stage and gradually decreased to 40% during the treatment. During ECMO treatment, the patient also continuously underwent pressure-controlled ventilation and his blood oxygen saturation was significantly improved. The ventilator conditions could be lowered to PS: 12 cmH_2O, PEEP: 8 cmH_2O, FIO_2: 40%. Finally, ECMO oxygen flow declined to 2.0 L/minute and was closed for observation for 12 hours on February 8, 2020. When the ventilator parameter pressure control mode PS: 16 cm H_2O, PEEP: 10 cm H_2O and FIO_2: 50% were given, the patient's oxygen saturation could be maintained at 97%. After re-examination of chest radiograph (Figure 1B), the patient was evacuated from ECMO.

Results

No complications (e.g., hemorrhage, thrombus, and pneumothorax) occurred during ECMO support treatment. Vital signs were normal under invasive mechanical ventilation after ECMO evacuation. The oxygen saturation could be maintained at 97% (oxygen concentration 50%) on February 9, 2020, when the percutaneous tracheostomy was connected with a ventilator for auxiliary ventilation. Blood gas analysis: PO_2 74 mmHg, PCO_2 43 mmHg, FIO_2 50%. The patient

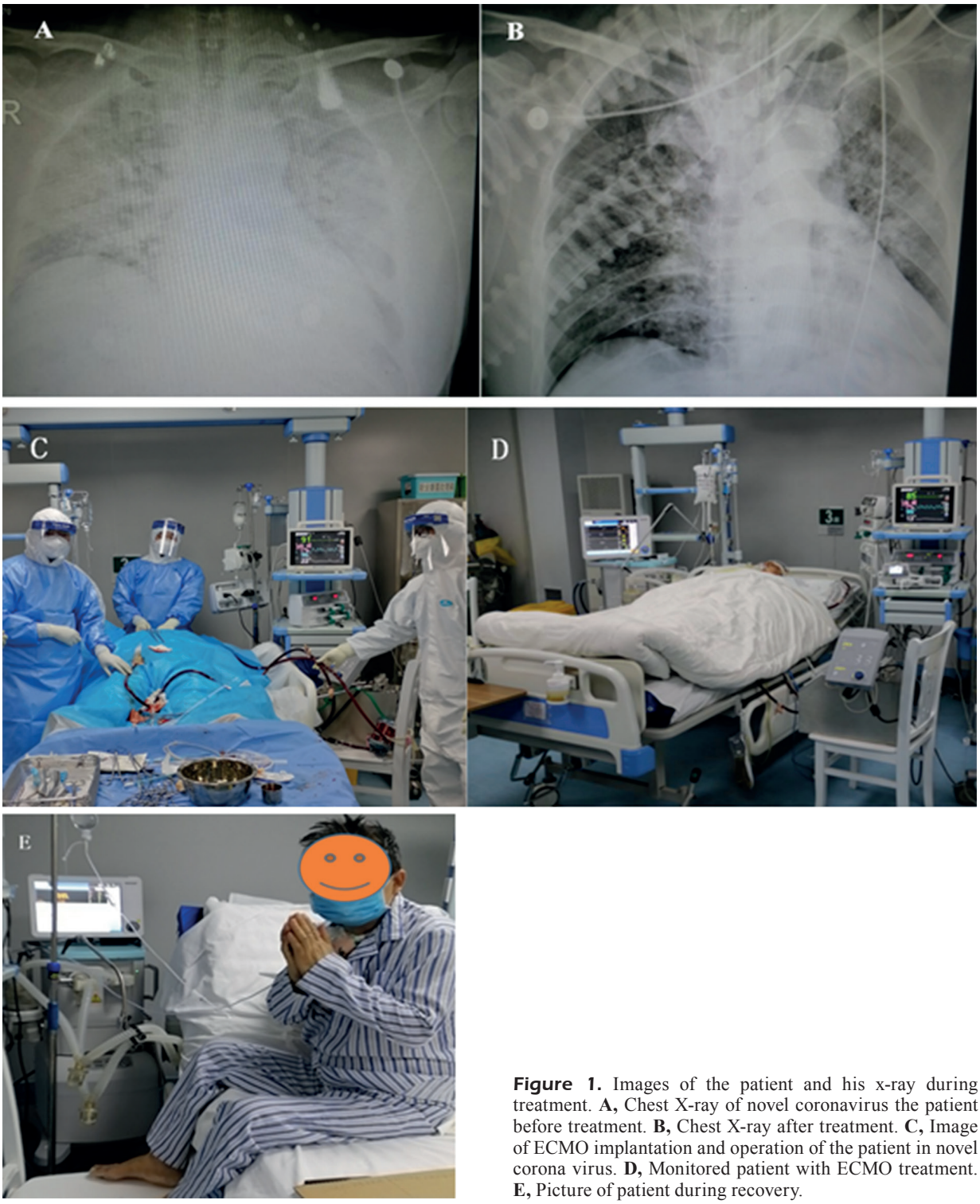

Figure 1. Images of the patient and his x-ray during treatment. **A,** Chest X-ray of novel coronavirus the patient before treatment. **B,** Chest X-ray after treatment. **C,** Image of ECMO implantation and operation of the patient in novel corona virus. **D,** Monitored patient with ECMO treatment. **E,** Picture of patient during recovery.

was removed from the ventilator on February 18, 2020 and changed to oxygen inhalation at the tracheostomy site. He currently remains in stable condition (Figure 1E). Re-examination of blood routine reported WBC 8.85*10^9/L, LYM 0.60*10^9/L; liver function: AST 28 U/L, ALT 30 U/L, LDH 286 U/L; renal function: BUN 6.6 umol/L, CR 10 mmol/l; inflammatory reaction

markers: PCT 0.02 ng/mL, CRP 11.4 mg/L. He was discharged from our hospital on February 24, 2020.

Discussion

ECMO refers to one of the extracorporeal lung assist (ECLA) technologies, primarily adopted to partially or completely replace the cardiopulmonary function of patients to protect the oxygen supply of the organs and strive for time to treat primary diseases[5-7]. Most patients with COVID-19 had mild symptoms and can be cured. However, some can progress to severe patients, which have developed dyspnea and hypoxemia about one week after the onset of the disease. Severe patients have rapidly developed into acute respiratory distress syndrome (ARDS), and subsequently multiple organ failures or even death. The mortality rate reached about 4.3%[8,9]. For the treatment of COVID-19, China Ministry of Health guidelines consider that extracorporeal membrane oxygenation (ECMO) can act as a salvage treatment measure.

The present report is the first case of COVID-19 successfully treated by ECMO in Xinyang City. The patient's condition was assessed as mild at the early stage, whereas the condition continued to progress; respiratory failure was caused on the 7th day after admission. Given active anti-infection treatment and invasive mechanical ventilation, oxygenation remains hard to maintain. After discussion by the expert group, ECMO was given supportive treatment and successfully operated for nearly 5 days before organ dysfunction caused by severe ischemia and hypoxia. After ECMO treatment, the circulatory function tended to be stable, and the functional indexes of liver, kidney and other multiple organs were maintained in the normal range. Furthermore, ventilator conditions were also reduced. After antibiotics were actively adjusted, the patient was finally successfully withdrawn from ECMO and ventilator and achieved good therapeutic effect.

Reviewing this case, for rare severe COVID-19 patients and relatively complex ECMO technology, it cannot be extensively popularized. The successful treatment experience of this case provides reference to treat other critical novel coronavirus patients. No definite conclusion has been currently drawn on the timing of ECMO treatment. The authors have consulted the relevant research on ARDS caused by influenza virus, among which Steimer et al[10] consider that early ECMO treatment can elevate the survival rate of patients. In this case, the authors chose to give ECMO support treatment at an early stage when oxygenation fell to about 90% under the condition that patients were given invasive mechanical ventilation ventilator. The authors believe that early ECMO support can protect the oxygen supply of organs and avoid the damage to lungs caused by long-term application of excessively high mechanical ventilation conditions, which complies with Vaquer et al[11] Moreover, the authors consider that lung damage attributed to novel coronavirus is as self-limiting as other viral pneumonia. Early ECMO support treatment for critically ill patients may help patients survive the most severe lung lesions and up-regulate the success rate of treatment for critically ill patients. For ECMO type, the authors chose VV-ECMO since the patient only had pulmonary failure but no basic cardiac diseases. The EF value of the heart measured by bedside B-ultrasound was about 67%. The unstable circulatory function of the patient before ECMO support showed relationships to deep sedation and the effect of higher ventilator conditions on venous return. In ECMO management, the authors monitored coagulation function, blood gas and took Chest x-ray film regularly to prevent complications (e.g., hemorrhage, thrombus and pneumothorax) during ECMO treatment. Meantime, ultrasound will assess the daily lung condition and ascertain the treatment effect, as an attempt to prepare for early withdrawal of ECMO.

Conclusions

We strongly recommend ECMO treatment at the early stage in severe COVID-19 patients from this successful experience. During ECMO treatment, the coagulation function and blood gas of the patient need to be regularly monitored to decide the time of ECMO use.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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