

# Nursing Management of Severe COVID-19 Patients Undergoing Extracorporeal Membrane Oxygenation Combined with Prone Position Ventilation

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## ABSTRACT

Acute respiratory distress syndrome (ARDS) is a serious lung injury in patients with severe coronavirus disease 2019 (COVID-19). This process often is difficult to reverse, eventually leading to the death of patients. Extracorporeal membrane oxygenation (ECMO) treatment can provide patients with cardiopulmonary function support and buy time for clinicians' treatment. However, some patients still suffer from poor oxygenation after ECMO treatment. At this time, nurses can change the patient's position to prone position to improve oxygenation level and promote sputum excretion. It is a great challenge for COVID-19 patients to change their postures while receiving ECMO treatment. This article provides suggestions for this process by reviewing our hospital's experience in treating severe COVID-19 patients.

## INTRODUCTION

As of May 12, 2020, a cumulative total of 4,178,091 confirmed cases of coronavirus disease 2019 (COVID-19) were reported in 212 countries and territories worldwide [WHO 2020]. In China, approximately 5% of critically ill patients with SARS-CoV-2 infection have presented rapidly progressive respiratory failure, development of acute respiratory distress syndrome (ARDS), and intensive care unit (ICU) admission [Novel Coronavirus Pneumonia Emergency Response Epidemiology Team 2020]. Of the critically ill patients with COVID-19, about half of them have died in the ICU [Namendys-Silva 2020]. The postmortem biopsies revealed that, apart from bilateral diffuse alveolar damage with cellular fibromyxoid exudates, the lungs of the patient showed pulmonary edema with desquamation of pneumocytes and hyaline membrane formation, indicating ARDS.

Several critically ill patients with COVID-19 have required invasive mechanical ventilation and rescue therapies [Huang 2020; Chen 2020; Wang 2020; Guan 2020]. Extracorporeal

membrane oxygenation (ECMO) has been proposed as a rescue therapy in severely hypoxemic patients with Middle East respiratory syndrome (MERS) caused by a coronavirus who failed conventional strategies [Alshahrani 2018].

ECMO can replace the respiratory function of patients to maintain the oxygen supply of various organs. However, we observed that some COVID-19 patients still had poor oxygenation after ECMO. Prone position ventilation (PPV) can improve alveolar ventilation/blood flow ratio, reduce dead space ventilation, and increase oxygenation by changing the patient's body position to increase the ventilation volume of the dorsal lung tissue [Zhu]. The use of ECMO and PPV are associated with high mortality in patients with ARDS, due to COVID-19 and refractory hypoxia. The complexity of them requires a well-qualified ICU team to deliver care. Here, we introduce the nursing experience of COVID-19 patients treated in our hospital, when receiving ECMO combined with PPV therapy.

## PATIENTS AND METHODS

From February 15 to March 24, 2020, a total of nine COVID-19 patients (age 51.23±9.72 years old, four male) were treated with ECMO in our department. The acute physiology and chronic health evaluation (APACHE) score was 31.52±6.19. ARDS or respiratory failure symptoms were observed when the patients entered our department, and SpO<sub>2</sub> fluctuated between 63% and 82%. Etiological examination: Throat swabs of nine patients were positive (+) for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) nucleic acid. Laboratory examination: pH value 7.28±0.08, PaCO<sub>2</sub> value 52.07±13.24mmHg, K<sup>+</sup> 3.68±0.92mmol/L, Ca<sup>2+</sup> 1.06±0.21mmol/L, PaO<sub>2</sub> value 52.24±12.86 mmHg, white blood cell count 2.71±0.17\*10<sup>9</sup>/L, red blood cell count 4.23±0.19\*10<sup>12</sup>/L, neutrophil count 1.59±0.08\*10<sup>9</sup>/L, lymphocyte count 0.46±0.03 \* 10<sup>9</sup>/L. Chest imaging examination: Nine patients had ground glass-like changes in the lungs, three patients had obvious inflammatory infiltration, and one patient had solid changes in the lungs. According to the diagnostic criteria of China's novel coronavirus Diagnosis and Treatment Plan (trial version 7th) [General Office of the National Health and Health Commission 2020], all patients were diagnosed as COVID-19.

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Treatment and outcome: All patients were treated with high flow oxygen inhalation, noninvasive positive pressure ventilation, invasive ventilator ventilation, and other sequential treatments after entering the department. The patient's blood oxygen saturation fluctuated between 84% and 89%, and ECMO treatment was decided by the multiple disciplinary team. After our discussion, a total of eight patients received venous-venous extracorporeal membrane oxygenation (VVA-ECMO, femoral vein-jugular vein), and one patient with severe cardiac dysfunction received venous-venous-arterial extracorporeal membrane oxygenation (VVA-ECMO, femoral vein-jugular vein-femoral artery).

As of March 29, three patients successfully were treated, and the reexamination of SARS-CoV-2 nucleic acid was negative. They were smoothly discharged from hospital; three patients successfully removed ECMO, and the SARS-CoV-2 nucleic acid was negative for reexamination. Their symptomatic and supportive treatment continues at present; one patient under ECMO treatment has successfully corrected hypoxemia correction. His blood oxygen saturation is 100%, and the circulation recently was stable; one VVA-ECMO patient has negative nucleic acid for reexamination, and his hypoxemia has been effectively improved, with blood oxygen saturation above 95%. CT showed pulmonary inflammatory absorption, but he is currently in multiple organ failure. Another patient had negative nucleic acid in blood oxygen saturation for reexamination, and the blood oxygen saturation had reached 100%. But this patient died of multiple organ failure eventually caused by circulation failure.

Nursing management of patients - Nursing management of ECMO - Patient analgesia and sedation: In order to reduce pain and discomfort of patients, improve sleep, reduce anxiety and agitation of patients, reduce oxygen consumption of patients and ensure the safety of the treatment process, patients receiving ECMO treatment need to use analgesic sedatives and muscle relaxants in combination. The ideal sedation score (Richmond Agitation-Sedation Scale, RASS score) was between -4 and 3 points [Rasheed 2017], and the critical care pain observation tool (CPOT) score was 0 [Kotfis 2017]. To reduce complications, such as accumulation of sedative drugs, nurses need to wake up the patients every day to evaluate the patient consciousness and cooperation degree. In addition, the vital signs of patients tend to be stable in the middle and late stages of ECMO treatment. In the preparation stage of withdrawal of ECMO, the nursing staff should make detailed records of the patient's state of consciousness, degree of cooperation and vital signs, and then gradually reduce the use of analgesic and sedative drugs and muscle relaxants, according to the doctor's advice. No adverse reaction events, such as accumulation of sedative and analgesic drugs, occurred in the patients who successfully withdrew from the machine in our department.

Anticoagulant and hemorrhage monitoring: The normal operation of ECMO requires systemic heparinization anticoagulation for patients. The biggest challenge faced by nursing staff is the bleeding risk of patients. We require the responsible nurse to carry out coagulation function tests twice an hour (recently changed to four times an hour) for patients and

to communicate with the superior doctors in a timely manner. None of the nine patients in our department had obvious bleeding. Only one patient had slight bleeding in the wound, which obviously improved after doctors changed the dressing and adjusted the anticoagulant content.

In order to detect the efficiency of the oxygenator in time, it is necessary to measure the blood gas value of the oxygenator every eight hours. Because of the extreme high pressure inside, the nursing staff must first check whether the tee is firm. In addition, blood collection should be done gently and quickly to prevent the tee from loosening. After blood collection, the tee must be flushed with 5 ml normal saline positive pressure pulse. Air should be exhausted to ensure that there are no bubbles in the pipeline, so as not to cause air embolism and machine alarm. The tee pipe should be washed clean without blood stains to prevent thrombosis. Close the tee with positive pressure joint. Hand hygiene must be strictly implemented, during the above steps. In addition to measuring the blood gas of the oxygenator and connecting the pipelines of the hemofiltration machine, it is forbidden to open ECMO pipelines to avoid the occurrence of blood flow-related infection. Nursing staff should use medical disinfection wet wipes to wipe the machine surface and pipelines every day. Because the membrane lung surface structure of ECMO is in a plurality of small lattices, using wet wipes is inconvenient and can be lightly wiped with alcohol cotton swabs.

ECMO pipeline: ECMO pipes shall be properly fixed. After the doctor marks the catheter scale on the skin of the puncture catheter, the nurse should immediately disinfect the wound and carefully cover it with auxiliary materials. The ECMO pipeline is separated from the skin by sterile cotton pad or sterile gauze. The tube at the head and neck of the patient is fixed around the head with a 3 M wide adhesive tape from the forehead, while the tube at the leg should be parallel to the long axis of the body [Xie 2018].

When binding the ECMO pipeline to the bed bar, it should be noted that a sufficient distance should be kept between the puncture point and ECMO machine to avoid slippage of the pipeline caused by pulling when the patient turns over. One patient in our department had a decrease of blood oxygen saturation without inducement, and the blood color of ECMO arterial and venous pipelines was not different. After ensuring the normal operation of the machine and tight connection of the oxygen source, the nurse correctly judged that the bending of the oxygen source pipeline was the main reason. After reattachment, the patient's blood oxygen saturation rose to normal, and the blood color of the arterial line turned red. The rest patients had no ECMO complications.

Nursing management of PPV - preparations: COVID-19 is a highly infectious disease, with ICU protection level of III. All medical personnel wear positive pressure protective clothing, goggles, and face shields. The patient has multiple pipelines, such as ECMO pipeline, renal dialysis pipeline, central venous catheter, arterial manometry catheter, tracheal cannula, urinary catheter, nasal feeding tube, and monitor lead. The medical staff in the ward should conduct multiple simulation exercises in the clean area in advance and enter the ward for field operation after tacit cooperation.

Before changing the patient's body position, observe the patient's vital signs, suck sputum thoroughly to remove respiratory secretions, stop enteral nutrition for 30 minutes, and clamp the nasal feeding tube. Sedate the patient with propofol and midazolam injection and relieve pain with remifentanyl hydrochloride injection. If the patient already has applied sedative and analgesic agents, increase the dose to ensure that the patient remains calm during the body position change, and ensure that the patient is free of agitation and can be woken up. At the same time, arrange the patient's pipelines. Before turning over in prone position, remove the ECG monitoring electrode plate and electrode wire and reinstall them on the back immediately after turning over. Observe whether the vital signs of the patient are stable and adjust the fraction of inspiration O<sub>2</sub> (FiO<sub>2</sub>) to 100%.

**Change to prone position:** The body position of the patient is changed by using a six-person transportation method. A doctor protects the tracheal intubation on the head side and acts as the commander. A doctor and a nurse stand on the right side of the patient to protect ECMO pipelines, a doctor and a nurse stand on the left side of the patient to protect dialysis pipelines and other pipelines. A nurse stands at the end of the bed to protect ECMO machines. Prepare three pillows and a sheet, and place the pillows on the upper chest, pubic symphysis, and knee joints of the patient, respectively. Then align the prepared bed sheet with the two side edges of the original bed sheet under the patient, roll from both sides to the middle, and roll until it is close to both sides of the patient's body. According to the commander's command, first move the patient to the rightmost side, then turn the patient over and place it in the middle of the bed. Then cooperate to remove the bed sheet and adjust the three pillows under the patient to be respectively located under the upper chest, iliac, and knee joints. To prevent the occurrence of skin pressure injury of patients. Connect ECG monitoring, invasive arterial pressure, and finger oxygen clamp to observe the vital signs of patients. After being stable, further arrange all pipelines and properly fix them so the pipelines are parallel to the long axis of the body and keep sufficient moving length to avoid pulling. The airway humidification of patients is strengthened by strengthening drug humidification and adjusting the temperature and humidity of the heating humidifier, and the knocking back or mechanical vibration of patients should be strengthened to assist sputum excretion.

**Nursing of ECMO in PPV:** In prone position, the patient's discomfort will increase and agitation easily will occur, which will increase the possibility of displacement and prolapse of ECMO pipeline and tracheal intubation. Nurses should properly fix the patient's ECMO pipeline with foam and high-viscosity dressing. And the puncture point should be pressurized and bandaged. The endotracheal tube should be properly fixed with a fixing belt, and the head of the patient should be fixed to one side to keep the airway of the patient unobstructed. Secondly, after changing to PPV, patients' sedation and analgesia should be strengthened. Meanwhile, the pupil size and light reflex of patients should be closely observed. Keep the RASS score of patients at -3.

The changes of arterial blood gas value and sputum drainage were closely observed. 43 PPV were given to the patients in this group. The average PaO<sub>2</sub> of the patients increased from 74.15 mmHg to 90.13 mmHg, the oxygenation index increased from 117.38 to 149.68, and the sputum drainage volume increased from 11.33 ml to 19.28 ml in 24 hours. The above showed that ECMO therapy can further oxygenate patients and promote sputum excretion when combined with PPV.

## DISCUSSION

In the past, we often applied PPV adjuvant therapy to patients with poor oxygenation. However, this is the first time that we have treated patients with SARS-CoV-2, a highly infectious disease, with PPV, and the medical staff all lack experience. The main difficulties in changing body position are: (1) All medical personnel wear protective clothing, goggles and face screen, which are easy to fog and cause blurred vision, thus affecting the accuracy during operation; (2) ECMO pipes and machines are the last safety insurance for patients. Once the pipes come out during posture change, disastrous consequences will result, even if the pipes are displaced, serious consequences will result [MacLaren 2020]; (3) Medical staff are under great psychological pressure, fearing that close and repeated contact with patients may lead to self-infection, and at the same time, they have obvious concerns about adverse events of pipelines caused by posture change. Correspondingly, after our discussion, we adopted the following measures: conducting simulation exercises in the clean area in advance, setting a commander-in-chief (doctor handling the patient's head) during handling, and defining the division of labor among personnel.

When COVID-19 patients receive ECMO and PPV treatment at the same time, the nurse's key task is to frequently observe the ECMO tubes and puncture points pressed on the ventral side by the patients, paying attention to the presence of bleeding at the puncture points, displacement, prolapse, and blockage of the tubes. At the same time, the tracheal cannula firmly should be fixed, and the back should be fully tapped before sputum suction. We observed that when COVID-19 patients receive ECMO therapy, PPV can further increase oxygenation and promote sputum excretion.

## CONCLUSION

Severe COVID-19 patients have severe lung injury. Some patients rapidly will progress to ARDS, which is difficult to reverse and has a high mortality rate. ECMO therapy can provide cardiac and pulmonary support and buy time for treatment. However, some patients still suffer from poor oxygenation after ECMO treatment. PPV can improve oxygenation and promote sputum excretion at this time. It is a great challenge for COVID-19 patients to change their body position, while receiving ECMO treatment. However, as long as medical staff are fully prepared, they can safely complete the change of body position and carry out effective treatment.

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