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Prone position ventilation and femoro-femoral veno-venous extracorporeal membrane oxygenation for COVID-19 treatment

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Abstract

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has resulted in significant morbidity and mortality worldwide. Approximately 5% of COVID-19 patients who suffer from pneumonia develop critical respiratory failure. Here, we report the case of a healthy 52-year-old man who had respiratory failure owing to SARS-CoV-2 infection and was treated using femoro-femoral veno-venous extracorporeal membrane oxygenation (VV-ECMO) and prone position ventilation (PPV). After this treatment, his blood oxygen levels, chest high-resolution computed tomography findings, and clinical parameters significantly improved. He was decannulated from VV-ECMO on day 6 and finally extubated on day 11. To our knowledge, this is the first reported case of SARS-CoV-2-associated acute respiratory distress syndrome that was successfully treated with a combination of femoro-femoral VV-ECMO and PPV.

Introduction

In 2019, novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified as the cause of a cluster of pneumonia cases in Wuhan, China. Since then, it has spread rapidly, resulting in a pandemic. This virus causes the coronavirus disease 2019 (COVID-19), which results in considerable morbidity and mortality, largely because of the progression of acute viral pneumonia to acute respiratory distress syndrome (ARDS). In this report, we present the case of a patient who developed severe ARDS and presented with significant high-resolution computed tomography (HRCT) findings on his chest. However, after providing femoro-femoral veno-venous extracorporeal membrane oxygenation (VV-ECMO) and prone position ventilation (PPV), his blood oxygen levels and lung condition significantly improved.

Case Report

A 52-year-old man visited a local hospital experiencing fever as a first symptom for two days. Two days later, he was diagnosed with COVID-19. Upon providing a nasopharyngeal swab for detection by reverse transcription-polymerase chain reaction, he was confirmed positive for SARS-CoV-2 infection and hence admitted to a nearby general hospital. However, his respiratory status worsened, and he rapidly developed progressive hypoxaemia, requiring intubation. After intubation, he was admitted to the intensive care unit (ICU) in our hospital. Chest HRCT revealed extensive bilateral reticulation and ground-glass opacities. His initial vital signs were as follows: 36.5°C body temperature, 161/110 mmHg blood pressure, and 90% oxygen saturation with a 60% fraction of inspired oxygen (FiO_2). The initial arterial blood gas analysis with an FiO_2 of 80% indicated a pH of 7.318, partial pressure of carbon dioxide ($PaCO_2$) of 51.9 mmHg, partial pressure of oxygen (PaO_2) of 61.9 mmHg, haemoglobin oxygen saturation (SaO_2) of 90.3%, and lactate and bicarbonate levels of 0.9 and 23.8 mmol/L, respectively, revealing profound hypoxaemia. The mechanical ventilator settings were as follows: peak inspiratory pressure of 28 cmH_2O, respiratory rate of

14 breaths/min, positive end-expiratory pressure (PEEP) of 14 cmH_2O, and FiO_2 of 80%. However, respiratory failure was too severe to be controlled by an optimal mechanical ventilation strategy and medication, such as favipiravir and dexamethasone. In addition, as no other organ failure was detected, VV-ECMO was applied 3 h after admission to our hospital. Femoro-femoral VV-ECMO was performed using a 21-Fr catheter placed in the right femoral vein for inflow and a 24-Fr cannula inserted in the left femoral vein for outflow (Fig. 1A, B), with an initial blood flow of 4.1 L/min and sweep gas flow of 4.1 L/min. The mechanical ventilator was set on a pressure-controlled mode with an inspiratory pressure of 15 cmH_2O, respiratory rate of 10 breaths/min, PEEP of 8 cmH_2O, and FiO_2 of 40%.

To achieve haemodynamic stability, PPV was implemented for more than 17 h from day 2 of admission to our hospital. PaO_2 gradually improved from 61.9 to 76.4 mmHg and lung compliance improved from 30 to 50 mL/cmH_2O within 72 h of performing two cycles of ventilation. Each cycle included prone position for 17 h and supine position for 7 h (Fig. 1C). VV-ECMO was successfully weaned off on day 6. A chest computed tomography (CT) scan was performed before extubating the patient to preclude worsening bilateral consolidation as shown in previous reports. The repeat chest CT scan revealed a new bilateral ventral reticulation, marked improvement in dorsal ground-glass opacities, and left lower lobe consolidations (Fig. 2A). After blood oxygen levels and clinical symptoms of the patient improved, he was successfully extubated on day 11. After timely rehabilitation, he was discharged from the hospital on day 21 (Fig. 2B).

Discussion

Here, we reported the case of a critical patient with COVID-19 pneumonia who exhibited a significantly positive response to VV-ECMO and PPV. Among the patients hospitalized with COVID-19, approximately one-quarter of them require ICU admission, and profound hypoxaemic respiratory failure from ARDS is the dominant finding in critically ill patients.

The mortality rate of patients with COVID-19 who develop ARDS ranges from 52% to 67% [1]. After the publication of the PROSEVA study [2], PPV and lung-protective ventilation, such as low tidal volume ventilation and high PEEP, have become standard procedures for managing patients with severe ARDS. For the most severe COVID-19 pneumonia cases, the use of VV-ECMO often

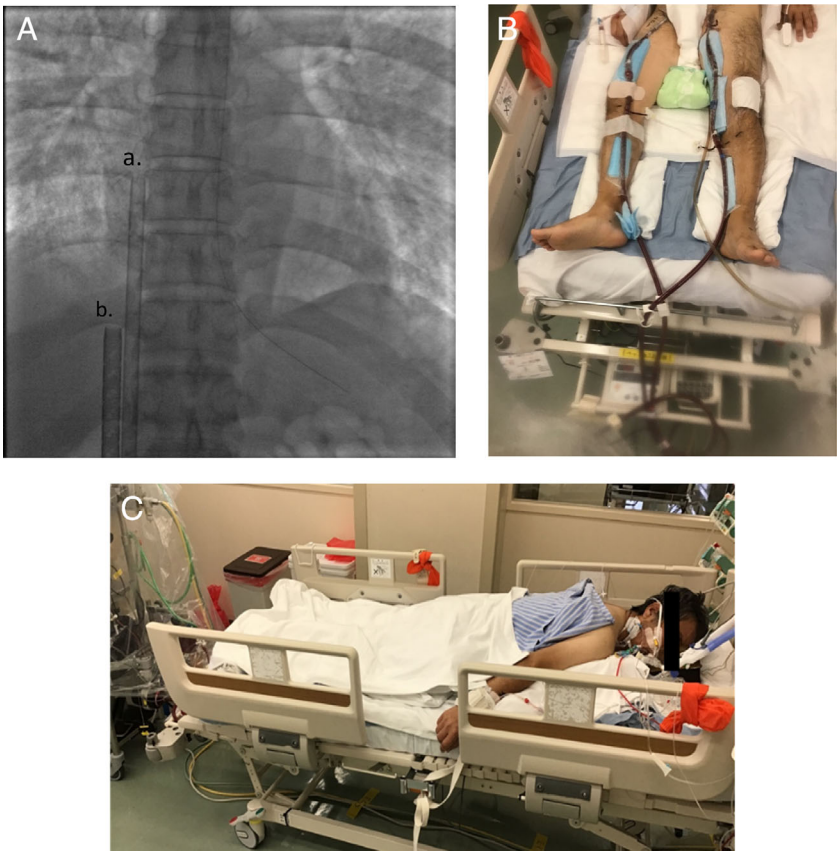

Figure 1. (A) a, Tip of return cannula in the right atrium. The distal part of the tip is radiolucent. b, Tip of access cannula in the inferior vena cava. (B) The femoro-femoral veno-venous ECMO was performed via the right femoral vein for inflow with a 21-Fr cannula and via the left femoral vein for outflow with a 24-Fr cannula. (C) Prone position ventilation was implemented with femoro-femoral venous ECMO. ECMO, extracorporeal membrane oxygenation.

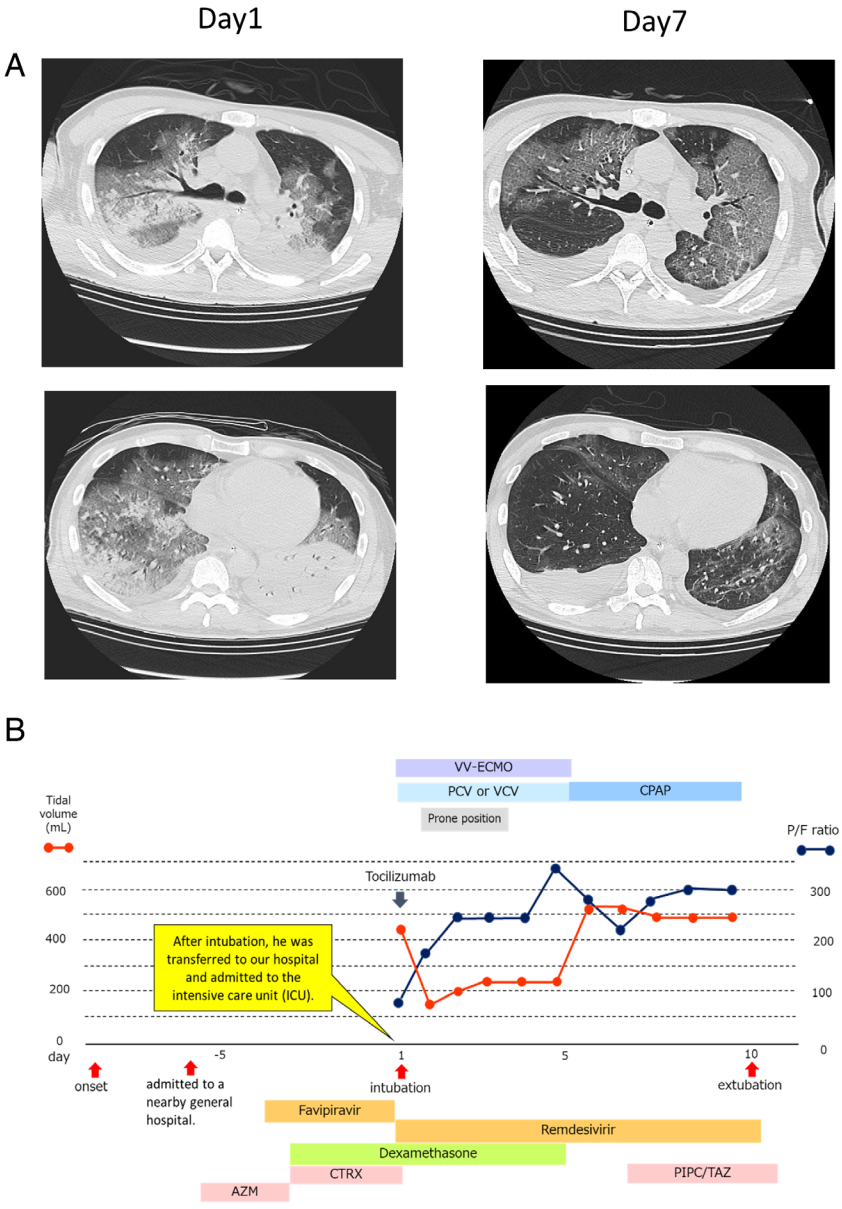

Figure 2. (A) Chest computed tomography scans of the patient with COVID-19 treated with femoro-femoral VV-ECMO and prone position ventilation. Day 1: Ground-glass opacities and bilateral dorsal consolidation were visible. Day 7: Bilateral dorsal consolidation improved, and this revealed that new bilateral ventral reticulation was visible. (B) Clinical course of the patient. Orange line shows tidal volume (mL). Blue lines are the P/F ratio. Mechanical ventilation settings before initiating VV-ECMO are described in the case presentation. AZM, azithromycin; COVID-19, coronavirus disease 2019; CPAP, continuous positive airway pressure; CTRX, ceftriaxone; FiO_2, fraction of inspired oxygen; PaO_2, partial pressure of oxygen; PCV, pressure-controlled ventilation; PEEP, positive end-expiratory pressure; P/F ratio, PaO_2/FiO_2 ratio; PIPC/TAZ, piperacillin-tazobactam; VCV, volume-controlled ventilation; VV-ECMO, veno-venous extracorporeal membrane oxygenation.

provides clinical benefits [3]. However, the efficacy of the femoro-femoral VV-ECMO combined with PPV remains unknown.

This case highlighted three clinically useful findings. First, PPV combined with VV-ECMO improved oxygen levels in a patient with SARS-CoV-2-associated ARDS and allowed for maintenance of his condition in an ICU. Second, venous cannulae are usually placed in the right or left femoral vein for drainage and the right internal jugular vein for infusion during VV-ECMO. However, in this case, the cannula was placed in the right femoral vein for infusion and the left femoral vein for drainage. Although femoral cannulation has traditionally been contraindicated for mobilization, we successfully performed femoro-femoral VV-ECMO without any complications. Third, the practice of using femoro-femoral VV-ECMO added the most important advantage that PPV could be performed without moving the ECMO circuit, unlike that in jugular-femoral VV-ECMO. Finally, PPV was efficient in improving the patient's blood oxygen levels and chest HRCT findings.

In conclusion, the combined femoro-femoral VV-ECMO and PPV therapy provided clinical benefits to the patient with COVID-19 and critical pneumonia, without any additional complication.

Disclosure Statement

Appropriate written informed consent was obtained for publication of this case report and accompanying images.

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