



Lung Rest with Femoro-Femoral Veno-Venous Extracorporeal Membrane Oxygenation for COVID-19 Severe Pneumonia with Pneumomediastinum

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) sometimes causes severe coronavirus disease 2019 (COVID-19) pneumonia. Here, we report the case of a 35-year-old man with obesity who showed severe respiratory failure from SARS-CoV-2 infection. Immediate high-resolution computed tomography (HRCT) of the chest after endotracheal intubation revealed a significant pneumomediastinum with diffuse ground-glass opacity and consolidation. Ventilator management was difficult with low tidal volume and low positive end expiratory pressure. Therefore, we administered extracorporeal membrane oxygenation (ECMO) to allow lung rest and prevent further progression of the pneumomediastinum and maintain oxygenation. Since implementing ECMO, the patient's oxygenation has stabilized and follow-up HRCT of the chest revealed dramatic improvement of the pneumomediastinum. We gradually tapered off ECMO and employed a pressure-control mode. He was extubated on day 11. To our knowledge, this is the first reported patient who showed complete pneumomediastinum recovery from COVID-19 pneumonia with ECMO.

Keywords: COVID-19; extracorporeal membrane oxygenation; lung rest; pneumomediastinum; prone position ventilation

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Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a novel RNA virus that can cause mild to severe pneumonia (Ren et al. 2021). SARS-CoV-2 has a unique presentation, which can include embolism of the target organ, sometimes causing pneumomediastinum (Chowdhary et al. 2021). In this report, we present the case of man who developed severe pneumomediastinum with profound respiratory failure. After commencing extracorporeal membrane oxygenation (ECMO), his pneumomediastinum was completely improved.

Case Presentation

A 35-year-old otherwise healthy man visited nearby hospital with intermittent fever and acute dyspnea. He had been diagnosed with coronavirus disease 2019 (COVID-19)

by salivary reverse transcription-polymerase chain reaction 5 days previously. He was a current smoker with a 30 pack-year smoking history and his body mass index was 31.8. On admission, he required 7 L/minute oxygen with a reservoir mask. He received high-flow nasal cannula therapy for 4 days and was administered subcutaneous heparin, intravenous remdesivir (an inhibitor of the viral RNA-dependent, RNA polymerase), intravenous dexamethasone, and oral baricitinib (a selective JAK1 and JAK2 inhibitor).

However, his respiratory failure progressed despite the previous intensive therapy. He ultimately required endotracheal intubation. Five days after symptoms onset, he was transferred to our hospital immediately after intubation for further intensive management (day 1). The laboratory findings were as follows: serum white blood cells 3,210/ μ L, lactate dehydrogenase 613 U/L, D-dimer 0.6 μ g/mL,

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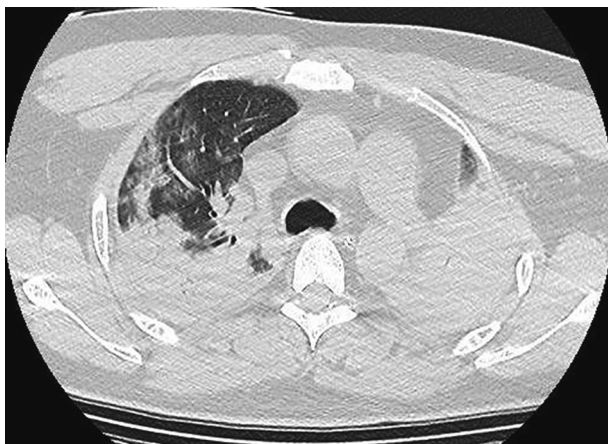
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C-reactive protein 6.8 mg/dL, ferritin 1,631 ng/mL, and interleukin-6 (IL-6) 361 pg/mL. Initial chest high resolution computed tomography (HRCT) showed a bilateral crazy paving pattern with vascular enhancement sign and dependent consolidation with significant pneumomediastinum on admission (Fig. 1A). He was admitted to the intensive care unit on mechanical ventilation. An initial blood analysis with 75% fraction of inspiratory oxygen (FiO_2) showed a pH of 7.423, partial pressure of carbon dioxide (PaCO_2) of 39 mmHg, partial pressure of oxygen (PaO_2) of 72.7 mmHg, hemoglobin saturation (SaO_2) of 95%, and ratio of $\text{PaO}_2/\text{FiO}_2$ (P/F ratio) of 96.9, which signified severe acute respiratory distress syndrome (ARDS). The mechanical ventilator settings were as follows: pressure-control mode, inspiratory pressure of 16 cmH₂O, respiratory rate of 15 breaths/min, positive end-expiratory pressure (PEEP) of 10 cmH₂O, and FiO_2 of 75%. However, main-



1A



1B

Fig.1. High-resolution computed tomography of the chest. A. Initial chest computed tomography scans on day 1. Chest computed tomography axial view showed bilateral crazy paving pattern, focal consolidation, and pneumomediastinum. An arrow indicates pneumomediastinum. B. Repeated chest computed tomography scans on day 5. Chest computed tomography axial view revealed dramatic improvement of the pneumomediastinum.

taining low-pressure oxygenation with low PEEP was difficult. Therefore, we administered femoro-femoral venovenous (VV)-ECMO because of severe respiratory failure without other organ failure. Regarding femoro-femoral VV-ECMO, a 21-Fr catheter was placed in the right femoral vein for inflow and a 24-Fr catheter was introduced into the left femoral vein for outflow with initial blood flow of 4.0 L/min. After starting ECMO, arterial saturation immediately improved to 100%. We used both midazolam and rocuronium bromide continuously for stable management of the ECMO. The mechanical ventilator was set on pressure-controlled mode with an inspiratory pressure of 15 cmH₂O, respiratory rate of 10 breaths/min, PEEP of 5 cmH₂O, and FiO_2 of 40%. On the day after ECMO introduction, we administered intravenous tocilizumab (TCZ; a monoclonal antibody against the IL-6 receptor) because of cytokine storm syndrome, including marked elevation of ferritin and IL-6. We simultaneously applied 2 cycles of prone position ventilation (PPV) (Fig. 2) because of severe respiratory failure with extensive shadow in posterior area of the bilateral lung.

On day 5, we performed repeated chest HRCT scan, which revealed a dramatic improvement of the pneumomediastinum (Fig. 1B). Based on the HRCT findings of the disappearance of pneumomediastinum, we gradually increased PEEP to 1 cmH₂O per day while tapering ECMO and stimulating spontaneous respiration. The patient was completely weaned off of ECMO on day 8, and was extubated safely on day 11. The following day, he was moved to a general ward receiving oxygen via the nasal cannula at 2 L/min. During respiratory rehabilitation we provided adequate exercise and control of bowel habits for prevention of pneumomediastinum recurrence. The patient was in ambient air on day 18 and was discharged home on day 22 with no complications. The clinical course of the patient is summarized in Fig. 3.

Appropriate written informed consent was obtained for



Fig. 2. Femoro-femoral veno-venous extracorporeal membrane oxygenation (VV-ECMO) was performed with prone position ventilation.

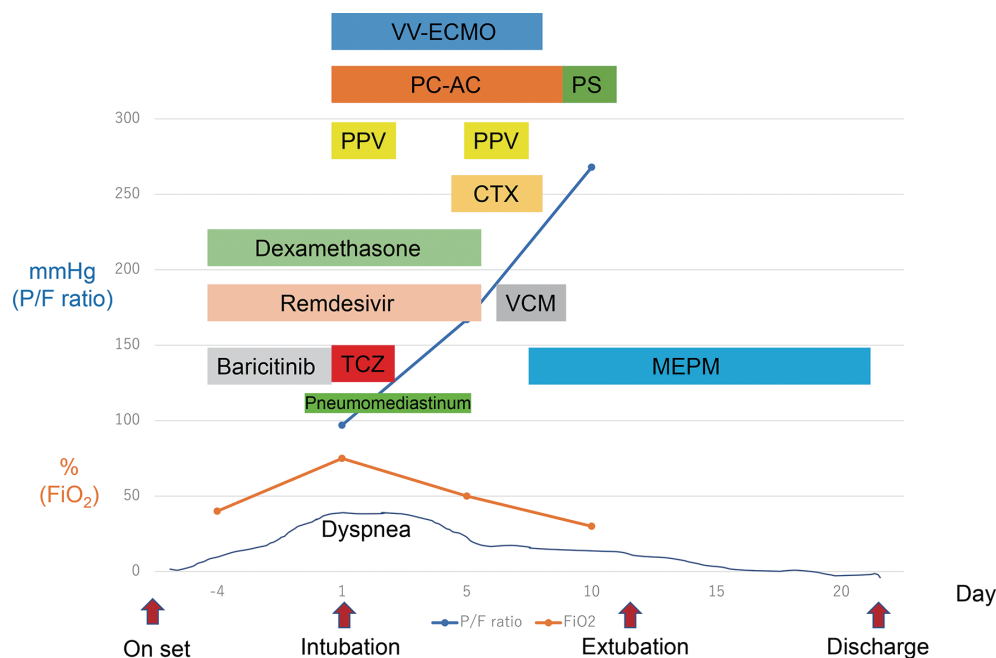


Fig. 3. Clinical course of the patient.

His condition was recovered after starting extracorporeal membrane oxygenation (ECMO), prone position ventilation (PPV), and tocilizumab. Day 1 is defined as on the day of admission to our hospital. Blue line indicates $\text{PaO}_2/\text{FiO}_2$ ratio (P/F ratio). Orange line indicates FiO_2 .

VV-ECMO, veno-venous extracorporeal membrane oxygenation; PC-AC, pressure controlled-assist control; PS, pressure support; PPV, prone position ventilation; CTX, cefotaxime; VCM, vancomycin; TCZ, tocilizumab; MEPM, meropenem; P/F ratio, ratio of partial pressure of oxygen and fraction of inspiratory oxygen; FiO_2 , fraction of inspiratory oxygen.

publication of this case report and accompanying images. Institutional Review Board of Okinawa Chubu Hospital approved this case report.

Discussion

We reported the case of a patient with critical COVID-19 pneumonia with extensive pneumomediastinum who showed significant improvement with lung rest using femoro-femoral VV-ECMO. The pneumomediastinum is sometimes complicated with severe COVID-19 pneumonia. This patient was an active smoker; however, the initial chest HRCT scan did not show a bulla or cyst, which is associated with interstitial emphysema. An immediate chest HRCT scan after endo-tracheal intubation showed the pneumomediastinum. Therefore, ventilation-associated lung injury was unlikely. Based on the clinical course, his pneumomediastinum could have been associated with fragility of the broncho-vascular bundle due to severe inflammation from SARS-CoV-2. When the intra-thoracic pressure increases in patients with pneumomediastinum, barotrauma can develop, which contributes to further complications, such as pneumothorax and profound hypoxemia (Sah et al. 2021). In ARDS who present pneumomediastinum or pneumothorax, a lung protective strategy with low PEEP may be applied. Our patient required a high oxygen concentration, and the P/F ratio decreased less than 100. COVID-19 pneumonia with pneumomediastinum

often has a poor prognosis, especially in patients with underlying disease (Xiang and Wu 2020). However, the patient was young, and no other organ failure was identified. In addition, given that patients with COVID-19 ARDS tend to develop barotrauma compared with those with classic ARDS (Güven et al. 2021), we commenced VV-ECMO for the purpose of lung rest, which contributes to maintaining low airway pressure (Giani et al. 2021). The combination of lung rest and PPV leads to oxygenation stabilization (Maeda et al. 2020). Our combination management including ECMO, PPV and TCZ contributed to the recovery of our patient. After confirmation of pneumomediastinum improvement, our gradual titration of PEEP was also useful for safe extubation.

Our case revealed a possible management strategy for COVID-19 pneumonia with pneumomediastinum. First, we used VV-ECMO in a young patient with COVID-19 pneumonia with pneumomediastinum to provide adequate lung rest. Timely selection of VV-ECMO for severe pneumomediastinum could be a useful strategy for critical patients with ARDS. Second, gradual titration of PEEP led to both recovery of spontaneous respiration and safe extubation. Third, the balance between respiratory muscle rehabilitation and control of bowel habits was important for prevention of pneumomediastinum recurrence.

In conclusion, lung rest using VV-ECMO could provide clinical merit for critical COVID-19 pneumonia with

pneumomediastinum. Meticulous titration of PEEP might also be helpful.

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Author Contributions

The conception or design of the work: T.K.; the acquisition of data for the work: T.K., T.S., S.Y., and H.N.; drafting the work or revising it critically for important intellectual content: T.K. and T.M.

Conflict of Interest

The authors declare no conflict of interest.

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