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CASE REPORT

Successful transition from intravenous to inhalation anesthesia for respiratory management of coronavirus disease pneumonia: A case report

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Abstract

Background: In patients with coronavirus disease pneumonia, strong spontaneous breathing increases pulmonary vascular permeability and induces self-inflicted lung injury, prolonging the intensive care unit stay and worsening prognosis. Therefore, spontaneous respiration must be strictly controlled.

Case Presentation: A 48-year-old man was admitted for respiratory management of severe coronavirus disease pneumonia. Despite immediate ventilatory management, ventilatory failure and air leak syndrome developed, necessitating venovenous extracorporeal membrane oxygenation, intravenous sedation, and muscle relaxation. Over time, the patient's inspiratory effort worsened and the requirement for transvenous anesthesia increased. Therefore, management was switched to inhalation anesthesia after discontinuation of all transvenous anesthetics, maintaining morphine-only analgesia. Subsequent management enabled effective control of spontaneous respiration, allowing eventual discontinuation of inhalation anesthesia, venovenous extracorporeal membrane oxygenation, and ventilation.

Conclusion: Management of spontaneous respiration in coronavirus disease pneumonia can be complicated by resistance to transvenous anesthesia; however, the use of an inhaled anesthetic may present a valuable alternative.

KEYWORDS
COVID-19, inhalation anesthesia, intravenous anesthesia, pneumonia, ventilation

BACKGROUND

Patients with coronavirus disease (COVID-19) exhibit a severe ventilation-perfusion (V/Q) mismatch causing hypoxemia; however, they have surprisingly few complaints of respiratory distress and exhibit strong spontaneous breathing. To prevent self-inflicted lung injury (P-SILI), strict spontaneous breathing control must be implemented.[1] However, prolonged administration of intravenous anesthetics and muscle relaxants for respiratory control can result in drug resistance.[2]

This report describes the case of a patient with severe COVID-19 pneumonia who had difficulty with spontaneous breathing control with intravenous anesthesia during ventilatory management and venovenous extracorporeal oxygenation (VV-ECMO). The patient was successfully transitioned to inhalation anesthesia, preserving life.

CASE PRESENTATION

A 48-year-old male patient (height, 175 cm; weight, 61.6 kg) visited a physician 2 days after the onset of fever. He was subsequently diagnosed with COVID-19 following antigen testing for severe acute respiratory syndrome coronavirus 2. As respiratory distress worsened, he was admitted to another hospital 6 days

after the onset of fever. However, oxygen demand increased, necessitating ventilatory support. At that time, his arterial oxygen partial pressure/fractional inspired oxygen (P/F) ratio was 111, and he was referred to our center for VV-ECMO.

The patient was prescribed remdesivir (100 mg), baricitinib (4 mg), and dexamethasone (6.6 mg). Airway obstruction pressure ($P_{0.1}$, reference value 0–4 cm H_2O) was used as an objective measure of P-SILI prevention during ventilatory management. Since $P_{0.1}$ was as high as −7 cm H_2O upon admission, the patient was deeply sedated with propofol (120 mg/h), midazolam (10 mg/h), and rocuronium (10 mg/h). Prone therapy was administered to treat acute respiratory distress syndrome.

On Day 16 of hospitalization, chest computed tomography (CT) revealed air leak syndrome (ALS). On Day 17, the P/F ratio was <100, indicating poor oxygenation. The patient was placed in the supine position, but the P/F ratio did not improve; therefore, VV-ECMO was introduced. His ALS improved on Day 24, and he was weaned off the VV-ECMO on Day 28. However, his $P_{0.1}$ subsequently increased to −10 cm H_2O. Therefore, on Day 32, propofol (210 mg/h), midazolam (13 mg/h), morphine (6 mg/h), rocuronium (30 mg/h), and dexmedetomidine (0.7 μg/kg/h) were initiated to suppress effortful breathing. Consequent chest CT imaging on Day 32 confirmed recurrent ALS with a P/F ratio <100, necessitating the reintroduction of VV-ECMO on Day 34. Morphine was administered as an analgesic and rocuronium as a muscle relaxant, while sedatives were administered in addition to the originally used propofol and midazolam, plus dexmedetomidine and thiopental; however, control of effortful breathing remained difficult ($P_{0.1}$ = −4.3 to −9.8). After obtaining approval from the hospital emergency ethics committee regarding the use of sevoflurane in intensive care units, inhaled anesthetics were initiated using an anesthetic vaporizer (AnaConDa®, manufacturer, Uppsala city, Sweden country) on Day 52. Sevoflurane (5.0 mL/h) was selected as the inhaled anesthetic, and the patient was managed using the Richmond Agitation-Sedation Scale, 0 to −2 without intravenous anesthetics. Inhalation anesthesia effectively maintained a tidal volume of 250 mL and controlled respiration ($P_{0.1}$ = −1.7 to −6.2) without any increase in $P_{0.1}$ (Figure 1). For Days 50–52, $P_{0.1}$ should have been measured; however, no data were available. Medical records and other findings revealed no signs of labored breathing. The sevoflurane dose was maintained at 1.5%–2.0% with continuous monitoring of end-expiratory concentrations. The patient continued to have effortless inspiration, was successfully weaned off the ventilator on Day 88, and was transferred alive on Day 100.

DISCUSSION

COVID-19 is unique because hypoxic pulmonary vasoconstriction is less likely to occur, causing a severe V/Q mismatch and hypoxemia despite good patient compliance.[3] Furthermore, patients often exhibit strong spontaneous breathing (hypercapnia), which in turn increases the vascular permeability and induces pulmonary edema, ultimately resulting in P-SILI.[1] Preventing P-SILI is critical for maintaining pulmonary oxygenation capacity, and spontaneous breathing must be strictly controlled.

However, prolonged use of sedatives and analgesics when managing spontaneous (effortful) breathing with intravenous sedatives and analgesics can lead to drug resistance.[2] An AnaConDa® is connected between the ventilator and the tracheal intubation tube, allowing for direct injection of

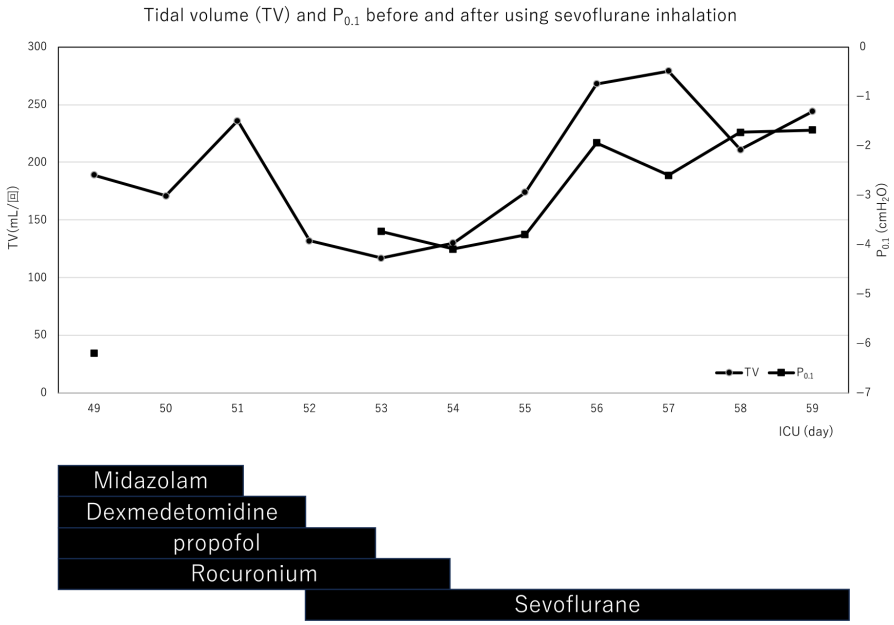

FIGURE 1 The tidal volume and $P_{0.1}$ before and after sevoflurane inhalation. Effortful respiration ($P_{0.1}$ < −4) is observed under intravenous anesthetics and muscle relaxants; however, after initiation of inhaled anesthetics, effortful respiration is suppressed, even with a single agent.

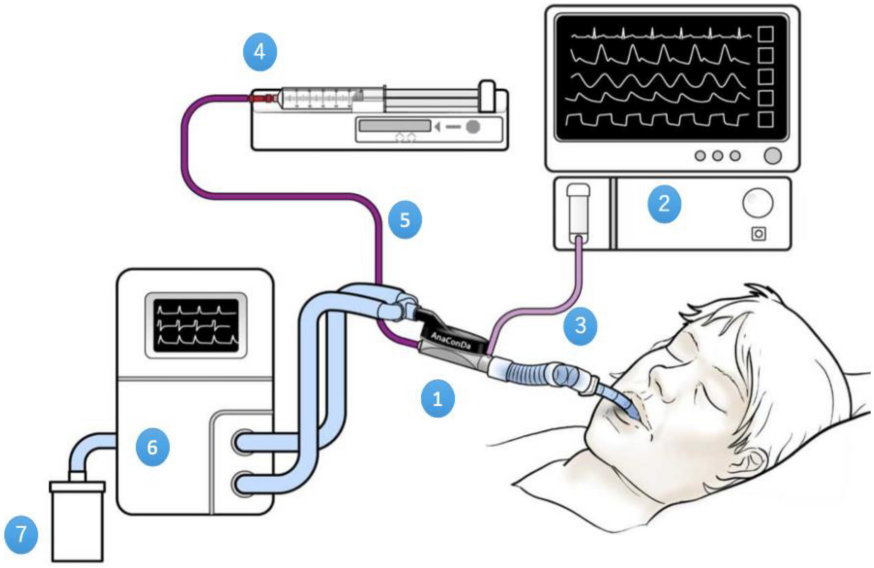

FIGURE 2 An AnaConDa® is connected between the ventilator and the tracheal intubation tube, and sevoflurane is continuously administered directly to the evaporator inside. Vaporized sevoflurane is recirculated by the reflector function in the artificial nose to reduce anesthetic consumption. ① AnaConDa®; ② gas monitor; ③ gas sampling line; ④ syringe pump; ⑤ chemical supply line; ⑥ ventilator; ⑦ Flur absorb®.

sevoflurane into the evaporator. Vaporized sevoflurane is then recirculated using a reflector function in the artificial nose, thereby reducing anesthetic consumption. Flur Absorb®, an activated carbon filter developed by Cedana Medical, captures anesthetic gas effluent from the ventilator exhaust, thus reducing exposure to healthcare workers (Figure 2).

Compared to intravenous anesthetics, sevoflurane has been shown to have bronchodilator effects and it increases the vascular bed, both beneficial for respiratory failure.[4] There is a report of the use of inhaled anesthetics in patients with severe asthma[5] and there have been some reports on the use of volatile inhalation anesthetics in severely ill patients with COVID-19,[6,7] but there have been few reports of their use in Japan.[6] Miyazaki et al. reported that sevoflurane was used when a patient failed to synchronize with a ventilator under intravenous anesthesia, followed by successful reduction of the intravenous anesthetic dose within 24 h.[6] In addition, Landoni et al.[7] reported that isoflurane was used as an inhaled anesthetic in most patients with COVID-19, without complications, successfully reducing the dose of intravenous anesthetics. Similar to these reports, sevoflurane was used in this case at a time when respiratory effort was strong under intravenous anesthetics and synchronization with the ventilator was difficult; the intravenous anesthetic dose was successfully reduced promptly after its use. Dupuis et al.[8] reported the use of sevoflurane in a patient with COVID-19 and complications of renal diabetes insipidus. In the present case, however, there was no obvious increase in urine output after sevoflurane inhalation, and there were no clinically suspicious findings of nephrogenic diabetes insipidus. Iwasaki et al.[9] reported that sevoflurane administered via ECMO gas flow to a patient with COVID-19 resulted in good sedation and reduced intravenous anesthetic doses, as in this case. In summary, sevoflurane administration to patients with COVID-19 may be useful even under ECMO management. However, it should be noted that the cost must be borne by the hospital, as this treatment is not currently covered by insurance in Japan.

CONCLUSION

This report presents the case of a patient with severe COVID-19 pneumonia who developed tolerance to transvenous anesthesia during ventilation and VV-ECMO. The consequent substitution of inhalation anesthesia enabled good sedation management. Therefore, the use of inhaled anesthetics as an alternative to intravenous anesthetics may be useful for managing patients with COVID-19 respiratory failure.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest associated with this manuscript.

DATA AVAILABILITY STATEMENT

Raw data were generated at Fukuoka University. Derived data supporting the findings of this study are available from the corresponding author, R. Kato, upon request.

ETHICS STATEMENT

Approval of the research protocol: Approval was obtained from the hospital Emergency Ethics Committee for the initiation of inhaled anesthetics.

Informed consent: The requirement for informed consent was waived by the Ethics Committee. The case was anonymized in accordance with the Personal Information Protection Law, and the consent of the individual involved was obtained for reporting and publishing the case.
Registry and the Registration No. of the study/trial: N/A.
Animal Studies: N/A.

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