We report on a successful configuration strategy of extracorporeal membrane oxygenation (ECMO) in two consecutive cases of acute lung injury. A 60-year-old woman with Streptococcus pneumoniae infection and a 22-year-old man with hemothorax were admitted to our hospital with failing lungs. Although treatment with a ventilator was started, oxygenation could not be maintained. ECMO with a femoro-femoral circuit was performed, which showed a slight improvement in oxygenation. However, not enough oxygen support was provided. To minimize the venous mixture at the right atrium, we added venous drainage from the right jugular vein which resulted in better oxygenation and patient survival.

Keywords: ECMO, ARDS, ventilation, intensive care

Introduction

Extracorporeal membrane oxygenation (ECMO) is a technique to provide sufficient oxygenation in patients with failing lungs. Although many studies have shown its benefits in newborns with acute respiratory failure, many have failed to show its effectiveness in adults. However, with improvements in ECMO technology and introduction of lung-protective ventilation strategy, the results are now promising. The configuration strategy of ECMO, however, differs among institutions. We report two consecutive cases of acute lung injury that were successfully treated by the addition of venous drainage catheter from the jugular vein to our previous femoro-femoral venovenous ECMO system.

Case 1

A 60-year-old woman was admitted to our hospital with Streptococcus pneumoniae infection. Despite treatment with antibiotics, her oxygenation was failing with the appearance of bilateral infiltrative shadows on the chest X-ray film (Fig. 1A). Although respiratory support with a ventilator was started, her oxygenation declined to PaO2/FiO2 ratio of 34.3. ECMO therapy with femoro-femoral venovenous bypass was established (Fig. 1B and 1C). For minimizing recirculation of oxygenated blood within the circuit, blood flow was started at 40% to 50% of cardiac output. The PaO2/FiO2 ratio showed an improvement measuring 92 after the introduction of ECMO treatment. Although the blood flow volume was adjusted for better oxygenation, it showed a poor response. Adjunct therapy by the addition of a venous drainage catheter from the right jugular vein was performed for more oxygenation support (Fig. 1D). A venous drainage catheter was inserted from the right internal jugular vein into the superior vena cava establishing a “double venous drainage system” (Fig. 2). The PaO2/FiO2 ratio was improved to 175 at the same blood
ECMO with Double Venous Drainage

flow volume, and the patient was successfully weaned off the ventilator after 12 days of intensive care.

Case 2

A 22-year-old man was admitted to our hospital with hemothorax and multiple bone fractures after falling from a 10 meter high bridge. Drainage of the right hemothorax, bone fixation of the fractured limbs, and transcatheter arterial embolization of the median sacral artery and bilateral internal iliac arteries were performed. Although his blood pressure was sustained by successful hemostasis, his respiratory system was failing due to a systemic inflammatory response. Venoarterial ECMO was an option, which provided oxygenation as well as a reduction in volume stress on the lungs. However, due to controlled hemostasis and stable blood pressure, femoro-femoral venovenous bypass was established. The circuit blood flow was started at 40% to 50% of cardiac output. Although the PaO2/FiO2 ratio had improved from 56 to 116, it decreased to 51 the next day. Blood flow volume of the circuit was adjusted to improve oxygenation support. However, due to the poor oxygenation response to the blood flow volume, a “double venous drainage system” was established by adding another catheter from the right internal jugular vein to the superior vena cava. The PaO2/FiO2 ratio improved to 139.8 at the same blood flow volume, and the patient was successfully weaned off the ventilator after 11 days of intensive care.

Discussion

Although ECMO is a promising technique for cardiopulmonary support, successful usage of this system depends on its management and configuration. Knight et al. reported a lower mean percutaneous oxygen saturation in the venovenous ECMO but a higher intravascular thrombosis in the venoarterial ECMO system, while others reported frequent bleeding complication in venoarterial ECMO.1,2) A study by Stohr, et al. suggested a lower mortality rate in patients treated with veno-venoarterial ECMO than in patients treated with venovenous or venoarterial ECMO.3) Furthermore, Lazar, et al. reported successful usage of bicaval dual-lumen catheter in neonates while Bonacchi, et al. reported an “X-configuration” system for veno-venous bypass by the use of a self-modified inflow cannula.4,5) Although many discussions have been made, the configuration strategies and management among institutions still vary.

Venoarterial ECMO provides oxygenated blood into the arterial system directly which results in cardiopulmonary support. On the contrary, venovenous ECMO only provides oxygenation support through the venous system. In
To provide sufficient oxygenation from the venous system, we have been using a femoro-femoral circuit, which is easily established. Although this system improved oxygenation, few patients with an aggravating pathology result in treatment failure within a few days. The blood flow volume of the circuit was adjusted to improve oxygenation. Catheter position and size are important factors in obtaining sufficient blood flow volume by the circuit. A 21 Fr venous line and 15 Fr artery line in the circuit are always sufficient for obtaining blood flow up to 3.0 L/min at 3000 RPM. However, in some cases, blood flow volume does not reflect oxygenation, due to blood recirculation within the circuit. In such cases, repositioning of the catheter or conversion to venoarterial ECMO may be useful in providing oxygen. However, in a patient with sufficient perfusion pressure, not enough oxygen is provided to the coronary artery and the carotid artery.

We have managed to improve oxygenation in these patients by adding another drainage catheter from the right jugular vein to the superior vena cava without changing the circuit blood flow. Although another puncture site was added, this adjunct therapy provided venous drainage from both superior vena cava and inferior vena cava, which minimized the venous mixture at the right atrium (Fig. 2). This modification has improved oxygenation support, which resulted in better patient survival.

Conclusion

In patients with respiratory failure, the selection of an ECMO system (venovenous or venoarterial) should be decided on the condition of the circulatory system. In patients with maintained systemic pressure, venoarterial ECMO may not provide sufficient oxygen to the coronary artery or the carotid artery. Although venovenous ECMO results in a lower mean percutaneous oxygen saturation than that of the venoarterial ECMO, it provides sufficient oxygen from the coronary orifice when an appropriate configuration strategy is used. Our ECMO system with double venous drainage from the superior vena cava and inferior vena cava was successful. Although there is a risk from vessel injury, the addition of venous drainage from the jugular vein is good adjunct therapy for patients refractory to femoro-femoral bypass alone.

Disclosure Statement

I acknowledge that 1) we have no financial or other interest in the manufacture or distribution of the device and that 2) we do not have a financial interest in the manufacturer of the device, or receive financial incentives from the manufacturer.

References