Case Report

A Case Report of Central Extracorporeal Membrane Oxygenation after Implantation of a Left Ventricular Assist System: Femoral Vein and Left Atrium Cannulation for ECMO

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Purpose: The left ventricular assist system (LVAS) is often used for end-stage heart failure. However, in severe lung disorder, the patient needs extracorporeal membrane oxygenation (ECMO) because oxygenation using only a ventricular assist system (VAS) is insufficient. We report a successful case of combining the use of LVAS and right VAS (RVAS) with ECMO.
Method: A 40-year-old female developed cardiogenic shock secondary to end-stage dilated cardiomyopathy, and percutaneous cardiopulmonary support (PCPS) was initiated. An echocardiogram showed a low ejection fraction (11%), and she underwent implantation of an LVAS (Toyobo Ventricular Assist System). She also required a RVAS with ECMO shunting between the right and left atrium because there was insufficient oxygenation resulting from pulmonary dysfunction followed by severe lung edema.
Result: Pulmonary function recovered successfully, and the RVAS-ECMO was removed after 7 days of support. There were no complications after operation, such as infection, bleeding, or systemic embolization.
Conclusion: LVAS combined with RVAS-ECMO in right and left atrial cannulation is a useful option for patients with severe pulmonary damage. (Ann Thorac Cardiovasc Surg 2009; 15: 408–411)

Key words: left ventricular assist system, extracorporeal membrane oxygenation, severe pulmonary damage

Introduction

The left ventricular assist system (LVAS) is often used for end-stage heart failure resistant to full medication. However, in a case of severe lung disorder with bleeding or pulmonary congestion, the patient needs extracorporeal membrane oxygenation (ECMO) because oxygenation using only a ventricular assist system (VAS) is insufficient.

We report a successful case of combining the use of LVAS and right VAS (RVAS) with ECMO shunting between the right and left atriums because of cardiogenic shock and severe secondary pulmonary congestion resulting from end-stage dilated cardiomyopathy.

Case Report

A 40-year-old female was diagnosed with dilated cardiomyopathy and treated with β-blocker, diuretics, and angiotensin-converting enzyme (ACE) inhibitor. Upon admission to our hospital, she had severe orthopnea. An

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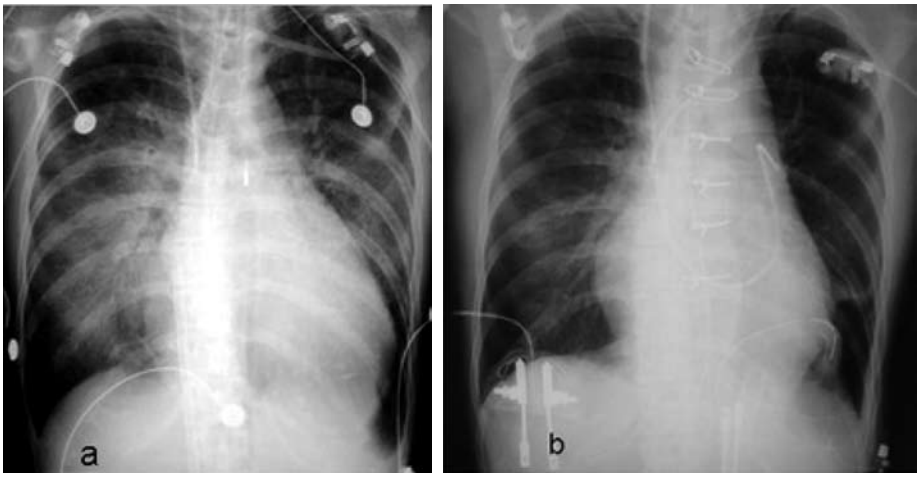

Fig. 1.
a: Radiography showing cardiomegaly and severely congested lung.
b: Chest X-ray 5 days after implantation of LVAS and RVAS-ECMO showing improvement of cardiomegaly and air-space opacity in the lungs.

echocardiogram showed diffuse hypokinesis, a left ventricular ejection fraction of 11%, a left ventricular end-diastolic diameter of 77 mm, and severe mitral regurgitation.

Her stature and body weight were 160 cm and 42 kg.

An electrocardiogram showed flat or inverted T waves in leads II, III, aVR, aVF, and V1–6. The QT interval was prolonged.

A Swan-Ganz catheter examination revealed that central venous pressure (CVP) was 15 mmHg; right ventricular mean pressure was 35 mmHg; mean pulmonary artery pressure was 24 mmHg; PCWP was 19 mmHg; and CI was 1.9 L × min^{-1} × m^{-2} with inotropic support.

Five hours after admission, the patient developed Vf requiring mechanical ventilation, percutaneous cardiopulmonary support (PCPS), and intra-aortic balloon pumping (IABP). A chest X-ray demonstrated progressively worsening lung congestion, and she eventually developed pulmonary hemorrhage (Fig. 1a). She underwent implantation of a Toyobo LVAS with left ventricular apex drainage (Nipro, Inc., Osaka, Japan). At the termination of cardiopulmonary bypass, the partial arterial pressure of oxygen (PaO_2) in the aorta was 43 mmHg under ventilator support with 100% O_2, and filling of the LVAS was quite poor, even though ECMO was used via the femoral vein and artery. Further cerebrovascular oxygen saturation was kept at 30%–40% using a cerebral oximeter, a situation in which the patient might experience hypoxia brain injury. We selected the left atrium for the outflow cannulation site of the ECMO, instead of the pulmonary artery concerning the exacerbation of pulmonary edema and hemorrhage (Fig. 2).

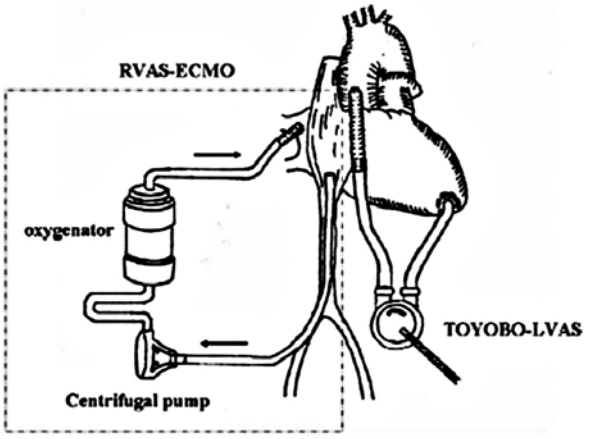

Fig. 2. Schema of LVAS (left ventricular assist system) and RVAS-ECMO (right ventricular assist system-extracorporeal membrane oxygenation).

The patient's hemodynamic condition was well maintained with a RVAS-ECMO flow of 3.0 L/min. The direct measurement of the left atrial pressure was 10 mmHg, and LVAS filling was quite good. The RVAS flow was gradually decreased to 2.0 L/min over the next 4 days via a monitoring of central venous pressure, systemic venous oxygen saturation (SvO_2), LVAS filling, and improvement of air-space opacity in chest X-rays (Fig. 1b). The RVAS

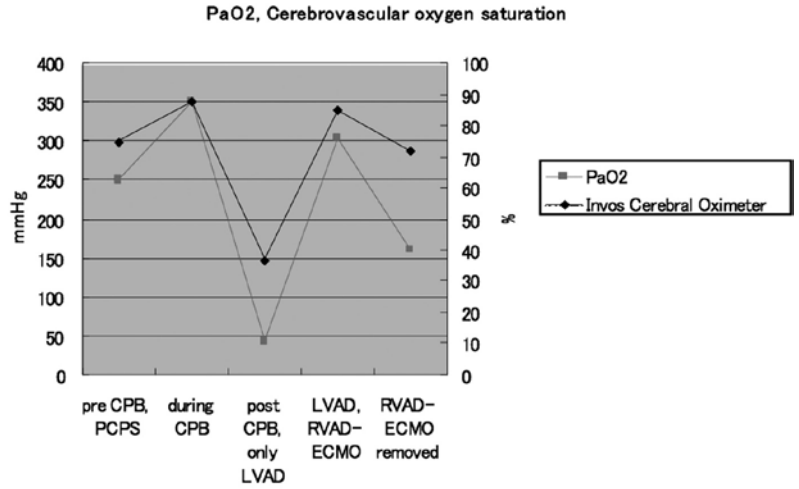

Fig. 3. The change of partial arterial pressure of oxygen (PaO_2) and cerebrovascular oxygen saturation.

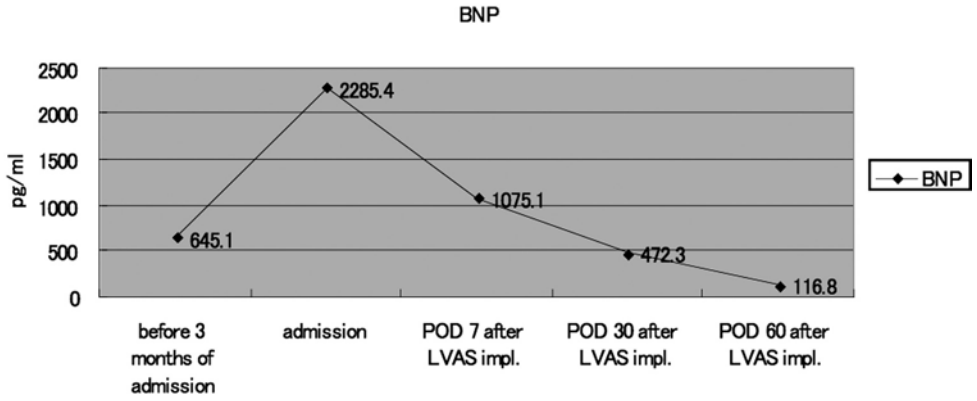

Fig. 4. The change of plasma BNP level.
LVAS, left ventricular assist system; POD, postoperative day.

was explanted on day 5 after RVAS implantation. Figure 3 showed the improvement of PaO_2 and cerebrovascular oxygen saturation before and after ECMO support. After ECMO explantation, the blood gas analysis showed good oxygenation (PaO_2 150 mmHg, PCO_2 35 mmHg, pH 7.402) using mechanical ventilation (FiO_2 0.5, SIMV mode, PEEP 5 cmH_2O).

On day 6 after LVAS implantation, right ventricular catheterization was performed. The patient's cardiac index was 1.9 L/min/m^2, pulmonary artery wedge pressure 9 mmHg; mean pulmonary pressure 19 mmHg; pulmonary vessel resistance 2.2 Wood; and 15 mmHg CVP under LVAS support. Mechanical ventilation was no longer required on day 5 after LVAS and RVAS-ECMO implantation. There were no complications after the operation, such as infection, bleeding, or systemic embolization. The plasma BNP level improved after mechanical circulation assist (Fig. 4)

She has been on LVAS support for 15 months and still awaits heart transplantation.

Discussion

The ECMO is useful as a life-saving option, especially for patients with cardiogenic shock accompanied by intractable ventricular fibrillation who require the rapid establishment of circulatory support.

However, ECMO has some disadvantages, including a

high incidence of bleeding, infection, stroke, and limited duration of support potential.[1)]

The other serious problem with ECMO is the inadequate decompression of the left ventricle, which may cause pulmonary edema and hemorrhage. The following questions are important for using ECMO as a bridge to LVAS: (1) When should the switch from ECMO to LVAD be made? (2) Which system is useful and effective? (3) What are the management and weaning processes of ECMO?

Pagani et al.[2)] reported that the recovery of pulmonary and liver functions are the more-important factors considered in the timing of ECMO-to-LVAS implant. Their group used an INR <1.5 and liver enzymes < 5 times the normal as important guidelines for the timing of ECMO to LVAS implant. Also, pulmonary compliance appears to be an important determinant of the outcome.

In a condition with severe pulmonary damage, only LVAS is insufficient to make enough oxygenation. The use of LVAS combined with RVAS-ECMO may be an optimal treatment option among several available for applying RVAS-ECMO. Fukushima et al.[3)] demonstrated that oxygenation and right ventricular function could be improved by veno-left atrial bypass and veno-pulmonary artery bypass rather than by veno-arterial bypass when applying ECMO in a swine model of respiratory failure complicated by a hypoxemic condition.

Furthermore, peripheral ECMO has the weak point of having poorly oxygenated blood during the perfusion of coronary and cerebral arteries, as observed in our case, and an additional ECMO with femoral veno-arterial bypass to BVAS is an intricate system. Minami et al.[4)] reported three efficacy cases of RVAS-ECMO after LVAS, heart transplantation, and redo-coronary artery bypass grafting with severe right ventricular function and poor oxygenation under mechanical ventilation alone. In their patients, the outflow and inflow cannulas for RVAS-ECMO were placed in the right pulmonary artery and the right atrium. However, if severe pulmonary hypertension and pulmonary edema or hemorrhage occur, such as in our case, it would be beneficial to place the outflow graft in the left atrium.

The management and weaning processes of RVAS-ECMO have not been discussed in earlier reports. We monitored hemodynamic parameters, LVAS filling, central venous pressure, and systemic venous oxygen saturation, and we gradually reduced RVAS-ECMO. In our method, systemic embolization is of great concern, but it can be avoided by using a heparin-coated system coupled with low-dose heparin.

In conclusion, LVAS combined with RVAS-ECMO in right and left atrial cannulation is a useful option for patients with severe pulmonary damage during ECMO support.

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