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Transfromation of Percutaneous Extracorporeal Life Support to Paracorporeal Ventricular Assist Device: A Case Report

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Percutaneous extracorporeal life support (P-ECLS) is a useful modality for the management of refractory cardiac or pulmonary failure. However, venoarterial P-ECLS may result in a complication of left ventricular distension. In this case report, we discuss a patient with drug-induced dilated cardiomyopathy managed with venoarterial P-ECLS and a left atrial vent catheter. The venoarterial P-ECLS was modified to a paracorporeal left ventricular assist device (LVAD) by removing the femoral venous cannula. After 28 days of hospitalization, the patient was successfully weaned from the paracorporeal LVAD and discharged home from the hospital.

Key words: 1. Heart failure
2. Extracorporeal membrane oxygenation
3. Dilated cardiomyopathy
4. Left ventricular assist device

CASE REPORT

A 26-year-old female patient was transferred to the Samsung Medical Center from an outside institution due to severe refractory cardiogenic shock. The patient was diagnosed with non-Hodgkin's lymphoma 2 years prior and underwent 6 cycles of chemotherapy, which included doxorubicin. After chemotherapy treatments were completed, the patient suffered from orthopnea and dyspnea, and an echocardiography revealed a severely depressed left ventricular (LV) ejection fraction (25%) and dilated LV. Due to complications from cancer treatments, she had an episode of acute decompensated heart failure and was referred to Samsung Medical Center.

On initial presentation, vital signs included arterial blood pressure of 79/27 mmHg, heart rate of 133 beats/min, respiratory rate of 28 breaths/min, and body temperature of 35.9°C. She had pulmonary edema with bilateral pulmonary congestion (Fig. 1) and multiorgan failure with liver and kidney involvement. Despite the use of inotropes and vasopressors, we were unable to achieve stable vital signs.

Percutaneous extracorporeal life support (P-ECLS) was then placed using the left femoral artery and vein. However, the left leg became ischemic after several hours, and we decided to shift the cannulas to the right groin. The patient was brought to a hybrid operating room, and the groin was opened bilaterally. First, we removed the left femoral arterial cannula and performed a thrombectomy. Then, the arterial and venous cannulas were inserted through the common femoral artery and vein, and the catheter for the superficial femoral artery was inserted at the same time.

The following day, transthoracic echocardiography revealed

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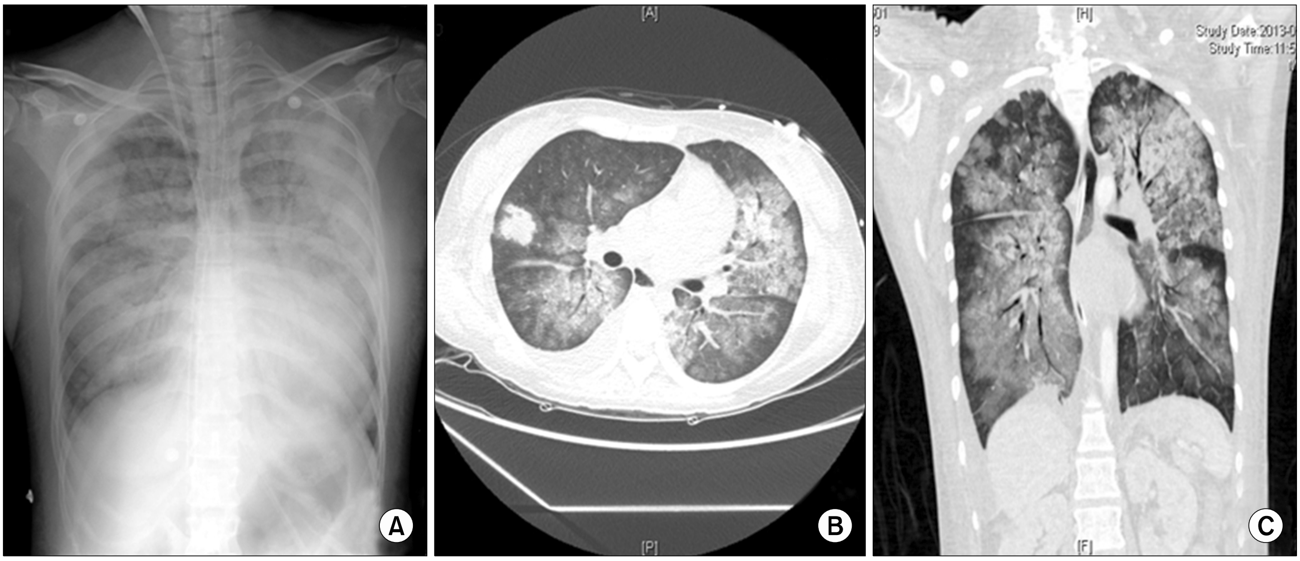

Fig. 1. (A) Chest radiograph and (B, C) computed tomography revealing pulmonary edema with bilateral pulmonary congestion.

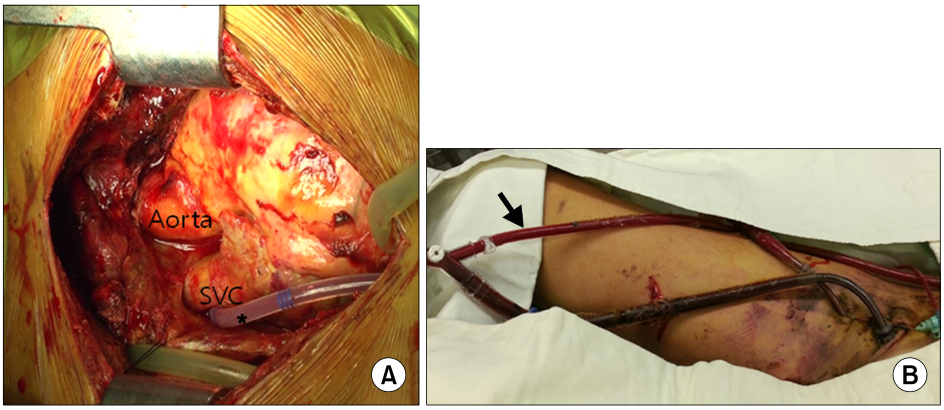

Fig. 2. (A) Intraoperative photograph showing a vent catheter (asterisk) in the right upper pulmonary vein. (B) Postoperative lines for extracorporeal circulation, including a left heart vent (arrow), a draining cannula in the femoral vein, a returning cannula in the femoral artery, and a catheter for distal perfusion. SVC, superior vena cava.

a distended left ventricle, and the chest X-ray showed worsening pulmonary edema. In this case, we determined that an atrial septostomy was not a viable option since both the femoral veins were already cannulated or had been surgically repaired. Instead, we performed an emergency standard median sternotomy and inserted a vent catheter (malleable 20 Fr.) with a tip-cut into the right upper pulmonary vein and passed it into the left ventricle. Then, the inserted vent catheter was connected to the venous line of the P-ECLS circuit via a Y-shaped connector (Fig. 2). A few hours later after the insertion of the vent catheter, the pump flow was maintained at 2.4 L/min/m^2, obtaining a mean systemic pressure of 60 mmHg and central venous pressure of 8 mmHg. The flow through the vent catheter was measured to be 1 to 2 L/min.

The patient was on P-ECLS and left heart venting for 5 days. During this time, the pulmonary edema was resolved (Fig. 3). Transthoracic echocardiography revealed improved right and LV function and decreased chamber size. The LV ejection fraction was 30% to 40%, when the pump was off. When the function of the right heart and the lung improved, the drainage from the femoral vein was gradually reduced by progressively clamping the venous line and lowering the r.p.m. In this way, the system was modified from P-ECLS to paracorporeal LV assist device (LVAD) by the complete clamping of the femoral venous drainage catheter. Thus, the femoral venous cannula and the oxygenator were removed on postoperative day 5. The reasons for our decision were complete LV support, possible longer-term support due to the ab-

Fig. 3. Chest radiograph taken when the patient was on percutaneous extracorporeal life support and left heart venting for 5 days showing normalized lung and resolved pulmonary edema.

sence of the oxygenator and the low level of anticoagulation, and the prevention of recurrent LV distension.

On postoperative day 8, we were able to wean the patient from LVAD and remove all cannulas from her chest and groin. She was extubated and was finally discharged home on hospital day 28. During follow-up, the LV ejection fraction worsened from 40% to 20%, and the symptoms of dyspnea became worse than before hospital discharge. Currently, this patient is on the heart transplant list and is waiting for transplantation.

DISCUSSION

P-ECLS provides effective circulatory support for patients in refractory cardiogenic shock. However, due to its inability to directly drain the left heart, its effectiveness in assisting the heart is limited [1]. Additionally, several factors including severely reduced LV function, blood from native pulmonary and bronchial circulation, and increased afterload due to retrograde perfusion from the arterial cannula may lead to LV distension. This resultant LV distension can cause pulmonary edema, pulmonary hemorrhage, and myocardial ischemia [2]. Although paracorporeal LVAD placed through a median sternotomy provide better hemodynamic support without the risk of LV distension, complications of central cannulation such as bleeding and infection limit the widespread use of this technique.

We report a case in which trans-sternal LV drainage was utilized while the patient was receiving P-ECLS that was followed by a subsequent switch to paracorporeal LVAD without further surgery. This strategy allowed the transformation of peripheral circulatory support into effective myocardial and systemic circulatory assistance and minimized the surgical risk.

Although P-ECLS offers excellent support to the blood circulation, its effect on the heart is less favorable. P-ECLS can commonly lead to LV distension and pulmonary edema. The pathophysiology of LV distension after P-ECLS is multifactorial. The left atrium can receive blood from the right heart and bronchial circulation. In the case of severe LV dysfunction, the LV cannot eject the received blood to overcome the increased afterload due to the retrograde P-ECLS flow. The presence of minimal aortic insufficiency can also result in LV distension. The consequences of LV distension include pulmonary edema, pulmonary hemorrhage, right ventricular distension, and increased intraventricular pressure, which can lead to myocardial hypoperfusion and ischemia.

The effect of P-ECLS on LV distension was investigated previously by some authors [1,3]. In an animal model of acute heart failure, Kawashima et al. [2] reported that the resolution of ventricular fibrillation was related to LV unloading and reduction in myocardial oxygen consumption. Myocardial perfusion is proportional to the decrease in the LV wall tension and the compression of intra-myocardial coronary vessels. Therefore, LV decompression favorably affects ventricular recovery and increases the possibility of weaning from P-ECLS [4]. For this reason, a careful evaluation of the status of the LV and prompt drainage in the case of a pressure increase should be considered essential in patients assisted by ECLS for acute cardiogenic shock [5].

There are several techniques to decompress the LV, including a percutaneous trans-septal left atrial approach, LV venting through the right upper pulmonary vein, and direct LV apex cannulation. Although percutaneous LV venting does not require a surgical incision, the effectiveness of LV decompression can be limited according to the degree of mitral regurgitation. Thus, surgical venting is a more favorable option than percutaneous septostomy. Massetti et al. [6] reported minimally invasive LV drainage in which an apical cannula is inserted into the LV apex transcutaneously. Although direct drainage of the LV through a trans-sternal approach is technically more complex, it has the advantage of high efficacy with respect to the intraventricular dynamics. Further, our group was more familiar with the trans-sternal approach at that time.

Management after an LV venting procedure is still controversial, particularly since there is uncertainty in terms of patient stability after weaning from P-ECLS. There are three ways of weaning from venoarterial ECLS, namely the one-stage removal of all ECLS cannulae, vent catheter removal and subsequent venoarterial ECLS weaning, and venous cannula removal and subsequent paracorporeal LVAD weaning. In this case, we decided to shift to paracorporeal LVAD from P-ECLS by progressively clamping the venous line and lowering the flow to the oxygenator until complete exclusion from the circuit. There are a few advantages of conversion from venoarterial ECLS to paracorporeal LVAD. This allows for a heparin- and oxygenator-free trial of extracorporeal circulation, which reduces the chances of bleeding or thromboembolism. The low risk of bleeding and thromboembolism allows longer-term support for heart transplant than venoarterial ECLS. The other advantages of our strategy include prevention of recurrent LV distension and pulmonary edema.

In summary, P-ECLS offers excellent circulatory support in emergency settings and assures rapid and systemic perfusion. However, P-ECLS can negatively affect LV physiology and can potentially jeopardize myocardial recovery. Thus, a careful evaluation of the LV status and prompt drainage in the case of pressure increases should be considered. Our strategy assures complete LV venting and allows for a simple conversion of P-ECLS to paracorporeal LVAD.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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