

Postcardiotomy Ventricular Assist Device

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=Abstract=

개심술후 심실 보조장치

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의료기술의 발달로 오늘날의 개심술은 대부분 성공적으로 시행되고 있지만 극히 일부는 아직도 개심술후 심한 심실기능의 저하로 사망하는 경우가 있다. 1960년대 중반 Spencer와 DeBakey에 의해 개심술후 심한 심실기능이 저하된 환자에게 심실보조장치를 이용하여 성공적으로 치험한 이후로 많은 발전을 거듭해 왔다.

저자들은 4개월(6.5 kg)된 남아에서 개심술후 심한 저심박출증으로 인공심폐기의 제거를 못하여 좌심실 보조장치(Centrifugal Biopump)를 사용하여 성공적으로 치험하였기에 보고하는 바이다.

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Key words : 1. Heart assist device
2. Cardiopulmonary bypass

Case Report

A 4-months old male patient (6.5 kg) underwent surgical repair of ventricular septal defect. On preoperative echocardiographic examination revealed Eisenmenger type large muscular outlet ventricular septal defect with grade II/IV mitral regurgitation and grade I/IV tricuspid regurgitation, left ventricular end-systolic dimension and end-diastolic dimension were 32, 19 mm respectively. On cardiac catheterization, pulmonary artery pressure was 83/20 mmHg (mean 56 mmHg), right ventricular systolic pressure was 91 mmHg (right ventricular end-diastolic

pressure, 9 mmHg), pulmonary to systemic flow ratio of 1.7:1, and pulmonary vascular resistance was 5.5 unit/m².

He had two times admission history due to congestive heart failure and pneumonia (Fig. 1). Preoperatively, he was medicated to congestive heart failure with dopamine (5 ug/kg/min), digitalis, diuretics, and vasodilator.

At operation, total cardiopulmonary bypass was instituted with bicaval and aortic cannulation. Heart was arrested with 20 ml/kg of modified St. Thomas cardioplegic solution at 4°C, and Dacron patch closure of the ventricular septal defect (patent foramen ovale was closed) was accomplished (total ischemic time, 20 min). Attempts

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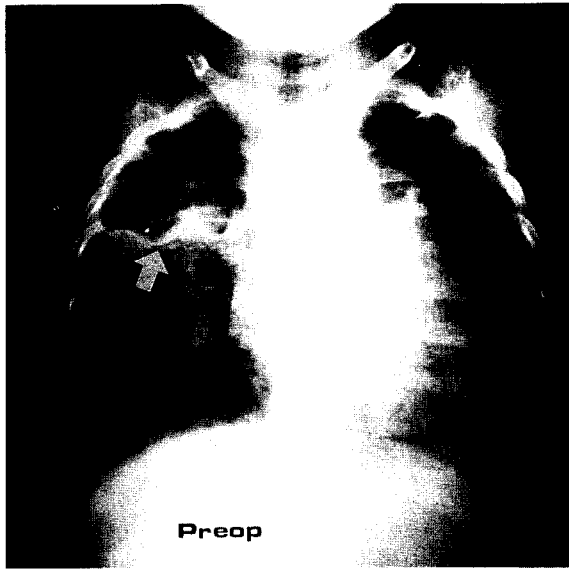


Fig. 1. Preoperative chest X-ray (arrow indicate pneumonic atelectasis)

to wean the patient from cardiopulmonary bypass was failed. Transesophageal echocardiogram revealed global left ventricular dysfunction with paradoxical septal motion. Despite maximal pharmacologic support, further attempts to wean the patient from bypass was failed. Thus, mechanical circulatory support with a Bio-Medicus (BP50; Bio-Medicus, minneapolis, MN) ventricular assist device was instituted. A 20 French Stocket-Shiley® straight cannula was inserted to the left atrium through the right upper pulmonary vein. Blood was returned to the ascending aorta through a 4.7 mm aortic cannula (Argyle®). Flow from the Bio-Medicus pump was maintained at 650~700 ml/min (cardiac index 2.5 L/min/m²) and patient was weaned from bypass (total bypass time, 315 min). After biopump institution, mean arterial pressure was 60~65 mmHg, left and right atrial pressure were 10~15 mmHg, and urine output was satisfactory amount. The sternum was left open and the skin was reapproximated with interrupted suture (Fig. 2). During the first 24 hours, the patient's condition was stabilized. Average pump flow was maintained 650 ml/min, and low dose dopamine and nitroglycerine were infused. Postoperative bleeding was 200 ml, necessitating the transfusion of 250 ml whole blood, and fresh frozen plasma of 300 ml during the first 24 hours

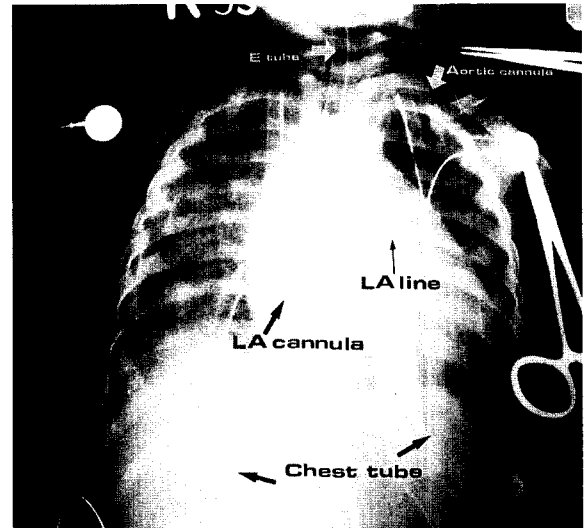


Fig. 2. After biopump institution (E-tube: endotracheal tube, LA: left atrium)

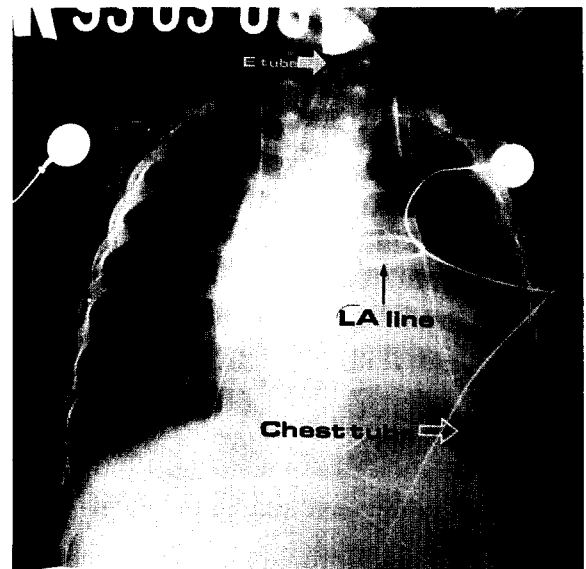


Fig. 3. After removal of biopump

of support. Transesophageal echocardiogram on postoperative 6 hour revealed slight improvement of ventricular wall motion and septal hypokinesia. Postoperative 1 day (20 hour) repeat TEE revealed good septal wall motion, but continued decreased apical wall motion. At postoperative 24 hour, during intermittent pump stop,

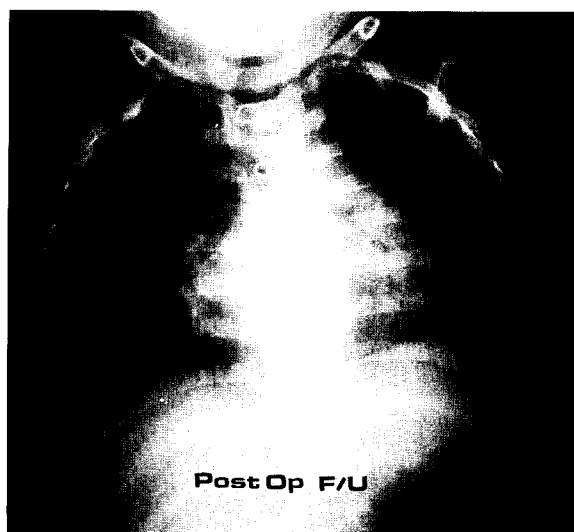


Fig. 4. Follow up chest X-ray after discharge

patient vital signs were stable (left and right atrial pressures, 10~13 mmHg, good ventricular function on echocardiogram). Before the weaning process was begun, systemic heparinization was instituted (100 unit per kg).

Bio-pump flows were progressively decreased without increase in left atrial or central venous pressure. At 25 hours of pump support, the patient was completely weaned from bio-pump support. The cannulas were removed and the sternum was closed (Fig. 3). The patient remained hemodynamically stable with extubated from mechanical ventilatory support at postoperative 5 days and transferred to pediatric department due to pneumonia at postoperative 14 days. He was discharged at postoperative 24 days and medicated digoxin, captopril, and furosemide. After then, he is well being state (Fig. 4).

Discussion

In spite of the current success of cardiac surgery, a small percent of patients develop severe postcardiotomy ventricular failure after operation that is refractory to pharmacologic and intra-aortic balloon pump support. The first successful application of mechanical circulatory support in a patient with cardiogenic shock after a cardiac operation was performed in the mid 1960s by Spencer and DeBakey. Postcardiotomy circulatory support has been

accomplished successfully in many patient with numerous systems, including roller pumps, centrifugal pumps, and the sac-type pulsatile pneumatic pumps^{1, 2)}.

Mechanical circulatory support devices have been used to support patients with cardiogenic shock after acute myocardial infarction and as a bridge to cardiac transplantation. A significant percentage of cardiac surgical candidates develop postoperative cardiogenic shock. The need for IABP support in elective cardiac surgical cases ranges from 1~7%^{3, 4)} and survival rate in these IABP patients range from 40~60%^{3, 4)}.

The rate of the using VAD support²⁾ in patients having cardiac surgery is 0.1 to 0.8% with survival ranging from 29% to 50% in some of the large series. By Norman and associates report⁴⁾, hemodynamic criteria include a cardiac index of less than 1.8 L/min/m², an elevated systemic vascular resistance (usually greater than 2,100 dyne/sec/cm⁵), systolic arterial pressure greater 20 mmHg, and urine output less than 20 ml/hr. These criteria should persist despite maximal pharmacologic and IABP support. Results⁵⁾ of patients receiving VAD support are the best survival in patients with congenital heart defect probably due to the lack of ischemic disease and a low incidence of previous muscle damage, the worst survival is in patients with postinfarction ventricular septal defect repairs, ischemic disease and aneurysms.

The risk factors⁶⁾ to evaluate before VAD insertion are unsuccessful operation, preoperative or intraoperative myocardial infarction, biventricular failure, multiple previous infarction history of congestive heart failure, more than 65 years old, uncontrollable bleeding while on cardiopulmonary bypass and cardiac surgical procedure within 10 days. The exclusion criteria⁵⁾ for patients requiring postcardiotomy mechanical circulatory support are include renal failure (BUN > 75 mg/dl, creatinine > 5), severe peripheral vascular disease, symptomatic cerebrovascular disease, cancer with metastasis, severe hepatic disease, coagulopathy, severe infections resistant to therapy, and history of congestive heart failure or multiple myocardial infarction (unless transplant candidate). Various types of mechanical circulatory support devices are currently available. Pneumatic sac-type pumps and implantable left ventricular assist device were purpose of

perfusing patients for greater than 7 days. Centrifugal and roller pumps were designed for short-term (several hours) use during cardiac operations^{1, 7)}. Approximately 40%⁸⁾ of postcardiotomy patients receiving assist device develop bleeding complications and require reexploration for bleeding. Factors for bleeding include multiple cannulation sites, coagulopathy induced by prolonged CPB, and the need for heparinization. Meticulous surgical technique is the best way to reduce the bleeding risk of multiple cannulation site. In patient with centrifugal pumps, heparin may be neutralized in the operating room and withheld for the first 24~36 hours until postoperative bleeding decreases. Thereafter low dose intravenous heparin (activated clotting time, 140~150sec) can be started electively. Weaning from the VAD should not begin until the hemodynamics have been stable for at least several hours. Once the patient is return to ICU, dopamine infusion reduce to one or 2 ug/kg/min and isoproterenol should be decrease to 0.01 ug/kg/min, low dose vasodilator such as nitroprusside and hydralazine are often necessary. The first 24 hours, assist device flow is maintained to keep the right and left atrial pressure at approximately 10~15 mmHg with a mean aortic pressure of 70~75 mmHg, pump flow index should be at 2.2~2.5 L/m²/min. After 24 hours, pump on-pump off data may be obtain with the device temporarily turn off (not more than 1 minute). Left and right atrial pulmonary artery, and systemic pressure, cardiac output, and mixed venous oxygen saturation should be measured and compared with similar data obtained with the device on. Once the patient is able to maintain an atrial pressure less than 15 mmHg, and a cardiac index greater than 2 L/min/m² with the device off, the weaning process should begin. A continuous heparin infusion should be instituted to maintain the activated clotting time at 140~150sec or the partial thromboplastin

time at 1.5 times control. Flow through the device should then be decreased gradually. During this initial period, inotropic support should not increase to maintain to stable hemodynamics. If a reduction in flow results in deterioration of preweaning hemodynamics, flow should be increased and weaning suspended for 12~24 hours. Once the patient able to maintain the preweaning hemodynamics with low doses of inotropic drugs, the device is ready to be removed.

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