

# Interhospital Air Transport of a Blind Patient on Extracorporeal Life Support with Consecutive and Successful Left Ventricular Assist Device Implantation

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**Abstract:** The use of extracorporeal life support systems (ECLS) in patients with postcardiotomy low cardiac output syndrome (LCO) as a bridge to recovery and bridge to implantation of ventricular assist device (VAD) is common nowadays. A 59-year-old patient with acute myocardial infarction received a percutaneous transluminal angioplasty and stenting of the circumflex artery. During catheterization of the left coronary artery (LAD), the patient showed ventricular fibrillation and required defibrillation and cardiopulmonary resuscitation. After implantation of an intra-aortic balloon pump, the patient immediately was transmitted to the operating room. He received emergency coronary artery bypass grafting in a beating heart technique using pump-assisted minimal extracorporeal circulation circuit

(MECC). Two bypass grafts were performed to the LAD and the right posterior descending artery. Despite initial successful weaning off cardiopulmonary bypass with high-dose inotropic support, the patient presented postcardiotomy LCO and an ECLS was implanted. The primary setup of the heparin-coated MECC system was modified and used postoperatively. As a result of the absence of an in-house VAD program, the patient was switched to a transportable ECLS the next day and was transferred by helicopter to the nearest VAD center where the patient received a successful insertion of a left VAD 3 days later. **Keywords:** minimized extracorporeal circulation, extracorporeal life support, interhospital air transport, left ventricular assist device. *JECT. 2014;46:166–169*

Previous reports in the literature demonstrate the feasibility and safety of portable extracorporeal life support systems (ECLSs) in interhospital transport of critically ill patients in cardiogenic shock from outlying community hospitals to specialized centers of maximum medical care for further treatment, e.g., implantation of a ventricular assist device (VAD) and transplantation. Air transport of patients on extracorporeal life support poses a high degree of logistic effort, equipment, and specialized personnel (1–3). ECLSs are also reported to offer prolonged and safe support as a bridge to a decision in patients with cardiogenic shock (4,5). In the following case, we illustrate the successful decision-making from initial presentation of the

patient in our catheterization laboratory, emergency aortocoronary bypass operation, modification of the used minimized extracorporeal cardiopulmonary bypass system as a postoperative ECLS, followed by switch to a transportable ECLS the next day, and the air transfer of the patient to a nearby cardiac center of maximum medical care for implantation of a left ventricular assist device (LVAD).

## DESCRIPTION

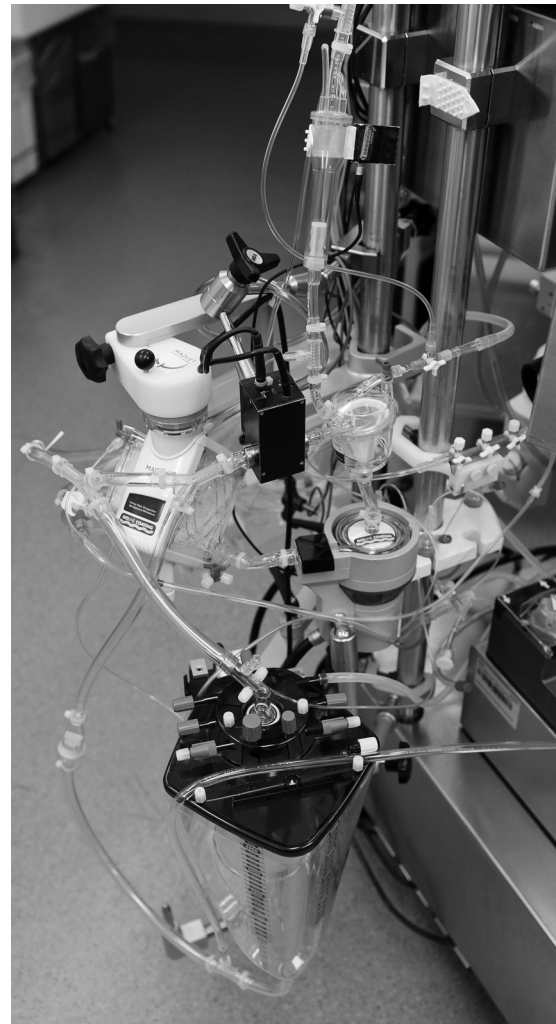
A 59-year-old blind man (height 176 cm, body weight 100 kg) with beginning cardiogenic shock, pulmonary edema, and sinus tachycardia presented to our catheterization laboratory for coronary angiography, which revealed triple-vessel disease with occlusion of left anterior descendens (LAD), circumflex artery (CX), and right posterior descending artery (RPDA). He received three drug-eluting stents (Science Pro; Abbott Vascular, Wetzlar, Germany) in the circumflex artery. During angioplasty of the CX, he suddenly developed hemodynamic

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instability and required cardiopulmonary resuscitation (CPR), inotropic support, and endotracheal intubation. After initial stabilization and during the angioplasty of the LAD, ventricular fibrillation occurred, which required defibrillation once. Two more episodes of CPR occurred during the percutaneous coronary intervention. An intra-aortic balloon pump using a 7.5-French linear balloon was implanted in the right femoral artery (MAQUET Cardiopulmonary AG, Hirrlingen, Germany). After consultation with the cardiac surgeon, the patient was immediately transferred to the operating room for emergency coronary artery bypass grafting. Intraoperative transesophageal echocardiography (TEE) revealed a mild regurgitation of the aortic valve (Grade I) with minor restriction of the left and right coronary leaflets. This finding was not considered as an indication for an aortic valve replacement at this time. The minimal extracorporeal circulation circuit (MECC) system (Figure 1), a closed heparin-coated (BIOLINE) minimized extracorporeal circuit (MAQUET Cardiopulmonary AG), was selected using standard priming of 500 mL mannitol 10%, 300 mL hydroxyethyl starch 6%, and 10,000 units heparin. A standard median sternotomy was performed and 42,000 units heparin were administered, aiming at the precalculated heparin concentration of 6.2 units/mL blood to reach an activated clotting time of 450 seconds. For calculation of the heparin concentration, the Hepcon<sup>®</sup> HMS Plus system was used (Medtronic GmbH, Meerbusch, Germany). The aorta was cannulated using a 21-French EZ Glide arterial cannula (Edwards Lifesciences Service GmbH, Unterschleissheim, Germany) and the right atrium was cannulated with a 29-French triple-stage cannula (MAQUET Cardiopulmonary AG) routinely. The MECC system was then connected to the cannulae. The minimized circuit comprised a Rotaflow centrifugal pump, a Quadrox-i oxygenator, and a venous bubble trap (VBT). As a result of the exclusion of cardiotomy suction, the use of a cell saver device was applied during the procedure to collect and process shed blood. Before institution of cardiopulmonary bypass (CPB) in normothermia and with a calculated flow of 2.5 L/min/m<sup>2</sup>, the retrograde autologous priming technique was applied to reduce prime to 350 mL and to fill the system with autologous blood to minimize hemodilution. The patient received two bypass grafts in an on-pump beating heart technique, the left internal mammary artery to the LAD and a saphenous vein graft to the RPDA. Total CPB time was 128 minutes. Initial weaning off CPB was successful despite increasing need of inotropic support (.6 µg/kg/min norepinephrine, .1 µg/kg/min epinephrine, and .5 µg/kg/min milrinone). During chest closure, hemodynamic instability occurred and the decision was made to implant an ECLS for temporary support. A 8-mm Dacron graft was anastomosed to the ascending aorta for later exit subxiphoidally and a heparin-coated 19-French arterial



**Figure 1.** Standard minimized extracorporeal circulation circuit mounted on a HL 20 heart-lung machine (MAQUET Cardiopulmonary AG, Hirrlingen, Germany). The hardshell reservoir functions as cell saver reservoir and is routinely clamped off during cardiopulmonary bypass. The modular setup offers the possibility to switch the system to conventional bypass (open circuit) at any time, e.g., in case of massive air entrance.

Bio-Medicus<sup>®</sup> cannula (Medtronic GmbH) was inserted into the prosthesis. For venous cannulation, the right femoral vein was chosen and a 21-French venous Bio-Medicus<sup>®</sup> cannula (Medtronic GmbH) was inserted percutaneously. A novel in-house approach was opted for selection of the ECLS by downsizing the preused MECC system for further application in terms of a prolonged reperfusion. The VBT was cut off and the MECC system was moved onto the Rotaflow ECLS console (Figure 2). After initiating of a flow of 5 L/min, the patient was transferred to intensive care unit with the chest closed and in stable hemodynamic condition. The inotropic support was reduced consecutively the following hours and only norepinephrine was given in a moderate dose of .2 µg/kg/min overnight. The lactate



**Figure 2.** Image section: x, indicate the position for cutoff and reconnection of the 3/8-inch tubing for conversion to the temporary extracorporeal life support system (ECLS); 1, venous line to venous bubble trap (routinely open); 2, inlet to modular hardshell reservoir (routinely clamped off); 3, outlet from modular hardshell reservoir to venous bubble trap (routinely clamped off); 4, venous bubble trap (VBT).

decreased from initial 13 to 2 mmol/L and the urine output remained moderate. On the next morning, a TEE under gradually reduced ECLS flow and stimulation with epinephrine showed no contractility of the left ventricle. In a team approach and after consultation with the relatives, the decision was made to transfer the patient to the next cardiac center of maximum medical care for implantation of a LVAD. The countywide responsible medical rescue helicopter service (DRF) was involved and an EC 145 helicopter with crew (pilot, emergency physician, paramedic) was ordered for the 80-km distance flight. Before the interhospital air transport, the ECLS was switched to Cardiohelp® (MAQUET Cardiopulmonary) using the same cannulae, mainly to provide the patient with a long-term ECLS support system (CE licensed for 30 days in Europe) and as a result of the valid air transport license of the system. During the 20-minute flight, the helicopter crew was accompanied by a local clinical perfusionist. Patient monitoring consisted of invasive blood pressure and central venous pressure measurement, electrocardiography, capnography, and pulse oximetry. In addition, the Cardiohelp® system provided continuous monitoring of the arterial pressure, the venous pressure, the internal systemic pressure, the venous saturation, hematocrit, hemoglobin, and venous temperature. The activated clotting time was kept between 150 and 180 seconds. Three days after arrival at the VAD and transplantation center and further evaluation and consultation with family regarding the patient's eligibility for assist device implantation as a result of the amaurosis, the patient received a scheduled implantation of a HeartWare® LVAD system (HVAD®; HeartWare GmbH, Hannover,

Germany). Preoperative TEE revealed a progressed aortic insufficiency of Grade III most likely resulting from the pre-existing mild regurgitation combined with the partial retrograde aortic flow pattern of the ECLS. For this reason, a 25-mm Perimount aortic valve prosthesis (Edwards Lifesciences, Unterschleissheim, Germany) was implanted. The operation was carried out by switching to a conventional heart-lung machine (Stoeckert S5; Sorin Group Deutschland, Munich, Germany) and administration of 1500 mL crystalloid Custodiol® cardioplegia (Dr. Köhler Chemie, Bensheim, Germany) with an aortic cross-clamp time of 62 minutes. The sewing ring was sutured to the apex, the HVAD® pump attached, and the outflow graft was anastomosed to the existing aortic ECLS graft. After slowly deairing the system, the flow of the CPB was gradually reduced while simultaneously increasing the speed of the LVAD to 2800 rpm and a flow of 5 L/min. The CPB time was 114 minutes. On the third postoperative day (POD), the patient was taken back to surgery for definite chest closure. The postoperative course was complicated by prolonged mechanical ventilation and required tracheostomy (POD 7) and renal replacement therapy for 6 days. The patient fully recovered from the implant surgery and was sent to rehabilitation 6 weeks after LVAD implantation. Three weeks later, he was discharged home and is currently functionally independent in his activities of daily life and competent with operation of the system. This was achieved both by the patient's strict adaption of a certain time scheme in his daily routine of changing the controller batteries, only supported by the timer of a wristwatch with synthesized voice and the controller's acoustic alarm signaling and the support by his family. It enables the patient to independently manage his life without being able to access visual alarms or the use of any additional features like Braille labeling of the device.

## DISCUSSION

The concept of ECLS-assisted prolonged reperfusion as a bridge to recovery, to implantation of a LVAD/VAD and to transplantation, or as in our case as an intermediate bridge to decision in patients with severe refractory cardiogenic shock has been well described in the literature (6,7). By a gain of time, the concept serves both the involved medical experts by providing valuable time for an optimal and comprehensive decision-making and the patient by being provided the best considered treatment option for his or her condition. A novel in-house approach was used by downsizing the intraoperatively applied MECC system to further function as an intermediate bridge-to-decision ECLS until POD 1. The advantages of our concept were the saving of time, effort, and costs of

setting up a new ECLS. As a result of the sole air license of the Cardiohelp<sup>®</sup> and the large cost differential between our two available ECLS sets (PLS and HLS), we established an in-house protocol to use the Cardiohelp<sup>®</sup> HLS set only for patients eligible for air and ground transport to nearby cardiac centers with an established assist device and transplantation program. A critical part was the patient's amaurosis, acquired in the year 2000 as a long-term consequence of a surgical correction of a traumatic retinal detachment in 1970. For this reason, intense and close involvement of the medical teams in both cardiac centers and the family at each single step of the treatment course was required. So far and despite intense medical research, we found this is the first report of implantation of a LVAD in a patient with acquired amaurosis. The patient was discharged home on POD 61 after 3 weeks of rehabilitation at an institution specialized in patients with LVAD. In conclusion, our experience suggests that the concept of air transport of critically ill patients on ECLS support from a cardiac center without a VAD and transplantation program to a center of maximum medical care is safe and feasible and further opens the opportunity to establish an interhospital network with

the aim to provide each patient with the individual level of medical care needed.

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