How-to-do-it

Implantation of left ventricular support under extracorporeal membrane oxygenation

Guillaume Lebreton *, Michaela Nicolescu, Philippe Léger, Pascal Leprince

Cardio-Thoracic Surgery Department, Pitié-Salpêtrière Hospital, Paris, France

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Abstract

Continuous-flow left ventricular assist devices (LVADs) are used to manage patients with end-stage heart failure. Protection of right ventricular (RV) function is important during LVAD implantation, but sometimes patients require temporary RV support. We describe the technique of LVAD implantation under extracorporeal membrane oxygenation (ECMO) we use in our center. This technique allows soft loading of the right ventricle once LVAD is started and even short-term RV support if required.

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1. Introduction

Continuous-flow left ventricular assist devices (LVADs) are used to manage patients with end-stage heart failure, while awaiting transplantation, recovery, or as a permanent implant. These devices are durable and reliable, and have both a survival [1] and a quality-of-life benefit [2]. Some patients in cardiogenic shock first require emergency implantation of extracorporeal membrane oxygenation (ECMO), followed by LVAD support [3].

Protection of right ventricular (RV) function is important during LVAD implantation, but sometimes patients require temporary RV support. The technique of LVAD implantation under ECMO we use in our center allows soft loading of the right ventricle once LVAD is started and even short-term RV support if required.

2. Patients and methods

2.1. Study population (Table 1)

Between March 2009 and March 2010, in 9 of the 15 LVADs implanted in our center, implantation was performed on peripheral ECMO. Among these nine patients, six were already receiving ECMO assistance for cardiogenic shock prior to LVAD implantation (bridge to bridge) (Table 2). In the other three patients, LVAD implantation was performed under elective ECMO.

Three patients required prolonged ECMO support after LVAD implantation due to RV failure; this regressed over a few days, allowing ECMO weaning. One of these patients died from severe sepsis 7 days after weaning.

2.2. ECMO characteristics

The extracorporeal system consisted of polyvinyl chloride tubing, a membrane oxygenator (Quadrox Bioline, Jostra-Maquet, Orléans, France), a centrifugal pump (Rotaflow, Jostra-Maquet, Orléans, France), and arterial (16–20 Fr) and venous (24–28 Fr) femoral cannulae (Biomedicus Carmeda, Medtronic, Boulogne-Billancourt, France). Vessels are surgically controlled through a transversal incision and cannulae are inserted according to the Seldinger technique. An oxygen/air blender (Sechrist Industries, Anaheim, CA, USA) was used to ventilate the membrane oxygenator. An additional 5-Fr cannula was inserted distally into the femoral artery to prevent possible leg ischemia.

2.3. LVAD implantation

After sternotomy, preparation of the LVAD pocket and drive-line tunnelization are carried out prior to heparin injection. If the patient is not ECMO-assisted, cannulae are surgically inserted at this time. After pericardotomy, the outflow line is anastomosed to the aorta under lateral clamping. Apical cannula insertion is performed on beating
heart and LVAD implantation is performed according to usual procedure. Moving the apex toward anterior direction is well tolerated on ECMO. Bleeding is treated through cell saver during the entire sequence and treated blood is reinjected into the ECMO circuit.

Pump rotation speed was progressively increased from 6000 to 8000, while the ECMO pump rotation speed was decreased to obtain an outflow around 2.5–3 l min⁻¹ depending on the body surface area of the patient. Then, pump rotation speed was adapted according to the filling of the left ventricle (LV) assessed with TOE (Transthoracic Echocardiogram). Usually, if the function of the right ventricle is good enough, there is a part of ‘auto-adaptation’ more flow being spontaneously pumped through the right ventricle. Of course, partial unloading of the right side with an ECMO allows adequate filling of the patient without stressing the right cavities. Moreover, this adaptation is performed progressively over at least 1 h, while surgical and biological hemostasis as well as chest closure are performed, and under continuous TOE assessment.

Once the chest is closed, attempt is made to wean the patient from the ECMO, still on TOE monitoring. If decreasing the ECMO outflow and increasing the pump rotation speed lead to LV cavity collapse or even if there is any doubt, then the ECMO is set up again between 2 and 3 l min⁻¹, and optimal pump rotation speed adapted to LV filling assessed with echo. The adequacy of the outflow is also determined through the stability of biology parameters such as lactates or creatinine. In this situation, it is rare to observe opening the aortic valve.

During the following days, once the patient is stabilized regarding hemodynamic, diuresis, bleeding, and inotropes, then the filling of the LV is assessed again with TOE, trying to increase the rotation speed of the pump and decreasing that of the ECMO. Of course, distension of the RV is also estimated at the same time but the main criteria is to be able to set up the pump rotation speed at least at 9000 rpm without experiencing LV cavity collapse and while decreasing the ECMO outflow. Finally, if weaning seems possible, then an ultimate test of 10–15 min ECMO stop is performed after a intravenous bolus of 5000 units of heparin. Removal of the cannulae is performed at bedside and does not require transfer to the operating room.

3. Discussion

It is vital to protect RV function during LVAD implantation as this will ensure right outflow adapted to LVAD outflow. The effects of LVADs on RV function are intricate, making cardiopulmonary bypass (CPB) weaning difficult. Although continuous axial flow LVAD appears to benefit RV function [4], implantation of an LVAD might reveal RV dysfunction [5]. Prior to LVAD implantation, right heart outflow is moderate as it is limited by left-side failure. Therefore, right dysfunction may be concealed by LV failure and reveal itself after LVAD implantation. In this case, CPB weaning is difficult or even impossible and may require transient support of the RV. Implanting an RV support in this situation means prolonging CPB duration, increasing the risk of bleeding complications, and reopening the chest at the time of weaning. The use of ECMO to assist LVAD implantation simplifies post-implantation management of RV function: it allows a progressive loading of the RV without prolonging either the CPB or the open chest time, does not require additional surgery, and can help patient oxygenation in case of pre-existing pulmonary edema. RV function is assessed after hemostasis and thorax closure, and ECMO weaning is discussed. Weaning is carried out under TOE monitoring. When immediate postoperative weaning seems questionable, ECMO assistance is maintained and RV function and weaning feasibility are reassessed in the intensive care unit (ICU). Of course, in patients already supported with a peripheral ECMO, implanting the LVAD on ECMO makes every step easier.

In conclusion, LVADs have a proven performance and efficacy for the management of end-stage heart failure. However, LVAD implantation remains difficult in terms of RV function, especially when weaning from CPB. The use of ECMO during LVAD implantation simplifies the procedure, particularly the management of RV function.

### Table 1. Patient characteristics.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Gender</th>
<th>Etiology</th>
<th>Ejection fraction (%)</th>
<th>Mean PAP (mmHg)</th>
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</thead>
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<td>18 [8–25]</td>
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<tr>
<td>Female</td>
<td>Male</td>
<td>Non-ischemic</td>
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</table>

Mean PAP, mean pulmonary artery pressure.

### Table 2. Surgical characteristics of the study population.

<table>
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<th>Patient no.</th>
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<th>Duration of ECMO before LVAD implantation (days)</th>
<th>Duration of ECMO after LVAD implantation (days)</th>
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LVAD, left ventricular assist device; ECMO, extracorporeal membrane oxygenation.
References


