

# Immediate Post-LVAD Implant Support: Two Approaches

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**Abstract:** Increased use of left ventricular assist devices (LVAD) as bridges to transplant has revealed the need for short-term right heart support for deairing and right ventricular recovery. The two approaches described are implemented as the patient is weaned from regular cardiopulmonary bypass. Dependent on patient needs, the surgeon may select a high-flow or low-flow approach to what is essentially right heart bypass. Both methods use the existing venous drainage from the right side of the heart. The higher flow returns blood through a 0.25-in tube connected to a modified adult vent (AV) to the pulmonary artery (PA).

This provides flows as high as 3.5 L/min. The low-flow method uses the cardioplegia line, which goes unused during LVAD insertion. It is attached to the same modified AV cannula, placed into the PA, with flows between 400 and 600 ml/min. Each method has its advantages, disadvantages, and quirks. The results are functionally successful in allowing support of the right heart and deairing of the ventricular device. **Keywords:** left ventricular assist device, implant, support, deairing, right heart bypass, pulmonary artery, right heart failure. *JECT. 2005;37:373–376*

This report describes two techniques developed to aid in deairing a left ventricular assist device (LVAD) and the native left ventricle (LV), as well as protect the right ventricle (RV) during immediate post-LVAD implantation. LVAD performance is dependent on RV function (1). Right ventricular failure necessitating long-term right ventricular assist device (RVAD) is difficult to predict, is poorly understood, and is associated with greater mortality (2). Previous investigators have described methods to protect RV function using right heart bypass (RHB) to ensure a smoother and safer transition from cardiopulmonary bypass (CPB) to LVAD, but our techniques differ from theirs (3). They performed right heart bypass to the left atrium (LA), LV, or superior pulmonary vein (SPV), whereas we return flow to the pulmonary artery (PA) (4). At this time, the LVAD device operator, anesthesiologist, and surgeon are all making adjustments to balance and fine tune the LVAD. Simultaneously, the left ventricle can be decompressed by the draw from the device. The decompressed left ventricle distorts the septal

wall, disturbing RV contractility (1). The challenged RV output drops, making the LA filling problem worse and further disrupting flow to the LVAD. This starts a downward cycle to RV failure and the possible need for a RVAD insertion.

One suggestion was to use a heart lung machine, converted to RHB, to support the RV and increase filling of the LA. This would reduce or avoid decompression of the LV and reduce possible air embolism (4).

## MATERIALS AND METHODS

Typical CPB is achieved using DLP 22- or 24-Fr (Medtronic, Minneapolis, MN) right angle and straight cannulae for dual venous cannulation and 21-Fr Aortic Flex or 24-Fr Soft Flow (Terumo, Ann Arbor, MI) cannulae for arterial return to the aorta. Two approaches were developed 1 day when the desire arose for right heart support after bypass. The goal was to use the cardioplegia line of a 4:1 blood cardioplegia system, isolated from the crystalloid cardioplegia, to perfuse the PA using the existing bicaval cannulation for drainage. However, the desired flow of 2–3 L/min would not be achievable through the smaller 3/16 by 1/16 cardioplegia delivery line. Therefore, this low-flow approach was not used on this day.

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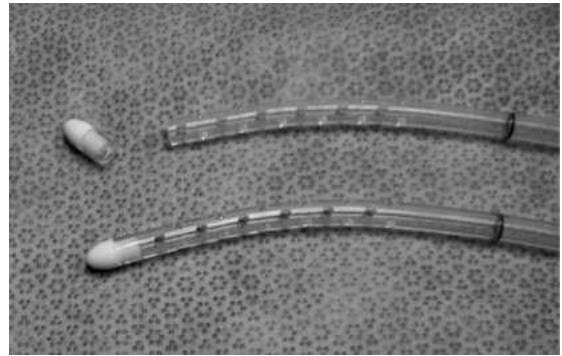
The second, high-flow approach uses a stock ¼ by 3/32-in 6-ft line, handed back sterile from the field, attached to an existing ¼-in Y connector on our recirculation line. The recirculation line runs postoutlet of the oxygenator to a filtered port on the cardiotomy reservoir.

Adaptation of a cannula for the PA return was also a consideration. Use of a 20-Fr adult vent (A-V vent), with the tip cut off, provides diffuse return to the artery in combination with flows up to 3.5 L (Figure 1). Resistance to flow has been as high as 280 mmHg at 3.5-L flow. The surgeon desired a simple solution with little or no change to the heart lung circuit. Both approaches achieve this goal.

The low-flow approach, using the cardioplegia system, can be used when less support or the sudden need for RV support arises. Flows close to a liter have been achieved when patient PA resistance was low. Typical flows range from 400 to 600 ml/min (Figure 2).

Some items to note with the low-flow method are the need to maintain flow through a recirculation line, that the main pump flow be maintained above the flow through the cardioplegia set, close monitoring of cardioplegia line pressures because of higher line resistance, and clamping the crystalloid cardioplegia line on the blood cardioplegia system. We do not routinely arrest the heart with LVAD insertion so the cardioplegia system is primed with Plas-malyte A (Baxter, Deerfield, IL).

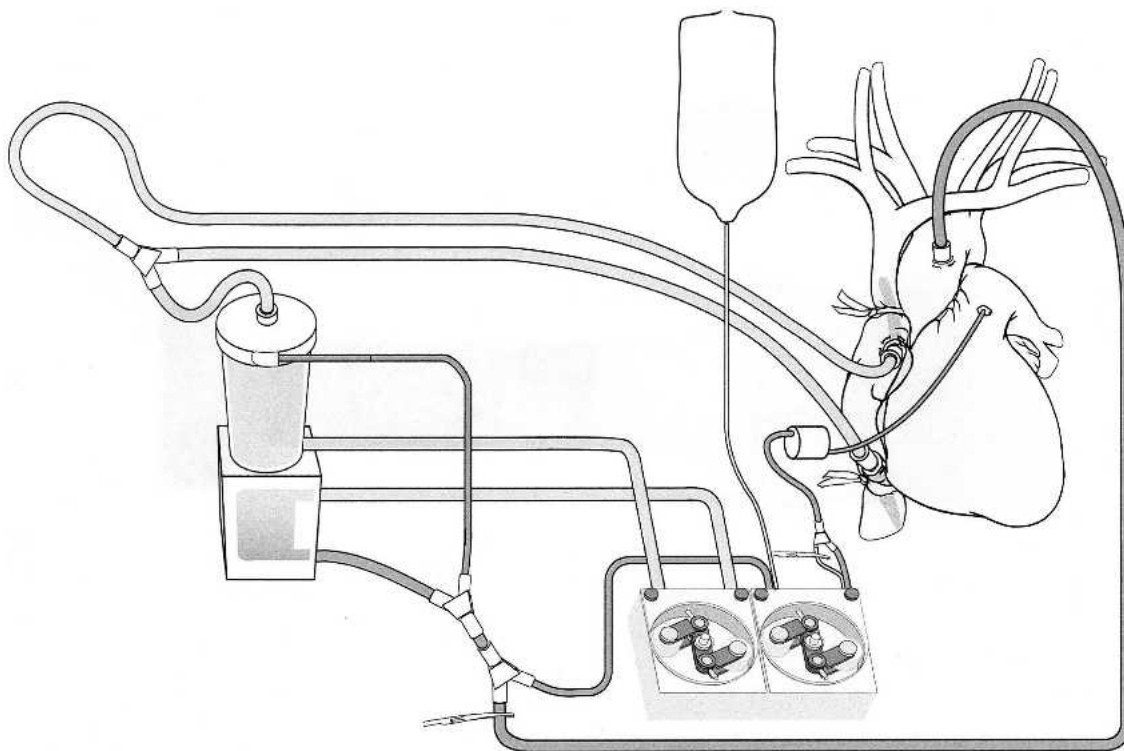
The approximate added cost of this system over and above the heart lung pack is the A-V vent used for rein-



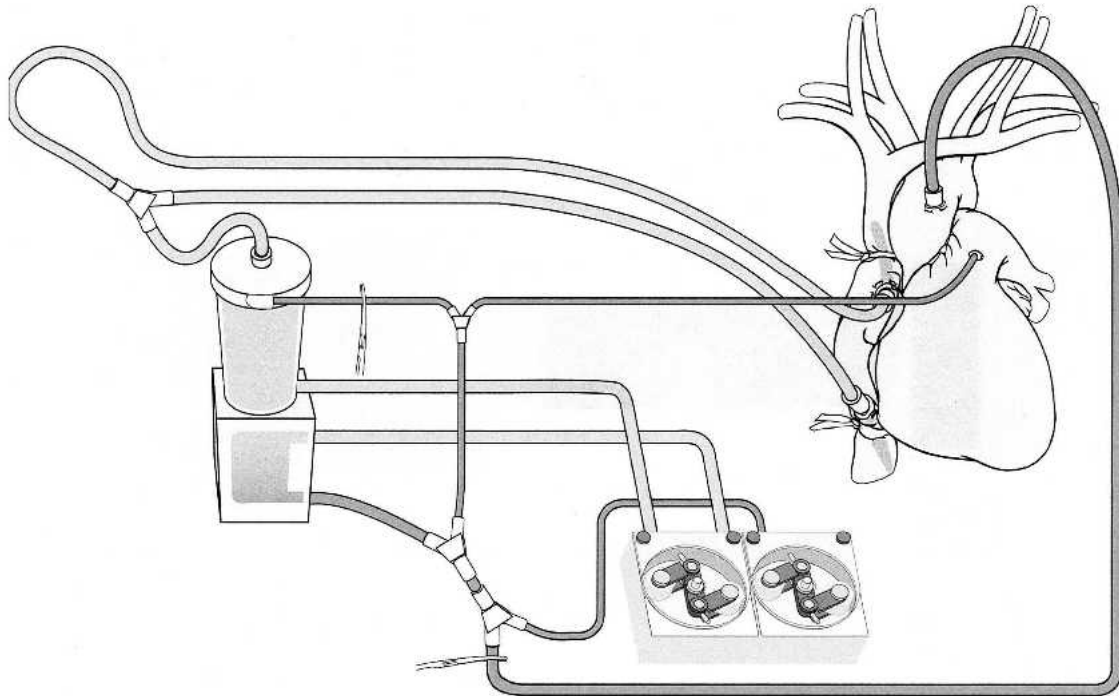
**Figure 1.** Adult vent (20 Fr) with tip removed to decrease resistance and increase flow.

fusion (\$20.00). One drawback is the possible need for a spare cardioplegia line if CPB, cross-clamping, and cardioplegia are needed for some reason after conversion to RHB.

The high-flow approach is easily set up for every LVAD insertion with the only added expense above the low-flow system being the ¼-in line cost (\$6.50). The flow to the PA is that of the arterial pump head because the recirculation line is clamped distal to the Y connection where the PA perfusion line is attached. This system also preserves the cardioplegia system if it is needed for the patient. Resistance to flow can be monitored if the clamp on the arterial (A) line is placed distal to the measuring point (Figure 3).



**Figure 2.** Low-flow approach. Run-through cardioplegia system with crystalloid cardioplegia clamped off and recirculation line to reservoir open.



**Figure 3.** High-flow approach. PA perfusion delivered through separate 1/4-in line off recirculation to reservoir. Recirculation line clamped distal to Y to PA.

Both systems are initiated while regular CPB is being used. Weaning from bypass takes place normally, with the exception that weaning is paused at about 2-L flow. The PA pressure is targeted to a mean of 25 mmHg before initiation of RHB. This provides adequate volume for a starting point in the process. Vacuum assisted venous drainage (VAVD) should be turned off at this time. When the surgeon is finished the deairing manipulation, the perfusionist clamps the arterial line. The low-flow approach requires opening of the recirculation line while clamping the regular arterial line distal to the recirculation line supply. The high-flow approach already would have a clamp distal to the 1/4-in Y on the recirculation line; therefore, only clamping of the arterial line would be necessary. Flow can be increased or decreased as needed, and the surgeon can again manipulate the heart to deair the LVAD if necessary. At this time, PA and arterial line pressures will likely equalize. With either approach, some restriction of venous drainage may be needed to balance volume to the right heart and the RHB system. Central venous pressure (CVP) should be at a positive pressure. Typically, the greater the drainage, the more venous restriction that will be needed.

Weaning is typical of any bypass by restricting the venous return, filling the heart, and decreasing PA perfusion until termination of the bypass is achieved.

## RESULTS

Some additional benefits have been observed. In the

event that the deairing process allowed air to travel to the coronary arteries, the RHB provided enough support for cardiac recovery. This leads to use of the aortic root vent for deairing purposes during RHB, with safe return of the vented volume and decreased chance of coronary and systemic air embolus.

Both approaches succeed in keeping changes to the heart lung circuit minimal, the cost low, and support of the right heart as simple and as safe as possible. Previously, the time required for LVAD adjustments and patient stabilization averaged 30 minutes. This time has been reduced to approximately 10 minutes. The patient is typically more stable and therefore at less risk.

The surgeon has expressed preference for the high-flow approach, which is now used on all Heartmate II implantations. Use with other LVAD insertions will be explored. One long-term goal with LVAD research is to use ventricular devices as destination therapy in place of transplant. The high-flow approach may also prove useful in deairing and stabilizing these total artificial hearts.

## DISCUSSION

Successful insertion of a LVAD is not without risk to right heart function. RV support becomes necessary because of pulmonary hypertension, slow recovery of the RV, manipulation of the heart to deair the LVAD, and lack of flow through the heart and device. Typically, most problems occur during the first 30 minutes after weaning from bypass and include decreased cardiac output, RV

injury, embolism, air entrainment, and RV decompensation (3). At the time of presentation, only six RHB-LVAD insertions have been performed, with five more performed at the time of document submission. Therefore, continued monitoring of the method is needed. While the approaches described here continue to work well, we currently only see an advantage to them for the immediate postbypass period, preventing the immediate need for RVAD implantation on a short-term basis. It is too soon to determine if any long-term outcome improvement can be expected.

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