Right-sided heart reperfusion ("Berlin bridge technique") for right ventricle support during left ventricular assist device (LVAD) implantation

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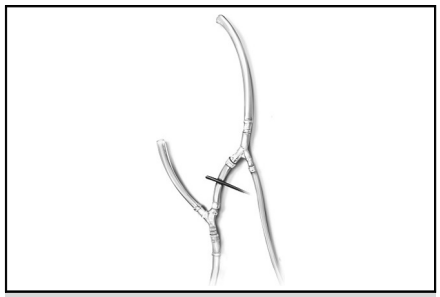

The Berlin bridge technique.

CENTRAL MESSAGE

This manuscript describes a technique of right-sided heart reperfusion (the "Berlin bridge technique") during left ventricular assist device implant.

Attention in recent literature has focused on perioperative right ventricular failure (RVF), although there is also a significant portion of patients who suffer from persistent RVF at the time of left ventricular assist device (LVAD) implantation. Certain factors may be involved, such as intraoperative damage caused by ischemia, volume overload, and increased pulmonary vascular resistance—all of which may worsen outcomes even in patients without severe RVF preoperatively.

RVF is multifactorial, and the increasing left ventricular output after initiation of LVAD support can lead to right ventricle (RV) impairment due to volume overloading of RV associated with increased flow in the systemic circulation or a decrease in RV contractility caused by an intraventricular septal shift into to the left ventricle (excessive drainage produced by LVAD).

In some cases, after LVAD implant because of the aforementioned reasons, the RV can present signs of severe failure and become unresponsive to maximal medical treatment, requiring a temporary ventricular support, which negative impacts the length of intensive care unit and hospital stay as well as affecting morbidity and mortality.

Several options have been described as RV temporary devices, such as venoarterial extracorporeal membrane oxygenation (ECMO), temporary right ventricular assist devices (Biomedicus, ProtekDuo TandemLife), and percutaneous devices (Impella RP, Abiomed, and TandemHeart).

Great interest has been paid to define predict factors of RVF post-LVAD, to allow better management and outcomes in this situation. At least 2 risk models, the Michigan RVF risk score and the CRITT score, have been used to identify patients and predict RVF occurrence and have been shown to be helpful in predicting RVF.[1-3] Despite efforts to better understand the pathophysiology of RVF post-LVAD and the attempt of risk models to predict this clinical situation, the occurrence of RVF remains a situation of great concern, negatively affecting the results after LVAD implant.

According to our experience, this extreme situation for the occurrence of RVF, and sometimes the need for right temporary mechanical support, can be managed through a simple and safe operative technique for immediate RV support. We advocate that through a simple method of initial and short-term RV support, we can safely allow for the gradual establishment of optimal medical treatment for RV function, until the patient has stable hemodynamic conditions for cardiopulmonary bypass (CPB) discontinuity.[4]

We have used a technique of right-sided heart reperfusion, which consists of transferring the aortic cannula flow to the pulmonary artery cannula, after the LVAD implantation. As soon as the CPB support has been reduced to 2 L/min of flow, we provide right ventricular support.[5]

SURGICAL TECHNIQUE

Using tube clamps, we interrupt the arterial flow directed to the aortic cannula and release this arterial flow to the pulmonary artery cannula; as a consequence, oxygenated blood is infused into the pulmonary circulation. We conventionally call this form of intraoperative right ventricular support the "Berlin bridge," as it was for so developed by one of us (Dr Matthias Loebe) at the German Heart Institute of Berlin.

The operative technique for using the "Berlin Bridge" right ventricular intraoperative support can be described as follows:

After systemic heparin has been administered, and immediately before CPB cannulation, the tubes of the CPB machine are connected through 2 Y-connectors, creating an arterial line, a pulmonary line, and a line that will be used as a vent. All these lines are connected and can be used in combination or individually based on the position of the tube clamps (Figure 1).

An aortic cannula is placed in the usual fashion into the ascending aorta and connected to the arterial line. A second cannula (usually a 21-Fr EZ Glide Aortic Cannula; Edwards Lifesciences) is inserted into the main pulmonary artery and connected to the vent suction. (Figure 2). During cannulation of the pulmonary artery, we try to ensure that the tip of the cannula is in the main pulmonary artery, avoiding selective cannulation of one side. Often palpation of the tip of the cannula is sufficient for proper positioning, thus avoiding selective perfusion of one of the pulmonary artery side branches.

The LVAD is implanted with the heart beating, while blood is drained through the vent line connected to the pulmonary artery, helping to keep the operative field bloodless, and the "bridge" tube between arterial and pulmonary cannulas is clamped during implantation (Figure E1).

After completion of the implant procedure, suction is halted, and the device is carefully deaired. When the flow is down to 2 L/min, we start the LVAD and switch to right heart bypass, clamping the aortic cannula and the vent line, the "bridge" connecting line is opened, and right-sided heart reperfusion is initiated (Figure E2).

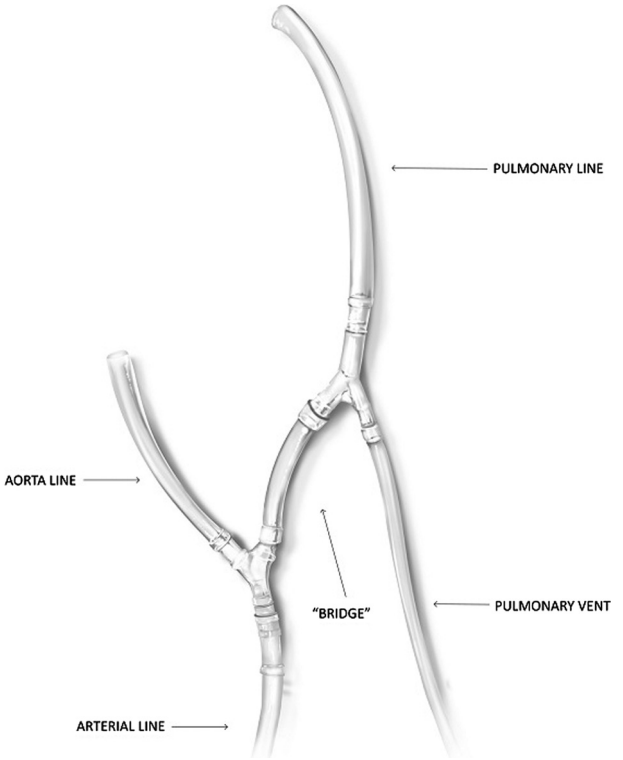

FIGURE 1. Total view of the tube setting before of cardiopulmonary bypass and the connection between arterial line and pulmonary line, during left ventricular assist device implantation pulmonary line is used as the vent.

DISCUSSION

Since its publication in 2001, the authors have used this strategy of temporary mechanical support of the RV to facilitate weaning from CPB during LVAD implant. In our experience, due to the ease of use with this method of temporary right ventricular support, all patients undergoing LVAD implantation, regardless of preoperative hemodynamic characteristics, are cannulated as previously described and discontinued from CPB with this right ventricular support.

This temporary right ventricular support allows the surgical team to maintain greater stability during this critical period of initiation of left ventricular support through the LVAD, while the RV still needs more time for its reperfusion, and for the medical therapy (including nitric oxide inhalation and catecholamine administration) to reach its maximum effect.

In this setting, the left ventricle is supported by the LVAD and the CPB supports the RV. During right-sided heart reperfusion, optimal LVAD function is adjusted, and medical therapy to support right ventricular function is begun. Once hemodynamic stabilization is achieved, CPB support is further reduced and finally discontinued. This simple technique provides excellent right ventricular support after LVAD implantation, and weaning from CPB can be performed under stable conditions without stressing the RV.

In 1998, Tector and colleagues[6] published their experience during LVAD implantation with ECMO shunt for safe transition from CPB to HeartMate. The authors reported that the use of the shunt was developed to allow complete removal of air from the left ventricular support system and to assist the RV during the transition from CPB to LVAD. The technique described in this work involves the insertion of a cannula into the left ventricle between the diagonal and left anterior descending coronary arteries proximal to the apical inflow cannulation site. The ECMO right atrial-to-left ventricular shunt removes venous blood from

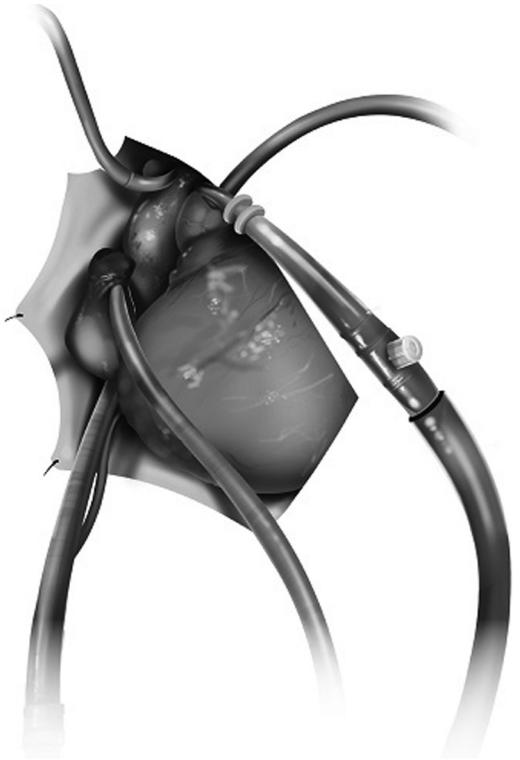

FIGURE 2. Cardiopulmonary bypass installation with aortic cannulation, superior and inferior vena cava cannulation, pulmonary artery cannulation.

the right atrium through the 2-stage venous cannula that was used for CPB. The venous blood passes through the oxygenator and is oxygenated. After the filter, there is a Y-connector that creates 2 arterial lines. One of the arterial lines is connected to the aortic cannula for CPB. The other arterial line is connected to the cannula that is inserted into the left ventricle, completing the ECMO shunt circuit. Despite the technical differences in cannulation sites, the purpose of this ECMO shunt is also to assist the RV during this period of depressed ventricular function, allowing the transition of the support from the CPB to the LVAD.

The "Berlin bridge" technique is used routinely in all our cases of LVAD implantation. The use of the cannula positioned in the pulmonary artery as a vent allows an operating field with less blood, and the positioning of the cannulas and lines do not interfere with access to the operative field, especially with a minimum length of tubes. In our experience, the use of this form of temporary right ventricular support does not increase the occurrence of "suckdown" events, and the use of transesophageal echocardiography allows adequate control of left ventricular filling.

From September 2020 to September 2021, we performed the implantation of 29 LVADs (HeartMate 3 devices). All patients underwent temporary right ventricular support through the "Berlin Bridge" technique and in none of these cases was there a need for prolonged RV support postoperatively.

This period of temporary mechanical ventricular support, until the maximization of other clinical measures, in our experience can represent the difference between the need for prolonged right ventricular support or not.

In conclusion, RVF represents a very serious complication with negative impact in postoperative outcomes after LVAD implant. We present a surgical technique to allow initial and short-term mechanical right ventricular support at the time of LVAD implantation. This technique has been shown to be safe and easily reproducible in the set of open-heart surgery and might achieve the possibility to avoid a temporary right ventricular support in these severe ill patients.

References

1. Atluri P, Goldstone AB, Fairman AS, MacArthur JW, Shudo Y, Cohen JE, et al. Predicting right ventricular failure in the modern, continuous flow left ventricular assist device era. *Ann Thorac Surg*. 2013;96:857-64.
2. MacGowan GA, Schueler S. Right heart failure after left ventricular assist device implantation: early and late. *Curr Opin Cardiol*. 2012;27:296-300.
3. Lo Coco V, De Piero ME, Massimi G, Chiarini G, Raffa GM, Kowalewski M, et al. Right ventricular failure after left ventricular assist device implantation: a review of the literature. *J Thorac Dis*. 2021;13:1256-69.
4. Loebe M, Potapov E, Sodian R, Kopitz M, Noon GP. A safe and simple method of preserving right ventricular function during implantation of a left ventricular assist device. *J Thorac Cardiovasc Surg*. 2001;122:1043.
5. Brozzi N, Cifuentes R, Haq S, Ghodsizad A, Loebe M. Aorto-pulmonary bypass shunt for intraoperative right ventricular support during LVAD implantation. *J Card Surg*. 2020;35:188-90.
6. Tector AJ, Kress DC, Downey FX, Schmahl TM, Dasse KA, Poirier VL. Transition from cardiopulmonary bypass to the HeartMate left ventricular assist device. *Ann Thorac Surg*. 1998;65:643-6.

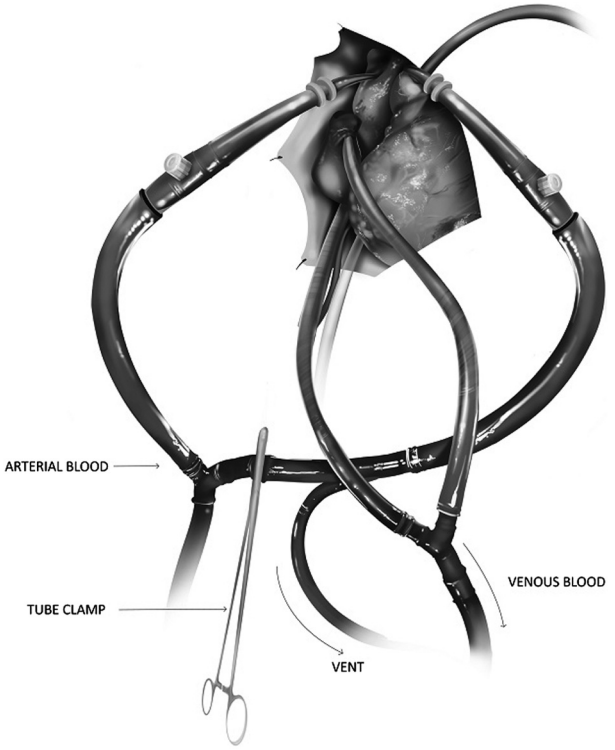

FIGURE E1. The connection between arterial line and pulmonary cannula is clamped. The pulmonary cannula is used as the vent.

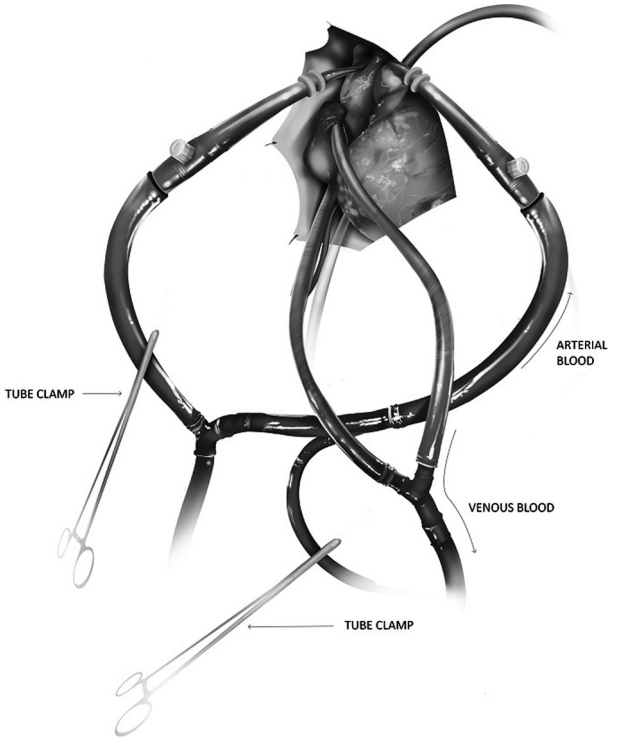

FIGURE E2. The connection between arterial line and pulmonary cannula is opened, and right-sided heart perfusion is initiated with 2 L/min of flow. On hemodynamic stabilization with central venous pressure below 12 mm Hg, cardiopulmonary bypass support is further reduced and finally discontinued.