Masters of Cardiothoracic Surgery

Extracorporeal membrane oxygenation for right ventricular support in left ventricular assist device recipients

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Clinical vignette

We present the case of a 65-year-old male, suffering from decompensated non-ischemic end-stage heart failure. He underwent mechanical aortic valve replacement and mitral valve annuloplasty 20 years ago and PCI of the LAD 5 years ago. Recent transthoracic echocardiography (TTE) showed a highly reduced left ventricular ejection fraction of 20%, a moderately reduced right ventricular function with moderate tricuspid valve regurgitation and an estimated systolic pulmonary pressure of 55 mmHg, as well as a moderate mitral valve regurgitation after annuloplasty. The aortic valve prosthesis showed a good long-term result with no signs for paravalvular leakage and a mean gradient of 4 mmHg.

While heart transplantation was considered, right heart catheterization revealed a significant secondary pulmonary hypertension with an elevated pulmonary vascular resistance of 5.2 Wood Units, not allowing immediate listing for heart transplantation. After medicinal recompensation with levosimendan and forced diuresis, the patient was referred to our center for implantation of a left ventricular assist device as bridge to candidacy. The preoperative computed tomography angiography (CTA) showed a porcelain aorta with a high risk for aortic cross clamping, we therefore decided against a switch from the mechanical aortic valve prosthesis to a biological one.

Surgical technique

Preparation

All LVAD candidates routinely undergo CTA of the aorta before surgery, in this case, significant calcifications of the ascending aorta were revealed, indicating alternative localization of the outflow graft anastomosis combined with a left sided thoracotomy for apical exposure. This technique is especially appealing in redo cases as dissection of the heart is limited to the apex and even in severe atherosclerosis, the subclavian artery is usually free of major plaques (1).

The patient is placed in a supine position with the left arm out, standard endotracheal intubation is performed and bilateral invasive blood pressure monitoring is established via arterial lines in both radial arteries. External defibrillator pads are placed on the patient's back to allow access to the left site of the thorax. The patient is draped similarly to a standard procedure, leaving enough space for a left infraclavicular incision for access to the left subclavian artery and access to both groins for veno-arterial extracorporeal membrane oxygenation (ECMO) cannulation.

Exposition

Left subclavian artery access

A small incision approximately 2 cm below and parallel to the left clavicle is performed. The subclavian vein is retracted caudally, the subclavian artery dissected as long as possible to allow later anastomosis of the outflow graft. The dissection is expanded to the thoracic wall and the first intercostal space is identified. A 16 mm sized Hegar dilator is used to determine whether part of the first is rib has to be resected to permit tunneling of the outflow graft.

Access to the left ventricular apex

The localization of the apex is identified via TTE and an incision in the fourth or fifth intercostal space is performed. Pushing a finger into the apex while observing the four-

chamber-view in the TEE can give further certainty regarding optimal localization of the thoracotomy and positioning of the sewing ring. Dissection of the apex is followed by anastomosis of the HeartMate 3™ Left Ventricular Assist System (HM3, Abbott, Chicago, IL, USA) apical sewing ring in standard fashion as described previously.

Preparation for VA-ECMO

The patient suffers from severe peripheral artery disease and the right subclavian artery had been used for arterial CPB cannulation in the previous operation, therefore the decision for femoral artery cannulation via an 8 mm Vascutek prosthesis was made. Incision in the right groin and dissection of the femoral artery are performed, followed by clamping, anastomosis of the prosthesis and insertion of a 21 French arterial ECMO cannula, after administration of 5,000 units of unfractionated heparin. Venous cannulation of the left femoral vein is gained by insertion of a 21 French venous ECMO cannula in Seldinger technique.

Operation

The ECMO circulation is started with approximately 4 liters of flow. Temporary pacemaker wires are placed for rapid pacing during coring and the patient is fully heparinized. Once the systemic arterial and pulmonary artery monitoring indicate a low output, the left ventricle is cored, using the Abbott coring tool (Abbott, Chicago, IL, USA) and the pump is inserted and secured with the slid-lock mechanism. The graft is deaired, tunneled through the left thoracic cavity to the left subclavian artery. The anastomosis is performed with a running 6.0 prolene suture to the undersurface of the subclavian artery. After tunneling of the driveline and connection to the controller, the HM3 is started with low rotations per minute, to allow further deairing. The pump speed is slowly increased under TEE control. The operation is completed by distal banding of the subclavian artery using a 2 mm polytetrafluoroethylene (PTFE) band to avoid hypo- or hyperperfusion to the arm.

Since the patient had a preoperatively impaired right ventricular (RV) function, we decided to leave the ECMO in place for temporary RV support in order to avoid possible perioperative RV failure (2-4). The LVAD and the ECMO flow are set under TEE control. When leaving the operating room, the LVAD flow was around 3.5 liters and the ECMO flow around 2.9 liters with moderate inotropic and vasopressor support.

Completion

Six hours after the operation, the patient was successfully extubated. The RV function improves over 48 hours following the operation: creatinine decreased from 1.54 to 1.06 mg/dL, dobutamine can be reduced from 5.21 to 2.6 mcg/kg/min with a reduced ECMO flow of 1.5 liters, no rise of central venous pressure or drop in mixed venous saturation were observed. Based on these clinical findings and supported by TTE results, the decision for ECMO weaning was made. The ECMO explantation can be performed complication free and successfully in the ICU on the awake, extubated patient by simply pulling out both cannulas and ligating the femoral artery prosthesis. On the seventh postoperative day, the patient can be transferred to the normal ward.

Comments

Clinical results

We had good experiences with temporary RV support following LVAD implantation, be it with ECMO or temporary graft facilitated RVAD to the pulmonary artery. Given the high impact of early RV failure on morbidity and mortality in LVAD recipients, we are rather aggressive in using this approach to avoid the development of severe RV failure in patients with a preoperative borderline RV function and to treat clinically significant RV failure after LVAD implantation. Weaning from temporary RVAD support was possible in 90% of our patients after a median duration of three days, however, recurrent RV failure occurred in two patients (4%) and re-implantation of a temporary RVAD was necessary in one patient (2%). By pursuing this policy, we are able to achieve low early mortality rates of around 19% and good long-term results with one-year survival rates between 70% and 75% for ECMO and temporary RVAD supported patients.

Advantages

We prefer the temporary support with short-term devices over the permanent BiVAD implantations, as the latter are associated with high short-term mortality rates (up to 40%) (5). Using this approach, we were able to avoid permanent BiVAD implantation in all patients, except for

three patients, were we already preoperatively decided to opt for BiVAD. ECMO as well as the temporary RVAD are easy to explant on the ICU in an awake and extubated patient setting. The adverse event rates are acceptable, major bleeding occurred in around 10–15% of our patients, cerebral vascular accidents (CVA) in around 15% within the ECMO facilitated RV support group, favoring the temporary RVAD approach where no CVA or thromboembolic event was observed.

Caveats

Setting of the LVAD in combination with ECMO or RVAD can be difficult, especially veno-arterial ECMO, which can lead to a competitive flow situation. On the other hand, temporary RVAD systems can cause pulmonary edema when set to inappropriately high flow. We always adjust the flow of both machines under echocardiography guidance: both ventricles should be decompressed, the septum position should be neutral to rightward and suction has to be avoided (2).

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Footnote

Conflicts of Interest: Dr. Zimpfer is a consultant to Abbott. The other authors have no conflicts of interest to declare.

References

1. Riebandt J, Haberl T, Mahr S, et al. Off-pump HeartWare ventricular assist device implantation with outflow graft anastomosis to the left subclavian artery. Ann Thorac Surg 2014;97:2214-6.
2. Riebandt J, Haberl T, Wiedemann D, et al. Extracorporeal membrane oxygenation support for right ventricular failure after left ventricular assist device implantation. Eur J Cardiothorac Surg 2018;53:590-5.
3. Aissaoui N, Morshuis M, Schoenbrodt M, et al. Temporary right ventricular mechanical circulatory support for the management of right ventricular failure in critically ill patients. J Thorac Cardiovasc Surg 2013;146:186-91.
4. Noly PE, Kirsch M, Quessard A, et al. Temporary right ventricular support following left ventricle assist device implantation: a comparison of two techniques. Interact Cardiovasc Thorac Surg 2014;19:49-55.
5. Kirklin JK, Naftel DC, Pagani FD, et al. Seventh INTERMACS annual report: 15,000 patients and counting. J Heart Lung Transplant 2015;34:1495-504.

