Implantation of the HeartWare HVAD: from full sternotomy to less invasive techniques

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Introduction

Left ventricular assist devices (LVADs) are increasingly used for the treatment of end-stage congestive heart failure, both as a bridge to transplantation and as destination therapy (1). The HeartWare HVAD (HeartWare Inc, Framingham, MA, USA) is a continuous centrifugal-flow left ventricular assist device with a magnetic levitating rotor pump. The pump weighs just 140 g and its small design allows for intra-pericardial placement. It is powered by two portable batteries that connect to the pump via a driveline tunneled through the abdominal wall, and these can be worn on a belt, allowing out of hospital support (2). The HVAD is currently indicated for use in patients with refractory end stage congestive heart failure. We outline two techniques for implanting the HeartWare HVAD: via a full median sternotomy, and using minimal access incision (*Video 1*).

Case 1

Clinical vignette

A 56-year-old man with refractory shock due to end-stage dilated cardiomyopathy was transferred to our institution. He was initially placed on peripheral veno-arterial Extra-Corporeal Membrane Oxygenator (ECMO), as a bridge to decision, and then underwent implantation of a HeartWare HVAD as a bridge to transplantation. After three months of HVAD support, he underwent successful heart transplantation.

Surgical technique

The procedure was performed under general anesthesia in a supine position via a standard median sternotomy. The patient was on ECMO support and the procedure was done on the beating heart.

The left ventricular apex was gently elevated and exposed and the correct location for insertion of the inflow cannula was determined using transesophageal echocardiography (TEE). The sewing ring was secured to the apex with interrupted pledgetted 2-0 polypropylene sutures and oriented so that the screw on the sewing ring was readily accessible to a screwdriver. The suture line was then sealed with BioGlue® (CryoLife, Inc., Kennesaw, GA, USA). At this point we administered 5,000 units of heparin to increase the level of anticoagulation. A cruciate incision was made within the sewing ring with a size 11 blade. The coring blade was then inserted through the incision and a core of apical myocardium was excised. The HeartWare's inflow cannula was then inserted through the sewing ring, aligned with the mitral valve and the pump was secured to the sewing ring with a screwdriver. De-airing was then performed through the outflow graft under TEE guidance and an occlusive clamp was applied to the outflow conduit.

The external coating of the driveline was soaked in an antibiotic solution. The driveline was then tunneled from the pericardium to exit the skin on the right side of the abdomen at the level of the umbilicus. The subcutaneous course of the driveline was made as long as possible to

maximize tissue ingrowth and minimize risk of ascending infection.

A side-biting clamp was applied to the ascending aorta, an aortotomy performed and the outflow graft anastomosed with a continuous stitch in an end to side fashion. During anastomosis, de-airing was performed by releasing the clamp from the outflow graft, allowing air to be expelled prior to securing the final stitch. Once the anastomosis was completed, it was sealed with BioGlue®. The HVAD was then activated at low speed, needle de-airing of the vascular graft was performed and the side-biting clamp was removed. The rotational speed of the HVAD was then increased to provide full support.

Case 2

Clinical vignette

An 18-year-old man with primary dilated cardiomyopathy was transferred to our unit in refractory cardiogenic shock despite maximal medical therapy. He was initially supported with ECMO as a bridge to decision, and was then taken to theatre for implantation of a HeartWare HVAD as a bridge to transplantation. After 11 months of support, the patient underwent successful cardiac transplantation.

Surgical technique

The procedure was performed under general anesthesia in a supine position. The patient was on ECMO support and the procedure was performed on the beating heart using a minimally invasive technique. The patient was already anticoagulated with heparin for ECMO.

A five cm left anterior mini-thoracotomy was performed in the fifth intercostal space. The sewing ring was secured to the left ventricular apex, taking particular care to ensure that the screw on the sewing would be sufficiently accessible so that it could be tightened using a screwdriver once the pump had been inserted. A core of myocardium was excised using the coring tool as previously described. The HeartWare's inflow cannula was then inserted and the pump was secured to the sewing ring. De-airing was performed and the outflow prosthesis was clamped.

The driveline was then tunneled from the pericardium to exit the skin on the left side of the abdomen at the level of the umbilicus, as previously described. Again, the subcutaneous course of the driveline was made as long as possible to maximize tissue ingrowth and minimize the risk of ascending infection.

An upper T-inverted ministernotomy was then performed and the aorta was exposed. The outflow graft was tunneled through the pericardium from the left anterior minithoracotomy to the upper T-inverted ministernotomy, with great care taken to avoid kinking and compression. A side-biting clamp was applied to the ascending aorta, anastomosis of the outflow graft and de-airing were performed as previously described, and the side-biting clamp was removed. The rotational speed of the HVAD was then increased to provide therapeutic levels of support.

During subsequent weaning of ECMO, the patient displayed severe right ventricular dysfunction. Hence the decision was taken to implant a temporary paracorporeal Right Ventricular Assist Device (RVAD). A side-biting clamp was applied to the pulmonary artery (PA). Via the upper T-inverted ministernotomy, an eight mm vascular prosthesis was anastomosed to the PA using a continuous suture. The vascular prosthesis was then tunneled through the right side of the same interspace that was incised to make the upper T-inverted ministernotomy. The ECMO circuit was then converted to an RVAD by removing the oxygenator and the femoral artery cannula, while the venous cannula was used as the inflow cannula and the vascular graft as the outflow cannula. The RVAD was weaned three days later and the patient was supported with the HVAD alone until transplant.

Comments

Currently, we routinely use the minimally invasive technique described above to implant the HVAD. This involves use of a minithoracotomy and upper T-inverted sternotomy with ECMO support.

The use of ECMO avoids the need for full heparinization, which is required for cardiopulmonary bypass (CPB), thus minimizing the risk of bleeding. Furthermore, ECMO results in less activation of the inflammatory system with respect to CPB. In addition to these advantages, it still provides hemodynamic support for this group of inherently unstable patients during manipulation of the hearing and implantation of the pump (3,4).

The smaller incisions used in our minimally invasive technique also bring significant advantages in terms of speed of functional recovery. In addition, the incisions provide direct access to both the left ventricular apex and the ascending aorta. As we have also shown, the upper T-inverted sternotomy provides access to the pulmonary

artery and the possibility of converting ECMO to an RVAD.

A further evolution of this technique has allowed off pump implantation without ECMO support and the use of regional paravertebral analgesia in selected patients (5). Yet another development is HVAD implantation via a sternal-sparing bilateral thoracotomy approach, utilizing the left fifth interspace for implantation of the pump and the right second interspace for anastomosis of the outflow graft (6). These minimally invasive techniques promise further advantages in terms of earlier extubation, more rapid recovery and earlier discharge from hospital.

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