Minimally Invasive Thoratec Heartmate II Implantation in the Setting of Severe Thoracic Aortic Calcification

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A minimally invasive approach for implantation of the Heart Mate II left ventricular assist device (LVAD) in the setting of severe thoracic aortic calcification is described. Cannulation of the left ventricular apex is performed through a left subcostal incision with peritoneal creation of the pump pocket. To avoid outflow graft anastomosis to a severely calcified ascending or descending aorta, the outflow graft is tunneled through the diaphragm, the right thoracic cavity, and the second intercostal space, and is anastomosed to the right subclavian artery. This technique is especially appealing in patients with generalized aortic calcification undergoing LVAD implantation.

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Left ventricular assist device (LVAD) implantation is an accepted treatment for patients with end-stage heart failure [1]. The standard approach for LVAD implantation is a median sternotomy with attachment of the LVAD inflow cannula to the left ventricular (LV) apex and of the outflow graft to the ascending aorta. Alternatively, implantation can be performed through a full left lateral thoracotomy with attachment of the LVAD inflow cannula to the LV apex and the outflow graft to the ascending aorta. Recently, an alternative technique for minimally invasive HeartMate II (Thoratec, Pleasanton, CA) implantation through a left subcostal incision for attachment of the inflow cannula to the LV apex and a right minithoracotomy for placement of the outflow graft to the ascending aorta has been described for selected patients [2]. We have modified this approach for patients with heavy calcification of the entire ascending and descending thoracic aorta by attaching the outflow graft to the right subclavian artery, which is usually disease free, even in patients with extensive aortic calcification.

Technique

Patient Preparation

The patient is placed in a supine position, and standard endotracheal intubation is performed because single lung ventilation is not required. External defibrillator pads are placed on the patient’s back to allow access to both sides of the thorax. Transesophageal echocardiography is performed in all patients to rule out relevant aortic or tricuspid regurgitation, as well as persistent foramen ovale, and for weaning patients from cardiopulmonary bypass. The patient is draped in a manner similar to that used in a standard procedure, leaving enough space for a right infraclavicular incision for access to the right subclavian artery and to both sides of the groin for venous cannulation.

Surgical Access to the Right Subclavian Artery and Institution of Cardiopulmonary Bypass

Surgical exposure of the right subclavian artery is performed through a 6-cm incision 2 cm below and parallel to the right clavicle. After division of the pectoralis major muscle, the subclavian vein is retracted caudally and the subclavian artery is dissected with as much length as possible to provide sufficient space for anastomosing a 10-mm Vascutek (Vascutek/Terumo, Renfrewshire, Scotland) prosthesis. Thereafter, dissection is carried down to the thoracic wall, and the second intercostal space is identified. Depending on the diameter of the intercostal space, the second rib is partially resected to prepare for tunneling of the LVAD outflow graft. At this time, the left subcostal incision and opening of the pericardium is performed to avoid surgical dissection under full heparinization. Thereafter, the patient is systemically heparinized. For institution of cardiopulmonary bypass, a 10-mm Vascutek prosthesis is anastomosed to the caudal side of the right subclavian artery and a standard straight arterial cannula is ligated into the graft. Venous
Cannulation is performed percutaneously in the right side of the groin.

**Left Subcostal Incision, Placement of Inflow Cannula, Tunneling of Outflow Graft, Anastomosis of the Outflow Graft to the Subclavian Artery, and Subclavian Artery Banding**

For exposure of the LV apex and dissection of the pump pocket, an 8- to 10-cm left subcostal incision is made. The anterior rectus sheath and the rectus muscle are divided, and a pocket of sufficient size to accommodate the Heartmate II pump is prepared. To allow rotation of the outflow graft to the right side, an 8-cm-long incision parallel to the linea alba is carried out medially. The diaphragm is partially detached, and the pericardium is identified and opened over the LV apex. Thereafter, insertion of the Heartmate II inflow cannula is performed in a standard fashion as described previously [3]. The pump is connected, air is removed, and it is placed in the preperitoneal pocket. We then tunnel the outflow graft through the right side of the diaphragm, thoracic cavity, and second intercostal space. To avoid kinking and compression at the passage through the second intercostal space, the outflow graft is covered with a ring-reinforced Gore-Tex graft (W.L. Gore & Associates, Inc, Flagstaff, AZ). Before anastomosing the outflow graft, the patient is weaned from cardiopulmonary bypass under appropriate inotropic support without starting the LVAD. The operation is completed by anastomosing the outflow graft to the subclavian artery either by anastomosing the outflow graft to the 10-mm Vascutek graft previously used for arterial cannulation and starting the LVAD. To avoid excessive blood flow to the right arm, we attach a permanent band (2-mm polytetrafluoroethylene to the right subclavian artery distal to the outflow graft anastomosis. The band is adjusted under invasive measurement of the blood pressure of the right and left radial arteries, targeting equal pressures to avoid hyper- or hypoperfusion. The operative result is depicted in Fig 1. Postoperative treatment including anticoagulation is performed with low-molecular-weight heparin, followed by phenprocoumon and aspirin, and is identical to than in other HeartMate II patients in our department.

**Comment**

We have established a minimally invasive and reproducible technique for LVAD implantation in patients with terminal heart failure and severe calcification of the ascending and descending thoracic aorta prohibiting standard placement of the outflow graft anastomosis because of an unacceptable risk of thromboembolic complications or even the technical impossibility of tangential clamp placement.

The subcostal approach for placement of the inflow cannula and preparation of the pump pocket has previously been described and is now routinely used in selected centers performing minimally invasive sternotomy-sparing LVAD implantation. This approach has been proved to be noninferior to the standard approach through a median sternotomy, both in first operations and redo cases, and will facilitate straightforward pump exchanges in the setting of pump thrombus formation or driveline fractures, rendering this approach especially attractive in patients receiving destination therapy. Still, it is technically more demanding because only the apex is exposed, requiring advanced experience in the selection of the proper site for apical coring.

There is only limited experience with attaching the outflow graft to the subclavian artery, which has been used in our department twice. Concerns include compression of the outflow graft at the passage through the second intercostal space, excessive blood flow to the arm, flow disturbances on extensive elevation of the arm, and downsizing of the outflow graft to 10 mm. To avoid compression of the outflow graft, we use a ring-reinforced Gore-Tex graft at the site of passage through the second intercostal space. We believe that banding of the subclavian artery is mandatory to avoid excessive blood flow to the arm, which is sometimes seen in patients who have received extracorporeal membrane oxygenation, with arterial cannulation through a graft to the subclavian artery. In addition, it is important to educate the patient that blood pressure monitoring should not be performed on the right side/arm. We have not observed any flow disturbances on elevation of the arm so far. Nevertheless, patients should be informed that such phenomena can potentially occur and that extensive elevations of the arm, especially for longer times, should be avoided. We have anastomosed the outflow graft of the HeartMate II to...
10-mm grafts on a few occasions and it seems to be unproblematic. So far we have observed no complications such as arm swelling or dysfunction or change of pump parameters with this technique.

The described approach is a novel, minimally invasive, and reproducible technique for LVAD implantation in patients with terminal heart failure and severe calcification of the ascending and descending thoracic aorta, which should at present should be restricted to this selected high-risk population.

References