Implantation of the permanent Jarvik-2000 left-ventricular-assist-device: surgical technique

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Abstract

The Jarvik-2000 is an axial-flow left-ventricular-assist-device (LVAD) designed for permanent use. The power supply is provided by a cable plugged into a skull-pedestal mounted in the retro-auricular area. We describe the surgical technique and discuss potential and encountered problems. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

The Jarvik-2000 (Fig. 1) is the first of the new-generation axial-flow left-ventricular-assist-devices (LVADs) designed for permanent use [1]. Common problems of conventional LVADs are bleeding, infection, and thrombo-embolic events [2]. The Jarvik-2000 offers several advantages to potentially reduce complications: limited surgical dissection, left thoracotomy [3], absence of an inflow-cannula, minimal foreign material, no fixation of the cardiac apex, no pseudo-capsule, anastomosis to the descending aorta, and extensive clinical experience with skin exit-sites from cochlear implants [4]. We present our technique for implantation of the permanent Jarvik-2000 based on four implants of this system without major complications, reoperations, or mortality.

2. Pre-operative evaluation

Patients in need of mechanical left-ventricular support with a Columbia-University risk score index ≤ 5 are considered for implantation [5], even if age precludes transplantation. Patients with fixed pulmonary-vascular-resistance > 7 Wood-units are considered for a conventional LVAD with access to the right-ventricle.

In addition to a work-up for heart transplantation [6], a computerized tomography (CT) of the chest and head is performed to allow site-selection of the outflow-graft anastomosis as well as for the skull-pedestal in an area with thick bone, at least 5 mm.

3. Operative procedure

The patient is positioned for a left thoracotomy. Nitric oxide and aprotinin are used routinely [7,8]. The surgical field includes the left groin and temporo-occipital area, drapes are secured to the skin.

4. Skull pedestal for power supply

The skin exit-site is punched-out. The corresponding site on the skull is marked. A broad-based, curvilinear incision is performed. Periosteal-flaps are elevated. The outer table is leveled for stable seating of the pedestal. The power-cable is tunneled from the chest and connected to the pedestal. The cable is placed in a zigzag fashion using two incisions, allowing neck motion without strain on the cable. Self-tapping screws anchor the pedestal, allowing a 0.5-mm safety-margin to prevent skull penetration. Additional burr-holes and pedestal coverage with periosteum promote bony ingrowth. Pedestal-implantation by a head-and-neck surgeon expedites the procedure.
5. Implantation of the Jarvik-2000

The left femoral vessels are exposed. A standard left-posterolateral thoracotomy is performed entering the sixth or seventh intercostal-space for dilative disease, the fifth for normal-sized hearts. The Jarvik-2000 is placed in the thoracic cavity, protected with a sterile glove and towels. The power cable is brought out through the second intercostal-space, between the medial border of the scapula and the spine. The skull-pedestal is mounted. Head-and-neck incisions are closed. In partial occlusion without Heparin, an end-to-site anastomosis of the 16-mm outflow-graft to the descending thoracic aorta is sewn using 4-0 Prolene (Ethicon Inc., Norderstedt, Germany) on a V-6 needle with felt-strip reinforcement (Fig. 2a). It is important to place the clamp with distal pulses maintained. The outflow-graft is clamped directly at the anastomosis. The pericardium is incised horizontally on both sides of the phrenic-nerve to allow good pericardial drainage. Complete hemostasis is achieved before heparin is administered. On femoro-femoral bypass, the cardiac-apex is elevated and vented if necessary. The position of the sewing-ring is marked with electrocautery. The asymmetrical sewing-ring allows placement slightly lateral to the apex, pointing the device away from the septum toward the left-ventricular-outflow-tract. To reduce bleeding complications, we prefer to take deep muscular bites entering and exiting the epicardium using plegetted 2-0 Ethibond-sutures (Ethicon Inc., Norderstedt, Germany) on atraumatic V-7 or MH needles (Fig. 2b). The heart is fibrillated. A special coring-knife is inserted through a cruciate incision. A myocardial core and muscular debris are removed. The Jarvik-2000 is inserted into the left-ventricular cavity and secured to the ring. The device is rotated to avoid rubbing of the power-connection or outflow-elbow (Fig. 1) against the rib-cage or diaphragm. After defibrillation, the heart is slowly filled with the apex elevated and continuous venting of the clamped outflow-graft. The Jarvik-2000 is started. Complete de-airing is confirmed by TEE before unclamping the outflow-graft. Cardiopulmonary bypass is terminated. Heparin reversal and meticulous hemostasis are followed by a standard thoracotomy-closure.

6. Post-operative care

The Jarvik is set to a minimal setting to allow pulsatile flow. Routine post-thoracotomy and post-LVAD care with early extubation, incentive spirometry, and aggressive mobilization with physical therapy is used. Infection prophylaxis is achieved with 48 h of intravenous antibiotics, antibiotic-coated catheters, and early central-line and catheter removal.

7. Potential and encountered problems

These often cachectic patients are at increased risk for skin breakdown. Determination of the pedestal position aided by CT-scanning is of utmost importance to avoid intracranial hemorrhage. We recommend testing the device
after tunneling the power-cable. Significant blood loss in the drapes with ensuing coagulopathy can result if the cable exit-site is left open during cardiopulmonary bypass. Clamping of the outflow-graft at the anastomosis avoids clot-formation before heparin is given. Complete clamping of the descending thoracic aorta precludes femoral bypass in case of sudden need. Hemostasis is of utmost importance as bleeding increases the risk of right-ventricular failure and infection [8]. De-airing with the outflow-graft unclamped allows the femoral cannula to blow air into the head vessels. Good patient selection, attention to details, and a multidisciplinary approach increase the likelihood of good outcomes.

8. Summary

We have presented our technique of implantation of the permanent Jarvik-2000 LVAD using left-lateral thoracotomy and femoral bypass, with a power-connector in the retro-auricular area. We emphasized attention to details and made suggestions to avoid surgical complications.

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References