Safe, Effective Off-Pump Sternal Sparing Approach for HeartMate II Exchange

William E. Cohn, MD, Hari R. Mallidi, MD, and O. H. Frazier, MD

Center for Cardiac Support, Texas Heart Institute, Houston, Texas

As left ventricular assist devices (LVADs) have become more widely used for treating patients with advanced heart failure, the incidence of pump dysfunction requiring pump replacement has increased. When dysfunction is due to pump failure or driveline injury, isolated pump replacement can be curative. We have developed a quick, safe pump-exchange technique that avoids a redo sternotomy and cardiopulmonary bypass. We have used this technique to exchange malfunctioning HeartMate II LVADs in 14 consecutive patients. The patients were extubated within 3 to 6 hours, and blood loss and transfusion requirements were nominal. There were no peri-procedural deaths or strokes.


Because of the growing use of left ventricular assist devices (LVADs) in patients with advanced heart failure, the incidence of pump dysfunction requiring pump replacement has increased. Pump dysfunction is frequently due to malposition of the left ventricular inflow cannula or kinking or twisting of the outflow cannula; however, it also may be caused by failure of the pump itself or injury to the driveline. In these instances, isolated pump replacement can be curative. We have recently developed a quick, safe pump-exchange technique that avoids a redo sternotomy and cardiopulmonary bypass (CPB). We have used this technique to exchange malfunctioning HeartMate II LVADs (Thoratec Corporation, Pleasanton, CA) in 14 consecutive patients.

Technique

In patients for whom an isolated pump exchange is appropriate, a left subcostal incision is our preferred approach. The procedure is designed to be performed without CPB, but one femoral artery is exposed in case CPB should later be required. A generous left subcostal incision is created, extending through the abdominal musculature to the pump pseudo-capsule. A heavy-duty self-retaining retractor (Thompson Surgical Instruments, Inc., Traverse City, MI) is invaluable for providing exposure (Fig 1A). One arm of the retractor is used to pull vigorously, anteriorly and cephalad, on the left costal margin. A second arm retracts the abdominal visceria inferiorly, and a third arm retracts the left body wall and left-sided rib cage laterally, away from the pump inlet. The incision and pump dissection are often extended several centimeters to the right of the midline to provide complete circumferential exposure of the connection between the outflow-graft collet and the detachable bend-relief component. The bend-relief is detached, and gentle traction is applied to the proximal end of the outflow graft (closest to the pump) to deliver a 2- to 3-cm segment long enough for a vascular clamp to be applied (Fig 1B). Although the outer aspect of the outflow graft is often stuck to the inner surface of the bend-relief by semisolid tissue, this problem can be overcome by using gentle traction, and the outflow graft’s corrugations will allow it to stretch somewhat and telescope out. The surgeon must avoid injuring the outflow graft on the sharp edge of the detached bend-relief.

The self-retaining retractor is adjusted, and additional dissection is performed to allow a vascular clamp to be placed across the white silicone elastic bellows between the sintered titanium inflow cannula and the pump. Running down the center of the bellows is a gel-impregnated Dacron graft. The bellows and graft can easily be compressed when the vascular clamp is applied, providing temporary inflow occlusion (Fig 1C). Last, the pump’s driveline is dissected circumferentially for 5 cm, so that it may be readily transected before pump removal.

At this point, systemic heparin is administered, and the patient is slowly weaned from the HeartMate II by gradually decreasing the pump’s rotational speed. Transesophageal echocardiography is extremely useful in deciding whether hemodynamic stability can be maintained for 10 to 15 minutes without LVAD support. Inotropic agents, vasoactive drugs, pacing, and other measures are used as indicated. Patients with extremely dysfunctional hearts may require CPB. The HeartMate II exchange can be performed without CPB if, at 6000 rpm, relatively normal hemodynamic parameters can be maintained (ie, the approximate rotational speed at which backward flow through the pump from the aorta to the left ventricle during diastole equals forward flow through the pump during systole).
The driveline of the new pump is tunneled through the abdominal wall and brought out in a suitable location. We do not use the inflow components packaged with the new pump, and they should not be attached to the new HeartMate II housing. If they have already been attached, they can be removed by rotating the inflow collet counterclockwise. Two large vascular clamps are applied to the exposed segment of outflow graft and to the silicone elastic bellows. Heavy scissors are used to transect the old driveline. The outflow collet is then rotated counterclockwise to detach the outflow graft (Fig 1D). Frequently, one will need a pump clamp or sterile pliers to loosen the collet. The inflow collet is then grasped with a pump clamp or other suitable tool (Fig 1E), and the old pump housing, now freed from both the pump outlet and the driveline, can be readily rotated counterclockwise (as viewed from the outlet aspect) and unscrewed from the old inlet components (Fig 1F).

At this point, the new pump can be attached to the retained inflow and outflow connections. If there is a concern about the inflow segment’s patency, the vascular clamp on the silicone elastic bellows can be released for a heartbeat to ensure brisk ejection of blood. This maneuver could entrain air but is unlikely to do so, because these patients have elevated left ventricular diastolic pressures. If partial inflow obstruction occurs, the operator should consider CPB and inflow revision, through either the current incision or a redo sternotomy. On occasion, we have inserted a large Fogarty embolectomy catheter (Edwards Lifesciences, Cupertino, CA) through the inflow elements into the left ventricle of a patient who has undergone CPB, but the reliability of determining patency with this method is uncertain. (Attempting to perform this maneuver off pump might be unwise.) To attach the new pump to the retained inflow components, we grasp the inflow collet firmly with a pump clamp or other suitable tool, then screw the new pump body into the collet by rotating the entire pump clockwise, as viewed from the outlet. By prewinding the new pump housing several turns counterclockwise before engaging

Fig 1. (A) The pump is exposed through an extended left subcostal incision. A self-retaining retractor is invaluable in visualizing the white silicone rubber bellows that surround the pump inlet graft. (B) The bend-relief is disconnected from the pump outlet to allow exposure of the outflow graft. After hemodynamic stability is ensured, the pump power is turned off, and the driveline is cut. (C) Clamps are immediately placed on the outlet graft and silicone rubber inflow bellows to prevent retrograde flow through the nonfunctioning pump. (D) The outflow graft is unscrewed from the curved titanium tube at the pump outlet. Brisk back-bleeding is confirmed by transiently releasing the clamp to ensure adequacy of the outflow graft. (E) A pump clamp is used to firmly grasp the collet at the pump inlet. (F) While the collet is held, the pump is rotated counterclockwise until it can be removed from the inlet. Brisk bleeding from the inlet is confirmed by transiently releasing the clamp on the inflow bellows to ensure adequacy of the pump inflow. The new pump is implanted by reversing the order of these steps.
the screw threads on the inflow collet, the surgeon can keep the driveline from interfering with the attachment process. After the new pump has been attached, the new driveline can be rotated in the body-wall tunnel to remove any residual torsion.

Last, the outflow graft is attached to the pump body. To confirm outflow-graft patency, the outflow-graft clamp can be released momentarily to ensure brisk arterial back-bleeding. Alternatively, a needle can be inserted through the graft wall proximal to the vascular clamp and attached to a transducer. Any gradient between the measured pressure and the systemic arterial pressure indicates an outflow-graft problem, and outflow revision should be considered.

A 19-gauge needle is inserted into the outflow graft to remove residual air. The pump is actuated, and the rotational speed is gradually increased while echocardiography is used to monitor hemodynamic values and left ventricular size. Protamine may be administered to maintain hemostasis, and the wound is closed anatomically in layers.

Comment

Using this technique, we have exchanged 14 consecutive HeartMate II pumps. All had preoperative evidence of hemolysis, increased power consumption, or poor pumping performance. All exchanges were performed without CPB or hemodynamic deterioration. In each case, the patient was extubated within 3 to 6 hours, and blood loss and transfusion requirements were nominal. There were no peri-procedural deaths or strokes. On examination, the removed pumps were generally found to have small (3- to 6-mm) entrapped pieces of thrombus adjacent to the inlet bearing or, less frequently, thrombus in the outlet bearing. In 1 patient, the entire pump was thrombosed. We could not determine whether the thrombus had formed within the pump or had been entrained. This technique is now our method of choice when isolated exchange of a dysfunctional HeartMate II pump is indicated.

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