A 61-year-old female underwent implantation of a Heartmate II left ventricular assist device (LVAD; Thoratec Corporation, Pleasanton, CA) for end-stage nonischemic cardiomyopathy. Six months later, she presented with chest pain and worsening heart failure symptoms. Computed tomography angiography revealed a large subxiphoid pseudoaneurysm with peripheral thrombus exerting a mass effect on the heart (Figures 1 and 2). Further evaluation by ultrasonography with anterior chest transducer placement confirmed a 13-cm pseudoaneurysm with multiple connections to the LVAD outflow Dacron graft (Figure 3). She was afebrile and had no physical or laboratory evidence of infection. Because of extensive comorbidities, including morbid obesity, restrictive lung disease, and chronic renal insufficiency, open repair via repeat sternotomy was considered risk-prohibitive, and an endovascular repair was pursued.

Off-label use of a Gore Excluder (W.L. Gore and Associates, Flagstaff, AZ) iliac limb stent graft (16 mm proximal diameter, 18 mm distal diameter×9.5 cm length) was considered the best commercially available device to attempt endovascular repair. This device was chosen because of the appropriate size match to the Dacron LVAD outflow graft and the short nose of the delivery catheter, which would permit advancement close to the LVAD pump mechanism. Because of a delivery catheter shaft length of only 55 cm, a left axillary artery approach was chosen for device delivery. The left axillary artery was exposed via an infraclavicular incision. An 8 mm Dacron conduit was sewn end-to-side to this artery and brought out through a separate stab incision on the lateral chest to minimize the angle of entry for the wires and sheaths, given patient obesity. Initial attempts at retrograde entry into the LVAD outflow tract from the ascending aorta proved difficult because of high LVAD flow. As such, the decision was...
made to temporarily turn off the LVAD, after full systemic heparinization to an activated clotting time of greater than 300, which the patient tolerated hemodynamically. An arteriogram of the ascending aorta/arch was then performed, and the location of the distal anastomosis of the LVAD outflow graft identified (Figure 4A) and successfully cannulated using a Cobra-2 catheter (AngioDynamics, Latham, NY), followed by an Amplatz superstiff wire with a 1-cm floppy tip (Cook Medical, Bloomington, IN) that passed into the LVAD outflow graft and down to above the pump portion of the LVAD. An 18-French Gore dry-seal sheath was passed into the LVAD outflow graft over the stiff wire, and a subsequent arteriogram revealed the pseudoaneurysm in the proximal portion of the LVAD outflow graft above the elbow portion of the LVAD (Figure 4A and 4B). The endograft was then deployed with 3 to 4 cm of seal both above and below the location of the pseudoaneurysm. Balloon molding was accomplished with a 16 mm×4 cm angioplasty balloon, and a completion arteriogram demonstrated complete exclusion of the pseudoaneurysm and a well-expanded endograft (Figure 4C and 4D), after which the LVAD was restarted (total LVAD pause time 22 minutes). The patient tolerated the procedure well and was discharged home after treatment of her heart failure exacerbation. Follow-up imaging 6 weeks later demonstrated a well-positioned stent graft without evidence of endoleak and complete resolution of the pseudoaneurysm (Figure 5A through 5C). The patient remains well 10 months postendovascular repair.

Discussion

Pseudoaneurysms associated with LVADs are rare, with prior reports of occurrence at the left ventricular apex, as well as the anastomosis of the outflow graft to the ascending aorta.1 Pseudoaneurysm of the LVAD outflow graft, thought to be secondary to graft contact with a sternal wire causing erosion of the graft, was reported in a patient with a Novacor N100 LVAD; this pseudoaneurysm required open repair under deep hypothermia and circulatory arrest.2 Additionally, endovascular repair of a fistula between the outflow graft of a Heartmate II and a portion of the right bronchial tree, with access from the right common carotid artery, has been described.3 In the present case, pseudoaneurysm formation could have resulted from prosthetic graft damage during implantation or contact with the sternal wires, as previously described. Additionally, detachment of the bend relief device (Figure 6), which overlies the LVAD outflow graft, could have caused outflow graft damage and pseudoaneurysm formation. To this latter possibility, a recent FDA warning was issued regarding concerns of the bend relief device causing graft obstruction and detachment from the LVAD.4 The endovascular repair strategy described herein represents the second placement

Figure 3. A, Sagittal ultrasonographic view of the anterior chest demonstrating a 13×9 cm fluid collection (demarcated by + symbols) surrounding the outflow tract (red arrow) from the left ventricular apex (yellow arrow) to the left ventricular assist device (LVAD). B, Sagittal Doppler view demonstrating swirling flow within the fluid collection consistent with pseudoaneurysm.

Figure 4. A, Initial angiography run demonstrating the large pseudoaneurysm (red arrow) at the base of the outflow graft (yellow arrow; ascending aorta indicated by green arrow). B, Fluoroscopy demonstrating wires (yellow arrow) in the left ventricular assist device (LVAD) outflow graft extending into the LVAD apparatus (red arrow). C, Early image of completion angiography run demonstrating contrast in the upper part of LVAD outflow graft within the newly placed endograft (blue arrow). D, Later image of completion run demonstrating good flow through the endograft (yellow arrow) and absence of the blush seen previously within the pseudoaneurysm (red arrow).
of an endovascular stent graft within an LVAD circuit, and the first endovascular repair of an LVAD outflow graft pseudoaneurysm to our knowledge. Potential complications of this repair strategy include endograft infection, potential for LVAD-related thrombus, especially given the temporary cessation of device flow (albeit during a period of full systemic heparinization), damage to the pump mechanism from catheters or wires, wire or catheter entrapment, and endoleak.

Lifelong surveillance follow-up imaging is therefore recommended, similar to other endovascular repair procedures. Nonetheless, the endovascular strategy presented seems to represent a novel, safe, and effective treatment for LVAD outflow tract pseudoaneurysm that avoids a highly morbid open operation in a compromised patient population.

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Disclosures

Dr Hughes is a paid consultant for W.L. Gore and Associates and Terumo Medical. Dr Milano is a paid consultant for Thoratec Corporation. Dr Rogers is a paid consultant for Thoratec Corporation.

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Endovascular Stent Grafting of a Left Ventricular Assist Device Outflow Graft Pseudoaneurysm
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