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Off-pump left ventricular assist device exchange via re-do left mini-thoracotomy with original outflow graft preservation

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Abstract

Complications associated with long-term left ventricular assist device (LVAD) use may require pump exchange due to device thrombosis or thromboembolism. Minimally invasive off-pump procedures represent an advantageous alternative to standard full sternotomy exchanges and those performed with the use of cardiopulmonary bypass. By mitigating surgical invasion and trauma to the central chest, the potential for post-operative bleeding, transfusions and complications can be reduced. This case report describes the successful off-pump exchange of a HeartWare LVAD via left re-do-thoracotomy with the re-use of the original outflow graft.

Keywords

left ventricular assist device (LVAD); HeartWare exchange; minimally-invasive; off-pump

Introduction

The use of mechanical circulatory support devices to treat progressive heart failure continues to grow, surpassing the number of annual heart transplants performed worldwide.[1] Donor shortages, approval for use as destination therapy and improved device technology have resulted in significantly longer durations of LVAD support. Prolonged device therapy inevitably leads to a greater incidence of device-related complications, including mechanical failure, bleeding, thrombosis, hemolysis and driveline infection which may require pump exchange.[2,3] Since device exchange procedures are considered re-do operations, limiting surgical trauma is significant in reducing the risk of complications for these high-risk patients.[4] Standard full sternotomies are associated with increased post-operative bleeding, transfusion requirements, sternal instability, wound infections and right heart failure. Minimally invasive procedures can circumvent these complications by decreasing recovery time, ICU stay and hospital costs.[1,5] Additionally, performing a device-exchange procedure without cardiopulmonary bypass (CPB) can shorten surgical time and decrease the activation of inflammatory and coagulation cascades, thereby, reducing post-operative complications.[1] As described by Rojas et al., off-pump minimally invasive exchanges via anterolateral thoracotomy with outflow graft anastomosis can offer an alternative to conventional full sternotomy procedures, potentially improving clinical outcomes.[4] Our patient successfully underwent a device change-out of a HeartWare LVAD via a left re-do thoracotomy, without cardiopulmonary bypass support. The original outflow graft was preserved and reconnected to the new LVAD. This case advances the minimally invasive exchange approach through preservation of the original outflow graft, further shortening the overall procedure time.

Medical History

A 53-year-old male with a history of myocardial infarction, ablation of atrial flutter, ventricular tachycardia, a

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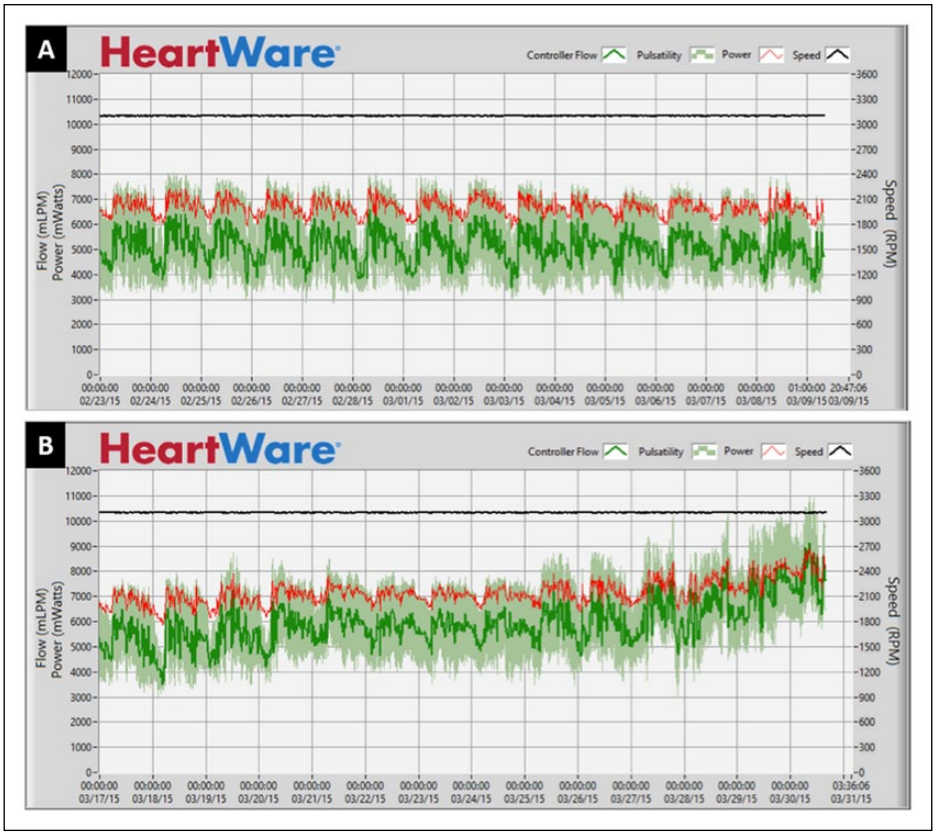

Figure 1. LVAD parameters and flow pulsatility displayed over 14 days. LVAD data demonstrating normal flow of 4.7 L/min at an RPM of 3100 with normal power consumption of 6.5 watts (A). Three weeks later, LVAD parameters indicated power consumption above normal operating ranges, with an RPM of 3100 and flow of 7.6 L/min (B).

bleeding disorder, hyperlipidemia, pulmonary embolism, congestive heart failure and ischemic cardiomyopathy underwent LVAD (HeartWare Ventricular Assist Device [HVAD]; HeartWare, Inc., Framingham, MA, USA) placement 18 months prior to admission to our institution. This was done via a left thoracotomy. After developing shortness of breath (SOB), hematuria and an increase in LVAD pump power (max. 9.9 watts) and pump flow (7 L/min), the patient was admitted to our hospital for possible device thrombosis. The patient presented with a subtherapeutic international normalized ratio (INR1.7), ongoing hematuria due to hemolysis, low serum haptoglobin, hypertension, acute kidney injury and persistently increasing LVAD power consumption (Figure 1). Additionally, serum lactate dehydrogenase (LDH) and creatine levels were elevated. Coumadin was withdrawn and a continuous heparin drip (900 units/h) was started in preparation for a potential device-exchange procedure. Transesophageal echocardiogram (TEE) displayed a dilated left ventricle with an ejection fraction of 5-10% and no thrombus formation. Furthermore, computed tomography angiography did not reveal any outflow graft thrombosis. Together, these findings indicated pump thrombus formation. Prior to surgical intervention, the device was checked every four hours, displaying flow rates up to 9-10 L/min and a pump power of 8 watts. Since the patient was in stable condition with no inotropic support, no thrombi in the left ventricle (LV) or outflow graft, a high hematocrit (>28%), a functional right heart with normal pulmonary artery (PA) pressures and no fall in mean arterial pressure (MAP) >10 mmHg, the decision was made to perform a minimally invasive LVAD device-exchange procedure off-pump.

Operative Procedure

The patient was placed in the supine position and prepped for a re-do left thoracotomy. Wires were inserted into the right common femoral artery and vein in anticipation of cardiopulmonary bypass, which was on standby support. Following activated clotting time (ACT)-guided full heparinization (ACT>480 s), the LVAD was weaned to 2,000 RPM and it was confirmed that the patient would tolerate an off-pump procedure with pressor and inotropic support. A re-do left thoracotomy via a small incision was then performed using a 10-blade knife and electro-cauterization. The apex of

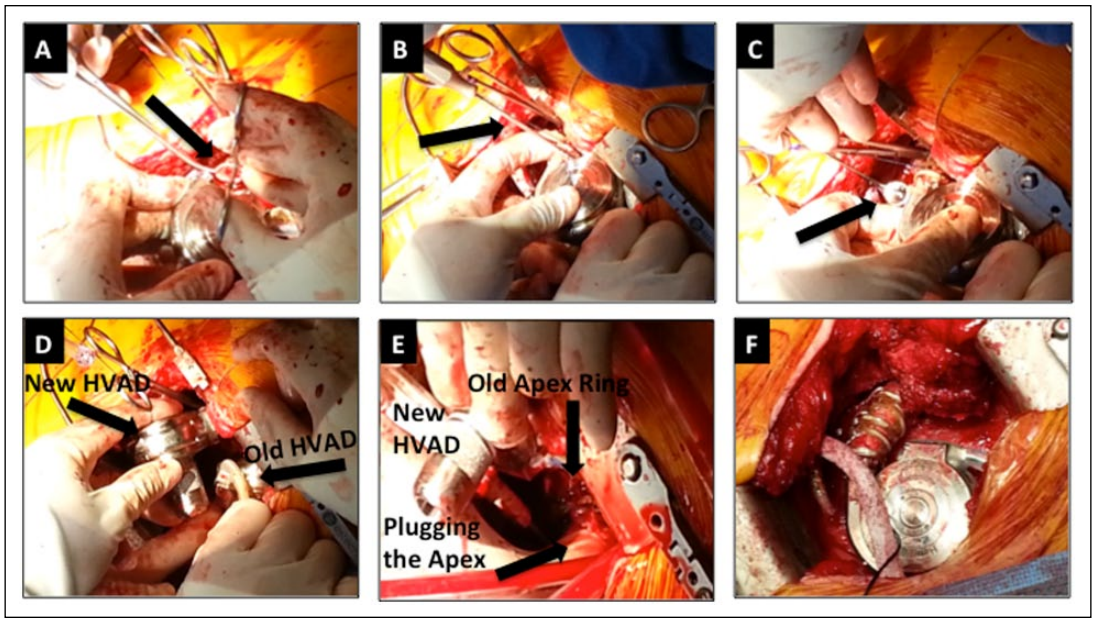

Figure 2. Surgical Technique of Device Exchange. The new HVAD was attached to the pre-existing outflow graft using mosquito clamps (A) and the hex driver (B). A dental mirror was used to check the attachment (C). The old HVAD was then removed (D) and the apex was plugged with a thumb (E). The new HVAD was subsequently connected to the patient's pre-existing apex sewing ring to complete the exchange and re-establish LVAD support (F).

the heart and the outflow graft were dissected. The peri-LVAD space was drained and the previous Gore-Tex membrane (utilized to prevent tissue adhesion) was removed, exposing the HeartWare pump with the nascent outflow graft.

After priming the new LVAD, the driveline was placed through the incision and tunneled into the left flank to a previously marked position away from the old driveline. The nascent LVAD was then completely weaned and the outflow graft was clamped. The LVAD was unscrewed from the native sewing ring and from the native outflow graft. The patient's mean arterial blood pressure was maintained at 60 mmHg. The intact original outflow graft and bend-relief were reconnected to the new LVAD using a mosquito clamp and a hex driver (Figure 2A-B). A dental mirror was used to inspect the attachment (Figure 2C). Subsequently, the patient was placed in the Trendelenburg position to prevent the risk of an air embolism, followed by 12 mg of adenosine induction to temporarily induce bradycardic arrest. The nascent pump was then quickly removed and the hole by the left ventricular apex was covered with a thumb to prevent excessive blood loss and air embolism (Figure 2D-E). Simultaneously, vasopressin (0.04 U/min), dobutamine (10 μg/kg/min) and milrinone (0.7 μg/kg/min) were administered at the discretion of the anesthesiologist in order to maintain proper hemodynamic support with a MAP>70 mmHg. The device inflow tract was attached and secured to the existing sewing ring. The bend-relief was then re-enforced and secured using 2x sternal wires (Figure 2E). Sufficient seal and hemostasis was achieved uneventfully. The new LVAD was initiated and de-aired using a hemostat needle at the outflow graft. The inflow position and the absence of air within the heart were confirmed using TEE. A Gore-Tex membrane was placed over the LVAD, creating a new neo-pericardium. Neither the pleural spaces nor the mediastinum were breached. In order to account for blood loss during the procedure, 500 cc of 5% albumin was administered to maintain adequate volume and pressure and to initiate pump flow. In addition, two units of cell saver blood were administered intra-operatively and post-operatively. The new LVAD was initiated and gradually increased to 3,000 RPM at 5.4 watts to achieve a flow of 5.5 L/min. A half-dose of protamine was then given to achieve an ACT of 180-220 s. A single 24 Fr Blake drain was placed in the peri-LVAD space and the mini-thoracotomy was closed.

The patient was transferred to the ICU in a stable condition with minimal inotropic (levophed at 1 μg/min) and vasopressor (vasopressin at 0.06 U/min) support to achieve a flow of 6 L/min and a cardiac index of 3.1. Heparin and insulin were continued and the patient was extubated fifteen minutes after arrival. Recovery continued without complications as the patient's hemodynamics normalized and LVAD power and flow remained stable. Post-operatively, the goal INR was 2.5-3.5 with a heparin-bridge (1000 U/hr) and with coumadin support (2.5mg daily). On post-operative day 3, the patient was alert and ambulatory.

Discussion

Despite improvements in device technology and durability, long-term LVAD use necessitates device exchange in some patients. Complications such as mechanical failure, infection, thrombosis and bleeding can result in the need for device change-out.[2,3] In this report, the indication of pump thrombosis required LVAD exchange. The procedure was performed without cardiopulmonary bypass support via a left thoracotomy to minimize cardiac manipulation and midline incisions. Such an approach can reduce post-operative bleeding, transfusion requirements, wound infections and right heart failure while decreasing recovery time and overall hospital cost.[1,5] There is growing consensus to avoid cardiopulmonary bypass in certain high-risk device patients as this can lessen inflammatory and coagulation responses, thereby, diminishing vasoplegic and coagulopathic effects post-operatively.[6,7] However, this approach should only be utilized for patients deemed as suitable candidates who can withstand the need for bypass support. These patients must be in a stable condition with no inotropic support, no thrombi in the LV or outflow graft, a high hematocrit (>28%), a functional right heart with normal PA pressures and no fall in MAP >10 mmHg. Our current technique improves upon previously described minimally invasive exchanges through complete preservation and re-use of the original outflow graft,[4] thereby, further reducing operation time. This is advantageous in limiting surgical trauma for vulnerable patients undergoing a re-do procedure. The patient described in this case successfully underwent minimally invasive off-pump LVAD exchange with rapid recovery and has since been successfully transplanted.

Conclusion

The minimally invasive off-pump technique represents a feasible and advantageous alternative to standard on-pump full sternotomy re-do procedures for LVAD exchanges. It can provide the potential for better clinical outcomes in the high-risk re-operative patient populations and should be further investigated in order to determine the effects on clinically relevant end-points, such as acute kidney injury, length of hospital stay and morbidity/mortality rates.

Declaration of Conflicting Interests

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