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CASE REPORT

ADVANCED

TCT CONNECT 2021 CLINICAL CASE

Percutaneous Decommissioning of a Left Ventricular Assist Device in a Patient With Myocardial Recovery

Pankaj Jain, MBBS, PhD, Michael S. Kiernan, MD, MS, Gregory S. Couper, MD, Ethan Y. Brovman, MD, Samantha R. Asber, MSN, RN, CCRN, Carey Kimmelstiel, MD

ABSTRACT

A 37-year-old man was referred for consideration of percutaneous decommissioning of a left ventricular assist device (LVAD). Following careful hemodynamic monitoring during pump turn-down and temporary outflow graft occlusion, the LVAD was permanently decommissioned by using a vascular plug to induce thrombosis of the outflow graft. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:354–358)
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HISTORY OF PRESENTATION

A 37-year-old man who had 2 years previously undergone implantation of a continuous-flow left ventricular (LV) assist device (LVAD) was referred for consideration of LVAD decommissioning after demonstrating evidence of recovery of LV systolic function.

PAST MEDICAL HISTORY

The patient had a past medical history of familial cardiomyopathy requiring insertion of a HeartWare HVAD device (Medtronic) in 2018. He had stage III chronic kidney disease (baseline creatinine, 1.67 mg/dL) and hypertension. In 2018 he also underwent insertion of an implantable cardioverter-defibrillator for ventricular tachycardia. After an initially difficult postoperative course following LVAD insertion, he had demonstrated good functional recovery with no hospitalizations for heart failure in the 12 months before LVAD decommissioning. He had been maintained on target doses of guideline-directed medical therapy consisting of sacubitril-valsartan (97/103 mg twice daily), carvedilol (25 mg twice daily), and spironolactone (25 mg daily), and a significant and sustained improvement in LV function was noted at 12-month surveillance echocardiography. The profound clinical and echocardiographic response to medical therapy prompted consideration of LVAD decommissioning.

LEARNING OBJECTIVES

- To appreciate key aspects of patient selection and real-time decision making regarding decommissioning of an LVAD.
- To understand the rationale for, device selection in, and key procedural considerations in percutaneous LVAD decommissioning.

INVESTIGATIONS

Transthoracic echocardiography (TTE) performed at baseline pump speed before the procedure showed a

From The CardioVascular Center, Tufts Medical Center, Boston, Massachusetts, USA.
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borderline dilated left ventricle with normal wall thickness and mild systolic impairment (LV ejection fraction [LVEF], 40%-45%). The right ventricle was mildly dilated, with moderate systolic impairment. There was mild mitral and tricuspid valve incompetence. At pump "turn-down," LVEF before the procedure was 50% to 55%. Cardiopulmonary exercise testing revealed maximum oxygen uptake (peak Vo_2) of 13.3 mL/kg/min.

MANAGEMENT

The procedure was performed with the patient under general anesthesia and with transesophageal echocardiographic guidance throughout. Following systemic heparinization and through a 6-F left common femoral access, a 6-F Langston catheter was positioned in the LV cavity. The LVAD speed was sequentially reduced, in increments of 60 RPM every 30 seconds, from baseline (2,440 RPM) to the point of zero net device flow (1,800 RPM). At each speed, steady-state measurements of LV, aortic, and femoral arterial pressure, pulmonary arterial oxygen saturation, LV and right ventricular (RV) dimensions, and LVEF and RV ejection fraction were made. There was no deterioration in any of these parameters during LVAD turn-down (**Figures 1A and 1B, Table 1**). There was restoration of arterial pulsatility, consistent with withdrawal of pump support, with no significant increase in LV end-diastolic pressure (LVEDP) (10 mm Hg) and maintenance of mean arterial pressure (MAP) within an acceptable range (66 mm Hg). LVEF improved with turn-down to 50% to 55%, whereas LV end-diastolic diameter (LVEDD) reduced slightly from 55 mm at baseline to 53 mm. Following a multidisciplinary discussion involving advanced heart failure, interventional cardiology, cardiac anesthesia, and cardiac surgery, a decision was made to decommission the LVAD by placing a vascular plug in the outflow graft.

Through a 9-F right common femoral access, the LVAD outflow graft was engaged with an MP-1 catheter, and angiography was performed (**Figure 2A**). Over an Amplatz Super Stiff wire (Boston Scientific), a 10 × 40 mm Armada 35 balloon (Abbott) was inflated to occlude the graft (**Figure 2B**). The patient was observed over a period of 22 minutes, with no deterioration in hemodynamics or echocardiographic parameters. The graft was re-engaged with the MP-1 catheter, and a 14-mm vascular plug was deployed (**Figure 2C**, Video 1). The LVAD was switched off, and the outflow graft subsequently thrombosed

ABBREVIATIONS AND ACRONYMS

LV = left ventricular

LVAD = left ventricular assist device

LVEDD = left ventricular end-diastolic diameter

LVEDP = left ventricular end-diastolic pressure

LVEF = left ventricular ejection fraction

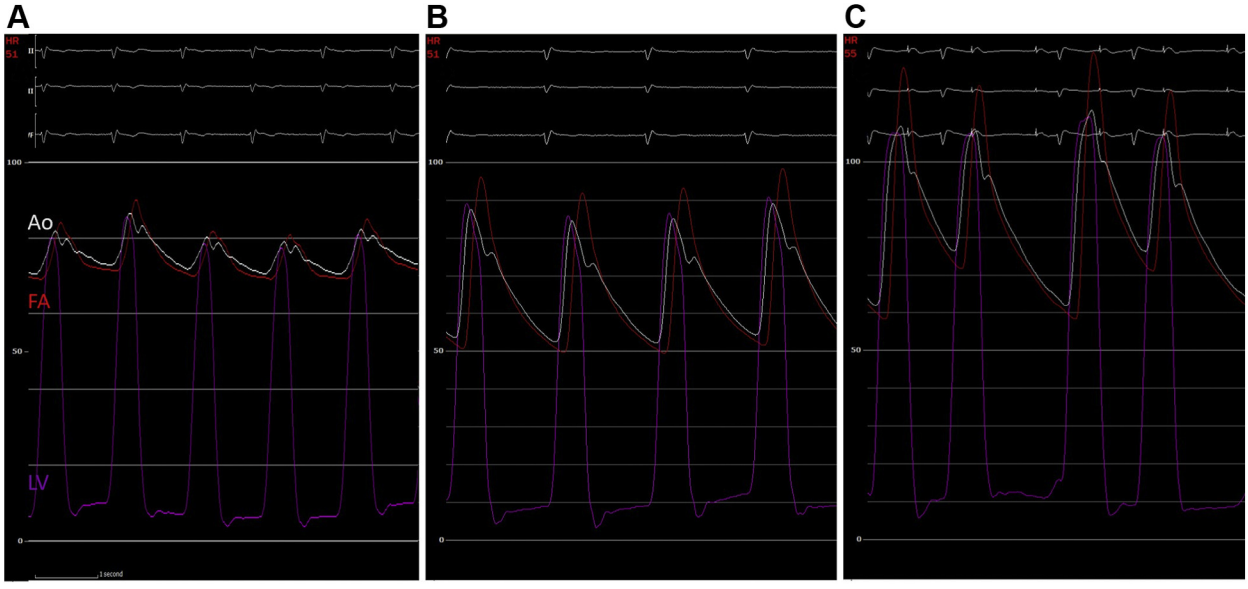
MAP = mean arterial pressure

PCWP = pulmonary capillary wedge pressure

RV = right ventricular

TTE = transthoracic echocardiography

FIGURE 1 Invasive Pressure Recordings



Recording were taken from the ascending aorta (Ao) **(white trace)**, the femoral artery (FA) **(red trace)**, and the left ventricle (LV) **(purple trace)**. **(A)** Baseline pump speed before decommissioning. **(B)** Turn-down speed (1,800 RPM) before decommissioning. **(C)** Immediately after decommissioning.

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TABLE 1 Selected Hemodynamic and Echocardiographic Parameters During LVAD Decommissioning

	Baseline Pump Speed	Turn-Down	Balloon Occlusion	Post-deployment
LVEDP, mm Hg	8	10	10	12
MAP, mm Hg	77	66	84	87
Aortic PP, mm Hg	9	34	33	48
LVEF, %	45-50	50-55	55-60	50-55
LVEDD, mm	55	53	49	53

LVAD = left ventricular assist device; LVEDD = left ventricular end-diastolic diameter; LVEDP = left ventricular end-diastolic pressure; LEVF = left ventricular ejection fraction; MAP = mean arterial pressure; PP = pulse pressure.

over 10 minutes (Videos 2 and 3). The patient remained stable, with cardiac output at 5.3 L/min, pulmonary capillary wedge pressure (PCWP) of 3 mm Hg, and normal MAP and LVEDP (**Figure 1C**). LVEF and LVEDD at the conclusion of the procedure were stable at 50% to 55% and 53 mm, respectively. The LVAD driveline was subsequently divided and sealed surgically. TTE performed before discharge showed improved LVEF (45%-50%) and RV systolic function compared with to preprocedure findings. He was discharged home on day 5.

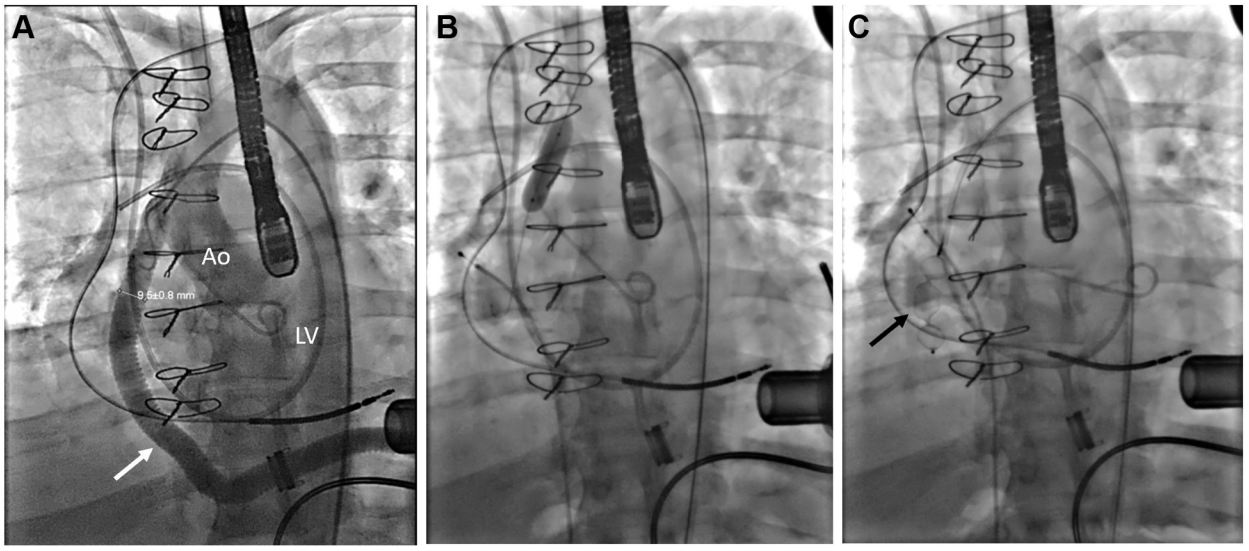
DISCUSSION

Continuous-flow LVAD therapy is a cornerstone of treatment of advanced heart failure, and it is used as both bridge-to-transplantation and destination therapy.[1] In a few patients, LVAD therapy is associated with significant recovery of LV function, thereby enabling decommissioning of the device.[2] Decommissioning can be performed through surgical explantation or, alternatively, by occlusion of the outflow graft with the device retained in situ. The latter method has the advantage of avoiding redo sternotomy, thus simplifying any future cardiac surgical interventions. In this case, given that the options for "rescue" for heart failure recurrence included LVAD reimplantation and heart transplantation, avoidance of an additional sternotomy was a key consideration, albeit at the cost of ongoing risk of infection associated with the retained pump and driveline.[2] Overall, there are no significant differences in survival between these techniques,[3] and both carry a Class IIa (Level of Evidence: C) recommendation in consensus guidelines.[4] Occlusion of the outflow graft, necessary to prevent torrential regurgitation from the aorta to the left ventricle through the retained device once stopped, can be performed with minimally invasive surgical ligation or percutaneously. Percutaneous occlusion, first described by Zeigler et al[5] and subsequently in case reports and series,[6-10] is most commonly performed using the Amplatzer Vascular Plug II device (Abbott), although use of a left atrial appendage occluder device has also been described.[11]

Patient selection for LVAD decommissioning is critical to ensure stability through the procedure itself, as well as for durable long-term clinical outcome. Gerhard et al[2] recently described favorable long-term outcomes (78% survival free of heart failure recurrence, LVAD reimplantation or heart transplantation at 3 years, with median LVEF 42%) in patients who met all of the following criteria under the turn-down condition: LVEDD and LV end-systolic diameter <60 mm and <50 mm, respectively; LVEF >45%; PCWP ≤15 mm Hg; and cardiac index >2.4 L/min/m^2. Using the same criteria, Birks et al[12] reported similarly favorable outcomes, with 77% survival free of LVAD reimplantation or heart transplantation at 3 years. Of these criteria, our patient met all echocardiographic criteria during work-up for decommissioning, and he met the hemodynamic criteria at turn-down immediately before decommissioning. In addition, we used a Langston catheter to measure LV and aortic pressure simultaneously to confirm "recoupling" of the ventricular-arterial system and allow interpretation of LV filling pressures in this context. Critically, in terms of our decision making, we observed maintenance of normal LV filling pressures and volume in the setting of normal arterial pulsatility and MAP at turn-down, consistent with normalization of the ventricular-arterial interaction. Finally, there was no decrement in any parameter with transient balloon occlusion, which we performed as a final check before device deployment. We thus combined rigorous patient selection with real-time multimodality assessment and multiple "stop points" for multidisciplinary discussion before irreversible occlusion of the outflow graft.

Technical aspects of the procedure warrant discussion. In terms of device selection, the vascular plug device, with 6 layers of braided nitinol mesh, achieves rapid thrombosis and occlusion with low migration risk, thereby making it suitable for use in high-flow vessels.[13] Rapid occlusion time is critical in the setting of LVAD decommissioning, to minimize the risk of regurgitation-induced LV decompensation. We used a 14-mm device, thus allowing 40% oversizing relative to the 10-mm diameter HVAD outflow graft, in keeping with manufacturer-recommended 30% to 50% oversizing to minimize the risk of

FIGURE 2 Fluoroscopic Images During Deployment of a Vascular Plug Device Within the Left Ventricular Assist Device Outflow Graft



(A) Angiography of the outflow graft **(white arrow). (B)** Balloon occlusion of the outflow graft. **(C)** After deployment and before release of the vascular plug device **(black arrow).** Abbreviations as in Figure 1.

device migration.[13] Finally, we deployed the device in the mid-distal graft, to leave enough room distally for placement of a second device if occlusion was not achieved with the first.

FOLLOW-UP

The patient remains clinically well at 9 months after the procedure, with no further hospitalizations.

CONCLUSIONS

Patient selection, intraprocedural hemodynamic monitoring, and multidisciplinary decision making are critical to the success of percutaneous LVAD decommissioning using a vascular plug.

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ADDRESS FOR CORRESPONDENCE: Dr Carey Kimmelstiel, The CardioVascular Center, Tufts Medical Center, 800 Washington Street, Boston, Massachusetts 02111, USA. E-mail: ckimmelstiel@tuftsmedicalcenter.org.

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KEY WORDS cardiac assist devices, chronic heart failure, hemodynamics, occluder

APPENDIX For supplemental videos, please see the online version of this paper.