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CASE REPORT

ADVANCED

CLINICAL CASE

Percutaneous Decommissioning 11 Years After Initial CF-LVAD Placement

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ABSTRACT

An 80-year-old man with severe nonischemic cardiomyopathy status post left ventricular assist device (LVAD) placement 11 years prior presented for recurrent LVAD alarms from internal driveline fracture. Given his partial myocardial recovery and his preference to avoid surgical procedures, percutaneous LVAD decommissioning was performed by occlusion of the outflow graft and subsequently driveline removal. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:101682) © 2022 Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

An 80-year-old man with nonischemic cardiomyopathy with reduced ejection fraction status post HeartMate II (Abbott Laboratories) left ventricular assist device (LVAD) was directly admitted for asymptomatic LVAD malfunctioning.

LEARNING OBJECTIVES

- To acknowledge that LVADs can act as a bridge to recovery though our current ability to predict who will have myocardial recovery before implantation is limited.
- To recognize the benefit of screening for myocardial recovery after LVAD implantation assessing for candidates for decommissioning.
- To compare methods of LVAD decommissioning with a particular focus on the benefits of newer, percutaneous methods.

PAST MEDICAL HISTORY

The patient had a long-standing history of nonischemic cardiomyopathy diagnosed at age 53 years (Figure 1). At age 69 years, he developed cardiogenic shock requiring inotropes and an intra-aortic balloon pump that could not be weaned, so he underwent LVAD implantation. He was started on carvedilol 3.125 mg twice daily at this time, which was uptitrated at age 74 years to his maximally tolerated doses of carvedilol 12.5 mg twice daily, lisinopril 5 mg daily, and spironolactone 25 mg daily. He continued to do well over the next several years, although he did require admissions at ages 72 and 75 years for diverticular gastrointestinal bleeding.

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ABBREVIATIONS AND ACRONYMS

CF = continuous flow

CI = cardiac index

CO = cardiac output

CTS = cardiothoracic surgery

GDMT = guideline-directed medical therapy

HF = heart failure

LVAD = left ventricular assist device

LVEF = left ventricular ejection fraction

PCWP = pulmonary capillary wedge pressure

TTE = transthoracic echocardiogram

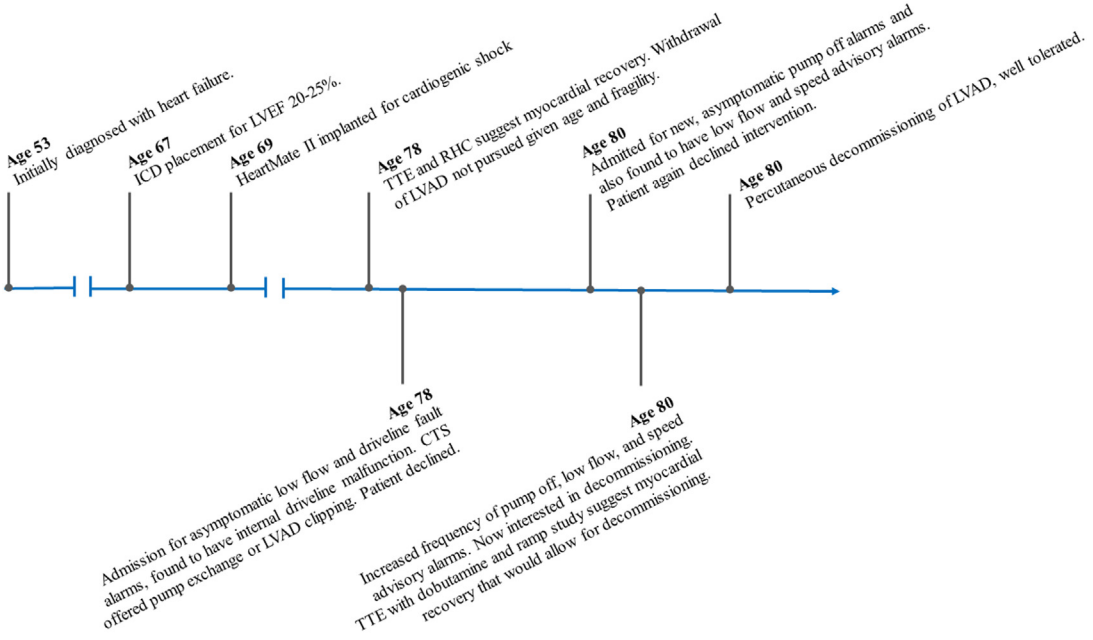
INVESTIGATIONS

At age 78, the patient had a transthoracic echocardiogram (TTE) that revealed left ventricular ejection fraction (LVEF) of 30% and a left ventricular internal diameter end diastole of 5.3 cm. A right heart catheterization showed the following hemodynamics: right atrium 10 mm Hg, right ventricle 37/10 mm Hg, pulmonary artery 37/13 (mean 23) mm Hg, pulmonary capillary wedge pressure (PCWP) 11 mm Hg, cardiac index (CI) 3.09 L/min/m^2, cardiac output (CO) 4.46 L/min.

One month later, the patient was admitted for asymptomatic driveline fault alarms and several "low-flow" alarms that were ultimately found to be from internal driveline wire malfunction with a functioning backup wire. The patient was evaluated by cardiothoracic surgery (CTS) who recommended pump exchange or LVAD decommissioning, given possible partial myocardial recovery. At that time, the patient declined any surgical procedures and was closely followed in the LVAD clinic. After discharge, he continued to have asymptomatic "low-flow" alarms. One year later, he was again admitted for several "pump off" events and low-speed operation alarms with ramp downs that occurred even when he was on ungrounded cable or batteries. The patient remained opposed to any surgical intervention even after ongoing discussions with CTS, palliative care, and the heart failure team about the risks associated with frequent pump stoppage alarms, including worsening heart failure (HF) symptoms and LVAD thrombosis and resultant systemic embolic events, including stroke. He was, therefore, discharged with an ungrounded wire to reduce the frequency of the alarms.

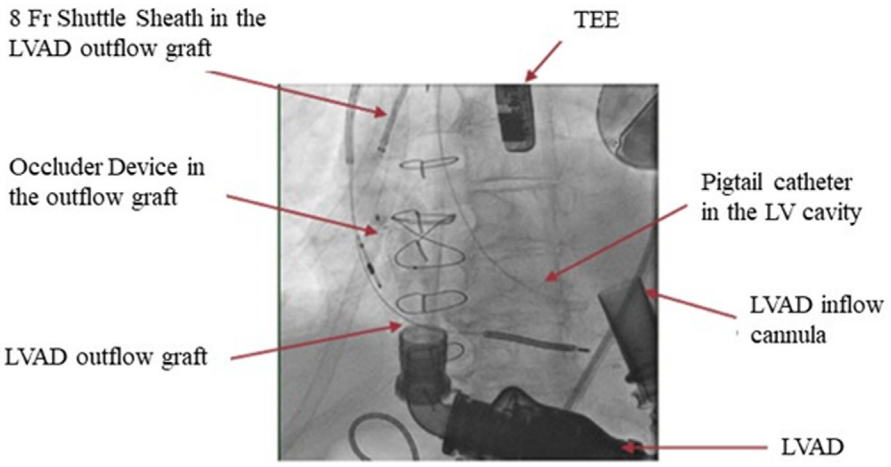
Over the next 2 weeks, the frequency of "pump off," "low-flow," and "speed advisory" alarms increased, so he was again directly admitted. The patient remained uninterested in surgical procedures, such as pump replacement, but decided to be evaluated for decommissioning of the LVAD. He had a more extensive evaluation of myocardial recovery with a dobutamine stress echocardiogram, which revealed contractile reserve with improvement of stroke volumes and LVEF from 39 mL and 28% at rest to 53 mL and 38% at peak dobutamine of 20 μg/kg/min. He also underwent ramp-down study with TTE and pulmonary artery catheter monitoring at device speeds of 8,800, 8,400, 8,000, 7,600, 7,200, 6,600,

FIGURE 1 Timeline of Key Events in This Patient's Partial Myocardial Recovery and LVAD Decommissioning



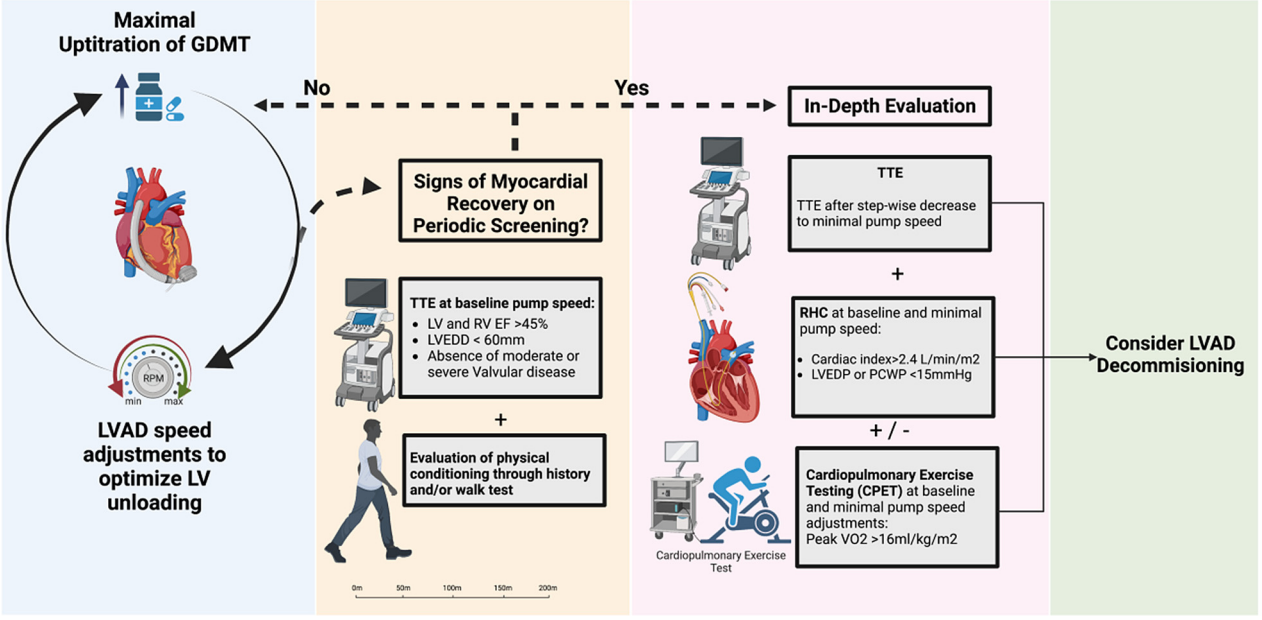
CTS = cardiothoracic surgery; ICD = intracardiac defibrillation; LVAD = left ventricular assist device; LVEF = left ventricle ejection fraction; RHC = right heart catheterization; TTE = transthoracic echocardiogram.

FIGURE 2 **Imaging of Occluder Device and 8-F Shuttle Sheath in the LVAD Outflow Graft During the Percutaneous Decommissioning Procedure**



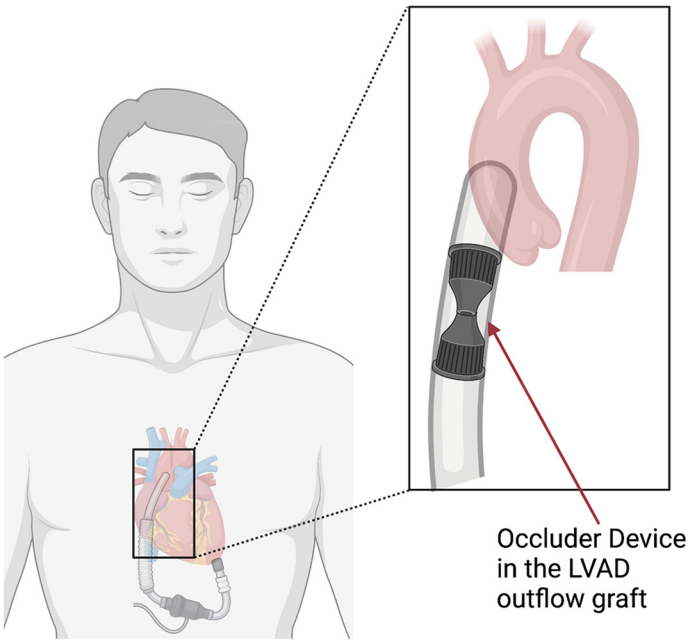
LV = left ventricle; LVAD = left ventricular assist device; TEE = transesophageal echocardiography.

FIGURE 3 **An Algorithimic Approach to Screening and In-depth Evaluation of Candidates for Device Decommissioning**



Developed using the protocols of Hrytsyna et al.[3] and Birks et al.[4] EF = ejection fraction; GDMT = guideline-directed medical therapy; LVEDD = left ventricular end diastole diameter; LVEDP = left ventricular end diastolic pressure; PCWP = pulmonary capillary wedge pressure; RV = right ventricle; other abbreviations as in Figures 1 and 2.

FIGURE 4 Depiction of the Location of the Occlude Device Placement in the LVAD Outflow Graft



LVAD = left ventricular assist device

and 6,000 RPM. No change in his hemodynamics was observed when weaning his LVAD from his baseline speed of 8,800 RPM (pulmonary artery 18/3 [mean 10] mm Hg, PCWP 2 mm Hg, CI 2.6 L/min/m^2, CO 5.2 L/min) to the minimum tested speed of 6,000 RPM (pulmonary artery 18/3 [mean 9] mm Hg, PCWP 2 mm Hg, CI 2.6 L/min/m^2, CO 5.4 L/min). For determining the optimal method of noninvasive LVAD decommissioning, he also had computed tomography imaging of the chest that showed the outflow graft was high underneath the sternum and would not have been easily accessible through a small subxiphoid approach to simply ligate the outflow graft.

MANAGEMENT

The patient underwent percutaneous decommissioning of his LVAD under general anesthesia in a hybrid operating room by structural cardiology with CTS backup using transesophageal echocardiography and fluoroscopic guidance. Percutaneous access was obtained in the bilateral common femoral arteries. After starting systemic heparin, the LVAD flow was weaned to 6,000 RPM and then ultimately turned off. A 6-F Multipurpose A-2 catheter was used obtain access to the LVAD outflow graft with placement confirmed with angiography. After exchange to an 8-F Shuttler Sheath over a 0.035-inch Rosen guidewire, a 14-mm Amplatzer Septal Occluder (Abbott Laboratories) was placed in the LVAD outflow graft (Figure 2). CTS then performed a small subxiphoid incision for driveline excision. He tolerated the procedure well and repeat TTE postoperatively showed an improvement of his LVEF to 35% compared with 25% preoperatively. Warfarin was restarted postoperatively, and he was discharged home 5 days after the procedure.

At 6 months since decommissioning, he has not required further admissions to the hospital. He can walk 2 blocks before feeling short of breath, which is an improvement in his functional capacity. As an outpatient, his guideline-directed medical therapy (GDMT) has been up-titrated. Most recent TTE demonstrated an LVEF of 35% and left ventricular internal diameter end diastole of 5.8 cm.

DISCUSSION

In addition to their role in augmenting CO, LVADs combined with optimal GDMT offload the myocardium, which can allow for reversal of cardiac remodeling and improvement in ejection fraction, CI, and PCWP.[1,2] In some cases of myocardial recovery, LVAD discontinuation can be considered. Although no consensus exists regarding exact criteria for determining candidates for LVAD withdrawal, data published to date support screening with TTEs at baseline pump speed followed by more detailed testing using TTE, hemodynamic assessment with a pulmonary artery catheter, and cardiopulmonary exercise testing at baseline and minimal pump speed in explant candidates (Figure 3).[3-5] Pump decommissioning remains a rare event in all-comers after LVAD implantation. A 2016 study of 13,454 LVAD patients from the Interagency Registry for Mechanically Assisted Circulatory Support found an explant rate of 0.9% and 3.1% at 1 and 3 years, respectively, but prospective protocols closely monitoring LVAD patients for myocardial recovery have been able to achieve explant rates as high as ~50%.[4,6] After LVAD explantation, no consensus exists regarding the need for anticoagulation or aspirin. In a study that followed 28 patients for a median follow-up of 26 months after LVAD explantation, no cerebrovascular events occurred in any patient regardless of therapy with aspirin only (42.9%), warfarin only (39.3%), both aspirin and warfarin (14.3%), or neither drug (29%).[7]

Traditionally, LVAD withdrawal was performed with device explantation, which involves a redo

median sternotomy, cardiopulmonary bypass, and removal of the various implanted components of the LVAD. However, minimally invasive methods to decommission the LVAD have emerged as appealing alternatives that do not require repeat sternotomy or cardiopulmonary bypass and instead leave the device within the body. Minimally invasive methods of LVAD decommissioning include exposure and ligation, which was not possible in this case given that the outflow graft was high above the sternum, or percutaneous plugging of the outflow graft (**Figure 4**).[8] A 2020 meta-analysis comparing explantation with LVAD decommissioning found no difference in rates of survival, infection, or cerebrovascular events at a median of 12 months of follow-up, although there was a trend toward higher rates of HF recurrence in those who underwent decommissioning as compared with explantation.[9] Improvements in LVAD technology have also improved likelihood of LVAD withdrawal with higher post-explanation LVEF (41.5% vs 24%) and lower rates of HF recurrence (6.6% vs 28.3%) and LVAD reimplantation (7.7% vs 37%) in those with continuous-flow (CF) versus pulsatile LVADs, respectively, in a 2016 meta-analysis.[10]

The reverse cardiac remodeling from GDMT and offloading the myocardium with a CF-LVAD, combined with minimally invasive decommissioning methods, set the stage for LVADs to be increasingly used as a bridge to recovery. However, our case highlights existing limitations in the bridge to recovery model. First, predicting those who will have myocardial recovery before LVAD placement remains a challenge. Prior studies have found that younger patients with acute-onset, nonischemic cardiomyopathy are more likely to have myocardial recovery, but our patient had long-standing cardiomyopathy and prolonged support of 11 years on LVAD and was 80 years old at the time of decommissioning, underscoring this limitation in current understanding.[11] Second, approximately 6.6% of patients will have HF recurrence after CF-LVAD withdrawal.[10] Although multiple screening protocols have been tested to try to minimize risk of complications after LVAD withdrawal, consensus regarding the optimal criteria is lacking. Last, surveillance programs for monitoring patients for LVAD withdrawal are not yet widely used, with data showing the true LVAD withdrawal rate is significantly lower than those found in more aggressive surveillance programs.[3,4,6] In this case, the prompting event for LVAD decommissioning was well-tolerated pump stoppage events that occurred due to internal driveline fracture. Further research is needed to address each of these limitations before bridge to recovery is an increasingly used LVAD goal.

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REFERENCES

1. Dandel M, Hetzer R. Recovery of failing hearts by mechanical unloading: pathophysiologic insights and clinical relevance. *Am Heart J*. 2018;206:30-50.

2. Hall JL, Fermin DR, Birks EJ, et al. Clinical, molecular, and genomic changes in response to a left ventricular assist device. *J Am Coll Cardiol*. 2011;57(6):641-652.

3. Hrytsyna Y, Kneissler S, Kaufmann F, et al. Experience with a standardized protocol to predict successful explantation of left ventricular assist devices. *J Thorac Cardiovasc Surg. Published online January*. 2021;9. https://doi.org/10.1016/j.jtcvs.2021.01.001

4. Birks EJ, Drakos SG, Patel SR, et al. Prospective multicenter study of myocardial recovery using left ventricular assist devices (RESTAGE-HF [Remission from Stage D Heart Failure]): medium-term and primary end point results. *Circulation*. 2020;142(21):2016-2028.

5. Kanwar MK, Selzman CH, Ton VK, et al. Clinical myocardial recovery in advanced heart failure with long term left ventricular assist device support. *J Heart Lung Transplant*. 2022;41(10):1324-1334.

6. Topkara VK, Garan AR, Fine B, et al. Myocardial recovery in patients receiving contemporary left ventricular assist devices: results from the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS). *Circ Heart Fail*. 2016;9(7). https://doi.org/10.1161/CIRCHEARTFAILURE.116.003157.e003157

7. Antonides CFJ, Schoenrath F, de By T, et al. Outcomes of patients after successful left ventricular assist device explantation: a EUROMACS study. *ESC Heart Fail*. 2020;7(3):1085-1094.

8. Jain P, Kiernan MS, Couper GS, Brovman EY, Asber SR, Kimmelstiel C. Percutaneous decommissioning of a left ventricular assist device in a patient with myocardial recovery. *J Am Coll Cardiol Case Rep*. 2022;4(6):354-358.

9. Choi JH, Weber MP, Horan DP, et al. Left ventricular assist device decommissioning compared with explantation for ventricular recovery: a systematic review. *ASAIO J*. 2020;66(1):17-22.

10. Phan K, Huo YR, Zhao DF, Yan TD, Tchantchaleishvili V. Ventricular recovery and pump explantation in patients supported by left ventricular assist devices: a systematic review. *ASAIO J*. 2016;62(3):219-231.

11. Wever-Pinzon O, Drakos SG, McKellar SH, et al. Cardiac recovery during long-term left ventricular assist device support. *J Am Coll Cardiol*. 2016;68(14):1540-1553.

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