Percutaneous endovascular stenting to treat left ventricular assist device outflow graft stenosis

Aaron Litvak, BA, Kshitij Desai, MD, MPHS, Craig Narins, MD, *and* Doran Mix, MD, *Rochester, NY*

ABSTRACT

A 72-year-old woman presented with acute symptoms of congestive heart failure exacerbation and cardiogenic shock secondary to flow alarms in her HeartMate II left ventricular assist device (LVAD) placed in 2013. Her rapid deterioration required venoarterial extracorporeal membrane oxygenation placement with subsequent cardiac catheterization. A computed tomography scan corroborated 90% stenosis of the LVAD outflow graft with mural thrombus causing cardiogenic shock. A multidisciplinary team proceeded with endovascular treatment of the LVAD outflow obstruction via realignment with percutaneous angioplasty and placement of covered stent grafts. After in-hospital recovery, she was discharged to a rehabilitation facility. (J Vasc Surg Cases Innov Tech 2024;10:101430.)

Keywords: Case report; Left ventricular assist device; LVAD; OGS; Outflow graft stenosis

Heart failure with a reduced ejection fraction is a significant healthcare burden, with considerable advancements in treatment during the past three decades.[1,2] Notably, left ventricular assist devices (LVADs) such as the Heartmate II and III (Abbott Cardiovascular) afford patients longer life expectancy, durability, and lower complication rates.[2,3] Complications include pump thrombosis, hemorrhage, drive line infections, and progressive right-sided heart failure.[1] Because LVADs historically have provided a bridge to cardiac transplantation, long-term sequalae are difficult to evaluate. However, given the cardiac transplantation limitations, LVADs are becoming destination therapy. Rarely, outflow graft (OG) stenosis (OGS) of longstanding LVAD outflow conduits occurs due to building of laminar thrombus.[4-6] Patients can present with delayed device thrombosis or cardiogenic shock and are generally not candidates for open LVAD revision, given the high cardiovascular risk factors. The present patient provided written informed consent for the report of her case details and imaging studies.

CASE REPORT

The patient is a 72-year-old woman with a medical history pertinent for atrial fibrillation, coronary artery disease (prior ST-elevation myocardial infarction), ischemic cardiomyopathy, hypertension, dyslipidemia, a 40 pack-year smoking history, type 2 diabetes mellitus, prior embolic stroke, an implantable cardioverter/defibrillator, and Heartmate II placement in 2013. She had no significant cardiovascular interventions for >5 years preceding her presentation in 2023. Her medical therapy was a single antiplatelet agent, supratherapeutic warfarin (baseline international normalized ratio, 5-6), and antihypertensive agents. Her chief concern was 2 weeks of worsening chest pain and dyspnea with low-flow LVAD alarms. She was hemodynamically stable, with a systolic blood pressure of 80 mm Hg. The physical examination revealed pitting edema in her lower extremities, jugular venous distension >8 cm bilaterally, rhonchi, and positive LVAD peripheral signals without electrical or device malfunctions noted.

Based on her presentation and LVAD settings, the initial differential diagnosis included congestive heart failure exacerbation and cardiogenic shock. Rapid deterioration led to a new-onset pressor requirement for hypotension, and she was transported to the cardiac catheterization laboratory with a temporizing plan for venoarterial extracorporeal membrane oxygenation (ECMO; right groin venous, left groin arterial, and reperfusion). The results from catheterization suggested severe LVAD OGS causing cardiogenic shock. Corroborating findings included elevated right- and left-sided heart filling pressures, moderate pulmonary hypertension, and a depressed cardiac index.

A subsequent computed tomography (CT) scan during high flow ECMO revealed limited outflow contrast opacification, consistent with outflow obstruction due to chronic graft dilation and thrombosis with significant outflow stenosis at zone 0 of the aorta (Fig 1). Cross-sectional imaging revealed a type I bovine arch configuration with ~35 mm of a nondilated, nonectatic aorta from the graft anastomosis to great vessel takeoff. There was 75 mm of mural thrombus lining the OG, consistent with a 90% stenosis. Cardiac surgery determined the patient was not a candidate for cardiac transplant or LVAD revision. In a multidisciplinary fashion, the patient, family, heart failure team, and consulting vascular surgery team proceeded with endovascular treatment of the LVAD outflow obstruction. The patient was counseled regarding the immediate- and long-term risks,

From the Division of Vascular Surgery, University of Rochester Medical Center.
Correspondence: Aaron Litvak, BA, Division of Vascular Surgery, University of Rochester Medical Center, 601 Elmwood Ave, Box 211, Rochester, NY 14642 (e-mail: aaron_litvak@urmc.rochester.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2024.101430

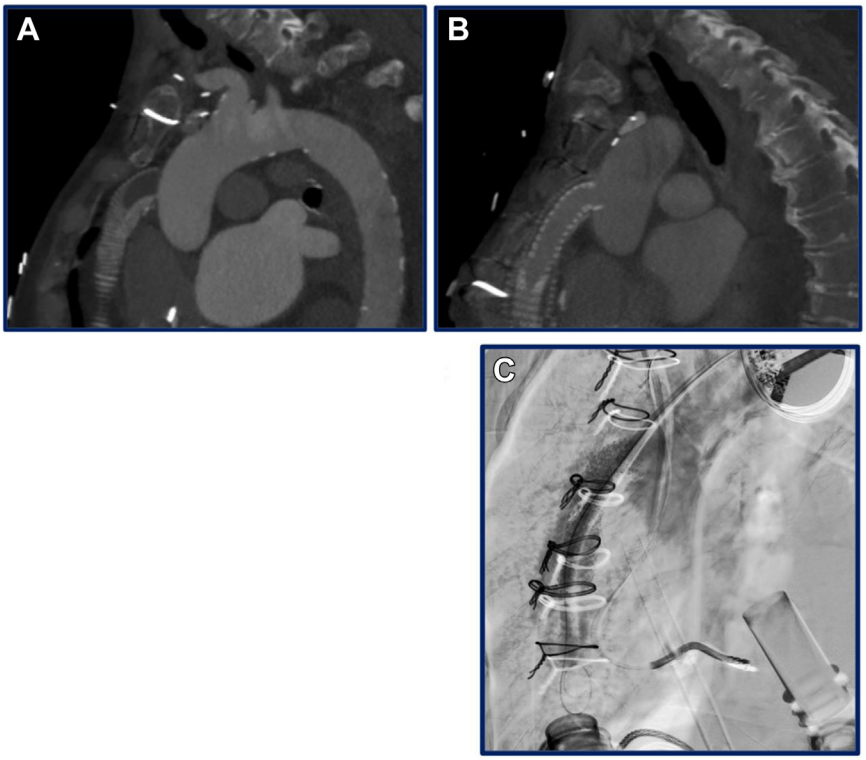

Fig 1. Computed tomography (CT) scan showing severe stenosis of left ventricular assist device (LVAD) outflow graft (**A**), deployment of VBX stents (W.L. Gore & Associates) in LVAD outflow track (**B**), and fully expanded VBX stents in LVAD outflow track (**C**).

including access complications, hemorrhage, LVAD thrombosis, myocardial infarction, and stroke and the need for close interval monitoring to ensure stent patency and proper LVAD function.

OPERATIVE COURSE

The case was performed in the cardiac catheterization laboratory under moderate sedation with the LVAD and ECMO settings modulated throughout the course. The right radial and femoral arteries were accessed via micropuncture under ultrasound guidance, confirmed with angiography, and upsized to 6F sheaths. A filter wire was placed in the right common carotid artery (CCA) via femoral access. Left CCA cannulation via radial and femoral access proved difficult due to tortuosity; thus, given concerns for dissection, left-sided neuroprotection was abandoned. A dual filter was discussed but was unavailable at our institution, and no other strategies, such as invasive left CCA access, were used due to the emergent nature of the case and unfavorable risk factors. The intracranial anatomy was not delineated preoperatively due to her emergent presentation. Via femoral access, a multipurpose angiographic catheter with a Glidewire Advantage catheter (Terumo Interventional Systems) were advanced into the LVAD OG and positioned above the rotor. The OG diameter was 14 mm. The hemodynamic pull-back pressure confirmed an 80-mm Hg pressure difference between the LVAD outflow and native zone 0 of the aorta, corroborating the presence of a critical stenosis. After anastomosis definition and obtaining confirmatory angiograms, initial balloon angioplasty with a 14-mm Atlas balloon (Becton Dickinson) was used to intentionally create a luminal channel. During angioplasty, the ECMO settings were increased to accommodate the obstructed aortic inflow. Interval angiography defined placement of a 11-mm × 79-mm balloon-expandable covered stent graft with adjunct mechanical supportive maneuvers. Outsizing was confirmed via 20% overestimation. The LVAD flow volumes increased to 3 to 4 L/min after first stent placement. Two minutes later, the LVAD flow ceased again, and repeat angiography showed most of the thrombus material had accumulated distally in the OG. An additional 11-mm × 59-mm balloon-expandable covered stent graft was placed, centered over this thrombus. Normal LVAD outflow was restored, and no gradient was noted across the realigned OG and native aorta (Tables I and II). The LVAD intraoperative parameters are reported in Fig 2. The right carotid artery filter was removed, and no dissection, flow-limiting stenoses, or technical complications were noted. Cerebral angiography revealed a widely patent bovine arch with bilateral vertebral and extracranial carotid artery filling. The

Table I. Left ventricular assist device (LVAD) settings before and after intervention for our patient and literature-reviewed cases

	Before intervention		After intervention	
LVAD setting	Our patient	Comparison (mean)	Our patient	Comparison (mean)
Flow, L/min	2.2	3.4	4.7	4.4
Speed, rpm	9000	7952.6	9400	8026.5
Pulsatility index	2.8	3.7	5.1	3.1
Power, W	3.7	4.2	5.5	4.6

Table II. Patients in the literature for whom the data presented in Table I were available

LVAD setting	Before intervention, No.	After intervention, No.
Flow	144	120
Speed	19	17
Pulsatility index	6	3
Power	88	64

LVAD, Left ventricular assist device.

femoral and radial access sites were closed with a Perclose ProGlide device (Abbott Cardiovascular) and TR band radial compression device (Terumo Interventional Systems), respectively. The distal signals were unchanged. The patient remained neurologically intact throughout the operation. She required 3 days in the intensive care unit postoperatively, with her recovery complicated by a delayed left middle cerebral artery distribution stroke by postoperative day 1 with a presumed cardioembolic etiology from LVAD outflow instrumentation. ECMO was weaned on postoperative day 1, with surgical closure of the access sites. There were no other significant complications, and single-agent anticoagulation and antiplatelet therapy was maintained. She was discharged to a rehabilitation center after marked in-hospital recovery.

DISCUSSION

Long-term complications of LVAD devices are rare due to the 5-year survival rate of 54% in HeartMate II patients.[7] Since 2013, our patient had no major interventions, other than driveline washouts from infection in the first postoperative year. Patients with long-term LVAD complications often require urgent mechanical support and advanced endovascular treatment uniquely suited for vascular surgeons.

Several case reports and series describe OGS and its endovascular treatment options.[4,5,8-10] Patients with LVAD obstructions often present with low-flow alarms and cardiogenic shock, frequently diagnosed with CT scans, angiography, presentation, and history.[4,5,8-10] There might be a role for intravascular ultrasound; however, we sought to minimize the number of wire exchanges and had effective sizing parameters determined from a gated CT scan. Comparisons in LVAD settings, before and after intervention, between our patient and literature-reviewed data are reported in Tables IandII.[5,6,8,9,11-14] The reasons for OGS include kinks and thrombosis, often in covered sections of the graft.[4,12] In our patient, the stenosis was most likely due to OG thrombosis, supported by the echocardiographic and cross-sectional imaging findings. During the procedure, thrombectomy was considered but not chosen due to the bulk and probable thrombus organization.

Frequently, these patients are unsuitable for sternotomy or heart transplant, leading to pursuit of endovascular ,interventions which appear to be safe and feasible overall, when other options are not viable.[6,13,15] Larger studies of OGS interventions also demonstrated technical success.[8] However, given the high risk of cardiac embolization, more investigation of the long-term outcomes for patients with endovascular treatment of OGS is needed to better delineate the treatment options for this rare, but increasingly occurring, complication.

CONCLUSIONS

With the increasing use and longevity of LVADs, understanding the presentation and treatments of long-term device complications will be vital to treating patients with LVADs. Percutaneous endovascular treatment should be considered as a safe and efficacious option for carefully selected patients.

DISCLOSURES

None.

Special acknowledgments to Chrystine Black, RN.

Fig 2. HeartMate II device (*HMII*) parameter graphs showing changes in power (*blue*), flow (*orange*), and speed (*green*) corresponding to labeled interventions during the procedure (*yellow*).

REFERENCES

1. Frazier OH, Myers TJ, Westaby S, Gregoric ID. Clinical experience with an implantable, intracardiac, continuous flow circulatory support device: physiologic implications and their relationship to patient selection. *Ann Thorac Surg*. 2004;77:133–142.
2. Rose EA, Gelijns AC, Moskowitz AJ, et al. Long-term use of a left ventricular assist device for end-stage heart failure. *N Engl J Med*. 2001;345:1435–1443.
3. Griffith BP, Kormos RL, Borovetz HS, et al. HeartMate II left ventricular assist system: from concept to first clinical use. *Ann Thorac Surg*. 2001;71:S116–S120. discussion: S114-6.
4. Karaca S, Erdinli D, Kahraman U, et al. Late outflow graft stenosis of left ventricular assist device and endovascular treatment. *J Artif Organs*. 2023. https://doi.org/10.1007/s10047-023-01400-4.
5. Nathan S, Ghotra AS, Rajagopal K, et al. Left ventricular assist device outflow graft obstruction: a case series. *ASAIO J*. 2020;66:657–662.
6. Wood CT, O'Malley TJ, Maynes EJ, et al. Survival outcomes of stenting outflow graft stenosis in continuous-flow left ventricular assist devices: a systematic review. *Heart Fail Rev*. 2020;25:985–992.
7. Hanke JS, Rojas SV, Mahr C, et al. Five-year results of patients supported by HeartMate II: outcomes and adverse events. *Eur J Cardio Thorac Surg*. 2018;53:422–427.
8. Agrawal A, Alexy T, Kamioka N, et al. Outflow graft obstruction after left ventricular assist device implantation: a retrospective, single-centre case series. *ESC Heart Fail*. 2021;8:2349–2353.
9. Dreessens E, Cox J, Ramsey J, et al. Transaxillary stenting of LVAD outflow graft obstruction. *JACC Case Rep*. 2021;3:1064–1068.
10. Wiedemann D, Schloglhofer T, Haberl T, et al. Interventional treatment of LVAD outflow graft stenosis by introduction of bare metal stents. *ASAIO J*. 2018;64:e3–e7.
11. Ajello S, Pieri M, Bertoglio L, Altizio S, Nardelli P, Scandroglio AM. Extrinsic outflow graft flow obstruction in patients with HeartMate3 LVAD. *Artif Organs*. 2023;47:786–790.
12. Dimitrov K, Kaider A, Angleitner P, et al. Incidence, clinical relevance and therapeutic options for outflow graft stenosis in patients with left ventricular assist devices. *Eur J Cardio Thorac Surg*. 2022;61:716–724.
13. Lanmueller P, Eulert-Grehn JJ, Unbehaun A, et al. Interventional procedures for left ventricular assist device-associated complications. *ASAIO J*. 2022;68:1332–1338.
14. Retzer EM, Tannenbaum SA, Fedson SE, et al. Successful percutaneous trans-catheter treatment of left ventricular assist device outflow graft stenosis with a covered stent. *ESC Heart Fail*. 2015;2:100–102.
15. Peters CJ, Zhang RS, Vidula MK, et al. Durable left ventricular assist device outflow graft obstructions: clinical characteristics and outcomes. *J Clin Med*. 2023;12:2430.

Submitted Nov 21, 2023; accepted Jan 2, 2024.