

CASE REPORT

ADVANCED

CLINICAL CASE

Crossing the Bridge to Heart Transplantation

Biventricular Impella to Support an Unstable LVAD Patient



Joban Vaishnav, MD,^a Steven Hsu, MD,^a Kavita Sharma, MD,^a Roberta Florido, MD, MPH,^a Sabra Lewsey, MD, MPH,^a Steven P. Schulman, MD,^a Matthews Chacko, MD,^a Ahmet Kilic, MD,^b Chun-woo Choi, MD,^b Nisha A. Gilotra, MD^a

JACC: CASE REPORTS CME/MOC/ECME

This article has been selected as this issue's CME/MOC/ECME activity, available online at <http://www.acc.org/jacc-journals-cme> by selecting the JACC Journals CME/MOC/ECME tab.

Accreditation and Designation Statement

The American College of Cardiology Foundation (ACCF) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

The ACCF designates this Journal-based CME/MOC/ECME activity for a maximum of 1 *AMA PRA Category 1 Credit(s)*[™]. Physicians should only claim credit commensurate with the extent of their participation in the activity. Successful completion of this CME activity, which includes participation in the evaluation component, enables the participant to earn up to 1 Medical Knowledge MOC point in the American Board of Internal Medicine's (ABIM) Maintenance of Certification (MOC) program. Participants will earn MOC points equivalent to the amount of CME credits claimed for the activity. It is the CME activity provider's responsibility to submit participant completion information to ACCME for the purpose of granting ABIM MOC credit.

Crossing the Bridge to Heart Transplantation: Biventricular Impella to Support an Unstable LVAD Patient will be accredited by the European Board for Accreditation in Cardiology (EBAC) for 1 hour of External CME credits. Each participant should claim only those hours of credit that have actually been spent in the educational activity. The Accreditation Council for Continuing Medical Education (ACCME) and the European Board for Accreditation in Cardiology (EBAC) have recognized each other's accreditation systems as substantially equivalent. Apply for credit through the post-course evaluation. While offering the credits noted above, this program is not intended to provide extensive training or certification in the field.

Method of Participation and Receipt of CME/MOC/ECME Certificate

To obtain credit for this CME/MOC/ECME activity, you must:

1. Be an ACC member or JACC: Case Reports subscriber.
2. Carefully read the CME/MOC/ECME-designated article available online and in this issue of the *journal*.
3. Answer the post-test questions. A passing score of at least 70% must be achieved to obtain credit.
4. Complete a brief evaluation.
5. Claim your CME/MOC/ECME credit and receive your certificate electronically by following the instructions given at the conclusion of the activity.

CME/MOC/ECME Objective for This Article: Upon completion of this activity, the learner should be able to: 1) identify indications and contraindications for temporary mechanical circulatory support; 2) identify and discuss common complications and approach to management of Impella (Abiomed) device; 3) recognize the clinical presentation of complications of left ventricular assist devices; and 4) discuss approach to management of right ventricular failure in the setting of a left ventricular assist device.

Author Disclosures: The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Medium of Participation: Online (article and quiz).

CME/MOC/ECME Term of Approval

Issue Date: February 2020

Expiration Date: January 31, 2021

From the ^aDivision of Cardiology, Department of Medicine, Johns Hopkins Hospital, Baltimore, Maryland; and the ^bDivision of Cardiac Surgery, Department of Surgery, Johns Hopkins Hospital, Baltimore, Maryland. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Informed consent was obtained for this case.

Manuscript received September 20, 2019; revised manuscript received November 4, 2019, accepted December 7, 2019.

Crossing the Bridge to Heart Transplantation

Biventricular Impella to Support an Unstable LVAD Patient

Joban Vaishnav, MD,^a Steven Hsu, MD,^a Kavita Sharma, MD,^a Roberta Florido, MD, MPH,^a Sabra Lewsey, MD, MPH,^a Steven P. Schulman, MD,^a Matthews Chacko, MD,^a Ahmet Kilic, MD,^b Chun-woo Choi, MD,^b Nisha A. Gilotra, MD^a

ABSTRACT

We report the first case of a patient with a durable left ventricular assist device admitted with cardiogenic shock and managed with biventricular Impella support as a successful bridge to heart transplantation.

(Level of Difficulty: Advanced.) (J Am Coll Cardiol Case Rep 2020;2:173-7) © 2020 The Authors. 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/>).

Left ventricular assist devices (LVADs) provide durable mechanical circulatory support (MCS) as destination therapy or bridge to heart transplantation (BTT). Despite significant improvements in survival, functional capacity, and quality of life, LVAD therapy is limited by potential long-term medical and surgical complications (1,2). We report a patient with an LVAD who presented with cardiogenic shock and underwent successful BTT with biventricular Impella (Abiomed, Danvers, Massachusetts) support.

HISTORY OF PRESENTATION

A 33-year-old man with nonischemic cardiomyopathy who had undergone BTT with a HeartWare LVAD 5 years prior was admitted with weeks of progressive dyspnea and fatigue. On physical examination, he had a Doppler mean arterial pressure of 64 mm Hg, a regular heart rate at 72 beats/min, and normal oxygen saturation. He had jugular venous distension with large V waves, prominent right ventricular (RV) heave, LVAD hum, early diastolic murmur at the left sternal border, apical holosystolic murmur, and cool extremities. LVAD interrogation showed flows of 2.7 to 3.1 l/min (decreased from a baseline of 4.0 to 4.5 l/min), diminished pulsatility (<1 l/min waveform excursions) (Figure 1), and stable power at set speed of 3,240 rpm. Laboratory results were notable for

elevated creatinine of 2.5 mg/dl (baseline 1.5 mg/dl), total bilirubin of 2.4 mg/dl (reference 0.2 to 1.2 mg/dl), direct bilirubin 0.4 mg/dl (reference 0 to 1.2 mg/dl), lactate dehydrogenase of 207 U/l (reference 100 to 220 U/l), and lactate of 2.1 mmol/l (reference 0.5 to 2.0 mmol/l).

MEDICAL HISTORY

Medical history was notable for stage 2 chronic kidney disease and mild aortic insufficiency (AI) that developed shortly after LVAD implantation.

DIFFERENTIAL DIAGNOSIS

The patient's presentation was consistent with cardiogenic shock, with potential etiologies including both patient- and LVAD-related factors (Table 1).

INITIAL EVALUATION

Transthoracic echocardiography showed a severely dilated left ventricle (end-diastolic dimension 8.7 cm), a rightward-bowing septum, a hypokinetic right ventricle, a closed aortic valve with moderate to severe AI, severe mitral and tricuspid regurgitation, and no pericardial effusion (Video 1). Computed tomography demonstrated external compression from proteinaceous material forming between the LVAD outflow graft, which connects the left ventricle to the aorta and traverses over the right ventricle, and the polytetrafluoroethylene covering used at the time of the initial LVAD implantation (Figure 2A). Right heart catheterization revealed a right atrial pressure of 14 mm Hg with V waves to 34 mm Hg, pulmonary artery pressure of 47/25 mm Hg (mean 32 mm Hg), pulmonary capillary wedge pressure of 28 mm Hg,

LEARNING OBJECTIVES

- To recognize the presentation and causes of cardiogenic shock in a patient with LVAD.
- To understand the applications and limitations of various biventricular MCS strategies.

cardiac index of 1.47 l/min/m², systemic vascular resistance of 1,634 dynes · s · cm⁻⁵, and pulmonary artery oxygen saturation of 33%.

MANAGEMENT

Acute medical management consisted of inotropic support, diuresis, LVAD speed adjustment, and multidisciplinary discussion including the coronary care unit, heart failure and transplantation, cardiothoracic surgery, and interventional cardiology teams. Aortic valve replacement was considered given AI; however, the patient was not a candidate, because of lack of appropriate anatomy for a transcatheter approach and prohibitive surgical risk. Because of hemodynamic status and echocardiographic findings consistent with severe RV failure and end-organ hypoperfusion, it was decided to first pursue percutaneous RV support with the contingency to escalate to biventricular support. He underwent successful percutaneous femoral vein Impella RP placement, but without significant improvement in LVAD hemodynamic status. He therefore immediately underwent surgical axillary artery Impella 5.0 placement (Figure 2B). The Impella 5.0 and Impella RP were set to deliver 4.0 and 3.5 l/min of flow, respectively, and the LVAD speed was decreased to 2,800 rpm. His cardiac index improved to 2.5 l/min/m², and pulmonary artery oxygen saturation increased to 62%.

FOLLOW-UP

The patient underwent heart transplantation and LVAD explantation 5 days later. His post-operative course was complicated by need for renal replacement therapy, likely because of pre-operative renal tubular dysfunction from hemolysis. He was ultimately discharged home in good condition and continues to do well post-transplantation.

DISCUSSION

We report the first successful case of biventricular Impella support as BTT in an LVAD patient with cardiogenic shock. Approximately 54% of LVADs are placed as BTT, yet fewer than one-third of BTT LVAD patients undergo heart transplantation by 1 year (1). Nearly 30% of LVAD-supported transplantation candidates develop complications, justifying higher urgency wait-list status. In this case, the use of biventricular temporary mechanical support in the setting of LVAD complications put our patient at equivalent risk to others at the most urgent wait-list status and allowed us to obtain status 1 listing

approval from the United Network for Organ Sharing Review Board. However, once a complication occurs, the risk for death or delisting markedly increases (2). Adverse events after continuous-flow LVAD placement include bleeding, stroke, infection, RV failure, AI, and device malfunction. Our patient's cardiogenic shock was secondary to a combination of AI, partial outflow graft compression, and RV failure. AI develops because of changes in aortic blood flow dynamics leading to chronic valve leaflet fusion and malcoaptation of the aortic valve leaflets. Progression of AI leads to increased left ventricular end-diastolic pressure, mitral regurgitation, and RV dysfunction, resulting in adverse outcomes including increased heart failure hospitalizations and worsening survival (3). An emerging cause of outflow graft occlusion is extrinsic compression from a polytetrafluoroethylene covering. Proteinaceous material or thrombus can form in the space between the polytetrafluoroethylene covering and outflow graft, causing clinically significant obstruction (4). RV failure is a well-established short- and long-term complication of durable LVAD therapy and may be exacerbated by causes of left-sided heart failure, in particular AI (1). Despite ongoing engineering advancements, LVAD complications continue to affect survival and quality of life. Thus, optimal patient selection, extensive informed consent, and a thorough understanding of LVAD complication management remain paramount in caring for patients with advanced heart failure.

When an LVAD patient presents with cardiogenic shock or hemodynamic instability, management

ABBREVIATIONS AND ACRONYMS

- AI = aortic insufficiency
- BTT = bridge to heart transplantation
- LVAD = left ventricular assist device
- MCS = mechanical circulatory support
- RV = right ventricular

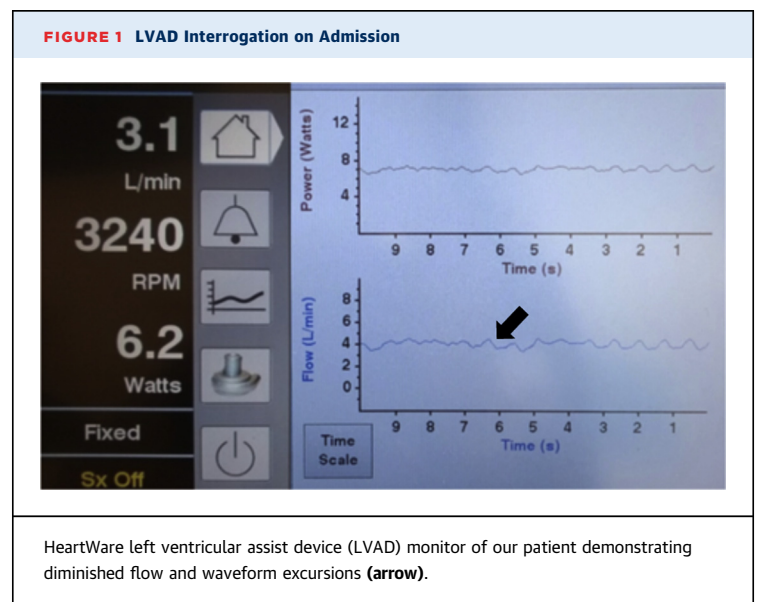
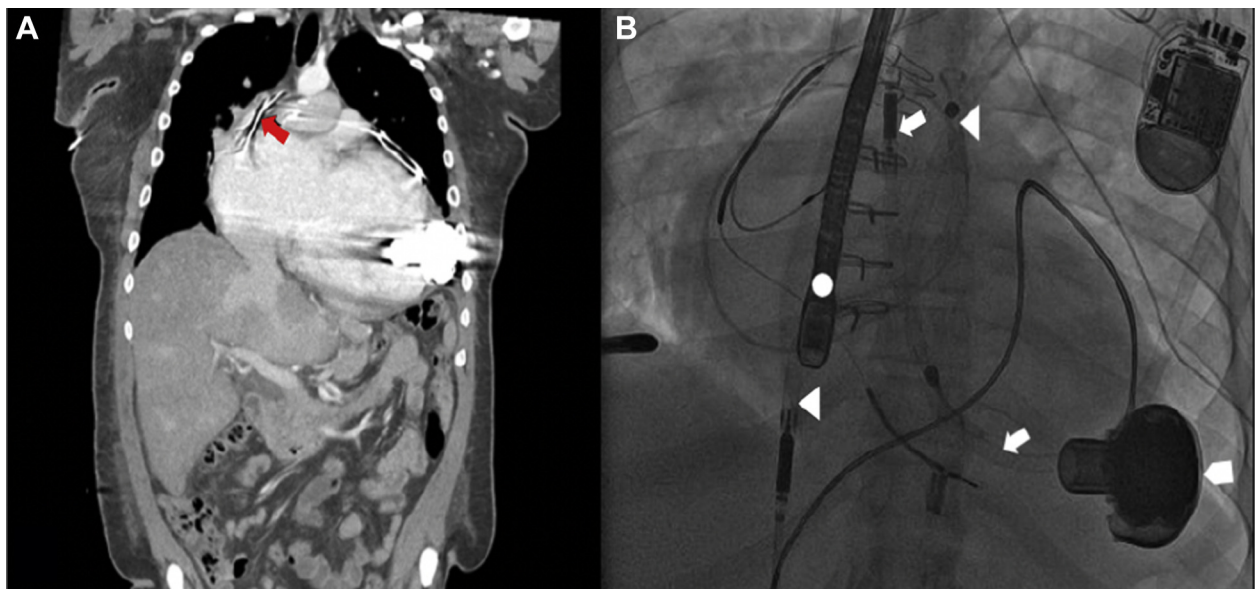


TABLE 1 Differential Diagnosis for Cardiogenic Shock in a Left Ventricular Assist Device Patient

Patient related	
Cardiac tamponade	
Pneumothorax	
Ventricular arrhythmia	
Early or late right ventricular failure	
Aortic valve insufficiency	
Pulmonary embolism	
Pump related	
Pump thrombosis	
Inflow or outflow cannula obstruction	
Power disconnection	
Driveline failure	
Inadequate pump speed	

centers on rapidly identifying the underlying etiology and stabilization. The first step is to ensure that all LVAD connections are secure, with an adequate power source. Bedside evaluation includes a focused physical examination (i.e., cardiac auscultation, volume assessment, palpation of pulses, and testing for focal neurological deficits), LVAD interrogation, electrocardiography, and echocardiography. Vasopressors may be needed to support perfusion while ascertaining the underlying etiology of decompensation; however, if inadequate or the

etiology is not readily reversed, additional MCS may be needed. Currently available options for temporary biventricular mechanical support include surgical approaches such as a CentriMag pump (Thoratec, Pleasanton, California), a paracorporeal ventricular assist device (Thoratec), or a total artificial heart (SynCardia Systems, Tucson, Arizona) and percutaneous approaches such as transvalvular microaxial flow catheters (Impella), extracorporeal centrifugal flow pumps (TandemHeart, Cardiac Assist, Pittsburgh, Pennsylvania), or venoarterial extracorporeal membrane oxygenation. Compared with surgically implanted devices, percutaneous devices are minimally invasive and may have less periprocedural mortality and less risk for bleeding. However, ambulation is not possible with devices requiring femoral cannulation, therefore limiting durability. Multiple factors must be considered when selecting the best form of temporary MCS, including: 1) patient condition and comorbidities; 2) the hemodynamic impact of the device; 3) technical feasibility; and 4) goals of support. There is a lack of published guidelines on the use of MCS in patients with cardiogenic shock, with few to no data in LVAD patients. This case highlights the need for registries and randomized controlled trials comparing different MCS strategies in unique patient populations.

FIGURE 2 CT Scan and Fluoroscopic Image

Coronal computed tomographic (CT) view showing partial extrinsic compression of the outflow graft (red arrow) near the right ventricle (A). Fluoroscopic image after placement of the Impella RP with inlet in inferior vena cava and outlet in pulmonary artery (white triangles), Impella 5.0 with inlet in the left ventricle and outlet in the ascending aorta (white arrows) with prior left ventricular assist device insertion (pentagon) under transesophageal echocardiographic (circle) guidance (B).

CONCLUSIONS

We report the first case of cardiogenic shock in an LVAD patient successfully managed with biventricular Impella support as BTT. Recognition and understanding of hemodynamic alterations as well as appropriate selection and management of mechanical support are critical to the success of

biventricular MCS use in decompensated LVAD patients.


ADDRESS FOR CORRESPONDENCE: Dr. Nisha Aggarwal Gilotra, Division of Cardiology, Johns Hopkins Hospital, 600 N. Wolfe Street, Carnegie Building, Suite 568, Baltimore, Maryland 21287. E-mail: naggaw2@jhmi.edu.

REFERENCES

1. Kirklín JK, Paganí FD, Kormos RL, et al. Eight annual INTERMACS report: special focus on framing the impact of adverse events. *J Heart Lung Transplant* 2017;3610:1080-6.
2. Fugar S, Okoh AK, Eshun D, et al. National trends and outcomes of patients bridged to transplant with continuous flow left ventricular assist devices. *Transplant Proc* 2019;51:852-8.
3. Truby LK, Garan AR, Givens RC, et al. Aortic insufficiency during contemporary left ventricular assist device support. *J Am Coll Cardiol HF* 2018;6:951-60.
4. Hsu S, Freed KE, Choi CW, Kilic A. Late-stage obstruction due to preventative wrapping of left ventricular assist device outflow graft. *Interact Cardiovasc Thorac Surg* 2019;293:489-90.

KEY WORDS acute heart failure, cardiac assist device, cardiac transplantation, cardiomyopathy

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



Go to <http://www.acc.org/jacc-journals-cme> to take the CME/MOC/ECME quiz for this article.