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CASE REPORT

ADVANCED

CLINICAL CASE

Cardiac Tamponade With a Transaortic Percutaneous Left Ventricular Assist Device

When Alarms Caused No Alarm

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ABSTRACT

A 57-year-old man with end-stage heart failure presented with incessant ventricular tachycardia in the setting of cardiogenic shock, requiring support with a percutaneous left ventricular assist device. He underwent ablation of the ventricular tachycardia. Hours later the console alarm was evident, and the patient experienced worsening shock and elevated central venous pressure, leading to a diagnosis of cardiac tamponade. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;19:101936) © 2023 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/).

A 57-year-old man was admitted to the hospital for acute-on-chronic decompensated heart failure, cardiogenic shock, and recent multiple shocks from his internal cardiac defibrillator. After extensive workup, he was deemed to have end-stage heart failure and underwent placement of an axillary intra-aortic balloon pump. Owing to his many episodes of ventricular tachycardia (VT) and inadequate hemodynamic support of an intra-aortic balloon pump in such a setting, he underwent placement of an Impella 5.5 (Abiomed) percutaneous left ventricular assist device (p-VAD) as he waited for a heart and a kidney transplantation. Videos 1 and 2 show echocardiographic images before and after implantation of p-VAD. He continued to have multiple, symptomatic VT episodes despite dual antiarrhythmic therapy, multiple echocardiography-guided device repositioning, and a stellate ganglion blockade. Hence, a VT ablation with endocardial and epicardial mapping was performed. The patient tolerated the procedure with successful ablation of epicardial basal and lateral left ventricle (LV), and endocardial between posteromedial papillary muscle and interventricular septum. The pericardial wires were removed, and a pericardial drain was introduced, followed by intrapericardial injection of 100 mg hydrocortisone and 20 mL bupivacaine. An

LEARNING OBJECTIVES

- To recognize cardiac tamponade in the presence of a p-VAD.
- To understand the physiology behind some common console alarms of p-VAD and development of a differential clinical diagnosis that led to the alarms.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

IVC = inferior vena cava

LV = left ventricle

LVEF = left ventricular ejection fraction

PV = pressure-volume

p-VAD = percutaneous left ventricular assist device

VAD = ventricular assist device

VT = ventricular tachycardia

intracardiac echocardiogram at the end of the procedure demonstrated no effusions, and the pericardial drain was therefore removed. Repeated imaging 3 hours after the procedure showed trace pericardial effusion. The patient remained intubated to maintain electrical stability, and 5 hours after the procedure the onset of intermittent mechanical assist device suction alarms occurred, and a persistent "device position unknown" alarm on the console occurred (**Figure 1**). A noninvasive blood pressure cuff measurement revealed pressures ranging from 60/59 mm Hg to 97/92 mm Hg on repeated measurements. Inasmuch as the patient did not have an arterial line and owing to his lack of pulsatility after the device placement, the accuracy of the cuff measurement was questioned, and the "cannula position unknown" alarm invalidated the pressure tracings on the console. His heart rate was 80 beats/min at a paced rhythm. The bedside intensive care team paged the on-call cardiology team for "device alarms."

MEDICAL HISTORY

The patient's medical history was significant for nonischemic cardiomyopathy (suspected familial dilated cardiomyopathy), history of VT, and chronic kidney disease.

DIFFERENTIAL DIAGNOSIS

The differential diagnoses for the device alarms include device dislodgement from the LV, preload reduction due to hemorrhagic shock or right ventricular failure, or cardiac tamponade and device malfunction.

INVESTIGATIONS

Bedside assessment by the cardiology on-call team confirmed the alarms and noted a central venous line pressure of 20 cm H_2O. An immediate bedside echocardiogram was performed, and the electrophysiologist was alerted. Echocardiography showed a large circumferential pericardial effusion, right ventricular diastolic collapse consistent with increased intrapericardial pressure, and a hyper-unloaded LV (**Figure 2**, Video 3)

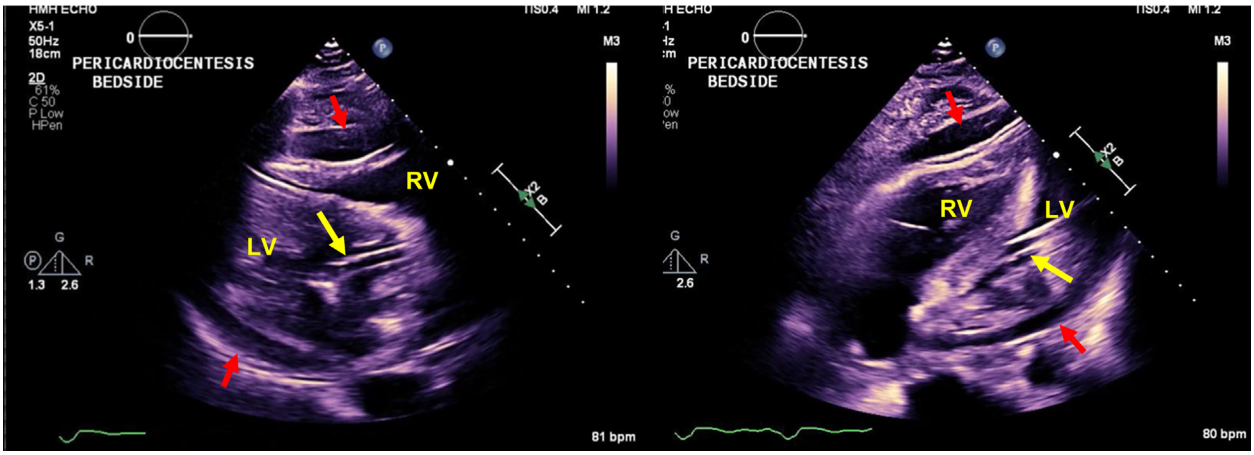
MANAGEMENT

The device level of support was reduced transiently to accommodate for the underfilled LV state while an emergent bedside pericardiocentesis was being set up. Relief of 700 mL bloody pericardial fluid immediately achieved hemodynamic improvement and a change in the console tracings, restoring a pulsatile

FIGURE 1 **Percutaneous Ventricular Assist Device Console Screen on Initial Bedside Assessment**

Console screen with "position unknown" **(red arrow)**. The placement signals show aortic (Ao) and left ventricular (LV) pressures dissociated with no pulsatility **(yellow arrow)**. The motor current and purge pressures are not elevated.

FIGURE 2 **Initial Point-of-Care Echocardiography**



Parasternal long-axis **(left)** and subcostal **(right)** echocardiographic images showing circumferential pericardial effusion **(red arrows)** with a very small left ventricular (LV) cavity caused by a hyperunloaded state in the presence of a percutaneous LV assist device **(yellow arrows)** and effusion. See Video 3 for corresponding cine loops. RV = right ventricle.

placement signal with improved pressures (**Figure 3**). Repeated echocardiography showed resolution of the pericardial effusion and tamponade (**Figure 4**, Video 4).

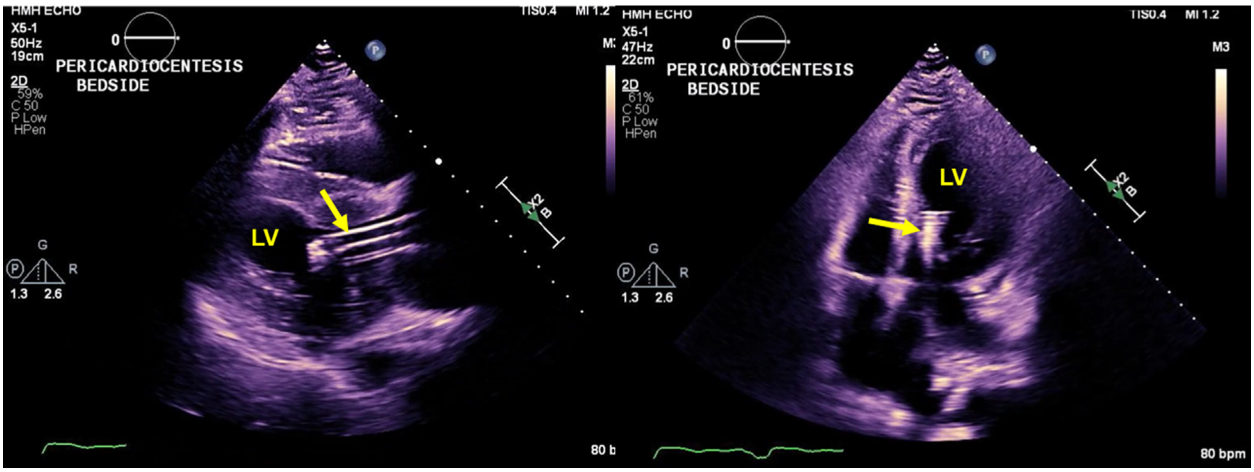
DISCUSSION

The impact of pericardial tamponade on the myocardial properties has been studied in PV loop

FIGURE 3 **Percutaneous Ventricular Assist Device Console Screen After Pericardiocentesis**

Console screen after pericardiocentesis showing normal aortic and left ventricular waveforms with restoration of pulsatility.

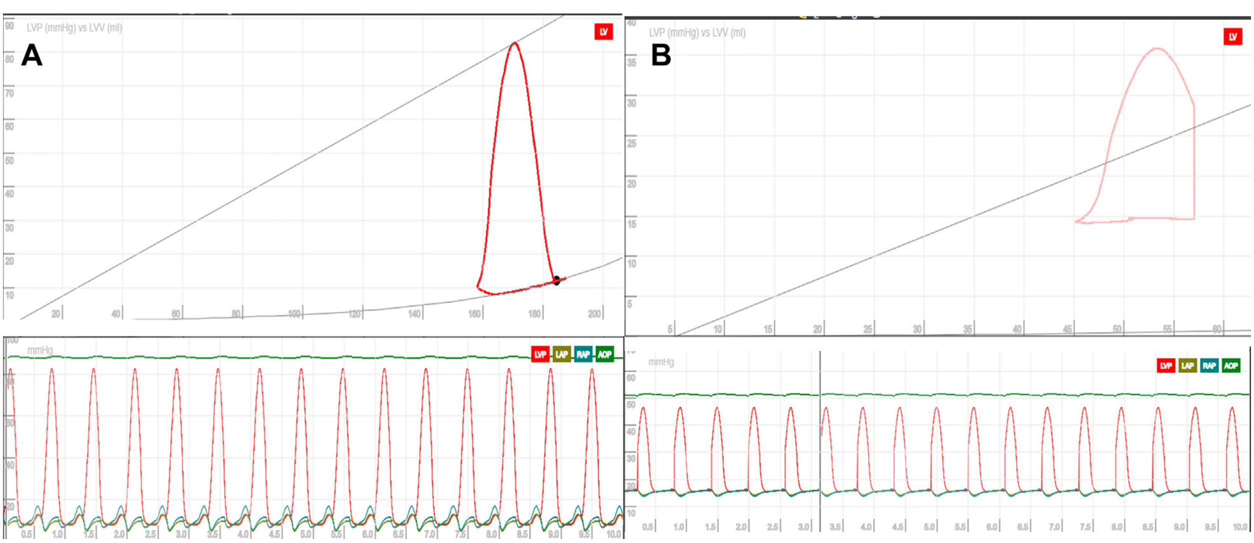
FIGURE 4 Point-of-Care Echocardiography After Pericardiocentesis



Parasternal long-axis **(left)** and apical 4-chamber **(right)** echocardiographic images after pericardiocentesis showing resolution of the pericardial effusion and opening of the left ventricle (LV) cavity, with proper position of the pVAD **(yellow arrows)** in the LV. See Video 4 for corresponding cine loops.

experiments in dogs.[1,2] The clinical scenario of a pericardial tamponade with a ventricular assist device (durable or percutaneous) creates a unique setting of a supported circulation and an unloaded left ventricle, making the diagnosis difficult. As reflected in **Figure 5**, the pressure volume loop in an unloaded LV and n increased pericardial pressure seem to have an exaggerated shift of the LV diastolic

FIGURE 5 Pressure-Volume Loops Simulation



Pressure volume loop simulations of the left ventricle from Harvi simulator. **(A)** Pressure volume loop representing a chronic heart failure state supported with a transaortic percutaneous left ventricular assist device with the lower area showing the dissociation of the aortic and the left ventricular tracing, representing an effectively unloaded and rested ventricle. **(B)** Pressure volume loop when a pericardial tamponade occurs with a transaortic percutaneous ventricular assist device. Although the systemic aortic pressure has significantly reduced from **(A)** it is still maintained because the device is pushing blood. Also, the pressure volume loop is no longer within the boundaries of the myocardial properties because the left ventricle is severely underfilled in the presence of increased external pericardial pressure.

pressures. Whereas dog experiments showed a reduction of RV more than LV volume in the setting of a tamponade,[1] the presence of an isolated LV unloading device probably exaggerates LV volume reduction. The presence of a tamponade typically also dissociates the PV loop from the boundaries of the myocardial properties reflected by the end-systolic and end-diastolic PV relationship. In the presence of a percutaneous left VAD, a pericardial tamponade physiology can present with a console alarm triggered by a low LV preload state. An already mechanically unloaded LV becomes severely decompressed from a combination of decreased preload and increased pericardial pressure (Video 1). The VAD console in our patient revealed a "position unknown" alarm caused by loss of a gradient between the aortic and LV pressures. The product manual of the chosen device classifies this alarm as a noncritical "advisory alarm,"[3] which is driven by the fact that loss of a gradient prevents the device from providing the guidance for accurate positioning across the aortic valve. Similarly, inadequate LV filling, incorrect position, and RV failure are listed as the differentials for "suction alarm," which is classified as a serious alarm.

FOLLOW-UP

The pericardial drain was removed after 2 days, and the patient continued to maintain clinical stability. He was successfully bridged to an orthotopic heart and kidney transplantation.

CONCLUSIONS

The differential diagnosis of "position unknown" and "suction" alarms in a p-VAD patient should include cardiac tamponade in the appropriate clinical scenario. We caution users of transaortic p-VADs to understand the basis of how the alarms are generated and not to take the manual's suggestions at face value. As reflected in our case, the alert from the bedside clinical team was raised in the context of the console alarm while suspicion of a tamponade as an emergency lagged.

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Dr Burkhoff has been a consultant for PVLoops LLC; and a member of the steering committee for Abiomed. Dr Bhimaraj has been a speaker for Abiomed and AstraZeneca; a consultant for Abbott; and an advisory board member for CareDx and Maquet. Dr Mathias has reported that he has no relationships relevant to the contents of this paper to disclose.

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KEY WORDS ablation, cardiac assist devices, pressure-volume loops, tamponade, ventricular tachycardia

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