

Pulseless Paradoxus: A Unique Sign of Cardiac Tamponade in the Era of Continuous Flow Left Ventricular Assist Devices



To the Editor: The change from pulsatile to nonpulsatile blood flow in patients supported with a continuous flow left ventricular assist device (cLVAD) alters the bedside cardiovascular physical exam. Diagnosing cardiac tamponade in patients supported with a cLVAD can be challenging for 2 reasons: First, classic findings such as Beck's triad and pulsus paradoxus are of limited diagnostic value. Second, isolated left heart tamponade is possible because of continuous unloading of the left ventricle, thereby reducing its pressure to below pericardial pressure. We recently encountered a case of cardiac tamponade in a patient with a cLVAD, whereby the diagnosis was supported by a unique finding we have termed "pulseless paradoxus."

A 62-year-old woman underwent implantation of a cLVAD for end-stage heart failure. The postoperative course was complicated by right ventricular (RV) dysfunction. Eleven days later, the left ventricular assist device (LVAD) flow decreased abruptly, associated with relative hypotension but without tachycardia. The examination was notable for elevation in jugular venous pressure (JVP), an LVAD hum, the absence of a palpable pulse, and lower extremity pitting edema.

Invasive hemodynamic monitoring revealed an inspiratory decrease in the mean arterial pressure of greater than 10 mm Hg (pulseless paradoxus), elevated central venous pressure, and relative hypotension (Figure A). Echocardiography revealed a small left ventricular cavity, but no definite effusion

(Figure B, asterisk). Clinical suspicion for cardiac tamponade remained high; therefore, computed tomography of the chest was performed. A pericardial hematoma tamponading the left ventricle and left atrioventricular junction was seen (Figure C, asterisk). Surgical evacuation resulted in immediate hemodynamic improvement.

Current generation LVADs generate continuous nonpulsatile blood flow, resulting in unique physical examination findings such as a diminished or absent pulse and a hum that overshadows the native heart sounds.¹

Historically, Beck's triad of a "failing arterial pressure" (hypotension), "rising venous pressure" (elevated JVP), and a "small quiet heart" (distant heart sounds) was used to diagnose acute cardiac tamponade.² These signs, however, are of limited use in a patient supported with a cLVAD. Hypotension has a

broad differential diagnosis postoperatively; the LVAD hum is the dominant precordial sound; and JVP can be elevated because of post-LVAD RV dysfunction. In our case, the diagnosis of cardiac tamponade was supported by a unique finding of an inspiratory decrease in the invasive mean arterial pressure of greater than or equal to 10 mm Hg, referred to as "pulseless paradoxus." Because blood flow is continuous and nonpulsatile in the presence of a cLVAD, there is no distinctly measured systolic or diastolic blood pressure. This is in distinction to "pulsus paradoxus," which is defined as an inspiratory decrease in systolic blood pressure of greater than 10 mm Hg.³ Hence, the classic pulsus paradoxus is of limited diagnostic value.

In the absence of systemic arterial pulsatility and the presence of RV dysfunction postoperatively, the classic physical examination signs

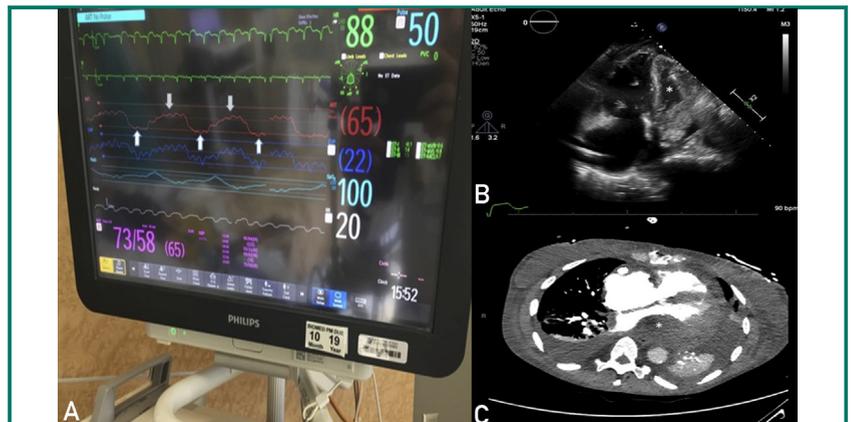


FIGURE. A, An arterial tracing showing no arterial pulsatility. The mean arterial pressure is 65 mm Hg (in red). There is an inspiratory decrease in the mean arterial pressure of greater than 10 mm Hg (upward arrows). The noninvasive blood pressure (in pink) captures this phenomenon nicely, measuring 73 mm Hg during the expiratory phase and 58 mm Hg during the inspiratory phase of the respiratory cycle. The mean noninvasive pressure is identical to the invasive mean arterial pressure. The central venous pressure is elevated, measuring 22 mm Hg (in blue). There is inappropriate relative bradycardia, and the heart rate is 88 beats/min (in green). B, Apical 4-chamber view showing right heart chamber enlargement and a small left ventricular cavity (asterisk). C, Computed tomography of the chest showing a small left heart chamber size and a compressive hematoma (asterisk) at the level of the atrioventricular junction.

such as Beck's triad and pulsus paradoxus may not be helpful. Conversely, the pathophysiological basis for the classic pulsus paradoxus, in the distinct form of pulseless paradoxus, can be helpful in supporting the diagnosis of cardiac tamponade in patients with a cLVAD.

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Commercial Cannabidiol Caution: A New Gold Rush



To the Editor: We recently read with interest the review by VanDolah et al¹ in *Mayo Clinic Proceedings*, summarizing the emerging landscape of commercially available cannabidiol (CBD) preparations, which are now subject to consumption by the general public because of the purported health benefits of CBD. We agree with the authors in that an open discussion exploring patient use of such substances is necessary for a complete history as well as for establishing patient rapport. We would add a word of caution about the use of products and would also suggest readers of

Mayo Clinic Proceedings consider additional factors when discussing commercial CBD use with patients.

First, although hemp farming is now legal under federal law, and for profit CBD commercial establishments are widespread, the actual sale of hemp-derived CBD food or supplement formulations remains illegal because plant-derived CBD (Epidiolex) is a Food and Drug Administration–approved drug.² Second, many commercial sellers of CBD imply medical claims for these products, which are both unsupported by clinical evidence and in violation of Food and Drug Administration labeling laws. Third, it should be recalled that the 2 large clinical trials that established CBD as an adjunct therapy for severe pediatric onset epilepsy syndromes—Dravet syndrome and Lennox-Gastaut syndrome—used doses of 10 to 20 mg/kg per day. Fourth, molecular analyses have revealed substantial deviation from the advertised label contents.³ Finally, and most importantly, approximately 8% of vaping-associated lung injury was subsequent to exposure to CBD tinctures.⁴ Although it is unknown whether CBD plays a direct pathogenic role in vaping-associated lung injury, the carrier solvents for these products have not been found to be safe at the currently administered levels and new pathogenic chemical entities may be generated through aerosolization. Ultimately, given that these substances are unregulated, possibly adulterated, and not found to be clinically effective, we urge the medical community to practice caution and forbearance with respect to patient-reported benefits of commercially acquired CBD.

With the passing of the Hemp Farming Act, academic institutions wishing to investigate hemp-derived cannabinoid products can now safely do so without being in violation of the

Federal Controlled Substances Act. As a result of these new legal protections, there is an ongoing Mayo Clinic analysis of aerosolized CBD that will hopefully bring a better understanding of what potential risks lie ahead.

Caveat emptor.

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In reply—Commercial Cannabidiol Caution: A New Gold Rush



We thank Scharf et al¹ for their thoughtful comments, which basically reinforce the cautionary notes we sounded in the original article.

We also agree that the legal environment remains challenging, with state and federal laws regarding the legality of cannabidiol (CBD) often appearing to be in conflict. The fact that CBD is now available as a drug