Breaking the ice with ICE

Charlene Rohm[1], Brian Howard[1], Baqir Lakhani[1], Marian Wilim[1], Rachel Waters[1], and David Snipelisky[1]

[1]WellStar Kennestone Hospital

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Abstract

Aortic insufficiency with recirculation syndrome can be a difficult diagnosis to make in patients with continuous flow left ventricular assist devices as it is generally underestimated by traditional transthoracic echocardiography. Transesophageal echocardiography can also underestimate aortic insufficiency and requires general anesthesia, which can be prohibitive in some cases. This case study demonstrates a novel use of intracardiac echocardiography to evaluate for and troubleshoot complications associated with continuous flow left ventricular assist devices. Intracardiac echocardiography was able to rule out aortic insufficiency in our patient, thereby preventing unnecessary procedures such as a valvular intervention.

Case report

A 58-year-old obese man with end-stage nonischemic cardiomyopathy underwent implantation of a HeartWare left ventricular assist device (LVAD) as destination therapy. Post-operative transesophageal and transthoracic echocardiography (TTE) demonstrated appropriate device positioning and neutral septal configuration without valvular abnormalities, including aortic insufficiency (AI). LVAD parameters were optimized with ramp echocardiography, and the patient was discharged home.

Three months later, the patient was hospitalized with progressively worsening shortness of breath, a 40-pound weight gain over 3 months, and peripheral edema. He weighed 387 pounds. The physical exam revealed a continuous hum of the LVAD, diffuse inspiratory crackles, and lower extremity pitting edema. Jugular venous pulsations could not be visualized due to body habitus.

Chest radiograph demonstrated bilateral pleural effusions and vascular congestion. Pertinent serum studies included N-terminal proBNP 13,613 pg/mL, LDH 329 IU/L, INR 2.1, negative urobilinogen, and negative serum free hemoglobin. Daily monitoring of LDH was consistent with the patient's baseline elevated LDH. An LVAD interrogation revealed no alarms, power spikes, or increased flow, a consistent speed of 2700 rpm, flow of 5.5 L/min, and power of 5.1 watts.

Considering the patient's presentation and initial work up, he had signs of right heart failure including elevated CVP and lower extremity edema, but also had evidence of left heart failure with dyspnea and diffuse crackles. The continuous hum of the LVAD was not suggestive of pump motor failure. Pump thrombosis was less likely given no alarms or power spikes, negative urobilinogen, and negative serum free hemoglobin. A left ventricular suction event or inflow obstruction were also ruled out. Furthermore, he received aggressive diuresis for over 1 week with marked volume loss, yet his symptoms persisted, which suggested the presence of a separate pathology.

A ramp echocardiogram demonstrated a neutral septal position and an ill-defined aortic regurgitant jet in the parasternal and short axis views. Upon increasing the LVAD speed, AI and mitral regurgitation persisted (Figure 1). Considering heightened suspicion of AI with concomitant recirculation syndrome (1), invasive testing was performed to assess the significance of AI.

A right heart catheterization demonstrated a mean right atrial pressure (mRAP) of 16 mmHg with a mean pulmonary capillary wedge pressure (mPCWP) of 21 mmHg (CI 2.6 L/min/m^2) at baseline speed (2700 rpm). With increased speed (2800 rpm), the mRAP was 18 mmHg and the mPCWP was 23 mmHg (CI 2.3 L/min/m^2), consistent with possible recirculation syndrome (1). Considering the mixed hemodynamic picture and difficult echocardiographic parameters, intracardiac echocardiography (ICE) was performed. The ultrasound tipped catheter was advanced via the right femoral vein into the right atrium. While in the right atrium, the probe was rotated to obtain a long axis view of the left ventricular outflow tract, which demonstrated flow turbulence within the aortic annulus but no evidence of AI (Video 1).

Based on the findings with ICE, the patient was continued on aggressive intravenous diuresis. LVAD parameters were optimized. After achieving euvolemia, he was discharged with additional oral diuretics and encouragement for medication and dietary compliance. He weighed 356 pounds on the day of discharge. The patient was regularly seen at the heart failure clinic on follow-up. He was stable at 355-360 pounds and remained compliant with diet and medications.

Discussion

LVADs have various consequences in the native heart including the development of AI. The incidence of new-onset AI increases with support duration, with 10% of patients developing at least moderate AI within 6 months of support and 25% to 30% of patients developing AI within the first year of implantation (2). If left untreated, recirculation syndrome can occur, causing worsening heart failure necessitating aortic valve surgical intervention or urgent cardiac transplantation in 50% of patients within 6 months of developing significant AI (3). While ICE has been a standard imaging modality for interventional and electrophysiological procedures, few studies report its utility in the management of LVADs (4,5).

Traditional TTE methods can underestimate the severity of AI in patients with LVADs, and poor acoustic windows can limit its effectiveness. Traditional TTE indices to grade the severity of AI underestimated AI in 33% of cases, especially in cases with less than moderate regurgitation (6,7). While current guidelines to evaluate AI have been previously validated, they do not extend to patients with continuous flow LVADs (CFLVAD) at present. Since current TTE parameters are suboptimal in grading AI severity in patients with LVADs, the clinical significance of AI in this population can be missed, ultimately portending a poor long-term prognosis.

Transesophageal echocardiography (TEE) is an alternative, but anesthesia requirements can be prohibitive. Anesthesia can also underestimate the severity of AI. General anesthesia lowers systemic vascular resistance so that the reduced afterload increases forward flow through the LVAD and reduces AI.

Given the limitations of TTE and TEE, we propose that ICE can be considered under the following circumstances in the setting of a CFLVAD: TTE assessment is limited due to poor acoustic windows, demonstrates probable AI, or does not demonstrate AI but clinical suspicion for AI remains high; the patient is unable to tolerate general anesthesia, which is needed for TEE; the patient needs a ramp study that cannot be adequately performed with TTE or TEE.

Conclusions

As demonstrated in our patient, ICE was able to exclude the diagnosis of AI. Compared with TTE and TEE, ICE provides superior imaging quality of the aortic annulus and does not require general anesthesia. Furthermore, ICE has the potential to supplement traditional TTE methods in the evaluation of suspected AI in the setting of a LVAD and, in our case, help avoid unnecessary procedures such as a valvular intervention.

Author contributions

Charlene L. Rohm and David F. Snipelisky contributed to the concept/design, data analysis/interpretation, drafting the article, critical revision of the article, and approval of the article. Brian G. Howard and Baqir A. Lakhani contributed to the concept/design, data analysis/interpretation, and approval of the article. Marian Wilim and Rachel Waters contributed to the data analysis/interpretation and approval of the article.

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Figure legends

Figure 1: Transthoracic echocardiographic evaluation of aortic regurgitant jets at different LVAD speeds. (A) mitral regurgitation at 2700 rpm, (B) probable aortic regurgitant jet at 2700 rpm, (C) short axis view of probable aortic regurgitant jet at 2700 rpm, (D) mitral regurgitation at 2860 rpm, (E) probable aortic regurgitant jet at 2860 rpm, (F) short axis view of probable aortic regurgitant jet at 2860 rpm.

Video 1: Intracardiac echocardiography demonstrating turbulence within the aortic annulus yet no evidence of aortic insufficiency.