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Assessment of myocardial viability and left ventricular function in patients supported by a left ventricular assist device

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single photon emission computed tomography;
speckle tracking echocardiography

BACKGROUND: Chronically supported left ventricular assist device (LVAD) patients may be candidates for novel therapies aimed at promoting reverse remodeling and myocardial recovery. However, the effect of hemodynamic unloading with a LVAD on myocardial viability and LV function in chronically supported LVAD patients has not been fully characterized. We aimed to develop a non-invasive imaging protocol to serially quantify native cardiac structure, function, and myocardial viability while at reduced LVAD support.

METHODS: Clinically stable ($n = 18$) ambulatory patients (83% men, median age, 61 years) supported by a HeartMate II (Thoratec, Pleasanton, CA) LVAD (median durations of heart failure 4.6 years and LVAD support 7 months) were evaluated by echocardiography and technetium-99m (^{99m}Tc)-sestamibi single photon emission computed tomography (SPECT) imaging at baseline and after an interval of 2 to 3 months. Echocardiographic measures of LV size and function, including speckle tracking–derived circumferential strain, were compared between ambulatory and reduced LVAD support at baseline and between baseline and follow-up at reduced LVAD support. The extent of myocardial viability by SPECT was compared between baseline and follow-up at reduced LVAD support.

RESULTS: With reduction in LVAD speeds (6,600 rpm; interquartile range: 6,200, 7,400 rpm), LV size increased, LV systolic function remained stable, and filling pressures nominally worsened. After a median 2.1 months, cardiac structure, function, and the extent of viable myocardium, globally and regionally, was unchanged on repeat imaging while at reduced LVAD speed.

CONCLUSIONS: In clinically stable chronically supported LVAD patients, intrinsic cardiac structure, function, and myocardial viability did not significantly change over the pre-specified time frame. Echocardiographic circumferential strain and ^{99m}Tc-sestamibi SPECT myocardial viability imaging may provide useful non-invasive end points for the assessment of cardiac structure and function, particularly for phase II studies of novel therapies aimed at promoting reverse remodeling and myocardial recovery in LVAD patients.

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Implantations of left ventricular assist devices (LVADs) as a bridge to heart transplantation or lifetime (destination) therapy have been increasing.[1] Although LVADs improve

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survival of patients in advanced heart failure (HF),[2,3] sufficient myocardial recovery to allow LVAD explantation has also been reported; however, pooled estimates indicate that recovery occurs in the minority (1%–15%) of patients.[1,4–6] This emphasizes the importance of exploring therapeutic options in the broader LVAD population to reverse myocardial dysfunction and promote recovery.[4–9] However, before the delivery of novel therapies, a basis for quantitatively assessing cardiac structure and function under different loading conditions as well as over time in LVAD patients must first be ascertained.[6,10,11]

Non-invasive imaging of cardiac structure and function is an important component in evaluating LVAD patients.[10] Transthoracic echocardiography is the mainstay because of its broad availability, ability to provide hemodynamic and valvular information, good spatial resolution, and lack of radiation,[10,12,13] Nuclear imaging with technetium-99m (^{99m}Tc)–sestamibi single photon emission computed tomography (SPECT) is a well-validated method for quantifying myocardial scar and offers complimentary information to that obtained with echocardiography.[14,15] Nuclear ^{123}I-meta-iodobenzylguanidine (MIBG) imaging has also been used to demonstrate improvement in sympathetic innervation in the first 6 months after LVAD.[16,17] However, MIBG imaging does not allow regional quantification of fibrosis or scar, is not widely available, and is more time-intensive than ^{99m}Tc-sestamibi SPECT imaging. Additional benefits of ^{99m}Tc-sestamibi include rapid tracer uptake, short SPECT imaging acquisition time (15–20 minutes), wide availability, and validation as a robust method for assessing global and regional LV response to therapies, including stem cells.[18,19]

A universally agreed on methodology for assessing cardiac structure and function in the LVAD population has not yet been established.[11] Moreover, most prior studies on cardiac structure and function in LVAD patients have focused on the early period of hemodynamic unloading (i.e., the first 6 months after implantation).[20,21] Whether hemodynamic unloading in patients chronically supported by LVADs is associated with changes in cardiac structure and function has been less well characterized.[22,23] Therefore, in this report we describe a prospective non-invasive imaging protocol designed to evaluate serial measurements of cardiac structure, function, and myocardial viability at reduced LVAD support in stable outpatients chronically supported by a continuous-flow axial LVAD.

Methods

The Brigham and Women's Hospital Institutional Review Board approved the study. All imaged patients provided written informed consent

Study population

Between December 1, 2011, and December 31, 2012, clinically stable outpatients supported by a HeartMate II (Thoratec Corp, Pleasanton, CA) LVAD who received their care at Brigham and Women's Hospital, Boston, were approached to voluntarily participate in this imaging protocol (Figure 1). Patients who had their first LVAD implantation within the preceding 2 years were eligible (n = 60), 28 of whom were excluded (8 dead, 8 post-cardiac transplant, 12 medically unstable). Of the 32 stable ambulatory LVAD patients, 9 did not provide consent, and 5 consented but were not imaged due to the development of medical instability or withdrawal of consent. The study population comprised 18 patients, of whom 17 completed the entire protocol and 1 underwent cardiac transplantation after baseline, but before follow-up.

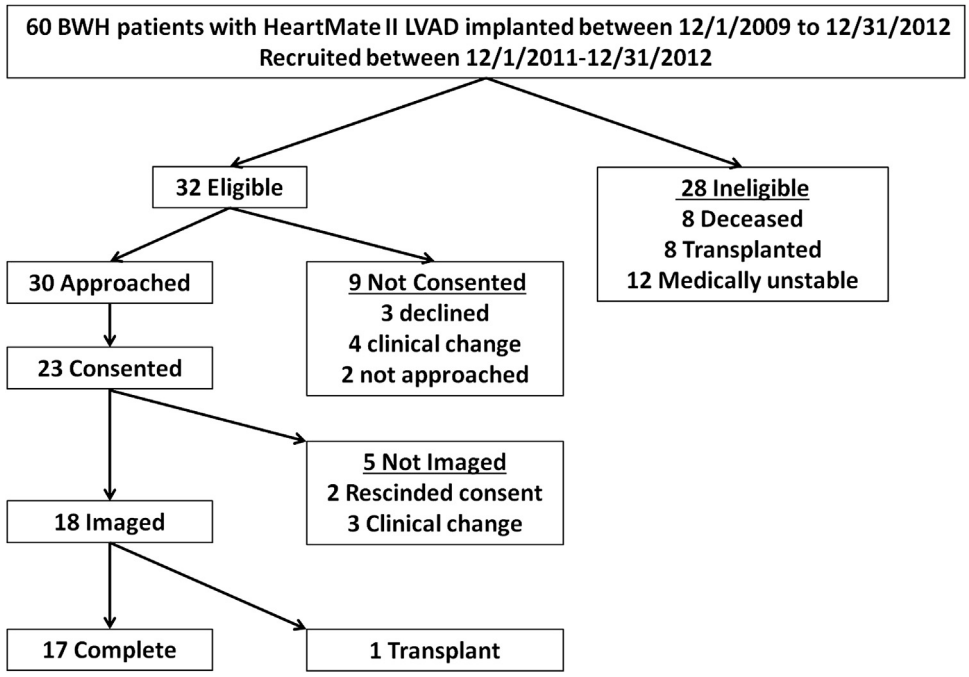

Figure 1 Consolidated Standards of Reporting Trials diagram of the left ventricular assist device (LVAD) imaging study at Brigham and Women's Hospital (BWH).