The management of advanced heart failure has been transformed in the past 2 decades by the advent of cardiac implantable electronic devices, such as implantable cardioverter defibrillators (ICDs) and cardiac resynchronization therapy, and more recently the left ventricular assist device (LVAD). All 3 of these devices have been found to improve survival in patients with advanced heart failure.1-6 Cardiac resynchronization augments cardiac output by coordinating the timing of intrinsic muscular contraction to enhance its efficiency in patients with pre-existing dyssynchrony. After LVAD placement, the contribution of native LV activity may be negligible, so that continued LV pacing likely does not significantly enhance cardiac function. However, LVAD recipients remain at high risk for ventricular arrhythmias (VAs) that may adversely affect right ventricular function, preload, and cardiac output. VAs (including ventricular fibrillation) are often tolerated for prolonged time periods in LVAD recipients, permitting patients to seek medical care when symptoms are present. In this setting, the incremental survival benefit of ICDs and LVADs in combination is not clear and, indeed, controversial. Enriquez et al7 report important data in this edition of Circulation Arrhythmia and Electrophysiology. This article is the largest study so far to examine this question in patients receiving the most commonly implanted LVAD at this time, and the only device Food and Drug Administration approved for bridge to transplant and destination therapy, the Heartmate II continuous flow device.

The investigators report the clinical outcomes and survival of a cohort of 106 patients, the majority of whom received an LVAD as bridge to cardiac transplantation. Patients surviving >30 days after implant were excluded, but are referenced separately in the article. After LVAD implantation, 36.7% of patients did not have an active ICD. VA after LVAD implantation was common and occurred in >55% of patients. VAs only resulted in syncope or altered mental status in <3% of patients, although 20% had symptoms of light-headedness, palpitations, or dyspnea. These findings are important and additive to previous studies which have demonstrated the absence of a significant decrease in VA burden after LVAD implantation,8,9 but also enhanced tolerance of VA compared with patients unsupported with a mechanical support device.10-13

The reason for tolerance of ventricular fibrillation with LVAD support in these cases likely relates to the marked reduction in pulmonary vascular resistance, which is evident in patients with chronic LVAD support.14,15 This allows for the creation of a Fontan-like circulation where even severely depressed or absent right ventricular function, which may occur in the setting of rapid ventricular tachycardia or ventricular fibrillation, can be tolerated without the development of cardiovascular collapse.13 In this context, the second important finding reported in this article, that an active ICD does not confer an additional survival advantage after implantation of an LVAD, makes intuitive sense. No patient died an arrhythmic death, and the one patient described who could not be resuscitated from refractory ventricular fibrillation was also in septic shock and multiorgan failure. The strength of this finding, however, is limited by the small study size.

These two important findings, the enhanced tolerance of VA in LVAD recipients, and the absence of an additive survival benefit from and ICD after LVAD implantation are thought-provoking and hypothesis-generating. It is important to note that, so far, no strict guidelines are yet available on the management of ICDs in LVAD-supported patients. In the majority, as shown here, VAs are well-tolerated, but prolonged ventricular tachyarrhythmias are likely to lead to negative clinical consequences if not treated. Hypothetically, when the pulmonary vascular resistance is high, VAs of even short duration are not likely to be well-tolerated. The fact that some patients experience syncope and the uncommon observations of sudden death in otherwise stable LVAD recipients without ICDs suggests that at least in some individuals VAs remain life-threatening, although this seems to be a small minority. Recommendations have since been made that given that VAs remain common after LVAD implantation, prophylactic ICD implantation should be considered.8,16 The controversial question is how, in an LVAD recipient, the ICD should be programmed. In this respect, recent recommendations on strategic ICD programming in patients receiving ICDs for primary prevention may be helpful, favoring antitachycardia pacing (ATP) therapy and reserving shock with ATP during charge for only the most rapid VAs.17

To add to the controversy, it is noteworthy that frequent ICD shocks in heart failure patients have been shown to have a negative impact on long-term outcome,18 and this seems to be the case even where pump failure is effectively treated by a LVAD.19 Ultimately, this article underscores that the role of an ICD in the LVAD-supported patient may no longer be prevention of sudden cardiac death, but rather to terminate VAs that
could potentially lead to clinical decompensation. The finding that outcomes in LVAD recipients are similar regardless of whether or not ICD therapies are active highlights that the appropriate use of ICD technology in LVAD patients requires ongoing study and refinement. In practice, ICD therapies may need to be individualized considering the preimplant arrhythmia history of each patient, and based on clinical judgment, how well VA is likely to be tolerated after LVAD implantation.

**Toward the Future: Managing Arrhythmias After LVAD Placement**

**Device Programming**

In the present era, where we now have implantable devices that maintain hemodynamic stability in the setting of advanced pump failure, a time has come where we need to further evaluate the risk–benefit ratio of continued ICD therapy post-LVAD implantation. As highlighted by Enriquez et al., post-LVAD VAs remain a common problem, affecting one third of patients. An important part of the equation, noticeably absent from many studies, is the specific ICD programming used. Non-nominal ICD parameter selection reduces morbidity and mortality in many clinical situations. Until additional data are available, a reasonable clinical strategy may be to activate ICDs to deliver shocks only for more rapid ventricular tachyarrhythmias (heart rate >200), while prolonging detection as much as feasible in light of the short-term tolerance of ventricular tachyarrhythmias. Given the recent data suggesting that ICD shock burden may adversely affect survival in LVAD recipients, patients receiving frequent therapies may benefit from adjunctive therapies, including antiarrhythmic drugs and catheter ablation. The difference in tolerance of VAs in LVAD recipients may mandate an alternative ICD programming strategy that will restrict shock therapy to those arrhythmias most likely to produce hemodynamic compromise.

**Novel Device Strategies**

Given the complexity of this patient population and limitations of current treatments, novel strategies may play an important role in managing VAs in LVAD patients. Device manufacturers could include LVAD settings in ICDs, in which time to therapy is programmable using intervals ranging from minutes to hours, rather than seconds to minutes, and ATP use is nominally generous. Various sensors have been developed that measure right ventricular and pulmonary pressure, and flow assessment may be possible. The LVAD population affords an ideal group in which to test linking therapy delivery to changes in cardiac output, potentially delaying shocks for hours, while delivering patient alerts and Internet-based physician alerts. Moreover, audible or vibratory patient alerts warning of impending shock and providing patients with magnets or other deactivators to withhold therapy in the absence of significant symptoms may improve the tolerability of ICD therapy. Ultimately, it may be rational for the LVAD itself to include defibrillator functionality and only apply therapy based on hemodynamic changes.

**Novel Surgical Strategies**

Particularly in symptomatic patients, catheter ablation provides rhythm palliation in patients with LVADs, although technical challenges exist. During ablation, great care must be taken to avoid catheter passage into the LVAD inflow. LVADs generate electromagnetic fields that may interfere with mapping systems. The inflow cannula, if made of a conductive metal, may distort electric or magnetic fields used for mapping, affect radiofrequency energy delivery, or mechanically block catheter positioning. Despite these challenges, early experience has demonstrated the feasibility of ablation in this population. These challenges, however, raise the question of whether arrhythmia surgery at the time of LVAD placement might be warranted to prevent post-LVAD VAs. Endocardial resection, epicardial cryotherapy, or other surgical strategies may prevent arrhythmias, but must be balanced against the added complexity of the LVAD placement procedure.

In conclusion, although evidence that VAs increase mortality is lacking, VAs remain clinically important in a substantial subset of LVAD patients and the role of ICD is controversial. At present, when ICDs are used after LVAD, maximally prolonged detection times, liberal ATP programming, and arming patients with magnets to deactivate therapies when symptoms are modest may be attractive options.

**Disclosures**

None.

**References**


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Role of Implantable Cardioverter-Defibrillators in Patients With Continuous Flow Ventricular Assist Devices
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