The Role of Implantable Cardioverter Defibrillators for the Prevention of Ventricular Arrhythmia in Left Ventricular Assist Device Recipients

Nikhil Reddy, BA[a], Cristina Ortiz, MD[b], Toshimasa Okabe, MD[b], Muhammad Afzal, MD[b], Mohamed H. Derbala, MD[b], Asvin Ganapathi MD[c] , Sakima A. Smith, MD, MPH[b]

[a]Boonshoft School of Medicine [b]Division of Cardiovascular Medicine. The Ohio State University Wexner Medical Center. [c]Department of Cardiothoracic Surgery. The Ohio State University Wexner Medical Center.

Summary

Advanced heart failure represents a significant strain on our health care system and is associated with increased morbidity and mortality. New device therapies, including left ventricular assist device (LVAD) implantation, have transformed management as both a destination therapy and as a bridge to transplantation. Although LVADs have improved patient outcomes, arrhythmias represent a significant and costly complication of this therapy. In recent years, implantable cardioverter-defibrillators (ICDs) have been developed to reduce the incidence of lethal arrhythmia. However, a gap in the literature exists for both guidelines in prevention of early ventricular arrhythmia (VA) in LVAD recipients and the effectiveness of ICDs when paired with various LVADs. Here, we clarify these guidelines and show that ICD selection should be tailored to the type of LVAD. We also show that subcutaneous ICDs represent an attractive alternative option for certain cohorts of patients, although transvenous ICDs remain a first-line choice at this time. Ultimately, understanding the various management options that affect outcomes in heart failure patients is important for treatment and clinical decision-making in an ever-growing population.

Methods: PubMed was searched for various studies published from January 2001 through December 2020, using subject terms “implantable cardioverter-defibrillator” OR “ICD” AND “acute heart failure”, “left ventricular assist device” OR “LVAD” AND “acute heart failure”, “HeartWare OR HVAD”, “HeartMate II” OR “HMII”, “HeartMate 3” OR “HMIII”, “Transvenous ICD” OR “TV-ICD” and “subcutaneous ICD” OR “S-ICD”. Authors included case reports and series, retrospective and prospective studies, systematic reviews and meta-analyses, clinical guidelines, and narrative reviews. This PubMed search only included studies published in English and those with human subjects. Initial literature search revealed over 442 articles. References in the articles were also evaluated for discovery of potentially relevant studies. Authors reviewed relevant articles and decided which studies to include for this review, with a concentration on acute HF-relevant articles. A total of 39 resources were selected for inclusion in this review.

Ventricular Arrhythmias in LVAD Patients

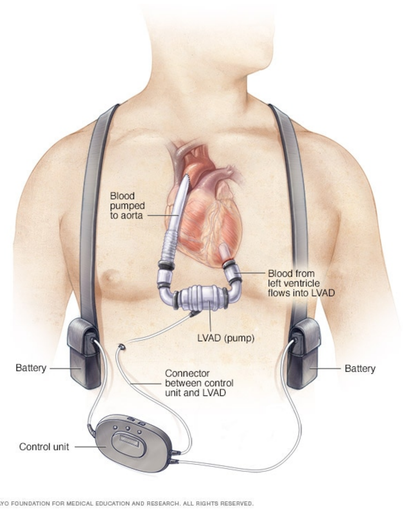

Figure 1: Diagram of LVAD .[1] Left ventricular assist devices are now commonly used in advanced HF to improve survival and reduce mortality. LVADs are used as both destination therapy (DT) and as a bridge to heart transplantation (BTT). LVAD implantation has been shown to result in prolonged ventricular repolarization, myocardial scarring and acute ventricular unloading, all of which have been shown to predispose patients to arrhythmias.[1,2]

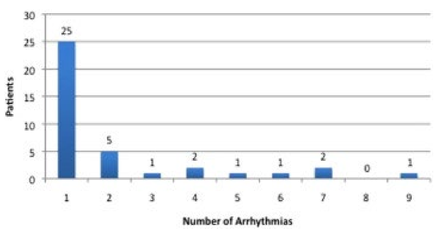

Figure 2: Number of early VA events. [3] In a group of 162 patients, 24% experienced at least one early VA. Among patients who experienced an early VA, 34% underwent more than one event. Preoperative VA was the biggest clinical predictor of early VA; non-ischemic cardiomyopathy and advanced age were also statistically significant predictors for VA.[3]

Contemporary LVADs and VA Risk

	Heartware[4]	HMII[5] †	HMIII[6] ‡
Number of patients	26	106	515
% of patients with VA §	35	35	21
% of patients with VT #	27	32	---
% of patients with VF ‖	8	13	---
Total VA episodes	21	109	---
% of patients with early VA	---	24	---
% of patients with late VA	---	18	---
Early VAs per patient-year	1.8	---	---
Late Vas per patient-year	0.8	---	---

†: HeartMate II, ‡: HeartMate III, §: Ventricular Arrythmia, ‖: Ventricular Fibrillation, #: Ventricular Tachycardia

Table 1: Summary of VA in LVAD Recipients. These data demonstrate that while HeartMate III (HMIII) recipients have a risk for VA after implantation, it is lower than patients who have been implanted with HeartMate II (HMII) or Heartware (HVAD), which suggests that the HMIII is less irritable to the heart.[7,8] Although no definitive conclusions have been reached in any study, possible reasons for this difference include differences in pump size, increased width of blood-flow pathways in HMIII, and HMIII’s intrinsic pulsatility diminishing shear stress and stasis of blood.[8]

ICD Therapy and Types of Devices

ICDs have transformed the management of HF patients by reducing the incidence of lethal arrhythmias and the risk of SCD.[9,10] There are two main types of ICD devices, a transvenous ICD (TV-ICD) and subcutaneous ICD (S-ICD), which may have different implications in LVAD patients. LVADs can cause electromagnetic interference (EMI), leading to sensing dysfunction in the S-ICD. However, EMI is more associated with HVAD and HMIII, with fewer cases occurring in concomitant S-ICD and HMII use.[10]

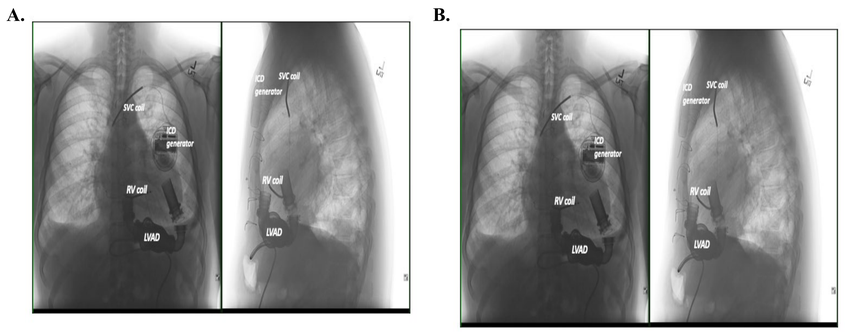

Figure 3: Types of ICDs

(A)TV-ICD and LVAD Diagram. TV-ICD and LVAD position in the chest. Left, Anterior view. Right, Lateral view. Advantages of the TV-ICD include the ability to deliver long-term bradycardia pacing and deliver anti-tachycardiac pacing .

(B) S-ICD and LVAD Diagram. S-ICD and LVAD position in the chest. Left, Anterior view. Right, Lateral view. Advantages of the S-ICD involve avoidance of an invasive procedure along with intravascular lead-related problems such as endocarditis and bacteremia.

Current Approach to ICD use in LVAD Patients

VT-LVAD	Variables	Score
V	VAs prior to LVAD implantation	2 points
T	Therapy : no ACE-inhibitor post-LVAD	2 points
L	FaiLure duration (>12 months)	2 points
V	VAs post LVAD implantation (<30 days)	2 points
A	Atrial fibrillation prior to LVAD	1 point
D	Idiopathic Dilated cardiomyopathy	1 point
	Maximum score	10 points

Figure 4: VT-LVAD score . [12] The ASSIST-ICD study used the results of their observational study assessing the clinical predictors of late VA to create a score to stratify patient risk, the “VT-LVAD score”.[12] They stated that high-risk and very high-risk patients should be considered for ICD therapy, while low-risk patients may consider forgoing ICD implantation due to the presence of a similar complication risk profile and a lower potential benefit. Although this study gives indications for the prevention of late VA, it takes no position on the prevention of early VA.

Recommendations for Clinical Care

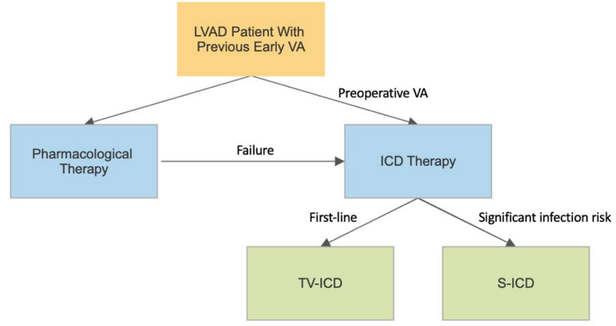

Figure 5: Flow diagram of early VA prevention in LVAD recipients

LVADs represent an important therapy for management of acute and chronic HF, however, they carry the risk of post-implantation VA. The HMIII appears to have the lowest risk of VA among its recipients (Table 1).

ICD for primary prevention of early post-VAD VAs should be considered at the time of LVAD implantation in patients who present with acute HF or risk factors for early VA . Prior to ICD use, pharmacological therapy may be attempted, however, post-LVAD VAs often fail to respond to antiarrhythmics. Despite the inherent risk associated with transvenous leads, TV-ICD should be considered a first-line treatment modality at present until the role of S-ICD is further evaluated in larger studies. S-ICD may be a viable option in patients with an exceptionally high risk of bloodstream infection or in patients with prior HMII use.

Future Directions

- Prospective, randomized trials directly comparing VA incidence in HVAD, HMII, and HMIII
- Further investigation and refinement of S-ICD sensing algorithm when used with different LVADs
- Randomized trial data in both BTT and DT patients to determine optimal device indications in LVAD patients at risk of VA.

References

1. “Left Ventricular Assist Device (LVAD).” Mayo Clinic, Mayo Foundation for Medical Education and Research, www.mayoclinic.org/tests-procedures/ventricular-assist-device/multimedia/left-ventricular-assist-device/img-20006714.
2. Pecha S, Wilke I, Bernhardt A, et al.: Clinical experience of combined heartware ventricular assist device and implantable cardioverter defibrillator therapy. J Cardiovasc Electrophysiol 2014; .
3. Garan AR, Levin AP, Topkara V, et al.: Early post-operative ventricular arrhythmias in patients with continuous-flow left ventricular assist devices. J Hear Lung Transplant 2015; .
4. Mosterd A, Cost B, Hoes AW, et al.: The prognosis of heart failure in the general population: The rotterdam study. Eur Heart J 2001;
5. Chia PL, Foo D: Overview of implantable cardioverter defibrillator and cardiac resynchronisation therapy in heart failure management. Singapore Med. J. 2016,.
6. Chieng D, Paul V, Denman R: Current Device Therapies for Sudden Cardiac Death Prevention – the ICD, Subcutaneous ICD and Wearable ICD. Hear Lung Circ [Internet] 2019; 28:65–75.
7. Enriquez AD, Calenda B, Miller MA, Anyanwu AC, Pinney SP: The role of implantable cardioverter-defibrillators in patients with continuous flow left ventricular assist devices. Circ Arrhythmia Electrophysiol 2013; .
8. Mehra MR, Uriel N, Naka Y, et al.: A Fully Magnetically Levitated Left Ventricular Assist Device — Final Report. N Engl J Med 2019; .
9. Biton Y, Baman JR, Polonsky B: Roles and indications for use of implantable defibrillator and resynchronization therapy in the prevention of sudden cardiac death in heart failure. Heart Fail Rev 2016; .
10. Lewis GF, Gold MR: Safety and Efficacy of the Subcutaneous Implantable Defibrillator. J Am Coll Cardiol [Internet] 2016; 67:445–454. Available from: http://www.sciencedirect.com/science/article/pii/S0735109715074793
11. Black-Maier E, Lewis RK, Barnett AS, et al.: Subcutaneous implantable cardioverter-defibrillator troubleshooting in patients with a left ventricular assist device: A case series and systematic review. Hear Rhythm 2020; .
12. Galand V, Flécher E, Auffret V, et al.: Predictors and Clinical Impact of Late Ventricular Arrhythmias in Patients With Continuous-Flow Left Ventricular Assist Devices. JACC Clin Electrophysiol 2018; .