Electrophysiologic characteristics and catheter ablation of ventricular tachyarrhythmias among patients with heart failure on ventricular assist device support

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BACKGROUND Ventricular tachyarrhythmias (VT) are common among ventricular assist device (VAD) recipients, yet electrophysiologic (EP) characteristics and catheter ablation outcomes remain uncharacterized.

OBJECTIVE To evaluate the EP characteristics and catheter ablation outcomes for VTs among heart failure patients on VAD support.

METHODS The Cleveland Clinic registry of consecutive patients undergoing VAD placement in 1991–2010 with medically refractory, symptomatic VT referred for EP study and catheter ablation.

RESULTS Among 611 recipients of VAD (mean age 53.3 ± 12.4 years, 80% men), 21 patients (3.4%) were referred for 32 EP procedures, including 11 patients (52%) presenting with implantable cardioverter-defibrillator therapy (13 shocks, 26 antitachycardia pacing). Data from 44 inducible tachycardias (mean cycle length 339 ± 59 ms) demonstrated monomorphic VT (n = 40, 91%; superior axis 52%, right bundle branch block morphology 41%) and polymorphic ventricular tachycardia (PMVT)/ventricular fibrillation (n = 4, 8%). Electroanatomic mapping of 28 tachycardias in 20 patients demonstrated reentrant VT related to intrinsic scar (n = 21 of 28, 75%) more commonly than the apical inflow cannulation site (n = 4 of 28, 14%), focal/microreentry VT (n = 2 of 28, 7%), or bundle branch reentry (n = 1 of 28, 3.5%). Catheter ablation succeeded in 18 of 21 patients (86%). VT recurred in 7 of 21 patients (33%) at a mean of 133 ± 98 days, and 6 patients (29%) required repeat procedures, with subsequent recurrence in 4 of 21 patients (19%).

CONCLUSIONS Catheter ablation of VT is effective among recipients of VAD. Intrinsic myocardial scar, rather than the apical device cannulation site, appears to be the dominant substrate.

KEYWORDS Ventricular tachyarrhythmias; Catheter ablation; Ventricular assist device; Implantable cardioverter-defibrillator

ABBREVIATIONS **EP** = electrophysiologic; **ICD** = implantable cardioverter-defibrillator; **LVAD** = left ventricular assist device; **RF** = radiofrequency; **VAD** = ventricular assist device; **VT** = ventricular tachyarrhythmia; **VTE** = ventricular tachyarrhythmia event.

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Introduction

Ventricular assist device (VAD) therapy has extended the survival of patients with advanced heart failure as a bridge to transplantation,[1] recovery,[2] and destination therapy[3] with improved quality of life[4] and use of donor heart resources.[5] In the left ventricular assist device (LVAD) experience, postoperative ventricular tachyarrhythmia events (VTEs) occur in up to 35% of the patients within 30 days,[6,7] with a resultant mean drop of 1.4 ± 0.6 L/min in LVAD flow output.[8] Despite the long-held belief that recipients of LVAD are unaffected by VTE, the crude mortality rate is as high as 52% for patients with VTE occurring within 1 week postoperatively.[9] A concomitant implantable cardioverter-defibrillator (ICD) during VAD support has been associated with a significant mortality reduction (hazard ratio 0.55; 95% confidence interval 0.32−0.94; $P = .028$) after adjustment for age, sex, left ventricular ejection fraction, VAD type, year placed, diagnosis and duration, complications, dialysis-dependent renal failure, and extended survival (median survival 295 days vs 226 days; $P = .024$) with a 25% incidence of appropriate ICD therapy in this population.[10]

According to 2006 American College of Cardiology/American Heart Association Task Force/European Society of Cardiology Committee guidelines, catheter ablation for ventricular tachycardia is indicated for patients receiving ICD shocks not manageable by reprogramming or drug therapy and symptomatic patients with drug-resistant monomorphic ventricular tachyarrhythmia (VT) or who are drug-intolerant and prefer ablative therapy.[11] Prior literature on catheter ablation for VT in the VAD population has been limited to a case series

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involving 3 patients, demonstrating feasibility in this population.[12] The electrophysiologic (EP) characteristics and outcomes associated with catheter ablation for VT in the VAD population have not yet been evaluated in a larger series.

Methods

The Cleveland Clinic registry of consecutive patients undergoing VAD placement in 1991–2010 was queried for patients subsequently referred for EP study and catheter ablation for ventricular tachycardia. All relevant clinical and procedural data, including ICD interrogation results, were evaluated. All patients or appropriate next of kin gave informed consent for VAD surgery, EP study, catheter ablation, clinical follow-up, and enrollment in the institutional review board–approved registries for quality assurance and research purposes. Standard of care monitoring for all recipients of VAD includes continuous telemetry monitoring for inpatients, regularly scheduled biweekly to monthly office visits, frequent telephone encounters, and both remote and in-person ICD interrogations for outpatients for the duration of therapy. VTs were defined as events greater than 30 seconds in duration or requiring abortive therapy. All available clinical data on presenting VTs were systematically collected prior to the time of EP study including electrocardiograms, telemetry, and cardiac device diagnostics.

EP study and catheter ablation

Indications for EP study included medical refractory VTs associated with ICD therapy or symptoms or patients intolerant of antiarrhythmic drugs preferring ablative therapy. All patients were accompanied to the EP laboratory by a VAD support nurse specialist. Femoral venous and arterial accesses were obtained for vascular access and hemodynamic monitoring under direct vascular ultrasound guidance. A quadripolar catheter was positioned in the right ventricular apex for programmed stimulation, burst ventricular pacing, and fluoroscopic reference. In selected cases, an additional deflectable quadripolar catheter was positioned at the His bundle and a multipolar deflectable catheter in the coronary sinus. Electroanatomic mapping was used in either the CARTO navigational system (Johnson & Johnson, New Brunswick, NJ, Biosense-Webster, Diamond Bar, CA) or EnSite NaVX (St Jude Medical, St. Paul, Minnesota). For left ventricular mapping and ablation, all patients were heparinized with bolus and infusion titrated to maintain an activating clotting time between 300 and 350 seconds at operator discretion. In all cases, radiofrequency (RF) ablation was performed by using an externally irrigated, deflectable mapping/ablation catheter. In selected cases, an intracardiac ultrasound catheter was used to evaluate the catheter-tissue interface, to evaluate for pericardial effusion, and to identify structural landmarks such as the VAD apical inflow cannula.

Standard approaches for the EP study and catheter ablation included VT induction by programmed stimulation with extrastimuli including long-short sequences, burst ventricular pacing, and diagnostic techniques including activation mapping, scar mapping, entrainment pacing, and pace mapping. Reentry mechanisms were elicited by activation mapping and, in some cases, entrainment pacing. Macroreentry was associated with early meeting late activation sequences circumscribing low-voltage (<0.5 mV) scar zones. Focal/microreentrant mechanisms were elicited by centrifugal propagation away from an early activation site. Pace mapping and bipolar voltage scar mapping techniques were also applied in selected cases. Epicardial access and mapping techniques were not used in any of the cases.

Statistical analysis

Categorical variables are described as numbers with corresponding percentages and compared by using the chi-square test. Continuous variables were described as mean ± SD and compared by using the *t* test or analysis of variance. Statistical analyses were performed by using PASW Statistics 18 (IBM SPSS Software, Chicago, IL). All *P* values were 2-tailed, with statistical significance set at .05. All confidence intervals were calculated at the 95% confidence interval.

Results

Baseline characteristics

The clinical characteristics of the entire patient cohort who underwent VAD placement are listed in Table 1. Overall, 611 patients underwent VAD support (mean age 53.3 ± 12.4 years, 80.2% men) between September 1991 and December 2010. The mean left ventricular ejection fraction was 14.3% ± 5.5%, and more than 99% of the patients had

Table 1 Baseline clinical characteristics at VAD placement (n = 611)

	n (%)
Age (y)	53.3 ± 12.4
Sex (man)	489 (80%)
New York Heart Association classification	
II	6 (1%)
III	86 (14%)
IV	519 (85%)
Left ventricular ejection fraction	14.3% ± 5.5%
Ischemic cardiomyopathy	338 (55%)
Prior myocardial infarction	136 (22%)
ICD system in place	97 (16%)
Present at VAD implant	93 (15%)
Implanted during VAD support	4 (0.6%)
Medications	
Beta-blocker	286 (46%)
ACE inhibitor/ARB	334 (54%)
Aldosterone antagonist	226 (37%)
Inotrope/vasopressor	495 (81%)
Class I antiarrhythmic drug	49 (8%)
Class III antiarrhythmic drug	183 (30%)
Sustained ventricular tachyarrhythmias pre-VAD	167 (27%)

ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; ICD = implantable cardioverter-defibrillator; VAD = ventricular assist device.