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ORIGINAL RESEARCH

Ventricular Arrhythmias Among Patients With Advanced Heart Failure: A Population-Based Study

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BACKGROUND: The epidemiology of ventricular arrhythmias (VAs) in patients with advanced heart failure (HF) is not well defined.

METHODS AND RESULTS: Residents of Olmsted County, Minnesota, with advanced HF from 2007 to 2017 were identified using the 2018 European Society of Cardiology criteria. Billing codes were used to capture VAs; severe VAs requiring emergency care were defined as events associated with emergency department visits or hospitalizations. The cumulative incidence of VAs postadvanced HF was estimated with the Kaplan–Meier method. Multivariable Cox analyses were used to determine the following: (1) Predictors of severe VAs postadvanced HF; and (2) Impact of severe VAs on mortality. Of 936 patients with advanced HF, 261 (27.9%) had a history of VA. The 1-year cumulative incidence of severe VAs postadvanced HF was 5.4%. Prior VAs (hazard ratio [HR] 2.22 [95% CI, 1.26–3.89], P=0.006) and left ventricular ejection fraction <40% (HR, 3.79 [95% CI, 1.72–8.39], P<0.001) were independently associated with increased severe VA risk postadvanced HF. New-onset severe VAs were associated with increased mortality (HR, 4.41 [95% CI, 2.80–6.94]; P<0.001), whereas severe VAs in patients with prior VAs had no significant association with mortality risk (HR, 1.08 [95% CI, 0.65–1.78]; P=0.77). Severe VAs were associated with increased mortality in patients without implantable cardioverter defibrillators (HR, 4.89 [95% CI, 2.89–8.26]; P<0.001), but not in patients with implantable cardioverter defibrillators (HR, 1.42 [95% CI, 0.92–2.19]; P=0.11).

CONCLUSIONS: Patients with left ventricular ejection fraction <40% and prior VAs have increased risk of severe VA postadvanced HF. New-onset severe VAs or severe VAs without implantable cardioverter defibrillators postadvanced HF are associated with increased mortality.

Key Words: advanced heart failure ■ epidemiology ■ ventricular arrhythmias

Heart failure (HF) is a chronic, progressive disease that affects >6 million people across the United States.[1] Despite the enormous strides that have been made in terms of HF management, some patients develop HF symptoms recalcitrant to currently available guideline-based therapies.[2] This phase of the HF disease process is often termed "advanced" HF, which in turn is used interchangeably with "Stage D" HF as defined by the American College of Cardiology/American Heart Association.[3] Advanced HF is a clinically important milestone given its hallmark of severe persistent symptoms and association with limited survival.[2] Yet, prompt and accurate recognition of advanced HF has been impeded by the complexity of its definition. In 2018, objective criteria for diagnosing advanced HF were published by the European Society of Cardiology,[4] which now enables systematic identification of patients with advanced HF among populations.

The adverse myocardial changes that come with the progression of HF can lead to the development of an electrophysiologic substrate that fosters ventricular arrhythmias (VAs).[5] As such, patients with advanced HF are at increased risk of VAs, which in turn promote further maladaptive remodeling and worsening pump

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CLINICAL PERSPECTIVE

What Is New?

- In a community-based cohort of 936 patients with advanced heart failure from Olmsted County, Minnesota, 261 (27.9%) had a prior history of ventricular arrhythmias.
- The 1- and 2-year cumulative incidences of severe ventricular arrhythmias (ie, leading to emergency department visits or hospitalizations) postadvanced heart failure diagnosis were 5.4% and 7.4%, respectively.
- Severe ventricular arrhythmias following advanced heart failure diagnosis were associated with elevated risk of death among patients with no prior history of ventricular arrhythmias or without an implantable cardioverter defibrillator.

What Are the Clinical Implications?

- There was a substantive ventricular arrhythmia burden among patients with advanced heart failure, and ventricular arrhythmias requiring emergency care were associated with increased mortality.
- Further investigation into the pathophysiology of ventricular arrhythmias in advanced heart failure and strategies for managing them are warranted.

Nonstandard Abbreviations and Acronyms

SCD	sudden cardiac death
VA	ventricular arrhythmia

function, creating a downward spiral that can ultimately culminate in death.[6] However, a precise characterization of this risk is currently unavailable, in part because of the aforementioned prior difficulties in identifying patients with advanced HF. To address these lapses in knowledge, we identified a population-based cohort of patients with advanced HF based on the 2018 European Society of Cardiology guidelines, and assessed the prevalence of VAs, its accompanying risk factors, and associations with mortality.

METHODS

Study Design and Setting

Adult residents from Olmsted County (Minnesota, United States) were reviewed in this retrospective cohort study. Patients were identified using the resources of the Rochester Epidemiology Project, which enables identification and linkage of patient data from all health care systems in the county.[7] Patients were excluded from analysis if they declined Minnesota Research Authorization (1.2% of patients); otherwise, all included patients gave informed consent. The study received approval from the Mayo Clinic (Rochester, Minnesota) and Olmsted Medical Center Institutional Review Boards. The data underlying this article cannot be shared publicly because of patient privacy. The data will be shared on reasonable request to the corresponding author.

Advanced HF Cohort Development

The methods used to identify patients with advanced HF have been previously described.[8] Briefly, all Olmsted County residents with prevalent HF were identified using *International Classification of Diseases Ninth or Tenth Revision* (*ICD-9/ICD-10*) billing codes (ICD-9 428 or ICD-10 I50) from the inpatient or outpatient setting from January 1, 2007 to December 31, 2017. Medical records were reviewed to confirm the diagnosis of HF based on clinicians' documentation.

Following this, the 2018 European Society of Cardiology criteria were applied to the population to identify the subset of patients with advanced HF.[4] These criteria were the following: (1) Episodes of congestion, low output, or malignant arrhythmias; (2) Evidence of severe cardiac dysfunction; (3) Severe exercise impairment; and (4) Severe and persistent HF symptoms. Hospitalizations or emergency department (ED) visits for HF or VA were considered potential advanced HF index dates. The above criteria were then assessed sequentially (Figure 1); all 4 criteria must be met despite optimal medical, surgical, and device therapy for inclusion into the cohort. The date of the first event where criteria for advanced HF were fulfilled was defined as the index date for advanced HF.

Patient Characteristics

Patient demographics and clinical histories were obtained from electronic medical records. For laboratory and echocardiographic characteristics, values closest to the advanced HF index date (within 1 year) were recorded. Cardiac implantable electronic device information including cardiac implantable electronic device type, implantation date, sustained VA, and tachycardia therapies were extracted from device interrogation reports. Antiarrhythmic drug use at the time of advanced HF diagnosis was defined as being on ≥1 of the following: amiodarone, dofetilide, dronedarone, flecainide, mexiletine, procainamide, propafenone, quinidine, and sotalol.

VAs Definitions

Billing codes were used to identify VAs preceding and following advanced HF diagnosis (ICD-9 427.1, 427.4, 427.4X, 427.5; ICD-10 I47.2, I49.01, I49.02, and I46.9). Prior VA was defined as having ≥1 of the above billing codes during an inpatient or outpatient visit before

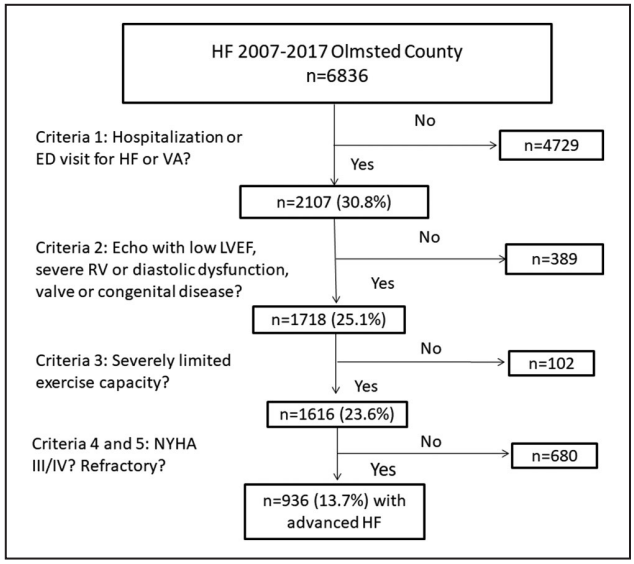

Figure 1. Study flow diagram highlighting the sequential application of the 2018 European Society of Cardiology criteria for identifying patients with advanced HF.
Echo indicates echocardiogram; ED, emergency department; HF, heart failure; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; RV, right ventricular; and VA, ventricular arrhythmia.

the advanced HF index date. A severe VA event was defined as a hospitalization or ED visit with a VA billing code as the primary diagnosis; this served to identify patients who experienced sustained VAs requiring urgent evaluation and treatment.[9]

Study Outcomes

All-cause mortality was identified using data from the Mayo Clinic registration office (which records deaths noted in clinical care and local obituaries) as well as from the State of Minnesota Department of Vital and Health Statistics. Severe VA was also examined as an outcome of interest. Among patients with implantable cardioverter defibrillators (ICDs), the number of VA events requiring tachycardia therapies and inappropriate shocks following advanced HF diagnosis were identified using device interrogation data and manually confirmed via chart review.

Statistical Analysis

Baseline characteristics were summarized using mean (SD) or median (25th–75th percentile) for continuous variables, and N (%) for categorical variables. Differences by prior VA status were assessed using Student *t* tests or Wilcoxon 2-sample tests for continuous variables, and Fisher exact tests or χ^2 tests for categorical variables.

The cumulative incidence of severe VAs postadvanced HF was estimated with the Kaplan–Meier method. Cox proportional hazards regression analyses were used to determine the associations of prior VAs and left ventricular ejection fraction (LVEF) with risk of severe VAs postadvanced HF. Differences in risk of severe VAs by LVEF and prior VA status were examined. Results were adjusted for age and sex.

The associations of prior VA and severe VA postadvanced HF diagnosis with mortality were examined using multivariable Cox proportional hazards regression analyses, with the latter modeled as a time-dependent covariate. Models were adjusted for age, sex, LVEF, and antiarrhythmic drug use. The latter 2 were included because depressed LVEF is an established risk factor for VAs and antiarrhythmic drugs are used to reduce VAs clinically. Differences in the associations of severe VAs with mortality by prior VA status and in those with and without an ICD were assessed using interaction terms. Stratified models were presented when interactions were <0.05.

Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC). For all Cox proportional hazards models, the Schoenfeld residuals were plotted over time; no evidence of the proportional hazards assumption being violated was found.

RESULTS

Advanced HF Cohort Baseline Characteristics

Of 6836 adult residents from Olmsted County, Minnesota with HF from 2007 to 2017, 936 had advanced HF (Figure 1). Among these, 261 patients (27.9%) had a prior history of VAs, of whom 60 (6.4%) experienced a severe VA. Patients with prior VAs were younger (mean age 73.6 versus 78.1 years, $P<0.001$), were more often men (75.5% versus 47.7%, $P<0.001$), had lower LVEF (mean 35.8% versus 46.5%, $P<0.001$), and more often had ICDs or cardiac resynchronization therapy defibrillator devices (44.1% versus 6.4%, $P<0.001$) compared with those without prior VAs (Table 1).

Cumulative Incidence of Severe VAs Following Advanced HF Diagnosis

The 1- and 2-year cumulative incidences of severe VAs postadvanced HF were 5.4% and 7.4%, respectively (Figure 2); a total of 54 patients in the cohort experienced severe VA events. The 2-year cumulative incidences of severe VAs following advanced HF for patients with and without prior VAs were 13.6% and 4.8%, respectively (Figure 3A), whereas the 2-year cumulative incidences of severe VAs postadvanced HF for LVEF<40%, LVEF 40%–49%, and LVEF≥50% were 12.9%, 6.1%, and 2.3%, respectively. Adjusting for age and sex, prior VA (hazard ratio [HR] 2.22 [95% CI,

Table 1. Baseline Characteristics of Patients With Advanced HF (n=936), Stratified by Prior VA Status

Characteristic	No prior VA (N=675)	Prior VA (N=261)	*P* value
Sex			
Male, n (%)	322 (47.7)	197 (75.5)	<0.001*
Female, n (%)	353 (52.3)	64 (24.5)	
Race, n (%)			
Missing, n	1	0	0.135†
Black	21 (3.1)	5 (1.9)	
Asian	12 (1.8)	2 (0.8)	
Hawaiian/Pacific Islander	1 (0.2)	0	
American Indian/ Alaska Native	0	1 (0.4)	
White	631 (93.6)	245 (93.9)	
Other/multiracial¶	9 (1.3)	8 (3.1)	
Age, y, mean (SD)	78.1 (14.3)	73.6 (14.8)	<0.001*
Peripheral vascular disease, n (%)	348 (51.6)	139 (53.3)	0.640*
Cerebrovascular disease, n (%)	150 (22.2)	67 (25.7)	0.262*
Chronic obstructive pulmonary disease, n (%)	379 (56.2)	158 (60.5)	0.224*
Diabetes, n (%)	302 (44.7)	113 (43.3)	0.690*
Charlson comorbidity score			
Mean (SD)	4.9 (2.5)	5.3 (2.5)	0.035‡
Median (25th, 75th)	5 (3, 7)	5 (3, 7)	0.033§
Hypertension, n (%)	606 (89.8)	223 (85.4)	0.062*
Hyperlipidemia, n (%)	487 (72.2)	197 (75.5)	0.303*
Coronary artery disease, n (%)	447 (66.2)	214 (82.0)	<0.001*
Albumin, mean (SD)	3.54 (0.53)	3.62 (0.49)	0.035‡
Bilirubin, mean (SD)	0.81 (0.68)	0.94 (0.71)	0.016‡
Creatinine, mean (SD)	1.57 (0.94)	1.64 (1.05)	0.299‡
Hemoglobin, mean (SD)	11.22 (1.98)	11.74 (2.10)	<0.001‡
Sodium, mean (SD)	137.7 (5.1)	137.6 (5.1)	0.700‡
eGFR, mean (SD)	49.0 (24.6)	50.4 (23.5)	0.426‡
LVEF, mean (SD)	46.5 (17.3)	35.8 (16.1)	<0.001‡
LVEF (categorical), n (%)			
<40%	236 (35.0)	160 (61.3)	<0.001*
40%–49%	94 (13.9)	40 (15.3)	
≥50%	345 (51.1)	61 (23.4)	
LVEF≤35%	203 (30.0%)	140 (53.6%)	<0.001*
RV dysfunction, n (%)			
Missing, n	7	1	0.231*
Less than moderate decrease	464 (69.5)	170 (65.4)	
Moderate or worse decrease	204 (30.5)	90 (34.6)	
Diastolic dysfunction, n (%)			
Missing, n	449	169	0.671*
Grade 1	58 (25.7)	27 (29.4)	
Grade 2	90 (39.8)	32 (34.8)	
Grade 3/4	78 (34.5)	33 (35.9)	
Increased LV filling pressure, n (%)	344 (95.6)	150 (96.8)	0.632†
E/e', mean (SD)	22.7 (11.4)	23.6 (16.1)	0.368‡
Moderate or greater regurgitation/ stenosis, mean (SD)	386 (57.2)	146 (55.9)	0.730*
Antiarrhythmic drug at time of advanced HF, n (%)	52 (7.7)	63 (24.1)	<0.001*
CIED placed, n (%)			
None	475 (70.4)	92 (32.3)	<0.001*
ICD before advanced HF	44 (6.5)	115 (44.1)	
New ICD postadvanced HF	21 (3.1)	7 (2.7)	
Pacemaker prior → ICD postadvanced HF	3 (0.4)	1 (0.4)	
Pacemaker only	132 (19.6)	46 (17.6)	

CIED indicates cardiac implantable electronic device; eGFR, estimated glomerular filtration rate; HF, heart failure; ICD, implantable cardioverter defibrillator; LV, left ventricular; LVEF, left ventricular ejection fraction; RV, right ventricular; and VA, ventricular arrhythmia.

*χ^2 test.

†Fisher exact test.

‡Student *t* test.

§Wilcoxon 2-sample test.

¶Race is self-reported. Other is an option for those who feel their race is not reflected in the response options.

1.26–3.89]; *P*=0.006), and lower LVEF (HR, 3.79 [1.72–3.89] for LVEF<40%, *P*<0.001; HR, 1.83 [0.59–5.68] for LVEF 40%–49%, *P*=0.295; reference LVEF ≥50%) were independently associated with increased risk of severe VAs following advanced HF.

Association Between VAs and Mortality Following Advanced HF Diagnosis

In total, 798 (85.3%) patients with advanced HF died during follow-up. The Kaplan–Meier estimated median 1-year and 2-year mortality were 48.0% and 65.7%, respectively. Patients with prior VAs experienced lower mortality during follow-up (unadjusted HR, 0.81 [95% CI, 0.69–0.94], *P*=0.007). However, this was largely because of their younger age; after adjustment for age and sex, there was no significant association of prior VAs with mortality (HR, 0.91 [95% CI, 0.77–1.08]; *P*=0.28). There was no significant difference in the association of prior VAs and presence

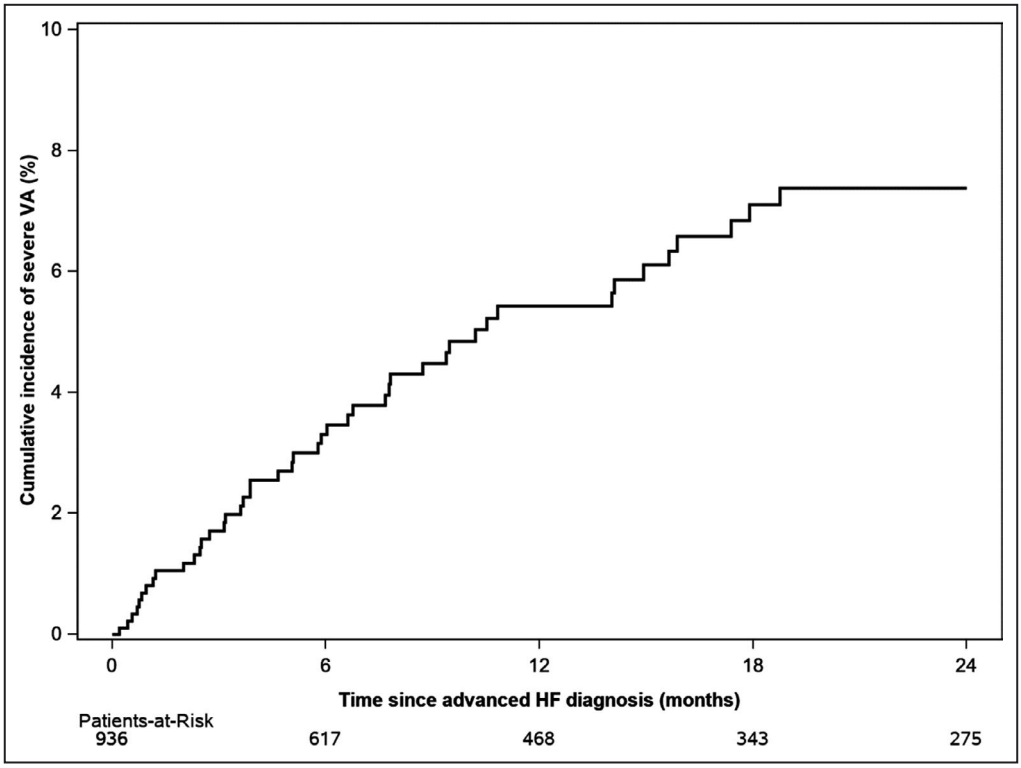

Figure 2. Kaplan–Meier curve of severe VA following advanced HF diagnosis.
HF indicates heart failure; and VA, ventricular arrhythmia.

of an ICD with mortality (*P* value for interaction ICD*prior VA=0.73).

The association of severe VAs postadvanced HF with mortality was of borderline statistical significance (unadjusted HR, 1.35 [95% CI, 0.98–1.86], *P*=0.067). However, after adjustment for age, sex, LVEF, and antiarrhythmic drug use, patients experiencing severe VAs during follow-up were at increased risk for death (HR, 1.74 [95% CI, 1.24–2.44]; *P*=0.001). The association of severe VAs with mortality varied according to prior VA status and in patients with and without an ICD (*P*<0.001 for interactions severe VA* prior VA and severe VA* ICD). When results were stratified by prior VA status (Table 2), severe VAs postadvanced HF were associated with increased mortality among patients without prior VA (HR, 4.41 [95% CI, 2.80–6.94]; *P*<0.001) but not in those with prior VA (HR, 1.08 [95% CI, 0.65–1.78]; *P*=0.77). Similarly, severe VAs following advanced HF were associated with increased mortality in patients with no ICD (HR, 4.89 [95% CI, 2.89–8.26]; *P*<0.001) but not among those with an ICD (HR, 1.42 [95% CI, 0.92–2.19]; *P*=0.11).

VAs and Tachycardia Therapies Among Patients With ICDs

At baseline, 159 patients (17.0%) with advanced HF had ICDs. Following advanced HF diagnosis, another 32 patients (3.4%) underwent either new ICD implantation or upgrade from pacemaker to ICD; hence, the total number of patients who received ICDs at any time was 191 (20.4%). In patients with LVEF ≤35% (n=343), there were 142 (41.4%) who had ICD at baseline or follow-up. Among all patients with ICDs (Table 3), 48 (25.1%) experienced VA requiring tachycardia therapies; the median number of VA events was 2 (25th to 75th percentile 1–5). Thirty-five patients (72.9%) received further treatment in the ED or inpatient setting. Five patients (2.6%) received inappropriate shocks.

DISCUSSION

In this population-based cohort of patients with advanced HF, we note the following key findings: (1) 27.9% of patients had a history of VAs preceding advanced HF; (2) There was a significant risk of severe VAs resulting in ED visits or hospitalization postadvanced HF; (3) Severe VAs following advanced HF diagnosis were significantly associated with mortality risk, with differential effects noted depending on prior VA status or ICD presence; and (4) One-quarter of patients with advanced HF with ICDs received appropriate tachycardia therapies for VAs.

The prior challenges faced in elucidating the epidemiology of advanced HF have by extension limited our knowledge regarding the burden of VAs in this

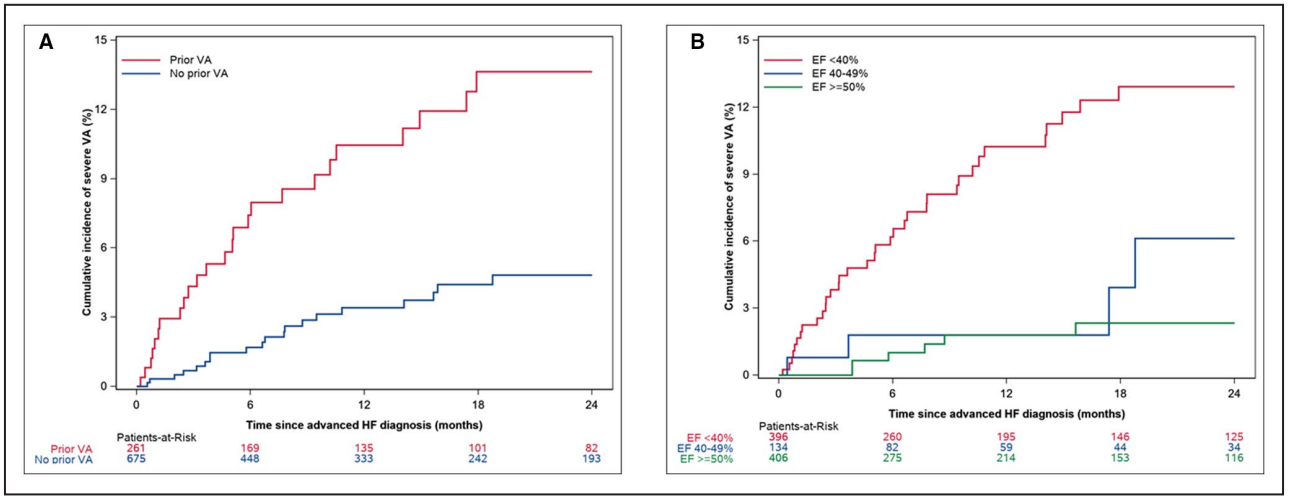

Figure 3. Kaplan–Meier curves of severe VAs postadvanced HF stratified by prior VA status (A) and LVEF category (B).
EF indicates ejection fraction; HF, heart failure; LVEF, left ventricular ejection fraction; and VA, ventricular arrhythmia.

patient population. Furthermore, VAs as defined in the literature have encompassed the spectrum of isolated premature ventricular contractions to sudden cardiac death (SCD),[10,11] making it difficult to establish direct comparisons as well as assess their impact on survival. The pathophysiology and risk of malignant VAs are best understood in the HF with reduced EF subset. Regions of heterogeneity within the myocardium as a result of ischemia/infarct, inflammation, dilatation, and adverse remodeling create conditions that allow for the initiation and maintenance of VAs, the occurrence of which can precipitate SCD.[5,10,12] Additionally, an elevated VA burden can lead to worsening structural changes and consequent pump failure, resulting in clinically deteriorating HF.[5,13,14] Data from the COMPANION (Comparison of Medical Therapy, Pacing, and Defibrillation in Heart Failure) trial demonstrated that New York Heart Failure (New York Heart Association) Class IV symptoms and LVEF <20% were strongly associated with SCD, highlighting the complex interplay between VAs and the myocardial substrate underpinning them.[6] In contrast, VA risk in HF with preserved ejection fraction has not been as well studied. A study using HF with preserved ejection fraction rat models demonstrated an elevated prevalence of SCD secondary to spontaneous VAs, possibly secondary to delayed repolarization and prolonged action potential duration.[15] In the I-PRESERVE (Irbesartan in Heart Failure with Preserved Systolic Function) and TOPCAT (Treatment of Preserved Cardiac Function Heart Failure with an Aldosterone Antagonist) trials, SCD accounted for ≈25% of cardiovascular deaths among patients with HF with preserved ejection fraction.[16,17]

To our knowledge, this is the first time that VAs have been characterized in a community-based study of patients with advanced HF. A large proportion of

Table 2. Multivariable Cox Proportional Hazards Model Predicting Mortality Following Advanced HF, stratified by prior VA status

	No prior VA		Prior VA	
Covariate	HR (95% CI)	*P* value	HR (95% CI)	*P* value
Severe VA postadvanced HF (time-dependent)	4.41 (2.80–6.94)	<0.001	1.08 (0.65–1.78)	0.77
Age	1.04 (1.03–1.04)	<0.001	1.04 (1.03–1.05)	<0.001
Sex				
Male	1.15 (0.97–1.37)	0.11	1.10 (0.79–1.54)	0.58
Female	1.00 (Ref)		1.00 (Ref)	
LVEF				
<40%	1.02 (0.84–1.23)	0.36	0.84 (0.59–1.19)	0.61
40%–49%	1.19 (0.93–1.52)		0.88 (0.55–1.39)	
≥50%	1.00 (Ref)		1.00 (Ref)	
Antiarrhythmic drug	0.86 (0.63–1.19)	0.36	1.02 (0.72–1.44)	0.90

HF indicates heart failure; HR, hazard ratio; LVEF, left ventricular ejection fraction; and VA, ventricular arrhythmia.

Table 3. VAs and Tachycardia Therapies Among Patients With ICDs (n=191)

Characteristic	Value
VA requiring tachycardia therapies (%)	48 (25.1%)
VA requiring ED visit or hospitalization (%)	35 (18.3%)
Median VA episodes (25th–75th percentile)	2 (1-5)
Number of patients receiving appropriate ATP (%)	40 (20.9%)
Number of patients receiving appropriate ICD shocks (%)	40 (20.9%)
Number of patients receiving inappropriate shocks (%)	5 (2.6%)

ATP indicates antitachycardia pacing; ED, emergency department; ICD, implantable cardioverter defibrillator; and VA, ventricular arrhythmia.

the cohort had a history of VAs before advanced HF diagnosis. It should be pointed out that we were more inclusive in our schema for identifying prior VAs (included patients with billing codes for VAs in both inpatient and outpatient setting), and therefore many of these patients likely had more "benign" manifestations including premature ventricular contractions and nonsustained ventricular tachycardia. Nevertheless, a noteworthy number (n=60; 6.4% of total cohort) did have severe VAs before advanced HF recognition. Additionally, although most patients with prior VAs had LVEF <50%, patients with HF with preserved ejection fraction still constituted a nontrivial minority in this group (23.1%). Prior VA history was significantly associated with the occurrence of severe VAs postadvanced HF, again consistent with the hypothesis that VAs may promote further myocardial structural/metabolic changes that create electrical substrates that beget more VAs.[5,18]

Following adjustment for demographics and LVEF, prior VAs were not predictive of mortality after advanced HF diagnosis. This may be reflective of the broad spectrum of VA manifestations among patients with HF, as discussed previously. However, the same is not true of severe VAs, defined by events leading to ED visits or hospitalizations. Furthermore, the effect of severe VAs on mortality is modified by prior VA status. In patients with advanced HF with no history of VA, new-onset VAs prompting urgent management is a powerful predictor of mortality. In patients with preexisting VA history, the mechanisms for VAs may be related to focal or scar-mediated substrate, with the rest of the myocardium relatively compensated. In contrast, new-onset VAs following the onset of advanced HF may be because of progressive myocardial disease and mechanical/bioenergetic uncoupling; with the development of VAs, there is a higher risk of myocardial decompensation as a result.[5,18] Just as interestingly, a significant interaction between severe VAs and ICD implantation was found; among patients with advanced HF and no ICD, severe VAs were strongly associated with mortality, whereas no increased mortality risk was seen with severe VAs for patients with ICDs. This provides observational evidence that SCD from VAs is an important contributor towards mortality in patients with advanced HF, and that ICDs may have some benefit in ameliorating this risk. Focused investigations are needed to explore these differential effects of severe VAs on mortality in advanced HF.

Cardiac implantable electronic devices, particularly ICDs, have become essential in the management of HF.[3,6,19–21] Accordingly, a significant fraction of our advanced HF cohort received ICDs. Potential reasons for not receiving these devices include not meeting guideline-based clinical (no sustained VA or cardiac arrest history) or echocardiographic (LVEF ≤35%) criteria for ICD; some patients might also have deferred ICD therapy following shared decision making. Many patients experienced VAs that were appropriately detected and acted upon by their ICDs. Inappropriate shocks, although observed in this study, were relatively infrequent.

We note several limitations in the present study. First, developing the advanced HF cohort relied on available testing and documentation in the medical records, which may result in misclassification. Second, billing codes were used to capture VA episodes; again, misclassification of VAs may occur and events may be missed because of incomplete/inaccurate billing. Third, the results obtained may not be generalizable to other advanced HF populations with differing ethnic or socioeconomic backgrounds. Fourth, although multivariable Cox regression modeling was implemented to adjust for selected covariates, residual confounding is a possibility given the nonrandomized, observational nature of the study. Finally, severe VAs resulting in SCD and death outside of the ED or hospital were not captured, which may lead to an underestimation of its incidence/prevalence. Nevertheless, the established Rochester Epidemiology Project infrastructure provides comprehensive capture of patient care in the Olmsted County region and enables robust population-based data for analysis. With implementation of objective criteria highlighted by the most contemporary guidelines, patients with advanced HF could be more accurately identified, which in turn allowed for appropriate characterization of the prevalence and prognostic impact of VAs in this patient population.

CONCLUSIONS

A high prevalence of VAs was noted in a community cohort of patients with advanced HF. Prior VAs and LVEF <40% were significant predictors of severe VAs following advanced HF diagnosis. New-onset severe VAs and severe VAs in the absence of ICDs were associated with increased mortality.

ARTICLE INFORMATION

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Disclosures

None.

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