ESC HEART FAILURE
ESC Heart Failure 2019; **6**: 1283–1290
Published online 21 November 2019 in Wiley Online Library (wileyonlinelibrary com) **DOI:** 10.1002/ehf2.12525

ORIGINAL RESEARCH ARTICLE

In-hospital ventricular arrhythmia in heart failure patients: 7 year follow-up of the multi-centric HEARTS registry

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Abstract

Aims The aim of this study was to determine the incidence, predictors, and short-term and long-term outcomes associated with in-hospital sustained ventricular tachycardia (VT) and ventricular fibrillation (VF) collectively termed ventricular arrhythmia (VA) in the heart failure (HF) patients.

Methods and results The HEart function Assessment Registry Trial in Saudi Arabia (HEARTS registry) is a prospective national registry of patients with chronic HF from18 tertiary care hospitals across Saudi Arabia. Diagnosis of HF was in accordance with American Heart Association/European Society of Cardiology definition criteria. The registry had enrolled 2610 HF patients during the 14 month recruitment period between October 2009 and December 2010. Occurrence of in-hospital cardiac events, prognosis, and outcome were monitored during the 7 year follow-up period. The incidence of in-hospital VA in HF was 4.2%. VA was more common among men, and mean age was lesser than non-VA patients (58.5 ± 16: 61.5 ± 15 years; $P = 0.042$). Smoking and family history of cardiomyopathy were significant risk factors of VA. Previous history of arrhythmia, ST elevated myocardial infarction, infections, and hypotension remained significant predictors of in-hospital VA associated with three to seven times more risk. Patients with VA had higher rates of in-hospital events like recurrent HF, haemodialysis, shock, sepsis, major bleeding, intra-aortic balloon pump, and stroke compared with those without VA, all being highly significant ($P < 0.001$). After adjustment for age, gender, and co-morbidities, in-hospital VA increased the risk of cardiogenic shock by 24 times, dialysis and major bleeding by 10 times, and recurrent congestive HF and pacing by five times. Survival analysis showed that all-cause mortality was significantly higher in the VA patients ($P < 0.001$). Presence of VA increased in-hospital and 1 month mortality to 23 and 17 times, respectively.

Conclusions Lower mean age of VA complicated HF patients is a matter of concern in the Saudi population. HF associated with VA increased in-hospital events and all-cause mortality indicating poor prognosis and survival. These findings enable risk stratification and reflect on the importance of early recognition of the clinical markers and predictors of VA prompting immediate management.

Keywords Heart failure; HEARTS registry; In-hospital ventricular arrhythmia; Saudi Arabia

Received: 27 January 2019; Revised: 20 August 2019; Accepted: 6 September 2019
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Introduction

Heart failure (HF) is a serious and progressive cardiac illness that adversely affects quality of life, increases healthcare costs substantially, and is a major cause of mortality.[1–3] It affects about 26 million people worldwide,[4] and the annual global cost burden was estimated at $108bn in 2012, which is projected to increase by 127% by 2030. The prevalence estimates are said to increase by 46% in the USA with characteristic dip in age at occurrence.[5] The global public health burden of HF is enormous accounting for high rates of prevalence in European and Southeast Asian population

ranging from 1% to 6.7% respectively with varying disparities in clinical characteristics due to geographical variations. However, owing to longevity in human lifespan, HF has been further projected to rise in population aged >64 years. These temporal trends are a cause of concern and demand urgent control measures based on etiological factors and prognostic outcomes of HF.[6] Technological advancements in imaging techniques not only have improved diagnosis but also have further facilitated survival prediction and risk stratification of HF patients.[7] But despite exceptional technological advances, HF is associated with high rates of disability and death, although the long-term mortality rates have improved over time.[8–10] The in-hospital and long-term outcomes of HF are determined by numerous intrinsic factors and presence of co-morbidities like obesity, diabetes, hypertension, renal health, and cardiac health by itself like compromised ejection fraction, ventricular arrhythmias being one of the major determinants associated with increased risk of short-term and long-term mortality.[11–13] Large international multi-centric prospective studies like EuroHeart Failure, GRACE, and ASCEND have documented in-hospital and long term outcomes associated with HF among multi-ethnic population,[14–16] but literature from Middle Eastern region on the contrary is mostly limited to prevalence studies reporting rates of occurrence of cardiovascular diseases. Prospective studies describing long-term outcomes of HF are rare, and one such study from the region of Saudi Arabia known as Saudi Project for Assessment of Coronary Events (SPACE) registry in 2012 had demonstrated risk factors and mortality due to VA in patients with acute coronary syndrome.[17] Although these studies focused on certain types of arrhythmias such as premature ventricular complexes (PVCs) and non-sustained ventricular tachycardia (NSVT) and their adverse outcomes, data related to sustained ventricular tachycardia and ventricular fibrillation in HF patients are sparse in Saudi Arabia. The present study is first to document the incidence of sustained VT and VF, henceforth will be termed as ventricular arrhythmia (VA), its predictors, and associated outcomes in patients hospitalized with HF using data from HEart function Assessment Registry Trial in Saudi Arabia (HEARTS registry). HEARTS is the first national registry of HF patients linking 18 cardiac care hospitals in Saudi Arabia, registering more than 2000 patients in just 1 year, which points towards the gravity of situation in Saudi Arabia. The current study describes the impact of ventricular arrhythmia by subgroup analyses presenting the clinical picture, predictors, and mortality rates of HF patients among already developed VA/VT patients compared with those without VA. Furthermore, patient characteristics associated with an increased risk of developing ventricular arrhythmia would help to establish a baseline from which further studies can determine temporal changes in the prognosis of VA-related HF. Evaluating these patient characteristics may help in identifying high-risk VA patients.

Methods

HEARTS registry is a national prospective registry involving cardiac care hospitals across the Kingdom of Saudi Arabia, forming a representative sample of Saudi population. To stay brief, the Kingdom of Saudi Arabia is the largest country in the Arabian Peninsula, and it is the second largest producer of crude oil in the world with a gross domestic product per capita of 21 057.33 USD in 2017. The study design, details of study population, definition of study variables, and procedures have been well described and published previously.[18,19] The registry had enrolled 2610 patients admitted into the coronary care unit/intensive care unit or the wards, with acute decompensated HF whether *de novo* (no previous history of HF) or with acute/chronic HF. Diagnosis of HF and the standard variables definitions were as per the American College of Cardiology, American Heart Association, and European Society of Cardiology definitions. HF patients with ejection fraction <30% and persistent New York Heart Association Class III or IV formed the study population. Development of sustained ventricular tachycardia or ventricular fibrillation or both while being hospitalized for HF management was the main outcome measure. VF was identified at admission or during the process of hospitalization if the patient showed irregular undulations of the electrocardiogram consistent with the diagnosis. VT was identified by a regular wide complex tachycardia lasting >30 s or requiring termination because of haemodynamic instability. Additionally, other in-hospital events and short-term and long-term all-cause mortality rates of the patients were also measured in the 7 year follow-up period. Patients less than 18 years of age, those who did not wish to participate, and those who were treated and discharged from the emergency department without hospital admission were excluded from the study. A verbal informed consent was obtained from the patients or their relatives. Ethical approval of the study was obtained by each of the hospital's ethics committee or the institutional review board.

Statistical methods

The statistical analyses were performed using SPSS version 21.0 (SPSS Inc.).Continuous variables of normally distributed data were described using mean and standard deviation (SD), while median and inter-quartile range were used to represent skewed data. Test of significance was performed using the *t*-test or Mann–Whitney *U* test as needed to satisfy the normality of assumptions. Categorical variables were presented as frequencies and percentages, and bivariate associations between the two groups were compared using a *Z* test for proportion. Predictors of mortality were assessed using both univariate and multivariate regression models to obtain independent predictors. Stepwise multiple regression models were applied to select independent predictors in the

multivariate models. Crude and adjusted odds ratios, *P* values, and 95% confidence intervals from regression models were used to report summary statistics. Kaplan–Meier curves were used to depict the survival pattern of the patients with HF in the cohort.

Results

Patient characteristics

The HEARTS study obtained 4.2% incidence of in-hospital VA after 7 years of follow-up. *Table 1* shows the comparison of the prevalence of risk factors among VA and non-VA complicated HF patients. In-hospital VA was significantly higher among men ($P = 0.029$), and the mean age was lesser compared with the non-VA group ($P = 0.042$). Other risk factors that appeared significant among the in-hospital VA patients were previous history of VF/VT ($P < 0.001$), family history of cardiomyopathy ($P = 0.020$), and smoking ($P = 0.003$). Although non-significant, VA patients were more likely to report history of non-ischaemic-related chronic HF followed by history of ischaemic heart disease. Hypertension and diabetes were the two most prevalent co-morbidities in both the groups.

Table 2 illustrates the differences in clinical presentation, investigations, and procedures between the two groups. Patients with VA had significantly higher heart rate and lower systolic blood pressure and diastolic blood pressure at the time of admission ($P < 0.001$). The most prevalent exacerbating factors for VA-related HF were history of arrhythmia (29%; $P < 0.001$), infections (28%, $P = 0.04$), ST elevated myocardial infarction (25.5%, $P < 0.001$), followed by uncontrolled hypertension (10.9%, $P = 0.017$). While ischaemic heart disease (60.9%:55.5%) was the most prevalent aetiology in both VA and non-VA HF patients; however, the differences were non-significant. Echocardiography and coronary angiogram showed higher left ventricular systolic dysfunction ($P = 0.002$) and higher prevalence of single and triple vessel disease compared with non-VA patients upon admission.

Table 1 Demographics, medical history, and risk factors between VA and non-VA patients

	Heart failure patients			
Variable	Total (2610)	VA (110)	Non-VA (2500)	*P* value*
Demographics				
Age, mean (SD)	61.3 (15.0)	58.5 (16.3)	61.5 (15)	0.042
Male gender	1717 (65.8)	83 (75.4)	1634 (65.3)	0.029
Saudi nation	2230 (85.4)	85 (77.3)	2145 (85.8)	0.013
Body mass index (kg/m^2), mean (SD)	29.2 (6.7)	28.7 (5.9)	29.2 (6.8)	0.417
Medical history				
Ischaemic heart disease	1376 (52.7)	54 (49.1)	1322 (52.9)	0.369
Congestive heart failure	1670 (64.1)	72 (65.5)	1598 (64.0)	0.780
Percutaneous coronary intervention	340 (13.0)	12 (10.9)	328 (13.1)	0.167
Coronary artery bypass graft	261 (10.0)	12 (10.9)	249 (9.9)	0.728
Rheumatic heart disease	183 (7.0)	7 (6.4)	176 (7.0)	0.790
Other valvular heart disease	390 (14.9)	21 (19.1)	369 (14.7)	0.222
Atrial fibrillation	408 (15.6)	12 (10.9)	396 (15.8)	0.170
VT/VF	64 (2.4)	13 (11.8)	51 (2.0)	<0.001
ICD	229 (8.7)	10 (9.0)	219 (8.7)	0.887
CRT	85 (3.2)	3 (2.7)	82 (3.3)	1.00
CVA/TIA	252 (9.6)	13 (11.8)	239 (9.5)	0.418
Peripheral arterial disease	99 (3.8)	2 (1.8)	97 (3.9)	0.437
Chronic renal insufficiency	771 (29.5)	33 (30.0)	738 (29.5)	0.935
Anaemia	538 (20.6)	23 (20.9)	515 (20.6)	0.964
Risk factors				
Diabetes	1668 (63.9)	68 (61.8)	1600 (64.0)	.698
Hypertension	1831 (70.1)	71 (64.5)	1760 (70.4)	.200
Dyslipidaemia	894 (34.2)	39 (35.4)	855 (34.2)	.872
Smoking[a]	872 (33.4)	51 (46.4)	821 (32.8)	.003
Thyroid disease	172 (6.6)	5 (4.5)	167 (6.7)	.376
Cardiotoxic chemotherapy	23 (0.9)	0 (0.0)	23 (0.9)	.622
Cardiotoxic substance	21 (0.8)	3 (2.7)	18 (0.7)	.055
Family history of SCD	23 (0.9)	2 (1.8)	21 (0.8)	.246
Family history of CAD	88 (3.3)	5 (4.5)	83 (3.3)	.389
Family history of cardiomyopathy	26 (0.9)	4 (3.6)	22 (0.8)	.020

CAD, coronary artery disease; CRT, cardiac resynchronization therapy; CVA/TIA, cerebrovascular accident/transient ischaemic attack; ICD, implantable cardioverter defibrillator; SCD, sudden cardiac death; SD, standard deviation; VA, ventricular arrhythmia; VT/VF, ventricular tachycardia/ventricular fibrillation.
Data are presented in *n* (%).
[a]Including current and ex-smokers.
*χ^2 test of proportions was performed to determine the significance. A *P* value less than 0.05 was considered significant.

Table 2 Differences in clinical presentation, investigations, and procedures among VA and non-VA patients

	Heart failure patients		
Variable	VA (110)	Non-VA (2500)	*P* value
Heart rate, mean (SD)	95.4 (21.9)	88.5 (20.9)	<0.001
SBP, mean (SD)	112.7 (25.8)	129.4 (31.4)	<0.001
DBP, mean (SD)	68.1 (17.9)	74.4 (17.8)	<0.001
Oxygen saturation, mean (SD)	92.9 (7.3)	94.1 (5.9)	0.048
Exacerbating factors			
STEMI	28 (25.4)	248 (9.9)	<0.001
Uncontrolled hypertension	12 (10.9)	504 (20.2)	0.017
History of arrhythmia	32 (29.1)	252 (10.1)	<0.001
Infections	31 (28.2)	506 (20.2)	0.044
Chronic obstructive pulmonary disease	2 (1.8)	99 (4.0)	0.442
Worsening renal failure	26 (23.6)	431 (17.2)	0.084
High-salt diet	31 (28.2)	628 (25.1)	0.471
Medications non-compliance	25 (22.7)	524 (21.0)	0.658
Heart failure aetiology			
Ischaemic heart disease	67 (60.9)	1387 (55.5)	0.264
Idiopathic dilated cardiomyopathy	21 (19.1)	410 (16.4)	0.458
Primary valvular heart disease	8 (7.3)	194 (7.7)	0.851
Hypertensive heart disease	6 (5.4)	301 (12.0)	0.036
Investigations			
Sodium (mmol/L), mean (SD)	134.8 (6.4)	135.2 (5.3)	0.591
Potassium (mmol/L), mean (SD)	4.2 (0.7)	4.3 (0.7)	0.534
ProBNP (pg/mL), mean (SD)	2875 (3564)	1177 (1652)	0.099
Positive troponin	53 (48.2)	814 (32.5)	0.004
Echocardiography			
LV systolic dysfunction[a]	97 (88.2)	2056 (82.2)	0.002
Coronary angiogram			
Left main vessel	4 (3.6)	24 (0.9)	0.049
Single vessel disease	0 (0.0)	105 (4.2)	0.010
Double vessel disease	7 (6.3)	109 (4.3)	0.621
Triple vessel disease	19 (17.2)	236 (9.4)	0.037
Normal angiogram	12 (10.9)	171 (6.8)	0.306

DBP, diastolic blood pressure; LV, left ventricular; proBNP, pro-brain natriuretic peptide; SBP, systolic blood pressure; SD, standard deviation; STEMI, ST elevated myocardial infarction; VA, ventricular arrhythmia.
Data are presented in *n* (%).
[a]Ejection fraction <40%.

Table 3 presents the results of multivariate regression analysis with in-hospital VA as dependent variable and various co-morbid conditions, past cardiac events, and other exacerbating factors as independent variables. ST elevated myocardial infarction, arrhythmia, hypotension (systolic blood pressure <90 mmHg), and infection at presentation remained significant as strong predictors in the final model showing independent association with VA.

The prevalence of in-hospital events and all-cause mortality is shown in *Table 4*. Recurrent and chronic HF,

Table 3 Multivariate regression analysis showing factors associated with in-hospital ventricular arrhythmia in heart failure patients

Associated factors	Odds ratio	95% CI	*P* value
Arrhythmia	7	2.4–19.3	<0.001
STEMI	4.7	1.6–14	0.006
Infection	3	1.2–7.6	0.024
Blood pressure <90 mmHg	3.6	1.2–11	0.023

CI, confidence interval; STEMI, ST elevated myocardial infarction.
In-hospital ventricular arrhythmia was the dependent variable, and all other associated conditions were taken as independent variables.

Table 4 Differences in in-hospital events and mortality between VA and non-VA patients

	Heart failure patients		
Variable	VA (110)	Non-VA (2500)	*P* value
In-hospital events			
Recurrent CHF	69 (62.7)	747 (29.9)	>0.001
Dialysis	25 (22.7)	100 (4.0)	>0.001
Intra-aortic balloon pump	28 (25.5)	58 (2.3)	<0.001
Sepsis	36 (32.7)	160 (6.4)	<0.001
Shock	64 (58.2)	164 (6.6)	>0.001
Pacing	6 (5.4)	30 (1.2)	0.003
Major bleeding	10 (9.1)	28 (1.1)	<0.001
ICD	8 (7.3)	142 (5.7)	0.483
CRT	5 (4.5)	63 (2.5)	0.208
TIA/stroke	5 (4.5)	43 (1.7)	0.049
All-cause mortality			
In-hospital	53 (48.2)	117 (4.7)	<0.001
1 month	53 (48.2)	159 (6.3)	<0.001
1 year	58 (52.7)	451 (18.0)	<0.001
2 year	61 (55.4)	554 (22.1)	<0.001
3 year	61 (55.4)	574 (23.0)	<0.001

CHF, chronic heart failure; CRT, cardiac resynchronization therapy; ICD, implantable cardioverter defibrillator; TIA, transient ischaemic attack; VA, ventricular arrhythmia.
Data are expressed in *n* (%). All-cause mortality includes cumulative of previous years.

haemodialysis, shock, sepsis, major bleeding, and intra-aortic balloon pump were highly significant among the patients with VA ($P < 0.001$). Survival analysis showed highly significant differences in all-cause mortality for in-hospital, 1 month, 1 year, and 3 years for VA patients compared with non-VA ($P < 0.001$).

The adjusted odds ratios of in-hospital events and mortality with respect to age and gender and in addition to presence of co-morbidities for VA are shown as differences in two groups in *Table 5*. Generally, presence of VA increased the odds of occurrence of adverse events and mortality. Cardiogenic shock when adjusted for co-morbidities showed the highest odds, escalating from around 20 to 24 times the risk. The estimated risk of developing other conditions like recurrent HF, haemodialysis, sepsis, major bleeding, and pacing increased manifold in presence of VA. Those with in-hospital VA had higher risk for in-hospital, 1 month, and 3 year mortality than those without VA.

Discussion

Development of ventricular arrhythmia in HF patients is a serious complication necessitating prompt intervention. Many studies have reported the magnitude and prognosis associated with VA in patients hospitalized with HF. [20,21] However, those studies were limited to PVCs and NSVT in HF and did not investigate sustained VT and VF due to high rate of mortality.[22] To the best of our knowledge, this is the first study that expands the knowledge base to include the incidence, associated factors, and outcomes of patients with HF complicated by sustained VT and VF in Saudi Arabia.

Table 5 Age-adjusted and gender-adjusted odds ratios for ventricular arrhythmia-related in-hospital events and mortality in heart failure patients

Variable	Age-adjusted and gender-adjusted odds ratio	Age-adjusted, gender-adjusted, and co-morbidities-adjusted odds ratio
In-hospital events		
Recurrent CHF	3.9 (2.6–5.8)	4.7 (3.0–7.2)
Dialysis	7.2 (4.4–11.8)	10.3 (5.8–18.4)
Shock	19.8 (13.1–30.0)	23.7 (15.3–36.7)
Pacing	5.1 (2.1–12.5)	5.8 (2.3–14.8)
CRT	1.7 (0.7–4.3)	1.7 (0.7–4.5)
ICD	1.1 (0.5–2.4)	1.2 (0.6–2.6)
Major bleeding	9.6 (4.5–20.6)	9.4 (4.3–20.7)
TIA/stroke	2.9 (1.1–7.4)	3.2 (1.2–8.6)
Mortality		
In-hospital	21.2 (13.8–32.6)	22.8 (14.5–35.9)
1 month	15.3 (10.1–23.3)	16.7 (10.8–25.9)
1 year	5.8 (3.9–8.7)	6.6 (4.3–10.1)
2 year	5.1 (3.4–7.6)	5.8 (3.8–8.9)
3 year	4.9 (3.3–7.3)	5.6 (3.7–8.5)

CHF, chronic heart failure; CRT, cardiac resynchronization therapy; ICD, implantable cardioverter defibrillator; TIA, transient ischaemic attack.
Data are presented as odds ratio (95% confidence interval).

The present study assessed the incidence, predictors, and mortality among HF patients with in-hospital VA using database from national HEARTS registry in Saudi Arabia. The cohort of HF patients showed 4.2% incidence of in-hospital VA. ST elevated myocardial infarction, previous history of arrhythmia, infection, and lower systolic blood pressure were independently associated with VA at the time of presentation. Other findings include strong association of VA with development of multiple in-hospital cardiac events and high rate of all-cause mortality. Some of the findings specific to Saudi population include lower age of occurrence and higher 1 month mortality.

The global incidence rates of in-hospital VA have been reported to be fairly consistent with our study. ATLAS study showed 5.5% and Worcester Heart Attack Study reported 4.7% incidence of in-hospital VA among myocardial infarction patients.[23,24] On the other hand, there was a decline in out-of-hospital ventricular fibrillation/ventricular tachycardia in the population as in Finnish study, which showed 48% decrease from 1994 to 1999, and another study in Sweden had reported 18% reduction in incidence of VA after 17 years of follow-up.[25,26] Clinical presentation at the time of admission of the VA complicated HF patients showed significant association with male gender, previous history of VT/VF, family history of cardiomyopathy, positive troponin, lower ejection fraction, higher heart rate at presentation, and triple vessel disease. HF registries from around the globe have identified older age and male gender as pivotal risk factors. To our surprise, the mean age was lower for VA complicated HF patients. Nevertheless, the mean age (61 years ± 15 SD) of the total cohort of HF patients in our registry was much lower in comparison with other registries from the American and European region (70–75 years ± 15 SD). [4,27] These regional differences are controlled by many factors including economic status, literacy levels, genetic and lifestyle factors, and individual patient characteristics.[4] However, this important finding reflects on implications like early mortality and multiple morbidity, thus necessitating urgent planning and implementation of framework of cardiac health intervention policies in Saudi Arabia. Other clinical risk factors were similar to reports from regional and global contemporary registries.[28,29]

With regard to in-hospital course, adverse events during hospitalization were more frequent in the VA group, thereby exerting a direct influence on the prognosis and outcome. In addition, HF patients with VA showed significantly higher precipitating factors, which together augmented the risk of short-term and long-term mortality. The HEARTS registry showed higher rates of all-cause mortality than the global trials like EVEREST and ASCEND-HF.[30,16] Other studies like GRACE, EFHS, and ATLAS are in accordance to our findings.[31–34] Nonetheless, despite adverse outcomes associated with VA, the investigators of PROMISE study demonstrated that NSVT specifically in addition to other clinical parameters did not add more to the prediction of sudden death in moderate-to-severe HF patients, but early recognition and

management of in-hospital VA by prompt defibrillation improved survival outcomes.[35] Herlitz and his colleagues and other studies demonstrated high rates of survival to hospital discharge upon <3 min defibrillation after collapse among in-hospital VF patients.[36–38] Hence, our findings suggest that the exacerbating factors may prompt vigilant monitoring of the parameters enhancing early recognition and facilitating swift initiation of defibrillation leading to substantial improvement in prognosis and better outcomes.

Furthermore, although standardized, the ICD and CRT therapy vary considerably between countries. The total prevalence of implant devices among HF patients in the present study was 12% with similar use between VA and non-VA patients. Although this figure was overtly lower compared with countries like Italy, Israel, and Czech Republic with CRT penetration rate of 31–93%, many other countries reported a prevalence range of 0–15%.[39] Data from the Gulf region involving seven countries also showed prevalence below 5%.[28] The reasons behind such regional disparities depend on several identified barriers like the type of healthcare centre, budget and finance, insufficient referrals, and lower physician awareness of guidelines. A detailed analysis of current cohort is however required to determine the cause of such low prevalence. Such underutilization may result in substandard healthcare delivery and management of HF patients raising concern. However, a larger study may be recommended involving referral hospitals and tertiary centres representative of the population to obtain unbiased results.

The study does contain certain limitations. First, the results of the study are based on data from a registry in which the enrolment of subjects is voluntary, which may impact the quality of data as being non-representative of the general population. Second, VA in our study included only patients with sustained VT and VF, which might have different prognostic implications in the setting of HF; information on other types such as PVCs and NSVT was not documented and hence beyond the scope of our study. Finally, the pre-hospital VA and/or sudden death were not captured in the registry, which might underestimate the incidence of VA in our population.

To summarize, smoking men aged above 55 years with previous history of arrhythmias or MI and with family history of cardiomyopathy are more likely to develop VA subsequent to HF. VA in HF was associated with higher risk of in-hospital events, adverse outcomes, and poor survival. The clinical implications of this research include risk identification based on presence of significant risk factors and predictors of VA that may potentially lead to early recognition and prompt management to improve outcomes. With regard to research implications, we suggest linking of more registries and develop risk stratification scores specific to Saudi population.

Conflict of interest

None declared.

Funding

HEARTS was financially co-sponsored by Servier and AstraZeneca. The College of Medicine Research Center at King Khalid University Hospital, King Saud University, Riyadh, Saudi Arabia, provided ethical approval and partial funding. The authors are grateful to the Deanship of Scientific Research, King Saud University, for funding through Vice Deanship of Scientific Research Chairs.

References

1. Najafi F, Jamrozik K, Dobson AJ. Understanding the 'epidemic of heart failure': a systematic review of trends in determinants of heart failure. *Eur J Heart Fail* 2009; **11**: 472–479.
2. Hunt SA, Abraham WT, Chin MH, Feldman AM, Francis GS, Ganiats TG, Konstam MA, Mancini DM, Rahko PS, Silver MA, Stevenson LW. Focused update incorporated into the ACC/AHA 2005 guidelines for the diagnosis and management of heart failure in adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines developed in collaboration with the International Society for Heart and Lung Transplantation. *J Am Coll Cardiol* 2009; **53**: E1–E90.
3. Dickstein K, Cohen-Solal A, Filippatos G, McMurray JJ, Ponikowski P, Poole-Wilson PA, Strömberg A, van Veldhuisen DJ, Atar D, Hoes AW. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). *Eur J Heart Fail* 2008; **10**: 933–989.
4. Ambrosy AAFG, Butler J, Fonarow GC, Chioncel O, Greene SJ, Vaduganathan M, Nodari S, Lam CS, Sato N, Shah AN, Gheorghiade M. The global health and economic burden of hospitalizations for heart failure lessons learned from hospitalized heart failure registries. *Journal of American College of Cardiology* 2014; **63**: 1123–1133.
5. Cook C, Cole G, Asaria P, Jabbour R, Francis DP. The annual global economic burden of heart failure. *Int J Cardiol* 2014; **171**: 368–376.
6. Savarese G, Lars H, Lund LH. Global public health burden of heart failure. *Card Fail Rev* 2017; **3**: 7–11.
7. Sinagra G, Iorio A, Merlo M, Cannatà A, Stolfo D, Zambon E, Di Nora C, Paolillo S, Barbati G, Berton E, Carriere C. Prognostic value of cardiopulmonary exercise testing in idiopathic dilated cardiomyopathy. *Int J Cardiol* 2016; **223**: 596–603.
8. Baker DW, Einstadter D, Thomas C, Cebul RD. Mortality trends for 23,505

Medicare patients hospitalized with heart failure in Northeast Ohio, 1991 to 1997. *Am Heart J* 2003; **146**: 258–264.
9. Levy D, Kenchaiah S, Larson MG, Benjamin EJ, Kupka MJ, Ho KK, Murabito JM, Vasan RS. Long-term trends in the incidence of and survival with heart failure. *N Engl J Med* 2002; **347**: 1397–1402.
10. Roger VL, Weston SA, Redfield MM, Hellermann-Homan JP, Killian J, Yawn BP, Jacobsen SJ. Trends in heart failure incidence and survival in a community-based population. *JAMA* 2004; **292**: 344–350.
11. Curtis LH, Greiner MA, Hammill BG, Kramer JM, Whellan DJ, Schulman KA, Hernandez AF. Early and long-term outcomes of heart failure in elderly persons, 2001–2005. *Arch Intern Med* 2008; **168**: 2481–2488.
12. Kosiborod M, Lichtman JH, Heidenreich PA, Normand SLT, Wang Y, Brass LM, Krumholz HM. National trends in outcomes among elderly patients with heart failure. *Am J Med* 2006; **119**.
13. Narang R, Cleland JGF, Erhardt L, Ball SG, Coats AJS, Cowley AJ, Dargie HJ, Hall AS, Hampton JR, Poole-Wilson A. Mode of death in chronic heart failure —a request and proposition for more accurate classification. *Eur Heart J* 1996; **17**: 1390–1403.
14. Lenzen MJ, Scholte op Reimer WJ, Boersma E, Vantrimpont PJ, Follath F, Swedberg K, Cleland J, Komajda M. Differences between patients with a preserved and a depressed left ventricular function: a report from the EuroHeart Failure Survey. *Eur Heart J* 2004; **25**: 1214–1220.
15. ÁlvaroAvezum PLS, Goldberg RJ, Brieger D, Stiles MK, Paolini R, Huang W, Gore JM, GRACE Investigators. Magnitude and prognosis associated with ventricular arrhythmias in patients hospitalized with acute coronary syndromes (from the GRACE Registry). *The Am J of Cardiol.* 2008; **102**: 1577–1582.
16. Pokorney SD, Al-Khatib SM, Sun JL, Schulte P, O'Connor CM, Teerlink JR, Armstrong PW, Ezekowitz JA, Starling RC, Voors AA, Velazquez EJ, Hernandez AF, Mentz RJ. Sudden cardiac death after acute heart failure hospital admission: insights from ASCEND-HF. *Eur J Heart Fail* 2017; **20**: 525–532.
17. Hersi AS, Alhabib KF, AlFaleh HF, Al Nemer K, Al Saif S, Taraben A, Kashour T, Abuosa AM, Al-Murayeh MA. Incidence of ventricular arrhythmia and associated patient outcomes in hospitalized acute coronary syndrome patients in Saudi Arabia: findings from the registry of the Saudi Project for Assessment of Acute Coronary Syndrome (SPACE). *Ann Saudi Med* 2012; **32**: 372–377.
18. AlHabib KF, Elasfar AA, AlBackr H, AlFaleh H, Hersi A, AlShaer F, Kashour T, AlNemer K, Hussein GA, Mimish L. Design and preliminary results of the Heart Function Assessment Registry Trial in Saudi Arabia (HEARTS) in patients with acute and chronic heart failure. *Eur J Heart Fail* 2011; **13**: 1178–1184.
19. AlHabib KF, Elasfar AA, Alfaleh H, Kashour T, Hersi A, AlBackr H, Alshaer F, AlNemer K, Hussein GA, Mimish L, Almasood A. Clinical features, management, and short- and long-term outcomes of patients with acute decompensated heart failure: phase I results of the HEARTS database. *Eur J Heart Fail* 2014; **16**: 461–469.
20. Unverferth DV, Magorien RD, Moeschberger ML, Baker PB, Fetters JK, Leier CV. Factors influencing the one-year mortality of dilated cardiomyopathy. *Am J Cardiol* 1984; **54**: 147–152.
21. Huang SK, Messer JV, Denes P. Significance of ventricular-tachycardia in idiopathic dilated cardiomyopathy—observations in 35 patients. *Am J Cardiol* 1983; **51**: 507–512.
22. Cleland JG, Chattopadhyay S, Khand A, Houghton T, Kaye GC. Prevalence and incidence of arrhythmias and sudden death in heart failure. *Heart Fail Rev* 2002; **7**: 229–242.
23. Cleland JG, Thygesen K, Uretsky BF, Armstrong P, Horowitz JD, Massie B, Packer M, Poole-Wilson PA, Rydén on behalf of the ATLAS investigators L. Cardiovascular critical event pathways for the progression of heart failure; a report from the ATLAS study. *Eur Heart J* 2001; **22**: 1601–1612.
24. CA Thompson JY, Goldberg R, Lessard D, Gore J, Dalen J. Changes over time in the incidence and case-fatality rates of primary ventricular fibrillation complication acute myocardial infarction: perspectives from the Worcester Heart Attack Study. *Am Heart J* 2000; **139**: 1014–1021.
25. Kuisma M, Repo J, Alaspaa A. The incidence of out-of-hospital ventricular fibrillation in Helsinki, Finland, from 1994 to 1999. *Lancet* 2001; **358**: 473–474.
26. Herlitz J, Andersson E, Bang A, Engdahl J, Holmberg M, lindqvist J, Karlson BW, Waagstein L. Experiences from treatment of out-of-hospital cardiac arrest during 17 years in Goteborg. *Eur Heart J* 2000; **21**: 1251–1258.
27. Komajda M, Hanon O, Hochadel M, Lopez-Sendon JL, Follath F, Ponikowski P, Harjola VP, Drexler H, Dickstein K, Tavazzi L, Nieminen M. Contemporary management of octogenarians hospitalized for heart failure in Europe: Euro Heart Failure Survey II. *Eur Heart J* 2009; **30**: 478–486.
28. Sulaiman K, Panduranga P, Al-Zakwani I, Alsheikh-Ali AA, AlHabib KF, Al-Suwaidi J, Al-Mahmeed W, AlFaleh H, Elasfar A, Al-Motarreb A, Ridha M. Clinical characteristics, management, and outcomes of acute heart failure patients: observations from the Gulf acute heart failure registry (Gulf CARE). *Eur J Heart Fail* 2015; **17**: 374–384.
29. Wang GG, Wang SJ, Qin J, Li CS, Yu XZ, Shen H, Yang LP, Fu Y, Zheng YA, Zhao B, Yu DM. Characteristics, management, and outcomes of acute heart failure in the emergency department: a multicenter registry study with 1-year follow-up in a Chinese cohort in Beijing. *Chin Med J (Engl)* 2017; **130**: 1894–1901.
30. O'Connor CM, Miller AB, Blair JE, Konstam MA, Wedge P, Bahit MC, Carson P, Haass M, Hauptman PJ, Metra M, Oren RM, Efficacy of Vasopressin Antagonism in Heart Failure Outcome Study with Tolvaptan (EVEREST) Investigators. Causes of death and rehospitalization in patients hospitalized with worsening heart failure and reduced left ventricular ejection fraction: results from Efficacy of Vasopressin Antagonism in Heart Failure Outcome Study with Tolvaptan (EVEREST) program. *Am Heart J* 2010; **159**: 841–849.
31. Avezum A, Piegas LS, Goldberg RJ, Brieger D, Stiles MK, Paolini R, Huang W, Gore JM, GRACE investigators. Magnitude and prognosis associated with ventricular arrhythmias in patients hospitalized with acute coronary syndromes (from the GRACE Registry). *Am J Cardiol* 2008; **102**: 1577–1582.
32. Nieminen MS, Brutsaert D, Dickstein K, Drexler H, Follath F, Harjola VP, Hochadel M, Komajda M, Lassus J, Lopez-Sendon JL, Ponikowski. EuroHeart Failure Survey II (EHFS II): a survey on hospitalized acute heart failure patients: description of population. *Eur Heart J* 2006; **27**: 2725–2736.
33. Uretsky BAP. Cleland Ischemia as a 'trigger' for sudden death in patients with cardiomyopathy and heart failure secondary to coronary artery disease: results from the ATLAS trial. *Circulation* 1998; **98**: 1–199.
34. Ballew KA, Philbrick JT, Caven DE, Schorling JB. Predictors of survival following in-hospital cardiopulmonary resuscitation. *A moving target Arch Intern Med* 1994; **154**: 2426–2432.
35. Teerlink JR, Jalaluddin M, Anderson S, Kukin ML, Eichhorn EJ, Francis G, Packer M, Massie BM. Ambulatory ventricular arrhythmias in patients with heart failure do not specifically predict an increased risk of sudden death. *Circulation* 2000; **101**: 40–46.
36. Herlitz J, Aune S, Bang A, Fredriksson M, Thoren AB, Ekstrom L, Holmberg S. Very high survival among patients defibrillated at an early stage after in-hospital ventricular fibrillation on wards with and without monitoring facilities. *Resuscitation* 2005; **66**: 159–166.
37. George AL, Folk BP, Crecelius PL, Campbell WB. Pre-arrest morbidity and other correlates of survival after in-hospital cardiopulmonary arrest. *Am J Med* 1989; **87**: 28–34.
38. Roberts D, Landolfo K, Light RB, Dobson K. Early predictors of mortality for

hospitalized patients suffering cardiopulmonary arrest. *Chest* 1990; **97**: 413–419.

39. Hatala R, Lunati M, Calvi V, Favale S, Goncalvesová E, Haim M, Jovanovic V, Kaczmarek K, Kautzner J, Merkely B, Pokushalov E. Clinical implementation of cardiac resynchronization therapy—regional disparities across selected ESC member countries. *Ann Noninvasive Electrocardiol* 2015; **20**: 43–52.