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Development and Validation of R-hf Risk Score in Acute Heart Failure Patients in the Middle East

Rajesh Rajan[1]*, Mohammed Al Jarallah[1], Ibrahim Al-Zakwani[2,3], Raja Dashti[1], Kadhim Sulaiman[4,5], Prashanth Panduranga[4,5], Peter A Brady[6] and Zhanna Kobalava[7]

[1]Department of Cardiology, Sabah Al Ahmed Cardiac Centre, Kuwait City, Kuwait
[2]Department of Pharmacology and Clinical Pharmacy, College of Medicine and Health Sciences, Sultan Qaboos University, Muscat, Oman
[3]Oman and Gulf Health Research, Muscat, Oman
[4]Department of Cardiology, Royal Hospital, Muscat, Oman
[5]Director General of Specialized Medical Care, Ministry of Health, Muscat, Oman
[6]Department of Cardiology, Illinois Masonic Medical Center, Chicago IL, USA
[7]Department of Internal Diseases with Courses of Cardiology and Functional Diagnostics, Peoples` Friendship University of Russia, Moscow, Russia

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ABSTRACT

Objectives: The Rajan's heart failure (R-hf) score was proposed to aid risk stratification in heart failure patients. The aim of this study was to validate R-hf risk score in patients with acute decompensated heart failure. ***Methods***: R-hf risk score is derived from the product estimated glomerular filtration rate (mL/min), left ventricular ejection fraction (%), and hemoglobin levels (g/dL) divided by N-terminal pro-brain natriuretic peptide (pg/mL). This was a multinational, multicenter, prospective registry of heart failure from seven countries in the Middle East. Univariable and multivariable logistic regression was applied. ***Results:*** A total of 776 patients (mean age = 62.0±14.0 years, 62.4% males; mean left ventricular ejection fraction = 33.0±14.0%) were included. Of these, 459 (59.1%) presented with acute decompensated chronic heart failure. The R-hf risk score group (≤ 5) was marginally associated with a higher risk of all-cause cumulative mortality at three months (adjusted odds ratio (aOR) = 4.28; 95% CI: 0.90–20.30; p = 0.067) and significantly at 12 months (aOR = 3.84; 95% CI: 1.23–12.00; p = 0.021) when compared to those with the highest R score group (≥ 50). ***Conclusions:*** Lower R-hf risk scores are associated with increased risk of all-cause cumulative mortality at three and 12 months.

Heart failure (HF) is a major cause of increased cardiovascular mortality yet identification of most at-risk patients is challenging and HF management difficult.[1] Early identification and initiation of guideline-directed medical therapy improves the outcomes. Major adverse cardiovascular events associated with HF are significant, and are associated with an increased risk of death.[2] Several risk prediction tools are available for patients with HF, but many are not user-friendly and require entering multiple variables.[3–23] In contrast, the Rajan's heart failure (R-hf) score is a unique risk-predicting tool that only requires four factors to be entered and is user-friendly for predicting mortality risk in HF patients with reduced ejection fraction (HFrEF).[24–26]

METHODS

This study uses data collected as part of the Gulf CARE registry, a multinational, multicenter, prospective registry of HF[27] in patients aged ≥ 18 years with a diagnosis of acute heart failure (AHF) admitted between 14 February 2012 and 14 November 2012 to 47 hospitals (research sites) in seven Middle Eastern countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE, and Yemen) were recruited for the current study.[28] Demographic information, behavioral risk factors, comorbidities, medical history, clinical presentations, investigation results, and in-hospital outcomes were all included in the baseline data. Follow-up at three months and outpatient clinic visits at one year were used to determine all-cause mortality.

*Corresponding author: ✉cardiology08@gmail.com

All data collected were entered into the Gulf CARE website's custom-made electronic case record form (www.gulfcare.org). The study was approved by all relevant ethics committees or review boards from each of the seven participating hospitals. The study was registered at www.clinicaltrials.gov (NCT01467973).

The clinical data standards for the American College of Cardiology and the 2008 European Society of Cardiology procedures were used to generate the data variables in the case record form, while the European Society of Cardiology criteria were employed to define AHF.[29,30] Within one month of the index admission, khat chewing was stipulated as chewing khat plant/leaves (catha edulis containing cathinone, an amphetamine-like stimulant) can lead to hypertension, euphoria, dilated cardiomyopathy, and myocardial infarction.[31] Chronic kidney disease was defined as serum creatinine levels > 177 mmol/L (or 2 mg/dL) for three months or an estimated glomerular filtration rate (eGFR) of < 60 mL/min/1.73 m^2. Anemia was defined as hemoglobin (Hb) levels of 12 g/dL in women and 13 g/dL in men. The R-hf risk score was computed by multiplying eGFR (mL/min), left ventricular ejection fraction (%), and Hb levels (g/dL) by N-terminal pro-brain natriuretic peptide (NT-proBNP) (pg/mL). R-hf scores of < 5 were considered high risk, 5–10 were considered moderate risk, 11–50 were considered low risk, and R-hf values of > 50 were considered zero risk.[24,25]

Frequencies and percentages were used to present the categorical variables and mean and SD for continuous variables. Pearson's chi-square tests (or Fisher's exact tests for cells with expected values of < 5) were used to examine differences across R-hf score groups and ordinary least squares regression was used to analyze the data. To investigate the impact of R-hf risk score on all-cause mortality (primary outcome) at three-month and 12-month post-hospital discharge, we used three multivariable logistic regression models at the same time.

Age, gender, body mass index, smoking, khat chewing, peripheral vascular disease, hypertension, diabetes mellitus, prior stroke/transient ischemic attack, systolic blood pressure, and diastolic blood pressure were all factored into the model adjustments. The model adjustments also included coronary artery bypass graft procedure, in-hospital percutaneous coronary intervention, or in-hospital course (comprised of non-invasive ventilation, cardiogenic shock, intubation/ventilation, intra-aortic balloon pump, inotropes, atrial fibrillation requiring therapy, acute dialysis/ultrafiltration, blood transfusion, stroke, major bleeding, and systemic infection requiring therapy). Discharged drugs (diuretics, digoxin, clopidogrel, oral nitrates, beta-blockers, angiotensin-converting enzyme inhibitors, calcium channel blockers, aldosterone antagonists, aspirin, angiotensin II receptor blockers, ivabradine (I_f channel blocker)) are among the other changes to the model.

The Hosmer and Lemeshow goodness-of-fit metric was used to analyze the multivariable logistic model.[32] A Hosmer and Lemeshow statistic with a $p > 0.05$ was deemed a good fit based on the chi-square distribution. The area under the receiver operating characteristic curve, commonly known as the C-index, was used to evaluate the logistic model's discriminatory capacity.[33] The a priori two-tailed level of significance was set at $p < 0.05$. For statistical analysis, STATA was employed (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.).

RESULTS

A total of 5005 AHF patients from the Gulf CARE registry were screened. Seven hundred seventy-six (15.5%) patients were included after excluding 4229 (84.5%) patients with missing NT-proBNP levels. The baseline characteristics of the study cohort are shown in Table 1. The cohort had a mean age of 62.0±14.0 years, 62.4% were male and the mean left ventricular ejection fraction was 33.0±14.0%. Of these, 59.1% (n = 459) of patients presented with acute decompensated chronic heart failure. Hypertension (n = 579; 74.6%), coronary artery disease (n = 474; 61.1%), diabetes mellitus (n = 514; 66.2%), and hyperlipidemia (n = 336; 43.3%) were among the most common comorbid conditions [Table 1].

High (< 5), moderate (5–10), low (11–50), and minimal risk (> 50) patients accounted for 41.8% (n = 324), 16.4% (n = 127), 31.2% (n = 242), and 10.7% (n = 83), respectively. Patients with higher R-hf risk ratings had a higher rate of peripheral vascular disease (7.7% vs. 3.6%; $p = 0.021$), but were less likely to have in-hospital percutaneous coronary intervention/coronary artery bypass graft (5.6% vs.

Table 1: Demographic and clinical characteristics of the cohort stratified by Rajan's heart failure (R-hf) score among patients with acute heart failure.

Characteristics	All n (%) (n = 776)	R-hf score risk category, n (%)				*p*-value
		High (n = 324)	Moderate (n = 127)	Low (n = 242)	Minimal (n = 83)	
Demographic						
Age, mean ± SD, years	62.0 ± 14.0	63.0 ± 15.0	61.0 ± 15.0	62.0 ± 13.0	60.0 ± 14.0	0.284
Male gender	484 (62.4)	199 (61.4)	89 (70.1)	150 (62.0)	46 (55.4)	0.167
BMI, mean ± SD, kg/m^2	29.5 ± 7.3	28.6 ± 7.0	28.6 ± 7.6	30.3 ± 7.2	32.0 ± 7.5	< 0.001
Smoking	97 (12.5)	34 (10.2)	21 (16.5)	30 (12.4)	12 (14.5)	0.337
Khat	6 (0.8)	1 (0.3)	2 (1.6)	2 (0.8)	1 (1.2)	0.535
Alcohol	36 (4.6)	15 (4.6)	7 (5.5)	8 (3.3)	6 (7.2)	0.484
Medical history						
Dyslipidemia	336 (43.3)	135 (41.7)	55 (43.3)	105 (43.4)	41 (49.4)	0.657
CAD	474 (61.1)	201 (62.0)	83 (65.4)	143 (56.1)	47 (56.6)	0.533
Hypertension	579 (74.6)	240 (74.1)	93 (73.2)	177 (73.1)	69 (83.1)	0.304
Diabetes mellitus	514 (66.2)	219 (67.6)	74 (58.3)	160 (66.1)	61 (73.5)	0.120
PVD	38 (4.9)	25 (7.7)	4 (3.1)	6 (2.5)	3 (3.6)	0.021
Asthma/COPD	95 (12.2)	26 (8.0)	12 (9.4)	40 (16.5)	70 (84.3)	0.001
Stroke/TIA	68 (8.8)	35 (10.8)	9 (7.1)	2 (0.8)	4 (4.8)	0.281
AF	136 (17.5)	55 (17.0)	23 (18.1)	47 (19.4)	11 (13.0)	0.626
Clinical parameters at presentation						
HR, mean ± SD, bpm	76.0 ± 12.0	76.0 ± 14.0	76.0 ± 11.0	76.0 ± 11.0	73.0 ± 11.0	0.291
SBP, mean ± SD, mmHg	142.0 ± 43.0	141.0 ± 34.0	137.0 ± 32.0	141.0 ± 33.0	151.0 ± 39.0	0.380
DBP, mean ± SD, mmHg	80.0 ± 21.0	80.0 ± 20.0	81.0 ± 19.0	80.0 ± 21.0	82.0 ± 24.0	0.938
Crea, mean ± SD, µmol/L	136.0 ± 114.0	189.0 ± 154.0	108.0 ± 38.0	99.0 ± 44.0	80.0 ± 34.0	< 0.001
LVEF, mean ± SD, %	33.0 ± 14.0	30.0 ± 13.0	32.0 ± 13.0	36.0 ± 13.0	43.0 ± 12.0	< 0.001
eGFR, mean ± SD, mL/min/1.73m^2	64.0 ± 36.0	47.0 ± 27.0	69.0 ± 31.0	75.0 ± 34.0	96.0 ± 41.0	< 0.001
Hb, mean ± SD, g/dL	12.2 ± 2.2	11.6 ± 2.1	12.3 ± 2.0	12.7 ± 2.1	12.8 ± 2.2	< 0.001
NT-proBNP, median (IQR), pg/mL	3126 (1280–7058)	8125 (5129–15793)	3457 (2370–4217)	1441 (924–2157)	442 (248–638)	< 0.001
In-hospital course						
PCI/CABG	65 (8.4)	18 (5.6)	9 (7.1)	23 (9.5)	15 (18.1)	0.003
Treatment course*	301 (38.8)	134 (41.4)	54 (42.5)	87 (36.0)	26 (31.3)	0.220
Admission diagnosis						
De novo AHF	317 (40.9)	122 (37.7)	50 (39.4)	102 (42.1)	42 (50.6)	0.169
ADCHF	459 (59.1)	202 (62.3)	77 (60.6)	139 (57.4)	41 (49.4)	
NYHA at discharge**						0.769
I	408 (54.1)	159 (51.6)	65 (52.0)	133 (55.9)	51 (61.4)	
II	297 (39.4)	125 (40.6)	53 (42.4)	91 (38.2)	28 (33.7)	
III	44 (5.8)	21 (6.8)	7 (5.6)	13 (5.5)	3 (3.6)	
IV	5 (0.7)	3 (1.0)	0 (0.0)	1 (0.4)	1 (1.2)	

*BMI: body mass index; CAD: coronary artery disease; PVD: Peripheral vascular disease; COPD: chronic obstructive pulmonary disease; TIA: transient ischemic attack; AF: atrial fibrillation; HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; Crea: first serum creatinin; LVEF: left ventricular ejection fraction; eGFR: estimated glomerular filtration rate; Hb: hemoglobin; NT-proBNP: N-terminal pro-brain natriuretic peptide; IQR: interquartile range; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; AHF: acute heart failure; ADCHF: acute decompensated chronic heart failure; NYHA: New York Heart Association. *Treatment course, intubation/ventilation, cardiogenic shock, included non-invasive ventilation, intra-aortic balloon pump, inotropes, atrial fibrillation requiring therapy, acute dialysis/ultrafiltration, blood transfusion, major bleeding, systemic infection requiring therapy and stroke; HR was absent in 14 of the cases, whereas SBP and DBP were absent in 11. ** Those who died in hospitals were not included in the previous NYHA classification. Due to rounding, percentages may not add up to 100 %.*

R-hf scores of 5: high danger; 5–10: moderate risk; 11–50: medium risk; > 50: negligible risk.

Table 2: Medication utilization of the cohort stratified by Rajan's heart failure (R-hf) score among patients with acute heart failure.

Characteristics	All n (%) (n = 776)	R-hf score risk category, n (%)				*p*-value
		High (n = 324)	Moderate (n = 127)	Low (n = 242)	Minimal (n = 83)	
Prior medications						
Diuretics	480 (61.9)	208 (64.2)	83 (65.4)	146 (60.3)	43 (51.8)	0.158
Digoxin	93 (12.0)	38 (11.7)	19 (15.0)	32 (13.2)	4 (4.8)	0.114
Oral nitrates	207 (26.7)	94 (29.0)	39 (30.7)	59 (24.4)	15 (18.1)	0.124
CCBs	159 (20.4)	62 (19.1)	15 (11.8)	59 (24.4)	23 (27.7)	0.011
ACEIs	284 (36.6)	108 (33.3)	51 (40.2)	91 (37.6)	34 (41.0)	0.396
ARBs	165 (21.3)	54 (16.7)	34 (26.8)	61 (25.2)	16 (19.3)	0.032
Statins	466 (60.1)	197 (60.8)	81 (63.8)	136 (56.2)	52 (62.7)	0.468
Aspirin	486 (62.6)	198 (60.1)	80 (63.0)	153 (63.2)	55 (66.3)	0.842
Ivabradine	36 (4.6)	13 (4.0)	8 (6.3)	12 (5.0)	3 (3.6)	0.718
Beta-blockers	464 (59.8)	205 (63.3)	73 (57.5)	138 (57.0)	48 (57.8)	0.421
Aldosterone antagonists	150 (19.3)	58 (17.9)	31 (24.4)	48 (19.8)	13 (15.7)	0.350
IV medications during admission						
IV frusemide – bolus	718 (92.5)	293 (90.4)	120 (94.5)	228 (94.2)	77 (92.8)	0.288
IV frusemide – infusion	117 (15.1)	58 (17.9)	19 (15.0)	30 (12.4)	10 (12.0)	0.264
IV nitrates – infusion	171 (22.0)	73 (22.5)	23 (18.1)	49 (20.2)	26 (31.3)	0.122
Discharged medications (n = 735)*						
Diuretics	694 (94.4)	285 (94.4)	115 (95.8)	220 (94.8)	74 (91.4)	0.584
Digoxin	113 (15.4)	47 (15.6)	22 (18.3)	40 (17.2)	4 (4.9)	0.023
Oral nitrates	270 (36.7)	114 (37.7)	43 (35.8)	86 (37.1)	27 (33.3)	0.899
CCBs	173 (23.5)	75 (24.8)	19 (15.8)	58 (25.0)	21 (25.9)	0.189
ACEI	351 (47.8)	132 (43.7)	60 (50.0)	115 (50.0)	44 (54.3)	0.269
ARBs	174 (23.7)	46 (15.2)	39 (32.5)	72 (31.0)	17 (21.0)	< 0.001
Statins	574 (78.1)	227 (75.2)	98 (81.7)	186 (80.2)	65 (80.2)	0.462
Aspirin	576 (78.4)	240 (79.5)	91 (75.8)	181 (78.0)	64 (79.0)	0.871
Ivabradine	59 (8.0)	23 (7.6)	13 (10.8)	21 (9.1)	2 (2.5)	0.138
Beta-blockers	617 (83.9)	255 (84.4)	100 (83.3)	195 (84.1)	67 (82.7)	0.981
Aldosterone antagonists	266 (36.2)	110 (36.4)	46 (38.3)	86 (37.1)	24 (29.6)	0.608

CCBs: calcium channel blockers; ACEIs: angiotensin converting enzyme inhibitors; ARBs: angiotensin receptor blockers.
R-hf scores of 5 were considered high risk; 5–10: moderate risk; 10–50: low risk; and > 50: minimal risk.
**Those who were discharged alive from the hospital and did not leave against medical advice (n = 735) were only given medications at discharge.*
Due to rounding off, percentages may not add up to 100%.

18.1%; $p = 0.003$). The majority of patients received the usual HF treatment [Table 2]. Patients with higher R-hf risk scores were more likely to be on digoxin (15.6% vs. 4.9%; $p = 0.023$), but less likely to be on angiotensin II receptor blockers (15.2% vs. 21.0%; $p < 0.001$).

The rates of all-cause mortality were 44 (13.6%) in high risk, 12 (9.4%) in moderate risk, 13 (5.4%) in low risk, and two (2.4%) in minimum risk at three-month, and 71 (21.9%) in high risk, 20 (15.7%) in moderate risk, 24 (9.9%) in low risk, and four (4.8%) in minimum risk at one-year. When compared to those with scores of > 50, those with scores < 5 were marginally associated with a higher risk of all-cause mortality at three months (adjusted odds ratio = 4.28; 95% CI: 0.90–20.30; $p = 0.067$) and significantly at 12 months (adjusted odds ratio = 3.84; 95% CI: 1.23–12.00; $p = 0.021$) after adjusting for demographic and clinical characteristics as well as medication use in the multivariable logistic regression model [Table 3].

DISCUSSION

This study is the first to employ the R-hf risk score (a derivative of eGFR, ejection fraction (EF), Hb, and

Table 3: Impact of Rajan's heart failure (R-hf) scores on mortality.

Mortality	R-hf score risk categories				Overall *p*-value
	High (n = 324)	Moderate (n = 127)	Low (n = 242)	Minimal (n = 83)	
In-hospital*					
n (%)	16 (4.9)	2 (1.6)	4 (1.7)	0 (0.0)	0.030
Three-months					
n (%)	44 (13.6)	12 (9.4)	13 (5.4)	2 (2.4)	0.001
aOR (95% CI);*p*-value	4.28 (0.90–20.30); 0.067	2.13 (0.37–12.30); 0.397	0.93 (0.16–5.27); 0.936	Ref	0.008
Goodness of fit statistics					
HL *p*-value	0.606				
ROC	0.820				
12-months					
n (%)	71 (21.9)	20 (15.7)	24 (9.9)	4 (4.8)	< 0.001
aOR (95% CI); *p*-value	3.84 (1.23–12.00); 0.021	2.03 (0.56–7.40); 0.281	1.24 (0.36–4.25); 0.734	Ref	< 0.001
Goodness of fit statistics					
HL *p*-value	0.906				
ROC	0.800				

aOR: adjusted odds ratio; HL: Hosmer-Lemeshow; ROC: receiver operating characteristic.
**Due to the short sample size, a multivariable logistic model was not used for the in-hospital study. R-hf scores of 5: high risk; 5–10: moderate risk; 11–50: low risk; > 50: minimal risk.*

NT-proBNP) in AHF to estimate all-cause mortality at three months (marginally) and 12 months after discharge. Patients with the lowest scores had the worst prognosis when using this measure. Prior risk prediction models that did not incorporate EF or renal function in their risk score had a lower mean death rate than expected.[16,23,34–40] Our study showed that the R-hf risk score model was successful in predicting the prognosis and mortality of HFrEF patients. R-hf score < 5 was previously suggested to reflect a poor prognosis, which was confirmed by this study. Given our population, this score is exclusively applied to the Gulf CARE cohort, which is a largely Arab population. For physicians, the application and the calculator are available online and are easily accessible at https://www.hfriskcalc.in.[24–26]

In comparison to the R-hf risk score, other risk calculators have produced varying predictions when applied to various registries around the world. The Get With The Guidelines (GWTG)-HF risk score reasonably accurately predicts short-term in-hospital mortality, the Seattle Heart Failure Model and Meta-analysis Global Group in Chronic (MAGGIC) Heart Failure risk score have demonstrated utility for estimating long-term death one-to-two years after discharge.[3] In terms of identifying relevant variables that potentially predict mortality, all the previously published HF risk scores had their advantages and disadvantages. Pro-BNP-guided HF treatment has a significant impact on HF patients' prognosis.[41] The R-hf risk score is simple, effective, and different from other existing HF risk scores since it includes the major variables implicated in HF pathophysiology, such as Hb, EF, eGFR, and pro-BNP.

The number of factors that must be entered into existing HF risk score calculators is a major disadvantage. The Seattle Heart Failure Model, for example, requires approximately 20 variables, whereas the MAGGIC score requires 13 and the GWTG-HF risk score contains seven variables.[3] In contrast, the GWTG-HF risk score contains three variables but is also effective at predicting in-hospital and post-discharge mortality in HF patients.[4] The majority of HF risk score calculators share four variables (age, blood pressure, renal function, and serum sodium) that they believe to be significant predictors of adverse outcomes.[42] The majority of risk score models are more accurate than pre-hospitalization rates in predicting mortality.[7] The R-hf score, like the GWTG score, predicts post-discharge mortality. The R-hf score can help identify high-risk patients and improve compliance, potentially lowering the rate of HF re-hospitalizations.

When compared to the MAGGIC score, eGFR was used instead of creatinine, with fewer variables needed in the R-hf risk score. The R-hf risk score

was developed from a relatively small cohort from the Arabian Gulf Care registry of AHF patients when compared to the Seattle Heart Failure Model. Nevertheless, the advantage of the R-hf risk score is that it only includes four variables and yet outperforms more complicated models.[43]

The HF-ACTION predictive risk score model, like the R-hf risk score, is one of the risk scores that predicts mortality in HFrEF patients.[9] The variables chosen in this case were also not user-friendly. It focused mostly on ambulatory HF patients, whereas our score was applied to AHF patients. They used blood urea nitrogen (BUN) as a potent variable, whereas we used eGFR, which is more accurate than BUN or creatinine alone in predicting outcomes.[43–47]

There are also important differences between the R-hf risk score and other published scores.[26] The ESCAPE risk model and discharge score also selected ambulatory HF patients and excluded those patients who had baseline characteristics, which predicts worse outcomes.[11] The R-hf risk score, by contrast, includes all patients who had AHF. Moreover, the development cohort for the CORONA prognostic risk model had older patients averaging 72 years, whilst other risk models had a lower age. Scores from the Seattle and CHARM models did not incorporate NT pro-BNP, which has been shown to improve risk stratification.[12] Lee et al,[17] clinical model for predicting mortality did not incorporate EF in the variables utilized for risk prediction. Moreover, BUN was the renal variable while eGFR was used in the R-hf risk score. Previous studies have reported more accurate risk prediction using eGFR.[44–48]

The major strength of this study is the inclusion of HF patients from seven countries based in the Middle East. Moreover, the current dataset was built from a registry, which could lead to bias as potential confounders such as iron levels and history of chronic anemia were not available for incorporation into the multivariable models. The impact of the R-hf score was only examined in AHF patients from the Middle Eastern nations. Multi-modality machine learning approach for risk stratification in HF is emerging,[49] and further studies are needed to examine whether this score has similar predictive values for cohorts with other ethnicities. Finally, only HFrEF patients are eligible for this score and needs to be validated for other HF subtypes, such as HF with midrange, preserved, or recovered ejection fraction.[50–53]

The results of the current study may not be completely generalizable since just a few hospitals in various countries participated in the registry. This study was also unable to determine reasons for the underuse of drugs or procedures. The measurement of natriuretic peptides was optional because they are not routinely measured in all countries. There was no centralized evaluation of echocardiographic interpretation; it was left to the discretion of the person performing the investigation. The renal function of patients at discharge is unclear, and there are no statistics on the number of patients who improve their renal function.

This study did not record the cognitive and disability status of stroke patients, which has a statistically significant impact on mortality and morbidity. Because mortality rates at follow-up were only gathered at three-month and one-year intervals without the particular date of death of each patient, Kaplan–Meier curves could not be produced. Future research must address these limitations.

CONCLUSION

In AHF patients, the R-hf risk score is accurate and useful in predicting three- and 12-month mortality. Further investigation is needed to substantiate these findings and to determine the impact of the R-hf score on HF treatment strategies and outcomes. It may be best to apply the score to cohorts from diverse geographical areas for good validation.

Disclosure

The authors declared no conflicts of interest. No funding was received for this study.

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REFERENCES

1. Schaufelberger M, Swedberg K, Köster M, Rosén M, Rosengren A. Decreasing one-year mortality and hospitalization rates for heart failure in Sweden; Data from the Swedish Hospital Discharge Registry 1988 to 2000. Eur Heart J 2004 Feb;25(4):300-307.
2. O'Connor CM, Stough WG, Gallup DS, Hasselblad V, Gheorghiade M. Demographics, clinical characteristics, and outcomes of patients hospitalized for decompensated heart failure: observations from the IMPACT-HF registry. J Card Fail 2005 Apr;11(3):200-205.
3. Sawano M, Shiraishi Y, Kohsaka S, Nagai T, Goda A,

Mizuno A, et al. Performance of the MAGGIC heart failure risk score and its modification with the addition of discharge natriuretic peptides. ESC Heart Fail 2018 Aug;5(4):610-619.

4. Win S, Hussain I, Hebl VB, Dunlay SM, Redfield MM. Inpatient mortality risk scores and postdischarge events in hospitalized heart failure patients: a community-based study. Circ Heart Fail 2017 Jul;10(7):e003926.
5. Berezin AE, Kremzer AA, Martovitskaya YV, Berezina TA, Samura TA. The utility of biomarker risk prediction score in patients with chronic heart failure. Clin Hypertens 2016 Mar;22(1):3.
6. Ouwerkerk W, Voors AA, Zwinderman AH. Factors influencing the predictive power of models for predicting mortality and/or heart failure hospitalization in patients with heart failure. JACC Heart Fail 2014 Oct;2(5):429-436.
7. Rahimi K, Bennett D, Conrad N, Williams TM, Basu J, Dwight J, et al. Risk prediction in patients with heart failure: a systematic review and analysis. JACC Heart Fail 2014 Oct;2(5):440-446.
8. Pocock SJ, Ariti CA, McMurray JJ, Maggioni A, Køber L, Squire IB, et al; Meta-Analysis Global Group in Chronic Heart Failure. Predicting survival in heart failure: a risk score based on 39 372 patients from 30 studies. Eur Heart J 2013 May;34(19):1404-1413.
9. O'Connor CM, Whellan DJ, Wojdyla D, Leifer E, Clare RM, Ellis SJ, et al. Factors related to morbidity and mortality in patients with chronic heart failure with systolic dysfunction: the HF-ACTION predictive risk score model. Circ Heart Fail 2012 Jan;5(1):63-71.
10. Senni M, Parrella P, De Maria R, Cottini C, Böhm M, Ponikowski P, et al. Predicting heart failure outcome from cardiac and comorbid conditions: the 3C-HF score. Int J Cardiol 2013 Feb;163(2):206-211.
11. O'Connor CM, Hasselblad V, Mehta RH, Tasissa G, Califf RM, Fiuzat M, et al. Triage after hospitalization with advanced heart failure: the ESCAPE (evaluation study of congestive heart failure and pulmonary artery catheterization effectiveness) risk model and discharge score. J Am Coll Cardiol 2010 Mar;55(9):872-878.
12. Wedel H, McMurray JJ, Lindberg M, Wikstrand J, Cleland JG, Cornel JH, et al; CORONA Study Group. Predictors of fatal and non-fatal outcomes in the controlled rosuvastatin multinational trial in heart failure (CORONA): incremental value of apolipoprotein A-1, high-sensitivity C-reactive peptide and N-terminal pro B-type natriuretic peptide. Eur J Heart Fail 2009 Mar;11(3):281-291.
13. O'Connor CM, Abraham WT, Albert NM, Clare R, Gattis Stough W, Gheorghiade M, et al. Predictors of mortality after discharge in patients hospitalized with heart failure: an analysis from the organized program to initiate lifesaving treatment in hospitalized patients with heart failure (OPTIMIZE-HF). Am Heart J 2008 Oct;156(4):662-673.
14. Pocock SJ, Wang D, Pfeffer MA, Yusuf S, McMurray JJ, Swedberg KB, et al. Predictors of mortality and morbidity in patients with chronic heart failure. Eur Heart J 2006 Jan;27(1):65-75.
15. Levy WC, Mozaffarian D, Linker DT, Sutradhar SC, Anker SD, Cropp AB, et al. The Seattle heart failure model: prediction of survival in heart failure. Circulation 2006 Mar;113(11):1424-1433.
16. Brophy JM, Dagenais GR, McSherry F, Williford W, Yusuf S. A multivariate model for predicting mortality in patients with heart failure and systolic dysfunction. Am J Med 2004 Mar;116(5):300-304.
17. Lee DS, Austin PC, Rouleau JL, Liu PP, Naimark D, Tu JV. Predicting mortality among patients hospitalized for heart failure: derivation and validation of a clinical model. JAMA 2003 Nov;290(19):2581-2587.
18. Varadarajan P, Pai RG. Prognosis of congestive heart failure in patients with normal versus reduced ejection fractions: results from a cohort of 2,258 hospitalized patients. J Card Fail 2003 Apr;9(2):107-112.
19. Bouvy ML, Heerdink ER, Leufkens HG, Hoes AW. Predicting mortality in patients with heart failure: a pragmatic approach. Heart 2003 Jun;89(6):605-609.
20. Kearney MT, Nolan J, Lee AJ, Brooksby PW, Prescott R, Shah AM, et al. A prognostic index to predict long-term mortality in patients with mild to moderate chronic heart failure stabilised on angiotensin converting enzyme inhibitors. Eur J Heart Fail 2003 Aug;5(4):489-497.
21. O'Connor CM, Gattis WA, Shaw L, Cuffe MS, Califf RM. Clinical characteristics and long-term outcomes of patients with heart failure and preserved systolic function. Am J Cardiol 2000 Oct;86(8):863-867.
22. Aaronson KD, Schwartz JS, Chen TM, Wong KL, Goin JE, Mancini DM. Development and prospective validation of a clinical index to predict survival in ambulatory patients referred for cardiac transplant evaluation. Circulation 1997 Jun;95(12):2660-2667.
23. Gradman A, Deedwania P, Cody R, Massie B, Packer M, Pitt B, et al; Captopril-Digoxin Study Group. Predictors of total mortality and sudden death in mild to moderate heart failure. J Am Coll Cardiol 1989 Sep;14(3):564-570, discussion 571-572.
24. Rajan R, Al Jarallah M. Prognostic risk calculator for heart failure. Oman Med J 2018 May;33(3):266-267.
25. Rajan R, Al Jarallah M, Al Zakwani I, Dashti R, Bulbanat B, Ridha M, et al. Impact of R-hf risk score on all-cause mortality in acute heart failure patients in the Middle East. J Card Fail 2019;25(8):S97.
26. Rajan R, Soman SO, Al Jarallah M, Kobalava Z, Dashti R, Al Zakwani I, et al. Validation of R-hf risk score for risk stratification in ischemic heart failure patients: a prospective cohort study. Annals of Medicine and Surgery 2022;80:104333.
27. Sulaiman KJ, Panduranga P, Al-Zakwani I, Alsheikh-Ali A, Al-Habib K, Al-Suwaidi J, et al. Rationale, design, methodology and hospital characteristics of the first Gulf acute heart failure registry (Gulf CARE). Heart Views 2014 Jan;15(1):6-12.
28. Al-Jarallah M, Rajan R, Al-Zakwani I, Dashti R, Bulbanat B, Sulaiman K, et al. Incidence and impact of cardiorenal anaemia syndrome on all-cause mortality in acute heart failure patients stratified by left ventricular ejection fraction in the Middle East. ESC Heart Fail 2019 Feb;6(1):103-110.
29. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats AJ, et al; Authors/Task Force Members; Document Reviewers. 2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure: the task force for the diagnosis and treatment of acute and chronic heart failure of the European society of cardiology (ESC). Developed with the special contribution of the heart failure association (HFA) of the ESC. Eur J Heart Fail 2016 Aug;18(8):891-975.
30. Radford MJ, Arnold JM, Bennett SJ, Cinquegrani MP, Cleland JG, Havranek EP, et al; American College of Cardiology; American Heart Association Task Force on Clinical Data Standards; American College of Chest Physicians; International Society for Heart and Lung Transplantation; Heart Failure Society of America. ACC/AHA key data elements and definitions for measuring the clinical management and outcomes of patients with chronic heart failure: a report of the American College of Cardiology/American heart association task force on clinical data standards (writing committee to develop heart failure clinical data standards): developed in collaboration with the American College of Chest Physicians and the International Society for Heart and Lung Transplantation: endorsed by the heart failure society of America. Circulation 2005 Sep;112(12):1888-1916.
31. Wabe NT. Chemistry, pharmacology, and toxicology of khat (catha edulis forsk): a review. Addict Health 2011;3(3-4):137-149.

32. Lemeshow S, Hosmer Jr DW. A review of goodness of fit statistics for use in the development of logistic regression models. Am J Epidemiol 1982;115(1):92-106.
33. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 1982 Apr;143(1):29-36.
34. Gottlieb SS, Abraham W, Butler J, Forman DE, Loh E, Massie BM, et al. The prognostic importance of different definitions of worsening renal function in congestive heart failure. J Card Fail 2002 Jun;8(3):136-141.
35. Kearney MT, Fox KA, Lee AJ, Prescott RJ, Shah AM, Batin PD, et al. Predicting death due to progressive heart failure in patients with mild-to-moderate chronic heart failure. J Am Coll Cardiol 2002 Nov;40(10):1801-1808.
36. Smith GL, Vaccarino V, Kosiborod M, Lichtman JH, Cheng S, Watnick SG, et al. Worsening renal function: what is a clinically meaningful change in creatinine during hospitalization with heart failure? J Card Fail 2003 Feb;9(1):13-25.
37. Anand I, McMurray JJ, Whitmore J, Warren M, Pham A, McCamish MA, et al. Anemia and its relationship to clinical outcome in heart failure. Circulation 2004 Jul;110(2):149-154.
38. Bibbins-Domingo K, Gupta R, Na B, Wu AH, Schiller NB, Whooley MA. N-terminal fragment of the prohormone brain-type natriuretic peptide (NT-proBNP), cardiovascular events, and mortality in patients with stable coronary heart disease. JAMA 2007 Jan;297(2):169-176.
39. Meta-analysis Global Group in Chronic Heart Failure (MAGGIC). The survival of patients with heart failure with preserved or reduced left ventricular ejection fraction: an individual patient data meta-analysis. Eur Heart J 2012 Jul;33(14):1750-1757.
40. Omland T, Sabatine MS, Jablonski KA, Rice MM, Hsia J, Wergeland R, et al; PEACE Investigators. Prognostic value of B-Type natriuretic peptides in patients with stable coronary artery disease: the PEACE trial. J Am Coll Cardiol 2007 Jul;50(3):205-214.
41. Troughton RW, Frampton CM, Brunner-La Rocca HP, Pfisterer M, Eurlings LW, Erntell H, et al. Effect of B-type natriuretic peptide-guided treatment of chronic heart failure on total mortality and hospitalization: an individual patient meta-analysis. Eur Heart J 2014 Jun;35(23):1559-1567.
42. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE Jr, Drazner MH, et al; American College of Cardiology Foundation; American Heart Association Task Force on Practice Guidelines. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American heart association task force on practice guidelines. J Am Coll Cardiol 2013 Oct;62(16):e147-e239.
43. Pfister R, Diedrichs H, Schiedermair A, Rosenkranz S, Hellmich M, Erdmann E, et al. Prognostic impact of NT-proBNP and renal function in comparison to contemporary multi-marker risk scores in heart failure patients. Eur J Heart Fail 2008 Mar;10(3):315-320.
44. Krumholz HM, Chen YT, Vaccarino V, Wang Y, Radford MJ, Bradford WD, et al. Correlates and impact on outcomes of worsening renal function in patients > or =65 years of age with heart failure. Am J Cardiol 2000 May;85(9):1110-1113.
45. Cowie MR, Komajda M, Murray-Thomas T, Underwood J, Ticho B; POSH Investigators. Prevalence and impact of worsening renal function in patients hospitalized with decompensated heart failure: results of the prospective outcomes study in heart failure (POSH). Eur Heart J 2006 May;27(10):1216-1222.
46. Klein L, Massie BM, Leimberger JD, O'Connor CM, Piña IL, Adams KF Jr, et al; OPTIME-CHF Investigators. Admission or changes in renal function during hospitalization for worsening heart failure predict postdischarge survival: results from the outcomes of a prospective trial of intravenous milrinone for exacerbations of chronic heart failure (OPTIME-CHF). Circ Heart Fail 2008 May;1(1):25-33.
47. Felker GM, Leimberger JD, Califf RM, Cuffe MS, Massie BM, Adams KF Jr, et al. Risk stratification after hospitalization for decompensated heart failure. J Card Fail 2004 Dec;10(6):460-466.
48. Yancy CW, Lopatin M, Stevenson LW, De Marco T, Fonarow GC; ADHERE Scientific Advisory Committee and Investigators. Clinical presentation, management, and in-hospital outcomes of patients admitted with acute decompensated heart failure with preserved systolic function: a report from the acute decompensated heart failure national registry (ADHERE) database. J Am Coll Cardiol 2006 Jan;47(1):76-84.
49. Tse G, Zhou J, Woo SW, Ko CH, Lai RW, Liu T, et al. Multi-modality machine learning approach for risk stratification in heart failure with left ventricular ejection fraction ≤ 45. ESC Heart Fail 2020 Dec;7(6):3716-3725.
50. Zhang X, Sun Y, Zhang Y, Chen F, Dai M, Si J, et al. Characteristics and outcomes of heart failure with recovered left ventricular ejection fraction. ESC Heart Fail 2021 Dec;8(6):5383-5391.
51. Sun Y, Wang N, Li X, Zhang Y, Yang J, Tse G, et al. Predictive value of H_2 FPEF score in patients with heart failure with preserved ejection fraction. ESC Heart Fail 2021 Apr;8(2):1244-1252.
52. Lakhani I, Leung KS, Tse G, Lee AP. Novel mechanisms in heart failure with preserved, midrange, and reduced ejection fraction. Front Physiol 2019 Jul;10:874.
53. Ju C, Zhou J, Lee S, Tan MS, Liu T, Bazoukis G, et al. Derivation of an electronic frailty index for predicting short-term mortality in heart failure: a machine learning approach. ESC Heart Fail 2021 Aug;8(4):2837-2845.