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The Effect of Echocardiographic Findings on the Predictive Accuracy of SHFM and MAGGIC

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ABSTRACT

Background and Objective: Heart failure is a common and serious disease associated with high mortality and morbidity. Accurate risk stratification is essential for clinical management and prognostic assessment. The aim of this study is to investigate the effect of echocardiographic findings on the predictive accuracy of the Seattle Heart Failure Model (SHFM) and the Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC) risk score in determining one-year prognosis in patients with heart failure.

Methods: This prospective cohort study was conducted on 175 patients with chronic heart failure admitted to Rohani Hospital in Babol from July 2021. The required patient data were collected using a questionnaire. Patients who had the necessary information for calculating the MAGGIC and SHFM risk scores were included in the study and were followed up by telephone one year after their initial visit.

Findings: Among the 175 patients studied, 160 survived the one-year follow-up period, while 15 died. The MAGGIC risk score (AUC=0.93) predicted one-year survival with greater accuracy than the SHFM risk score (AUC=0.89). With respect to right ventricular size, among the 15 patients who died during follow-up, 12 (80%) did not have a dilated right ventricle, while the remaining 3 (20%) had moderate right ventricular dilatation (p=0.026). Among the 15 patients who died, 5 (33.3%) had a normal inferior vena cava diameter, whereas 10 (66.7%) had inferior vena cava dilatation (p=0.007). No significant association was observed between right ventricular function and patient survival.

Conclusion: The findings of this study indicate that dilatation of the right ventricle and the inferior vena cava are significantly correlated with patient survival. Additionally, while both the SHFM and MAGGIC risk scores demonstrated good predictive capacity for one-year mortality, the MAGGIC model exhibited superior prognostic performance.

Keywords: *Heart Failure, Risk Factor, Echocardiography, Prognosis.*

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Introduction

Heart failure (HF) is a common and serious disease that affects millions of people worldwide. This condition is associated with high morbidity and mortality, and accurate risk stratification is required to guide clinical management and prognostic assessment (1). Several models have been developed to predict the risk of adverse outcomes, such as death or hospitalization, in patients with HF (2). The Seattle Heart Failure Model (SHFM) and the Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC) are among the most widely used models. These tools employ various variables and methodologies to estimate the risk in patients with HF across different ejection fraction (EF) ranges. However, limited evidence exists regarding how these models compare with each other and their performance in predicting one-year prognosis in HF patients (3).

The SHFM was developed in 2006 based on data from 10,701 patients with heart failure with reduced ejection fraction (HFrEF) who were enrolled in 12 clinical trials. This model estimates survival probability at one, two, and three years for patients with HFrEF (2). The SHFM has been validated in several cohorts of HFrEF patients and has demonstrated good discrimination and calibration (4). However, the SHFM has certain limitations, including the need for complex calculations, derivation from clinical trial populations that may not reflect real-world practice, and limited applicability to patients with heart failure with preserved ejection fraction (HFpEF) or mid-range ejection fraction (HFmrEF) (5).

The MAGGIC model was developed in 2011 based on data from 39,372 patients with heart failure enrolled in 30 cohort studies. This model includes 13 variables encompassing demographics, clinical characteristics, laboratory values, and medications. It estimates three-year survival probability in patients with HF across the full spectrum of ejection fraction. The MAGGIC model has been validated in multiple HF cohorts and has demonstrated good discrimination and calibration. The MAGGIC model offers several advantages over the SHFM, including simpler calculation, derivation from a broader and more diverse population, and applicability to patients with HFpEF or HFmrEF (6). However, the MAGGIC model has limitations, such as the absence of therapeutic interventions, lower accuracy for short-term outcomes (e.g., one-year), and reduced sensitivity to changes in clinical status over time (7).

Comparing these two models in predicting one-year outcomes in HF patients is an essential issue for both research and clinical practice. Several studies have compared these two models across different populations and settings, but the results have been inconsistent and inconclusive (8-10). Therefore, further evidence is needed regarding how these two models perform in predicting one-year outcomes in HF patients and how they might be better utilized or integrated for risk stratification. In this study, the characteristics, strengths, and main limitations of the two models are compared, and the available evidence regarding their comparative performance and applicability in predicting one-year outcomes in HF patients is reviewed.

Methods

The present investigation was designed as a prospective cohort study and was formally approved by the Research Ethics Committee of Babol University of Medical Sciences, under the code IR.MUBABOL.HRI.REC.1400.191. The study was conducted on a cohort of 175 patients who had been diagnosed with heart failure and were admitted to the Cardiovascular Clinic of Rohani Hospital in Babol. Patients were considered eligible for inclusion if they met the following criteria: age 18 years or older, a confirmed diagnosis of heart failure with either reduced EF or preserved EF, availability for scheduled follow-up assessments, and completeness of all clinical and laboratory data required for the calculation of both the SHFM and MAGGIC risk scores. All eligible patients provided written informed consent prior to

their enrollment in the study. Conversely, patients were excluded from the analysis if they lacked any of the individual components necessary for the calculation of the SHFM or MAGGIC scores, if death occurred due to causes other than heart failure, or were not accessible for follow-up. Demographic characteristics, comorbid conditions, heart failure pharmacotherapy, laboratory parameters, and cardiac device utilization were extracted from patients' electronic medical records at the baseline visit to facilitate calculation of the SHFM and MAGGIC risk scores.

Following hospital discharge, patients were regularly assessed by a cardiologist at the heart clinic of Rohani Hospital in accordance with their clinical requirements. All patients were followed for a period of 12 months post-discharge, and survival status was ascertained through comprehensive review of hospital records, heart clinic documentation, and official death certificates. In instances where records were incomplete or unavailable, supplementary information was obtained via structured telephone interviews with the patient or their next of kin.

We used the online tools of the SHFM and MAGGIC models (https://depts.washington.edu/shfm and heartfailurerisk.org) to calculate the predicted one-year mortality scores. Statistical analyses were performed using SPSS version 26. The correlation between SHFM and MAGGIC scores was assessed using Pearson's correlation coefficient. Predictive performance, including sensitivity and specificity, was evaluated using receiver operating characteristic (ROC) curve analysis and Cox proportional hazards regression. Associations between echocardiographic parameters (right ventricular size, right ventricular function, and inferior vena cava diameter) and mortality were examined using the Chi-square test or Fisher's exact test. Differences in continuous variables between surviving and deceased patients were compared using the independent samples t-test. A p-value<0.05 was considered statistically significant.

Results

The study cohort comprised 175 patients with heart failure aged over 18 years, with a mean age of 60.59±14.73 years. Female patients accounted for 55.4% of the cohort. Ischemic heart disease was present in 71.4% of patients. Baseline pharmacotherapy included angiotensin-converting enzyme inhibitors in 17.7%, angiotensin receptor blockers in 57.1%, beta-blockers in 88%, statins in 54.9%, and potassium-sparing diuretics in 69.7%. Over a one-year follow-up period, 15 patients (8.57%) died (Table 1).

Prognostic analysis based on the SHFM and MAGGIC risk scores: The mean predicted survival probability for patients who survived the one-year follow-up (n=160) was 90.39±8.30%, while the mean predicted survival probability for those who died during follow-up was 72.04±15.47%. The mean difference between the two groups was 18.35% (p<0.001). Thus, a statistically significant difference was observed in the prediction of survival probability based on the SHFM risk score. The mean predicted survival probabilities for surviving and deceased patients at one-year follow-up were 85.93±9.70% and 64.51±8.86%, respectively. Using the independent t-test, the mean difference between the two groups was 21.41% (p<0.001). Therefore, the one-year survival predicted by the MAGGIC risk score was also statistically significant.

At the end of the one-year follow-up, 15 of the 175 patients had died, while 160 remained alive, yielding an actual survival rate of 91.4%. The mean predicted survival rate by the MAGGIC risk score was 84.09%, indicating that the MAGGIC score underestimated patient survival. The mean predicted survival rate by the SHFM was 88.82%, which, although closer to the actual survival rate, still slightly underestimated patient survival. The ROC curve was used to compare the sensitivity and specificity of the MAGGIC and SHFM risk scores. The MAGGIC risk score (AUC=0.93, 95% CI: 0.91-0.97) predicted one-year survival with greater accuracy than the SHFM (AUC= 0.89, 95% CI: 0.79-0.92) (Figure 1).

Table 1. Baseline demographic and clinical characteristics of heart failure patients stratified by one-year follow-up outcome status

Variable	All Patients (n=175) Mean±SD or n(%)	Alive (n=160) Mean±SD or n(%)	Deceased (n=15) Mean±SD or n(%)	p-value
Age (years)	60.59±14.73	59.53±1.14	71.93±13.68	0.002
Gender				
Male	78(44.6)	70(89.7)	8 (10.3)	0.475
Height (cm)	168.19±9.36	168.06±9.45	169.67±8.60	0.526
Weight (kg)	77.38±13.64	77.81±13.90	72.87±9.77	0.181
BMI (kg/m²)	27.54±5.37	27.74±5.47	25.42±3.78	0.109
Current smoker	17(9.7)	17(100)	0(0)	0.184
Systolic BP (mmHg)	120.21±21.51	120.75±21.72	114.40±18.70	0.276
Ischemic etiology	125(71.4)	114(71.3)	11(73.3)	0.864
Ejection fraction (%)	31.34±13.55	31.97±13.63	24.67±10.93	0.046
NYHA class				
I	32(18.3)	32(20)	0(0)	0.001
II	47(26.9)	46(28.7)	1(6.7)	
III	51(29.1)	47(29.4)	4(26.7)	
IV	45(25.7)	35(21.9)	10(66.7)	
History of IHD	73(41.7)	68(42.5)	5(33.3)	0.491
History of COPD	16(9.1)	15(9.4)	1(6.7)	0.728
History of diabetes	73(41.7)	68(42.5)	5(33.3)	0.491
Serum sodium (mmol/L)	136.39±4.24	136.36±4.25	136.80±4.19	0.700
Total cholesterol (mmol/L)	144.91±31.19	146.65±31.21	142.67±23.64	0.019
Uric acid (mmol/L)	6.90±2.06	6.80±1.90	8.07±3.32	0.041
Creatinine (µmol/L)	1.48±0.91	1.43±0.91	1.98±0.73	0.270
Beta-blocker use	154(88)	142(90.6)	9(60)	<0.001
ACEI use	31(17.7)	28(17.5)	3(20)	0.808
ARB use	100(57.1)	94(58.8)	6(40)	0.161
Daily furosemide	128(73.1)	115(71.9)	13(86.7)	0.507
Allopurinol	26(14.9)	24(15)	29(13.3)	0.862
Statin	96(54.9)	89(55.6)	7(46.7)	0.505
Cardiac devices	149(58.10)	138(86.30)	11(73.3)	0.482
ICD*	18(10.3)	15(9.4)	3(20)	
BiV Pacer*	6(3.4)	5(3.1)	1(6.7)	
BiV ICD*	2(1.1)	2(1.3)	0(0)	
MAGGIC score	87.80 (77.30-93.70)	87.80 (80.90-93.70)	63.10 (57.30-80.70)	<0.001
SHFM score	91.60 (85.50-95.90)	92.60 (87.25-96.17)	74.90 (66.90-83.90)	<0.001

***ICD= Implantable Cardioverter-Defibrillator; BiV Pacer= Biventricular Pacemaker; BiV ICD= Biventricular Implantable Cardioverter-Defibrillator.**

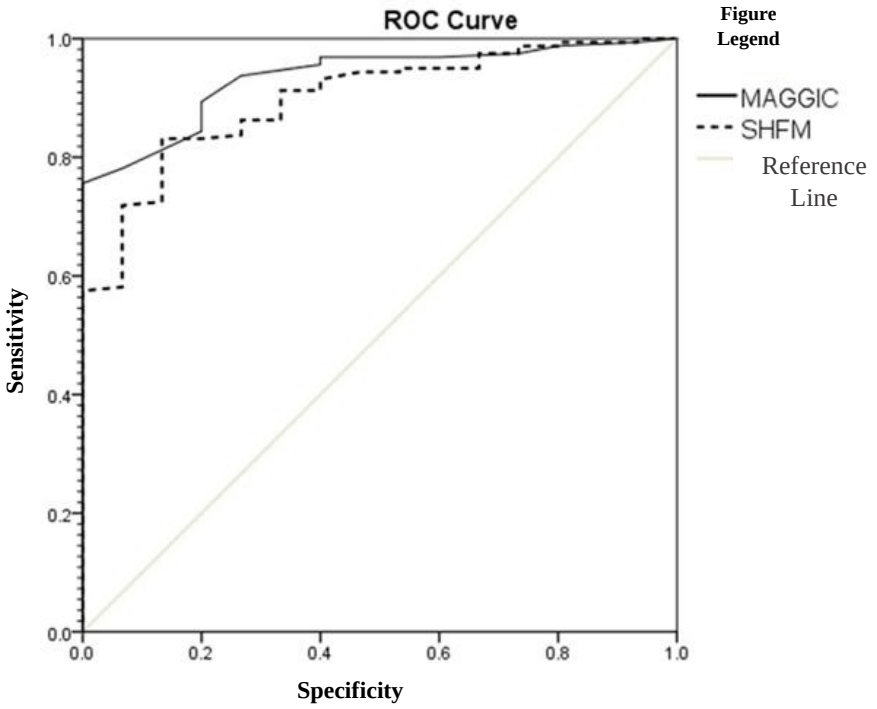

Figure 1. ROC curve for SHFM and MAGGIC risk scores

In the analysis of survival according to right ventricular function among the 15 patients who died, 7 patients (46.7%) had normal right ventricular function, 3 patients (20%) had mild right ventricular dysfunction, and 5 patients (33.3%) had moderate right ventricular dysfunction. None of the deceased patients had severe right ventricular dysfunction. The Chi-square test was used to compare survival across right ventricular function categories, yielding a p-value of 0.579; therefore, no significant association was observed between right ventricular function and patient survival (Table 2).

Table 2. Frequency distribution of patients according to right ventricular function, inferior vena cava diameter, and right ventricular size

Variable	Deceased Patients		Alive Patients		Total	
	n(%)	Percentage by survival status	n(%)	Percentage by survival status	n(%)	Percentage by survival status
Right Ventricular Function						
Normal	7(8.5)	46.7%	75(91.5)	46.9%	82(100)	46.9%
Mild dysfunction	3(5.6)	20%	51(94.4)	31.9%	54(100)	30.9%
Moderate dysfunction	5(13.5)	33.3%	32(86.5)	20%	37(100)	21.1%
Severe dysfunction	0(0)	0%	2(100)	1.3%	2(100)	1.1%
Inferior Vena Cava Diameter						
Normal	5(4.4)	33.3%	109(95.6)	68.1%	114(100)	65.1%
Dilated	10(16.4)	66.7%	51(83.6)	31.9%	61(100)	34.9%
Right Ventricular Size						
Normal	12(8.4)	80%	131(91.6)	81.9%	143(100)	81.7%
Mild dilatation	0(0)	0%	22(100)	13.8%	22(100)	12.6%
Moderate dilatation	3(30)	20%	7(70)	4.4%	10(100)	5.7%

Similarly, patient survival was compared according to inferior vena cava (IVC) diameter. Among the 15 patients who died, 5 (33.3%) had a normal IVC diameter, while 10 (66.7%) had IVC dilatation. The Chi-square test was used to compare patient survival based on IVC diameter, yielding a p-value of 0.007 (Table 2).

Finally, patient survival was also compared according to right ventricular size. Among the 15 patients who died during the one-year follow-up, 12 (80%) had no right ventricular dilatation, while the remaining 3 (20%) had moderate right ventricular dilatation. None of the deceased patients had mild or severe right ventricular dilatation. Fisher's exact test was used to analyze the association between survival and right ventricular size, yielding a p-value of 0.026 (Table 2).

Cox regression analysis interprets the adjusted hazard ratio (AHR) as a fraction of one. For the SHFM, the AHR was calculated as 0.914 (95% CI: 0.886-0.924), indicating that for each one-unit increase in the SHFM risk score, mortality increased by 8.6%, which was statistically significant ($p<0.001$). For the MAGGIC risk score, the AHR was calculated as 0.887 (95% CI: 0.846-0.930), indicating that for each one-unit increase in the MAGGIC risk score, mortality increased by 11.3%, which was also statistically significant ($p<0.001$).

Discussion

This study demonstrated that while both risk score models were able to predict one-year survival in patients, the MAGGIC risk score performed better and with greater accuracy than the SHFM risk score. Several studies conducted in recent years have reported similar findings (11-13). This convergence of results supports the validity and reliability of our study.

Cheng et al. conducted a similar study and found that the SHFM risk score was more accurate than the MAGGIC risk score (8). It is important to note that more than half of the patients in that study received an ICD—a device to which the SHFM assigns a high score, whereas such devices are not incorporated into the MAGGIC risk score model.

Furthermore, in this study, it was observed that the mean predicted survival by the MAGGIC risk score was closer to the actual survival of patients compared to the SHFM risk score. This finding contrasts with the study by Vishram-Nielsen et al. (11), who found that the predicted survival rate by the SHFM was closer to the actual patient survival. As previously noted, this discrepancy may be attributable to the fact that the SHFM generally estimates higher survival probabilities for patients who use cardiac devices or are treated with an appropriate medication regimen, compared to the MAGGIC risk score.

An additional observation in our study was that the MAGGIC risk score systematically underestimated the mean survival of patients, a finding consistent with the results reported by Michaels et al. (7). We also observed that the SHFM underestimated survival in our study population; however, in contrast to our findings, Canepa et al. reported that the SHFM overestimated patient survival (13). Given that the SHFM assigns considerable prognostic weight to cardiac devices, this discrepancy may be attributable to a substantially higher proportion of patients with implantable cardiac devices in their study population compared to our study population.

Our interpretation of these findings is that the SHFM's limitations may stem from its disproportionate emphasis on cardiac device therapy and certain laboratory parameters. While there may be indications for implantation of cardiac devices such as ICDs based on clinical judgment and outside established guidelines for some patients with these conditions, laboratory findings with high scores—such as lymphocyte percentage and cholesterol—have limited prognostic value and credibility in clinical practice and guidelines, yet they receive high weighting in the SHFM risk score. At the same time, the SHFM considers

the patient's medication history, such as furosemide dosage, as an important parameter, which is one of its strengths. One of the strengths of the MAGGIC risk score is that it takes into account comorbidities and the duration since the onset of heart failure in the patient. On the other hand, the failure to consider diuretic use may be considered a weakness of this risk score.

Our study demonstrated that right ventricular size and inferior vena cava diameter were significantly associated with patient survival. A study conducted on 223 patients with heart failure compared various echocardiographic parameters with patient survival based on the SHFM and concluded that left ventricular end-systolic volume, left ventricular stroke volume, left atrial diameter, right ventricular systolic and diastolic areas, E-wave velocity, and E/A ratio were significantly associated with patient survival (12). Nevertheless, studies on the addition of echocardiographic findings to heart failure risk scores are very limited.

In some studies, the utility of combining NT-proBNP with MAGGIC, or combining certain scales such as HFSS-apelin and MAGGIC-apelin, has been reported (14, 15). Of course, the use of echocardiography has always facilitated appropriate treatment with favorable outcomes in these patients (16, 17).

Ultimately, in this study, although both the SHFM and MAGGIC risk scores were able to predict survival probability in heart failure patients, the MAGGIC model demonstrated better performance than the SHFM.

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