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HEART score, an optimal tool for predicting cardiovascular events in chest pain patients in emergency department: a prospective single-center study

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Abstract: **Objective:** Chest pain is a prevalent and potentially life-threatening presentation in emergency departments, necessitating prompt and precise risk stratification to identify patients at high risk, particularly those with acute coronary syndrome (ACS). This study evaluates the predictive accuracy of the HEART score in stratifying short-term major adverse cardiac events (MACE) risk among chest pain patients in Bandar Abbas, aiming to enhance clinical decision-making and resource utilization in emergency departments.

Method: This prospective observational study was conducted on patients presenting with chest pain at Shahid Mohammadi Hospital's emergency department. Patients aged ≥18 years with chest pain were included, while those with STEMI or incomplete records were excluded. The HEART score was used for risk stratification, and patients were classified into low, moderate, or high-risk groups. The primary outcome was MACE within six weeks, confirmed via follow-up calls. Data analysis included logistic regression and ROC curve analysis.

Result: A total of 1,501 individuals participated in the study, with a mean age of 48.99±14.71 years. Among the participants, 28.6% were diagnosed with MACE. The most common risk factors for MACE included a history of coronary artery disease (79.1%) and hypertension (77.2%). Based on the HEART score, patients were categorized into low-risk (≤ 3), moderate-risk (4-6), and high-risk (≥ 7) groups. The majority of non-MACE patients were classified as low-risk (78.3%), while 65.6% of MACE patients fell into the moderate-risk category. The mean HEART score was significantly higher in the MACE group (5.73±1.68) compared to the non-MACE group (2.31± 1.54). The optimal HEART score cutoff for predicting MACE was determined to be 3.5, with the ROC curve demonstrating strong predictive performance (AUC=0.932).

Conclusion: The HEART score is a reliable tool for risk stratification in chest pain patients in the emergency department. Our study shows that a score of ≤ 3.5 indicates low risk, while higher scores predict a greater likelihood of MACE. The HEART score effectively guides clinical decisions, highlighting its high sensitivity and specificity for identifying low- and high-risk patients, making it an essential tool for patient management in emergency settings.

Keywords: HEART Score; Major Adverse Cardiac Events; Predictive Values

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1. Introduction

Chest pain is one of the most common and potentially life-threatening clinical complaints among adults presenting to emergency departments (EDs). Its management constitutes a significant challenge in emergency medicine. Rapid and accurate risk stratification is essential for managing acute patients, particularly in identifying individuals at high risk of immediate complications, such as those with acute coronary syndrome (1). Acute coronary syndrome (ACS) arises from an abrupt reduction in coronary blood flow, resulting in myocardial ischemia and, if untreated, progression to infarction (2).

The diagnosis of ACS requires a combination of clinical history, physical examination, and laboratory findings, none of which are sufficient independently (3). This diagnostic complexity leads to the erroneous discharge of more than 2% of ACS patients annually (4). Consequently, emergency physicians often subject chest pain patients, even those at low risk, to invasive testing. This approach, while intended to mitigate risk, sometimes results in the overuse of resources and increased healthcare costs without significant improvement in patient outcomes (5). According to the guidelines of the American College of Cardiology (ACC) and the American Heart Association (AHA), ACS patients should be categorized into low-, intermediate, and high-risk groups to facilitate appropriate treatment strategies. High-risk patients require immediate antiplatelet therapy, statins, and prompt reperfu-

sion interventions. For intermediate- and low-risk patients, in addition to suitable pharmacological treatments, close monitoring of electrocardiograms (ECG), cardiac biomarkers, and symptom changes is critical. Stress testing and/or cardiac imaging following discharge from the ED is also recommended for these patients (6).

Over time, clinicians have developed various tools to predict the risk of major adverse cardiac events (MACE), a composite outcome typically including cardiovascular death, myocardial infarction, and the need for urgent revascularization, in patients presenting with chest pain, aiming to prevent critical complications (7). One such novel predictive model is the HEART (history, ECG, age, risk factors, troponin) score, developed through specialized studies and literature reviews (8). This scoring system was specifically designed to simultaneously identify low-risk patients and those at high likelihood for MACE. Given the necessity of evaluating the validity and accuracy of the HEART score across diverse populations and adapting it as needed, the present prospective study focuses on assessing its predictive value in short-term MACE risk stratification. This investigation aims to assist clinicians in Bandar Abbas in making evidence-based decisions regarding chest pain management.

2. Methods

2.1. Study design

This study was designed to evaluate the diagnostic accuracy of the HEART score clinical scoring system in predicting the six-week outcomes of patients presenting to the emergency department of Shahid Mohammadi Hospital in Bandar Abbas, Iran, with chest pain as their chief complaint. This prospective observational study was conducted over a one-year period, throughout 2022, during which data collection and patient registration were performed. The study was approved by the ethics committee of Hormozgan University of Medical Sciences, and the re-searchers adhered to the principles of Helsinki Declaration and patient data confidentiality throughout the study. A written informed consent was obtained from all the patients for participating in the study.

2.2. Participants

All the patients with chest pain, were included in the study. A census sampling approach was employed. The inclusion criteria encompassed patients aged ≥18 years. Exclusion criteria included patients diagnosed with ST-elevation myocardial infarction (STEMI), those with incomplete medical records, and individuals who were not reachable for follow-up within six weeks post-discharge.

2.3. Data collection

Chest pain characteristics were documented using a predesigned checklist based on patient history. Pain was categorized into three groups: typical, atypical, and non-diagnostic. Typical chest pain, described as retrosternal or precordial discomfort characterized by pressure, heaviness, or tightness, with possible radiation to the left shoulder, neck, or jaw. The pain could occur intermittently or persistently, at rest or during exertion. Atypical chest pain, defined as pain occurring in locations other than those described above or radiating to atypical sites. Non-diagnostic pain, applied to cases where the pain exhibited only atypical characteristics.

Patients with features of both typical and atypical chest pain were categorized as "moderately suspicious," while those with exclusively typical characteristics were placed in the "highly suspicious" category (9).

Electrocardiographic (ECG) findings were evaluated based on the initial ECG ordered by the attending physician. Troponin levels were interpreted according to laboratory standards and reference ranges. The five components of the HEART score (history, ECG, age, risk factors, and troponin) were combined to determine a final score. Patients were stratified into three distinct risk groups based on their HEART score: those with scores ranging from 0 to 3 were classified as low risk, scores between 4 and 6 as moderate risk, and scores of 7 or higher as high risk (10).

The primary outcome was the occurrence of MACE within six weeks, defined as all-cause mortality, non-fatal myocardial infarction (MI), or coronary revascularization. Follow-up was conducted via telephone calls to gather information on the occurrence of MACE. When necessary, additional confirmation of MI or coronary interventions was obtained during follow-up.

2.4. Statistical analysis

Statistical analyses were conducted using SPSS software, version 23. Descriptive statistics, including frequencies, percentages, and means, were reported to present the findings. Chi-squared test and independent t-test were applied for group comparisons. The diagnostic accuracy of the HEART score for predicting 6-week MACE was evaluated using the area under the receiver operating characteristic (ROC) curve. The optimal cut-off point was identified based on the highest combined sensitivity and specificity. Screening performance metrics of the HEART score at this cut-off were calculated and reported with 95% confidence intervals (CI). A significance level of 0.05 was considered.

3. Result

3.1. Participants

The outcomes of ED chest pain visits, for a total of 1501 included patients, are presented in figure 1. A total of 1,501 patients with a mean age of 48.99±14.71 years were included in the study. Table 1 shows the baseline characteristic of the patients. The most common risk factors in the MACE group were a history of coronary artery disease (79.1%) and hypertension (77.2%).

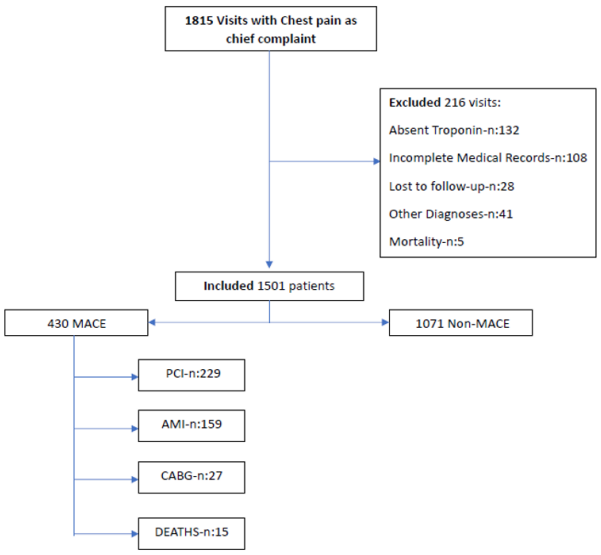

Figure 1 Patients flow chart

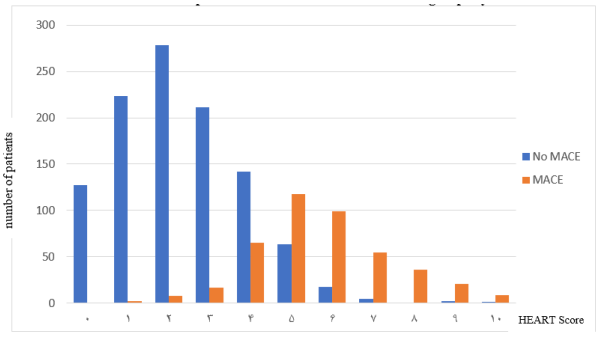

Figure 2 The distribution of patients in the MACE and non-MACE groups by HEART score

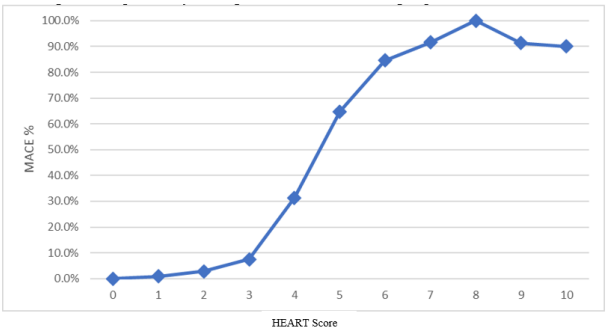

Figure 3 The probability of being classified into the MACE group based on the HEART score

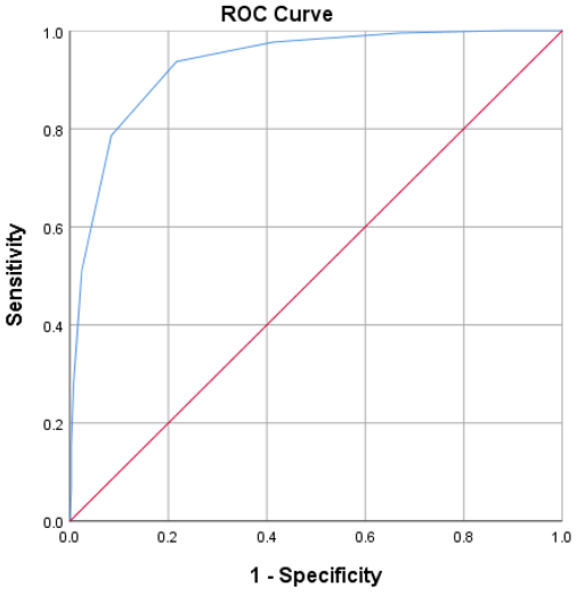

Figure 4 ROC Curve for HEART score in predicting the occurrence of MACE

3.2. Test results

The receiver operating characteristic (ROC) curve for the HEART score in predicting the occurrence of MACE is presented in figure 4. According to the ROC curve and the area under the curve (AUC), the HEART score demonstrates strong predictive performance in identifying patients at high risk of MACE. The AUC value of 0.932, with a 95% confidence interval ranging from 0.918 to 0.945, supports the utility of this score as an effective tool for evaluating and predicting MACE risk in patients.

According to the ROC curve and each of the cutoff points, the optimal cutoff point was determined to be 3.5. This table shows the performance indicators of the HEART score based on the best cutoff point derived from the ROC curve in patients presenting with chest pain to the emergency department of Shahid Mohammadi Hospital.

The predictive and classification performance metrics of the HEART score for two risk groups, low-risk (HEART score≤3) and high-risk (HEART score≥7) are presented in table 3. Considering the optimal cutoff point determined by the ROC curve was 3.5, the performance metrics for the low-risk and high-risk groups align with the values reported in table 3.

4. Discussion

The HEART score is a simple and reliable tool for risk stratification in patients with chest pain, commonly used in emergency departments (11). This score facilitates diagnostic and therapeutic decision-making by predicting patient outcomes and is recognized as a fast and efficient method for evaluating and triaging patients in emergency settings (10). Moreover, it helps prevent unnecessary hospitalizations and costly, time-consuming diagnostic procedures in low-risk patients (12).

this study aimed to evaluate the risk stratification of chest pain patients using the HEART score and the occurrence of MACE. The mean age of participants was 48.99±14.71 years. A higher percentage of patients in the MACE group were aged 45-65 (53%) and 65 or older (31.2% vs. 9% in the non-MACE group). The MACE group had a significantly higher mean age (58.57±13.47 years) compared to the non-MACE group (45.14±13.38 years), confirming that older age is a significant risk factor for cardiovascular events.

The most prevalent risk factors in the MACE group were a history of coronary artery disease and hypertension, both of

Table 1 Clinical characteristics of patients complaining of chest pain

Variable		Non-MACE N:1071	MACE (%) N:430	Total (%)	P-value
Age	< 45	608 (56.8)	68 (15.8)	676 (45)	< 0.001
	45 - 65	367 (34.2)	228 (53)	595 (39.6)	
	≥ 65	96 (9)	134 (31.2)	230 (15.4)	
Gender	Male	565 (52.8)	199 (46.3)	764 (50.9)	0.023
	Female	506 (47.2)	231 (53.7)	737 (49.1)	
Chest pain	Slightly suspicious	365 (34.1)	27 (6.3)	392 (26.1)	< 0.001
	Moderately suspicious	469 (43.8)	173 (40.2)	642 (42.8)	
	Highly suspicious	237 (22.1)	230 (53.5)	467 (31.1)	
Risk factors	No risk factor	449 (41.9)	3 (0.7)	452 (30.1)	< 0.001
	One or two	479 (44.7)	98 (22.8)	577 (38.4)	
	Three or more	143 (13.4)	329 (76.5)	472 (31.4)	
Underlying disease	Diabetes mellitus	173 (16.2)	159 (37)	332 (22.1)	< 0.001
	Hypertension	300 (28)	332 (77.2)	632 (42.1)	< 0.001
	Hyperlipidemia	216 (20.2)	238 (55.3)	454 (30.2)	< 0.001
	Smoking	112 (10.5)	74 (17.2)	186 (12.4)	< 0.001
	Family history of CAD	75 (7)	61 (14.2)	136 (9.1)	< 0.001
	Obesity	8 (0.7)	6 (1.4)	14 (0.9)	0.237
	History of CAD	181 (16.9)	340 (79.1)	521 (34.7)	< 0.001
	History of stroke	37 (3.5)	40 (9.3)	77 (5.1)	< 0.001
	No underlying disease	449 (41.9)	3 (0.7)	452 (30.1)	< 0.001
ECG	Normal	966 (90.2)	148 (34.4)	1114(74.2)	<0.001
	Non-specific repolarization disturbance	80 (7.5)	180 (41.9)	260 (17.3)	
	Significant ST deviation	25 (2.3)	102 (23.7)	127 (8.5)	
Troponin	< normal limit	1033 (96.5)	307 (71.4)	1340(89.3)	<0.001
	normal limit × 1-3	24 (2.2)	67 (15.6)	91 (6.1)	
	≥ normal limit × 3	14 (1.3)	56 (13)	70 (4.7)	
HEART Score	Low risk	839 (78.3)	27 (6.3)	866 (57.7)	<0.001
	Moderate risk	224 (20.9)	282 (65.6)	506 (33.7)	
	High risk	8 (0.7)	121 (28.1)	129 (8.6)	
Disposition Status	Discharge	929 (86.7)	185 (43)	1114(74.2)	<0.001
	Admission to the ward	31 (2.9)	83 (19.3)	114 (7.6)	
	Admission to the ICU	7 (0.7)	25 (5.8)	32 (2.1)	
	Discharge (AMA)	104 (9.7)	137 (31.9)	241 (16.1)	

CAD: Coronary artery disease; ICU: Intensive care unit; AMA: Against medical advice; ECG: Electrocardiography; MACE: Major adverse cardiac event

Table 2 Optimal cut-off point derived from the ROC curve

Index	Value	Standard Error	CL (%)	
			Lower bound	Upper bound
Sensitivity	93.72	1.17	91.43	96.01
Specificity	78.34	1.26	75.87	80.81
PPV	63.46	1.91	59.72	67.21
NPV	96.88	0.59	95.72	98.04
PLR	4.327	0.092	2.855	6.558
NLR	0.080	0.092	0.053	0.121

PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio

Table 3 Performance metrics of the HEART score

Index		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	PLR	NLR
HEART score < 3							
Value		93.72	78.34	63.46	96.88	4.33	0.08
CI (95%)	Lower	91.43	75.87	59.72	95.72	2.85	0.8
	Upper	96.01	80.81	67.21	98.04	6.56	0.12
HEART score ≥ 7							
Value		28.14	99.25	93.80	77.48	37.67	0.72
CI (95%)	Lower	23.89	98.74	89.64	75.27	18.22	0.35
	Upper	32.39	99.77	97.96	79.69	77.91	1.50

CI: Confidence interval; PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio

which are well-known contributors to the development of cardiovascular events. Given the higher prevalence of risk factors and the significant association between these factors and MACE, it is crucial for clinicians to tailor their approach based on individual patient profiles. Comprehensive risk assessment, including demographic and clinical factors, can aid in identifying patients at higher risk of MACE and guide clinical decision-making, including the need for further diagnostic workup, hospitalization, or intensive care.

Based on the findings of the present study the mean HEART score of MACE group was significantly higher that others and the incidence of MACE in high-risk patients was significantly higher. While only 3% of patients in the low-risk group were categorized as MACE. This finding is consistent with the results of several similar studies, where the incidence of MACE in low-risk patients was reported to be less than 5%. For example, in the study by Backus et al.(13), the incidence of MACE in low-risk patients was 1.7% (18). Additionally, in the study by Mahler et al.(14), the incidence was reported to be less than 1% (35), and in the study by Nathalie et al.(15), the incidence of MACE in low-risk patients was 2.5% . In contrast, the study by Alimohammadi et al. reported an incidence of MACE of 6.8% in the low-risk group (11). The larger sample size in our study likely accounts for the difference in results.

Chest pain is one of the most common complaints that leads many patients to seek care in the emergency department. Therefore, the management and accurate risk assessment of these patients are of paramount importance. The results of the present study indicated that the majority of patients presenting with chest pain, were classified into the low-risk group. This finding is consistent with the results of studies by Melki et al. (16) and Qorai et al. (17), where most patients were categorized into the low-risk group as well. In contrast, the studies by Six et al. and Alimohammadi et al. reported that a higher proportion of patients were classified into the moderate-risk group (11,18). Chest pain can have various causes, and it is our duty to assess all patients presenting with this symptom. The easy and affordable access to healthcare services in Bandar Abbas likely leads to a higher volume of patient visits, which may account for the observed difference in results.

In our study, the most common outcome among patients in the MACE group was the performance of percutaneous cardiac intervention (PCI), which is consistent with the findings of the study by Backus and Alimohammadi (11,18).

The analysis of the ROC curve and evaluation of cutoff points in this study revealed that the optimal cutoff point for the HEART score was 3.5, demonstrating a sensitivity of 93.72% with a 95% confidence interval. The cutoff point of 3.5 in this study demonstrated higher sensitivity and a more precise confidence interval compared to previous studies (11, 19), suggesting that it may provide improved predictive accuracy for identifying patients at risk for MACE.

In the low-risk group (HEART score ≤ 3.5), the high sensitivity (93.7%) indicates that this score can effectively identify most patients with MACE. Therefore, these patients typically do not require extensive interventions. On the other hand, in the high-risk group (HEART score ≥ 7), the very high specificity (99.25%) demonstrates that this score accurately identifies patients who are likely to experience MACE. Overall, based on our findings, the HEART score should be considered the primary tool for risk stratification and decision-making regarding the discharge of low-risk patients. The AHA/ACC guidelines recommend the use of risk classification scores to assist clinical decision-making. In this context, tools such as the TIMI and GRACE scores have been proposed. However, these two scores were not specifically designed for stratifying chest pain risk in the emergency department and are more commonly used for prognostication of hospitalized patients with ACS. Previous studies have shown that some components of the TIMI score, including age, ECG changes, and troponin, are also present in the HEART score. Therefore, following initial risk assessment, clinicians should use the HEART score as the primary tool for final MACE prediction in patients with chest pain. These findings have important implications for clinical guidelines and policy (20).

When evaluating patients with chest pain, the primary objective for emergency physicians is to accurately diagnose clinically significant coronary ischemia. However, as numerous studies have indicated, there is currently no universally accepted, objective criterion for the diagnosis of coronary ischemia that can be easily applied in clinical practice. Consequently, MACE are commonly used as a reference standard to assess the patient's clinical status. In other words, MACE serves as a practical method for defining and diagnosing clinically significant coronary ischemia, based on the occurrence of adverse outcomes or the need for critical intervention (21).

In our study, patients were evaluated in the emergency department rather than in specialized cardiology units. As a result, the prevalence of ACS and the proportion of at-risk patients in this study were consistent with findings from previous research. However, assessing patients in specialized units, such as cardiac intensive care units, could potentially lead to a lower negative predictive value and a higher positive predictive value. This suggests that the results observed in these specialized units may differ from those seen in a general emergency department setting (22,23).

In contrast, our study, conducted in a general emergency department, demonstrated a significantly higher negative predictive value in the low-risk group. This indicates that patients with a HEART score of less than 3.5 are less likely to experience MACE. Similarly, a higher HEART score in the high-risk group was associated with a greater positive predictive value, suggesting that patients with a higher score are more likely to experience MACE.

These findings highlight the importance of evaluating patients in a general emergency department setting, which, in contrast to specialized units, may provide more accurate and actionable predictions for diagnosing cardiovascular dis-

eases. This is particularly beneficial for identifying both low- and high-risk patients.

5. Limitations

One of the limitations of this study is the reliance on patient medical records for outcome extraction, which may result in the omission of details. To mitigate this risk, we endeavored to obtain more precise information by directly contacting the patients. Furthermore, due to study constraints, a number of patients were excluded.

6. Conclusion

The HEART score is a reliable and practical tool for risk stratification of chest pain patients in the emergency department. Our study confirms its ability to predict MACE, with a HEART score ≤ 3.5 indicating low risk and a higher score associated with increased likelihood of MACE. The findings support the use of the HEART score in guiding clinical decisions, such as patient discharge or further intervention, and emphasize its high sensitivity and specificity in identifying low- and high-risk patients. Overall, the HEART score is an essential tool for efficient and accurate patient management in emergency settings.

7. Declarations

7.1. Acknowledgement

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7.2. Authors' contribution

Study concept and design: LJ, SH; analysis and interpretation of data: SH, ZA; drafting of the manuscript: ZA, RY, SAT; critical revision of the manuscript for important intellectual content: SH, LJ.

7.3. Conflict of interest

The authors declare that they have no competing interests.

7.4. Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

7.5. Ethical considerations

This present study was approved by the institutional review board (IRB) of Hormozgan University of Medical Sciences under the ethics code: IR.HUMS.REC.1401.161.

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