ORIGINAL RESEARCH

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Comparison of GRACE, HEART and TIMI Scores in Predicting Major Adverse Cardiac Events in Patients Visiting the Emergency Department

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Abstract

Objective: Age, Risk factors, and Troponin (HEART), Thrombolysis in Myocardial Infarction (TIMI), and Score, and Global Registry of Acute Coronary (GRACE) Scores are critical for identifying patients at risk for major adverse cardiac events (MACE), guiding timely interventions, and optimizing resource utilization. This study aimed to evaluate the comparative utility of these three scoring systems in predicting MACE in patients visiting the emergency department (ED).

Materials and Methods: This prospective observational study included 502 adult patients visiting the ED with chest pain of a tertiary hospital between December 2014 and March 2015. HEART Score, TIMI, GRACE Score were evaluated for MACE over a 14-day and six-week, period. Data collected included demographic characteristics, clinical findings, laboratory results, and outcomes such as myocardial infarction, coronary angiography, revascularization, and mortality. Statistical significance was set at $p<0.05$.

Results: At 14-day follow-up, the HEART Score identified 192 patients as "low risk", of which 2.5% missed MACE. The GRACE Score identified 276 patients as "low risk", of which 10.5% missed MACE. The TIMI Score identified 288 patients as "low risk", of which 12.8% missed MACE. The area under the curve (AUC) for HEART Score, TIMI Score, and GRACE Score for 14-day MACE was calculated as 0.767, 0.678, and 0.674. In addition, the AUC for HEART Score, TIMI Score, and GRACE Score for MACE at 6-week follow-up was calculated as 0.700, 0.649 and 0.704.

Conclusion: The HEART Score demonstrates higher prognostic value for predicting MACE within 14 days than the TIMI and GRACE Scores in patients visiting the ED with chest pain. The TIMI Score has lower prognostic value for predicting MACE over a 6-week period compared to the HEART and GRACE Scores.

Keywords: TIMI Score, GRACE Score, HEART Score, chest pain, emergency department

Introduction

Chest pain is one of the most common major complaints in emergency departments (EDs) worldwide, representing a significant proportion of patient presentations. Rapid and accurate risk stratification of patients presenting with chest pain is crucial to identifying individuals at high risk for adverse cardiac events, such as myocardial infarction (MI), and guiding timely and appropriate management strategies. However, the heterogeneous etiologies and clinical presentations of chest pain pose a major challenge for emergency physicians (1).

ED visits have been increasing each year (2). In an overcrowded ED, the risk stratification of patients presenting with complaints such as chest pain is of critical importance for both ED management and patient care. To facilitate risk stratification, various clinical decision-making tools have been developed (3-5). Among these, the history, electrocardiography (ECG), Age, Risk factors, and Troponin (HEART)

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Score, the Thrombolysis in MI (TIMI) Score, and Global Registry of Acute Coronary Events (GRACE) Score have emerged as prominent and widely used tools (4). Each scoring system incorporates different clinical, laboratory, and historical parameters to estimate the likelihood of adverse cardiac outcomes (4,5). Despite their widespread use, consensus on the comparative utility and predictive accuracy of these scoring systems in the ED setting remains elusive. The HEART Score is specifically designed for rapid evaluation in the ED and provides a streamlined approach to categorizing patients into low, intermediate, and high-risk groups (6). The TIMI Score, originally designed for patients with unstable angina and non-ST-elevation MI (STEMI), offers a validated tool to assess risk over a 14-day period (7). In contrast, the GRACE Score provides hospital-based risk assessment for predicting adverse outcomes, including in-hospital mortality (8).

Given the differing methodologies and clinical contexts in which these scoring systems are applied, their comparative performance in the ED warrants rigorous investigation (9-11). This study aims to evaluate the effectiveness of the HEART, TIMI, and GRACE Scores in predicting major adverse cardiac events (MACE) in patients presenting with chest pain in the ED.

Materials and Methods

This prospective observational study was conducted in the ED of University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital from December 1, 2014, to March 1, 2015, following Ethical Approval (decision number: 2014/16/06, date: 24.11.2014). Adults aged 18 years and older presenting with chest pain were included in the study.

Study Implementation

A total of 502 patients visiting the ED with chest pain between December 1, 2014, and March 1, 2015, were included in the study. The HEART Score, TIMI Score, and GRACE Score were evaluated for MACE over 14-day and 6-week periods. MACE was defined as in-hospital mortality, new or recurrent MI, and ischemia requiring revascularization during this timeframe. Collected data included demographic characteristics (age, gender, and medical history), vital signs (heart rate, blood pressure, respiratory rate, body temperature, and oxygen saturation), imaging results (e.g., chest X-rays, CT scans), laboratory findings (e.g., hemoglobin, hematocrit, troponin levels), and outcomes such as coronary angiography, MI, bypass surgery, and mortality.

Inclusion Criteria

Patients aged 18 years and older who visited the ED with chest pain and provided informed consent were included in the study.

Exclusion Criteria

The following exclusion criteria were applied:

- Patients under 18 years of age.
- Chest pain secondary to trauma.
- Patients identified with STEMI during the initial evaluation.
- Patients with non-cardiac causes of chest pain (e.g., costochondritis, pulmonary embolism, pericarditis) during initial evaluation.
- Conditions such as sepsis, altered mental status, acute cerebrovascular disease, tachyarrhythmias, or cardiac arrest.
- Patients who refused to participate or did not present with chest pain.

Data Collection

Patients were initially assessed in the triage area under physician supervision by trained nurses or emergency medical technicians. Vital signs and 12-lead ECGs were recorded within the first 10 minutes after presentation. Detailed histories, physical examinations, and treatment plans were documented by emergency physicians. Clinical decision-making tools were blinded during treatment to avoid bias. Calculation of Risk Scores

- HEART Score: Calculated based on clinical history, ECG findings, risk factors, age, and initial troponin levels. Scores range from 0 to 10 and are categorized into low, intermediate, and high-risk groups (6).
- TIMI Score: Evaluated using seven variables, including age ≥65 years, known coronary artery disease, recent aspirin use, severe angina, elevated biomarkers, ST deviation, and risk factors for coronary artery disease (7).
- The GRACE Score: Uses eight variables, including age, heart rate, systolic blood pressure, creatinine levels, Killip class, ST deviation, cardiac biomarkers, and cardiac arrest at presentation. Scores were divided into low, intermediate, and high-risk groups (8).

Statistical Analysis

The data used in this study were analyzed using SPSS 21.0 for Windows® statistical software package (IBM Inc., Chicago, IL, USA). Descriptive statistics were presented as median (minimum-maximum) values, mean ± standard deviation for continuous variables, and frequencies and percentages for categorical variables. The normality of the distribution of continuous variables was assessed using the Kolmogorov-Smirnov test, followed by the application of parametric or non-parametric tests as appropriate. For comparisons between groups, the t-test was used when normality was met, while the Mann-Whitney U test was applied for non-normally distributed data. Within-group comparisons were performed using the Wilcoxon signed-rank test. For categorical variables, the Pearson chi-square test and Fisher's exact test were employed. A p-value of <0.05 was considered statistically significant.

Results

A total of 62,486 patients visited the ED between December 1, 2014 and March 1, 2015. Of these, 2,125 patients (3.4%) visited with complaints of chest pain. A total of 502 patients who met the inclusion criteria were included in the study. The study population comprised 227 women (45.2%) and 275 men (54.8%). Patient ages ranged from 18 to 92 years, with a mean age of 56.57±17.97 years. Age distribution revealed that 131 patients (26.1%) were younger than 45 years, 202 patients (40.2%) were between 45 and 65 years, and 169 patients (33.7%) were older than 65 years.

The mean vital signs at presentation were within normal ranges: systolic blood pressure 136±27 mmHg (range: 74-230), heart rate 89±25 bpm (range: 35-130), oxygen saturation 96±4.4% (range: 62-100), respiratory rate 17±4/min (range: 12-30), and body temperature 36.8±0.3°C (range: 36.0-39.7).

The most common coronary artery disease risk factors were male gender (54.8%), hypertension (44.8%), and smoking (41%). Additionally, a family history of coronary artery disease was identified in 185 patients (36.9%). The distribution of risk factors is shown in Figure 1.

HEART Risk Score Evaluation: Among the 502 patients, 197 (39.2%) were classified as low risk, 180 (35.9%) as intermediate risk, and 125 (24.9%) as high risk according to the HEART Score (Table 1). MACE was observed in 92 patients (18.1%) within 14 days. When patients were stratified according to the HEART Score, the incidence of MACE within 14 days was 2.5% (n=5) in the low-risk group, 23.9% (n=43) in the intermediate-risk group, and 34.4% (n=43) in the high-risk group (p<0.001) (Table 1).

Over a six-week follow-up, MACE occurred in 18.3% of low-risk, 38.3% of intermediate-risk, and 59.2% of high-risk patients (Table 2). Mortality rates were 1.01%, 2.22%, and 8% in the low-, intermediate-, and high-risk groups, respectively.

TIMI Risk Score Evaluation: Based on the TIMI Score, 288 patients (57.4%) were classified as low risk, 154 (30.7%) as intermediate risk, and 60 (12%) as high risk. When patients were stratified according to the TIMI Score, the incidence of MACE within 14 days was 12.8% (n=37) in the low-risk group, 22.1% (n=34) in the intermediate-risk group, and 33.3% (n=20) in the high-risk group (p<0.001) (Table 1). Over a six-week follow-up, MACE occurred in 28.1% of low-risk, 40.3% of intermediate-risk, and 60.0% of high-risk patients (Table 2). Mortality rates were 0.7%, 5.8%, and 8.3% in the respective groups.

GRACE Risk Score Evaluation: The mean GRACE Score was 108.11±45.02 (range: 23-302). Based on the GRACE Score, 276 patients (55.0%) were low risk, 98 (19.5%) were intermediate risk, and 128 (25.5%) were high risk. When patients were stratified according to the GRACE Score, the incidence of MACE within 14 days was 10.5% (n=29) in the low-risk group, 26.5% (n=26) in the intermediate-risk group, and 28.1% (n=36) in the high-risk group (p<0.001) (Table 1). Over a six-week follow-up, MACE occurred in 23.6% of low-risk, 38.8% of intermediate-risk, and 59.4% of high-risk patients (Table 2). Mortality was observed in one patient (0.7%) in the high-risk group.

The HEART Score showed a good prognostic value for 14-day MACE with an area under the curve (AUC) of 0.767. However, the AUC for 14-day MACE was calculated as 0.678 for the TIMI Score and 0.674 for the GRACE Score. The HEART Score showed a good prognostic value with an AUC of 0.700 for MACE at 6 weeks. Additionally, the AUC for MACE at 6-week follow-up was 0.649 for the TIMI Score and 0.704 for the GRACE Score (Figure 2).

Table 1. Distribution of major adverse cardiac events over 14 days among patients stratified by risk scores

Risk stratification	Major adverse cardiac events			
	Total, n (%)	None, n (%)	Yes, n (%)	p
HEART Score				
Low	197 (39.2)	192 (46.7)	55 (5.5)	<0.001
Intermediate	180 (35.9)	137 (33.3)	43 (47.3)	
High	125 (24.9)	82 (20.0)	47.3)	
TIMI Score				
Low	288 (57.4)	251 (61.1)	37 (40.7)	<0.001
Intermediate	154 (30.7)	120 (29.2)	34 (37.4)	
High	60 (12.0)	40 (9.7)	20 (22.0)	
GRACE Score				
Low	276 (55.0)	247 (60.1)	29 (31.9)	<0.001
Intermediate	98 (19.5)	72 (17.5)	26 (28.6)	
High	128 (25.5)	92 (22.4)	36 (39.6)	
Total	502 (100)	411 (100)	91 (100)	

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial İnfarction (**TIMI**), and Score, GRACE: Global Registry of Acute Coronary

Table 2. Distribution of major adverse cardiac events over 6 weeks among patients stratified by risk scores

Risk Stratification	Major adverse cardiac events			
	Total, n (%)	No, n (%)	Yes, n (%)	p
HEART Score				
Low	197 (39.2)	161 (49.8)	36 (20.1)	<0.001
Intermediate	180 (35.9)	111 (34.4)	69 (38.5)	
High	125 (24.9)	51 (15.8)	74 (41.3)	
TIMI Score				
Low	288 (57.4)	207 (64.1)	81 (45.3)	<0.001
Intermediate	154 (30.7)	92 (28.5)	62 (34.6)	
High	60 (12.0)	24 (7.4)	36 (20.1)	
GRACE Score				
Low	276 (55.0)	211 (65.3)	65 (36.3)	<0.001
Intermediate	98 (19.5)	60 (18.6)	38 (21.2)	
High	128 (25.5)	52 (16.1)	76 (42.5)	
Total	502 (100)	379 (100)	123 (100)	

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial Infarction and Score, GRACE: Global Registry of Acute Coronary

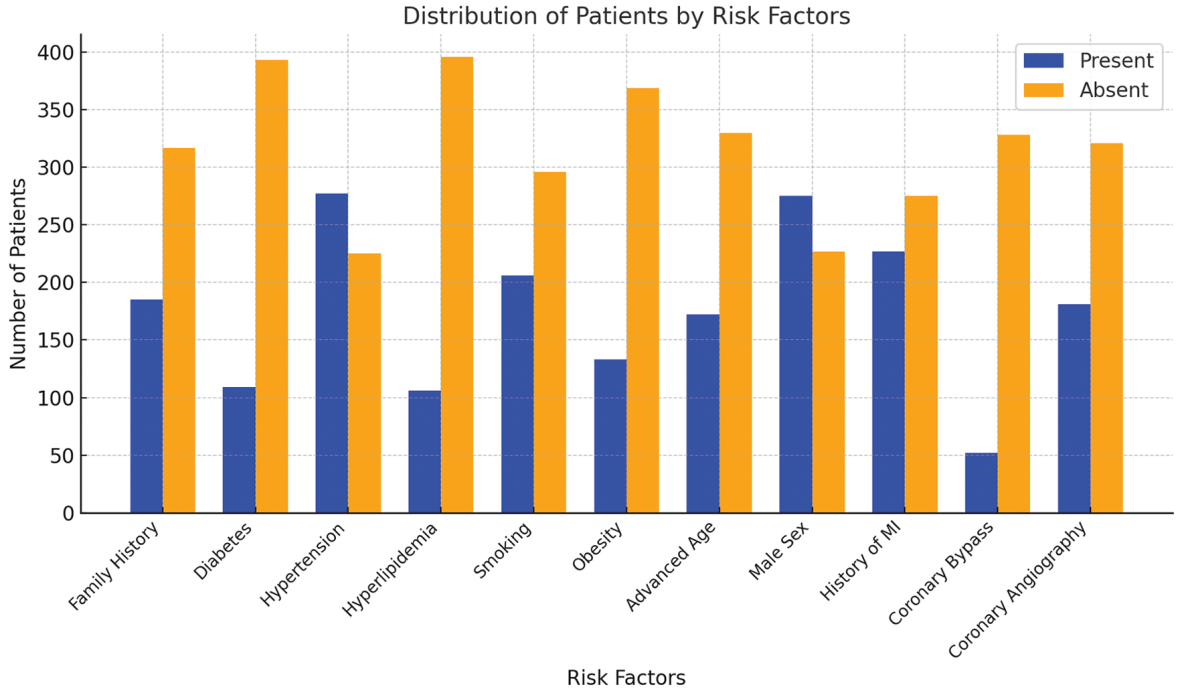

Figure 1. Distribution of risk factors for coronary artery disease

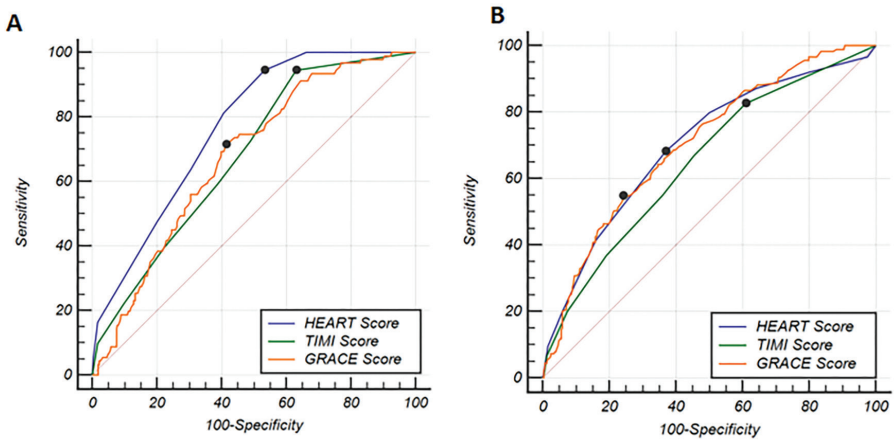

Figure 2. AUC of the HEART Score, GRACE Score, and TIMI Score for prediction of MACE at day 14 (A) and week 6 (B) in patients with chest pain. (A) The AUC for MACE at 14 days of follow-up shows a HEART Score of 0.767 (0.727 to 0.803), a TIMI Score of 0.678 (0.635 to 0.718), and a GRACE Score of 0.674 (0.632 to 0.715). B) AUC for MACE at 6 weeks follow-up HEART Score 0.700 (0.658 to 0.740), TIMI Score 0.649 (0.606 to 0.691), GRACE Score 0.704 (0.662 to 0.744)

HEART: Age, Risk factors, and Troponin, TIMI: Thrombolysis in Myocardial Infarction and Score, GRACE: Global Registry of Acute Coronary, AUC: Area under the curve, MACE: Major adverse cardiac events

Discussion

Chest pain, the second most common presenting complaint in the United States, accounts for 7.8 million ED visits annually (12). While only 5-13% of patients presenting to the ED with chest pain are diagnosed with acute coronary syndrome (ACS), a much larger proportion undergo prolonged ED observation or hospital admission to rule out ACS (13,14). Early diagnosis and timely intervention can significantly reduce morbidity and mortality rates and allow for more effective management of complications during follow-up. Various scoring systems used for risk stratification in patients presenting to the ED with chest pain provide clinicians with valuable assistance, particularly in assessing low-risk patients for ACS (3). This study evaluated the comparative effectiveness and utility of the HEART, TIMI, and GRACE Scores in predicting adverse cardiac outcomes in patients presenting to the ED with chest pain. A total of 502 patients were analyzed, and the risk stratifications and adverse cardiac outcome predictions of these three scoring systems were thoroughly assessed. The HEART Score is a predictive model designed for short-term risk stratification in suspected ACS patients (6). Developed in a Dutch Hospital, it incorporates history, ECG, HEART levels as MACE predictors (6,15). Our study confirms its effectiveness in MACE prediction. Adverse events were observed in 2.5% of the low-risk group, 23.9% of the moderate-risk group, and 34.4% of the high-risk group. Similarly, in a study by Six et al. (6) cardiac adverse outcomes were found in 2.5% of the low-risk group, (0-3%), 20.3% of the moderate-risk group, (4-6%), and 72.7% of the high-risk group, (7-10%). During a six-week follow-up, patients with higher HEART Scores had significantly higher rates of adverse cardiac outcomes (59.2%) compared to those in the low-risk group. The HEART Score has been evaluated by multiple independent research groups in both validation and clinical impact studies (15-17). Furthermore, the HEART Score has demonstrated superior performance compared to alternative predictive models in comparative studies (18,19). Additionally, the HEART Score is intuitive for emergency physicians, emphasizing clinical experience over statistically derived predictors commonly used in other models. A systematic review and meta-analysis of the HEART Score was published in May 2017 (20). The aim of this review was to summarize the evidence on the diagnostic accuracy of the HEART Score in predicting MACE in ED patients with possible ACS. The authors found an overall pooled prevalence of MACE of 15.4% during a mean follow-up of six weeks. Among 4,101 patients categorized as low-risk and suitable for early ED discharge (HEART Score 0-3), the pooled prevalence of MACE was 1.6%. The pooled sensitivity and specificity of the HEART Score for predicting MACE were 96.7% and 47.0%, respectively (20). In this study, the adverse cardiac event rates for low-, moderate-, and high-risk groups, as stratified by the TIMI Score, were 25%, 39.6%, and 58.3%, respectively. A study by Lakhani et al. (21) in 2008 evaluated 200 patients presenting to the ED. Severe coronary artery disease (defined as >70% stenosis) was identified, and early PCI was shown to be beneficial for patients with TIMI Scores >4. Although the TIMI Score is commonly utilized for assessing high-risk patients in the literature, its performance in predicting adverse cardiac events in low- and moderate-risk groups was limited in our study. Nevertheless, the TIMI Score contributes to risk assessment through its criteria, which include evaluating cardiac biomarkers and symptom duration. However, compared to the HEART Score, the TIMI Score was found to be less effective in predicting adverse cardiac events. The GRACE Score demonstrated moderate performance

in predicting both in-hospital and long-term adverse cardiac outcomes in this study. MACE rates for the low-, moderate-, and high-risk groups were 12.8%, 22.1%, and 33.3%, respectively. A study by van der Zee et al. (22) highlighted the GRACE Score's strong predictive ability for long-term cardiovascular mortality. The GRACE Score was particularly effective in predicting adverse cardiac outcomes in high-risk patients. However, the need for more data and the complexity of GRACE Score calculations limit its utility in ED settings. The comparison of HEART, TIMI, and GRACE Scores highlighted the differing effectiveness of these three systems in various patient groups. The HEART Score was deemed the most practical scoring system in the ED due to its ease of calculation and clinical applicability. The TIMI and GRACE Scores, on the other hand, provided additional value, particularly in identifying high-risk patients. These findings suggest that the HEART Score provides superior performance in predicting adverse cardiac outcomes and may serve as a primary evaluation tool in the ED.

Study Limitations

This study has several limitations. First, it was conducted at a single center, and the results may not be generalizable to different patient populations. Second, the six-week follow-up period may be insufficient for assessing long-term outcomes. Finally, differences in the timing of biomarker measurements and patient management could have influenced the results.

Conclusion

The HEART, TIMI, and GRACE Scores play a significant role in risk stratification in the ED. The HEART Score, in particular, demonstrated high performance in predicting adverse cardiac outcomes and may be prioritized in ED applications. However, all three scores are complementary in patient management and should be selected based on the clinical context. Future multicenter studies with broader patient populations are recommended to further evaluate the effectiveness of these scoring systems.

Ethics

Ethics Committee Approval: University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital from December 1, 2014, to March 1, 2015, following Ethical Approval (decision number: 2014/16/06, date: 24.11.2014).

Informed Consent: Informed consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.Y., Concept: H.Y., H.D., Design: H.Y., S.I., H.D., Data Collection or Processing: H.Y., S.I., Analysis or Interpretation: H.Y., H.D., Literature Search: H.Y., S.I., H.D., Writing: H.Y., S.I.

Conflict of Interest: No conflict of interest was declared by the authors.

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