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Research Article

Comparison of E-HEART, HEART, TIMI, and T-MACS Scores in Predicting 30-Day Major Adverse Cardiac Events among Patients with Undifferentiated Chest Pain

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ABSTRACT

Background: Chest pain is a common presentation in emergency departments and requires prompt risk stratification to identify patients at risk of major adverse cardiac events (MACE). Several scoring systems such as E-HEART, HEART, TIMI, and T-MACS are used for this purpose, but their comparative performance remains uncertain. **Aim:** To compare E-HEART, HEART, TIMI, and T-MACS scores in predicting 30-day major adverse cardiac events among patients with undifferentiated chest pain. **Materials and Methods:** This was a prospective observational study conducted in a tertiary care hospital over a period of one year. A total of 40 patients presenting with undifferentiated chest pain were included. Clinical history, ECG findings, and laboratory investigations including troponin were recorded. E-HEART, HEART, TIMI, and T-MACS scores were calculated for each patient. Patients were followed for 30 days to assess the occurrence of MACE. Statistical analysis included chi-square test, t-test, and receiver operating characteristic (ROC) curve analysis. **Results:** Patients with MACE had significantly higher mean scores across all scoring systems ($p < 0.001$). E-HEART demonstrated the highest predictive accuracy with an AUC of 0.924, followed by T-MACS (0.903), HEART (0.881), and TIMI (0.816). E-HEART also showed the highest sensitivity (90.9%), specificity (86.2%), and diagnostic accuracy (87.5%). Troponin positivity and ischemic ECG changes were significantly associated with MACE. **Conclusion:** E-HEART score showed superior performance in predicting 30-day MACE compared to HEART, TIMI, and T-MACS scores. It can be considered the most reliable tool for risk stratification in patients with undifferentiated chest pain in emergency settings.

KEYWORDS: Chest Pain. E-HEART Score. Major Adverse Cardiac Events (MACE).

INTRODUCTION

Chest pain is one of the most common presenting complaints in emergency departments worldwide and poses a significant diagnostic challenge due to its

wide differential diagnosis ranging from benign musculoskeletal causes to life-threatening acute coronary syndromes (ACS). Early and accurate risk stratification is crucial in patients with undifferentiated chest pain to identify those at high risk of major adverse cardiac events (MACE), while avoiding unnecessary admissions and investigations in low-risk individuals. Traditional diagnostic approaches relying solely on clinical assessment, electrocardiography (ECG), and cardiac biomarkers may not be sufficient to predict short-term outcomes reliably.[1]

To address this challenge, several clinical risk scoring systems have been developed and validated. Among them, the HEART score (History, ECG, Age, Risk factors, Troponin) has gained widespread acceptance due to its simplicity and strong predictive ability for short-term cardiac events. The TIMI (Thrombolysis in Myocardial Infarction) score, originally developed for patients with unstable angina and non-ST elevation myocardial infarction (NSTEMI), is also commonly used in emergency settings. More recently, the T-MACS (Troponin-only Manchester Acute Coronary Syndromes) decision aid has been introduced, which integrates clinical variables and troponin levels to provide rapid rule-in and rule-out decisions.[2]

An advancement over the conventional HEART score is the E-HEART (Extended HEART) score, which incorporates additional clinical and laboratory parameters to enhance predictive accuracy. Comparative evaluation of these scoring systems is essential to determine the most reliable tool for predicting 30-day MACE in patients presenting with undifferentiated chest pain, particularly in resource-limited settings.[3]

Despite the availability of these scoring systems, there remains variability in their predictive performance across different populations. Studies have shown that while HEART score demonstrates superior sensitivity and specificity compared to TIMI, newer models like T-MACS and E-HEART may offer improved diagnostic precision and risk stratification. However, direct comparisons among these four scoring systems in a single cohort remain limited, especially in Indian tertiary care settings.[4]

AIM

To compare E-HEART, HEART, TIMI, and T-MACS scores in predicting 30-day major adverse cardiac events in patients with undifferentiated chest pain.

OBJECTIVES

1. To assess the predictive accuracy of E-HEART, HEART, TIMI, and T-MACS scores for 30-day MACE.
2. To compare sensitivity, specificity, and diagnostic performance of these scoring systems.
3. To determine the most reliable scoring system for risk stratification in emergency settings.

MATERIAL AND METHODOLOGY

Source of Data

The data for the present study were collected from patients presenting with undifferentiated chest pain to the emergency department and inpatient wards of a tertiary care hospital. Relevant clinical, laboratory, and imaging data were obtained from hospital records and direct patient evaluation.

Study Design

This study was a hospital-based observational, prospective comparative study.

Study Location

The study was conducted in the Department of General Medicine and Emergency Medicine at a tertiary care teaching hospital.

Study Duration

The study was carried out over a period of 12 months.

Sample Size

A total of 40 patients presenting with undifferentiated chest pain were included in the study.

Inclusion Criteria

- Patients aged ≥18 years presenting with chest pain suggestive of possible cardiac origin
- Patients with undifferentiated chest pain requiring evaluation for ACS
- Patients who provided informed consent

Exclusion Criteria

- Patients with confirmed ST-elevation myocardial infarction (STEMI) at presentation
- Patients with non-cardiac causes of chest pain (e.g., trauma, pulmonary embolism confirmed)
- Patients with incomplete clinical or laboratory data
- Patients unwilling to participate

Procedure and Methodology

After obtaining informed consent, detailed clinical history including characteristics of chest pain, risk factors, and past medical history was recorded. Physical examination was performed for all patients.

All patients underwent:

- Electrocardiography (ECG)
- Cardiac biomarkers (Troponin levels)
- Routine blood investigations

Based on collected data, E-HEART, HEART, TIMI, and T-MACS scores were calculated for each patient at presentation. Patients were followed up for 30 days to assess the occurrence of major adverse cardiac events (MACE), including myocardial infarction, need for revascularization, or cardiac death.

Sample Processing

Blood samples were collected under aseptic conditions and analyzed using standardized automated analyzers. Troponin levels were measured using high-sensitivity assays. All laboratory procedures followed institutional protocols.

Statistical Methods

Data were entered into Microsoft Excel and analyzed using SPSS software.

- Descriptive statistics were expressed as mean ± standard deviation and percentages
- Chi-square test was used for categorical variables
- Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated
- Receiver Operating Characteristic (ROC) curves were plotted to compare diagnostic accuracy
- A p-value <0.05 was considered statistically significant

Data Collection

Data were collected using a structured proforma including:

- Demographic details (age, gender)
- Clinical features and risk factors
- ECG findings
- Troponin values
- Score calculations (E-HEART, HEART, TIMI, T-MACS)
- 30-day follow-up outcomes (MACE)

All data were recorded systematically and maintained confidentially for analysis.

OBSERVATION AND RESULTS

Table 1: Comparison of baseline characteristics and mean risk scores between patients with and without 30-day MACE (N = 40)

Variable	30-day MACE Present (n = 11)	30-day MACE Absent (n = 29)	Test of significance	95% CI	P value
Age (years), Mean ± SD	61.8 ± 8.4	54.7 ± 9.1	t = 2.21	0.61 to 13.59	0.033*
Male gender, n (%)	8 (72.7)	17 (58.6)	$\chi^2 = 0.66$	-0.17 to 0.45	0.416
Hypertension, n (%)	8 (72.7)	11 (37.9)	$\chi^2 = 3.79$	0.02 to 0.67	0.049*
Diabetes mellitus, n (%)	6 (54.5)	7 (24.1)	$\chi^2 = 3.18$	-0.01 to 0.58	0.074
Dyslipidemia, n (%)	7 (63.6)	9 (31.0)	$\chi^2 = 3.43$	-0.00 to 0.61	0.064
Smoking history, n (%)	5 (45.5)	10 (34.5)	$\chi^2 = 0.41$	-0.22 to 0.44	0.523
Initial troponin positive, n (%)	8 (72.7)	6 (20.7)	$\chi^2 = 8.94$	0.19 to 0.73	0.003*
Ischemic ECG changes, n (%)	7 (63.6)	5 (17.2)	$\chi^2 = 7.65$	0.14 to 0.67	0.006*
E-HEART score, Mean ± SD	**8.27 ± 1.19**	**4.36 ± 1.41**	**t = 8.16**	**2.94 to 4.88**	**<0.001***
HEART score, Mean ± SD	**7.19 ± 1.08**	**4.41 ± 1.33**	**t = 6.18**	**1.87 to 3.69**	**<0.001***
TIMI score, Mean ± SD	**4.08 ± 1.03**	**2.14 ± 0.97**	**t = 5.41**	**1.21 to 2.67**	**<0.001***
T-MACS probability (%), Mean ± SD	**67.4 ± 14.8**	**28.9 ± 13.2**	**t = 7.77**	**28.42 to 48.58**	**<0.001***

*Statistically significant

In the present study, comparison of baseline characteristics between patients with and without 30-day major adverse cardiac events (MACE) revealed several important findings. The mean age of patients with MACE (61.8 ± 8.4 years) was significantly higher than those without MACE (54.7 ± 9.1 years), indicating that advancing age was associated with increased risk (p = 0.033). Although a higher proportion of males was observed in the MACE group (72.7%) compared to the non-MACE group (58.6%), this difference was not statistically significant (p = 0.416). Hypertension was significantly more prevalent among patients with MACE (72.7% vs 37.9%), suggesting its strong association with adverse outcomes (p = 0.049). While diabetes mellitus and dyslipidemia were more common in the MACE group, these associations did not reach statistical significance (p = 0.074 and p = 0.064, respectively). Smoking history was

comparable between groups and showed no significant association (p = 0.523).

Among clinical and investigative parameters, initial troponin positivity (72.7% vs 20.7%) and ischemic ECG changes (63.6% vs 17.2%) were significantly higher in patients with MACE (p = 0.003 and p = 0.006, respectively), highlighting their strong predictive value. Furthermore, all four scoring systems demonstrated significantly higher mean values in the MACE group compared to the non-MACE group. The E-HEART score showed the highest difference (8.27 ± 1.19 vs 4.36 ± 1.41, p < 0.001), followed by HEART, TIMI, and T-MACS scores, all of which were highly significant. These findings indicate that higher risk scores are strongly associated with increased likelihood of 30-day MACE

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Table 2: Predictive accuracy of E-HEART, HEART, TIMI, and T-MACS scores for 30-day MACE (N = 40)

Score / Parameter	MACE Present (n = 11) Mean ± SD	MACE Absent (n = 29) Mean ± SD	Test of significance	95% CI of mean difference	P value
E-HEART score	**8.27 ± 1.19**	**4.36 ± 1.41**	**t = 8.16**	**2.94 to 4.88**	**<0.001***
HEART score	**7.19 ± 1.08**	**4.41 ± 1.33**	**t = 6.18**	**1.87 to 3.69**	**<0.001***
TIMI score	**4.08 ± 1.03**	**2.14 ± 0.97**	**t = 5.41**	**1.21 to 2.67**	**<0.001***
T-MACS probability (%)	**67.4 ± 14.8**	**28.9 ± 13.2**	**t = 7.77**	**28.42 to 48.58**	**<0.001***
AUC for E-HEART	**0.924 ± 0.041**		Z = 10.34	0.844 to 1.000	<0.001*
AUC for HEART	**0.881 ± 0.056**		Z = 6.80	0.771 to 0.991	<0.001*
AUC for TIMI	**0.816 ± 0.067**		Z = 4.72	0.685 to 0.947	<0.001*
AUC for T-MACS	**0.903 ± 0.048**		Z = 8.40	0.809 to 0.997	<0.001*

*Statistically significant

The predictive accuracy of E-HEART, HEART, TIMI, and T-MACS scores for 30-day MACE was assessed by comparing their mean values and area under the curve (AUC). All scoring systems demonstrated significantly higher mean scores among patients who developed MACE compared to those who did not (p < 0.001 for all), indicating good discriminatory ability. Among them, the E-HEART score exhibited the greatest difference between groups (mean difference 2.94 to 4.88), followed by T-MACS, HEART, and TIMI scores.

Receiver operating characteristic (ROC) analysis further supported these findings. The E-HEART score demonstrated the highest AUC (0.924 ± 0.041), indicating excellent predictive accuracy. T-MACS also showed strong performance with an AUC of 0.903 ± 0.048, followed by the HEART score (0.881 ± 0.056) and TIMI score (0.816 ± 0.067). All AUC values were statistically significant (p <

0.001), confirming that each scoring system was effective in predicting 30-day MACE, with E-HEART providing the best overall discrimination.

Table 3: Comparison of sensitivity, specificity, and diagnostic performance of E-HEART, HEART, TIMI, and T-MACS scores for predicting 30-day MACE (N = 40)

Scoring system	Sensitivity %	Specificity %	PPV %	NPV %	Diagnostic accuracy %	95% CI	P value
E-HEART	**90.9**	**86.2**	**71.4**	**96.2**	**87.5**	73.2 to 95.8	<0.001*
HEART	**81.8**	**79.3**	**60.0**	**92.0**	**80.0**	64.4 to 90.9	0.002*
TIMI	**72.7**	**72.4**	**50.0**	**87.5**	**72.5**	56.1 to 85.4	0.011*
T-MACS	**81.8**	**82.8**	**64.3**	**92.3**	**82.5**	67.2 to 92.7	0.001*

*Statistically significant

The comparison of diagnostic performance of the four scoring systems revealed that E-HEART had the highest sensitivity (90.9%), specificity (86.2%), and overall diagnostic accuracy (87.5%). It also demonstrated a high negative predictive value (96.2%), indicating its strong ability to rule out MACE in low-risk patients. T-MACS showed comparable performance with sensitivity of 81.8% and specificity of 82.8%, with an overall accuracy of 82.5%. The HEART score also performed well, with sensitivity of 81.8% and specificity of 79.3%, though slightly lower than E-HEART and T-MACS. TIMI score demonstrated relatively lower sensitivity (72.7%) and specificity (72.4%), indicating comparatively lesser diagnostic performance. All scoring systems showed statistically significant diagnostic accuracy ($p < 0.05$), with E-HEART showing the strongest performance ($p < 0.001$).

Table 4: Comparison of risk stratification ability of E-HEART, HEART, TIMI, and T-MACS in identifying 30-day MACE (N = 40)

Scoring system / Risk category	30-day MACE Present n (%)	30-day MACE Absent n (%)	Test of significance	95% CI	P value
E-HEART High risk	9 (81.8)	4 (13.8)	$\chi^2 = 14.72$	0.38 to 0.82	<0.001*
E-HEART Low/Intermediate risk	2 (18.2)	25 (86.2)			
HEART High risk	8 (72.7)	6 (20.7)	$\chi^2 = 8.94$	0.19 to 0.73	0.003*

HEART Low/Intermediate risk	3 (27.3)	23 (79.3)			
TIMI High risk	7 (63.6)	8 (27.6)	$\chi^2 = 4.34$	0.04 to 0.68	0.037*
TIMI Low/Intermediate risk	4 (36.4)	21 (72.4)			
T-MACS High probability	8 (72.7)	5 (17.2)	$\chi^2 = 10.40$	0.23 to 0.75	0.001*
T-MACS Low/Intermediate probability	3 (27.3)	24 (82.8)			

*Statistically significant

The ability of the scoring systems to stratify patients into risk categories was also evaluated. The E-HEART score demonstrated the strongest risk stratification capability, with 81.8% of patients in the high-risk category developing MACE compared to only 13.8% in the non-MACE group, which was highly statistically significant ($p < 0.001$). Similarly, HEART score identified 72.7% of MACE patients as high risk, compared to 20.7% in the non-MACE group ($p = 0.003$). The T-MACS score also showed strong predictive ability, with 72.7% of MACE patients classified as high probability compared to 17.2% without MACE ($p = 0.001$).

Although TIMI score also demonstrated a significant association, its discriminative ability was relatively lower, with 63.6% of MACE patients classified as high risk compared to 27.6% in the non-MACE group ($p = 0.037$).

DISCUSSION

The present study evaluated the clinical characteristics and comparative performance of E-HEART, HEART, TIMI, and T-MACS scores in predicting 30-day major adverse cardiac events (MACE) among patients with undifferentiated chest pain. The findings provide important insights into both baseline risk factors and the relative diagnostic accuracy of these scoring systems.

With respect to demographic variables (Table 1), the present study demonstrated that patients who developed MACE were significantly older compared to those who did not (61.8 ± 8.4 vs 54.7 ± 9.1 years; $p = 0.033$). This finding is consistent with Akman et al.(2023)[1], who reported that increasing age is a strong independent predictor of adverse cardiac outcomes. Similarly, Yuvaraj et al.(2023)[2] observed that age contributed significantly to risk stratification in chest pain patients using newer scoring models. In contrast, gender distribution in the present study did not show a statistically significant association with MACE, which aligns with findings of Kesgün et al.(2022)[3], where gender alone was not a strong predictor after adjustment for other clinical variables.

Hypertension was found to be significantly associated with MACE (72.7% vs 37.9%; $p = 0.049$), supporting previous evidence by Aktemur et al.(2025)[4], who identified hypertension as a key contributor to cardiovascular events in acute chest pain cohorts. Although diabetes mellitus and dyslipidemia were more prevalent in the MACE group, they did not reach statistical significance, possibly due to the smaller sample size. Similar trends were reported by Ke et al.(2021)[5], where traditional

cardiovascular risk factors showed variable statistical significance depending on population characteristics and sample size.

Among investigative parameters, initial troponin positivity and ischemic ECG changes were strongly associated with MACE in the present study ($p = 0.003$ and $p = 0.006$, respectively). These findings are in agreement with Ho et al.(2024)[6], who emphasized that elevated troponin and ischemic ECG findings are among the strongest predictors of short-term adverse cardiac events, even in patients initially categorized as low risk.

Regarding the performance of risk scores (Table 2), all four scoring systems demonstrated significantly higher mean values in patients with MACE, confirming their predictive utility. The E-HEART score showed the highest discriminatory ability with an AUC of 0.924, followed by T-MACS (0.903), HEART (0.881), and TIMI (0.816). These findings are consistent with studies by Yuvaraj et al.(2023)[2], who reported superior performance of E-HEART compared to conventional scoring systems. Furthermore, Yukselen et al.(2024)[7] demonstrated that T-MACS provides high diagnostic accuracy comparable to or better than traditional scores, supporting the findings of the present study.

In terms of diagnostic performance (Table 3), the E-HEART score showed the highest sensitivity (90.9%), specificity (86.2%), and overall accuracy (87.5%), followed by T-MACS and HEART scores, whereas TIMI demonstrated relatively lower performance. These results are comparable to findings by Dawson et al.(2022)[8], who showed that newer risk prediction models outperform traditional scoring systems such as TIMI. Similarly, Ashburn et al.(2021)[9] and Body et al.(2020)[10] reported that contemporary scoring systems, particularly T-MACS and HEART-based tools, offer improved diagnostic precision, especially in ruling out low-risk patients. The high negative predictive value of E-HEART (96.2%) in the present study further supports its clinical utility in safely discharging low-risk patients from emergency settings.

The risk stratification analysis (Table 4) further confirmed that E-HEART had the strongest ability to classify patients accurately into high-risk and low-risk categories, with a highly significant association ($p < 0.001$). Similar observations were reported by Altundağ et al.(2025)[11] and Nie et al.(2025)[12], who highlighted the improved stratification capability of HEART-based scoring systems and their derivatives. T-MACS and HEART scores also demonstrated strong predictive ability, whereas TIMI showed comparatively lower discrimination. These findings are in line with Ng et al.(2020)[13] and Smulders et al.(2022)[14], where TIMI was originally developed for higher-risk ACS populations and was found to be less effective in undifferentiated chest pain scenarios compared to newer risk models.

CONCLUSION

The present study was conducted to compare the effectiveness of E-HEART, HEART, TIMI, and T-MACS scoring systems in predicting 30-day major adverse cardiac events (MACE) among patients presenting with undifferentiated chest pain in a tertiary care setting. Early and accurate risk stratification in such patients is critical for timely intervention, optimal utilization of healthcare resources, and prevention of adverse outcomes. The findings of this study provide important insights into the comparative diagnostic and prognostic performance of these widely used scoring systems.

In the present study, it was observed that advancing age and hypertension were significantly associated with the occurrence of 30-day MACE, highlighting their importance as key clinical predictors. Although other conventional cardiovascular risk factors such as diabetes mellitus, dyslipidemia, and smoking were more prevalent in patients who developed MACE, these associations did not reach statistical significance, possibly due to the limited sample size. Importantly, initial troponin positivity and ischemic ECG changes were found to be strong predictors of adverse outcomes, reaffirming their established role in the evaluation of suspected acute coronary syndrome.

All four scoring systems evaluated in the study demonstrated statistically significant ability to discriminate between patients with and without MACE. However, there was a clear hierarchy in their predictive performance. The E-HEART score emerged as the most accurate and reliable scoring system, demonstrating the highest mean difference between groups, the highest area under the curve (AUC = 0.924), and superior sensitivity (90.9%), specificity (86.2%), and overall diagnostic accuracy (87.5%). These findings indicate that E-HEART has excellent discriminatory power and is highly effective in identifying both high-risk and low-risk patients.

The T-MACS score also showed strong predictive performance, with an AUC of 0.903 and good sensitivity and specificity. Its ability to incorporate probability-based risk estimation makes it particularly useful in emergency settings for rapid decision-making. The HEART score, which is widely used in clinical practice due to its simplicity, also demonstrated good predictive ability with an AUC of 0.881, although slightly inferior to E-HEART and T-MACS. In contrast, the TIMI score showed comparatively lower performance, with an AUC of 0.816 and lower sensitivity and specificity. This may be attributed to the fact that TIMI was originally developed for higher-risk populations with confirmed acute coronary syndromes and may not be ideally suited for undifferentiated chest pain presentations.

The risk stratification analysis further supported these findings. The E-HEART score demonstrated the highest ability to correctly classify patients into high-risk and low-risk categories, with a significantly higher proportion of patients in the high-risk group developing MACE. T-MACS and HEART scores also showed strong stratification capability, whereas TIMI score demonstrated relatively limited discriminative ability. These findings underscore the importance of selecting an appropriate scoring system tailored to the clinical setting and patient population.

From a clinical perspective, the high negative predictive value of E-HEART and T-MACS scores suggests that these tools can be effectively used to safely rule out MACE in low-risk patients, thereby reducing unnecessary hospital admissions and investigations. At the same time, their high sensitivity ensures that high-risk patients are appropriately identified and managed without delay. This has important implications for emergency department workflow, patient safety, and cost-effective healthcare delivery.

In conclusion, the present study demonstrates that while all four scoring systems are useful in predicting 30-day MACE, the E-HEART score provides the best overall performance, followed closely by T-MACS and HEART scores. TIMI score, although useful, is comparatively less effective in the context of undifferentiated chest pain. Therefore, E-HEART can be considered the most reliable

and efficient tool for risk stratification in emergency settings. Future large-scale, multicentric studies are recommended to validate these findings and further refine risk prediction models for improved clinical outcomes.

LIMITATIONS OF STUDY

1. The sample size was relatively small (N = 40), which may limit the generalizability of the findings.
2. The study was conducted at a single tertiary care center, which may not reflect variations in different healthcare settings.
3. Short follow-up duration of 30 days may not capture long-term cardiovascular outcomes.
4. Some risk factors such as lifestyle variables and socioeconomic status were not extensively evaluated.
5. Inter-observer variability in ECG interpretation and clinical assessment was not assessed.
6. Biomarker variability (single troponin measurement) may have influenced diagnostic accuracy.
7. External validation of scoring systems was not performed in a separate cohort.
8. Selection bias may be present as only hospital-attending patients were included.

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