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Comparative evaluation of HEART, T-MACS, and HE-MACS scores for risk stratification and management of patients with chest pain in the emergency department

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Abstract

This study evaluated the effectiveness of history, electrocardiogram, age, risk factors, and troponin (HEART), troponin-only Manchester acute coronary syndromes (T-MACS), and history and electrocardiogram-only Manchester acute coronary syndromes (HE-MACS) in diagnosing and managing acute coronary syndrome in patients presenting with chest pain in the emergency department. These scoring systems are crucial for risk stratification and the prediction of major adverse cardiac events (MACEs) and mortality within 30 days. A single-center prospective analytical study was conducted following the STROBE guidelines, with 560 patients presenting with chest pain or ischemic equivalent symptoms at the Ege University Faculty of Medicine Hospital from August 2020 to March 2021. The HEART, T-MACS, and HE-MACS scores were calculated for each patient, and their predictive values for MACE and mortality were analyzed using receiver operating characteristic analysis. The HEART score demonstrated an area under the curve (AUC) of 0.929 for predicting mortality, with 100% sensitivity and 81% specificity. It has been identified as the most reliable predictor of mortality. The T-MACS score showed an AUC of 0.875 for mortality prediction with 85.7% sensitivity and 83.9% specificity. It is particularly effective for high-risk patients, predicting 30-day MACE development rates, which is consistent with the literature. The HE-MACS score yielded an AUC of 0.729 for mortality prediction, with 71.4% sensitivity and 80.7% specificity. Although it effectively excludes MACE in very-low-risk patients, it is limited by its application to a highly isolated group. The discussion interprets the results and compares them with existing literature. The study confirms the high effectiveness of the HEART score in mortality risk assessment, the specificity of the T-MACS score for high-risk patients, and the utility of the HE-MACS score for excluding very-low-risk cases. The limitations of each scoring system are discussed and recommendations for their application in clinical practice are provided. The study concluded that selecting the most appropriate scoring system based on individual patient characteristics is essential for optimal patient management in the emergency department. For optimal patient management, it is essential to select the most appropriate scoring system based on the individual patient characteristics.

Abbreviations: ACS = acute coronary syndrome, AUC = area under the curve, CI = confidence interval, ECG = electrocardiogram, ED = emergency department, HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndromes, hs-cTn = high-sensitivity cardiac troponin, MACE = major adverse cardiac event, NPD = negative predictive value, ROC = receiver operating characteristic, T-MACS = troponin-only Manchester acute coronary syndrome.

Keywords: acute coronary syndrome, chest pain, HEART, HE-MACS, major adverse cardiac event, T-MACS

1. Introduction

Suspicion of acute coronary syndrome (ACS) is a problem that should be meticulously managed in emergency services. Every year, dozens of patients are diagnosed with ACS by emergency services. This decision process included medical history recording and evaluation of electrocardiogram (ECG) and troponin measurements.[1] Acute ST-segment elevation myocardial infarction patients can easily be recognized by ECG evidence. Non-ST segment elevation myocardial infarction and patients with unstable angina pectoris, especially those in the low-risk

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The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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group, should be carefully evaluated by emergency medicine specialists. The mortality rate of patients with ACS could be attenuated with early diagnosis and treatment beginning with emergency department (ED) specialists.[2]

Although ACS is a pathology that occurs because of decreased blood flow in the coronary arteries due to any cause, chest pain is observed in only 25% to 30% of all ACS cases.[3] Traditional methods such as medical examination, ECG, and cardiac biomarkers cannot be fully convenient to differentiate patients with ACS from low-risk patients consulting the ED with chest pain. Thus, various clinical risk scores, such as history, ECG, age, risk factors, troponin (HEART), troponin-only Manchester acute coronary syndromes (T-MACS), and history and electrocardiogram-only Manchester acute coronary syndromes (HE-MACS) have been developed for the risk stratification of patients with suspected ACS.[4]

The HEART score, created in 2008, is a risk assessment tool for patients with chest pain in the ED.[5,6] The incidence of major adverse cardiac events (MACEs) was 0.9% in patients classified as low risk by the HEART score, 12% in those with intermediate risk, and 65% in those categorized as high risk.[7] Table 1 details the components of the HEART scores.[5]

T-MACS was developed by Dr Body et al to address the limitations of chest pain rules, including lack of specificity, insufficient management guidance, and rigid diagnostic thresholds, with its development spanning 2006–2007, several separate analyses published from these cohorts, and its final publication in 2017.[7] It is an updated scoring system that may improve the safe discharge of patients with chest pain from the ED, and the main aim of this scoring system is to eliminate the possibility of ACS in patients.[1,8] T-MACS comprises high-sensitivity troponin T, ECG findings, and clinical data, similar to the MACS rule. However, the heart fatty acid–binding protein level is omitted in its risk stratification process. T-MACS rules can predeclare the risk of a MACE within 30 days with 96.3% to 98.1% sensitivity.[8,9]

The HE-MACS is a scoring system derived from the T-MACS score, developed by Alghamdi in 2018. The difference between the 2 scoring models is that HE-MACS does not require troponin values for scoring; it aids decision-making in evaluating chest pain of potential cardiac origin, particularly in prehospital settings where troponin testing is not easily feasible.[10]

This study assessed and evaluated various risk stratification methods used in patients presenting with chest pain in the ED. By synthesizing the current evidence, we primarily aimed to compare the performance of the HEART, T-MACS, and HE-MACS scoring systems currently used in the ED to exclude non-ST elevation-ACS in patients presenting with chest pain and ischemia-equivalent symptoms. This study also sought to determine the predictive value of these scoring systems for predicting the 30-day risk of MACE.

Table 1

Components of the HEART score for patients with chest pain in the emergency department.[5]

History	
Highly suspicious	2
Moderately suspicious	1
Slightly suspicious	0
ECG	
Significant ST-depression	2
Nonspecific repolarization disturbance	1
Normal	0
Age (yr)	
≥65	2
45–65	1
≤45	0
Risk factors	
≥3 risk factors or history of atherosclerotic disease	2
1 or 2 risk factors	1
No risk factors known	0
Troponin	
≥3× normal limit	2
1–3× normal limit	1
≤Normal limit	0

ECG = electrocardiogram, HEART = history, ECG, age, risk factors, and troponin.

2. Materials and methods

2.1. Study design and settings

For this single-center prospective cross-sectional study, study reporting was performed following the STROBE guidelines.[11] A total of 888 patients who presented to the Emergency Department of Ege University Faculty of Medicine Hospital between August 1, 2020 and March 1, 2021 with chest pain or ischemia-equivalent symptoms (right-left arm pain, diaphoresis, nausea, etc) were diagnosed with ACS. Our study was initiated after obtaining approval from the Ege University Medical Faculty Hospital Ethics Committee (Decision number 20-7.1T/1 dated July 22, 2020).

2.2. Participants

According to the inclusion and exclusion criteria, 560 patients with ICD-10 codes of R07.1 (chest pain on breathing) and R07.9 (chest pain, unspecified) were included in the study, while 328 patients who met the exclusion criteria were excluded from the study. Figure 1 shows the included and excluded patients and their discharge or hospitalization status.

2.3. Data collection

Age, sex, blood pressure, pulse rate, examination findings (sweating, type of chest pain, and radiating pain), and history of chronic diseases were recorded on a preformed study form. The ECG of the patients included in the study was evaluated by a senior emergency medicine resident or emergency medicine specialist. Whether the increase or decrease in troponin in cardiac scoring was significant was evaluated according to the current algorithm in the latest guidelines. The 30-day outcome data of the patients were obtained via telephone contact with the consent obtained from the patients.

2.4. Variables

HEART, T-MACS, and HE-MACS scores were calculated from these values. Hospitalization, discharge, presence of invasive and/or noninvasive interventions (coronary angiography and myocardial perfusion scintigraphy), and 30-day MACE scores were calculated. The Elecsys Corporation-Roche (Olathe, KS) brand high-sensitivity cardiac troponin (hs-cTn), a troponin electrochemiluminescence immunological test, was used in this study. Quantitative values between 5 and 14 in the T-MACS scoring system, which could change the calculation, could not be detected. Therefore, we accepted all values <14 ng/dL given by the hs-cTn kit as 5 ng/dL in the calculation of the T-MACS scores of the patients included in our study.

2.5. Statistical analysis

The data obtained were analyzed using the SPSS Package Programme version 20.0 (Chicago, IL). Descriptive data are presented as numbers, percentages, means, standard deviations, medians, minimums, and maximums. The suitability of the data for normal distribution was evaluated using the Kolmogorov–Smirnov test. Pearson χ^2 test and Fisher exact test were used to analyze categorical variables. Receiver operating characteristic

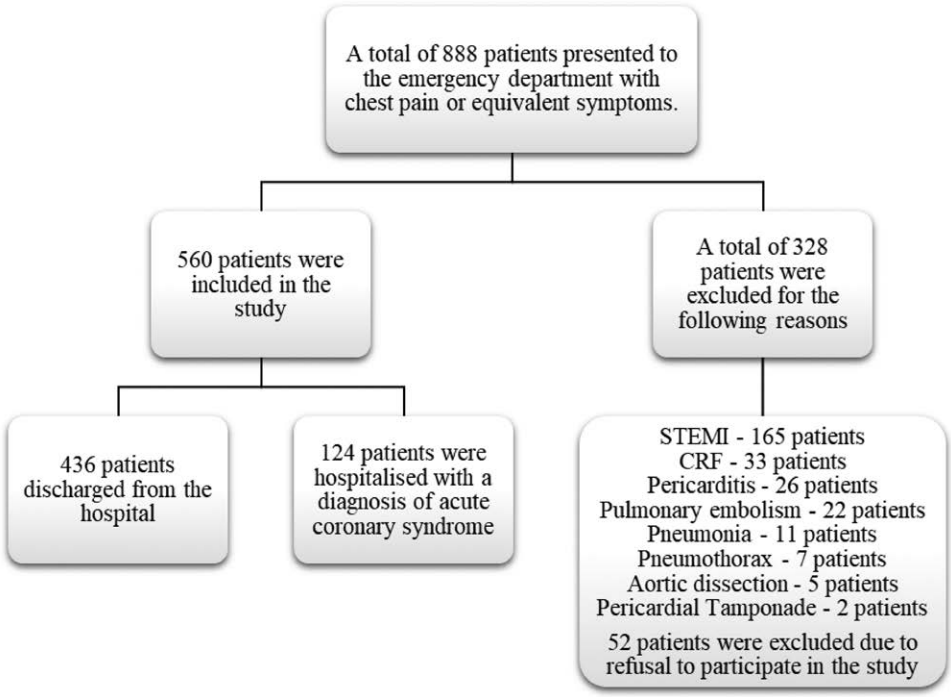

Figure 1. Number of excluded, included, hospitalized, and discharged cases. CRF = chronic renal failure, STEMI = ST-segment elevation myocardial infarction.

(ROC) curve analysis was performed for sensitivity and specificity evaluation according to the cutoff values of the cases. Statistical significance was set at $P < .05$.

3. Results

A total of 560 patients were included in this study, with a median age of 55.0 years (range: 46–66 years). Of these, 64.5% (n = 361) were male and 35.5% (n = 199) were female. Patient characteristics are shown in Table 2.

When the predictive value of the scoring systems for mortality and progression to MACE was analyzed, it was observed that the progression to MACE increased significantly with increasing HEART, T-MACS, and HE-MACS scores (Table 3). While the rate of low-risk patients was 33.4% for HEART, this rate was 40.8% in the very-low-risk group for T-MACS and 5.7% for HE-MACS. The HEART and T-MACS scores failed to recognize 4.3% and 4.8% of patients in the low-risk classification, respectively. On the other hand, this rate was 0% in the HE-MACS. This scoring system, which offers highly reliable exclusion, was only able to exclude 57 out of every 1000 patients.

The sensitivity and specificity of the HEART, T-MACS, and HE-MACS scores in determining the development of MACE in patients are shown in Figure 2 and Table 4.

The data obtained when the sensitivity and specificity of the HEART and T-MACS scores were evaluated to determine mortality within 30 days are shown in Figure 3 and Table 5.

4. Discussion

Evaluation of risk stratification methods for patients presenting with chest pain in the ED is crucial for improving patient outcomes and efficient resource utilization. This study compared 3 widely used scoring systems, HEART, T-MACS, and HE-MACS, assessing their predictive value for MACE and mortality within 30 days.

Previous studies have demonstrated that the incidence of MACE in patients with a HEART score of 0 to 3 ranges from 0.99% to 2.0%, with some studies using a modified HEART score reporting rates as low as 1.1%. In our cohort, the MACE rate in this group was 4.3%, exceeding the range reported in the literature. For patients with a HEART score of 4 to 6, the reported incidence of MACE varies between 11.6% and 28.0%, whereas in our study, it was observed at 25.5%. Among patients with a HEART score of 7 to 10, prior studies have documented MACE rates ranging from 63.0% to 73.7%, which corresponds closely with our finding of 64.5%.[5,12–15]

We investigated the validity of the T-MACS scoring system for MACE risk stratification in patients presenting to the ED was investigated. We compared the rates of MACE development in patients stratified according to the T-MACS score with the rates of MACE development in the literature. We found that the rates of MACE development in patients whose T-MACS scores were classified as very low-, low-, medium-, and high-risk were 4.8%, 19.8%, 40.5%, and 88.9%, respectively. These rates were reported as 1.2% to 3.8% for very-low-risk patients, 6.3% to 6.6% for low-risk patients, 12.5% to 47% for medium-risk patients, and 76.1% to 100% for high-risk patients in the previous studies.[10,12,16] In conclusion, the T-MACS yielded results consistent with those reported in the literature. Since the rate of MACE development is high, especially in high-risk patients, these patients should be hospitalized in the ED, and their treatment should be properly designed. Therefore, the T-MACS scoring system is thought to perform better than the HEART scoring system.

The HE-MACS score was found to exclude MACE by 100% in the very-low-risk group, as demonstrated in the study by Alghamdi et al,[10] where the number of patients in this group was 44 (5.5%) out of a total of 804. While this number was 53 (8.8%) on average in validation studies, in our study, it was 32 (5.7%) and the overall number of patients was 560. These results were similar to those reported in the literature. Although HE-MACS can exclude MACE by 100% in the very-low-risk group, it can be used to exclude very-low-risk cases, but its use in the ED is limited because this group is highly isolated. Therefore, validation studies with larger numbers of cases are required. In our study, MACE did not develop in this group, and this result is consistent with our findings. Although the MACE rate in the low-risk group was between 3.2% and 7.7% in the

literature, it was only 10% in our study. In the medium-risk group, the MACE rate was between 17% and 21.5% in the literature, whereas it was 26.5% in our study. In the high-risk group, the MACE rates ranged between 52.3% and 71.8% in the literature and 67.8% in our study. These results are in general agreement with those in the literature.

The ROC analysis conducted in this study provides crucial insights into the predictive performance of the HEART, T-MACS, and HE-MACS scoring systems for patients presenting with chest pain in the ED.

ROC analysis for the HEART score revealed an area under the curve (AUC) of 0.827, with a sensitivity of 87% and specificity of 63.5% for predicting MACE within 30 days. The 95% confidence interval (CI) for the AUC ranged from 0.791 to 0.864, indicating an important level of accuracy in distinguishing patients at risk of MACE. For mortality prediction within 30 days, the HEART score demonstrated an even higher AUC of 0.929, with perfect sensitivity (100%) and specificity of 81%. The 95% CI for this analysis was 0.875 to 0.982, further highlighting the reliability of the HEART score in identifying patients at risk of death.

Table 2

Characteristics of the study group.

Characteristics	n (%)
Sex	
Male	361 (64.5)
Female	199 (35.5)
Comorbidities	
Hypertension	279 (49.8)
Coronary artery disease	252 (45.0)
Diabetes mellitus	152 (27.1)
Hyperlipidemia	91 (16.3)
Congestive heart failure	47 (8.4)
COPD	29 (5.2)
Cardiomyopathy	4 (0.7)
CAD risk factors	
Smoking history	314 (56.1)
Diabetes mellitus	152 (27.1)
CABG story	52 (9.3)
Family history of CAD	51 (9.1)

CABG = coronary artery bypass surgery, CAD = coronary artery disease, COPD = chronic obstructive pulmonary disease.

The T-MACS score showed an AUC of 0.851, with a sensitivity of 80.8% and specificity of 68.8% for predicting MACE within 30 days. The 95% CI for the AUC was 0.814 to 0.889, demonstrating robust predictive power. In terms of mortality prediction, the T-MACS achieved an AUC of 0.875, with a sensitivity of 85.7% and specificity of 83.9%. The 95% CI for the AUC ranged from 0.751 to 0.999, indicating robust performance, although slightly lower than that of the HEART score.

The HE-MACS score yielded an AUC of 0.806 for predicting MACE, with a sensitivity of 81.5% and specificity of 68.4%. The 95% CI ranged from 0.765 to 0.848, reflecting good predictive capability, but was slightly lower than the HEART and T-MACS scores. For mortality prediction, the HE-MACS score had an AUC of 0.729, with a sensitivity of 71.4% and specificity of 80.7%. The 95% CI for the AUC was between 0.512 and 0.946, indicating moderate predictive ability. In a triage scoring study conducted by Alghamdi et al,[10] the HE-MACS score had an AUC value of 0.82, with a sensitivity of 100% and 98.9% in validation studies.[17] Based on these data, we believe that the HE-MACS score is the most successful at predicting the likelihood of low-risk patients with chest pain returning to the ED with similar complaints.

In our study, the HE-MACS score was the most successful test for ruling out MACE in the low-risk group, while the T-MACS score was the most successful in detecting MACE in the high-risk group. This is because the T-MACS score uses high-sensitivity troponin, which increases its specificity compared with HE-MACS. In addition, the fact that the T-MACS score classifies 95% of patients as high-risk, whereas the HE-MACS score classifies only 50% as high-risk also contributes to this outcome.

In the reviewed studies, the sensitivity of T-MACS scores for ruling out MACE in low-risk groups ranged from 99.1% to 100%.[8,18] However, in our study, this rate was 80.2%, which is lower than that reported in the literature. We believe that this discrepancy is due to our inability to determine the quantitative values of 5 to 14 for hs-cTn, a crucial factor for the T-MACS score. For patients with hs-cTn <14 and no increase in control hs-cTn levels, we quantified the troponin level as 5. We believe that the quantitative method used in our study has some limitations.

In the study by Body et al,[16] the MACE development rate for the very low- and low T-MACS score groups was 1.1%, compared with 3.0% for the HEART score. Ruangsomboon et al.[19] divided low-risk groups into very low (HEART score < 2) and low-risk groups (HEART score < 3), finding the HEART score's

Table 3

Analysis of scoring systems based on their ability to predict MACE and mortality within a 30-day period.

	30 d MACE progress		30 d mortality		
Scoring system	**Progressed n (%)**	**Not progressed n (%)**	**Observed n (%)**	**Not observed n (%)**	***P***
HEART classification					
0–3 Point	8 (4.3)	179 (95.7)	0 (0.0)	187 (100.0)	**<.001***
4–6 Point	67 (25.5)	196 (74.5)	0 (0.0)	263 (100.0)	
7–10 Point	71 (64.5)	39 (35.5)	7 (6.4)	103 (93.6)	
T-MACS classification					
<2% Very low	12 (4.8)	216 (95.2)	0 (0.0)	228 (100.0)	**<.001***
2%–4% Low	17 (19.8)	69 (80.2)	1 (1.2)	85 (98.8)	
5%–94% Medium	85 (40.5)	125 (59.5)	2 (1.0)	208 (99.0)	
≥95 High	32 (88.9)	4 (11.1)	4 (11.1)	32 (88.9)	
HE-MACS classification					
<4% Very low	0 (0.0)	32 (100.0)	0 (0.0)	32 (100.0)	**<.001***
4%–6.9% Low	11 (10.0)	99 (90.0)	1 (0.9)	109 (99.1)	
7%–49.9% Medium	95 (26.5)	264 (73.5)	3 (0.8)	356 (99.2)	
≥50 High	40 (67.8)	19 (32.2)	3 (5.1)	56 (94.9)	

HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndrome, MACE = major adverse cardiovascular event, T-MACS = troponin-only Manchester acute coronary syndrome.

**P* value below <.05 indicates statistical significance.

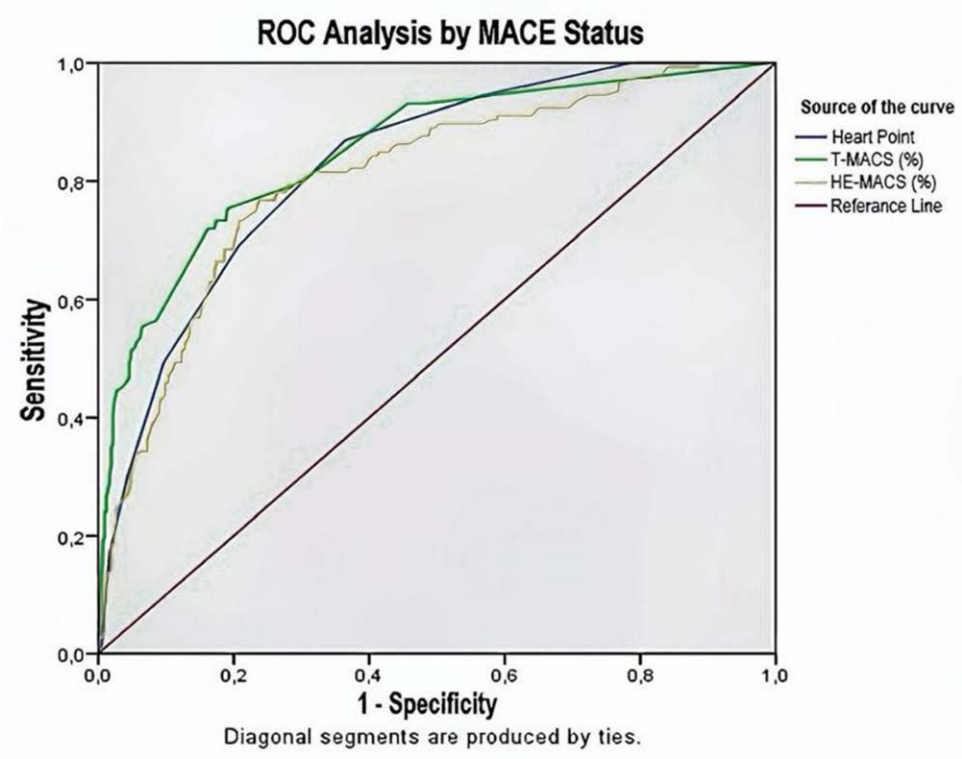

Figure 2. ROC analysis of HEART, T-MACS, and HE-MACS in determining the MACE status of cases. HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndrome, MACE = major adverse cardiac event, ROC = receiver operating characteristic, T-MACS = troponin-only Manchester acute coronary syndrome.

Table 4

ROC analysis of HEART and T-MACS in determining 30-day MACE status of patients.

					95% CI		
Parameter	**Cutoff**	**AUC**	**Sensitivity**	**Specifity**	**Lower bound**	**Upper bound**	***P***
HEART	4.5	0.827	87	63.5	0.791	0.864	**<.001***
T-MACS	4.5	0.851	80.8	68.8	0.814	0.889	**<.001***
HE-MACS	13.85	0.806	81.5	68.4	0.765	0.848	**<.001***

AUC = area under the curve, CI = confidence interval, HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndrome, MACE = major adverse cardiovascular event, ROC = receiver operating characteristic, T-MACS = troponin-only Manchester acute coronary syndrome.
**P* value below <.05 indicates statistical significance.

sensitivity and negative predictive value (NPV) to be 100% for very low risk, and 96.6% sensitivity and 97.1% NPV for low risk. The HE-MACS scores were not included in this study. Poldervaart et al[14] reported a HEART score NPV of 98% for low-risk patients, increasing to 99% when revised for very-low-risk patients (HEART score < 2). Alghamdi et al[10] found the sensitivity and NPV to be 100%, with validation studies showing 98.9% sensitivity and 98.8% NPV. Our study aligns with these findings, indicating no mortality in the very low- and low-risk groups and no significant differences in mortality prediction among the scoring systems. These results highlight the need for larger validation studies and more balanced scoring system revisions, particularly for low-risk cases.

Based on our study data, we believe that the superiority of T-MACS in identifying MACE, regardless of risk classification, is due to its parameters, which include current complaints, vital signs, and physical examination findings, thus providing a better reflection of MACE. In terms of mortality, our study suggests that the HEART score is superior to the T-MACS score in predicting mortality. This is likely because the parameters of the HEART score focus on the patient's risk factors and comorbidities rather than their immediate condition, thereby providing a better prediction of 30-day mortality.

The comparative analysis of these scores through ROC curves indicates that while all 3 scoring systems (HEART, T-MACS, and HE-MACS) are effective in predicting 30-day MACE and mortality, the HEART score demonstrates the highest overall accuracy, particularly in mortality prediction. The high sensitivity and specificity values, particularly for the HEART score, underline its utility in clinical settings for risk stratification.

In our study, we found that patients visited clinics without complaints across all scoring systems and risk groups. While there is no specific ED study on this topic, the recommendation for follow-up visits from the ED for further investigation and treatment creates a limitation for comparison. Thus, more comprehensive and targeted studies are needed to compare the scoring systems. On the other hand, we investigated whether patients had recurring cardiac complaints or visited any healthcare facility. Some patients revisited healthcare facilities without recurring cardiac complaints, often because of their primary care physician's recommendation for cardiology follow-up, even without active complaints. This limits the comparison among the scoring systems.

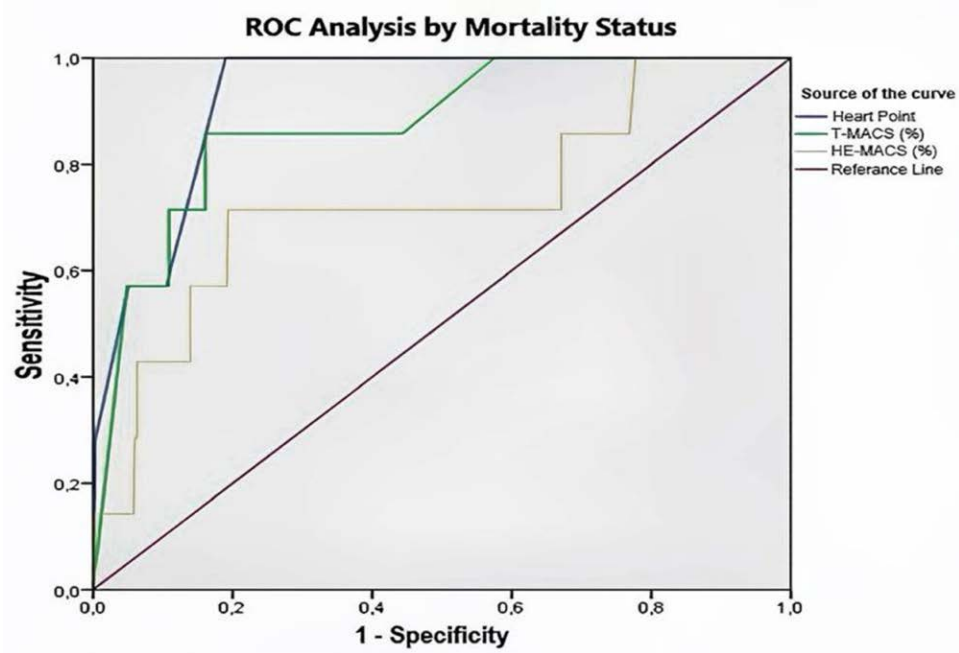

Figure 3. ROC analysis of HEART, T-MACS, and HE-MACS in determining mortality status of cases. HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndrome, ROC = receiver operating characteristic, T-MACS = troponin-only Manchester acute coronary syndrome.

Table 5

ROC analysis of HEART and T-MACS in determining mortality status of cases.

					95% CI		
Parameter	**Cutoff**	**AUC**	**Sensitivity**	**Specificity**	**Lower bound**	**Upper bound**	***P***
HEART	6.5	0.929	100	81	0.875	0.982	**<.001***
T-MACS	32.5	0.875	85.7	83.9	0.751	0.999	**<.001***
HE-MACS	40.95	0.729	71.4	80.7	0.512	0.946	**.037***

AUC = area under the curve, CI = confidence interval, HEART = history, ECG, age, risk factors, and troponin, HE-MACS = history and electrocardiogram-only Manchester acute coronary syndrome, ROC = receiver operating characteristic, T-MACS = troponin-only Manchester acute coronary syndrome.

**P* value below <.05 indicates statistical significance.

5. Summary

In our study evaluating the HEART, T-MACS, and HE-MACS scores for diagnosing and managing ACS in patients presenting with chest pain in the ED, we found that the HE-MACS score had the highest sensitivity, especially for low-risk patients. However, it should be noted that this score targets a highly isolated group and must be evaluated along with troponin levels. The HEART score was found to be the strongest predictor of mortality risk owing to its parameters and remains important for practical use in the ED. The T-MACS score had the highest specificity for high-risk patients and was the most capable of predicting 30-day MACE, making it crucial for emergency use. In addition, we recommend using high-sensitivity troponin kits that provide quantitative values from 0 and results within the first hour to accelerate patient management. Each scoring system has advantages and disadvantages. Therefore, selecting the most appropriate scoring system for each patient and managing the process accordingly would provide the greatest benefit to patients.

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