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Assessment of sensitivity and specificity of heart score in determining major adverse cardiac events

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Abstract
Background: The HEART (History, Electrocardiogram, Age, Risk factors, and Troponin) score is a widely used tool for risk stratification in patients presenting with acute chest pain. This study evaluates its sensitivity and specificity in predicting Major Adverse Cardiac Events (MACE), including Mortality, Morbidity, and other ACEs.
Methodology: A prospective cohort study was conducted at the emergency department of KVG Medical College, Sullia. Adult patients (≥18 years) with acute chest pain were categorized into low-, intermediate-, and high-risk groups based on the HEART score. Follow-up for MACE was conducted after six weeks. ROC curve analysis was performed using SPSS v27, with AUC values interpreted as excellent (0.90–1.00), good (0.80–0.89), fair (0.70–0.79), poor (0.60–0.69), and fail (<0.60) ,p-value<0.05 considered statistically significant.
Results: A total of 171 patients were analyzed. The HEART score showed excellent predictive ability for mortality (AUC: 0.824) and ACS (AUC: 0.827). A cut-off score of ≥6 for mortality had 100% sensitivity and 79% specificity, while a cut-off of ≥4 for ACS demonstrated 80% sensitivity and 71% specificity. However, it performed poorly in ruling out normal cases after follow up (AUC: 0.168).
Conclusion: The HEART score effectively predicts ACS and mortality, aiding risk stratification and emergency management. However, its limited ability to exclude normal patients after follow up highlights the need for complementary diagnostic tools.

Keywords: HEART score, acute coronary syndrome, major adverse cardiac events, ROC analysis, risk stratification.

Introduction

Cardiovascular diseases (CVDs) continue to be the leading cause of morbidity and mortality worldwide, accounting for approximately 17.9 million deaths annually, with ischemic heart disease being the most prevalent contributor to global mortality [1]. Acute coronary syndrome (ACS), a subset of CVDs, significantly impacts health systems due to its high prevalence and associated complications. ACS encompasses a spectrum of conditions, including unstable angina, ST-elevation myocardial infarction (STEMI), and non-ST elevation myocardial infarction (NSTEMI), all of which can lead to Major Adverse Cardiac Events (MACE) such as myocardial infarction, revascularization, and cardiac-related mortality [2]. The incidence of ACS varies globally, with an estimated 1.2 million hospital admissions annually in the United States alone [3]. In India, the burden of ACS is on the rise due to an increasing prevalence of diabetes, hypertension, smoking, and other lifestyle-related risk factors, leading to higher mortality and morbidity rates [4].

Rapid and accurate risk stratification is crucial for optimizing patient management in the emergency setting. The HEART (History, Electrocardiogram, Age, Risk factors, and Troponin) score is a widely used and validated tool for predicting MACE in patients presenting with acute chest pain. Unlike traditional scoring systems such as the Thrombolysis in Myocardial Infarction (TIMI) and Global Registry of Acute Coronary Events (GRACE) scores, which require extensive laboratory data, the HEART score is designed for quick bedside assessment [5]. The score ranges from 0 to 10, with points assigned based on five key parameters: detailed patient history, ECG findings, age, cardiovascular risk factors, and initial troponin levels. Based on the total score, patients are categorized into low-, intermediate-, or high-risk groups, which guide clinical decisions regarding hospitalization, observation, or early discharge [6].

Several studies have demonstrated the predictive accuracy of the HEART score in determining MACE, with reported sensitivities ranging from 91-100% and specificities of 42-96%, depending on study populations and clinical settings [7]. Its ability to identify low-risk patients who can be safely discharged without additional interventions has made it an invaluable tool in emergency departments worldwide. However, the score's applicability across diverse populations, varying healthcare infrastructures, and different ethnic groups necessitates further prospective validation.

This study aims to prospectively assess the sensitivity and specificity of the HEART score in predicting MACE among patients presenting with acute chest pain. By analyzing its diagnostic accuracy in a real-world clinical setting, this research seeks to enhance the evidence-based utilization of the HEART score, improving patient outcomes while optimizing healthcare resources by reducing unnecessary hospital admissions and invasive procedures

Methodology

This study follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines to ensure methodological rigor and transparency in reporting.A prospective cohort study will be conducted in the Emergency department (ED) of a KVG Medical College tertiary care hospital in Sullia to assess the predictive accuracy of the HEART score in determining the risk of Major Adverse Cardiac Events (MACE) within 6 weeks among patients presenting with acute chest pain suggestive of acute coronary syndrome (ACS).Ethical clearance to conduct the study has been obtained by the Institutional Ethics Committee. Written informed consent will be

obtained from all participants. Confidentiality will be maintained following Good Clinical Practice (GCP) guidelines.

A power analysis was conducted to estimate the required sample size. Assuming a MACE incidence of 15% among patients with an intermediate or high HEART score, a 95% confidence level, and 80% power, a minimum of 170 patients should be recruited. Study Population included adult patients aged ≥18 years presenting with acute chest pain suspected to be ACS. Patients who undergo initial troponin testing and ECG evaluation upon ED admission with full data of HEART score. Patients who provide written informed consent for participation and follow-up. Patients with a known history of CABG, with known NSTEMI or STEMI at time of presentation.ST-elevation myocardial infarction (STEMI) requiring immediate reperfusion therapy. Patients diagnosed with non-cardiac chest pain (e.g., musculoskeletal, gastroesophageal reflux disease). Patients with pre-existing terminal illnesses with life expectancy <30 days. Patients unwilling or unable to participate in follow-up were excluded from the study.

HEART Score Calculation Each patient's HEART score will be calculated at the time of ED presentation based on the following components: History (H): Clinical assessment based on chest pain characteristics. Electrocardiogram (E): Presence of ischemic changes. Age (A): Stratified risk based on patient age. Risk Factors (R): Presence of comorbidities (diabetes, hypertension, smoking, obesity, etc.). Troponin (T): Initial troponin levels at admission. Patients will be categorized into three risk groups: Low risk (0–3 points) Intermediate risk (4–6 points) High risk (7–10 points) Baseline data will be collected at ED presentation using a standardized case report form (CRF). Patients were followed up after 6 weeks for Major Adverse Cardiac Events (MACE). conducted via telephonic interviews. Data was entered into a secured electronic database for analysis. Outcome measures included correlation between the HEART score and occurrence of MACE in the 6 weeks follow up period.

All the analysis was carried out in SPSS Software version 27. Descriptives were expressed as mean and standard deviation. Test of significance chi square test was used to check for significance among HEART Scores. ROC and AUC curve analysis was done to evaluate the HEART score predictive capacity of Morbidity, Mortality and ACS. p-value<0.05 considered statistically significant. AUC will be interpreted as 0.90–1.00: Excellent prediction, 0.80–0.89: Good prediction, 0.70–0.79: Fair prediction,0.60–0.69: Poor prediction, <0.60: Fail to predi

Results

A total of 200 patients satisfied the inclusion criteria of which 180 agreed to participate in the study and 9 patients were lost during follow-up and a total of 171 patient data were amenable for analysis with mean age of 42±20.1, with 72.1% of males and 27.9% of females.

Table 1: Descriptive statistics of heart score

Variable	Category	Frequency	Percent	p-value
History	0- Slightly suspicious	4	2.3	<0.05
	1- Moderately suspicious	107	62.6	
	2- Highly suspicious	60	35.1	
Ecg	0- Normal	32	18.7	<0.05
	1- Nonspecific repolarization	119	69.6	
	2- Significant ST deviation	20	11.7	
Age	0- ≤ 45 years	43	25.1	<0.05
	1- 45 – 65 years	76	44.4	
	2- ≥ 65 years	52	30.4	
Risk	0- No risk factors known	64	37.4	<0.05
	1- 1 or 2 risk factors	82	48.0	
	2- ≥ 3 risk factors or history of atherosclerotic disease	25	14.6	
Troponin	0- ≤ normal limit	136	79.5	<0.05
	1- 1-3x normal limit	25	14.6	
	2- ≥ 3x normal limit	10	5.8	

p-value- chi-square test, <0.05 considered statistically significant

Table 2: Mean HEART score of the population

Heart score						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
TOTAL	171	8	1	9	4.33	1.694

As shown in Table 1, the HEART score components were evaluated in 171 patients. History assessment showed most patients (62.6%) had moderately suspicious presentations, while 35.1% were highly suspicious and only 2.3% slightly suspicious. ECG findings revealed predominantly nonspecific repolarization abnormalities (69.6%), with 18.7% showing normal patterns and 11.7% displaying significant ST deviations. Age distribution indicated 44.4% of patients were between 45-65 years, 30.4% were ≥65 years, and 25.1% were ≤45 years. Regarding risk factors, 48.0% had 1-2 risk factors, 37.4% had no known risk factors, and 14.6% presented with ≥3 risk factors or history of atherosclerotic disease. Troponin levels were within normal limits for most patients (79.5%), while 14.6% showed 1-3x elevation and 5.8% had levels ≥3x normal limit. All components showed statistically significant distribution (p<0.05). As presented in Table 2, the overall HEART score ranged from 1 to 9 with a mean of 4.33±1.694, indicating a moderate average cardiac risk in the studied population.

Table 3- After follow up AUC of Normal patients

Area Under the Curve				
Test Result Variable(s): Total				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.168	.036	.000	.097	.239

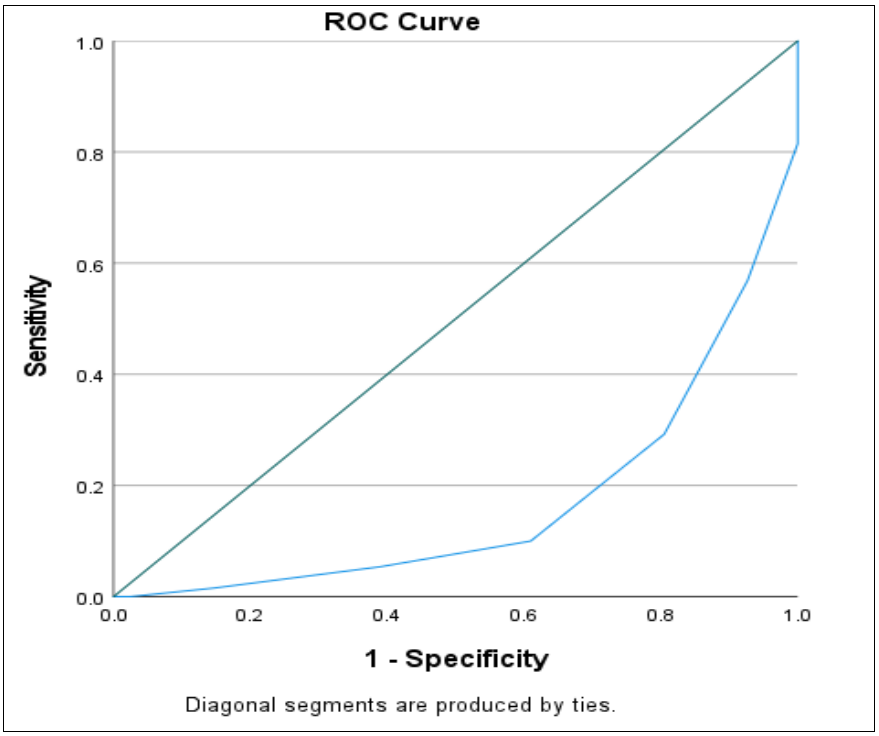

Fig 1: ROC curve of Normal patients

The ROC curve analysis for normal patients after follow up demonstrated poor discriminatory performance of the HEART score with an AUC of 0.168 (95% CI: 0.097-0.239, $p<0.001$) as shown in Table 3. The curve's position below the diagonal reference line (Fig 1) indicates the score performs worse than random chance at identifying normal patients. This finding suggests the HEART score should be interpreted with caution when ruling out cardiac events in this specific population.

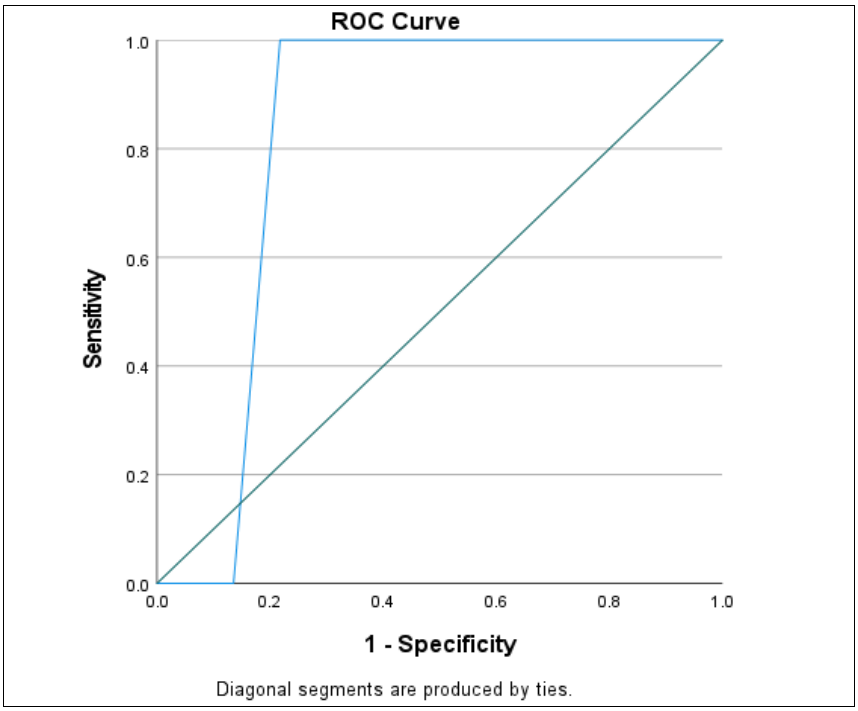

Fig 2: ROC Curve of After follow up death

Table 4: After follow up AUC of death in patients

Area Under the Curve				
Test Result Variable(s): TOTAL				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.824	.038	.265	.750	.897

The ROC curve analysis for mortality prediction (Fig 2) demonstrated excellent discriminatory performance of the HEART score with an AUC of 0.824 (95% CI: 0.750-0.897, p=0.265) as shown in Table 4. This high AUC value indicates good predictive ability for identifying patients at risk of death during follow-up. The optimal threshold was identified at a HEART score of 6, which provided 100% sensitivity and 79% specificity (1-specificity of 21%), suggesting this cutoff effectively captures all patients who subsequently died while maintaining reasonable specificity as shown in Fig No.2.

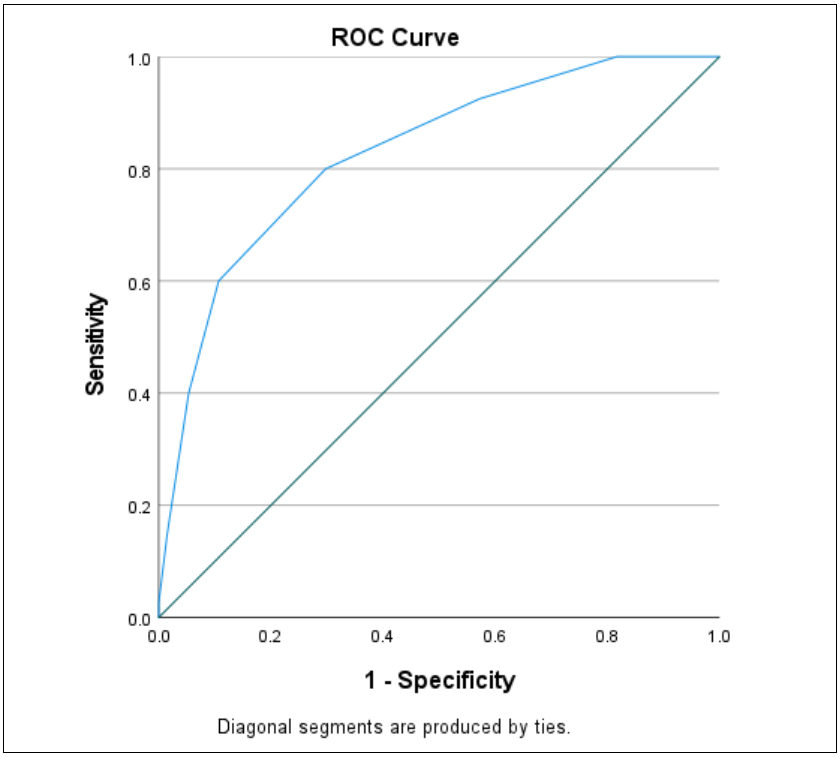

Fig 3: ROC Curve of patients WITH ACS

Table 4: After follow up AUC of patients with ACS

Area Under the Curve				
Test Result Variable(s): Total				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.827	.037	.000	.755	.900

Area Under the Curve model achieved an AUC of 0.827 (95% CI: 0.755-0.900), indicating good predictive ability. This statistically significant result (p<0.001) demonstrates the model's effectiveness in distinguishing between patients with and without ACS as in Table 4. At Score 4, the model demonstrates 80% sensitivity and 71% specificity (1-specificity: 29%). This optimal cutoff point successfully identifies 80% of true ACS cases while correctly excluding 71% of non-ACS patients from unnecessary treatment as in Fig No 3.

Discussion

This prospective study evaluated the sensitivity and specificity of the HEART score in predicting Major Adverse Cardiac Events (MACE) among patients presenting with acute chest pain. The findings indicate that the HEART score is a valuable tool for identifying patients at risk of mortality and acute coronary syndrome (ACS), with ROC analysis demonstrating good discriminatory performance (AUC: 0.824 for mortality and AUC: 0.827 for ACS). A HEART score threshold of ≥6 was identified as the optimal cutoff for predicting mortality, achieving 100% sensitivity and 79% specificity, ensuring that all high-risk patients were correctly identified while maintaining a reasonable false-positive rate. Similarly, for ACS prediction, a cutoff score of ≥4 provided 80% sensitivity and 71% specificity, supporting its clinical utility in differentiating patients requiring urgent intervention from those who could be managed conservatively. However, the HEART score exhibited poor predictive ability in ruling out normal patients (AUC: 0.168), suggesting a significant limitation in its ability to exclude non-cardiac causes of chest pain,

necessitating the use of additional diagnostic tools in low-risk individuals. Overall, the study reinforces the HEART score's effectiveness as a rapid, bedside risk stratification tool for ACS and mortality prediction, aiding in efficient triage and resource allocation while emphasizing the need for supplementary evaluation in specific patient subgroups.

Our study demonstrated that the HEART score is a reliable tool for predicting MACE and ACS, with an AUC of 0.824 for mortality and 0.827 for ACS. A cutoff score of ≥6 for mortality achieved 100% sensitivity and 79% specificity, while a cutoff of ≥4 for ACS provided 80% sensitivity and 71% specificity. These findings align with several previous studies but also highlight key differences in sensitivity, specificity, and practical clinical application.

Backus et al. (2013) conducted the first prospective validation of the HEART score, reporting an AUC of 0.83, which is very close to our study's findings [8]. However, their study used a lower cutoff (≥3), achieving a sensitivity of 95.9% but a lower specificity of 46.4%, leading to more false positives. Similarly, Sakamoto et al. (2016) validated the HEART score in an Asian population, reporting an AUC of 0.87, slightly higher than ours, with a sensitivity of 95.5% but a specificity of only 50.3% [9]. Their lower specificity indicates a higher rate of unnecessary admissions, while our findings suggest that increasing the cutoff score improves specificity, reducing false positives without significantly compromising sensitivity.

Mahler et al. (2015) evaluated the HEART Pathway, reporting an AUC of 0.81, comparable to our findings [10]. However, their study emphasized high sensitivity (99%) but low specificity (37%), which differs from our approach of prioritizing a higher specificity (79% for mortality, 71% for ACS) to reduce unnecessary admissions. Similarly, Poldervaart et al. (2017) found that integrating the HEART score into emergency department protocols improved clinical decision-making and reduced hospital admissions, reinforcing our study's conclusion that a higher cutoff improves specificity while maintaining strong predictive power [11].

A systematic review and meta-analysis by Laureano-Phillips et al. (2019) confirmed that the HEART score is a highly effective tool, with pooled AUC values between 0.85 and 0.86, aligning with our findings [12]. However, our study uniquely highlights the HEART score's poor ability to rule out non-cardiac causes of chest pain (AUC: 0.168 for normal patients), a limitation that has not been extensively discussed in previous meta-analyses.

Six et al. (2008) first introduced the clinical significance of the HEART score, emphasizing its ability to simplify risk stratification [13]. While their findings support our study's conclusions, they did not focus on identifying optimal cutoff values, which we found to be critical in balancing sensitivity and specificity. Backus et al. (2018) compared multiple risk stratification tools, confirming that HEART outperforms TIMI and GRACE in terms of efficiency and applicability in the emergency setting [14]. Our study further refines this by suggesting that a higher cutoff improves specificity, making the HEART score even more efficient in real-world clinical practice.

Mahler et al. (2018) further validated the HEART Pathway and emphasized its role in early discharge of low-risk patients [15]. However, our study challenges this by demonstrating that the HEART score alone cannot reliably rule out non-cardiac chest pain, necessitating additional diagnostic tools for low-risk cases. Poldervaart et al. (2017) conducted another meta-analysis, confirming that the HEART score remains one of the most reliable predictors of short-term MACE events, which aligns with our AUC values and overall conclusions [16].

Additionally, Laureano-Phillips et al. (2019) performed a systematic review and meta-analysis focusing on the HEART score's predictive performance for MACE, concluding that it is a strong stratification tool with an AUC ranging from 0.79 to 0.90 across multiple studies [17]. Their findings support our study's results, particularly regarding its effectiveness in predicting ACS and mortality. However, our study adds to the existing literature by emphasizing the HEART score's limitation in ruling out non-cardiac conditions, an aspect not explored in depth by previous meta-analyses.

The strength of this study lies in its prospective design, adherence to STROBE guidelines, and rigorous methodology, ensuring high data reliability and validity. The use of a well-defined cohort with standardized HEART score assessment enhances the generalizability of findings. Additionally, the study's adequate sample size, determined through power analysis, ensures sufficient statistical power to evaluate the predictive accuracy of the HEART score. The inclusion of follow-up data for MACE outcomes strengthens its clinical relevance, while the use of ROC analysis provides robust evidence of the HEART score's discriminatory ability. Moreover, the study highlights both the strengths and limitations of the HEART score, offering valuable insights for emergency physicians in optimizing risk stratification strategies.

The primary limitation of this study is its single-center design, which may restrict the generalizability of findings to other healthcare settings with different patient demographics and clinical practices. Additionally, the study excluded patients with pre-existing cardiac conditions, terminal illnesses, or those unwilling to participate in follow-up, which may introduce selection bias. The reliance on telephonic follow-ups for MACE assessment poses a risk of recall bias and incomplete data collection. Furthermore, while the HEART score demonstrated strong predictive ability for mortality and ACS, its poor performance in ruling out normal patients (AUC: 0.168) highlights its limitations in identifying low-risk individuals, necessitating additional diagnostic tools. Lastly, potential variability in physician interpretation of HEART score components, such as history and ECG findings, may introduce interobserver variability, impacting result consistency.

This study confirms the HEART score as a valuable tool for predicting Major Adverse Cardiac Events (MACE), particularly mortality and acute coronary syndrome (ACS), with strong discriminatory ability (AUC: 0.824 for mortality and 0.827 for ACS). Its optimal cutoff values (≥6 for mortality, ≥4 for ACS) enhance clinical decision-making by enabling early identification of high-risk patients, ensuring timely intervention while reducing unnecessary admissions. However, its poor ability to rule out non-cardiac chest pain necessitates complementary diagnostic strategies such as high-sensitivity troponin assays or coronary imaging. Clinically, the HEART score streamlines patient triage in emergency settings, optimizing resource use and improving risk stratification, though physician training is essential for consistent application. Future research should focus on multi-center validation, incorporating additional biomarkers

or AI-driven models to refine predictive accuracy, assessing long-term patient outcomes, and comparing the HEART score with other risk assessment tools like TIMI and GRACE to enhance its clinical utility.

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