ORIGINAL ARTICLE

# HEART Score: Prospective Evaluation of Its Accuracy and Applicability

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## Abstract

**Background:** The History, Electrocardiogram, Age, Risk factors, and Troponin I (HEART) score is a simple method to risk stratify patients with chest pain according to the risk for incidence of major adverse cardiac events (MACEs).

**Materials and methods:** A 202-patient prospective, single center study at Sri Siddhartha Medical College, Tumkur. Patients included were those who were presented to the emergency department (ED) due to non-traumatic chest pain, irrespective of age or any previous medical treatments, and were later referred to the cardiac care unit (CCU), cardiology department (CD). The end point of the study was the incidence of MACE.

**Results:** There was a high occurrence of endpoint-myocardial infarction (MI) as MACE among patients with a high-risk HEART score ($p < 0.001$). About 52 patients (81.3%) who had MI had a high-risk score and 2 patients (3.1%) who had an endpoint of MI had a low-risk score. Sensitivity of HEART score to anticipate MACE was 91%, and the specificity was 80%.

**Conclusions:** Our prospective study demonstrates the high sensitivity of the HEART score to effectively risk stratify patients and project the phenomenon of MACE. We support the use of the HEART score as a fast and accurate risk stratification tool in the ED.

**Keywords:** Age, risk factors, and troponin I score, Cardiology, Emergency medicine, History electrocardiogram, Major adverse cardiac events, Myocardial infarction, Risk stratification.

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## Highlights

Our prospective study demonstrates the high sensitivity of History, Electrocardiogram, Age, Risk factors, and Troponin I (HEART) score to effectively risk stratify patients and project the phenomenon of major adverse cardiac events (MACEs). We support the use of HEART score as a fast and accurate risk stratification method. We believe the application of the HEART score in most Emergency and Cardiology Departments can help in early intervention, leading to saving more lives.

## Introduction

The HEART score is a simple method to triage patients with chest pain for the risk of occurrence of MACEs.[1]

Major adverse cardiac events include mortality, or myocardial infarction (MI) or coronary revascularization.[2]

History, electrocardiogram, age, risk factors, and troponin I score efficiently divide patients into low, moderate, and high-risk groups.[3] These aids to steer workforce, better resource usage, quick emergency department (ED) discharge, and rapid mediation.[3]

Efficient and valid risk stratification in the ED is important.[4] Chest pain management is the most taxing in the ED. This symptom accounts for 5–20% of all ED admissions.[5] Typical MI symptoms accompanying ST elevation or depression seen in electrocardiogram (ECG) is a sign of coronary revascularization or reperfusion, and troponin I is estimated only in difficult to diagnose cases of MI.[6]

Clinical difficulty occurs in identifying patients with acute coronary syndrome (ACS) needing prompt intervention from those that do not have life-threatening disease.

To improve the perfection in the clinical estimation of MACE in patients, the European society of cardiology (ESC) and the national institute for health and care excellence (NICE) suggested the application of the global registry of acute coronary events (GRACE) and the thrombolysis in myocardial infarction (TIMI) risk scores.[7–10]

In 2013, Backus et al.[11] proved in a study that the c-statistic of the HEART score (0.83) was significantly higher than that of the TIMI (0.75) and GRACE (0.70) scores ($p < 0.0001$).

Our aim was a prospective study of HEART score, it's accuracy and applicability among patients presenting with chest pain in the ED who were later referred to the cardiology department (CD).

## Materials and Methods

### Study Design

This was a prospective, single center observational study conducted after approval of institutional ethics committee (SSMC/MED/IEC-159/Nov-2023).

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**Conflict of interest:** None

### Study Population and Inclusion Criteria

We included patients who presented to the ED due to chest pain of all age-groups and were later referred to cardiac care unit (CCU) of CD, Sri Siddhartha Medical College, Tumkur. Patients who presented to the ED from 6th October 2023 to 12th December 2023 were part of the study.

### Data Collection

The patient's demographic details were entered in the case sheet on presentation to the ED and history was noted by emergency medicine residents, which included history of presenting illness, past history, including risk factors and co-morbidities, and a general physical examination.

On presentation, a blood sample of the patient was collected and sent to the laboratory for troponin I level. Troponin I was estimated from a blood specimen collected immediately on presentation to the ED and was used for the calculation. A printout of the ED presentation ECG was attached to the patient file.

### HEART Score Criteria

Total HEART Score and required risk management.

- Score 0–3: Low risk that requires early discharge.
- Score 4–6: Moderate risk that requires observation and further investigations.
- Score 7–10: High-risk that requires immediate intervention.[12]

#### *History*

Score 0: Nonspecific history for ACS; Score 1: Mixed history elements; Score 2: Specific history for ACS.[12]

Relevant ACS history-angina, radiation of chest pain to the arm, cramping pain in the chest with nausea, emesis, or diaphoresis, chest pain on exertion and exercise, and effects of oral nitroglycerin.[13]

Non-ACS history-pleuritic pain, pain synonymous with palpation; stabbing/pinching pain, pain in the mediastinum occurring in an area smaller than a coin.[13]

#### *ECG*

Score 0: Normal ECG; Score 1: Abnormal ECG, for repolarization abnormalities without ST elevation/depression, which may include bundle branch block (BBB) or left ventricular hypertrophy (LVH) or implanted pacemaker or drug digoxin usage; Score 2: ST elevations or depressions.[12]

The American Heart Association established the following ECG criteria for ST-elevation myocardial infarction (STEMI):[14]

- Recently developed ST elevation at the J point in 2 adjacent leads with the cut-off point greater than 0.1 mV in every lead with V2 or V3 as an exception.[14]

#### *Age*

Score 0: Age < (less than) 45 years; Score 1: Age 45–64 years; Score 2: Age ≥ (greater than or equal to) 65 years.[12]

#### *Risk Factors*

Score 0: No risk factors; Score 1: one or two risk factors; Score 2: ≥ 3 risk factors; and past history of ACS.[12]

Risk factors include: Hyperlipidemia, hypertension, diabetes mellitus, smoking, family history, obesity and past history.[13]

#### *Troponin I Level (ng/mL)*

Score 0: Troponin levels normal and <0.01 ng/mL; Score 1: Troponin levels elevated one to three times the normal (0.02–0.06 ng/mL); Score 2: Troponin levels elevated more than three times (>0.06 ng/mL).

There is no data on cardiac troponin I value of the Indians.[15]

### Follow-up and Outcome

Follow-up was from the date of admission until the date of discharge, all in between 6th October 2023 and 12th December 2023. Data was taken from the patient files in the medical records department, including discharge letters. Outcome was the diagnosis mentioned in the specific patient files of the CD.

### Endpoints

The end point of the study was the incidence of MACE. Major adverse cardiac events includes all events of MI, percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass grafting (CABG), and death.

### Statistical Analysis

Data was analyzed with the aid of SPSS (V-20) package. Descriptive statistics were expressed by mean, standard deviation, frequency, and percentages. Association of severity with history, ECG, age, troponin I, MACE and diagnoses were tested using the Chi-square test. The area under the receiver operating characteristic (ROC) curve was evaluated to measure the diagnostic accuracy of the HEART score. The *p*-value less than 0.05 was deemed statistically noteworthy.[16]

## Results

### Risk Stratification, MACE Occurrence and Diagnosis

The proportion of high-risk patients was 122 (60.4%), moderate risk patients were 56 (27.7%) and low risk patients was 24 (11.9%). The occurrence of MACE was among 152 (75.2%) patients. 64 patients (31.7%) had MI, 16 patients (7.9%) underwent CABG, 52 patients (25.7%) had undergone PTCA, and 20 patients (9.9%) had an endpoint as death. The most common diagnosis was STEMI (ST-elevation myocardial infarction) for 88 patients (43.6%). The 52 patients (25.7%) had a diagnosis of NSTEMI (non-ST-elevation myocardial infarction), and 20 patients (9.9%) were diagnosed with unstable angina. The least common diagnosis was coronary artery disease (CAD) for 23 patients (11.4%) and a typical chest pain for 19 patients (9.4%) (Table 1).

### Association of MACE and Various HEART Factors with Total Score Severity

There was a high occurrence of endpoints-MI as MACE among patients with high-risk HEART score ($p < 0.001$). About 52 patients (81.3%) who had MI had high-risk and 2 patients (3.1%) who had an endpoint of MI had a low-risk score. Around 38 patients (73.1%) who had undergone PTCA had a high-risk association, and 2 patients (3.8%) had a low-risk association. Sixteen patients (80.0%) with had an end point of death had a high-risk score, whereas no patients with a low-risk score had died. About 18 patients (36.0%) had low risk and No MACE occurrence while 26 patients (52.0%) had a moderate score with no MACE occurrence.

**Table 1:** Risk stratification, MACE occurrence and diagnosis

| *Factors* | *Category* | *Frequency* | *Percent (%)* |
|---|---|---|---|
| Risk stratification | High risk | 122 | 60.4 |
| | Moderate risk | 56 | 27.7 |
| | Low risk | 24 | 11.9 |
| MACE occurrence | MI | 64 | 31.7 |
| | PTCA | 52 | 25.7 |
| | CABG | 16 | 7.9 |
| | Death | 20 | 9.9 |
| Total MACE occurrence | | 152 | 75.2 |
| No MACE occurrence | | 50 | 24.8 |
| Diagnosis | NSTEMI | 52 | 25.7 |
| | STEMI | 88 | 43.6 |
| | Unstable angina | 20 | 9.9 |
| | A typical chest pain | 19 | 9.4 |
| | CAD | 23 | 11.4 |

A highly suspicious history of chest pain had high association with high risk ($p < 0.001$). No patients had a highly suspicious chest pain history of score 2 with low-risk severity. Electrocardiogram with significant ST-elevation was seen amongst high-risk score patients ($p < 0.001$). About 116 patients (80.6%) had ST changes with high-risk severity and 2 patients (1.4%) had low risk. No patients with normal sinus rhythm ECG had high risk. A total of 12 patients (100%) overall had a score of 1 with non-specific repolarization disturbances, 6 (50%) were at high risk. There was a high-risk association with the age-group 45–64 ($p < 0.001$). There are 70 patients (61.4%) with high risk were from the age-group 45–64. Out of 32, 18 patients (56.3%) were from the age-group <45 and had moderate risk. Very few, 2 patients (3.6%) in the age-group 65 and above, had a low-risk association. Around 44 patients (78.6%) were at high risk and in the age-group 65 and above. A total of 32 patients (57.1%) had ≥ 3 risk factors and history of atherosclerotic disease, along with a high-risk severity score. There are no known risk factors for 12 patients (35.3%) and had high-risk severity. There was a high-risk association with ≥ 3 times the normal limit of troponin I level and high-risk severity scores ($p < 0.001$) (Table 2).

**Table 2:** Association of MACE and various HEART factors with total score severity

| | | *Severity* | | | | |
|---|---|---|---|---|---|---|
| *Factors* | *Category* | *High risk* | *Low risk* | *Moderate risk* | *Total* | *Chi-square, p-value* |
| MACE | CABG | 10 (62.5%) | 2 (12.5%) | 4 (25.0%) | 16 (100%) | 75.372, <0.001 |
| | Death | 16 (80.0%) | 0 (0.0%) | 4 (20.0%) | 20 (100%) | |
| | MI | 52 (81.3%) | 2 (3.1%) | 10 (15.6%) | 64 (100%) | |
| | None | 6 (12.0%) | 18 (36.0%) | 26 (52.0%) | 50 (100%) | |
| | PTCA | 38 (73.1%) | 2 (3.8%) | 12 (23.1%) | 52 (100%) | |
| History | Slightly suspicious | 6 (20.0%) | 12 (40.0%) | 12 (40.0%) | 30 (100%) | 83.943, <0.001 |
| | Moderately suspicious | 10 (23.8%) | 12 (28.6%) | 20 (47.6%) | 42 (100%) | |
| | Highly suspicious | 106 (81.5%) | 0 (0.0%) | 24 (18.5%) | 130 (100%) | |
| ECG | Normal | 0 (0.0%) | 22 (47.8%) | 24 (52.2%) | 46 (100%) | 119.401, <0.001 |
| | Non-specific repolarization disturbance/LBBB/PM | 6 (50.0%) | 0 (0.0%) | 6 (50.0%) | 12 (100%) | |
| | Significant ST-elevation | 116 (80.6%) | 2 (1.4%) | 26 (18.1%) | 144 (100%) | |
| Age (in years) | <45 | 8 (25.0%) | 6 (18.8%) | 18 (56.3%) | 32 (100%) | 26.462, <0.001 |
| | 45–64 | 70 (61.4%) | 16 (14.0%) | 28 (24.6%) | 114 (100%) | |
| | 65 and above | 44 (78.6%) | 2 (3.6%) | 10 (17.9%) | 56 (100%) | |
| Risk factors | No risk factors known | 12 (35.3%) | 10 (29.4%) | 12 (35.3%) | 34 (100%) | 19.499, 0.001 |
| | 1 or 2 risk factors known | 78 (69.6%) | 10 (8.9%) | 24 (21.4%) | 112 (100%) | |
| | ≥3 risk factors or history of atherosclerotic disease | 32 (57.1%) | 4 (7.1%) | 20 (35.7%) | 56 (100%) | |
| Troponin | ≤ Normal limit | 42 (40.4%) | 24 (23.1%) | 38 (36.5%) | 104 (100%) | 44.847, <0.001 |
| | 1–3× Normal limit | 34 (89.5%) | 0 (0.0%) | 4 (10.5%) | 38 (100%) | |
| | ≥3× Normal limit | 46 (76.7%) | 0 (0.0%) | 14 (23.3%) | 60 (100%) | |
| Sex | Male | 78 (62.9%) | 16 (12.9%) | 30 (24.2%) | 124 (100%) | 2.059, 0.357 |
| | Female | 44 (56.4%) | 8 (10.3%) | 26 (33.3%) | 78 (100%) | |
| Diagnosis | NSTEMI | 50 (96.2%) | 0 (0.0%) | 2 (3.8%) | 52 (100%) | 110.186, <0.001 |
| | STEMI | 64 (72.7%) | 2 (2.3%) | 22 (25.0%) | 88 (100%) | |
| | Unstable angina | 4 (20.0%) | 6 (30.0%) | 10 (50.0%) | 20 (100%) | |
| | A typical chest pain | 0 (0.0%) | 10 (52.6%) | 9 (47.4%) | 19 (100%) | |
| | CAD | 4 (17.4%) | 6 (26.1%) | 13 (56.5%) | 23 (100%) | |

**Table 3:** Sensitivity analysis of HEART score

| *AUC* | *Cut-off* | *Sensitivity* | *Specificity* | *PPV* | *NPV* | *Accuracy* |
|---|---|---|---|---|---|---|
| 0.92 | 5.50 | 91% | 80% | 93% | 74% | 88% |

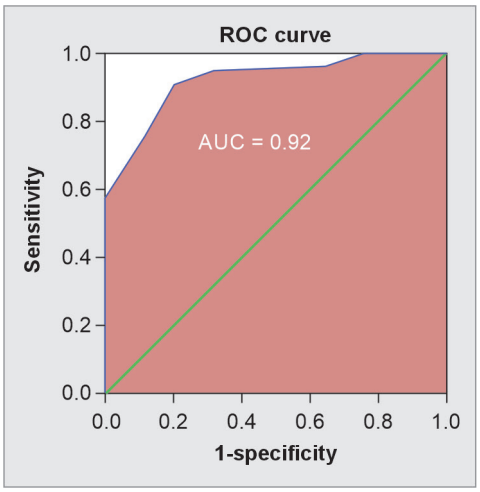


**Fig. 1:** Receiver operating characteristic (ROC) curve

### Sensitivity Analysis of HEART Score

The area under the ROC was 0.92. Sensitivity of HEART score to project the phenomenon of MACE was 91%, and specificity was 80%. The positive predictive value (PPV) calculated was 93%, and the negative predictive value (NPV) derived was 74%. Accuracy assessed was 88% (Table 3 and Fig. 1).

## Discussion

The study identifies the prognostic performance of HEART score and occurrence of MACE. The proportion of high-risk patients were 122 (60.4%), moderate risk patients was 56 (27.7%) and low risk patients was 24 (11.9%), as compared to a study a conducted in Spain whose results were: Low-risk ($n = 116$, 38.7%), moderate-risk ($n = 164$, 54.7%) and high-risk ($n = 20$, 6.7%).[17]

Chest pain is the most recurring symptom of ED patients. In our study, the most common diagnosis was STEMI for 88 patients (43.6%). About 52 patients (25.7%) had a diagnoses of NSTEMI, and 20 patients (9.9%) were diagnosed with unstable angina. This high occurrence of ACS in the ED was noted in a study conducted by Hess et al.[18]

The incidence of MACE among our study population was 75.2%, which was high compared to a study in which MACE occurrence was 18.9% during HEART care and 22.2% during usual care.[1] This was expected because our study population included patients who shifted from the ED to the CCU. There was a high occurrence of endpoints-myocardial infarction (MI) as MACE among patients with a high-risk HEART score ($p < 0.001$). There are 52 patients (81.3%) who had MI had a high-risk score, and 2 patients (3.1%) who had an endpoint of MI had a low-risk score, which was similar to a study by Judith M Poldervaart et al.[1]

There was a high association with high-risk severity among highly suspicious histories of chest pain and ST changes in the ECG. About 32 patients (57.1%) had greater than or equal to 3 risk factors, and a history of ACS in association with a high-risk severity score. This shows how the HEART score with individual parameters can also predict severity. Such data was also seen in a prospective study conducted by Backus BE et al.[19]

Sensitivity of the HEART score to project the phenomenon MACE was 91%, and specificity was 80% in our study, as compared to a study conducted in China by Dai et al. in which the HEART score demonstrated a 100% sensitivity and 46.7% specificity in estimating cardiovascular events.[20] The differences might be due to the protocols and demographic features of the health systems. However, both studies promote the use of the HEART score among ED physicians and cardiologists to estimate MACE occurrence and risk associations.

### Limitations

The limited sample size of the study may affect the applicability of its results to a larger group. Conducting the study in a single center limits its external validity and may not reflect the diversity of healthcare systems. Complete follow-up of participants over the entire study period was tasking, leading to potential loss of data and bias.

## Conclusions

Our prospective study demonstrates the high sensitivity of the HEART score to effectively risk stratify patients and project the phenomenon of MACEs. We support the use of HEART score as a fast and accurate risk stratification method. We believe the application of the HEART score in most Emergency and Cardiology Departments can help in early intervention, leading to saving more lives. In countries with a high population and relatively low bed availability, this can be a turning point for risk stratification and providing immediate care. Patients from low economic background can benefit by avoiding unnecessary cardiac tests and an early discharge. The HEART score assists the clinician in making perfect diagnostic and therapeutic interventions in an uncertain environment. It is useful for triage. Research should be done towards uniform enforcement around the world. The HEART score surely cannot replace decision-making but should be used to upgrade it. The final power should lie in the hands of the doctor.

## Orcid

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