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Original Article

Predictive value of HEART score in the outcome of acute coronary syndrome and disposition

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Abstract

Objective: Disposition in acute coronary syndrome (ACS) is pivotal in an emergency department (ED). HEART score is a recent scoring system for finding primary endpoints in undetermined ACS. This study aimed at evaluating the predictive value of HEART score in ACS outcome and disposition.

Methods: In this prospective study, all patients with chest pain presentation compatible with our inclusion criteria referring to ED were enrolled during one year. Demographic data, triage level, hospital length of stay, admission ward, coronary angiography result, HEART score, thrombolysis in myocardial infarction (TIMI) score, 1-month primary ACS endpoints and major adverse cardiac events (MACE) were evaluated.

Results: In our studied population (200 cases), 49 patients (24.5%) had at least one score for MACE. Comparing the prognostic values of TIMI vs HEART score in MACE revealed that the HEART had a larger AUC. The best cut-off point of HEART score in MACE prediction was calculated to be ≥5. There was a statistically significant relation between HEART score and hospital length of stay. The higher the HEART score, the more probability of patients being admitted to either hospital cardiac ward or coronary care unit (CCU). There was a significant relationship between the triage level and HEART score. Patients with higher HEART score had more acuity (lower triage level 1 or 2).

Conclusion: HEART predicted MACE better than TIMI in low risk ACS. Patients with higher HEART score were more admitted to the hospital with longer hospital stay and patients with lower HEART score had higher triage level with less acuity.

Keywords: Acute coronary syndrome, HEART score, TIMI score, MACE score, Disposition

Introduction

Chest pain is one of the most common presentations in the emergency department (ED), about 6.3% of ED visits (1). There is a great deal of differential diagnosis when facing a patient with the chest pain, acute coronary syndrome (ACS), pulmonary emboli, vascular events, and noncardiac presentations (2,3). In an overcrowded environment such as an ED, it is essential and vital to find patients with major cardiac events (especially acute myocardial infarction, AMI) as soon as possible in order to limit the adverse events and mortality with the best management. In the meantime, detecting low risk patients with atypical presentations is another medical worrisome. One must precisely decide with courage to discharge these patients safely to home and be sure that no cardiac threats occur in the future. It is evident that less than 25% of all chest pain patients have truly ACS (4). By finding low risk ACS, we can reduce health care system expenses, hospital length of stay, occupied hospital bed and disease burden (5-7). In the United States of America, there is an annual rate of more than 7 million ED visits because of suspected ACS, but ¾ of these cases are finally found to have noncardiac chest pain (8). Evaluation and treatment of these patients cost American health care system more than 10 billion dollars each year (9). On the other hand, it has been reported that almost 2%-4% of AMI patients are being discharged from ED without the correct diagnosis. This is one of the major judicial and legal issues for emergency physicians (10).

Clinicians use different scoring tools besides patient history, electrocardiography (ECG), echocardiography (Echo) and serum biomarkers (notably troponin I [Tr I]). Thrombolysis in myocardial infarction (TIMI) (11), Global Registry of Acute Cardiac Events (GRACE) (12) and HEART score (3) are now widely used to diagnose ACS and predict major adverse cardiac events (MACE)

(13-15). MACE includes AMI, percutaneous coronary infection (PCI), coronary artery bypass graft (CABG) and death. HEART score can be used in low risk patients whose diagnosis of ACS is not yet confirmed. Clinicians can decide whether to release and discharge patients or admit them for further evaluations (16). In previous studies, it is reported that there is a significant difference in the predictive value of HEART score comparing to other scoring tools (2,15). Literature still needs more research in this field to estimate the exact value of HEART score in patients' disposition in ED.

In this prospective study, we evaluate the diagnostic and prognostic values of HEART score in an ED full of cases with multiple underlying diseases. We also evaluate patients' disposition and triage level according to HEART score.

Methods

This was a diagnostic accuracy study performed during 1 year in 3 major general hospitals of Tehran University of Medical Sciences (TUMS). The inclusion criterion was age older than 18 years old with acute chest pain of at least 5 minutes duration referring to the ED. The exclusion criteria were patients with: evidence of ST segment elevation in ECG, syncope, dyspnea, unusual complaints and angina equivalents, tachy- or brady-dysrhythmia, traumatic chest pain, missing data, incomplete or inaccurate documentation. The method and study process were explained to patients. Informed written consent was taken from all patients who decided to participate in our study. The study was approved by the ethics committee of TUMS (ID: IR.TUMS.IKHC.REC.1396.3888).

Demographic data, cardiovascular risk factors, TIMI and HEART scores, MACE outcome, hospital length of stay, disposition and triage level based on Emergency Severity Index (ESI) were all evaluated and documented in a predesigned checklist. Patients were initially admitted to ED and finally were either discharged (less than 24 hours after admission), stayed longer in ED, cardiac hospital ward or coronary care unit (CCU). All patients were followed closely for further 30 days after admission via face-to-face appointment or phone call and primary ACS endpoints (MACE) were documented. One-month outcome was assessed by either face-to-face interview in follow-up sessions or phone call. emergency physicians enrolled patients, observed the treatment course and completed the checklist.

Our primary outcome was to compare the prognostic value of HEART score vs TIMI score in MACE prediction. Our secondary outcomes were evaluating the relationship of HEART score with patients' triage level, disposition and hospital length of stay.

Based on reference number (17), we calculated a sample size of 200 patients, by considering $P = 0.22$, $d = 0.06$, $\alpha = 0.05$ and power = 80%. After gathering all data, they were inserted into SPSS (version 25.0) and Stata (version 15.0) software packages. The descriptive indices such as frequency (percentage) and mean (standard deviation, SD) were used to express the results. Chi-square test, independent t test, ANOVA analysis of variance and Pearson correlation analysis were used accordingly. The predictive value of scoring systems was evaluated by area under receiver operating characteristic (ROC) curve (AUC) with 95% confidence interval (CI). The best cut-off point of scoring systems based on the best sensitivity and specificity was determined by 95% CI (Youden index). The level of significance was 0.05.

Results

In this study, we evaluated 237 suspected cases of ACS during 6 months. Twenty cases were excluded and 17 cases were missed to follow-up (Figure 1). Data of 200 remaining cases were complete and we enrolled them in our study. In our sample size, 119 patients were males and 81 patients were females. The age range was from 24 to 88 years with the mean ± SD of 58.0 ± 12.5 years old. The mean time of hospital length stay was 3.6 ± 2.0 days (1 to 25 days). Most of our patients were admitted shorter than 5 days. Most of our cases were admitted to the ED (45.0%)

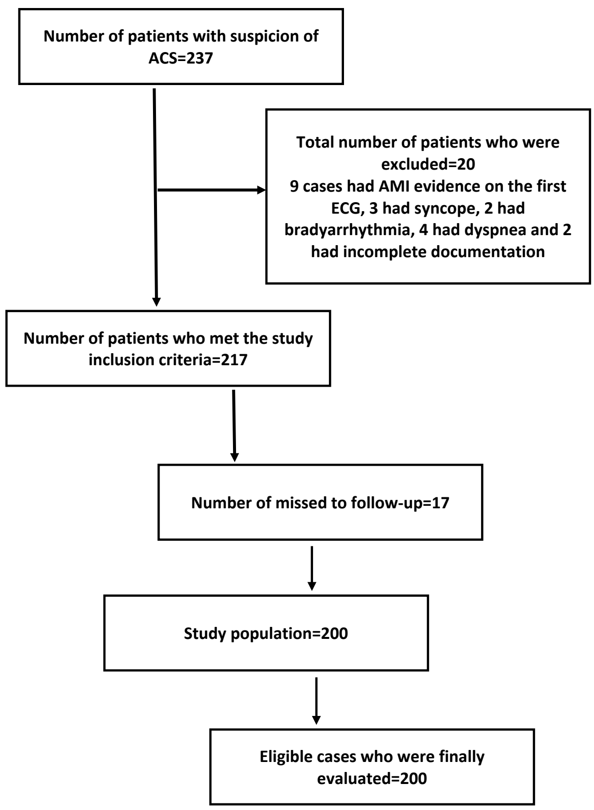

Figure 1. Flow chart of the study.

with the triage level of 2 (91.5%). Among all suspected ACS cases, 49 patients (24.5%) had at least 1 positive score for MACE. PCI was the most common MACE (in 34 patients (17.0%)). Baseline data is shown in Table 1.

We evaluated the relationships of our study variables with MACE score. We observed that there was a significant association between triage level and MACE score. Patients with more ACS acuity (level 1 triage) had more probability of MACE occurrence ($P=0.019$).

Patients in whom MACE happened had significantly longer hospital length of stay ($P<0.001$). Incidence of abnormal (positive) scores in all HEART score components was significantly more in patients with MACE occurrence ($P<0.05$). HEART score had a significant relationship with MACE score. Patients with higher HEART score had more probability of MACE occurrence ($P<0.001$).

Some cases had indeterminate history of coronary stenosis > 50%. Thus, we excluded these patients in TIMI score assessment and we evaluated 176 patients for this score. Incidence of abnormal (positive) scores in all TIMI score components (except age older than 65 years old) was significantly more in patients with MACE occurrence ($P<0.05$). TIMI score had a significant relationship with MACE score. Patients with higher TIMI score had more probability of MACE occurrence ($P<0.001$). Data is depicted in Table 2.

The value of HEART score in MACE prediction based on AUC (ROC curve) was estimated to be 0.850 (95% CI: 0.792 to 0.896). HEART score ≥4 was the cut-off point in MACE prediction with the highest sensitivity and HEART score ≥ 7 was the cut-off point in MACE prediction with the highest specificity. The best cut-off point was calculated to be ≥ 5.

The value of TIMI score in MACE prediction based on AUC (ROC curve) was estimated to be 0.814 (95% CI: 0.749 to 0.869). TIMI score ≥ 3 was the cut-off point in MACE prediction with the highest sensitivity and TIMI score ≥ 5 was the cut-off point in MACE prediction with the highest specificity. The best cut-off point was calculated to be ≥ 3. Data is shown in Table 3.

The result of predictive value comparison of HEART vs TIMI scores revealed that AUC for HEART was bigger than TIMI, although this difference was not significant ($P=0.133$) (Figure 2). For this analysis, as we mentioned before, we could enroll data of 176 patients in TIMI score.

We also evaluated the relationship of our studied scoring systems with patients' triage level, disposition and hospital length of stay. Patients with higher scores in both HEART

Table 1. Baseline and demographic data

Variable		
Gender, No. (%)	Male	119 (59.5)
	Female	81 (40.5)
Age (y), Mean ± SD		58.0 ± 12.5
Hospital length of stay (day), Mean ± SD		3.6 ± 2.0
Triage level, No. (%)	1	5 (2.5)
	2	183 (91.5)
	3	12 (6.0)
Disposition, No. (%)	ED longer than 24 hours	10 (5.0%)
	Cardiac ward	74 (37.0)
	CCU	34 (17.0)
	Discharged shorter than 24 hours	82 (41.0)
MACE outcome, No. (%)	Negative	151 (75.5)
	CABG	12 (6.0)
	AMI	1 (0.5)
	PCI	34 (17.0)
	Cardiac death	2 (1.0)

Abbreviations: MACE, major adverse cardiac events; AMI, acute myocardial infarction; PCI, percutaneous coronary infection; CABG, coronary artery bypass graft; CCU, coronary care unit; ED, emergency department.

Table 2. Relationship of study variables with MACE score

Variable		MACE not happened	MACE happened	*P* value
Triage level, No. (%)	1	2 (40.0)	3 (60.0)	0.019
	2	137 (74.9)	46 (25.1)	
	3	12 (100)	0 (0.0)	
Hospital length of stay (day), Mean ± SD		2.8 ± 2.6	6.2 ± 5.4	< 0.001
HEART score, No. (%)	≤3	87 (97.8)	2 (2.2)	< 0.001
	4-6	58 (63.0)	34 (37.0)	
	≥7	6 (31.6)	13 (68.4)	
HEART score, Mean ± SD		3.35 ± 1.67	5.65 ± 1.30	< 0.001
TIMI score, No. (%)	0-2	95 (89.6)	11 (10.4)	< 0.001
	3-4	37 (61.7)	23 (38.3)	
	5-7	1 (10.0)	9 (90.0)	
TIMI score, Mean ± SD		1.55 ± 1.36	3.33 ± 1.32	< 0.001

Table 3. Validity of HEART vs TIMI score in MACE prediction

Validity 95% CI	Cut-off points of HEART score			Cut-off points of TIMI score	
	≥4	≥5	≥7	≥3	≥5
Sensitivity	95.92 (86.0 99.5)	81.63 (68.0 91.2)	26.53 (14.9 41.1)	74.42 (58.8 86.5)	20.93 (10.0 36.0)
Specificity	57.62 (49.3 65.6)	72.85 (65.0 79.8)	96.03 (91.6 98.5)	71.43 (63.0 78.9)	99.25 (95.9 100.0)
Positive predictive value	42.3 (33.0 52.1)	49.4 (38.1 60.7)	68.4 (43.4 87.4)	45.7 (33.7 58.1)	90.0 (55.5 99.7)
Negative predictive value	97.8 (92.1 99.7)	92.4 (86.1 96.5)	80.1 (73.5 85.7)	89.6 (82.2 94.7)	79.5 (72.6 85.4)

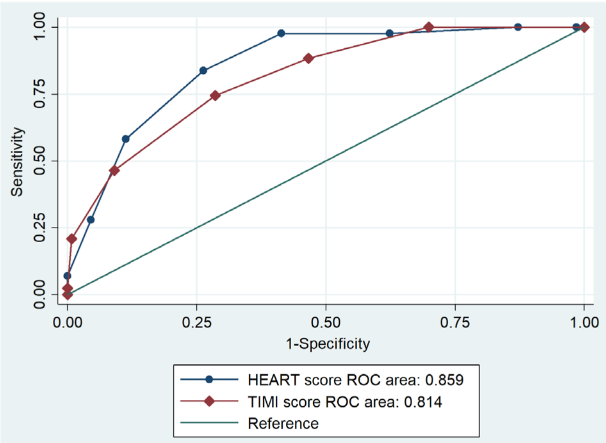

Figure 2. Area under ROC curve of HEART vs TIMI score in MACE prediction.

and TIMI were all admitted and managed in either triage level 1 or 2 ($P<0.001$). Patients with higher scores in both HEART and TIMI were significantly more admitted in either cardiac ward or CCU ($P<0.001$) (Table 4).

There was a statistically significant correlation between scoring systems and hospital length of stay ($P<0.05$). Pearson correlation coefficients were 0.439 for HEART score and 0.396 for TIMI score.

Discussion

In the present study, we enrolled 200 suspected cases of ACS during 6 months. It was revealed that the mean ± SD hospital length of stay was 3.6 ± 2.0 days and ACS patients with positive MACE were hospitalized longer than patients with negative MACE. Most of our ACS patients as well as most of cases with positive MACE were males. This result is consistent with the findings of other studies (15,18).

Most of our patients (91.5%) were admitted at triage level 2. There was a significant difference between MACE score and triage level. The prevalence of MACE at triage level 1 was 60% and MACE occurrence was less common in lower acuity triage level (level 2 and 3).

We observed that 75.5% of our cases had negative MACE, while 17% PCI, 6% CABG, 1% cardiac death and 0.5% AMI happened. Poldervaart et al in 2017 determined that MACE occurred in 19% of their cases, while 43% had PCI, 14% had CABG, 3% had AMI and only 1 patient died of cardiovascular reason (15).

In our study, it was declared that patients with positive MACE had significantly higher scores in both HEART and TIMI scores. The mean score of HEART in patients with MACE occurrence was 2.4 times more than its mean score in patients with negative MACE. The same result was observed in previous studies. Six et al in 2008, found a HEART score of 6.51 in positive MACE and a score of 3.71 in negative MACE (3). Backus et al in 2013, estimated a HEART score of 6.54 in positive MACE, while the score was 3.96 in negative MACE (19). In Bolvardi et al study, a similar result was observed: 7.42 in positive MACE and 5.42 in negative MACE (2).

Analytical results of our study showed that the mean TIMI score in patients with the endpoint of MACE happening was 1.8 times more than the score in negative MACE. TIMI score in the study conducted by Backus et al was estimated to be 3.68 in positive MACE and 2.21 in negative MACE (19). Sun et al calculated TIMI scores of

Table 4. Mean ± SD of HEART and TIMI score by triage level and disposition type

Variable		HEART	P-value	TIMI	*P* value
Triage level	1	5.40 ± 1.52	<0.001	1.67 ± 0.58	<0.001
	2	4.04 ± 1.79		2.11 ± 1.53	
	3	1.33 ± 0.89		0.18 ± 0.40	
Disposition	Discharge in less than 24 hours	2.66 ± 1.42	<0.001	1.12 ± 1.17	<0.001
	Admission at emergency department	3.70 ± 1.25		1.43 ± 1.27	
	Admission at cardiac ward	4.45 ± 1.57		2.34 ± 1.45	
	Admission at cardiac care unit	5.85 ± 1.87		3.29 ± 1.36	

2.11 in MACE positive group and 1.28 in MACE negative group (20).

Our findings proved that cases with HEART score of 3 or less might have almost 98% chance of not having MACE and there might be less probability of further workup. Six et al. in 2008 evaluated 122 patients and they showed that in patients with HEART score 0-3 there would be a risk of 2.5% for MACE occurrence. When HEART score was 4-6 this rate was 20.3% and in HEART score ≥ 7 MACE had a chance of 72.7% (3). Balvardi et al in 2016 evaluated 100 cases and their results revealed that in HEART score 0-3, MACE occurred in 0% of patients, in HEART scores 4-6 and ≥7 MACE happened in 14.5% and 46.4% of cases, respectively (2). Jain et al. in 2016 announced their results as follows: 0.6% in HEART score 0-3, 9.5% in 4-6 and 38% in ≥7 (21). In other studies by Backus et al in 2011 and 2016, we observed the same results and they found a chance of more than 60% for MACE in HEART score ≥ 7 (5,22).

We found out that HEART score ≥4 was the cut-off point in MACE prediction with the highest sensitivity and HEART score ≥7 was the cut-off point in MACE prediction with the highest specificity. Sun et al showed that HEART score with the cut-off point > 3 had a sensitivity of 85.8%, and a specificity of 51.2% (20). Visser et al calculated a sensitivity of 93% and a specificity of 44% for 0-3 HEART score cut-off point. They also reported a sensitivity of 52% and a specificity of 90% for 7-10 HEART score cut-off point (23). The same results with high sensitivity for lower HEART score and high specificity for higher HEART score were determined by other studies (18,24).

We also detected that patients with lower TIMI score had less chance of MACE occurrence. Even in TIMI score of 0-2 (low risk patients), there was a 10.4% probability of MACE. This rate was more than the rate in low risk HEART score. Our finding supported this idea that HEART score might have a better predictive value in low risk patients in comparison to TIMI score when we are assessing MACE.

Sun et al concluded that cases with TIMI score of 0-2 had a 14.4% chance of MACE (20).

In the present study, it was perceived that TIMI score ≥3 was the best cut-off point in MACE prediction with the highest sensitivity and TIMI score ≥5 was the cut-off point in MACE prediction with the highest specificity. Six et al stated that TIMI score ≥1 had a sensitivity of 87.4% and a specificity of 47.5% in MACE prediction (18). Manini et al in 2007, remarked on a sensitivity of 35% and a specificity of 85% in ACS prediction (25). The research by Poldervaart et al reported a sensitivity of 95% and a negative predictive value of 97% for TIMI score = 0 (15). The overall findings showed that validity indicators of TIMI score in low risk patients (in lower cut-off points) for MACE prediction were not significant because they had a low sensitivity.

Comparing the predictive value of HEART score versus TIMI score for MACE manifested that the former score had AUC of 0.850, while the latter had AUC of 0.814. HEART score was a better predictive value but this difference was not significant. Poldevaart et al estimated an AUC of 0.86 for HEART score and an AUC of 0.80 for TIMI score (15). In the prospective study by Chen et al. in 2016, it was demonstrated that HEART score had AUC of 0.726 and TIMI score had AUC of 0.700. This supported our findings that HEART score had a more powerful predictive value (24). C-statistic predicted probability of HEART score was roughly approximated to be 0.9 for HEART score and 0.6 for TIMI score (22).

We figured the best cut-off point of MACE prediction for HEART and TIMI scores to be ≥5 and ≥3, respectively. Chen et al. enumerated a sensitivity of 48.9% and a specificity of 83.7% for HEART score in 30-day MACE prediction at the optimal cut-off value > 5 (24).

In this research, we also added that patients with higher scores in both HEART and TIMI were all admitted and managed in either triage level 1 or 2. Patients with higher scores in both HEART and TIMI were significantly more admitted in either cardiac ward or CCU. There was a statistically significant correlation between scoring systems and hospital length of stay. By using a simpler, faster yet more sensitive scoring system like HEART score in an ED, we can predict the outcome of ACS patients and disposition much better.

Limitations of the study

One limitation we faced in our study was that medical documentations were not accurate and complete in some cases. In addition, the follow up of patients was difficult after 1 month of admission.

Conclusion

The mean of HEART and TIMI scores in MACE positive cases were significantly more than MACE negative cases. HEART score had a higher sensitivity in low risk patients in MACE prediction in comparison to TIMI score. The best cut-off point was estimated to be ≥ 5. By increasing the acuity of patient's condition (level 1 and 2 triage), we should expect higher HEART score and worse MACE outcome. Patients with higher HEART score were admitted longer at the hospital and there was a more probability of being admitted at CCU.

Authors' contributions

AA and EV conceived the study, designed the trial, supervised the conduct of the trial and collected data. MB and EV undertook the recruitment of participating centers and patients and managed the data, including quality control. AA and EV provided statistical advice on study design and analyzed the data. EV drafted the manuscript, AJ and JS also undertook recruitment of participating centers and patients and managed the data, including quality control. and all authors contributed substantially to its revision. EV takes responsibility for the paper as a whole.

Ethical issues

The present study was approved by the ethics committee of TUMS (ID: IR.TUMS.IKHC.REC.1396.3888). All patients enrolled in this study were given a brief report of the study process and informed written consent was granted.

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