Original Article

Validation study of the modified HEART and HEAR scores in patients with chest pain who visit the emergency department

Yohei Otsuka,* and Satoshi Takeda

Department of Emergency Medicine, Jikei University School of Medicine, Minato-ku, Japan

Aim: To validate the efficacy of the history, electrocardiogram, age, risk factors, and troponin (HEART) and history, electrocardiogram, age, and risk factors (HEAR) scores in a Japanese cohort.

Methods: We used the data of patients who visited our emergency department between 1 December, 2015 and 31 May, 2017. Patients aged ≥20 years who presented with non-traumatic and undifferentiated chest pain were eligible for the study. On the basis of the total score, the patients were stratified as low risk (HEART and HEAR scores of 0–3), intermediate risk (HEART and HEAR scores of 4–6), and high risk (HEART score of 7–10 and HEAR score of 7–8). The major adverse cardiac events (MACEs) that occurred within 6 weeks were investigated, and the diagnostic value and efficiency of both scores were analyzed.

Results: In total, 132 patients were included in the HEART score analysis and 220 patients in the HEAR score analysis. The incidence rates of MACEs in patients with low, intermediate, and high risks were 0%, 23.2%, and 63.6% in the HEART score analysis and 4.7%, 22.9%, and 62.5% in the HEAR score analysis ($P < 0.001$), respectively. The identification of MACEs in low-risk patients had a negative predictive value in the HEART score (1.00; 95% confidence interval, 0.90–1.00) and HEAR score (0.95; 95% confidence interval, 0.89–0.99) analyses.

Conclusion: The modified HEART and HEAR scores were effective in identifying patients with chest pain who are at low risk of MACEs at an emergency department in Japan.

Key words: Acute coronary syndrome, chest pain, emergency department, HEART score, risk stratification

INTRODUCTION

CHEST PAIN IS one of the most common symptoms in patients visiting the emergency department (ED). In Tokyo, Japan, 15,709 patients with non-traumatic chest pain were transferred to EDs by ambulance in 2018.[1] Ruling out of acute coronary syndrome (ACS) is a major challenge. ST segment elevation myocardial infarction (STEMI) is easy to diagnose. However, it is difficult to differentiate from non-ST elevation acute coronary syndrome (NST-ACS). In addition, the long-term outcomes of NST-ACS were worse than those of STEMI in a Japanese cohort.[2] Hence, NST-ACS, which is difficult to diagnose, should be appropriately ruled out.

The international guidelines recommend that patients with chest pain who visit the ED should be evaluated using a risk stratification tool or risk scoring system.[3] The history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) score was designed to predict the occurrence of short-term major adverse cardiac events (MACEs).[4] The score is easy to calculate at the ED, and the efficacy has been validated in previous studies.[5–6]

To prevent the delay of therapeutic interventions, patients who require percutaneous coronary intervention (PCI) should be transferred directly from prehospital settings to capable hospitals. Although a prehospital 12-lead ECG is not widely used in Japan, it can be utilized for this purpose. Nevertheless, paramedics should not measure troponin levels. We believe that the use of a risk-stratifying instrument without measuring troponin levels is required to optimize hospital selection in these conditions.

To the best of our knowledge, the efficacy of using the HEART score in EDs in Japan has not been evaluated. We hypothesized that the HEART score is effective in stratifying patients with chest pain in Japan. Hence, the current study aimed to validate the efficacy of the modified HEART and history, ECG, age, and risk factors (HEAR) scores, which do not include the measurement of troponin levels, in EDs in Japan.

METHODS

Study design and population

W E UNDERTOOK A retrospective, observational cohort study. The data of all consecutive adult patients with non-traumatic chest pain, except for cardiac arrest patients, who visited the ED between 1 December, 2015 and 31 May, 2017 were reviewed. These data were based on paper records. Chest pain encompasses not only pain but also symptoms such as discomfort, pressure, and squeezing in the chest. Patients with dyspnea or palpitations alone were not included. Patients aged at least 20 years were included. However, those with ST elevation on ECG were excluded because of the lack of diagnostic uncertainty. Patients who did not present with MACEs, as defined below, were not included. The local ethics committee approved the research protocol, and the study was in accordance with the Declaration of Helsinki.

Calculation of the modified HEART and HEAR scores

The components of the modified HEART and HEAR scores are shown in Table 1. The first author, who is an emergency physician in our department, calculated both scores retrospectively from 2018 to 2019 in our facility. The history score was interpreted by the first author, and it was classified as follows: 2 points, high; 1 point, moderate; 0 points, low suspicion for ACS. The 12-lead ECG result was also reviewed by the first author. In patients with normal or non-specific findings, 0 points were given. In patients with complete left bundle branch block or inverted T wave in more than two consecutive leads, 1 point was assigned. In patients with significant ST-segment depressions in more than two consecutive leads, 2 points were assigned. In terms of age, 0 points were allocated if the patient's age was below 45 years; 1 point, if 45 years or between 45 and 65 years; 2 points, if 65 years or older. In terms of the risk factors of coronary artery disease, the following were considered: hypertension, diabetes mellitus, dyslipidemia, and current or

Table 1. Modified history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) and history, ECG, age, and risk factors (HEAR) scores

Component	Rank	Points
History	Slightly or non-suspicious	0
	Moderately suspicious	1
	Highly suspicious	2
ECG	Normal or nonspecific	0
	CLBBB or inverted T wave	1
	Significant ST depression	2
Age, years	<45	0
	≥45, <65	1
	≥65	2
Risk factors	None	0
	1 or 2	1
	≥3 or history of CAD	2
Troponin	Negative (<0.1 ng/mL)	0
	Positive (≥0.1 ng/mL)	2
Total	HEART score	0–10
	HEAR score	0–8

Risk factors were: hypertension, diabetes mellitus, dyslipidemia, and current or previous history of smoking. CAD, coronary artery disease; CLBBB, complete left bundle branch block.

previous smoking history. In patients without risk factors, 0 points were given. In patients with one or two risk factors, 1 point was allocated. In patients with three or more risk factors, 2 points were assigned. In addition, 2 points were allocated for those with a history of coronary artery disease. Troponin T levels were measured using a troponin kit (Trop T sensitive; Roche Diagnostics, Basel, Switzerland). If the troponin T level at admission was below the threshold value for positivity (<0.1 ng/mL), 0 points were given. If the level was high (≥0.1 ng/mL), 2 points were assigned.

According to the total score, we classified the patients under the low-risk (HEART and HEAR scores of 0–3), intermediate-risk (HEART and HEAR scores of 4–6), and high-risk (HEART score of 7–10 and HEAR score of 7–8) categories. The categorization was based on previous reports.[4–6]

End-points

The primary end-points were the occurrence of MACEs within 6 weeks, which include ACS, PCI, and coronary artery bypass grafting (CABG), and all-cause mortality. To identify the occurrence of MACEs, we reviewed the paper-based records, which included information on clinical

records, discharge summaries, revascularization reports, and other relevant data.

Statistical analysis

Continuous data are presented as mean (standard deviation); categorical data, as number and percentage. Student's *t*-test was used to compare means for continuous variables. The χ^2-test was utilized to compare categorical variables and evaluate differences in the event rates for increasing risk score and categories. We evaluated the discriminative power of the score using the C-statistic, also known as the area under the receiver operating characteristic curve. We calculated the sensitivity, specificity, positive predictive value, and negative predictive value (NPV) for the incidence of MACEs that occurred within 6 weeks using risk categories.

All statistical analyses were undertaken with R (version 3.0.2; The R Foundation for Statistical Computing, Vienna, Austria). *P*-values < 0.05 were considered statistically significant.

RESULTS

Study population

THE STUDY POPULATION included 457 consecutive adult patients with non-traumatic undifferentiated chest pain who visited the ED between 1 December, 2015 and 31 May, 2017. We obtained data from paper-based records, which were relevant enough in that period. After excluding 45 patients for ST elevation on ECG and 147 patients for missing data of MACEs, 265 were finally included. Moreover, we undertook listwise deletion of missing data on the HEART and HEAR scores for each component. Finally, 132 patients were included in the HEART score analysis and 220 patients in the HEAR score analysis (Fig. 1). In addition, we analyzed the differences in the characteristics between included and excluded patients. First, the ECG, age, and troponin scores in patients who were excluded for missing data regarding MACE occurrence were lower than in eligible patients (*P* < 0.001, *P* < 0.001, and *P* = 0.002, respectively). Second, in the HEAR score analysis, the history score in patients excluded for incomplete data, except for the troponin component, was lower than in included patients (*P* = 0.01). Finally, in the HEART score analysis, the age score in patients excluded for missing data of the troponin component was lower than in included patients (*P* = 0.02).

In the HEART score analysis, the proportion of male patients and those with dyslipidemia was higher in the MACE group than in the group without MACE. In the HEAR score analysis, there was a higher proportion of men and prevalence of hypertension (Table 2).

Dispositions and major adverse cardiac events

In this study, ED dispositions of patients were decided by attending emergency physicians or each specialist who were consulted from the staff of our ED. The decision-making of dispositions was finally done as follows. In the HEART score analysis, 41.7% by attending emergency physicians, 49.2% by cardiologists, 2.3% by cardiac surgeons, 0.8% by vascular surgeons, and 6.1% by other specialists. In the HEAR score analysis, these proportions were 37.3%, 45.9%, 2.3%, 3.2%, and 10.9%, respectively. In the HEART score analysis, 65.2% of patients were discharged, 34.1% admitted, and 0.8% transferred to other hospital; in the HEAR score analysis, the proportions were 60.0%, 39.6%, and 0.5%, respectively.

The details of MACEs were as follows: total number of MACEs (*n* = 23), death (*n* = 1, non-cardiac), ACS (*n* = 15), PCI (*n* = 18), and CABG (*n* = 3) in the HEART score analysis, and total number of MACEs (*n* = 34), death (*n* = 5, including four non-cardiac deaths), ACS (*n* = 22), PCI (*n* = 24), and CABG (*n* = 4) in the HEAR score analysis. Additionally, the final diagnosis of the patients with MACEs were as follows: angina pectoris (AP) (*n* = 6), unstable angina pectoris (UAP) (*n* = 10), non-ST elevation myocardial infarction (*n* = 5), and aortic dissection (*n* = 2) in the HEART score analysis, and AP (*n* = 6), UAP (*n* = 16), non-ST elevation myocardial infarction (*n* = 6), aortic dissection (*n* = 2), rupture of aortic aneurysm (*n* = 2), and sepsis (*n* = 1) in the HEAR score analysis.

Modified HEART and HEAR scores

Higher modified HEART and HEAR scores were associated with an increased incidence of MACEs within 6 weeks (*P* < 0.001; Fig. 2).

The numerical distribution of the scores for each component in the groups with or without MACEs is presented in Table 3. In the HEART score analysis, history, ECG findings, and troponin T levels, but not age or risk factors, differed significantly between the groups with or without MACEs (*P* < 0.001). In the HEAR score analysis, history and ECG findings, but not age or risk factors, differed significantly between the two groups (*P* < 0.001).

The average modified HEART scores were 5.8 (1.4) in the group with MACEs and 3.7 (1.7) in the group without MACEs, and the modified HEAR scores were 4.9 (1.4) and 3.3 (1.7) in the groups with MACEs and without MACEs,
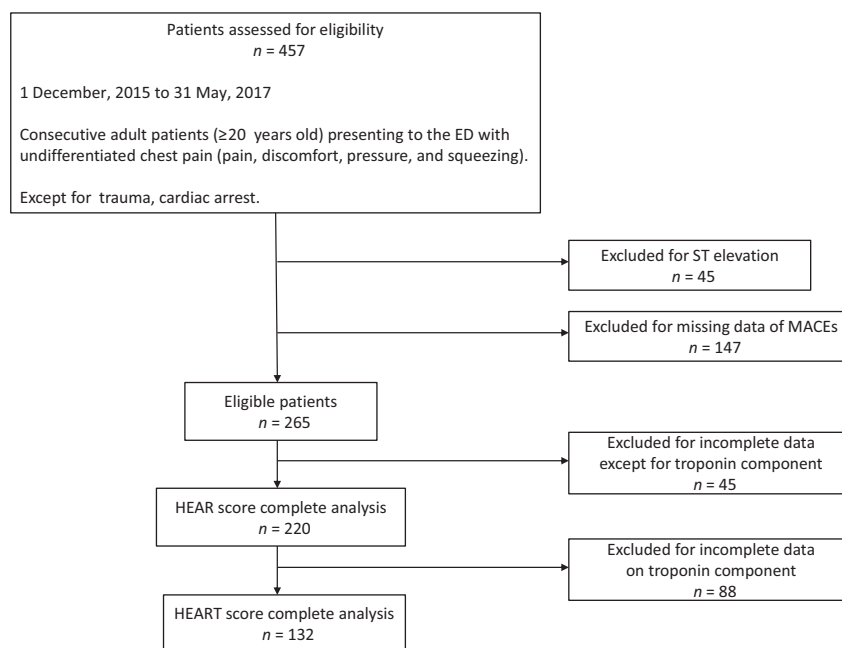
Patients assessed for eligibility
n = 457

1 December, 2015 to 31 May, 2017

Consecutive adult patients (≥20 years old) presenting to the ED with undifferentiated chest pain (pain, discomfort, pressure, and squeezing).

Except for trauma, cardiac arrest.

Excluded for ST elevation
n = 45

Excluded for missing data of MACEs
n = 147

Eligible patients
n = 265

Excluded for incomplete data except for troponin component
n = 45

HEAR score complete analysis
n = 220

Excluded for incomplete data on troponin component
n = 88

HEART score complete analysis
n = 132

Fig. 1. Flowchart of the study population. ED, emergency department; HEAR, history, electrocardiogram, age, and risk factors; HEART, history, electrocardiogram, age, risk factors, and troponin; MACE, major adverse cardiac event.

Table 2. Baseline characteristics of the groups with or without major adverse cardiac events (MACEs)

	HEART score				HEAR score			
	All patients, *n* = 132	Without MACEs, *n* = 109	With MACEs, *n* = 23	*P*-value	All patients, *n* = 220	Without MACEs, *n* = 186	With MACEs, *n* = 34	*P*-value
Age, years; mean (SD)	60 (17)	60 (18)	60 (15)	0.93	58 (18)	58 (18)	58 (16)	0.93
Male sex	97 (73.5)	76 (69.7)	21 (91.3)	0.04	159 (72.3)	127 (68.3)	32 (94.1)	0.001
Hypertension	49 (37.7)	39 (36.4)	10 (43.5)	0.64	72 (33.5)	55 (30.2)	17 (51.5)	0.03
Diabetes mellitus	33 (25.4)	25 (23.4)	8 (34.8)	0.29	48 (22.3)	37 (20.3)	11 (33.3)	0.11
Dyslipidemia	26 (20.0)	17 (15.9)	9 (39.1)	0.02	44 (20.5)	33 (18.1)	11 (33.3)	0.06
Smoking	68 (56.7)	54 (54.5)	14 (66.7)	0.34	109 (54.0)	88 (51.5)	21 (67.7)	0.12
CAD	31 (23.8)	24 (22.4)	7 (30.4)	0.43	42 (19.5)	33 (18.1)	9 (27.3)	0.24

Data are shown as *n* (%) unless otherwise indicated. CAD, coronary artery disease; HEAR, history, electrocardiogram, age, and risk factors; HEART, history, electrocardiogram, age, risk factors, and troponin; SD, standard deviation.

respectively. The C-statistic values of the HEART and HEAR scores were 0.83 (95% confidence interval [CI], 0.75–0.90) and 0.76 (95% CI, 0.69–0.84).

Risk stratification

To stratify patients with chest pain who visited the ED, we classified them into three groups based on the modified HEART and HEAR scores (Table 4). We obtained a good discrimination of the incidence of MACEs within 6 weeks: 0% in the low-risk category, 23.2% in the intermediate-risk category, and 63.6% in the high-risk category in the HEART score analysis and 4.7%, 22.9%, and 62.5%, respectively, in the HEAR score analysis ($P < 0.001$; Fig. 3). The NPVs with a cut-off ≤3 points for low-risk categories were 1.00 (95% CI, 0.90–1.00) in the HEART score analysis and 0.95 (95% CI, 0.89–0.99) in the HEAR score analysis (Table 5).
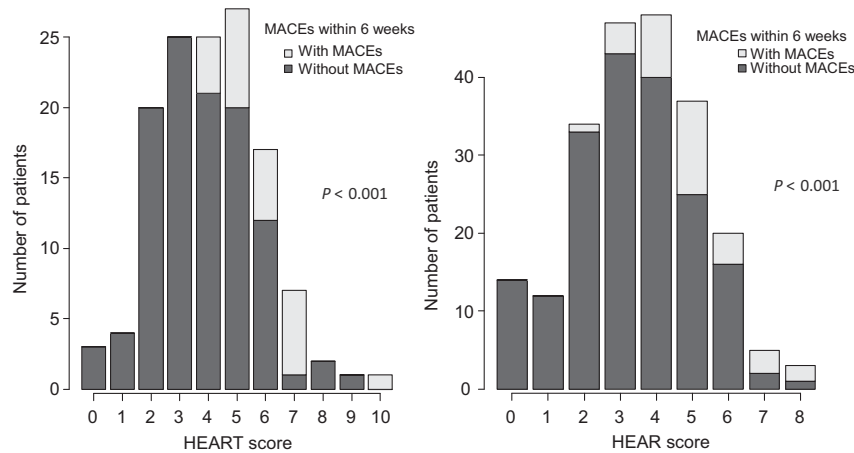
Fig. 2. Incidence of major adverse cardiac events (MACEs) within 6 weeks in the history, electrocardiogram, age, risk factors, and troponin (HEART) and history, electrocardiogram, age, and risk factors (HEAR) score analyses among Japanese patients with chest pain who visited the emergency department. Gray and black columns indicate the number of patients who presented with MACEs within 6 weeks and those who did not, respectively.

Table 3. Number of patients according to each component of the history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) and history, ECG, age, and risk factors (HEAR) scores

	Without MACEs, $n = 109$			With MACEs, $n = 23$			P-value
HEART score							
Points	0	1	2	0	1	2	
History	42 (38.5)	46 (42.2)	21 (19.3)	2 (8.7)	7 (30.4)	14 (60.9)	<0.001
ECG	88 (80.7)	11 (10.1)	10 (9.2)	11 (47.8)	4 (17.4)	8 (34.8)	<0.001
Age	15 (13.8)	40 (36.7)	54 (49.5)	2 (8.7)	9 (39.1)	12 (52.2)	0.630
Risk factors	20 (18.4)	54 (49.5)	35 (32.1)	3 (13.0)	11 (47.8)	9 (39.1)	0.440
Troponin	101 (92.7)	ND	8 (7.3)	15 (65.2)	ND	8 (34.8)	<0.001
	Without MACEs, $n = 186$			With MACEs, $n = 34$			P-value
HEAR score							
Points	0	1	2	0	1	2	
History	80 (43.0)	71 (38.2)	35 (18.8)	5 (14.7)	11 (32.4)	18 (52.9)	<0.001
ECG	155 (83.3)	18 (9.7)	13 (7.0)	15 (44.1)	9 (26.5)	10 (29.4)	<0.001
Age	38 (20.4)	66 (35.5)	82 (44.1)	4 (11.8)	13 (38.2)	17 (50.0)	0.300
Risk factors	46 (24.7)	85 (45.7)	55 (29.6)	3 (8.8)	18 (52.9)	13 (38.2)	0.070

Data are shown as *n* (%). MACE, major adverse cardiac event; ND, no data.

DISCUSSION

THIS RETROSPECTIVE STUDY showed that the modified HEART and HEAR scores, which do not include troponin assays, were effective in stratifying patients with chest pain who visit our ED. Our facility does not have a tertiary ED, and it is located in the metropolitan area. Annually, approximately 7,000 patients are transferred to our ED by ambulance, and 18,000 patient visits were recorded. Results showed high NPVs for the HEART and HEAR scores. Furthermore, the HEART score had a good discriminatory power in predicting MACEs within 6 weeks. Hence, the modified HEART and HEAR scores are effective screening tools.

In this study, the low-risk category represented 39.4% of the included patients in the HEART score analysis, and

Table 4. Risk stratification of the history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) and history, ECG, age, and risk factors (HEAR) scores

Classification	HEART score			HEAR score		
	Patients, n (%)	With MACEs (n)	Incidence rate of MACEs (%)	Patients, n (%)	With MACEs (n)	Incidence rate of MACEs (%)
Low	52 (39.4)	0	0	107 (48.6)	5	4.7
Intermediate	69 (52.3)	16	23.2	105 (47.7)	24	22.9
High	11 (8.3)	7	63.6	8 (3.6)	5	62.5

Risk categorization was based on the total scores, which were: low risk, 0–3 points; intermediate risk, 4–6 points; and high risk, 7–10 points in the HEART score analysis; and high risk, 7–8 points in the HEAR score analysis. MACE, major adverse cardiac event.
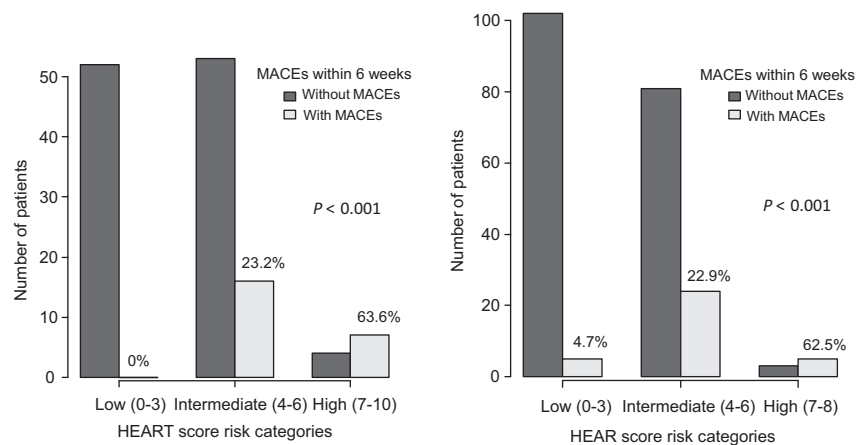

Fig. 3. Risk stratification of the history, electrocardiogram, age, risk factors, and troponin (HEART) and history, electrocardiogram, age, and risk factors (HEAR) scores among Japanese patients with chest pain who visited the emergency department. Risk categorization was based on total scores: low risk, 0–3 points; intermediate risk, 4–6 points; and high risk, 7–10 points in the HEART score analysis; and high risk, 7–8 points in the HEAR score analysis. The gray and black columns indicate the number of patients who presented with major adverse cardiac events (MACEs) within 6 weeks and those who did not, respectively. The incidence rate of MACEs in each risk group is shown as a percentage.

Table 5. Diagnostic accuracy of the history, electrocardiogram (ECG), age, risk factors, and troponin (HEART) and history, ECG, age, and risk factors (HEAR) scores

	HEART score	HEAR score
Sensitivity (95% CI)	1.00 (0.79–1.00)	0.83 (0.69–0.95)
Specificity (95% CI)	0.48 (0.38–0.58)	0.55 (0.47–0.62)
Positive predictive value (95% CI)	0.29 (0.19–0.40)	0.26 (0.18–0.35)
Negative predictive value (95% CI)	1.00 (0.90–1.00)	0.95 (0.89–0.99)

Diagnostic accuracy of a cut-off ≤3 points for low-risk categories is presented. CI, confidence interval.

48.6% in the HEAR score analysis. In addition, there was a trend for younger and lower-risk patients to be excluded. Several studies from Europe and North America reported that the proportion of the low-risk category was from 32.5% to 40.5% of the study populations in the HEART score analysis, and 33.2% in the HEAR score analysis.[4–7] Moreover, the incidence of acute coronary syndrome in Japan was lower compared to other countries.[8–9] Hence, more patients with chest pain could be stratified into the low-risk category in Japan than in other countries.

In previous reports, delay in the transfer process indicated the role of triaging patients directly to PCI centers.[10] In such conditions, the modified HEAR score can be a useful screening tool. However, the prehospital use of the HEAR score

requires 12-lead ECGs, which are not widely used in Japan. Furthermore, the problem encountered by paramedics in assessing the history of chest pain and ECG findings remains unresolved. The evaluation of medical history could be resolved by training paramedics and standardizing symptom checklists. To resolve difficulties in ECG interpretation, the mobile telemedicine system transmission of prehospital 12-lead ECG and training of paramedics could be useful.

The international guidelines recommend that serial cardiac troponin levels should be assessed for early risk stratification.[3] The HEART pathway, which combines the HEART score with serial troponin assays, has been developed to identify patients with chest pain who are eligible for early discharge, and a randomized trial showed the efficacy.[11–12] Hence, validation studies of the pathway in a Japanese cohort should be carried out.

LIMITATIONS

THE CURRENT STUDY had several limitations. It has a retrospective design. Moreover, many patients with incomplete data, including MACEs, were excluded, and there was a trend for younger and lower-risk patients to be excluded. We cannot explicitly explain how the trend affected the results of this study, which could lead to selection bias. In terms of risk factors, we did not refer to strict definitions of hypertension, diabetes mellitus, and dyslipidemia, and we did not consider whether patients had taken any medicine for these risk factors. Moreover, only history of smoking was assessed, and information that includes when, how long, and how many cigarettes the patients smoke was not evaluated. Data on family history and body mass index were not available. In addition, we did not measure high-sensitivity cardiac troponin levels because the system of measurement was not introduced to our hospital.

CONCLUSIONS

THIS STUDY REPORTED that the HEART score was effective when used in a Japanese population. The modified HEART and HEAR scores had high NPVs for MACEs that occurred within 6 weeks. Nevertheless, prospective studies, which include the assessment of serial troponin assays, on Japanese cohorts should be carried out.

ACKNOWLEDGMENTS

DISCLOSURE

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