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Original Article

The Role of HEART Score in Predicting Major Adverse Cardiac Events in Patients with Possible Acute Coronary Syndrome Presenting to the Emergency Department

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Key Words : *HEART score, acute coronary syndrome, Major adverse cardiac events, Bangladesh.*

Abstract:

Introduction: *Acute coronary syndrome is very challenging & sometimes very confusing to diagnose. The HEART score was designed to be a prognostic prediction model, using information from the patient's history, ECG, age, risk factors, and troponin level at the initial emergency department. This study was conducted to assess the role of HEART score in predicting major adverse cardiac events in patients with possible acute coronary syndrome presenting to the emergency department.*

Methods: *This prospective observational study was conducted among 453 patients presented with acute coronary syndrome (ACS) at the Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka, Bangladesh from January 2023 to June 2023 to assess the role of HEART score in predicting major adverse cardiac events (MACE) in patients with possible acute coronary syndrome. The study population was divided into two groups depending on HEART score. MACE was observed between these two groups.*

Results: *Mean age of the respondents was 53.45±11.23 years where 77.7% of them were male. 55% had smoking habit, 36% had history of Diabetes Mellitus, and 38% had history of HTN. Among the respondents 62.9 % was improved. 11.03 % respondents developed heart failure, 14.34% recurrent ischemic pain, 7.9% of recurrent MI, 2.8 % cardiogenic shock, and 0.88 % cases of death. HEART score as predictor was statistically significant (X^2=69.7, df=1, p<0.05), indicated to distinguish between major adverse cardiac events and no major cardiac events.*

Conclusion: *Almost one third of respondents with high HEART score had heart failure and recurrent ischemic pain. There was statistically significant difference in incidence of major adverse cardiac events between high and low HEART score groups. The HEART score can be used to predict risk for major adverse cardiac events effectively in patients with suspected ACS. This can help us to determine needs for urgent treatment and hospitalization among the patients who present with suspected ACS.*

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Introduction:

Myocardial infarction can be diagnosed by the clinical history, ECG, cardiac imaging and an increase & decrease of cardiac troponin I concentration (as an evidence of myocardial necrosis).[1] Test assay sensitivity improvement now permits the quantification of very low concentrations troponin, which allows lower diagnostic thresholds.[2]

The Universal Definition of Myocardial Infarction (MI) recommends that an increase in troponin level above the 99th percentile of a normal reference range should be used as the threshold for diagnosis of MI. However, Troponin

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concentration differs with gender and suggests gender-specific diagnostic thresholds be applied when using high-sensitivity cardiac troponin level permit use of lower thresholds for the diagnosis of MI.[3,4] The use of hs-cTnI assays and lowering the diagnostic threshold to the 99th percentile remains an issue now-a-days;[5] therefore, irrespective of guideline recommendations,[1] some hospitals worldwide have adopted high-sensitivity assays.[6,7] Introduction of hs-cTnI assays will improve patient outcomes. However, the increase sensitivity may lead to poor specificity, and then patients could be misdiagnosed, given inappropriate medications, that lead to adverse outcomes. Sometimes we may face some challenges. Firstly, with hs-cTnI tests it is tough to differentiate between patients who present to the emergency department with acute MI and those who came with other causes of myocardial injury.[8] Secondly, the actual timing of getting the second blood sample is a matter of debate, and recommendations vary between 1 hour and 6 hours.[9] Thirdly, the long-term prognosis in patients who do not have MI but who have persistently elevated hs-cTnI concentrations remains unclear. Comparing outcomes in such patients with those in the general population may increase the understanding of individual risk.[10]

There are no guidelines for what rate of missed ACS is acceptable in emergency medicine practice. Surveys of emergency physicians (EPs) find a large majority desire a miss rate of less than 1%.[11] Acute coronary syndrome is very challenging & sometimes very confusing to diagnose. To exclude Unstable Angina, the clinician must have full confidence in the patient history as, by definition, markers of cardiac injury are undetectable and the ECG may be normal. The term "possible ACS" can be used during initial ED evaluation if elements of the history are of concern, the ECG is unrevealing, and initial cardiac biomarker data are not yet available or undetectable.[12] Given the diagnostic challenge, it is sensible for EPs to have an approach to prognosticate patients with possible ACS. In the absence of a definitive diagnosis, patients perceived to be at unacceptable risk for adverse outcomes can be referred for additional observation and investigation in hospital. Many clinicians naturally incorporate elements from patient's demographics, risk factors, symptoms, physical exam, and investigations to formulate both diagnostic and prognostic impressions. However, many doctors disagree with prediction models for lacking evidence of superiority.[13] For diagnostic confusion such as in possible ACS, a formal prognostic prediction model can help Emergency Physician to take decision.[14] Multiple prediction models have been developed to help identify patients with possible ACS at increased risk of adverse outcomes.[15] The HEART score is a user-friendly & easily understandable prediction model for physicians assessing patients presenting to the Emergency Department with possible ACS. In addition, the impact of incorporation, verification, and outcome blinding biases with the potential to overstate the score's predictive performance has not been fully explored. The HEART score was designed to be a prognostic prediction model, using information from the patient's history, ECG, age, risk factors, and troponin level at the initial emergency department.[16,17]

Table-I

Composition of the HEART score for patients in the ED with possible ACS

History	Highly suspicious	2
	Moderately suspicious	1
	Slightly suspicious	0
ECG	Significant ST depression	2
	Non-specific repolarization disturbance	1
	Normal	0
Age	≥65 years	2
	45–65 years	1
	<45 years	0
Risk Risk factors*	≥3 risk factors	2
	1 or 2 risk factors	1
	No risk factors	0
Troponin	≥3× normal limit	2
	1–3× normal limit	1
	≤normal limit	0

*Risk factors for coronary artery disease include currently treated diabetes mellitus, current or recent (<1 month) smoker, diagnosed hypertension, diagnosed hypercholesterolemia, family history of coronary artery disease, and obesity.

A systematic review and meta-analysis involving the HEART score was published in May 2017.[18] HEART score 0–3 represented a negative index

test and HEART score 4–10 represented a positive index test in calculating measures of diagnostic accuracy.

We used this cut-off was selected as the authors considered patients with HEART score 0–3 at low risk of developing MACE and potentially eligible for immediate discharge from the ED.

Methods:

A Prospective observational study was done to assess the role of heart score in predicting major adverse cardiac events in patients with possible acute coronary syndrome. The study was conducted from July 2022 to June 2023 in the Department of Cardiology, National Institute of Cardiovascular Diseases, Dhaka, Bangladesh.

The study was conducted among 453 patients presented with acute coronary syndrome (ACS) to assess the role of HEART score in predicting major adverse cardiac events (MACE) in patients with possible acute coronary syndrome. The study population was divided into two groups depending on HEART score. MACE was observed between these two groups.

Primary enrollment was started from CCU, PCCU patients who presented with Acute Coronary Syndrome (ACS). Meticulous history will be taken and detailed clinical examination was performed and recorded in predesigned structured questionnaire. Demographic data such as, age and sex were recorded. Risk factor profile including smoking, hypertension, diabetes, obesity and family history of coronary artery disease was noted. Laboratory investigations were done on index hospitalization: hs Troponin I, Serum Creatinine, Random Blood Sugar and Serum Electrolytes. 12 lead resting ECG was done at a paper speed of 25 mm/s and 10mm standardization at admission. Echocardiography was done to assess LVEF (by modified Simpson's method). HEART score was calculated and the study population was divided into two groups; Group 1: Possible ACS patients with low HEART Score (0-3), Group 2: Possible ACS patients with high HEART Score (4-10).

The numerical data obtained from the study was analyzed and significance of differences were estimated by using statistical methods. The Statistical Package for Social Sciences version 20 software (SPSS Inc., Chicago, Illinois, USA) was used for data analysis. Categorical variables are expressed as percentage and frequency and continuous variables as mean and standard deviation. Continuous variables was compared through the Student's t-test and for the categorical variables the chi-square test and Fisher's Exact test was done as appropriate. Multivariate logistic regression analysis was done to identify independent effect of HEART score on ACS. A p- value of less than 0.05 was considered statistically significant.

Results:

Among 453 respondents 77.7% were male and rests were female.

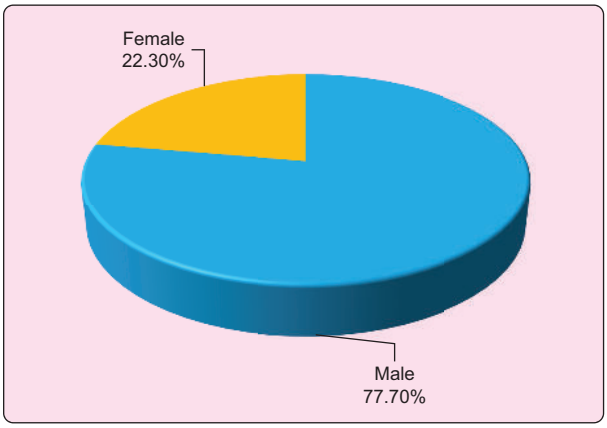

Fig.-1: *Distribution of respondents by sex (n-453).*

Mean age of the respondents was 53.45±11.23 years. Among the respondents 20.3% were from less than 45 years of age group, 62.5% were from 45-65 years of age group and rests are from more than 65 years of age group.

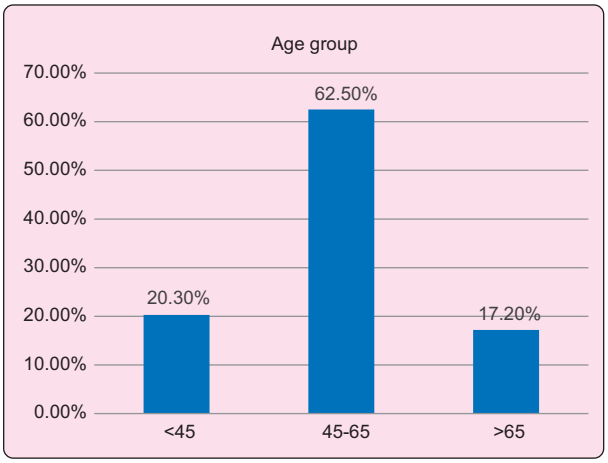

Fig 2: *Distribution of respondents by age group (n-453).*

Table-II

Distribution of respondents by risk factors (n-453).

Risk factors	Yes	No	Total
Smoking habit of the patients	55%	45%	100%
History of DM	36%	64%	100%
History of HTN	38%	62%	100%
History of Dyslipidemia	7.3%	92.7%	100%
Family history of CAD	11%	89%	100%
Post PCI or CABG	3.8%	96.2%	100%
Other co-morbidities	9.3%	90.7%	100%

Among the respondents 55% had smoking habit, 36% had history of Diabetes Mellitus, 38% had history of HTN, 7.3% had history of Dyslipidemia and 9.3% had history of other co-morbidities.

Table III

Distribution of respondents by components of HEART score (n-453).

Variable	Category	Percentage
History	Slightly suspicious	11.5%
	Moderately suspicious	39.1%
	Highly suspicious	49.4%
	Total	100%
ECG	Normal	10.2%
	Non-specific polarization disturbance	30%
	Significant ST depression	59.8%
	Total	100%
Age	<45	20.3%
	45-65	62.5%
	>65	17.2%
	Total	100%
Risk factor	No risk factor	15.5%
	1 or 2 risk factors	71.1%
	More than 2 risk factors	13.4%
	Total	100%
Troponin result	Normal limit	22.1%
	1-2 times to normal limit	24.1%
	3 or more times to normal limit	53.8%
	Total	100%

3Among the respondents 49.4% had highly suspicious history, 59.8% had significant ST depression in ECG, 62.5% were from 45-65 years of age group, 71.1% has 1or 2 risk factors and 53.8% has 3 or more times to normal limit troponin result.

Distribution of respondents by their improvement (n-453)

Among the respondents 58.3% was improved but rests had adverse cardiac events.

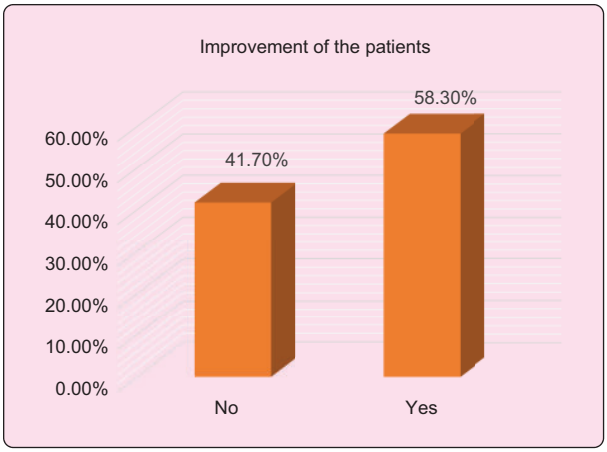

Fig.-3: *Distribution of respondents by their improvement (n-453)*

Table-IV

Distribution of respondents by adverse cardiac events (n-453)

Adverse Cardiac Outcomes	Low HEART score(0-3)	High HEART score(4-10)	p-value
Heart failure	1 (0.9%)	116 (99.1%)	0.000
Recurrent Ischemic Pain	0 (0%)	121 (100%)	0.000
Recurrent MI	0 (0%)	9 (100%)	0.207
Stroke	0 (0%)	2 (100%)	0.555
Death	0 (0%)	4 (100%)	0.403

Among the respondents 117 had heart failure among them almost all (99.1%) belongs to high HEART score group, 121 had recurrent ischemic pain, 9 had recurrent MI, 21 had cardiogenic shock, 2 had stroke and 4 were died. There is a significant association between high HEART score group and adverse cardiac events.

Binary logistic regression was performed to assess the impact of HEART score on major adverse cardiac event. This model contained one independent variable. The full model containing HEART score as predictor was statistically significant (X^2=69.7, df=1, p<0.05), indicated that the model was able to distinguish between major adverse cardiac events and no major cardiac events. As shown in table- 4.1.3, heart score had statistically significant contribution in predicting major adverse cardiac events. High risk heart score (4-10) were over 62 times more likely to occur major adverse cardiac events (OR=62.02) than low risk heart score (0-3).

Table-V

Logistic regression predicting likelihood of major adverse cardiac events (n-453)

	B	S.E.	Wald	df	p	OR	95% C.I.for EXP(B)	
							Lower	Upper
Heart score	4.127	1.013	16.612	1	.000	62.020	8.522	451.366
Constant	4.190	1.008	17.291	1	.000	.015		

Table-VI

Relationship between major adverse cardiac events (MACE) and HEART score categories

			HS category		Total	
			Low risk	High Risk		
MACE category	No major cardiac event	Count	66	199	265	X^2= 51.84 Df=1 P<0.05
		% within MACE category	24.9%	75.1%	100.0%	
	Major cardiac event	Count	1	187	188	
		% within MACE category	0.5%	99.5%	100.0%	
Total		Count	67	386	453	
		% within MACE category	14.8%	85.2%	100.0%	

A chi-square test was performed to assess the relationship between major adverse cardiac events (MACE) and HEART score categories. A significant association was found between these two variables ($p<0.05$).

Discussion:

A prospective observational study was done in patients presented with acute coronary syndrome in emergency department of National Institute of Cardiovascular Disease. The research aims to find out the correlation between the HEART Score and adverse outcome in patients presenting with possible ACS in emergency department. A total number of 453 patients were included in the study.

In the study among the respondents 20.3% were from less than 45 years of age group, 62.5% were from 45-65 years of age group and rests are from more than 65 years of age group. In this study mean age was 53.45+11.23 years.

In similar study done by Kuehner ZC et al. found Age, mean ± SD 58.8±16.9 [22]. In another study McCord J et al. showed overall Total (N=661) Age ± standard deviation 58.3 ± 13.0 years.[28] Nieuwets A et al. in their study found among 640 patients 59% were male.[26]

In this study among the respondents 55% had smoking habit, 36% had history of Diabetes Mellitus, 38% had history of HTN, 7.3% had history of Dyslipidemia and 9.3% had history of other co-morbidities. McCord J et al. found 57.3% had hypertension, 16.6% had diabetes mellitus, 21.8% had AMI, 27.1% had H/O percutaneous coronary intervention, 10.9% had history of unstable angina, 2.9% had congestive heart failure, 3.9% had smoking history.[28]

In similar study Mark DG et al. showed 48% had hypertension, 47% had hypocholesteremia, 23% had diabetes mellitus, 15% had coronary artery disease, 12 % had Coronary revascularization, 9% had MI, 6% had stroke, 2% had peripheral artery disease, 12% were smoker, 20% had premature history of coronary disease.[20] In another study conducted by Wang G et al. found current smoker were 14.3%, 25.6% had DM, 60.4% had hypertension, 10.2% had hyperlipidemia, 17.9% had family h/0 of premature CAD.[29] In another study 27.3% had smoking history, 47.7% had history of HTN,30.9% had dyslipidemia, 14.9% had diabetes, 21.3% had previous history of MI, 23% had PCI history, 7.4% had CABG, 2.7% had

stroke.[24] In another study 16% had Diabetes mellitus,44% had HTN,37% had hypercholesteremia, 32% had smoking history, 40% had family history of CVD, 21% had obesity ,19% had myocardial infarction, 9% had CABG, 21% had PCI.[26]

In this study among the respondents 49.4% had highly suspicious history, 59.8% had significant ST depression in ECG, 62.5% were from 45-65 years of age group, 71.1% has 1or 2 risk factors and 53.8% has 3 or more times to normal limit troponin result.

In another study Mark DG et al. found Slightly suspicious = 0 points (%) 28 (27–29),Moderately suspicious = 1 point (%) 63 (61–63), Highly suspicious = 2 points (%) 10 (9–10),ECG sub score of Heart, Normal = 0 points (%) 64 (63–65), Nondiagnostic = 1 point (%) 35 (34–36),Ischemic changes = 2 points (%) 2 (1–2), Risk factor sub score of Heart, No risk factors = 0 points (%) 16 (16–17). 1 or 2 risk factors = 1 point (%) 42 (41–43), e" 3 risk factors or known, atherosclerotic disease = 2 points (%),42 (41–43), Troponin sub score of Heart, Troponin I < 0.04 ng/mL = 0 points (%) 96 (95–96), Troponin I 0.05–0.12 ng/mL = 1 point (%) 2 (2–2), Troponin I > 0.12 ng/mL = 2 points (%) 2 (2–3).[20]

In another study History (symptoms) high suspicion rate was 8.5%, ECG ST depression or elevation was 9.2%, Age e"65 y 31.2%, 15.3%, 57.7% ,45–64 y 54.2% ,62.7%, 39.9%, <45 y 97 14.7%. Risk factors e"3 risk factors or history of atherosclerotic disease was 36.9%.[32]

In this study among the respondents 62.9 % was improved. 11.03 % respondents devolved heart failure, 14.34% recurrent ischemic pain, 7.9% of recurrent MI, 2.8 % cardiogenic shock, and 0.88 % cases of death.

The main finding of our study is that a low-risk group can be identified in the ED in patients evaluated for possible AMI by applying an m-HS: serial hs-cTnT<14 ng/L over 4 to 14 hours or applying the 1-hour delta hs-cTnT algorithm and a HSd"3.

In patients with a known hs-cTnT over 4 to 14 hours, there were 413/1053 (39.2%) such low-risk patients whose MACE rate (death or AMI) was 0.2% at 30 days[28]. whereas HEARTd"3 would have identified 524 (24.0%) patients as low-risk (P < .001). The MACE rate in discharged patients was 2.2% (20/926) and would have been 5.2% (27/524) in those with HEARTd"3 (P = .002). For discharged patients, the MACE rates in HEARTd"3 vs HEART>3 groups were not significantly different (1.5% vs 2.7%, P = .225) [29] There were 8815 patients enrolled.

At 30 days, the composite event rate was 8.0% (660 patients): 108 deaths, 410 acute myocardial infarction, and 301 revascularizations. Of the 485 patients with both a TIMI score of 0 and a HEART score of 0, there were no cardiovascular events (95% confidence interval, 0–0.8%); but no other score combination had an upper limit confidence interval less than 1%.[32]

From above discussion, many clinical trials have defined MACE as the composite of death, AMI, or revascularization. In our study, we defined MACE as either death or AMI, and we think that this is more appropriate in low-risk patients evaluated in the ED for possible AMI. Revascularization is a softer end point as compared with death or AMI, and the need for revascularization can be subjective, which has been recognized by other authors.

Conclusion

The study concluded that heart score was statistically significant to create a difference between major adverse cardiac events and no major adverse cardiac events. Almost one third of respondents had heart failure and recurrent ischemic pain. Half of respondents had smoking history .Utilization of the HEART score provided excellent determination of risk for MACE. Utilizing the HEART score allowed for an excellent assessment of 30-day MACE risk. This study externally verifies earlier findings that the HEART score is an effective clinical tool in this situation. It distinguishes both immediately a significant portion of high-risk patients, whose early discharge without additional testing carries a risk of MACE of just 1.7%, and low-risk individuals who could benefit from early intrusive measures.

Conflict of Interest - None.

References

1. Thygesen K, Alpert JS, Jaffe AS, Simoons ML, Chaitman BR, White HD. Third universal definition of myocardial

infarction. *Circulation*. 2012;126(16):2020-2035. doi:10.1161/cir.0b013e31826e1058

2. Apple FS, Collinson PO; IFCC Task Force on Clinical Applications of Cardiac Biomarkers. Analytical characteristics of high-sensitivity cardiac troponin assays [published correction appears in Clin Chem. 2012 Apr;58(4):796]. *Clin Chem*. 2012;58(1):54-61. doi:10.1373/clinchem.2011.165795
3. Kimenai DM, Janssen EBNJ, Eggers KM, et al. Sex-Specific Versus Overall Clinical Decision Limits for Cardiac Troponin I and T for the Diagnosis of Acute Myocardial Infarction: A Systematic Review. *Clin Chem*. 2018;64(7):1034-1043. doi:10.1373/clinchem.2018.286781
4. Shah A, Griffiths M, Lee K, et al. High sensitivity cardiac troponin and the under-diagnosis of myocardial infarction in women: Prospective cohort study. *BMJ*. 2015;350(feb03 2). doi:10.1136/bmj.h626
5. Mills NL, Lee KK, McAllister DA, et al. Implications of lowering threshold of plasma troponin concentration in diagnosis of myocardial infarction: Cohort study. *BMJ*. 2012;344(mar15 3). doi:10.1136/bmj.e1533
6. Bagai A, Alexander KP, Berger JS, et al. Use of troponin assay 99th percentile as the decision level for myocardial infarction diagnosis. *Am Heart J*. 2017;190:135-139. doi:10.1016/j.ahj.2017.04.016
7. Anand A, Shah AS, Beshiri A, Jaffe AS, Mills NL. Global adoption of high-sensitivity cardiac troponins and the universal definition of myocardial infarction. *Clinical Chemistry*. 2019;65(3):484-489. doi:10.1373/clinchem.2018.298059
8. Kavsak PA, Jaffe AS, Greene DN, Christenson RH, Apple FS, Wu AHB. Total Analytic Error for Low Cardiac Troponin Concentrations (d"10 ng/L) by Use of a High-Sensitivity Cardiac Troponin Assay. *Clin Chem*. 2017;63(5):1043-1045. doi:10.1373/clinchem.2017.271361
9. Roffi M, Patrono C, Collet J-P, et al. 2015 ESC guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *European Heart Journal*. 2015;37(3):267-315. doi:10.1093/eurheartj/ehv320
10. Blankenberg S, Salomaa V, Makarova N, et al. Troponin I and cardiovascular risk prediction in the general population: The biomarcare consortium. *European Heart Journal*. 2016;37(30):2428-2437. doi:10.1093/eurheartj/ehw172
11. Than M, Herbert M, Flaws D, et al. What is an acceptable risk of major adverse cardiac event in chest pain patients soon after discharge from the Emergency Department?: a clinical survey. *Int J Cardiol*. 2013;166(3):752-754. doi:10.1016/j.ijcard.2012.09.171
12. Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC Guideline for the Management of Patients with Non-ST-Elevation Acute Coronary Syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines [published correction appears in J Am Coll Cardiol. 2014 Dec 23;64(24):2713-4. Dosage error in article text]. *J Am Coll Cardiol*. 2014;64(24):e139-e228. doi:10.1016/j.jacc.2014.09.017
13. Visser A, Wolthuis A, Breedveld R, ter Avest E. HEART score and clinical gestalt have similar diagnostic accuracy for diagnosing ACS in an unselected population of patients with chest pain presenting in the ED. *Emerg Med J*. 2015;32(8):595-600. doi:10.1136/emermed-2014-203798
14. Six AJ, Backus BE, Kelder JC. Chest pain in the emergency room: value of the HEART score. *Neth Heart J*. 2008;16(6):191-196. doi:10.1007/BF03086144
15. Scheuermeyer FX, Wong H, Yu E, et al. Development and validation of a prediction rule for early discharge of low-risk emergency department patients with potential ischemic chest pain. *CJEM*. 2014;16(2):106-119. doi:10.2310/8000.2013.130938
16. Moons KG, de Groot JA, Bouwmeester W, et al. Critical appraisal and data extraction for systematic reviews of prediction modelling studies: The charms checklist. *PLoS Medicine*. 2014;11(10). doi:10.1371/journal.pmed.1001744
17. Backus BE, Six AJ, Doevendans PA, Kelder JC, Steyerberg EW, Vergouwe Y. Prognostic factors in chest pain patients. *Critical Pathways in Cardiology: A Journal of Evidence-Based Medicine*. 2016;15(2):50-55. doi:10.1097/hpc.0000000000000075
18. McCord J, Cabrera R, Lindahl B, et al. Prognostic Utility of a Modified HEART Score in Chest Pain Patients in the Emergency Department. *Circ Cardiovasc Qual Outcomes*. 2017;10(2):e003101. doi:10.1161/CIRCOUTCOMES.116.003101
19. Wang G, Zheng W, Wu S, et al. Comparison of usual care and the heart score for effectively and safely discharging patients with low risk chest pain in the emergency department: Would the score always help? *Clinical Cardiology*. 2019;43(4):371-378. doi:10.1002/clc.23325
20. de Hoog VC, Lim SH, Bank IE, et al. Heart score performance in Asian and Caucasian patients presenting to the emergency department with suspected acute coronary syndrome. *European Heart Journal: Acute Cardiovascular Care*. 2017;7(7):591-601. doi:10.1177/2048872617700870
21. Soares WE 3rd, Knee A, Gemme SR, et al. A Prospective Evaluation of Clinical HEART Score Agreement, Accuracy, and Adherence in Emergency Department Chest Pain Patients. *Ann Emerg Med*. 2021;78(2):231-241. doi:10.1016/j.annemergmed.2021.03.024
22. McCord J, Cabrera R, Lindahl B, et al. Prognostic Utility of a Modified HEART Score in Chest Pain Patients in the Emergency Department. *Circ Cardiovasc Qual Outcomes*. 2017;10(2):e003101. doi:10.1161/CIRCOUTCOMES.116.003101
23. de Hoog VC, Lim SH, Bank IE, et al. Heart score performance in Asian and Caucasian patients presenting to the emergency department with suspected acute coronary syndrome. *European Heart Journal: Acute*

Cardiovascular Care. 2017;7(7):591-601. doi:10.1177/2048872617700870

24. Kuehner ZCD, Dmitriew MD, Wu LK, Shearing AD. The impact of the HEART score on the prevalence of cardiac testing and patient outcomes in a rural emergency department. *Can J Rural Med*. 2020;25(3):105-111. doi:10.4103/CJRM.CJRM_77_19
25. Mark DG, Huang J, Kene MV, et al. Automated Retrospective Calculation of the EDACS and HEART Scores in a Multicenter Prospective Cohort of Emergency Department Chest Pain Patients. *Acad Emerg Med*. 2020;27(10):1028-1038. doi:10.1111/acem.14068
26. Wang G, Zheng W, Wu S, et al. Comparison of usual care and the HEART score for effectively and safely discharging patients with low-risk chest pain in the emergency department: would the score always help?. *Clin Cardiol*. 2020;43(4):371-378. doi:10.1002/clc.23325
27. Nieuwets A, Poldervaart JM, Reitsma JB, et al. Medical consumption compared for Timi and heart score in chest pain patients at the Emergency Department: A retrospective cost analysis. *BMJ Open*. 2016;6(6). doi:10.1136/bmjopen-2015-010694
28. Six AJ, Cullen L, Backus BE, et al. The HEART score for the assessment of patients with chest pain in the emergency department: a multinational validation study. *Crit Pathw Cardiol*. 2013;12(3):121-126. doi:10.1097/HPC.0b013e31828b327e
29. Marcoon S, Chang AM, Lee B, Salhi R, Hollander JE. Heart score to further risk stratify patients with low TIMI scores. *Critical Pathways in Cardiology: A Journal of Evidence-Based Medicine*. 2013;12(1):1-5. doi:10.1097/hpc.0b013e31827377e1
30. Frisoli TM, Nowak R, Evans KL, et al. Henry Ford HEART Score Randomized Trial: Rapid Discharge of Patients Evaluated for Possible Myocardial Infarction. *Circ Cardiovasc Qual Outcomes*. 2017;10(10):e003617. doi:10.1161/CIRCOUTCOMES.117.003617