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Can the HEART Score Safely Reduce Stress Testing and Cardiac Imaging in Patients at Low Risk for Acute Coronary Syndrome?

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Abstract

Background—Patients with low risk chest pain have high utilization of stress testing and cardiac imaging, but low rates of acute coronary syndrome (ACS). The objective of this study was to determine if the HEART score could safely reduce objective cardiac testing in patients with low risk chest pain.

Methods—A cohort of chest pain patients was identified from an Emergency Department-based observation unit registry. HEART scores were determined using registry data elements and blinded chart review. HEART scores were dichotomized into low (0–3) or high risk (>3). The outcome was MACE; a composite endpoint of all cause mortality, myocardial infarction, or coronary revascularization during the index visit or within 30 days. Sensitivity, specificity, and potential reduction of cardiac testing were calculated.

Results—Over 28 months, the registry included 1070 low risk chest pain patients. MACE occurred in 0.6% (5/904) of patients with low-risk HEART scores compared to 4.2% (7/166) with a high-risk HEART scores, OR=7.92, (95% CI 2.48–25.25). A HEART score >3 was 58% sensitive (95% CI 32–81%) and 85% specific (95% CI 83–87%) for MACE. The HEART score missed 5 cases of ACS among 1070 patients (0.5%) and could have reduced cardiac testing by 84.5% (904/1070). Combination of serial troponin > 0.065 ng/ml or HEART score >3 resulted in 100% sensitivity (95% CI 72–100%), specificity of 83% (95% CI 81–85%), and potential reduction in cardiac testing of 82% (879/1070).

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Conclusions—If used to guide stress testing and cardiac imaging, the HEART score could substantially reduce cardiac testing in a population with low pre-test probability of ACS.

Keywords

HEART score; chest pain; cardiac testing; observation; risk stratification

Introduction

Approximately 8–10 million patients complaining of chest pain present to an Emergency Department (ED) annually in the United States.¹ The total cost of chest pain evaluations has been estimated at \$5–10 billion annually yet only about 10% of these patients are ultimately diagnosed with an acute coronary syndrome (ACS).^{2–5} The American College of Cardiology/ American Heart Association (ACC/AHA) guidelines suggest patients with symptoms consistent with ACS be stratified into low, intermediate, and high risk and that serial markers plus objective cardiac testing (stress testing or cardiac imaging) be performed on patients felt to be at low risk for ACS. These evaluations are commonly completed in an observation unit (OU) setting. However, OU cohorts at low risk for ACS have low major adverse cardiac event (MACE) rates, leading some to question the utility of stress testing all low risk patients.^{6–7}

Unfortunately, clinical decision aids, such as the Thrombosis in Myocardial Infarction (TIMI) risk score or Global Registry of Acute Coronary Events (GRACE) score, have lacked the sensitivity necessary to avoid additional diagnostic testing or inpatient care.^{8–9} To improve healthcare delivery, more accurate risk stratification is needed to properly select which patients are unlikely to benefit from objective cardiac testing.

The HEART score is a recently developed decision aid designed to identify ED patients, with chest pain or related symptoms, which can safely forgo objective cardiac testing.¹⁰ It was recently retrospectively validated in a cohort of 910 patients presenting to European Cardiology Emergency Rooms with undifferentiated chest pain.¹¹ In this study, patients with a low risk HEART score (0–3) had a MACE rate less than 1% at 6 weeks.¹¹ However, the HEART score has yet to be tested in patients presenting to an ED within the United States or among low risk patients likely to be managed in a chest pain OU. It is possible that the HEART score could be used for incremental risk stratification in a similar way that the Pulmonary Embolism Rule out Criteria is used in patients at low risk for pulmonary embolism.¹² By applying the HEART score to patients already identified as low risk for ACS it may be possible to minimize missed MACE to an acceptable level and decrease the utilization of costly cardiac testing. The objective of this study is to determine if the HEART score is predictive of MACE, and to evaluate its potential for safely reducing objective cardiac testing in a United States ED cohort of low risk chest pain patients.

Methods

Study Design

This is a cohort study of patients included in the ED based OU Chest Pain Registry at (institution name withheld for review) from 1/2008–4/2010. Registry data elements include a combination of prospectively collected cross-sectional data and retrospective data. The registry and this analysis were approved by the Internal Review Board of the sponsoring organization; a waiver of consent was granted.

Study Setting and Population

The study institution is a tertiary referral center with an annual ED volume of approximately 96,000 patients per year. Patients with chest pain suggestive of a cardiac etiology, but determined to be at low risk for ACS by TIMI risk score <2 and clinician assessment of low risk were admitted to the ED based OU and were included in the registry. Care providers were encouraged to use the ACC/AHA framework for risk assessment.¹³ Inclusion criteria for the registry include a normal or non-diagnostic ECG and negative first set of cardiac biomarkers (troponin I, CK-MB). The OU cares for 400–500 low risk chest pain patients annually and is open seven days a week, with 24 hour nursing and physician coverage. Patients admitted to the OU receive serial ECGs, serial cardiac biomarkers, and objective cardiac testing prior to discharge. The cardiac testing modality is at the discretion of the treating physician and can consist of exercise stress echocardiogram (ESE), dobutamine stress echocardiogram (DSE), coronary computed tomography angiography (CCTA), or stress cardiac magnetic resonance (CMR). ECG stress tests without imaging are not performed at the study institution.

Study Protocol and Measures

Patients in the registry were queried for MACE, defined as a composite endpoint of all cause mortality, myocardial infarction, or coronary revascularization during the index visit or within 30 days. Myocardial infarction was determined based on the 2000 Joint European Society of Cardiology/American College of Cardiology consensus definition, using an institutionally accepted troponin cut-off of 1.0 ng/ml (TnI-Ultra™ assay, Siemens, Munich Germany).¹⁴ Coronary revascularization was defined as emergent or non-emergent revascularization procedures including angioplasty with or without stent placement, or coronary artery bypass surgery. All patients in the OU registry receive a record review to determine MACE within 30 days. Potential objective cardiac testing reduction was assessed based on the premise that patients determined to be low-risk by heart score could forgo further objective cardiac testing. This was calculated by dividing the number of patients determined to be low risk by the HEART score by the total number of patients in the cohort. This represents the percentage of patients in the cohort that could have avoided cardiac testing if the HEART score was used to guide cardiac testing decisions.

A HEART score was determined for all patients in the registry. The methods for determining a HEART score have been previously described (Table 1).^{10–11} Patients in the registry with incomplete or missing data elements required for calculation of a HEART score underwent a blinded chart review conducted by study investigators (SM,CM) using a standardized data collection tool. Body Mass Index (BMI) was not included for calculation of the HEART score as height and weight were not routinely recorded in the ED or OU. Data abstraction was duplicated on 50 patients for calculation of inter-observer agreement. The HEART score was calculated based on the initial troponin drawn in the ED and was considered positive if it was above 1.0 ng/ml. At institution name withheld for review a troponin of 1.0 ng/ml was accepted as positive for acute myocardial infarction, values between 0.066–0.999 ng/ml were considered indeterminate, and values of 0.065 ng/ml or less were considered normal.

Statistical Analysis

The primary outcome measure was the presence or absence of MACE during the index visit or within 30 days. The predictor variable was the HEART score. Consistent with prior applications of the HEART score, this variable was dichotomized into low risk (0–3) or high risk (4 or more).^{10–11} Univariate logistic regression was used to model the relationship between HEART scores and MACE. Sensitivity, specificity, positive and negative likelihood ratios, and potential cardiac testing reduction from use of the HEART score were

calculated. A kappa statistic was generated to measure the interobserver agreement from HEART score data abstraction. A secondary analysis was conducted to determine the diagnostic accuracy of the combination of HEART score and a second serum troponin (obtained 4–6 hours after ED admission) using a cutoff of 0.065 ng/ml (the upper limit of normal at institution name withheld for review). The 4–6 hour troponin was tested in combination with the HEART score, based on a single post-hoc hypothesis. Multiple comparisons with different variable combinations were not performed. Sensitivity analyses were performed to assess the potential impact of missing BMI data. First, obesity was added as a risk factor to 320 subjects (30% of the cohort)¹⁵ using simple random selection without replacement. Second, since obesity was likely to coexist with other risk factors, an analysis was performed assigning obesity to all subjects with hypertension or diabetes. A third sensitivity analysis was performed adding obesity as a risk factor to all of the patients in the cohort. An additional sensitivity analysis was performed to assess the rate of missed cases of ACS and potential reduction in cardiac testing if the cohort had a higher rate of MACE, by using the upper bound of the confidence interval of MACE rate. Statistical analysis was performed using SAS 9.2 (Cary, North Carolina).

Results

From 1/2008–4/2010, 1070 low risk chest pain patients, with normal or non-diagnostic ECGs and negative initial cardiac biomarkers, were included in the OU Chest Pain Registry at (institution name withheld for review). Characteristics of the cohort are summarized in Tables 2 and 3. Out of the 1070 patients, 532 required a chart review for missing data elements necessary for HEART score calculation. Inter-observer agreement among blinded abstractors for HEART high versus low risk was excellent (kappa= 0.81). Stress testing or cardiac imaging was completed in 93.7% (1003/1070) patients. Record review for MACE was completed on all registry patients with complete 30 day follow up data available in 70% (753/1058) of the patients without index MACE. See Figure 1.

MACE occurred in 1.1% (12/1070) of patients in the cohort. Among patients with a low-risk HEART score 0.6% (5/904), (95%CI 0.2–1.1%) had a MACE compared to 4.2% (7/166), (95%CI 1.9–8.6%) with a high-risk HEART score, for an odds ratio (OR) of 7.92, (95%CI 2.48–25.25), $p < 0.001$. A high risk HEART score (4 or greater) was 58.3% sensitive, (95%CI 32–81%) and 85.0% specific, (95%CI 83–87%) for MACE with positive and negative likelihood ratios of 3.89, (95%CI 2.36–6.39) and 0.49 (95%CI 0.25–0.96) respectively. The AUC for the HEART score was 0.72. Use of the HEART score to guide patient disposition would have resulted in 5 cases of missed ACS, a miss rate of less than 0.5% (5/1070) (95%CI 0.2–1.1%) and a potential reduction in cardiac testing of 84.5% (904/1070) (95%CI 82–86.5%). See Table 4 for a summary of the HEART score test characteristics. The combined use of a 4–6 hour serial troponin greater than 0.065 ng/ml or a high risk HEART score resulted in 100% sensitivity, (95% CI 72–100%) with a specificity of 83.1%, (95%CI 81–85%), and a potential cardiac testing reduction of 82.1% (879/1070), (95%CI 80–84%). See Table 5 for the test characteristics of the combined use of the HEART score and troponin testing. The sensitivity analyses for missing BMI data had little impact on the test characteristics of the HEART score (Appendix 1). If the rate of MACE increased to 2.0% the miss rate of the HEART score for ACS would remain less than 1% and potential reduction in cardiac testing would remain high (Appendix 2). Table 6 provides the clinical characteristics of the 12 patients with MACE.

Discussion

The HEART score has recently been proposed as a method of risk stratification with the potential to define patients at very low risk, who are unlikely to benefit from further testing.

This report examined the use of a HEART score in patients selected to receive an observation unit chest pain evaluation. This patient population poses the greatest diagnostic challenge to emergency physicians and is the most likely to benefit from incremental risk stratification using a clinical decision aid, such as the HEART score.

The results of these analyses indicate that the HEART score has utility in further stratifying patients with symptoms suggestive of ACS after a care provider's clinical assessment of low risk. A high risk HEART score was strongly associated with MACE (OR of 7.92). However, exclusive reliance on the HEART score to determine the need for additional objective cardiac testing would have led to 5/1070 patients (0.5%) with a missed MACE. These results are consistent with the European multicenter validation study of the HEART score, which demonstrated a cardiac event rate of less than 1% in patients with HEART scores of 3 or less.¹¹ The combined use of the HEART score with serial troponin testing to rule out MACE may be even safer.

Using the HEART score in our study population to select patients for objective cardiac testing demonstrated promise to reduce cardiac imaging and reduce potential for harm from diagnostic radiation. In patients stratified as low risk, based on an emergency physician's risk assessment and a TIMI risk score <2, using a HEART score of ≥ 4 to determine the need for cardiac testing would have reduced cardiac testing by 85%. At an average cost of \$290–\$527 (US) per cardiac stress or imaging study this practice would have resulted in a cost savings of approximately \$262,160–\$476,408 at the study institution, over the 28 month study period.¹⁶ In addition, since nearly a third of the patients in the cohort underwent coronary computed tomography angiography, reduced testing would have also decreased radiation exposure in the cohort. Even if the MACE rate was 2% rather than the 1.1% observed, assuming the same sensitivity and specificity, the potential cardiac testing reduction from using the HEART score would remain high and the missed ACS rate would remain below 1%.

While the potential reduction in objective cardiac testing using the HEART score is substantial, missing 0.5% of patients who will experience a MACE may not be acceptable. Given the potentially devastating outcome from missing a patient with MACE, high sensitivity is a critical characteristic of a chest pain decision aid. Unfortunately, the exclusive use of the HEART score lacked sensitivity (58.3%) and had only fair diagnostic accuracy (AUC= 0.72).

With the aim of minimizing missed cases of MACE, we assessed the incremental value of adding serial cardiac biomarkers to the HEART score. In this cohort, combination of a high risk HEART score or an elevated troponin at 4–6 hours from time of ED presentation was 100% sensitive for MACE. Despite a substantial increase in sensitivity, specificity and potential cardiac testing reduction remained high. These findings suggest that in properly selected low risk patients, it is likely that the exclusion of myocardial infarction reduces post-test probability to an acceptable level without additional cardiac testing. The concept that stress testing is unlikely to be beneficial in some subsets of low risk patients is consistent with a study by Hermann et al.⁷ In aggregate, our findings suggest that the HEART score, when used with negative serial cardiac biomarkers, may be useful for identifying those patients who are least likely to benefit from cardiac testing.

Limitations

There are several limitations of this study. This study used patients included in an OU registry at a single medical center. (Institution name withheld for review) is a tertiary referral center, with an Emergency Medicine residency program, and an annual ED volume of approximately 96,000. The results of this study may not be generalizable to chest pain

patients presenting to other institutions. The decision to admit a patient to the OU was ultimately at the discretion of the emergency physician and therefore this cohort, by design, is a highly selected group. In addition, while the data elements from our registry could be used to determine HEART scores, this registry was not designed to determine HEART scores. Chart abstraction was necessary in 532 subjects in order to calculate a HEART score. Abstractors were blinded to patient outcomes in an attempt to minimize any intentional or unintentional bias. High inter-observer agreement suggests that data abstraction was reliable. Also, the registry did not contain height and weight data necessary for body mass index (BMI) calculation. For this reason BMI was not included in the risk score determination of the HEART score which could have resulted in an underestimation of HEART score sensitivity and an overestimation of specificity. However, sensitivity analyses conducted to assess the potential impact of missing BMI data supported the inferences presented here. An additional limitation is that 6.3% of patients in this cohort did not receive stress testing or cardiac imaging as part of their OU care.

The primary outcome measure in this study was MACE during the index visit or within 30 days, but 305 patients had only index data for MACE. This could have resulted in a misclassification bias and underestimation of the primary outcome. However, the likelihood of MACE occurring shortly after discharge in this cohort seems low. Nearly all patients received objective cardiac testing and of the patients with complete 30 day follow up data, none had MACE that was not identified during the index visit. This is consistent with the literature, which has demonstrated that short-term occurrence of ACS after discharge has been very low in patients receiving objective cardiac testing.¹⁷ It is also possible that OU care and testing in this study resulted in changes to patients' medical management, which may have reduced the 30 day event rate in a way that is not accounted for in this analysis. However, even an increase in the rate of MACE to 2%, in our sensitivity analysis, had a negligible effect on potential reduction of cardiac testing while maintaining the rate of missed ACS under 1%. Finally, our results regarding the combined use of an elevated 4–6 hour troponin or a high risk HEART score should be interpreted with caution. This hypothesis was generated after testing the primary hypothesis regarding the sole use of the HEART score and requires further validation.

Conclusions

A high risk HEART score is strongly associated with MACE in a population with a low pre-test probability of ACS. Use of a low-risk HEART score to identify patients who do not require further ACS evaluation in this cohort would have resulted in missing MACE in 0.5% of patients. If used to guide objective cardiac testing, the HEART score could have substantially reduced cardiac testing in this cohort. Combining the HEART score with the results of 4–6 hour troponin testing may improve sensitivity without significantly decreasing specificity or the potential reduction in cardiac testing, but this approach requires validation.

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Appendix 1

Appendix 1

Results of the primary analysis compared to the sensitivity analyses with obesity added at random, obesity added to all subjects with hypertension or diabetes, and obesity added to all subjects.

Analysis	Sensitivity (95%CI)	Specificity (95%CI)	AUC	Odds Ratio (95%CI)	Potential cardiac testing reduction (95%CI)
Primary	58.3% (32–81%)	85.0% (82.7–87.0%)*	0.72	7.92 (2.48–25.25)*	84.5% (82.2–86.5%)
Obesity added randomly to 30% of cohort	58.3% (32–81%)	82.0% (79.6–84.2%)	0.70	6.40 (2.0–20.37)*	81.6% (79.2–83.8%)
Obesity added to all patients with hypertension or diabetes	58.3% (32–81%)	77.3% (74.7–79.7%)	0.68	4.77 (1.5–15.17)*	76.9% (74.3–79.3%)
Obesity added to all patients	58.3% (32–81%)	72.6% (68.9–76.0%)	0.65	3.71 (1.17–11.78)*	72.2% (69.5–74.9%)

* $p < 0.05$.

Appendix 2

Appendix 2

Missed ACS rate and potential cardiac testing reduction of the primary analysis compared to the sensitivity analyses with a higher rate of MACE (using upper bound of 95% confidence interval for MACE rate) assuming generalizable sensitivity and specificity.

Analysis	MACE Rate (95%CI)	Sensitivity	Specificity	Missed ACS rate (95%CI)	Potential cardiac testing reduction (95%CI)
Primary	1.1% (0.6–2.0%)	58.3%	85.0%	0.5% (0.2–1.1%)	84.5% (82.2–86.5%)
Higher MACE rate HEART score	2.0%	58.3%	85.0%	0.8% (0.4–1.6%)	84.2% (81.9–86.2%)
Higher Mace rate HEART and 4–6 hour troponin	2.0%	100%	83.1%	0% (0–0.4%)	81.5% (79.0–83.7%)

References

1. Owens PL, Barrett ML, Gibson TB, Andrews RM, Weinick RM, Mutter RL. Emergency department care in the United States: a profile of national data sources. *Ann Emerg Med.* 2010; 56:150–65. [PubMed: 20074834]
2. Pope JH, Aufderheide TP, Ruthazer R, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med.* 2000; 342:1163–70. [PubMed: 10770981]
3. Pines JM, Isserman JA, Szyld D, Dean AJ, McCusker CM, Hollander JE. The effect of physician risk tolerance and the presence of an observation unit on decision making for ED patients with chest pain. *Am J Emerg Med.* 2010; 28:771–9. [PubMed: 20837253]
4. Fleischmann KE, Goldman L, Johnson PA, et al. Critical pathways for patients with acute chest pain at low risk. *J Thromb Thrombolysis.* 2002; 13:89–96. [PubMed: 12101386]
5. Roger VL, Go AS, Lloyd-Jones DM, et al. Heart disease and stroke statistics--2011 update: a report from the American Heart Association. *Circulation.* 2011; 123:e18–e209. [PubMed: 21160056]
6. Chan GW, Sites FD, Shofer FS, Hollander JE. Impact of stress testing on 30-day cardiovascular outcomes for low-risk patients with chest pain admitted to floor telemetry beds. *Am J Emerg Med.* 2003; 21:282–7. [PubMed: 12898483]
7. Hermann LK, Weingart SD, Duvall WL, Henzlova MJ. The limited utility of routine cardiac stress testing in emergency department chest pain patients younger than 40 years. *Ann Emerg Med.* 2009; 54:12–6. [PubMed: 19231025]
8. Lyon R, Morris AC, Caesar D, Gray S, Gray A. Chest pain presenting to the Emergency Department--to stratify risk with GRACE or TIMI? *Resuscitation.* 2007; 74:90–3. [PubMed: 17360096]
9. O'Connor RE, Bossaert L, Arntz HR, et al. Part 9: acute coronary syndromes: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation.* 2010; 122:S422–65. [PubMed: 20956257]
10. Six AJ, Backus BE, Kelder JC. Chest pain in the emergency room: value of the HEART score. *Neth Heart J.* 2008; 16:191–6. [PubMed: 18665203]
11. Backus BE, Six AJ, Kelder JC, et al. Chest pain in the emergency room: a multicenter validation of the HEART Score. *Crit Pathw Cardiol.* 2010; 9:164–9. [PubMed: 20802272]
12. Kline JA, Courtney DM, Kabrhel C, et al. Prospective multicenter evaluation of the pulmonary embolism rule-out criteria. *J Thromb Haemost.* 2008; 6:772–80. [PubMed: 18318689]
13. Anderson JL, Adams CD, Antman EM, et al. ACC/AHA 2007 guidelines for the management of patients with unstable angina/non-ST-Elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines for the Management of Patients With Unstable Angina/Non-ST-Elevation Myocardial Infarction) developed in collaboration with the American College of Emergency Physicians, the Society for Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation and the Society for Academic Emergency Medicine. *J Am Coll Cardiol.* 2007; 50:e1–e157. [PubMed: 17692738]
14. Alpert JS, Thygesen K, Antman E, Bassand JP. Myocardial infarction redefined--a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. *J Am Coll Cardiol.* 2000; 36:959–69. [PubMed: 10987628]
15. United States Obesity Trends. Trends by State. 1985–2009. Accessed at
16. Takakuwa KM, Halpern EJ, Shofer FS. A time and imaging cost analysis of low-risk ED observation patients: a conservative 64-section computed tomography coronary angiography “triple rule-out” compared to nuclear stress test strategy. *Am J Emerg Med.* 2011; 29:187–95. [PubMed: 20825785]
17. Amsterdam EA, Kirk JD, Bluemke DA, et al. Testing of low-risk patients presenting to the emergency department with chest pain: a scientific statement from the American Heart Association. *Circulation.* 2010; 122:1756–76. [PubMed: 20660809]

Figure 1. Flow chart for adjudication of MACE at the index visit and within 30 days. MACE=major adverse cardiac events.

Table 1

The HEART score; Low risk= 0–3, High risk= 4 or greater.

		Points
H istory	Highly Suspicious	2
	Moderately Suspicious	1
	Slightly Suspicious	0
E CG	Significant ST-depression	2
	Non-specific repolarization abnormality	1
	Normal	0
A ge	≥ 65	2
	45–65	1
	≤ 45	0
R isk factors	3 or more risk factors	2
	1–2 risk factors	1
	No risk factors	0
T roponin	≥ 3× normal limit	2
	1–3× normal limit	1
	≤ normal limit	0
Total		

ECG= electrocardiogram. Risk factors include; currently treated diabetes mellitus, current or recent (<90 days) smoker, diagnosed and/or treated hypertension, diagnosed hypercholesterolemia, family history of coronary artery disease, obesity (body mass index >30), or a history of significant atherosclerosis (coronary revascularization, myocardial infarction, stroke, or peripheral arterial disease).

Table 2

Cohort patient characteristics.

Patient Characteristics	Number (n = 1070)	Percent
Age—mean $\pm$ SD	46.3 $\pm$ 9.7	
Gender		
Male	648	60.6%
Female	422	40.4%
Ethnicity		
Caucasian	605	56.5%
African American	415	38.8%
Asian	13	1.2%
Other	37	3.5%
Observation Unit Disposition		
Admitted	86	8.0%
Discharged	984	92.0%
Chest pain		
Description		
Pressure	595	55.6%
Sharp	190	17.8%
Ache	100	9.3%
Burning	37	3.5%
Other	32	2.9%
Not Specified	118	11.0%
Location		
Substernal	482	45.0%
Left Chest	351	32.8%
Right Chest	36	3.4%
Epigastric	16	1.5%
Other	38	3.6%
Not Specified	147	13.7%
Risk Factors		
Hypertension	413	38.6%
Smoking	368	34.4%
Family History	317	29.6%
Hyperlipidemia	229	21.4%
Diabetes	80	7.5%
TIMI Score		
0	472	44.1%
1	508	47.5%
>1	42	3.9%
Not available	48	4.5%
Initial Cardiac Imaging Modality		

Patient Characteristics	Number (n = 1070)	Percent
CCTA	343	32.1%
ESE	514	48.0%
DSE	113	10.6%
CMR	26	2.4%
Cardiac Catheterization	7	0.7%
None	67	6.3%

TIMI=Thrombosis In Myocardial Infarction, CCTA= coronary computed tomography angiography, ESE= exercise stress echocardiogram, DSE= dobutamine stress echocardiogram, CMR= cardiac magnetic resonance

Table 3

Frequency and percentage of the HEART score categories.

HEART score category	Number (n = 1070)	Percent
History		
Highly suspicious	53	5.0%
Moderately suspicious	629	58.8%
Slightly suspicious	388	36.2%
ECG		
Significant ST-depression	0	0%
Non-specific repolarization abnormality	259	24.2%
Normal	811	75.8%
Age		
≥65	31	2.9%
45–65	532	49.7%
≤45	507	47.4%
Risk		
3 or more risk factors	155	14.5%
1–2 risk factors	678	63.3%
No risk factors	237	22.1%
Troponin (initial)		
Less than normal limits	1070	100%
Total HEART Score		
0	41	3.8%
1	172	16.1%
2	371	34.7%
3	243	22.7%
4	131	12.2%
5	32	3.0%
6	3	0.3%
High risk	166	15.5%
Low risk	904	84.5%

ECG=electrocardiogram, High risk = HEART score of 4 or more, Low risk = HEART score of 3 or less.

Table 4

Test characteristics of the HEART Score for detection of major adverse cardiac events (MACE) among low risk Emergency Department patients with chest pain.

HEART Score	MACE		Total (n)
	Yes (n)	No (n)	
High risk (n)	7	159	166
Low risk (n)	5	899	904
Total (n)	12	1058	1070
Sensitivity		58.3% (7/12), 95% CI 32–81%	
Specificity		85.0% (899/1058), 95% CI 83–87%	
Positive Predictive Value		4.2% (7/166), 95% CI 2–9%	
Negative Predictive Value		99.4% (899/904), 95% CI 99–100%	
Positive Likelihood Ratio		3.89 95%CI 2.36–6.39	
Negative Likelihood Ratio		0.49 95%CI 0.25–0.96	
Potential Cardiac Imaging Reduction		84.5% (904/1070), 95% CI 82–86.5%	

n=number.

Table 5

Test characteristics of the the combined use of a high HEART Score or an elevated 4–6 hour troponin for detection of major adverse cardiac events (MACE) among low risk Emergency Department patients with chest pain.

HEART Score + 4–6 hour troponin	MACE		Total (n)
	Yes (n)	No (n)	
High risk (n)	12	179	191
Low risk (n)	0	879	879
Total (n)	12	1058	1070
Sensitivity	100% (12/12), 95% CI 72–100%		
Specificity	83.1% (879/1058) 95% CI 81–85%		
Positive Predictive Value	6.3% (12/191) 95% CI 3.5–11%		
Negative Predictive Value	100% (879/879) 95% CI 99–100%		
Potential Cardiac Imaging Reduction	82.1% (879/1070) 95% CI 80–84%		

n=number.

Table 6

Characteristics of 12 subjects with MACE including HEART score, troponins, and description of MACE.

Age	Sex	Race	HEART score	4–6 hour troponin	Peak Troponin	MACE
59	Female	African American	6	0.09	0.11	PCI
46	Female	African American	5	0.14	1.15	NSTEMI
61	Male	African American	2	1.09	1.15	NSTEMI
48	Male	Caucasian	5	0.40	3.40	NSTEMI
43	Male	Caucasian	2	0.15	3.96	NSTEMI
46	Male	Other	4	3.50	6.49	NSTEMI
55	Male	Caucasian	2	2.88	11.00	NSTEMI
47	Male	Caucasian	2	0.65	1.26	NSTEMI, PCI*
47	Female	Caucasian	3	0.47	1.65	NSTEMI, PCI*
49	Female	Caucasian	4	2.04	4.095	NSTEMI, PCI*
58	Male	Caucasian	4	0.01	0.32	CABG
64	Male	Caucasian	4	0.00	0.04	Sudden Cardiac Death

* Note that NSTEMI occurred prior to coronary intervention.