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Retrospective Validation of HEART Score for Chest Pain Patients in the Emergency Department

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Abstract: Acute chest pain is one of the most common presentations to the emergency department yet only about 10% of these cases are diagnosed with acute coronary syndrome. Emergency physicians are faced with the dilemma of determining the etiology of the chest pain and appropriately dispositioning the patient. The HEART score was created as a decision tool to aide emergency physicians in risk-stratification of chest pain patients. Despite the growing evidence surrounding the use of the HEART score, there remains a paucity of literature involving its efficacy in community hospitals in the United States. This is a multicenter retrospective validation study conducted on 500 patients with the chief complaint of chest pain who subsequently underwent diagnostic or therapeutic coronary angiography from 2013 to 2015 at four community hospitals. The HEART score was calculated based on emergency department documentations. The study found that a positive coronary angiogram had a higher percentage of high risk HEART scores than low risk HEART scores. The majority of positive coronary angiograms among the four campuses had HEART scores between the 4-6 range, the intermediate category. This data parallels the larger validation studies previously published pertaining to the HEART score. Thus, the HEART score is a valid screening score for determining risk of a major adverse cardiac event and facilitates disposition of patients from emergency departments in community hospitals.

Keywords: HEART Score, Chest Pain, Acute Coronary Syndrome, ACS

1. Introduction

Emergency Department (ED) providers treat a wide variety of clinical presentations, yet one of the most common remains acute chest pain. Though chest pain elicits a diverse list of differential diagnoses; it remains essential that an acute coronary syndrome (ACS) versus a non-cardiac cause be deciphered. In the United States, 25% of all paid malpractice claims are related to missed ACS [1]. In a setting such as the ED, a quick, evidence-based decision is necessary and fundamental to avoiding a missed diagnosis or wrongful discharge surrounding an uncertain etiology for the chest pain. To this end, a prediction tool, the HEART score was developed to help emergency physicians risk-stratify chest pain patients who will have a major adverse cardiac event (MACE) in the next 6 weeks. It is a scoring system that assigns 0-2 points based on history, EKG, age, risk factors, and troponin, with each factor being weighed equally. Total scores of 0-3 supports immediate discharge; 4-6 supports admission for clinical observation and >7 supports early intervention.

In 2008, Six, Backus, and Kelder from the Netherlands published their pilot study introducing the HEART score as a reliable predictor of chest pain outcome to be utilized in a triage setting [2]. This was followed by their multicenter validation study in 2010, in which 880 patients presenting with chest pain were followed over a 3-month period. In a retrospective analysis, they concluded that most major adverse cardiac events (MACE) occurred in the first 6 weeks. They found a S-shaped relationship between heart score and the probability of MACE (scores 0-3 had 0.99% risk of MACE, scores 4-6 had 11.6% MACE, and scores >7 had 65.2% MACE). In a statistical analysis of the low HEART score (0-3) and High HEART score (>7) groups, 53% of patients had proper disposition decisions made based on their HEART score [3].

A group of emergency medicine physicians brought the

HEART score to the United States in their 2011 retrospective study of 1070 patients. They found the HEART score missed 5 cases of MACE (0.5%) but reduced cardiac testing by 84.5% [4]. In 2013, a multinational study was conducted that compared TIMI score to the HEART score and concluded that HEART score allowed identification of high risk patients with greater accuracy than TIMI score (c-statistic 0.83 for HEART score vs 0.75 for TIMI score) [5]. Larger validation studies conducted in Europe and Asia have further validated the HEART score as the ideal evidence-based risk-stratification tool for emergency medicine physicians to aide in the disposition of chest pain patients [5, 6].

The HEART score was originally proposed in an effort to create a decision tool that utilized the decision-making factors that emergency medicine physicians value in current practice. They recognized the other scoring methods, including PURSUIT, GRACE, and TIMI, were developed to stratify high risk patients in a hospitalized population already diagnosed with acute coronary syndrome and not specific to the emergency department [3]. With 8-10 million patients in the United States presenting to the emergency department annually with chest pain, of which only 20% are diagnosed with acute coronary syndrome, it became clear a disposition decision tool created for the emergency physician was essential [4, 7]. The HEART score was designed specifically for the chest pain population in the emergency department. Recent studies have found a total HEART score < 3 has a 99% sensitivity for ruling out ACS [8].

The components of the HEART score are based on two essential questions: a.) What made emergency physicians decide to admit chest pain patients? and b.) What were predictors of AMI, need for revascularization, and death? [9] The scoring criteria is based on both clinical experience and medical literature. Unique to the HEART score is the numerical classification of patient history, putting an emphasis on clinical gestalt rather than relying solely on database values. The HEART score allows for clear evidence-based disposition guidelines in the emergency room and facilitates communication between emergency physicians and cardiologists.

Despite the growing evidence surrounding the use of the HEART score, there remains a paucity of literature involving its efficacy in community hospitals in the United States, in particular, in a patient population at high risk for ACS. We conducted a retrospective validation study of patients presenting to the emergency department with chest pain over a two-year period that then underwent coronary angiography. Within this subset of patients, a HEART score was calculated from emergency department data. Coronary angiography reports up to six weeks from presentation were reviewed for significant coronary artery disease. The HEART score was then evaluated to determine the reliability of the score in predicting disposition from the emergency department. It was our hypothesis that a direct relationship exists between HEART score and prevalence of significant coronary artery disease seen on coronary angiography, i.e. these patients will have HEART scores of at least >4 recommending admission for further testing. Further validation of the HEART score could reduce hospital costs related to admission and imaging modalities (stress testing, ECHO, etc.).

2. Hypothesis

It is our hypothesis that a direct relationship will exist between HEART score and prevalence of significant coronary artery disease seen on coronary angiography, i.e. these patients will have HEART scores of at least >4 recommending admission for further testing.

3. Methods

3.1. Study Design

This is a multicenter retrospective validation study that was performed at four hospitals in the Greater Chicagoland area. The sites are community-based hospitals with annual ED volumes of approximately 50,000 patients per year. Inclusion criteria for this study included patients over the age of eighteen presenting to the emergency department with a chief complaint of chest pain who subsequently underwent diagnostic or therapeutic coronary angiography within six weeks of ED presentation from 2013 to 2015. Cases where ST-segment elevations were noted on the EKG and the patient was immediately taken for interventional cardiology were excluded from the study. Cases were selected via a database search through the electronic medical record database (EPIC). Of the 4,984 patients that were identified as meeting these criteria, 500 subjects were chosen at random to be included in the study. 125 patients were chosen from each of the four sites (Franciscan Health Olympia Fields, Franciscan Health Chicago Heights, Franciscan Health Dyer, and Franciscan Health Hammond). Data was retrieved from the electronic medical record (EMR) of the patients retrospectively. Only emergency room documentation was used to calculate the HEART score. In patients who presented to the emergency room more than once with chest pain during the two-year period, only data from their original presentation was included. No protected health information (PHI) was collected.

3.2. Scoring Guidelines

History – Patient history was classified based on narrative documented in the history and physical obtained in the emergency department. Specific elements considered included pattern of chest pain, heaviness sensation, onset and duration, relation to exertion, middle or left sided pain, radiation of pain, associated symptoms, and reaction to sublingual nitroglycerin. In the absence of the above specific elements, the history was classified as “nonspecific” and it was granted 0 points. If the history contained both specific and nonspecific elements, it was classified as “moderately suspicious” and granted 1 point. If the history contained primarily specific elements it was classified as “highly suspicious” and granted 2 points.

EKG- Initial EKG taken in the emergency department was

reviewed. A normal EKG by the Minnesota criteria was given 0 points. Repolarization with no significant ST-segment depression or elevation was given 1 point. EKGs showing significant ST segment depressions or elevations in absence of bundle branch block, left ventricular hypertrophy, or use of digoxin were given 2 points.

Age- Patients younger than 45 years received 0 points, patients ages 45-65 years received 1 point, and patients older than 65 years received 2 points.

Risk Factors- The following risk factors were taken into account: diabetes mellitus, smoker, hypertension, hypercholesterolemia, family history of coronary artery disease, obesity, and significant atherosclerosis. If the patient had no risk factors, 0 points were received. If the patient had one-two risk factors, 1 point was received. If the patient had greater than three risk factors, 2 points were received.

Troponin- Initial troponin I or point of care (POC) troponin levels were taken into consideration for scoring. If the troponin was below the normal limit established by the local laboratory standards, 0 points were given. 1 point was given for troponin 1-3x normal limit, and 2 points given for troponin >3x normal limit.

Table 1. *HEART Score Calculation [12].*

HEART Score		Points
	Highly Suspicious	2
History	Moderately Suspicious	1
	Slightly Suspicious	0
	Significant ST-depression	2
ECG	Non-specific repolarization abnormality	1
	Normal	0
	≥65	2
Age	45-65	1
	≦45	0
	3 or more risk factors	2
Risk factors	1-2 risk factors	1
	No risk factors	0
	≥3x normal limit	2
Troponin	1-3x normal limit	1
	≦ normal limit	0
Total		

3.3. MACE Definitions

Major adverse coronary event (MACE) was defined as acute myocardial infarction, percutaneous coronary intervention, coronary artery bypass surgery, coronary angiography revealing significant stenosis managed conservatively, or death occurring within six weeks of presentation. This was the definition of MACE provided in the original 2008 HEART Score study.[9]

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3.5. Primary End Points

Primary End Point in this study was coronary angiography within six weeks of presentation to the emergency department revealing >80% stenosis in any vessel, need for percutaneous coronary intervention, or need for surgical intervention.

3.6. Statistical Analysis

The data was analyzed using statistical methodology involving correlation analysis, p-values, and chi-square calculation. In order to validate the results, a biostatistician, Amy Stein, at Midwestern University did the data analysis.

4. Results

After performing statistical analysis of the data, Figure 1 displays the correlation of HEART score with positive coronary angiography results. A positive coronary angiogram result was associated with a higher HEART score (mean 5.84), when compared to the average negative coronary angiogram HEART score (mean 4.78). The p-value was statistically significant at <0.0001. The standard deviations were almost identical at 1.39 and 1.37 for negative and positive coronary angiograms, respectively.

	Negative	Positive
Mean HEART score	4.78	5.84
Standard Deviation HEART score	1.39	1.37
Range HEART score	1 – 9	3 - 10

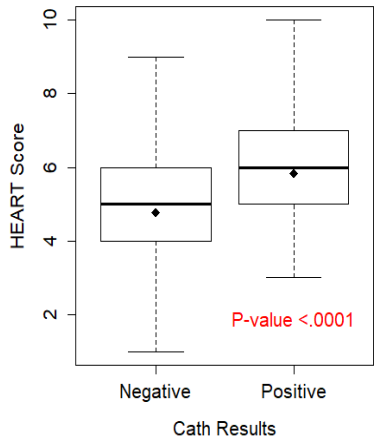


Figure 1. *Correlation of HEART score with positive coronary angiogram results.*

Next, we sought out to compare HEART score risk category (low, intermediate, or high) to the pathology found on the coronary angiogram report (Figure 2). This was done via chi-square analysis. As expected, a negative coronary angiogram had a lower percentage of high risk HEART scores than low risk HEART scores. Likewise, a positive

coronary angiogram had a higher percentage of high risk HEART scores than low risk HEART scores. Interestingly, the percentage of intermediate risk HEART scores was fairly similar among both coronary angiogram groups.

	Low Risk	Intermediate Risk	High Risk
Negative cath (N = 287)	50/287 (17%)	206/287 (72%)	31/287 (11%)
Positive cath (N = 213)	6/213 (3%)	146/213 (69%)	61/213 (29%)

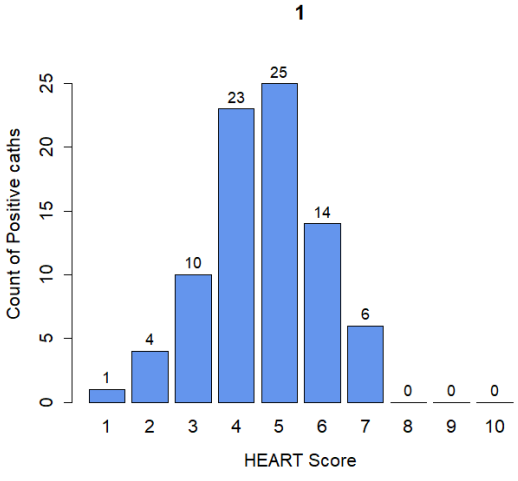
Figure 2. *Percent of risk compared to coronary angiogram result.*

Of the 500 randomly patients selected, we also analyzed the raw number of coronary angiograms in each group (Figure 3). Interestingly, the vast majority (352) of the patients fell into the intermediate HEART score category. The high risk category had the next highest number of coronary angiograms performed at 92. Of these, the majority (66%) were positive, as expected. The low risk category contained 56 coronary angiograms, of which 89% were negative.

	Low Risk (N=56)	Intermediate Risk (N=352)	High Risk (N=92)
Negative cath	50/56 (89%)	206/352 (59%)	31/92 (34%)
Positive cath	6/56 (11%)	146/352 (41%)	61/92 (66%)

Figure 3. *Percent of coronary angiogram in each group.*

Six patients who were found to have positive coronary angiogram results had low risk HEART scores of <3, meaning they would have been inappropriately discharged with a potential for MACE. This result is consistent with previous studies that have found HEART score <3 to have an associated 1-2% risk of MACE [7].



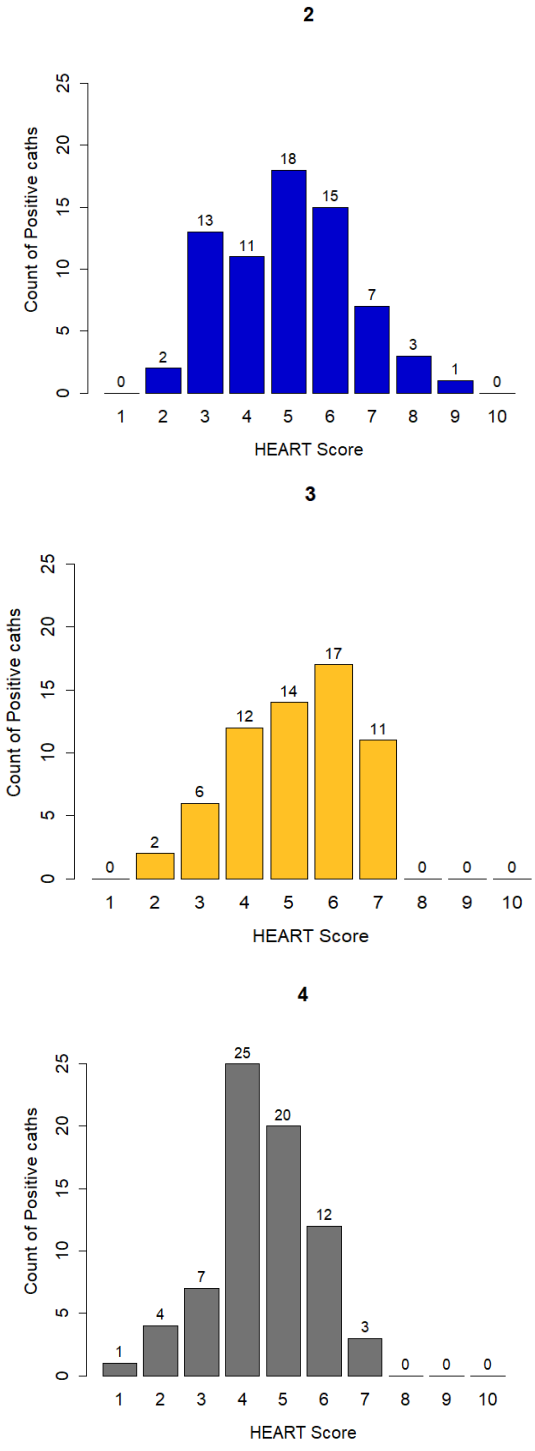


Figure 4. *HEART score vs. Positive coronary angiograms for each campus.*

Finally, we wanted to determine if there were any relationships between the four campuses in regards to positive coronary angiogram results and the HEART score (Figure 4). Based on the graphs, it appears the majority of positive coronary angiograms among the four campuses had HEART scores between the 4-6 range, the intermediate category. Each campus resembles a bell-shaped curve as well. These graphs indicate that for each campus, the greater majority of HEART scores calculated fall in the intermediate category.

5. Discussion

In conclusion, the HEART score for chest pain patients in the emergency department provides the emergency medicine physician a quick and reliable tool for early risk stratification and appropriate disposition of the patient. Working in a community-based hospital system, we sought to validate the HEART score by determining whether a direct relationship exists between HEART score and significant coronary artery disease seen on coronary angiography. Overall, our data parallels the larger validation studies previously published pertaining to the HEART score.

As displayed in the data above, a higher HEART score should predict a higher chance of MACE. This is apparent in Figure 1, where on average, a positive coronary angiogram had a higher associated HEART score compared to a negative coronary angiogram, 5.84 and 4.78, respectively. However, despite the coronary angiogram being negative or positive, the majority of HEART scores calculated fall in the intermediate category. It would be interesting to determine the specific breakdown for each component of the HEART score calculation (i.e. which component of the HEART score contributes the most points?). Determining if the subjective factors (i.e. history) or the predetermined factors (i.e. age) contribute more to the score may provide insight into which factor of the HEART score is more clinically significant.

Our research study also verifies the HEART score in regards to raw number of coronary angiograms and the HEART score risk category. From a purely empirical approach, a negative coronary angiogram result should be associated with a low risk HEART score (0-3). Likewise, a positive coronary angiogram should be linked to a high risk HEART score (>7). Our data correlates well with the predicted pattern. Figure 3 indicates that 89% of low risk HEART scores had a negative coronary angiogram; whereas 66% of high risk HEART scores had positive coronary angiograms. Interestingly, the intermediate risk HEART scores were split 60/40 as to whether the coronary angiogram was negative or positive, respectively. Essentially, almost 60% of patients scoring in the intermediate risk category had coronary angiograms that were negative. Though there will likely never exist a scoring system to rule out MACE completely, further research could shed light into different methodologies for creating a more precise scoring system.

Finally, in comparing the HEART scores and positive coronary angiogram results across all four campuses, an interesting trend emerges. Each campus elicits a bell-shaped graph when plotted on a histogram. Out of the 125 patients chosen from each campus, the positive coronary angiogram results ranged from 62 to 83 per 125 patients. This means that out of only 125 patients, there is a difference of over 20 positive coronary angiograms (16%) between the campuses. This could be due to differences in screening mechanisms with the HEART score, or isolated factors pertaining to different interventional cardiologists performing the coronary angiograms, variations in reading the coronary angiogram reports, or simply a difference in prevalence of cardiac disease at one campus versus another.

By and large, our data clearly indicates that the HEART score is a valid screening score for determining risk of MACE and thus facilitates disposition of the patient from the emergency department.

6. Limitations

There are several limitations of this study to highlight. For starters, the nature of a retrospective study introduces possible interpretation bias. Furthermore, the subjective nature of some of the elements of the HEART score allow for possible interrater differences in scoring. Specifically, the subjective nature of the history and EKG interpretation components affect consistency and reproducibility. A study from Vanderbilt University found discordance between HEART score calculated by cardiologists vs emergency medicine physicians [10]. Interestingly, the EKG and risk assessment showed agreement, but cardiologists and emergency medicine physicians showed disagreement in the history component of the HEART score [10]. Nevertheless, a 2017 study conducted in Hong Kong compared clinical prediction scores for chest pain after removing such subjective elements of clinical gestalt and found the HEART score to have the best discriminative capacity in predicting MACE when compared to TIMI, GRACE, and North America Chest Pain Rule [11].

Furthermore, there may be patients that received their follow up care in other hospitals or were otherwise lost to follow up, creating the potential for underrepresentation of MACE in our study. Additionally, enrollment in this study was from four hospitals in the Greater Chicagoland area, which can limit the generalizability of our results to the greater population.

A final limitation to the study may be due to differences in troponin measurements at the various hospitals. The chest pain protocol of some hospitals includes a point-of-care Troponin I ran in the emergency department; whereas other hospitals measure a Troponin I ran in the hospital laboratory. Subtle differences in these varying laboratory techniques may result in some discrepancy in the calculated HEART score.

7. Conclusion

Overall, our retrospective study supports the larger validation studies previously conducted and further validates the HEART score in community hospitals in the United States. The HEART score is the ideal evidence-based risk-stratification tool for emergency medicine physicians to aide in the disposition of chest pain patients. Appropriate early identification of low risk patients may lead to a reduction in diagnostic procedures and hospital admission and hence lead to potential healthcare savings. Further research into each component of the HEART score and its predictability of MACE could shed light into different methodologies for creating a more precise scoring system. In the meantime, the HEART score is a reliable and valid disposition tool for community hospital emergency departments in the United States.

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