Validation of the HEART Score in Predicting the Occurrence of Major Adverse Cardiac Events (MACE) Among Chest Pain Patients at the Emergency Department of a Private Tertiary Hospital*

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ABSTRACT

Objective: Different risk stratifying tools are available among patients presenting with a non-traumatic chest pain at the emergency department. Thus, validation of their potential utility is important.
Objective: This study aimed to determine the validity of the HEART scoring system in predicting outcome in patients who present with chest pain at the emergency department of a private tertiary hospital.
Methods: This is a chart review study that included adult patients who presented with non-traumatic chest pain at the emergency department from January 2020 to March 2021. Medical charts of patients were included using total enumeration sampling strategy. Demographic profile as well as components of the HEART score were extracted from available data sources. Patients were stratified based on their total HEART score: low risk (≤ 3 points), intermediate risk (4-6 points), and high risk (7-10 points). Presence or absence of any of the MACE within 30 days following the index event were also assessed. Extended Chi-square, Fisher's Exact Test, or Student's T Test were used to compare baseline characteristic variables. Fisher's Exact Test was used to determine association between HEART risk stratification and MACE status. Association between the specific MACE and risk stratification was also determined using Fisher's Exact Test. Area under the ROC curve (AUC), also known as the C-statistic was generated to determine the discriminative power of the HEART score based on the different cut-off points.
Results: A total of 121 patients were included mostly older males (63.64%) with different comorbidities and almost 72% have MACE. Significantly higher proportion of patients without MACE was noted among the patients with low and intermediate risk while all patients with high risk were all noted to have MACE ($p<0.0001$). Using a cutoff value of ≥ 5 points, the positive and negative predictive value (95% CI) were 98.9% (93.8-100.0%) and 97.1% (84.7-99.9%), respectively. The area under the curve (AUC) using the cutoff value of ≥ 5 was 0.9795 (0.9486 – 1.0000) with an overall accuracy of 98.35%.
Conclusion: Based on the set cut off points of the HEART score for the occurrence of MACE, the authors were able to demonstrate its utility in this institution by risk stratifying the patients.

Key words: HEART score, major adverse coronary events (MACE), non-traumatic chest pain

Chest pain is one of the important presenting symptoms that must be given due importance in any patient who come in the emergency room (ER). It may entail a benign acid related disease, a muscle strain or it can be life-threatening as in an acute coronary syndrome (ACS). It is therefore vital to differentiate whether a chest pain is cardiac, or non-cardiac in origin. Another important decision to make is whether to discharge or admit these patients seen at the ER. These are among the dilemmas that an emergency physician faces whenever a chest pain patient comes

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in, and through the years, different scoring systems like the Thrombolysis in Myocardial Infarction (TIMI) score, and Global Registry of Acute Coronary Events (GRACE) score have been used to risk stratify and predict prognosis among ACS patients, however none of them were able to differentiate non-ACS patients based on the risk score. To aid in making clinical decisions, an easy screening tool was developed to risk stratify patients presenting with chest pain of suspected cardiac in origin at the emergency department, the HEART scoring system. It categorizes patients using 5 elements comprising the following: history, electrocardiogram (ECG), age, risk factors, and troponin. Several international studies had used the HEART scoring system to predict outcome of patients with chest pain on ER consult, however, locally, there is paucity of such study. As an institution with diverse patient population, the use of the HEART scoring system would help in risk stratification of patients, in distinguishing who among them are more likely to be cardiac and thereby sparing non-cardiac patients from having unnecessary treatments. This study aimed to determine the validity of the HEART scoring system in predicting outcome in patients who present with chest pain at the emergency department of a private tertiary hospital.

Review of Literature

Coronary artery disease, presenting as acute coronary syndrome (ACS), is one of the leading causes of mortality worldwide and is responsible for about 70% of deaths, based on the World Health Organization (WHO) Noncommunicable Disease Monitor 2020. Chest pain is one of the most discernible symptoms of ACS, and deserves due attention whenever a patient comes in at any time in the emergency room (Hussain, et.al, 2014). According to the study of Januzzi and McCarthy in 2018, each year, around seven million patients have ER visits in the US due to chest pain, and this accounts for a hospital cost of approximately five billion dollars. Around 20% of these patients have a cardiovascular cause, only 5.5% have a serious condition, while half of them have chest pain of noncardiac in origin. Physicians have this vital role of distinguishing which patients can safely be discharged and which have high risk of developing major adverse cardiac events later on, needing admission. Consequences of having wrong clinical judgment would include inapt cardiac work-ups, prolonged assessment and high hospital bills among non-cardiac patients, while doubling the mortality risk for those cardiac patients having acute coronary syndrome who were inappropriately discharged from the emergency room (Januzzi and McCarthy, 2018).

Aragam, et al., in 2009[1], emphasized that risk stratification is essential in managing patients with chest pain, especially in whom ACS is highly suspected. The AHA/ACC guidelines encourage the employment of the Global Registry of Acute Coronary Events (GRACE) and Thrombolysis in Myocardial Infarction (TIMI) risk scores in the assessment of the in-hospital as well as the post-discharge risk of ACS patients. The Thrombolysis in Myocardial Infarction (TIMI) score for unstable angina/non-ST elevation myocardial infarction (UA/NSTEMI), which is lifted from clinical-trial cohorts, prognosticates the mortality risk and ischemic events at the time of initial presentation.[2] The GRACE score is used to risk stratify ACS patients to estimate their in-hospital and 6-month to 3-year mortality.[3]

In 2008, Six, et al.[4] proposed the use of a novel scoring system that considers the history, ECG findings, age of the patient, risk factors for cardiovascular disease, and Troponin I levels, this is called the HEART scoring system. Each of these five factors can be scored with zero, one or two points, with a maximum score of ten points. This scoring system has been demonstrated by observational and retrospective studies in predicting outcomes among patients with chest pain in the emergency room. A validation of the scoring system was done by Six and colleagues in 2013[5], wherein about one third of patients had HEART scores zero to three, with a six-week incidence of developing major adverse coronary events (MACE) of one to 2 percent. The HEART score was purposely created to risk stratify, as early as possible, those patients presenting with chest pain of suspected cardiac origin at the emergency department. Poldervaart, et al.[6] compared the three scoring systems, TIMI, GRACE, and HEART in a large-scale prospective cohort study in 2017 among chest pain patients at the ER. The main endpoint was the occurrence of MACE within six weeks after the index event. MACE consisted of non-ST elevation myocardial infarction (NSTEMI), unstable angina (UA), percutaneous coronary intervention (PCI), STEMI, coronary arterial bypass grafting (CABG), cardiovascular death and non-cardiovascular death, as well as death from unknown cause. From this study,

the HEART score was able to identify the greatest number of patients as low risk to develop MACE and therefore undergone early ER discharge, without compromising patient's safety.

This study aimed to determine the validity of the HEART scoring system in predicting outcome in patients who present with chest pain at the emergency department of a private tertiary hospital.

MATERIALS AND METHODS

Research Design

A chart review study design was employed in this study.

Target Population

Medical charts of adult patients aged 19 years and above who presented with chest pain in the emergency department of FEU-NRMF Medical Center.

Eligibility Criteria and Time Period

Inclusion Criteria

Medical charts of adult Filipino patients aged 19 years and above with chest pain at the emergency department were considered for the study. Medical charts from January 2020 to March 2021 were included.

Exclusion Criteria

Medical charts of adult Filipino patients were excluded from the study if:

- the chest pain is due to a traumatic cause;
- the presentation is only dyspnea or palpitations;
- patient has a terminal illness;
- the troponin level was not measured; and
- with missing of at least one of the components of the HEART scoring system as well as absence of follow-up records for the occurrence of MACE.

Study Procedure

Sampling Methodology and Recruitment of Participants

Total enumeration sampling strategy was used to recruit all the eligible participants from FEU-NRMF Medical Center. Medical charts were used as the sampling frame where the eligible participants were drawn. Each eligible medical chart was assigned with a unique identification code in order to maintain anonymity. Each medical chart was assessed based on the parameters of the HEART scoring system. A letter of permission was secured and submitted to the Head of the Medical Records Section prior to accessing the health records of patients. FEU-NRMF Medical Center was chosen as the primary site of the study based on the proximity and the availability of data. Moreover, this is where the principal investigator is currently doing her residency training under the Department of Internal Medicine.

Data Collection, Method, and Instrument/s to be Used

Demographic profile (age, sex, and BMI), health history (past health history and risk factors as stated in the HEART scoring system), and laboratory findings (ECG and troponin levels) were extracted from the available health records using an assessment form developed by the principal investigator.

Sample Size Calculation

The sample size was estimated using the method as described by Hajian-Tilaki (2014). Based on the previous study, the pre-determined prevalence of patients classified as low risk through the HEART score system is 28.2% while the expected sensitivity is 96.3% (Six et al., 2013). With a 95% confidence interval and maximum acceptable width of 10%, a sample size of 99 was obtained which was adjusted to 119 accounting for attrition and/or data losses.

Data Management and Analysis

All data were encoded using Microsoft Excel and analyzed using Stata ver 13.0. Categorical data such as sex, BMI, and health history-related findings were presented as frequencies and percentages. Continuous variables such as age and troponin level were presented as median and interquartile range (if not normally distributed) or mean and standard deviation (if normally distributed). Extended Chi-square, Fisher's Exact Test, or Student's T Test were used to compare baseline characteristics variables. Fisher's Exact Test was used to determine association between HEART risk stratification and MACE status. Association between the specific MACE and risk

stratification was also determined using Fisher's Exact Test. Area under the ROC curve (AUC), also known as the C-statistic was generated to determine the discriminative power of the HEART score based on the different cut-off points. All measures were expressed with 95% confidence interval.

Ethical Consideration

Ethics and Review Board approval was obtained prior to the start of the study. Only the researcher was given access to the health records as by the Head of the Medical Records Section. The researcher had to retain and use any research results that have already been collected for the study evaluation. No further study-related activities took place.

There are no conflicts of interest observed in the study. No personal or identifying data were disclosed to anyone not involved in the study. Anonymity was maintained at all times and ensured through the use of codes to all assessed health records. A standardized data collection tool developed by the researcher was used in the data extraction. All obtained data were kept securely in a safe place and were not held any longer than necessary. All data and procedures were handled in accordance with the Data Privacy Act of 2012 and discarded at least one week after the final paper was submitted to the department research committee.

All collected information were kept confidential to the extent allowed by law. The codes that link patients' names were kept in a password-protected folder. Name or other facts that might point to the participant's identity will not appear when the result of the study is published. No data were reused to protect the privacy of the respondent.

Moreover, there is only minimal risk involved in this study as there is no direct human participant involvement. There was no cost nor payment as well as reimbursements and incentives given to patients whose health records were included in this study. There will be no direct effect on the community but this study will help care providers to efficiently monitor future patients and provide appropriate management based on their predicted level of risk.

RESULTS

A total of 121 medical charts of patients with chest pain were included in this study in which majority were males (63.64%). Those with MACE were significantly older (63.0 ± 14.9) compared to those who do not have ($p < 0.0001$). Generally, MACE was noted to be significantly higher among patients aged 46 years old and above. On the other hand, there were significantly less patients with MACE among those who aged 45 years old and below. Although no significant difference was noted, among the males, greater proportion have MACE while less was observed among females. Hypertension (74.38%), hypercholesterolemia (41.32%), and diabetes mellitus (35.54%) were the most common comorbidities ($p=0.047$, $p<0.0001$, and $p=0.032$, respectively). Smoking ($p=0.007$), family history of CAD ($p<0.0001$), and having been diagnosed with ST-elevation myocardial infarction ($p=0.033$) were significantly higher among patients with MACE compared to those without MACE. Lastly, cardiovascular death was noted among patients with MACE while all patients without MACE were discharged. These findings were found significant ($p<0.0001$) (Table 1).

Risk stratification based on the HEART score was significantly higher in patients without MACE among those with low and intermediate risk. Notably, all patients with high risk also have MACE. These findings were significant ($p<0.0001$) (Table 2).

The researcher also looked into the different categories of MACE (diagnosis, procedure, outcome) and the corresponding risk. She noted that no MACE was found among those with low risk. Among patients with non-ST elevation myocardial infarction and STEMI there were significantly more patients with high risk (61.8% and 38.2%, respectively, $p<0.0001$). Coronary arterial bypass grafting was significantly higher among intermediate risk patients while PCI was significantly higher among high risk patients ($p<0.0001$). All cardiovascular deaths were noted among patients with high risk based on their total HEART score ($p<0.0001$) (Table 3).

Lastly, the researcher compared the different diagnostic parameters of the HEART score based on the three discriminatory points. Using a cutoff value of ≥ 4 points, the positive-predictive value (95% CI) was 89.7 % (81.9-94.9%) and the negative-predictive value (95% CI) was 100.0% (85.8-100.0%). Meanwhile, using a cutoff value of ≥ 5 points, the positive-predictive value (95% CI) was 98.9% (93.8-100.0%) and the negative-predictive value (95% CI) was 97.1% (84.7-99.9%). Lastly, using a cutoff value of ≥ 7 points, the positive-predictive value (95% CI) was 100.0% (95.3-100.0%) and the negative-

Table 1. Baseline characteristics.

	No MACE n = 34 n (%)	MACE n = 87 n (%)	p value
Age mean ± SD	49.4 ± 15.8	63.0 ± 14.9	<0.0001[a]
45 years old and below	15 (44.1)	12 (13.8)	<0.0001[b]
46-64 years old	13 (38.2)	35 (40.2)	
65 years old and above	6 (17.7)	40 (46.0)	
Sex			
Male	18 (52.9)	59 (67.8)	0.126[b]
Female	16 (47.1)	28 (32.2)	
Health History			
Diabetes Mellitus	7 (20.6)	36 (41.4)	0.032[b]
Smoking	2 (5.9)	25 (28.7)	0.007[b]
Hypercholesterolemia	5 (14.7)	45 (51.7)	<0.0001[b]
Hypertension	21 (61.8)	69 (79.3)	0.047[b]
Family history of CAD	0 (0.0)	24 (27.6)	<0.0001[c]
non-ST elevation myocardial infarction (NSTEMI)	0 (0.0)	3 (3.4)	0.558[c]
Unstable angina (UA)	2 (5.9)	3 (3.4)	0.619[c]
Percutaneous coronary intervention (PCI)	0 (0.0)	8 (9.2)	0.104[c]
STEMI	0 (0.0)	11 (12.6)	0.033[c]
Peripheral artery disease	0 (0.0)	1 (1.2)	1.000[c]
Outcomes			
Cardiovascular death	0 (0.0)	27 (31.0)	<0.0001[c]
Discharged	34 (100.0)	60 (69.0)	

[a]Student's T-test; [b]Chi-square test; [c]Fisher's exact test

Table 2. Risk stratification and MACE status.

Risk stratification	MACE (n %) (+)	(-)	p value
Low	0 (0.0)	24 (70.6)	<0.0001
Intermediate	11 (12.6)	10 (29.4)	
High	76 (87.4)	0 (0.0)	

Table 3. MACE within each risk group.

MACE	Risk Stratification n (%) Low (n=24)	Intermediate (n=21)	High (n=76)	p-value
By Diagnosis				
non-ST elevation myocardial infarction	0 (0.0)	10 (47.6)	47 (61.8)	<0.0001
STEMI	0 (0.0)	0 (0.0)	29 (38.2)	
By Procedure				
Coronary arterial bypass grafting	0 (0.0)	1 (4.8)	2 (2.6)	<0.0001
PCI	0 (0.0)	2 (9.5)	22 (23.0)	
By outcome				
cardiovascular death	0 (0.0)	0 (0.0)	27 (35.5)	<0.0001

predictive value (95% CI) was 77.3% (62.2-88.5%) (Table 4). The area under the curve (AUC) using the cutoff values of ≥ 4, ≥ 5, and ≥ 7 points (95% CI) were 0.8529 (0.7752 – 0.9307), 0.9795 (0.9486 – 1.0000), and 0.9425 (0.9088 – 0.97623) (Figure 1).

DISCUSSION

In this current single center validation study, the researcher determined the utility of the HEART score in a local setting among patients who presented with non-traumatic chest pain in the emergency department. The demographic characteristics and clinical history of patients in this present study reflected previous report made by Six and colleagues (2013)[5] in which older males, with hypertension, hypercholesterolemia, diabetes mellitus, and family history of CAD were the ones more likely to have MACE.

Present data also revealed that MACE is significantly higher among patients with high risk based on their total HEART score. This finding seems to agree to the previous reports that the six-week MACE occurred in at least 50% of high risk patients based on the HEART score. At the same time, MACE among intermediate and high risk patients in this present study seem to be higher than that of the previous studies.[7] This finding might be explained by the fact that this retrospective study did not consider the time frame wherein MACE among non-traumatic chest pain patients will occur. This might have led to the discrepancy in the findings of the present and previous reports. This might be one of the considerations for further studies that will try to validate the HEART score in the local setting. Among those patients with low risk HEART score, no occurrence of any MACE were noted. This did not reflect previous reports wherein the maximum incidence of MACE among low risk patients is 2%.[6,7,8] It was also inferred that one of the reasons that there is a very low number of events noted among low risk patients might be due to the relatively low follow-up duration as most of the previous studies followed up patients to a maximum of six weeks.[8]

To the best of the researcher's knowledge, this is the first time that MACE is grouped into three: diagnosis, procedure, and outcome which are then stratified based on the risk of patients based on their total HEART score. Although she found significant associations between the variables, emphasis regarding caution in interpreting results should be

Table 4. Accuracy of the MACE Score for estimating the risk among patients with chest pain.

	Cut-off: ≥ 4	Cut-off: ≥ 5	Cut-off: ≥ 7
Sensitivity, %	100.00 (95.8, 100.0)	98.85 (93.8, 100.0)	88.51 (79.9, 94.3)
Specificity, %	70.59 (52.5, 84.9)	97.06 (84.7, 99.9)	100.00 (89.7, 100.0)
Likelihood ratio (+)	3.4 (2.02, 5.72)	33.6 (4.87, 232)	-
Likelihood ratio (-)	-	0.12 (0.011, 0.083)	0.12 (0.06, 0.21)
Positive predictive value, %	89.7 (81.9, 94.9)	98.9 (93.8, 100.0)	100.0 (95.3, 100.0)
Negative predictive value, %	100.0 (85.8, 100.0)	97.1 (84.7, 99.9)	77.3 (62.2, 88.5)
Overall accuracy, %	91.74	98.35	91.74
Area under the curve	0.8529 (0.7752 – 0.9307)	0.9795 (0.9486 – 1.0000)	0.9425 (0.9088 – 0.97623)

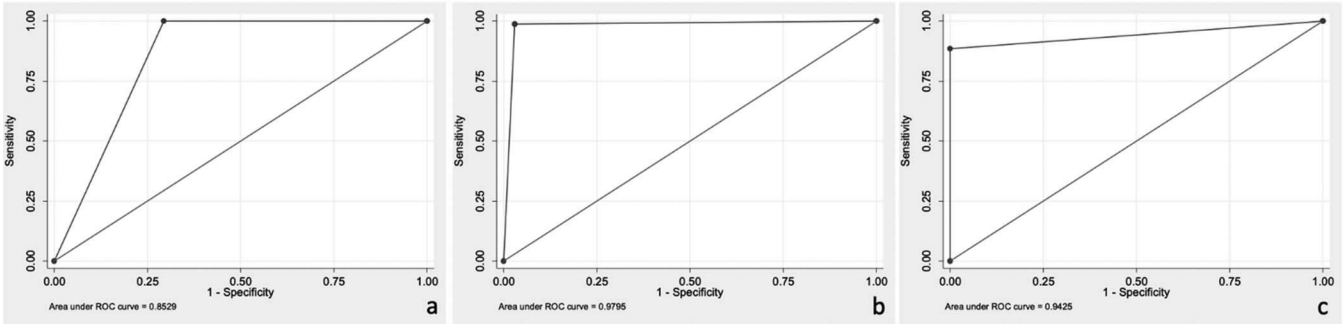

Figure 1. Area under the ROC (AUROC) of HEART score based on 4, 5, and 7 cut off points.

noted due to the relatively small sample size of this current study compared to the previous validation studies done in foreign setting. Some considerations that must be taken into account with this inference is the level of emergency department utilization of patients as well as the consistency of analyzing subjective components of the MACE score. It was recently reported that patient history, risk factors, and even electrocardiogram, elements critical to calculate HEART scores, seem to not have a sufficient discriminatory ability to risk stratify ACS.[9,10,11] Moreover, outcome measure determination among chest pain patients is very subjective plus the fact that all the components of the HEART score carry the same weight in risk stratifying the patients. One of the possible effects of this observation is that low-risk patients were more often being discharged without even utilizing the HEART score where in fact they could have been categorized as non-low risk had the HEART score was applied.[12,13] This is very crucial as to who was the primary healthcare provider in the emergency department.

It was also noted that from previous reports that HEART score might be of less utility when used among emergency department high utilizers.[14] In the same study, due to the lack of primary care physician and high psychosocial risks, some patients use the emergency department as their primary medical setting.[14,15] With this, a higher index of suspicion must be taken into consideration as their ACS risks could theoretically be lower than their HEART scores indicate.[16] On the contrary, other studies showed that those who were treated as inpatients have high ED utilizations even though their MACE outcomes were similar.[17,18] This, however, was not taken into consideration in this present study and was also beyond its scope.

In this local validation of the HEART score, we determined the optimal cut off that can determine high risk patients with MACE by analyzing the HEART score above the low-risk threshold. This is unconventional as other previous studies did validation studies based on the low risk cut off of the HEART score. In this particular set of patients, HEART score cut off of ≥ 5 points has the best diagnostic parameter compared to the ≥ 4 and ≥ 7 cut off points. This is based on the negative and positive predictive value as well as the overall accuracy of the HEART score based on the occurrence of MACE. The AUC was used to determine the discriminating ability of the different cut off points for the HEART score. It was previously mentioned that although acceptability of the AUC varies, generally, AUC should have at least 0.7 to consider utility of the diagnostic tool. On the other hand, AUC of 0.5 or lower confers lack of discriminating ability of the diagnostic or screening tool (Hosmer et al., 2000). In the present study, there was a relatively high AUC (0.9795 [0.9486 – 1.0000]) using the 5 points cut off score with an overall accuracy of 98.35%. This is relatively higher based on the previously done validation studies.[6,19] Shannon and colleagues (2019)[19] also did an exploratory validation which reported that using a cut of point of 4 had the highest sensitivity for both short-term mortality and myocardial infarction while a cut off of 7 had the highest specificity for short-term MACE. Caution must be taken into consideration when interpreting this result as the 4-point cut off might or will only be applicable to the patients of this present study.

This study has many limitations. First, its being retrospective in nature might affect one of the elements of the HEART score which is subjective and heavily reliant to the skill of the physician taking the history of the patient. Second, assessment of patients was not standardized whether in the emergency or the internal medicine department. Thus, this may contribute to the inter observer discrepancy in assessing other elements of the HEART score. This aspect should be taken into consideration in future studies. A standard criterion for the observer who will interpret the ECG of the patients should also be set to minimize bias in future studies. Third, since this is a single center study, caution must be taken into consideration when interpretating results as this involved relatively smaller sample size as compared to previous validation studies. Thus, multicenter and/or larger sample size is warranted. The application of this study in the primary health care setting should also be taken into account in future studies.

CONCLUSION

This is the first local validation study done for HEART score among Filipino patients. Based on the set cut off points of the HEART score for the occurrence of MACE, the author was able to demonstrate its utility in this institution by risk stratifying the patients. Comparison and standardization between HEART score assessors, larger sample size, prospective design and application in the primary health care setting are warranted to generate a more robust data regarding

the utility and validation of HEART score in the local setting.

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