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The Association Between Patient Outcomes and the Initial Emergency Severity Index Triage Score in Patients with Suspected Acute Coronary Syndrome.

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Abstract

Background: The Emergency Severity Index (ESI) is a widely used tool to triage patients in Emergency Departments. The ESI tool is employed to assess all complaints and has significant limitation for accurately triaging patients with suspected acute coronary syndrome (ACS).

Objective: We evaluated the accuracy of ESI in predicting serious outcomes in suspected ACS, and to assess the incremental re-classification performance if ESI is supplemented with a clinically validated tool used to risk stratify suspected ACS.

Methods: We used existing-data from an observational cohort study of chest pain patients. We extracted ESI scores documented by triage nurses during routine medical care. Two independent reviewers adjudicated the primary outcome, incidence of 30-day major adverse cardiac events (MACE). We compared ESI to the well-established modified HEAR/T (patient History, Electrocardiogram, Age, Risk factors, but without Troponin) score.

Results: Our sample included 750 patients (age 59 ± 17 years, 43% female, 40% black). A total of 145 patients (19%) experienced MACE. The area under the receiver operating characteristic curve for ESI score for predicting MACE was 0.656, compared to 0.796 for the modified HEAR/T score. Using the modified HEAR/T score, 181 out of the 391 (46%) false positives and 16 out of the 19 (84%) false negatives assigned by ESI could be reclassified correctly.

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Conclusion: The ESI score is poorly associated with serious outcomes in patients with suspected ACS. Supplementing the ESI tool with input from other validated clinical tools can greatly improve the accuracy of triage in patients with suspected ACS.

Keywords

Triage; chest pain; acute coronary syndrome; emergency department

1. Background

Emergency department (ED) nurses triage over 145 million patients per year in the United States.¹ The goal of triage is to assess and identify clinical conditions in order to prioritize those with the most significant risk of morbidity and mortality. This is important because rapid recognition of time-sensitive clinical conditions can reduce negative patient outcomes while minimizing over-triage of patients who do not require immediate care. Unfortunately, ED overcrowding is widespread and triage tools that are both accurate and efficient are sorely needed. Presence of overcrowding has been associated with delays in recognizing high morbidity conditions such as acute coronary syndrome (ACS) and septic shock.^{2,3} As such, nurses are tasked with the unique job characteristic of being able to pick out a clinically acute condition among a group of undifferentiated patients. ACS is a condition that is commonly encountered in ED settings and recognizing patients with ACS in the ED can be very challenging. This difficulty of identifying patients stems from numerous presenting symptoms, a variety of presenting chief complaints, and even how the patient appears to the nurse at the initial emergency department nurse encounter.⁴⁻⁶ Nursing decision making in the triage setting in the emergency department has been well documented in the literature. Unfortunately, nurses have shown to have both cultural biases, and stereotypes when triaging patients who present with suspicion of ACS.⁷ It is also known that nursing experience, intuition, attitudes, and patient presenting demographics and appearance all play an integral part of the cardiac triage decision making process.^{7,8} Unfortunately, prior studies have shown that nurses' accuracy rates of triaging suspected ACS patients are as low as 54%.^{4,7,9-12}

The Emergency Severity Index (ESI) tool is the most commonly used triage tool in EDs across the United States.¹³ It is a five-level ordinal scale used to categorize patients based on resource utilization in the ED and likelihood of admission.¹⁴ It is easy to use and can be universally applied to any patient that presents to the ED. Unfortunately, this tool has significant limitations. ESI scores are not patient outcome driven; the tool is validated against predicting ED resource utilization and hospital admission.¹⁴ ESI scores are highly subjective; different nurses can assign different scores based on their personal clinical judgement.¹⁴ Also, the ESI tool provides poor discrimination for middle acuity patients; more than 50% of patients are classified with an ESI score of 3.^{13,15,16} Furthermore, while the ESI is a generalizable tool that facilitates the triage of undifferentiated patients regardless of chief complaint, it may not be effective for triaging the specific subset of patients where the greatest concern is the identification of ACS. On the other hand, multiple clinical tools exist that can be used to risk-stratify patients with symptoms that are concerning for ACS. The widely used HEART score (**H**istory, **E**lectrocardiogram, **A**ge, **R**isk Factors, **T**roponin)

is highly accurate in identifying suspected ACS patients at low risk for adverse outcomes.^{17,18}

Although both the ESI and HEART score are designed to help emergency department clinicians risk-stratify patients to identify those patients in greatest need of immediate evaluation, these scores have never been compared. Therefore, the purpose of this study was to 1) evaluate the accuracy of the initial ESI score at ED nurse triage in identifying those at increased risk of adverse events among patients evaluated for suspected ACS, and then to 2) assess the incremental re-classification performance if ESI is supplemented with other established clinical tools like the modified HEAR/T score.

2. Methods

2.1 Study Design

We conducted a secondary analysis of patients from the EMPIRE (Electrocardiogram Methods for the Prompt Identification of Coronary Events) study.¹⁹ This was an observational cohort study of patients with non-traumatic chest pain with the chief complaint of chest pain or equivalent (i.e., shortness of breathing, palpitation, syncope). Enrolled patients were 18 years of age or older and were transported via ambulance by Emergency Medical Services (EMS) to one of three participating affiliated tertiary care centers with 24-hour cardiac catheterization centers. The EMS agency is a municipal, third-service EMS agency which responded to emergency calls with a dual paramedic team during the study period. All consecutive eligible patients were enrolled under a waiver of informed consent and there were no restrictions to sex and race. This study had institutional internal review board approval. For this secondary analysis, we used the initial cohort of the EMPIRE study that enrolled patients transported between May 2013 and August 2014 (n=750).

2.1.1 Data Collection—Independent reviewers manually extracted pertinent clinical data from in-hospital electronic health records. Each reviewer received data collection training from an expert user of the electronic health record. For data extraction, reviewers used a standardized author developed data collection tool with well-defined variables. Basic demographics and clinical characteristics for each patient (i.e., age, sex, past medical history, etc.) were collected per an a priori defined data coding scheme that has been described in detail previously.¹⁹

2.1.2 ESI Score—Patients underwent retrospective electronic chart review by study investigators (SOF, BL) to obtain the ESI score. If the score was missing, this was recorded as missing data. The 5-level ESI score is a triage tool that asks 3 questions including: (1) Does the patient require immediate life-saving intervention?; (2) Can the patient wait in the waiting room?; and (3) What resources will the patient use?¹⁴ The tool takes into account the patient's vital signs and the nurse's intuition, which affords the nurse the subjectivity and leniency to increase the acuity score. The original ESI triage tool was validated with associations with the following patient outcomes: ED resource consumption, inpatient admission, ED length of stay and 60-day mortality.²⁰⁻²³ The ESI tool helps nurses to assign different levels based on a 1–5 scale: level 1, immediate life-saving intervention is required; level 2, patient is considered high risk/ emergent; level 3, urgent but stable and can safely

wait in the waiting room; level 4, non-urgent; and level 5, no ED resources needed. For example, to be an ESI level 1, a patient requires an airway, emergency medications, or another intervention to maintain life; these patients are considered unstable and need a team response to initiate immediate care.¹⁴ In contrast, ESI level 5 is a low acuity patient that does not require any immediate resources, such as a patient with a simple rash or who is in need of a prescription refill.¹⁴ The ESI score helps to classify patients into two broad categories. As described in the ESI manual, ESI scores 1 and 2 represent high-acuity and ESI scores 3–5 represent middle to low acuity.¹⁴ High acuity patients should require immediate attention (i.e., ESI score 1 and 2), and those who are stable and can wait in the waiting room (i.e., ESI score 3–5). For our analysis, we separated high-acuity from middle to low acuity in the same fashion.

2.1.3 HEART Score—Patients underwent retrospective electronic chart review conducted by study investigators (ZF, SA) to calculate the HEART score. The HEART score^{17,18,24} is based on the following components: 1) history of present illness, 2) electrocardiogram, 3) age, 4) risk factors, and 5) troponin value. Each factor of the risk stratification score is assigned to a points system. The total score calculation 0–3 is deemed to be low risk while a total score of 4–10 is intermediate to high risk. Low risk means that the patient can be safely discharged home from the ED, while score 4–10 should be admitted to the hospital for further testing. We have previously reported the diagnostic accuracy of the HEART score for predicting ACS in this dataset. The HEART score outperformed other risk scores and had the highest area under the receiver operating curve (0.087), with sensitivity and negative predictive value of 0.94 and 0.98, respectively.²⁵

A modified version of the HEART score was developed because the laboratory troponin value is not typically available to EMS providers in the pre-hospital setting and early ED nurse triage. We recalculated the HEART score after removing the troponin value. This modified HEAR/T score (i.e., without the “T” component) has been previously validated.²⁶ For our analysis, we considered modified HEAR/T scores 0–3 to represent low risk (i.e., can be discharged safely from the ED) and scores 4–10 to represent intermediate to high risk (i.e., patient should be evaluated/ admitted for further diagnostic testing).

2.1.4 Adjudication of Primary Study Outcome—The primary study outcome was 30-day major adverse cardiac event (MACE) defined as a composite endpoint of one of the following conditions as previously described in the literature:²⁴ 1) all-cause death; 2) acute coronary syndrome; 3) coronary revascularization; 4) post-admission pulmonary embolus; 5) fatal ventricular arrhythmia; 6) cardiogenic shock; and 7) acute heart failure during the indexed hospitalization or within 30 days, as determined by electronic health record review. Acute coronary syndrome was defined as per the American Heart Association (AHA) / American College of Cardiology (ACC) Universal Definition.²⁵ Two independent ED physician reviewers examined all available in-hospital and out-of-hospital medical records to adjudicate the outcome and disagreement was resolved by a third ED physician reviewer.

2.2 Statistical Analysis

All data analyses were performed using SPSS® software version 25 (IBM, Armonk, NY) and an alpha of 0.05 or less was considered to be significant. Detailed descriptive statistics were used to report demographic and clinical characteristics. The sensitivity and specificity for both ESI score and modified HEAR/T score were calculated for the primary outcome. The positive and negative predictive value of the ESI score for MACE were examined. The area under the receiver operating characteristic (ROC) curve was calculated for both ESI score and modified HEAR/T score for the outcome of MACE. The area under the ROC curves were compared using the Hanley and McNeil method.²⁷ The net reclassification index²⁸ was calculated comparing the ESI score to the modified HEAR/T score for the outcome of MACE.

3. Results

Our sample included 750 patients (mean (SD) age 59 (17) years, 43% female, and 40% black). Overall, we observed a total of 259 MACE events in 145 patients (19%), including ACS (n=115), death (n=9), cardiac arrest (n=12), ventricular tachyarrhythmia (n=13), coronary revascularization (n=74), post-admission pulmonary embolism (n=2), post-admission acute heart failure (n=11), and 30-day re-infarction (n=23). Of note, most of those experiencing MACE (n=119/145, 83%) had their event during the indexed hospitalization. Table 1 compares the demographics and clinical characteristics between those with or without MACE. Those who experienced MACE were more likely to be older and black, as well as to have a past medical history of diabetes, previous myocardial infarction, and prior coronary revascularization procedure or coronary artery by-pass graft surgery.

The distribution of ESI scores of 1 to 5 in this sample were 18%, 48%, 28%, 0.3%, and 0% respectively. Those who had an ESI score of 4 (n=2) were collapsed with the group of ESI 3 (n= 209) in subsequent analysis. The ESI scores were missing for 39 patients (5%) in this sample. Our analysis showed that these patients were not missing at random based on their association with MACE, and thus, were included in further analysis and labeled that ESI group as “Not Reported”. Figure 1 compares the distribution of MACE events to each ESI triage score. As shown in Figure 1-A, there were approximately 36% of patients with initial ESI score of 1 had a MACE event, compared to 16% for ESI score 2 and 9% for ESI score 3. Conversely, 80% of all patients assigned ESI score 1 or 2 were event-free. On the other hand, Figure 1-B compares the distribution of MACE events to each modified HEAR/T score. There is a smooth gradual increase in the rate of MACE events as the risk score increases.

Figure 2 compares the classification performance between ESI score and the modified HEAR/T score in predicting the primary study outcome. We compared the area under the ROC curve²⁷ for ESI score versus modified HEAR/T score which was 0.656 versus 0.796 (p< 0.001). The sensitivity and specificity of ESI score 2 versus modified HEAR/T score 4 for predicting MACE were 75% and 32% versus 83% and 51%, respectively.

Figure 3 compares the association between the patient acuity levels with the ESI tool versus the reclassification performance using the modified HEAR/T score. A total of 391 patients

were assigned a high-acuity level by ESI but did not experience a MACE event (false positives). Of those, 181 (46%) were reclassified correctly as low-risk by the modified HEAR/T score. Similarly, a total of 19 patients were assigned middle-acuity level by ESI but did experience a MACE event (false negatives). Of those, 16 (84%) were reclassified correctly as intermediate to high-risk by the modified HEAR/T score. The net reclassification index comparing the ESI scores to the modified HEAR/T scores is 0.49.²⁸

4. Discussion

In this study, we evaluated the accuracy of the initial ESI score in identifying those at increased risk of adverse events among patients with suspected ACS. We also assessed the incremental re-classification performance if ESI is supplemented with the clinically validated modified HEAR/T score. Both the ESI tool and HEART score were originally validated for negative outcomes, including mortality within 30 to 60 days.^{17,20,21} Overall, the ESI failed to well-differentiate the acuity of illness in patients with suspected ACS (i.e., ~50% of the sample had an ESI score of 2). Importantly, the ESI score had poor classification performance in predicting MACE in this population (i.e., area under the ROC curve < 70%). The ESI also had low positive predictive value where 80% of those classified as high acuity level (ESI scores 1 and 2) were event-free. When compared to the modified HEAR/T score, we noticed that nearly 40% of patients with high ESI scores were over-triaged (i.e., unnecessary cost) and around 40% of patients with middle-acuity ESI scores were under-triaged (i.e., potential patient harm). Adding the modified HEAR/T score to the ESI allowed, more than 50% of false positives and false negatives to be re-classified correctly. These findings demonstrate both that the ESI tool is inadequate for triaging patients with suspected ACS, and that existing tools could provide substantial improvement in how nurses triage this vulnerable patient population. To our knowledge, this is the first study to evaluate the performance of the ESI tool to predict cardiac patient outcomes and compare its performance to the modified HEAR/T score.

An article by DeLaney, Neth and Thomas (2017) investigated current chest pain triage trends in the United States, but failed to include the Emergency Severity Index score.²⁹ Mirhaghi contributed in follow-up commentary that the Emergency Severity Index score could help understand the current state of triage for chest pain patients as it is the most widely used triage tool in the United States.³⁰ This failed opportunity to further examine the relationship between triaging chest pain patients and the ESI tool could add to the literature regarding the current state of triaging chest pain patients and should be examined in the future. We have included findings from a similar 5-level triage scale because there is a lack of literature exploring the relationship of Emergency Severity Index scores to patients with suspicion of ACS. The Canadian Triage and Acuity Scale is a five-level triage tool where score III, IV and V (corresponding to urgent, less urgent and nonurgent, respectively) are considered low acuity triage scores. A study by Atzema et al. (2009) found that 50% of acute myocardial infarction patients were given an inappropriate low triage score.⁵ This low acuity score was associated with substantial delays in door-to-ECG and door-to-needle time. These results raise concern about the process of triage and the tools that nurses are currently using to quickly and accurately identify patients that have significant risk for acute coronary syndrome.

Current triage evaluation using the ESI tool may not always accurately identify those patients who would be best served by early care. In our study, 8% of patients with MACE at 30 days were triaged to an ESI category of 3. This mid-level triage assessment means that some high-risk patients may have been under triaged. This potentially incorrect triage acuity may cause delays in treatment and ultimately compromise patient outcomes.^{12,31} Further, of those patients that were triaged with an ESI score of 1 or 2, 80% did not develop MACE. This may be an indication of being over-triaged, taking scarce and valuable resources away from patients that could potentially use them.

When comparing the area under the ROC curve, the modified HEAR/T score performs better, with an area under the curve (AUC) of 0.796 [95% confidence interval, (0.754, 0.837), $p < 0.001$]. This classification is a very good classification compared to the ESI score AUC = 0.656, (0.602, 0.710), $p < 0.001$, which is fair. This is important to note because the modified HEAR/T score assesses the past medical History, ECG findings, Age and Risk factors of a patient and formulates a number which deems the patient at low versus intermediate to high-risk of developing MACE. This modified *HEAR/T score* (i.e. without the “T” component) has been previously validated for application in the prehospital setting by emergency medical service providers and has been shown to have equivalent positive likelihood ratio (95% confidence interval) of 1.37 (1.18– 1.55) versus 1.47 (1.33– 1.61) compared to the original HEART score.²⁶ We combined ESI scores 1 and 2 to represent high-acuity patients, we were able to identify the ESI score’s false positive cases. False positive cases can represent over-triaging patients to a high-acuity because they did not develop MACE. These cases have potential to be prioritized to use scarce ED resources that other high-risk patients could use. From the data, our middle-acuity ESI score of 3 represented the nineteen false negative cases. False negative cases are concerning because it may jeopardize patient care and potentially delay patient treatment. By using the modified HEAR/T score, we reclassified 16 (46%) cases to be truly intermediate to high-risk according to HEAR/T assessment criteria. As seen in our net reclassification index, moving from ESI score to modified HEAR/T score we were able to increase the number of patients who were both true negative and true positive.

Information contained in the modified HEAR/T score can be obtained in the prehospital setting and upon arrival to the emergency department. Nurses’ application of an ESI score could be informed by an initial calculation of a modified HEAR/T score, thus potentially improving the deployment of resources in working-up and treating the patient. This addition could alert nurses to patients at high risk for developing MACE, lead to better assessments of patient acuity at triage, and potentially lead to improved patient outcomes.

Limitations

This study has few limitations. This analysis is limited to chest pain patients who arrive to the ED via ambulance and did not include patients without chief complaint of chest pain or who arrived other than via ambulance. The modified HEAR/T score was retrospectively calculated via chart review. This score was assigned solely upon review of all progress notes in the electronic health record and could be biased based on what was documented by clinicians. Another possible limitation was loss of follow-up in adjudicating the primary 30-

day composite outcome of MACE, due to the observational nature of our study. While we reviewed all in-patient and out-patient electronic health records within a large 40-hospital regional health system and are likely to have captured most repeat visits for care, there is a possibility that we missed some cases. Our data collection may have missed 30-day death or reinfarction events where the patient did not have a repeat visit somewhere in the health system. Also, while the use of the modified HEAR/T score has been validated in the pre-hospital setting, using this risk-stratification tool in patients who report to the ED may affect the generalizability of the results. The pre-hospital-setting and the initial ED encounter have many similarities but may have some differences. These potential differences should be further investigated.

5. Conclusion

Emergency department nurse triage is challenging and requires optimized tools to prioritize patients with time-sensitive conditions, allocate resources, and positively impact morbidity and mortality. Our study demonstrates that the ESI tool is inadequate in triaging patients with suspected ACS, and that there is room for substantial improvement in how nurses triage this vulnerable patient population. Most chest pain patients assigned ESI scores 1 and 2 are event free from MACE suggesting over triage. When the modified HEAR/T score was used to supplement ESI, more than 50% of patients improperly triaged could be reclassified correctly. By incorporating risk factors from the modified HEAR/T score into nurse triage, there is potential to increase identification of patients at greater risk for developing MACE. This early recognition of high-risk patients could lead to initiating treatment that has potential to improve patient outcomes.

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Figure 1: Distribution of Primary Study Outcome in each Mechanism of Triage: Emergency Severity Index Score and Modified HEAR/T Score

This figure compares the distribution of major adverse cardiac events to each ESI triage score (A) and to each modified HEAR/T score (B).

Abbreviations: ESI: Emergency Severity Index; MACE: Major adverse cardiac event; ED: Emergency Department

Figure 2: Comparison between the classification performance of ESI score and modified HEAR/T scores in predicting major adverse cardiac events

This figure compares the area under the ROC curve for predicting MACE using the ESI score (A) versus using the modified HEAR/T score (B). There is a significant difference in the area under the ROC curves between ESI and modified HEAR/T ($p < 0.001$).

Abbreviation: ESI: Emergency Severity Index

Figure 3: Association between the initial patient classification by ESI score versus modified HEAR/T score at the emergency department

This figure compares the association between the patient acuity levels assigned by ESI score versus the reclassification performance using the modified HEAR/T score.

Abbreviation: ESI: Emergency Severity Index.

Table 1:

Patient Demographics and Clinical Characteristics of the Study Sample

Variables	All Patients (n=750)	Major Adverse Cardiac Events (MACE)	
		MACE (n=145, 19%)	No MACE (n=605, 81%)
Demographics			
Age (years; mean, Standard deviation)	59 ± 17	64 ± 15	58 ± 17
Sex (Male)	427 (57%)	86 (59%)	347 (57%)
Race (Black)	300 (40%)	33 (23%)	268 (44%)
Major Adverse Cardiac Event Risk Factors			
Ever Smoked	434 (58%)	85 (59%)	350 (59%)
Hypertension	519 (70%)	100 (69%)	419 (70%)
Diabetes Mellitus	196 (26%)	48 (33%)	148 (25%)
Hyperlipidemia	259 (35%)	53 (37%)	206 (34%)
Coronary Artery Disease	248 (33%)	57 (39%)	191 (32%)
Old Myocardial Infarction	205 (28%)	53 (37%)	152 (25%)
Known Heart failure	130 (18%)	32 (22%)	98 (16%)
Prior PCI or CABG	207 (28%)	59 (41%)	148 (25%)
Chief Complaint			
Chest Pressure	645 (87%)	127 (88%)	518 (87%)
Shortness of Breathing	215 (29%)	44 (30%)	171 (29%)
Heart Rhythm Abnormalities	126 (17%)	26 (18%)	100 (17%)
Atypical Symptoms	94 (13%)	21 (15%)	73 (12%)

Abbreviations: PCI: percutaneous coronary intervention; CABG: coronary artery by-pass grafting surgery.

Bolded numbers indicate p-value < 0.05.