Effectiveness of Modified HEART Score in Predicting Major Adverse Cardiac Events

Sultan Tuna Akgol Gur[1], Meryem Betos Kocak[2], Abdullah Osman Kocak[1], Mert Vural[1], Ilker Akbas[3], Sinem Dogruyol[4], Bugra Kerget[5], Zeynep Cakir[1]

ABSTRACT

Objective: The most important problem for emergency physicians in patients presenting with chest pain is deciding whether to discharge the patient or not. Therefore, many scoring systems have been developed to help with this decision making process. We aim to achieve a modified HEART value by combining the VAS value with the HEART score.

Materials and Methods: Data were collected on age, sex, duration of the symptoms, pain severity using a 10-point visual analog scale (VAS), and the presence of a major adverse cardiac event (MACE). The HEART score was calculated and modified (mHEART) by adding 1 point to the total HEART score for a VAS score of ≥7.

Results: During the study period, 4781 patients were admitted, and 293 participants were analyzed. Of the patients, 34(11.6%) experienced MACE within a month after the encounter. The mean VAS scores were 5.65±1.44. However, 77(26.3%) patients had VAS scores ≥7. Taking 3 as the threshold, 42(14.3%) patients had HEART scores of 4 and above, where 47(16.0%) had mHEART scores ≥4. The mHEART scoring demonstrated better test indicators than the HEART score. According to the HEART score, 6(2.3%) of the 251 patients predicted as negative would develop MACE, but this number decreased to 1(0.4%) in 246 using the mHEART score.

Conclusion: Although the HEART score performs reasonably well in discriminating patients who are MACE negative, it is possible to further improve the score by adding the VAS item. After validation by other studies, we would suggest modifying the HEART score by including the VAS item.

Keywords: Heart score, acute coronary syndrome, chest pain

Cite this article as: *Akgol Gur ST, Betos Kocak M, Kocak AO, et al. Effectiveness of Modified HEART Score in Predicting Major Adverse Cardiac Events. Eurasian J Med 2021; 53(1): 57-61.*

[1]Department of Emergency Medicine, Ataturk University School of Medicine, Erzurum, Turkey
[2]Department of Family Medicine, Sukrupasa Family Health Center, Erzurum, Turkey
[3]Department of Emergency Medicine, Bingol State Hospital, Bingol, Turkey
[4]Department of Emergency Medicine, Manisa Merkez Efendi State Hospital, Manisa, Turkey
[5]Department of Pulmonary Diseases, Ataturk University School of Medicine, Erzurum, Turkey

Received: October 9, 2020
Accepted: December 15, 2020

Correspondence to: Sultan Tuna Akgol Gur
E-mail: sultantuna@hotmail.com

DOI 10.5152/eurasianjmed.2021.20341

Introduction

According to a 2018 report on the global burden of diseases, armed conflicts, cancers, and cardiovascular diseases are becoming increasingly dangerous to worldwide health. In 2017, non-communicable diseases accounted for 73.4% of deaths, of which, 43.4% were because of cardiovascular diseases [1]. The principal ailments related to cardiovascular diseases are angina pectoris (AP) and acute coronary syndrome (ACS), which classically present with chest pain as the main symptom [2]. Therefore, it is crucial to understand the reasons for chest pain in the context of cardiac diseases.

The diagnostic workup of patients with chest pain demands substantial resources, including cardiology and other departments [3]. To decide whether a patient with chest pain will have a major adverse cardiac event (MACE), an urgent response is required. Any delay in the treatment of a MACE will negatively influence the prognosis [4]. Besides, the laboratory workup to detect a MACE requires time and economic reserves. Thus, early and correct recognition of the condition reduces patient anxiety as well as community loads.

Several risk scores, including the GRACE [5], HEART [6], and TIMI scores [7], have been developed to identify a MACE. Although the HEART score is considered the most reliable among the available tools, it fails to identify 2% of the low-risk patients [8], which suggests that there is still room for improvement.

We hypothesize that adding a pain parameter to the HEART score could improve its predictive capacity in estimating major cardiac events and identifying patients with chest pain at low risk for a MACE.

This study aims to investigate the effectiveness of the modified HEART (mHEART) score in predicting MACEs. It also aims at evaluating the usability of the mHEART score in the emergency department.

Materials and Methods

Study Design

This study was conducted with a cross-sectional design from September 1-15, 2019, with the STROBE guidelines followed in the reporting [9]. All the participants were asked to give individual written informed consent to participate. The study protocol was approved by the local ethics committee of the study hospital (2020/08/73).

Participants

To prevent selection bias, all the patients with chest pain were invited to participate without sampling. None of the included patients had applied before the study period. A total of 3 meetings were conducted with the research team concerning standard data collection and handling. Error checking and debugging were performed after the data were entered into the computer. All the patients (adults >18 years old) with chest pain during the study period were invited to participate in the investigation. A total of 135 patients refused to participate, and patients with ST-elevation myocardial infarction (STEMI) were excluded (n=15). Patients who presented with chest pain and received another diagnosis were similarly excluded from the study as were the patients with any of the following conditions: thoracic wall pathologies (n=3), costochondritis (n=3), fibromyalgia (n=6), pneumonia (n=8), pulmonary embolism (n=3), pneumothorax (n=2), pericarditis (n=1), aortic dissection (n = 2), intestinal pathologies (n=7), and traumatic chest pain (n=14), as well as patients who developed cardiac arrest (n=3) during their evaluation in the emergency room (Figure 1).

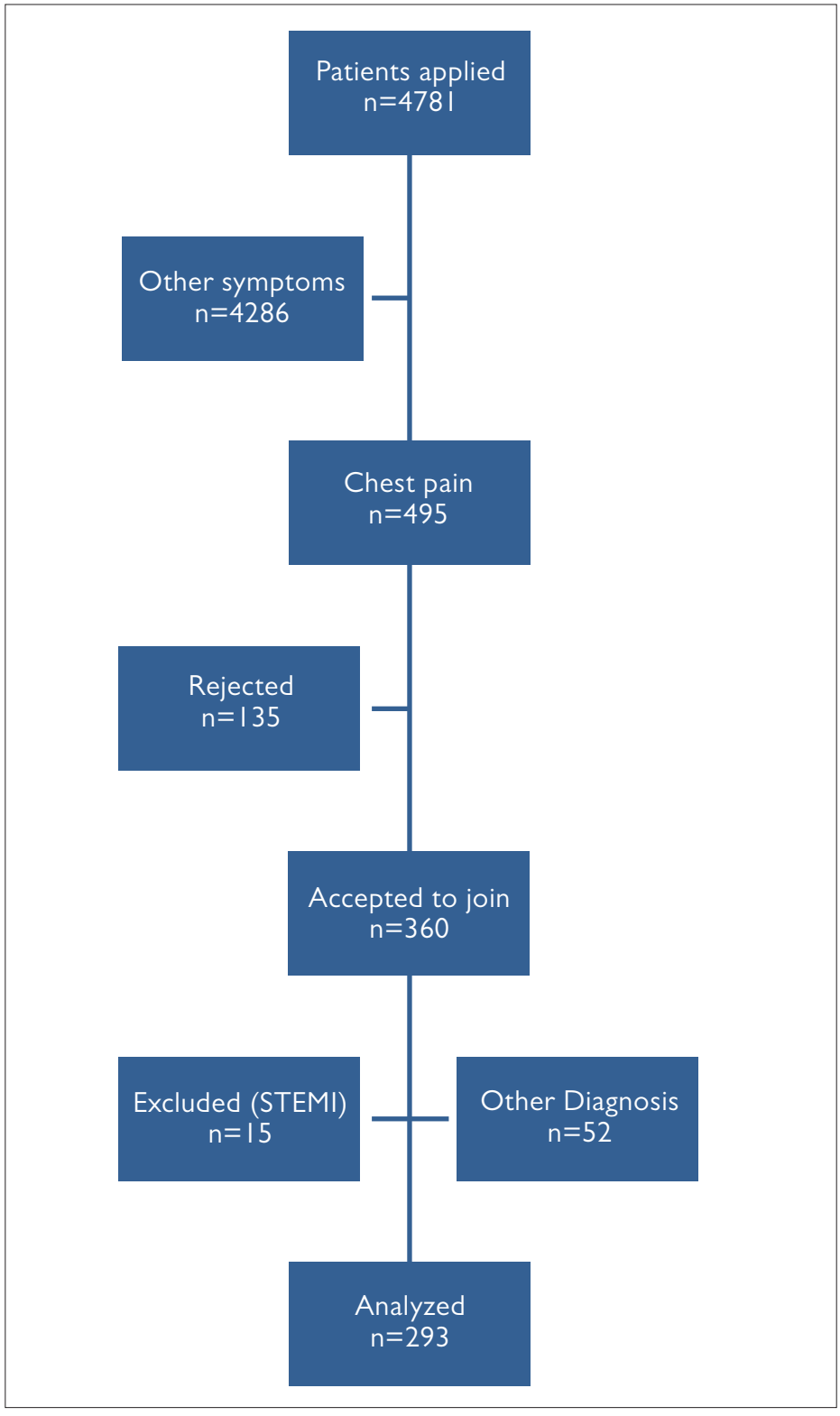

Figure 1. Study flow diagram

Main Points

- This study will contribute to patient management in the emergency department.
- It will bring a new approach to patient discharge from the emergency department.
- A new scoring system from our country will come into use.

Variables

Data were collected on age, sex, vital signs, smoking status, duration of the symptoms, pain severity, presence of comorbidities, and the presence of a MACE. A MACE was defined as the confirmation of any of the following conditions: acute MI (STEMI) or a non-ST-segment elevation myocardial infarction (NSTEMI), need for urgent revascularization, cardiovascular death, cardiac shock, and high-grade atrioventricular block or ventricular arrhythmia requiring intervention. Coronary artery bypass grafts, coronary stent placements, and other percutaneous coronary interventions were

interpreted as emergency revascularization [10].

Pain assessment was done by self-reporting using a visual analogue scale (VAS) ranging from 0 (no pain at all) to 10 (extremely intense pain). The HEART score was calculated using age, patient history (physician suspicion and previous atherosclerotic disease), ECG findings, and the presence of risk factors (smoking status, presence of diabetes mellitus, family history of cardiovascular disease, hypercholesterolemia, hypertension, and obesity), as described by Six et al. [6]. A HEART score ≤3 is associated with a low risk of developing an endpoint. Thus, it is used as a reference when discharging patients [11].

The primary outcome variable of the study was the mHEART score, which was calculated by adding 1 point to the total HEART score if the patient described a VAS score ≥7.

Each patient was followed for up to 30 days after application to the emergency unit for the presence of a MACE. Follow-ups were made by phone interviews, checking the electronic patient records, and, if necessary, arranging a control visit.

Study Size

The required sample size was calculated for receiver operating characteristics (ROC) analysis, as suggested by Negida et al. [12]. Based on an expected area under the curve (AUC) of 0.860 and an alpha error of 0.05, 286 participants were required to estimate the AUC with a precision of 0.810–0.910 (estimated error=0.05) at a confidence interval of 95%.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 software (IBM SPSS Corp.; Armonk, NY, USA). The results were presented as frequencies, percentages, means, and standard deviations (SDs). The Kolmogorov-Smirnov test was performed to test if the numerical variables were normally distributed. The Mann-Whitney U test was used to compare independent groups for numerical variables, and the chi-squared test was used for categorical variables. ROC analysis was applied to calculate the AUC for HEART and mHEART scores. The best cut-off points were selected to check for variables independently affecting domestic violence. A multivariable Cox regression analysis was used to determine the factors associated with MACE prediction. A p-value of <0.05 was considered statistically significant.

Table 1. Descriptive study findings

	No		Yes	
	n	%	n	%
Increase of symptoms with exercise	180	61.4	113	38.6
Pain during rest	106	36.2	187	63.8
Smoking	240	81.9	53	18.1
Comorbidities				
CAD	232	79.2	61	20.8
HT	224	76.5	69	23.5
DM	253	86.3	40	13.7
CRF	287	98.0	6	2.0
CHF	278	94.9	15	5.1
CVA	291	99.3	2	0.7
Hyperlipidemia	256	87.4	37	12.6
COPD	282	96.2	11	3.8
Malignancy	291	99.3	2	0.7
ECG findings				
Normal sinus rhythm	10	3.4	283	96.6
Ischemic changes	283	96.6	10	3.4

CAD: coronary artery disease; HT: hypertension; DM: diabetes mellitus; CRF: chronic renal failure; CHF: congestive heart failure; CVA: cardiovascular accident; COPD: chronic obstructive pulmonary disease; ECG: echocardiography.

Results

Participants

Of the 4781 patients admitted during the study period, 495 (10.3%) complained of chest pain. In this study, the results of 293 participants (112 females [38.2%] and 181 males [61.8%]) were analyzed. The mean age was 45.31±17.94 years (22–89 years). A total of 67 participants (22.8%) were below the age of 30. The mean systolic and diastolic blood pressures were 126.19±8.04 (110–138) mmHg and 79.89±4.24 (72–88) mmHg, respectively. The body temperatures of all the patients were within the normal limits (35.55°C±0.18°C; 36.4°C–37.0°C).

Descriptive Data

There was a wide variation in the mean duration (4.46±8.85 h) of the symptoms (10 min to 48 h). The median symptom duration was 1.5 h. The descriptive findings of the participants are presented in Table 1. A total of 17 patients (5.8%) had elevated (>0.06 ng/mL) troponin levels, all of whom (100%) developed MACE to some extent. However, 17 (6.1%) of the 276 patients with normal troponin levels also had MACE. In the study, 16 patients were diagnosed with NSTEMI, and 18 were diagnosed with unstable angina pectoris.

Outcome Data

A total of 34 patients (11.6%) experienced a MACE within a month after the encounter. The mean initial VAS score reported was 5.65±1.44 (4–10), and 77 participants (26.3%) had VAS scores ≥7. The mean HEART score was 1.57±1.90 (0–10), and the mean mHEART score was 1.83±2.01 (0–11). The ROC analyses revealed an AUC value of 0.733 (p<0.001, 95% confidence interval [CI]: 0.561–0.815) for VAS scores for predicting MACE. The best cut-off value for the VAS scores was calculated to be 7.

The AUC for mHEART scores for predicting MACE was 0.987 (p<0.001, 95% CI: 0.976–0.999) (Figure 2). Considering the sensitivity and specificity values, the best cut-off value for the mHEART score was calculated as 3.5 (≤3 vs. ≥4).

Taking 3 as the threshold, 42 patients (14.3%) had HEART scores ≥4, and 47 (16.0%) had mHEART scores ≥4. Using the same cut-off values, the mHEART scoring demonstrated better test indicators than the HEART scoring (Table 2). Therefore, although 6 (2.3%) of the 251 patients predicted as negative would develop a MACE based on the HEART score, this number decreased to 1 (0.4%) in 246 using the mHEART score.

According to the multivariate Cox regression for mHEART score, patient age (HR=1.04, 95% CI: 1.02–1.07, p<0.001) and presence of

Table 2. Test classification results of HEART and mHEART scores in predicting MACE

		Major Adverse Cardiac Event			
		No	Yes	Total	
HEART ≥4	No	245	6	251	NPV=245/251=97.6%
	Yes	14	28	42	PPV=28/42=66.7%
Total		259	34	293	
		Specificity= 245/259=94.6%	Sensitivity= 28/34=82.4%		
mHEART≥4	No	245	1	246	NPV=245/246=99.6%
	Yes	14	33	47	PPV=33/47=70.2%
Total		259	34	293	
		Specificity= 245/259=94.6%	Sensitivity= 33/34=97.1%		

MACE: major adverse cardiac event. PPV: positive predictive value.NPV: negative predictive value.

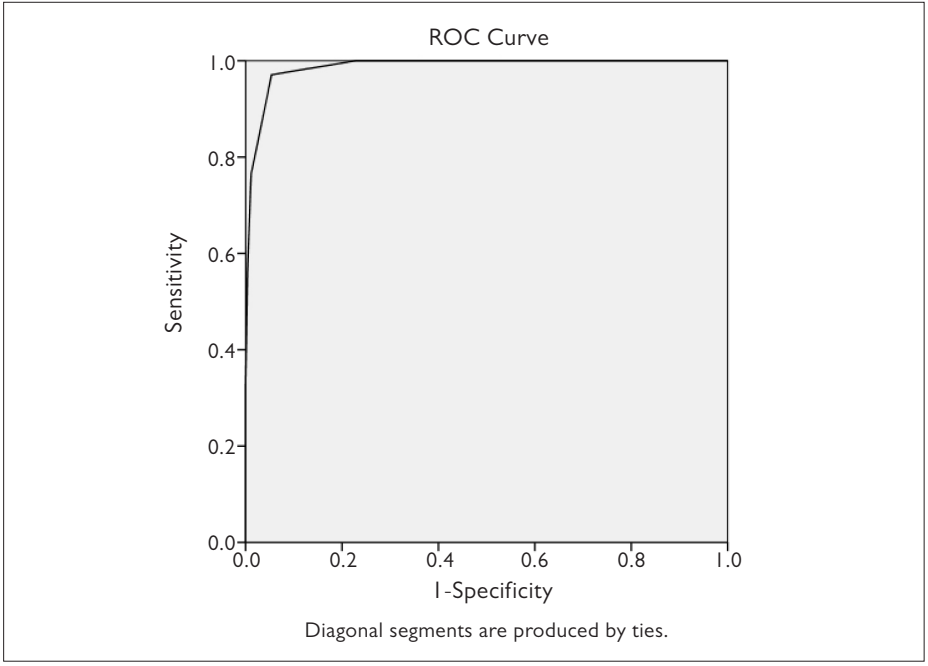

Figure 2. ROC analysis for mHEART scores in predicting MACE

diabetes mellitus (HR=0.35, 95% CI: 0.16–0.78, p=0.011) were associated with significantly greater odds for predicting MACE.

Discussion

The descriptive information in our study was compatible with the literature. This study demonstrated that MACEs are still a critical issue for emergency service physicians. A total of 11% of the discharged, apparently healthy patients with chest pain experienced some MACE within a month. Adding the pain severity experienced by the patient to the HEART score increased its sensitivity from 82.4% to 97.1%, its negative predictive value (NPV) from 97.6% to 99.6%, and its positive predictive value (PPV) from 66.7% to 70.2%, without affecting its specificity of 94.6%.

In this study, the number of male patients was almost double the number of female patients (181 males and 112 females). Sex differences among patients applying to emergency departments because of chest pain are well-known. Men experience more coronary artery-related issues compared with women [13]. In this context, it was even suggested that the clinical guidelines for men and women be modified. In patients with chest pain, the 6-week MACE proportions were 1.6 times lower in women than in men [14]. Thus, early discharge of patients with acute chest pain and a low-risk HEART score might be less safe for men as compared to women. Although we did not check for sex differences in this study, we believe that the issue should be elaborated.

There is continuing search for the best non-invasive test to identify populations at risk for cardiovascular events. Aside from sex, age is considered a primary determinant of cardiovascular risk [10]. Older patients with symptoms of coronary heart disease are at a substantially higher risk of positive non-invasive test results [15]. In our sample, we had an age distribution ranging from 22 to 89 years, and 22.8% of the participants were below 30 years of age. Therefore, we believe that although most cardiac events occur in the elderly, patients with chest pain have a wide range of ages; and therefore, a rigorous evaluation of younger patients is required.

Symptom duration is the principal question that needs to be evaluated in the event of chest pain. Owing to the disturbing nature of chest pain because of myocardial infarction, patients usually present to a health center within 3 h [16]. In our population, there was a wide variation in the mean duration of the symptoms, ranging from 10 min to 48 h, with a median duration of 1.5 h. As an acute myocardial infarction is more likely if the symptom lasts for 20–59 min, we suggest that this parameter be studied further as a discriminator of MACE.

Troponin is the most established indicator of myocardial ischemia. It is a fundamental part of the emergency workup of patients with chest pain and is included in all major risk stratification instruments [17], and 17 (5.8%) of our patients had elevated troponin levels, all of whom developed MACEs.

Correlations of the severity of chest pain with MACEs were not extensively studied. Scientific reports in this regard are non-conclusive. Although Galinski et al. [18] have mentioned that there is no relationship between pain severity and a diagnosis of acute myocardial infarction, Fukuoka et al. [19] have claimed that severe chest pain may be a signal for interpreting the symptom as cardiac-origin in men. In our study, a cut-off level of 7 in the initial VAS scores provided relatively high values in predicting MACEs.

Chest pain constitutes a significant part of presentations to the emergency department. These patients require utmost attention because of the possibility of severe consequences. However, it is not easy to establish a balance between hospitalizing and discharging patients. If patients are hospitalized, invasive testing, such as coronary angiography, can have drawbacks [20]. The other option is to apply non-invasive stress testing or imaging. Early recognition of a MACE

can reduce the patient burden as well as costs [8]. Several decision support tools, such as the GRACE, HEART, and TIMI scores, were developed to decrease the proportions of MACEs in discharged patients.

At this point, the specificity and NPVs of the tool under question must be reviewed. The NPV of a HEART score ≤3 has been reported as 98% [8]. However, a meta-analysis of 30 studies found the sensitivity and specificity of a HEART score ≥4 in predicting MACE to be 95.5% and 44.6%, respectively. We found comparatively similar values for the HEART score, although they were slightly lower than these reports. Furthermore, an increase in the predictive capacity of the scoring could be achieved by including the VAS criteria. Of the 251 patients, 6 (2.3%) predicted as negative would develop a MACE according to the HEART score; however, this number decreased to 1 (0.4%) in 246 using the mHEART score.

In our article, the HEART score, which consists of objective criteria, has been blended with the VAS value, which is a subjective parameter. It involves the evaluation of subjective criteria and throws light on a different perspective.

In conclusion, this study demonstrates that chest pain is an imperative condition in the emergency department, as it constitutes approximately 10% of all presentations, and major cardiac events require further attention. Approximately 11% of the discharged, apparently healthy patients with chest pain will experience a MACE within a month. Although the HEART score performs fairly well in discriminating MACE-negative patients, it is possible to further improve the score by adding the VAS item. As pain severity is a must-asked variable in all patients with chest pain, this refinement of the HEART score requires no extra time and resources. We, therefore, suggest modifying the HEART score by including the VAS value. The mHEART score can be used in a manner similar to the HEART score; thus, preserving the method of interpretation.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ataturk University Ethics Committee (Decision Number 2020/08/73).

Informed Consent: Informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - S.T.A.G., M.B.K., A.O.K.; Design - S.T.A.G., M.V., I.A.; Supervision -M.B.K. S.D., B.K.; Resources - S.T.A.G., M.B.K., B.K., Z.C.; Materials - A.O.K., M.V., I.A., S.D., Z.C.; Data Collection and/or Processing - S.T.A.G., M.V., I.A.; Analysis and/or Interpretation - M.B.K., M.V., S.D., B.K.; Literature Search - S.T.A.G., M.B.K., S.D., B.K., Z.C.; Writing Manuscript - S.T.A.G., M.B.K., A.O.K.; Critical Review - S.T.A.G., M.B.K., A.O.K., I.A., Z.C.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Roth GA, Abate D, Abate KH, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet (London, England) 2018; 392: 1736-88. [Crossref]
2. Yasue H, Mizuno Y, Harada E. Coronary artery spasm-Clinical features, pathogenesis and treatment. Proc Jpn Acad Ser B Phys Biol Sci 2019; 95: 53-66. [Crossref]
3. Fox KF. Investigation and management of chest pain. Heart 2005; 91: 105-10. [Crossref]
4. Bax JJ, Baumgartner H, Ceconi C, et al. Third universal definition of myocardial infarction. J Am Coll Cardiol 2012; 60: 1581-98. [Crossref]
5. Granger CB, Goldberg RJ, Dabbous O, et al. Predictors of hospital mortality in the global registry of acute coronary events. Arch Intern Med 2003; 163: 2345-53. [Crossref]
6. Six AJ, Backus BE, Kelder JC. Chest pain in the emergency room: value of the HEART score. Neth Heart J 2008; 16: 191-6. [Crossref]
7. Antman EM, Cohen M, Bernink PJ, et al. The TIMI risk score for unstable angina/non-ST elevation MI: A method for prognostication and therapeutic decision making. JAMA 2000; 284: 835-42. [Crossref]
8. Poldervaart JM, Langedijk M, Backus BE, et al. Comparison of the GRACE, HEART and TIMI score to predict major adverse cardiac events in chest pain patients at the emergency department. Int J Cardiol 2017; 227: 656-61. [Crossref]
9. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. PLoS Med 2007; 4: 1623-7. [Crossref]
10. Choi BG, Rha S-W, Yoon SG, Choi CU, Lee MW, Kim SW. Association of Major Adverse Cardiac Events up to 5 Years in Patients With Chest Pain Without Significant Coronary Artery Disease in the Korean Population. J Am Heart Assoc 2019; 8: e010541. [Crossref]
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. [Crossref]
12. Negida A, Fahim NK, Negida Y. Sample Size Calculation Guide - Part 4: How to Calculate the Sample Size for a Diagnostic Test Accuracy Study based on Sensitivity, Specificity, and the Area Under the ROC Curve. Adv J Emerg Med 2019; 3: e33.
13. Hess EP, Perry JJ, Calder LA, et al. Sex differences in clinical presentation, management and outcome in emergency department patients with chest pain. CJEM 2010; 12: 405-13. [Crossref]
14. Bank IEM, de Hoog VC, de Kleijn DP V, et al. Sex-Based Differences in the Performance of the HEART Score in Patients Presenting to the Emergency Department With Acute Chest Pain. J Am Heart Assoc 2017; 6: e005373. [Crossref]
15. Lowenstern A, Alexander KP, Hill CL, et al. Age-Related Differences in the Noninvasive Evaluation for Possible Coronary Artery Disease: Insights From the Prospective Multicenter Imaging Study for Evaluation of Chest Pain (PROMISE) Trial. JAMA Cardiol 2020; 5: 193-201. [Crossref]
16. Solomon R, Nowak R, Hudson M, Moyer M, Jacobsen G, McCord J. Is Duration of Symptoms Predictive of Acute Myocardial Infarction? Curr Probl Cardiol 2021; 46: 100555. [Crossref]
17. Reaney PDW, Elliott HI, Noman A, Cooper JG. Risk stratifying chest pain patients in the emergency department using HEART, GRACE and TIMI scores, with a single contemporary troponin result, to predict major adverse cardiac events. Emerg Med J 2018; 35: 420-7. [Crossref]
18. Galinski M, Saget D, Ruscev M, et al. Chest pain in an out-of-hospital emergency setting: no relationship between pain severity and diagnosis of acute myocardial infarction. Pain Pract 2015; 15: 343-7. [Crossref]
19. Fukuoka Y, Dracup K, Moser DK, et al. Is severity of chest pain a cue for women and men to recognize acute myocardial infarction symptoms as cardiac in origin? Prog Cardiovasc Nurs 2007; 22: 132-7. [Crossref]
20. 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. [Crossref]