The feasibility of HEAR score in comparison to Modified HEART score as a risk stratification tool for chest pain patients presented to Emergency Department Hospital Universiti Sains Malaysia

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ABSTRACT

Introduction: Risk stratification tools that integrate clinical, ECG findings and cardiac biomarkers have been used to facilitate the management of chest pain patients in the emergency department (ED). We studied the feasibility of history, age, electrocardiogram and risk factors (HEAR) score as a risk stratification tool for chest pain patients presented to ED Hospital Universiti Sains Malaysia (HUSM) in comparison to modified HEART score (MHS) based on major adverse cardiac events (MACE) within 6 weeks' time.

Materials and Methods: We analysed retrospective data of chest pain patients presenting to ED HUSM from 1st June 2020 till 31st January 2021 based on the patient's history, ECG findings, risk factors, age and troponin level. The patients were stratified as low risk (MHS and HEAR score of 0–3), intermediate risk (MHS and HEAR score of 4–6), and high risk (MHS of 7–10 and HEAR score of 7–8). The association of the MHS and HEAR score with MACE at 6 weeks' time was evaluated using simple logistic regression.

Results: This study included 147 patients in the MHS analysis and 71 patients in HEAR score analysis. The incident rate of MACE in low, intermediate and high risk was 0%,16.3%, and 34.7%, in the MHS group, and 0%, 3.22%, and 6.66% in HEAR score group. The mean difference between MACE and non-MACE in MHS and HEAR score groups was −2.29 (CI: −3.13,1.44, p<0.001) and −2.51(CI: −5.23, 0.21, p=0.070), respectively. There was no significant association between the incidence rate of MACE with modified HEART score (MHS) and HEAR score groups (p>0.95).

Conclusion: HEAR score is not feasible to be used as a risk stratification tool for chest pain patients presenting to ED HUSM in comparison to MHS. Further studies are required to validate the results.

KEYWORDS:
Chest pain, risk stratification tool, HEAR score, HEART score

INTRODUCTION

Chest pain is one the commonest symptoms in patients presenting to emergency department (ED), with the incidence rate of 8–19 per 1000 person per year.[1] These patients constitute a logistic and diagnostic challenge to emergency practitioners as to distinguish between cardiac related or nonthreatening disease. Acute coronary syndrome (ACS) must be ruled out in all patients with chest pain. Approximately 2% of chest pain patients with ACS are speciously discharged from the ED, which was associated with a two-fold increase in 30-day morbidity and mortality.[2]

In Malaysia, ACS remained as the leading cause of death comprised of 15% of medically certified deaths in 2019.[3] ACS is a clinical spectrum ranging from unstable angina (UA), non-ST segment elevation myocardial infarction (NSTEMI) to ST segment elevation myocardial infarction (STEMI) depending on the onset and intensity of the coronary artery occlusion.[4] Initiation of treatment for ACS in the emergency setting is based upon clinical evaluation of cardiac ischemia or infarction based on history, electrocardiogram (ECG) changes and elevation of cardiac biomarker.[5]

Risk stratification tools that integrate clinical, ECG findings and biomarkers in chest pain patients have been used to facilitate management of chest pain patients in ED. HEART score, which is an acronyms for history, electrocardiogram (ECG), age, risk factors and troponin level, has the strongest scientific evidence supporting its application and has been validated in many studies performed in theAsia Pacific, United States (US) and Europe.[6] The HEART score was established in the Netherlands in 2008 as a risk stratification tool for patients with chest pain based on their 6 weeks risks of major adverse cardiac events (MACE).[7] MACE is defined as acute myocardial infarction (AMI), percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG), and death due to any cause.[7] The structure of the five classification with a 0, 1, and 2 scoring system aids in stratifying patients with chest pain into scoring system of 0 to 10, which further sub categorised them into low, intermediate, and high-risk groups. Low-risk patients (a score 3 or less) were found to have a low MACE rate (1.7%), are those who are safe for ED discharge without requiring further cardiac evaluation or inpatient admission. On the other hand, higher score was associated with higher incidence rate of MACE (50.5%), warranted additional investigations.[8] In comparison to Global Registry of Acute Coronary Events

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(GRACE) and Thrombolysis in Myocardial Infarction (TIMI) Score, HEART score is superior in discriminating between those with and without MACE in chest pain patients, anddetected the largest group of low-risk patients at the same level of safety.[9]

The original HEART score utilised conventional troponin I as cardiac biomarker. Several studies validated the use of high sensitive cardiac assays which provide excellent sensitivity to diagnose myocardial injury and predicting major adverse cardiovascular events.[10] The performance of a single level of high-sensitivity troponin I (hsTnI), high-sensitivity troponin T (hsTnT)in comparison with conventional troponin I (cTnI) in association with 30-day MACE turned out to be 100% sensitivity.[11] Thus, certain centers have used these highly sensitive troponin assays as cardiac biomarker to diagnose ACS, including Hospital Universiti Sains Malaysia (HUSM). However, this troponin is not available or may be in limited numbers in many medical facilities especially at the district hospitals and primary cares. A modified scoring system without troponin level; HEAR score (History, Electrocardiogram, Age, and Risk factors) is an alternative to help stratifying chest pain patients. This scoring had been validated in a few studies for stratifying chest pain patients in ED and can be used as a guide for early discharge in low risk patients.[12-14]

In this study, we would like to investigate the feasibility of using HEAR score as a risk stratification tool for chest pain patients presented to ED HUSM in comparison to previously practiced modified HEART score which use highly sensitive Troponin T (hsTnT) by looking for the association with 6 weeks' risks of MACE.

MATERIALS AND METHODS

Study design and population

The study was conducted in Emergency Department Hospital Universiti Sains Malaysia (ED HUSM) from June 2020 till January 2021. Hospital Universiti Sains Malaysia (HUSM) is a teaching hospital under the Ministry of Higher Education, recognised as the regional tertiary referral center located in Kubang Kerian, Kelantan.

This study was a retrospective cross-sectional study looking for the effectiveness of HEAR score in comparison to modified HEART score (MHS) as risk stratification tool for chest pain patients presented to ED HUSM. Medical records of patients presented with chest pain in ED HUSM were traced from the records' office. Data for MHS were collected between June 2020 till September 2020, whereas data for HEAR score were obtained between October 2020 till January 2021. It was a shorter period than previous 1-year study plan as data obtained within this 8months' period sufficed the sample size required. Patients of 18 years old or more, having non-traumatic chest pain and had ECG done during the presentation in ED HUSM were enrolled in this study. Patient who developed cardiac arrest, having ST elevation in ECG and those ACS patients without chest pain were excluded from this study. Also, those subgroup of patients with missing data and those who refused any intervention despite being counselled were excluded from this study. Patients' data were extracted and combined in data collection sheet. Sample size for this study was calculated using web calculator, https://wnarifin.github.io/ssc_web.html. The minimum sample size for MHS analysis is 135 and sample size for HEAR score is 63, based on previous study conducted in Japan.13 The Human Research Ethics Committee Universiti Sains Malaysia approved the study (USM/JEPeM/21040340), and informed consent was waived as this was a retrospective non-interventional study.

Calculation of modified HEART score (MHS) and HEAR score

MHS was calculated based on five variables: history, ECG, age, risk factors, and troponin level whereas HEAR Score only used the first four variables of HEART score without troponin level. Patients' history was interpreted based on documentation from the emergency clerking sheet at the initial presentation and was classified as follow: highly suspicious (2 points), moderately suspicious (1 point) and low suspicion (0 point). The 12-leads ECG was reviewed and categorised into three groups: normal or non-specific findings (0 point), complete left bundle branch block or inverted T wave in more than two consecutive leads (1 point) and significant ST-segment depressions in more than two consecutive leads (2 points). In term of age, 0 point was assigned for those below 45 years; 1 point for those of 45 years or between 45 and 65 years and 2 points if age was 65 years or older. As for risk factors of coronary artery disease, the following were considered: hypertension, diabetes mellitus, hyperlipidaemia, positive family history, obesity and current or previous smoking history. In patients without risk factors, 0 point was allocated; one or two risk factors, 1 point was given and in patients with ≥3 risk factors or having previous history of coronary heart disease, 2 points were assigned. To complete the MHS, highly sensitive troponin T (hsTnT) level was measured. If the hsTnT level at admission was below the threshold value for positivity (<0.14 ng/mL), 0 point was given. If the level was high (≥0.14 ng/mL), 2 points were allocated.

According to the total scores, the patients were further classified into lowrisk (MHS and HEAR scores of 0–3), intermediaterisk (MHS and HEAR scores of 4–6), and highrisk (MHS of 7–10 and HEAR score of 7– 8) categories. This classification was based on previous study.[13]

End points

The end points for the study were the occurrence of major cardiac events (MACE) within 6 weeks' time form initial presentation to ED HUSM. MACE is a composite of AMI, percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), coronary angiography and death due to any cause.[15] In identifying MACE, we reviewed the paper-based records which included information on clinical records, discharge summaries, revascularisation reports, via direct phone calls to patients or relatives and other relevant data.

Statistical analysis

All data were collected and analysed using IBM SPSS version 26. Continuous data were expressed in term of mean with standard deviation and categorical data were expressed in term of number and percentage. Independent t-test was used

Table I: The baseline characteristics of chest pain patients presented to Emergency Department of Hospital Universiti Sains Malaysia (n=218)

Variable	HEART score n (%)	HEAR score n (%)	Total n (%)
Gender			
Female	47(32.0)	27(38.0)	74(33.9)
Male	100(68.0)	44(62.0)	144(66.1)
Age in years (mean±SD)	58.27(13.36)	57.75(14.23)	58.10(13.62)
MACE			
No	123(83.7)	69(97.2)	192(88.1)
Yes	24(16.3)	2(2.8)	26(11.9)

MACE: major adverse cardiac events
HEAR: history, age, electrocardiogram and risk factors
HEART: history, electrocardiogram (ECG), age, risk factors and troponin level

Table II: The proportion of patients with chest pain presentation to Emergency Department of Hospital Universiti Sains Malaysia based on the risk group and risk stratification score (n=218)

Variable	Risk stratification		Total n (%)
	Modified HEART score n (%)	HEAR score n (%)	
Risk group			
Low	25(17.0)	25(35.2)	50(22.9)
Intermediate	76(51.7)	31(43.7)	107(49.1)
High	46(31.3)	15(21.1)	61(28.0)

Table III: The comparison of mean HEART score between the presence of MACE in patients with chest pain presented to Emergency Department of Hospital Universiti Sains Malaysia based on the risk group and modified score (n=147)

Variable	MACE Mean (SD)	NO MACE Mean (SD)	t-stat (DF)	Mean difference (95% CI)	*p* value[a]
HEART score	7.46(1.50)	5.17(1.98)	-5.36(145)	-2.29 (-3.13, -1.44)	<0.001
HEAR score	7.00(1.41)	4.49(1.91)	-1.84(69)	-2.51(-5.23, 0.21)	0.070

[a]Independent t-test was applied; Normality and equal variance assumptions were met
The Proportion of Patients in Different Risk Groups that Develop MACE within 6 weeks' time Using Modified HEART and HEAR Score

Table IV: The risk stratification score and incidence rate of MACE according to category

Variable	Risk stratification Modified HEART score			HEAR score		
	n (%)	With MACE (n)	Incidence rate of MACE (%)	n (%)	With MACE	Incidence rate of MACE (%)
Risk group						
Low	25(17.0)	0	0	25(35.2)	0	0
Intermediate	76(51.7)	8	10.52	31(43.7)	1	3.22
High	46(31.3)	16	34.78	15(21.1)	1	6.66

Association between the risk group and developing MACE

Table V: The association between high-risk group and developing MACE in chest pain patients presented to Emergency Department of Hospital Universiti Sains Malaysia according to modified HEART score and HEAR score using Simple Logistic Regression (n=147)

Scoring Tool	Variable	B	Odds ratio (95% CI)	Wald statistic	*p* value
Modified HEART Score	Risk group				
	Low	0	1		
	Intermediate	19.06	-	-	>0.95
	High	20.57	-	-	>0.95
HEAR Score	Risk group				
	Low	0	1		
	Intermediate	17.80	-	-	>0.95
	High	18.56	-	-	>0.95

3.6 The Association of Proportion of HEAR Score of ≤4 and >4 With MACE
There was no significant association between HEAR score category and MACE group (p>0.05)(Table VI).

Table VI: Theproportion of chest pain patients developing MACE presented to the Emergency Department of Hospital Universiti Sains Malaysia based on HEAR score category (n=71)

Variable	MACE n (%)	NO MACE n (%)	Total n (%)	*p* value[b]
Score category				0.494
≤4	0(0.0)	34(49.3)	34(47.9)	
>4	2(100.0)	35(50.7)	37(52.1)	

[b]Fisher exact test applied; more than 20% expected count less than 5.

to compare mean difference of the continuous data, whereas simple logistic regression test was used to evaluate the association of the HEAR and HEART score with MACE at 6 weeks' time. Fisher exact test was applied to evaluate significance of association of MACE with proportion of patients having HEAR score ≤4 with score >4. *p* values < 0.05 were considered statistically significant.

RESULTS

Baseline characteristics

A total of 218 patients enrolled in this study encompassed 147 patients (67.4%) in MHS and 71 patients (32.6%) in HEAR score groups. Majority of the patients were male, whereby 100 males (68%) and 47 females (32%) were in MHS group, 44 males (62 %) and 27 females (38%) were in HEAR score group. The mean (SD) age of patients in the MHS and HEAR score group was 58.27 (13.36) years old and 57.75 (14.23) years old, respectively. A total of 24 patients (16.3%) in the MHS group had MACE, and only two patients (2.8%) in HEAR score group had MACE (See Table I).

Proportion of patients according to the risk group and modified score

The proportion of chest pain patients with high risk in the MHS group was 46 patients (31.3%), whereas 76 patients (51.7%) were in intermediate-risk category. In HEAR score group, the total of 15 patients (21.1%) and 31 patients (43.7%) in a high-risk and intermediate-risk group, respectively. Comparing the population of patients, percentage of patients in low-risk category was higher in HEAR score group, 35.2% compared to 17% in MHS group (Table II).

Comparison of risk stratification scores between patients Having MACE and Without MACE

There was a significant mean difference in scores between patients with and without MACE ($p<0.001$) in MHS group. The mean HEART score was found to be slightly higher in MACE and no MACE group in comparison to HEAR score group, with 7.46 and 5.17, respectively. The result indicated no significant mean difference of HEAR score between those with and without MACE ($p>0.05$). (Table III)

The study showed that the highest incidence rate of MACE occurred in high-risk group in MHS and HEAR score analysis with 16 cases (34.78%) and 1 case (6.66%), respectively. No MACE reported in low-risk group for both score (0%) (Table IV).

Based on the MHS and HEAR score, there was no significant association between major adverse effect events and patients in a high-risk group ($p>0.05$). (Table V)

DISCUSSION

Evaluation of clinical symptoms and a prognostic risk stratification should be made in all patients presenting with chest pain, to initiate specific therapy when indicated and reduce avoidable admissions and inappropriate discharges. HEART score has been widely used and validated in counterparts of the world, to aid in the risk stratification of patients with undifferentiated chest pain in the ED.[16] In our local setting in ED HUSM, instead of using conventional troponin, hsTnThad been integrated into modified HEART score, where the cut point of ≥14ng/L is used as positive cardiac biomarker. As we are relying on troponin level to diagnose ACS, restriction, or unavailability of cardiac troponin markers in hospitals may delay management and increase rate of missed diagnosis in ED. In HUSM, due to limited availability of troponin, HEAR score (HEART score without troponin) was applied as the modified risk stratification tool for chest pain patients presented to ED HUSM since October 2020. Numerous validation studies regarding this risk stratification tool for chest pain patients were based on short term major adverse cardiac event (MACE) within 30-days or 6 weeks' time, which include AMI, death , coronary angiogram and CABG.[12-14]

In this study, we found that the majority proportion of chest pain patients were in intermediate risk for both MHS group (51.7%) and HEAR score group (43.7%). Comparing the population of patients, percentage of patients in low-risk category was higher in HEAR score group, 35.2% compared to 17% in MHS group. A total of 24 patients (16.3%) in the MHS group had MACE and only two patients (2.8%) in HEAR score group had MACE. The highest incidence rate of MACE occurred in high-risk group in MHS and HEAR score analysis with 16 cases (34.78%) and 1 case (6.66%), respectively. No MACE was reported in low-risk group for both score (0%). This study also revealed the mean MHS and HEAR score for MACE group was 7.46 (±1.50) and 7.00 (±1.41) in contrast to non-MACE group, mean MHS and HEAR score were 5.17 (±1.98) and 4.49 (±1.91), respectively. The mean difference of MACE and non-MACE group for MHS was −2.29 (CI: −3.13,1.44) which is statistically significant ($p<0.001$), whereas mean difference for HEAR score was -2.51(CI: -5.23, 0.21) which is not statistically significant ($p=0.070$). These results conveyed that those patients with score less than 5 in MHS and less than 4 in HEAR score are less likely to develop MACE.

From our study, we found that there was no significant association between incidence rate of MACE with MHS and HEAR score groups ($p>0.95$). Comparatively, previous study has shown there was a significant association between HEART and HEAR score with MACE, respectively, 100% and

83% sensitive (p<0.001).[13] The proportion of patients in low-risk group for MHS group was 17%, whereas in HEAR score group was 35.1%, which demonstrated 0% occurrence of MACE within 6 weeks' time from first initial presentation. In one meta-analysis encompassing 25 HEART score studies from 2010 till 2017, among patients with low-risk HEART scores, short-term MACE (30 days to 6 weeks) occurred in 2.1% of the population.[17] In comparison, Constable et al and Otsuka et al in their HEAR score studies found that there were 1.7% to 4.7% incidence rate of MACE occurred in low-risk HEAR score group (p<0.001).[12]

In ED HUSM, as per local guideline, patients with HEAR score of ≤4, can be discharged from ED with follow-up, whereas HEAR score of >4 needs to be admitted and investigated further for acute coronary syndrome. From this result, it suggested patients in low risk had very low rate of MACE. Our study reported that the association between HEAR score with MACE was not statistically significant, p=0.494 (p>0.05), with two patients (100%) who had developed MACE were in HEAR score > 4. As shown from the results of this study, low-risk category patient had 0% of MACE, which might suggest for safe early discharge from ED, nevertheless, further validation studies need to be carried out.

A retrospective, double-centred, observational, cohort study in US had found HEAR scores overestimate risk when hs-cTnT<99th percentile, in which they reported that those with baseline quantifiable hs-cTnT within the reference range (<99th percentile), a higher risk (>1%) for 30-day MACE exists even in those with low HEAR scores.[19] In comparison, another study by Smith et alfound that the sensitivity to rule out MACE in very low-risk patients (HEAR score ≤1) wasexcellent with missed rate of 0.9% (95% CI: 0.2%-2.3%).[20] As in our study, we did not perform the troponin testing for patients in HEAR score group, so we could not analyse the sensitivity of HEAR score for low-risk group, thus, further studies need to validate our results.

Apart from emergency department in tertiary hospital, this HEAR score can be used in primary care centres or district hospitals to guide which patients need urgent referral. As those in low risk HEAR score, referral can be as follow ups whereas those in high-risk group need to be referred urgently to tertiary hospital. Additional studies can be done in those centres to look for any significant result. On the other hand, the international guidelines had recommended the use of serial troponin levels as the early risk stratification for chest pain patients.[18,21] HEART pathway, EDACS, ADAPT, 2020 ESC/hs-cTnT pathway are amongst validated studies using serial troponin to identify low risk patients who can be safely discharged from ED which have shown to be effective.[18,21,22] This pathway can be further studied in the Malaysian population to look for diagnostic validity and efficiency.

This current study had limitations. It was a retrospective study design, thus those with missing data including MACE were excluded from the study. We also did not include patient who refused for any intervention like CABG, angiogram, and PCI in this study. We could not explicitly explain how this can affect the trend of the results; thus, it could lead to selection bias. This was a cross-sectional study, with small study population compared to previous studies. A study with larger population involving multicentre should be conducted in the future which will have better representation of Malaysian population that may yield different and/or more significant results. We also did not conduct validity test for this study, looking into sensitivity and predictive values which should be included in the other study.

CONCLUSION

Our study found that there was statistically no significant association of HEAR score in comparison with modified HEART score with MACE (p>0.95). Thus, we would like to conclude that HEAR score is not feasible to be used as risk stratification tool for chest pain patients presented to ED HUSM. A further prospective study can be conducted to validate the results.

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REFERENCES

1. Hollander JE, Than M, Mueller C. State-of-the-art evaluation of emergency department patients presenting with potential acute coronary syndromes. Circulation 2016; 134(7): 547-64.
2. Yean KS, Mahathar M Bin, Zakaria MI Bin. A study on modified accelerated diagnostic protocol to safely discharge low-risk chest pain patients in emergency department. Hong Kong J Emerg Med 2020; 27(3): 134-45.
3. Rohaida Mohamad. Department of Statistics Malaysia Press Release: Statistics on Causes of Death, Malaysia, 2019. Dep Stat Malaysia. [cited October 2022] Accessed from: https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=RUxlSDNkcnRVazJnakNCNVN2VGgrdz09
4. Ministry of Health Malaysia. June 2011 MOH/P/PAK/219.11(GU). Clin Pract Guidel Manag Unstable Angina/Non ST Elev Myocard Infarct. 2011. [cited June 2022] Accessed from: https://www.moh.gov.my/moh/resources/Penerbitan/CPG/CARDIOVASCULAR/12.pdf
5. Roffi M, Patrono C, Collet JP, Mueller C, Valgimigli M, Andreotti F, et al. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent st-segment elevation: Task force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J 2016; 37: 267-315.
6. Stepinska J, Lettino M, Ahrens I, Bueno H, Garcia-Castrillo L, Khoury A, et al. Diagnosis and risk stratification of chest pain patients in the emergency department: focus on acute coronary syndromes. A position paper of the acute cardiovascular care association. Eur Hear J Acute Cardiovasc Care 2020; 9(1): 76-89.
7. Backus BE, Six AJ, Kelder JC, Bosschaert MAR, Mast EG, Mosterd A, et al. A prospective validation of the HEART score for chest pain patients at the emergency department. Int J Cardiol 2013; 168(3): 2153-8.
8. Mahler SA, Miller CD, Hollander JE, Nagurney JT, Birkhahn R, Singer AJ, et al. Identifying patients for early discharge: performance of decision rules among patients with acute chest pain. Int J Cardiol 2013; 168(2): 795-802.

9. Poldervaart JM, Langedijk M, Backus BE, Dekker IMC, Six AJ, Doevendans PA, 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; Jan 15; 227: 656-61.
10. Jarolim P. High sensitivity cardiac troponin assays in the clinical laboratories. Clin Chem Lab Med 2015; 53(5): 635-52.
11. Tan JWC, Tan HJG, Sahlen AO, Yeo KK, Chin WLC, Gao F, et al. Performance of cardiac troponins within the HEART score in predicting major adverse cardiac events at the emergency department. Am J Emerg Med 2020; 38(8): 1560-7.
12. Costabel J, Cortes M, Lambardi F, Ariznavarreta P, Resi S, Campos R. Usefulness of the heart score without troponin valueto stratify patients with suspected non-st elevation acute coronary syndrome. J Am Coll Cardiol 2019; 73(9): 271.
13. Otsuka Y, Takeda S. Validation study of the modified HEART and HEAR scores in patients with chest pain who visit the emergency department. Acute Med Surg. 2020; 7(1): 2–9.
14. Moumneh T, Sun BC, Baecker A, Park S, Redberg R, Ferencik M, et al. Identifying patients with low risk of acute coronary syndrome without troponin testing: validation of the HEAR Score. Am J Med 2021; 134(4): 499-506.e2.
15. Six AJ, Backus BE, Kelder JC. Chest pain in the emergency room: Value of the HEART score. Netherlands Hear J. 2008; 16(6): 191-6.
16. Stepinska J, Lettino M, Ahrens I, Bueno H, Garcia-Castrillo L, Khoury A, et al. Diagnosis and risk stratification of chest pain patients in the emergency department: focus on acute coronary syndromes. A position paper of the Acute Cardiovascular Care Association. Eur Hear J Acute Cardiovasc Care 2020; 9(1): 76-89.
17. Laureano-Phillips J, Robinson RD, Aryal S, Blair S, Wilson D, Boyd K, et al. HEART Score Risk Stratification of Low-Risk Chest Pain Patients in the Emergency Department: A Systematic Review and Meta-Analysis. Ann Emerg Med. 2019; 74(2): 187-203.
18. Gulati M, Levy PD, Mukherjee D, Amsterdam E, Bhatt DL, Birtcher KK, et al. 2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. J Am Coll Cardiol. 2021; 78(22): e187-285.
19. Abstract 14283: Influence of the HEAR Score for 30-day risk-stratification in emergency department patients evaluated with high-sensitivity cardiac troponin T | Circulation. 2022; 146: A14283
20. Smith LM, Ashburn NP, Snavely AC, Stopyra JP, Lenoir KM, Wells BJ, et al. Identification of very low-risk acute chest pain patients without troponin testing. Emerg Med J [Internet]. 2020; 37(11): 690-5.
21. Jason Stopyra PP, Miller CD, Hiestand BC, Lefebvre CW, Nicks BA, Cline DM, et al. Chest pain risk stratification: a comparison of the 2-hour accelerated diagnostic protocol (ADAPT) and the HEART. Crit Pathw Cardiol. 2016; 15(2): 46-9.
22. Stopyra JP, Harper WS, Higgins TJ, Prokesova J V., Winslow JE, Nelson RD, et al. Prehospital Modified HEART score predictive of 30-day adverse cardiac events. Prehosp Disaster Med. 2018; 33(1): 58-62.