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Comparison of C2HEST and MC2HEST Scores as Predictors of New-Onset Atrial Fibrillation in Patients with Acute Coronary Syndrome Undergoing Percutaneous Coronary Intervention at Haji Adam Malik Hospital Medan

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ABSTRACT

Introduction: To evaluate whether the C2HEST and mC2HEST scores have good ability as predictors of new-onset atrial fibrillation in patients with acute coronary syndrome undergoing percutaneous coronary intervention at HAM Hospital Medan.
Method: This study is a retrospective cohort study. Retrospective data were collected by total sampling from all medical records of ACS patients at Adam Malik Hospital from January to September 2024. Prospective data were collected consecutively until the minimum sample size was met. Samples included in the research analysis were those that met the inclusion criteria without exclusion criteria.
Results: As a predictive method, the mC2HEST score is as good as the C2HEST score, with AUCs of 0.713 and 0.728, respectively. The cut-off point obtained is the same for both scores, which is >3. The C2HEST score has a sensitivity of 73.7%, specificity of 52.6%, while the mC2HEST score has a sensitivity of 78.9%, specificity of 55.1%. The total number of samples that met the criteria was 108 patients. Patients with new-onset atrial fibrillation numbered 19 (17.6%). The youngest patient was 30 years old and the oldest was 81 years old. The average age in patients with new-onset atrial fibrillation was 67 years and without new-onset atrial fibrillation was 57 years. This study also yielded a new scoring system as an alternative predictive method.
Conclusion: The mC2HEST score is as good as the C2HEST score as a predictor of new-onset atrial fibrillation in patients with acute coronary syndrome undergoing percutaneous coronary intervention at HAM Hospital Medan.

Keywords MC2HEST score, C2HEST score, Atrial fibrillation, ACS.

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INTRODUCTION

Atrial fibrillation (AF) is one of the most common cardiac conditions, significantly affecting both primary and secondary healthcare services. The prevalence of AF is expected to double in the coming decades owing to the aging population, increasing burden of comorbidities, greater awareness, and new technologies for detection. The effects of AF vary among patients; however, the morbidity associated with AF remains a major concern. Patients with AF may experience various symptoms and have a poor quality of life. Stroke and heart failure as consequences of AF are well understood by healthcare professionals, and AF is also linked to a range of thromboembolic complications, including subclinical brain damage and thromboemboli in other organs, all contributing to a higher risk of death associated with AF.[1,2]

The onset and progression of AF are triggered by a series of comorbidities and associated risk factors. To provide optimal care for patients with AF, it is widely accepted that comorbidities and risk factors must be addressed early and dynamically. Failing to do so contributes to recurrent AF cycles, treatment failure, poor patient outcomes, and healthcare resource wastage. Patients with AF also experience high rates of hospitalisation due to complications from underlying medical conditions. The most common non-fatal outcome in patients with AF is heart failure, which occurs in approximately half of patients over time. Patients are a four to five times higher relative risk (RR) of heart failure than those without AF. AF is also associated with an increased mortality rate. In 2017, AF was responsible for more than 250,000 deaths globally, with an age-specific mortality rate of 4.0 per 100,000 people.[3]

New-onset atrial fibrillation (NOAF) can complicate the clinical course of patients with acute myocardial infarction (AMI). Up to 20% of patients may develop NOAF after AMI or percutaneous coronary intervention (PCI). The underlying mechanisms of NOAF after AMI/PCI are multifactorial, including increased inflammation, atrial ischaemia, reperfusion injury, and oxidative stress following acute coronary artery occlusion.[4] NOAF occurrence post-AMI has been associated with high AF recurrence rates over time (>20%), the need for long-term oral anticoagulation, and poorer clinical outcomes, including ischaemic stroke and vascular death. In the Global Use of Strategies To Open Occluded Coronary Arteries (GUSTO-III) trial, 6.5% of 13,858 patients with sinus rhythm at baseline developed AF, which was associated with an increased risk of death compared with patients without AF.[4]

Several laboratory markers, such as NT-pro-BNP and high-sensitivity C-reactive protein (CRP), along with clinical risk factors (e.g. age, sex, and Killip class) and imaging variables (e.g. left ventricular ejection fraction [LVEF] and left atrial size), have been linked to the risk of NOAF. However, a structured, simple, and cost-effective clinical risk stratification strategy to identify patients at a higher risk of NOAF after AMI has not yet been established.[4]

Recently, a new simple score, C2HEST, was introduced to identify the risk of subclinical or overt AF in the general population. The C2HEST score includes factors such as coronary artery disease, chronic obstructive pulmonary disease (COPD), hypertension, age ≥75 years, systolic heart failure, and thyroid disease, each contributing to the total score. This score has been used in various studies in China, Korea, and Denmark to screen populations vulnerable to AF. A 2019 study in France also used the C2HEST score to screen patients with AF who had experienced a stroke. In 2021, a study in China used the C2HEST score to predict the occurrence of sustained atrial high rates in patients with implanted cardiac devices.[5,6] In the C2HEST score, age > 75 years is assigned a score of 2 out of a total of 8 points, whereas the average life expectancy in Indonesia is less than 75 years. The general life expectancy in Indonesia in 2023 is 73.93 years, with females having a higher life expectancy (76.37 years) than males (71.61 years) in the same year. In the population with acute coronary syndrome, male patients are more prevalent than female patients.[7]

Recently, several studies have proposed a modified version of the C2HEST score, adding age ≥65 years as an additional variable (1 point) to emphasise that the occurrence of AF increases with age. This study aimed to investigate the predictive value of the simple C2HEST and modified C2HEST (mC2HEST) scores for NOAF in patients with AMI who underwent PCI.[5,6]

METHOD

This was an analytical observational study with a retrospective cohort design. This study aimed to examine the predictive value of the C2HEST and mC2HEST scores for the occurrence of new-onset atrial fibrillation (NOAF) in patients with acute myocardial infarction (AMI) who underwent primary percutaneous coronary intervention (PCI). The study was conducted at RSUP Haji Adam Malik Medan, starting once ethical clearance was granted. Data were collected from medical records available within a one-year timeframe, specifically from January to October 2024.

The independent variables in this study were the C2HEST and mC2HEST scores, which were both numeric (ratio), and the dependent variable was the occurrence of new-onset atrial fibrillation, which was categorical (nominal). The study population consisted of patients who had acute myocardial infarction and underwent PCI at RSUP Haji Adam Malik Medan, and among these, those who developed new-onset atrial fibrillation. The study sample was chosen based on inclusion and exclusion criteria, utilising consecutive sampling methods from secondary data in medical records, including sex, age, vital signs, laboratory results, and echocardiography findings.

The sample size was calculated using a sample size formula for prognostic studies, resulting in an estimated sample size of 107 participants. The inclusion criteria were patients aged > 18 years, diagnosed with acute coronary syndrome, undergoing PCI at RSUP Haji Adam Malik Medan, and possessing complete medical records. The exclusion criteria included a history of paroxysmal atrial fibrillation, incomplete medical records, thrombolytic therapy or coronary artery bypass surgery, valvular heart disease or congenital abnormalities, and death before PCI.

Once informed consent was obtained and ethical approval was granted by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara, demographic and clinical data were recorded, including age, sex, vital signs, and laboratory results. Data were analysed using SPSS version 23.0. Categorical variables are presented as frequencies and percentages, whereas numeric variables are presented as means and standard deviations for normally distributed data or as medians for non-normally distributed data. Normality tests were conducted using the Kolmogorov-Smirnov test for large samples (n > 50) and the Shapiro-Wilk test for smaller samples (n < 50). Univariate analysis was performed to analyse demographic and clinical characteristics, whereas multivariate analysis was used to analyse the relationship between independent and dependent variables when the p-value was less than 0.1. The cutoff values of the C2HEST and mC2HEST scores for predicting NOAF were assessed using receiver operating characteristic (ROC) curve analysis, which included calculating the sensitivity, specificity, positive predictive value, and negative predictive value. Ethical approval for this study was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara.

RESULTS

Table 1. Clinical Characteristics of Patients with or Without New-Onset Atrial Fibrillation

Variable	FAAB (+) n = 19 (17.6%)	FAAB (-) n = 89 (82.4%)	p-value
Age			
Age ≤ 65 years	6 (31.5%)	65 (73%)	0.001a
Age ≥ 65 years	13 (68.4%)	24 (26.9%)	0.001b
Age ≥ 75 years	6 (31.5%)	8 (8.9%)	0.022b
Gender			
Male	13 (68.4%)	68 (76.4%)	0.355b
Female	6 (31.6%)	21 (23.6%)	
Onset of FA			
Late Onset	9 (47.0%)	0 (0%)	<0.001b
Early Onset	10 (53.0%)	0 (0%)	
Hypertension	16 (66.0%)	50 (42%)	0.044b
Heart Failure	8 (33.3%)	11 (12.4%)	0.006b
Diabetes Mellitus	7 (36.8%)	26 (29.2%)	0.512b
Smoking	13 (68.4%)	68 (76.4%)	0.466b
History of Smoking	5 (26.3%)	5 (5.6%)	0.005b
COPD	6 (30.5%)	6 (6.7%)	0.006b
History of Stroke	0 (0%)	2 (2.2%)	0.510b
History of Cancer	0 (0%)	4 (4.5%)	0.346b
Active Cancer	0 (0%)	4 (4.5%)	0.346b
PAD	2 (10.5%)	3 (3.4%)	0.178b
Hyperthyroidism	3 (15.1%)	1 (1.1%)	0.016b
Hyperlipidemia	4 (21.1%)	4 (4.5%)	0.035b
C2HEST Score	4.15 ± 1.53	3.16 ± 1.5	0.014c
mC2HEST Score	4.42 ± 1.64	3.32 ± 1.6	0.009c

This retrospective cohort study aimed to assess the predictive ability of the C2HEST and mC2HEST scores for the occurrence of new-onset atrial fibrillation (NOAF) in patients with acute myocardial infarction (AMI) undergoing primary percutaneous coronary intervention (PCI) (Table 2). The study was conducted at RSUP Haji Adam Malik Medan using data from patients admitted between January and October 2024. A total of 164 patients were initially included; however, 55 were excluded for not undergoing PCI, and one patient was excluded because of death prior to the procedure.

Table 2. Presentation of Acute Coronary Syndrome in Patients with or without New-Onset Atrial Fibrillation

Variable	FA (+) n = 19 (17.6%)	FA (-) n = 89 (82.4%)	p-value
Diagnosis			
UAP	2 (10.5%)	13 (14.6%)	0.228b
NSTEMI	6 (31.6%)	17 (19.1%)	
STEMI	11 (57.9%)	58 (65.2%)	
Stenosis Location			
LAD	8 (42.1%)	51 (57.3%)	0.430b
LCx	3 (15.8%)	8 (9%)	
RCA	8 (42.1%)	30 (33.7%)	
Cardiogenic Shock	4 (21.1%)	4 (4.5%)	0.012b
Cardiac Arrest	3 (15.8%)	1 (1.1%)	0.002b
LVEF	42.05 ± 8.91	48.29 ± 11.5	0.028a
LAVI	33.0 ± 3.8	29.55 ± 3.56	0.001c
Multivessel Disease	6 (31.6%)	37 (41.6%)	0.419b

Following PCI, 19 patients developed new-onset atrial fibrillation (FA), whereas 89 did not. The average age of patients with new-onset FA was 67.15 years (SD = 10.39), significantly higher than the 57.66 years (SD = 10.35) of patients without FA (p = 0.001). Both groups were predominantly male, with 68.4% of patients with FA and 76.4% of patients without FA being male. ST-Elevation Myocardial Infarction (STEMI) was the most common diagnosis in both groups, with 57.9% of patients with FA and 65.2% of those without FA diagnosed with STEMI.

Regarding stenosis location, the LAD region was most commonly affected in patients without FA, whereas both the LAD and RCA regions were prevalent among those with FA. The study included nine patients with slow-onset FA and ten with early onset FA. Hypertension, heart failure, chronic obstructive pulmonary disease (COPD), and hyperthyroidism were more common in patients with FA than in those without FA, with statistically significant differences ($p < 0.05$). Patients with FA were more likely to have hyperlipidaemia (21.1%) than those without FA (4.5 %; P = 0.035).

Cardiogenic shock and cardiac arrest were more frequent in patients with new-onset FA (p = 0.012 and p = 0.002, respectively). Left ventricular ejection fraction (LVEF) was significantly lower in the FA group (42.05 ± 8.91) than in those without FA (48.29 ± 11.5, p = 0.028), and left atrial volume index (LAVI) was significantly higher in the FA group (33.0 ± 3.8 vs. 29.55 ± 3.56, p = 0.001). No significant differences were observed in terms of eGFR, haemoglobin levels, anaemia, or kidney dysfunction.

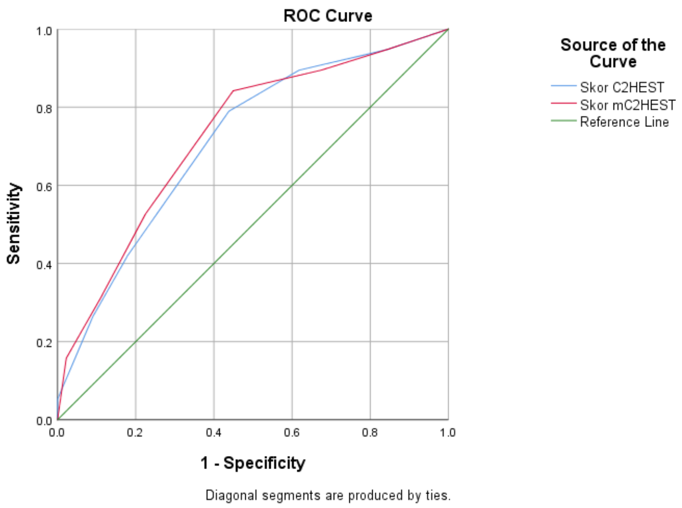

Figure 1. ROC Curve of C2HEST and mC2HEST Scores as Predictors for New-Onset Atrial Fibrillation

ROC curve analysis demonstrated that both the C2HEST and mC2HEST scores were significant predictors of the occurrence of FA, with AUC values of 0.713 and 0.728, respectively ($p < 0.05$). The optimal cut-off values for the C2HEST and mC2HEST scores were both 3, yielding a sensitivity of 73.7% and 78.9% and a specificity of 56.2% and 55.1 %, respectively (Table 3).

Multivariate logistic regression analysis revealed several factors significantly associated with the onset of FA, including LAVI, age ≥ 65 years, hypertension, heart failure, COPD, and mC2HEST score. These factors were found to increase the likelihood of FA occurrence, with odds ratios (OR) greater than 1 (Table 4)

Table 3. Determining the Ideal Cut-off for C2HEST and mC2HEST Scores in Predicting New-Onset FA Post-PCI

Scoring System	Cut-off	Sensitivity	Specificity	Youden's Index
C2HEST	0	100%	0%	0
	> 1	94.7%	15.7%	10.46
	> 2	84.2%	38.2%	22.41
	> 3	73.7%	56.2%	29.86*
	> 4	36.8%	82%	18.86
	> 5	21.1%	91%	12.06
	> 6	5.3%	100%	5.26
mC2HEST	0	100%	0%	0
	> 1	94.7%	15.7%	10.46
	> 2	84.2%	32.6%	16.79
	> 3	78.9%	55.1%	34.01*
	> 4	47.4%	77.5%	24.89
	> 5	26.3%	88.8%	15.08
	> 6	10.5%	97.8%	8.27

Table 4. Multivariate Analysis of Variables for Predicting FA Onset

Parameter	p-value	Odds Ratio (95% CI)
LVEF	0.827	0.993 (0.934 - 1.056)
LAVI	0.015	18.127 (1.385 - 206.067)
Age ≥ 65 years	0.025	9.946 (1.339 - 73.891)
Age ≥ 75 years	0.013	23.104 (1.921 - 277.906)
Hypertension	0.050	1.490 (0.975 - 20.208)
Heart failure	0.017	19.354 (1.685 - 222.331)
Hyperthyroidism	0.313	1.631 (0.214 - 121.571)
COPD	0.045	6.582 (1.042 - 41.587)
Smoking History	0.054	0.229 (0.051 - 1.029)
Cardiogenic Shock	0.448	0.469 (0.066 - 3.318)
Cardiac Arrest	0.128	0.116 (0.007 - 1.859)
Hyperlipidemia	0.548	1.341 (0.561 - 1.812)
C2HEST Score	0.004	1.694 (1.184 - 2.425)
mC2HEST Score	0.002	1.683 (1.202 - 2.358)

Table 5. Logistic Regression Analysis of Five Variables

Parameter	p-value	Odds Ratio (95% CI)
LAVI	0.015	18.127 (1.385 - 206.067)
Age ≥ 65 years	0.025	9.946 (1.339 - 73.891)
Age ≥ 75 years	0.013	23.104 (1.921 - 277.906)
Heart failure	0.017	19.354 (1.685 - 222.331)
COPD	0.045	6.582 (1.042 - 41.587)
Constant		2.548

A new scoring system was developed based on the significant factors identified using logistic regression. The scoring system incorporates LAVI, age ≥ 65 years, heart failure, and COPD. The new score was tested on the sample, and its ROC curve analysis showed that it performed similarly to the mC2HEST score in predicting FA onset, with an AUC (0.726). The optimal cutoff for the new score was three, with a sensitivity of 63.2% and specificity of 67.4%. In conclusion, both the C2HEST and mC2HEST scores were effective in predicting the onset of new atrial fibrillation post-PCI. A newly developed scoring system that incorporates significant clinical factors has also shown promise as an effective risk stratification tool.

Table 6. New Score System Calculation

Variable	Score
LAVI	2
Age ≥ 65 years	1
Age ≥ 75 years	2
Acute Coronary Syndrome	1
Heart failure	2
COPD	1
Total	7-8

Table 7. ROC Curve Analysis for New Score as Risk Stratification

Test Result Variable(s)	Area
C2HEST Score	0.713
mC2HEST Score	0.728
New Score	0.726

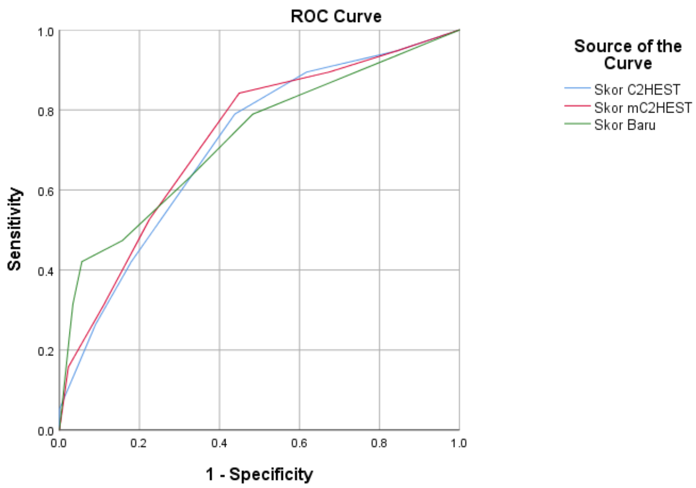

Figure 2. AUC Calculation of the New Score as Risk Stratification

Figure 2. displays the Area Under the Curve (AUC) calculation for the newly developed scoring system. ROC curve analysis showed that the new score performed similarly to the C2HEST and mC2HEST scores in predicting new-onset atrial fibrillation (FA) after percutaneous coronary intervention (PCI). An AUC value of 0.726 indicates the robust ability of the new score for effective risk stratification, similar to the other two established scoring systems.

Table 8. Performance of the New Score in Predicting New-Onset FA

Area	Std Error	P-value	CI	Sensitivity	Specificity	Cut-off
0.726	0.07	0.002	0.589 - 0.863	0.632	0.674	3

DISCUSSION

This hospital-based study explored the predictive value of the C2HEST and modified C2HEST (mC2HEST) scores for new-onset atrial fibrillation (FAAB) in patients with acute coronary syndrome (ACS) who underwent primary percutaneous coronary intervention (PCI). The results indicated that the mC2HEST score, with the addition of age ⩾65 years as one point, demonstrated better predictive accuracy for FAAB than the original C2HEST score.

In this study, the average age of patients with FAAB was significantly higher (67.15 years) than that of those without FAAB (57.66 years), with a notable correlation between age ⩾65 years and the incidence of

FAAB. Similar findings have been reported in other large population-based studies, highlighting age as a critical risk factor for AF development. The prevalence of AF increases with age, as shown in studies where the risk of incident AF doubles with each decade of life, and those aged 71–80 years have a five-fold higher risk of developing AF than younger populations.[8] Thyroid dysfunction, particularly hyperthyroidism, was more common in patients with FAAB, although it was not statistically significant in this study. Previous research suggests that hyperthyroidism, including subclinical cases, is associated with a three-fold increase in the development of AF due to the effects of thyroid hormones on atrial electrical impulses and atrial conduction.[9] While hyperthyroidism is a known risk factor for AF, its role in FAAB may be underrepresented due to subclinical detection in this study.

Heart failure (HF) was strongly associated with the occurrence of FAAB, consistent with the existing literature. Both heart failure with reduced ejection fraction (HFrEF) and preserved ejection fraction (HFpEF) contribute to atrial remodelling and increase the risk of AF [10]. In this study, the presence of HF in patients with FAAB was significantly higher, supporting the well-established relationship between heart failure and an increased risk of AF. Furthermore, the left atrial volume index (LAVI) was identified as a significant predictor of FAAB development. LAVI is a marker of atrial remodelling, which occurs in AF, and has been shown to be a strong predictor of AF recurrence [11]. Patients with larger LAVI measurements were more likely to develop FAAB, emphasising the importance of echocardiographic parameters in assessing AF risk. The study also highlighted the increased risk of FAAB in patients with chronic obstructive pulmonary disease (COPD), which was associated with a 28% higher risk of developing AF. COPD is linked to atrial remodelling due to hypoxia and other molecular pathways, further complicating the management of patients with COPD [12].

Although shock and cardiac arrest were more common in patients with FAAB, these factors did not reach statistical significance in the multivariate analysis. Previous research has indicated that cardiogenic shock, a severe condition typically associated with MI, increases the likelihood of arrhythmias, including AF [13]. Finally, we introduced a new scoring system that includes five clinical parameters and one echocardiographic parameter, LAVI, to predict FAAB. This new score, with an AUC of 0.726, offers an alternative method for stratifying the risk of FAAB in patients with ACS undergoing PCI. The score outperformed the original C2HEST score in terms of sensitivity and specificity, indicating its potential for clinical use in screening and preventive strategies for FA. Early detection of FAAB is critical for preventing complications such as stroke and heart failure, and effective screening could lead to timely anticoagulation initiation.

In conclusion, this study reinforces the importance of age, heart failure, and atrial structural changes in predicting FAAB incidence. The mC2HEST score and the new scoring system based on clinical and echocardiographic parameters offer valuable tools for identifying at-risk patients, potentially improving outcomes through early detection and intervention. Further studies are required to validate these scores in broader patient populations.

CONCLUSION

This study validated the C2HEST and mC2HEST scores as effective predictors of new-onset atrial fibrillation (FA) in patients with acute coronary syndrome (ACS), emphasising the significant role of age as a risk factor. The modified mC2HEST score, which has improved age stratification, performed similarly to the original C2HEST score. Key factors such as age, chronic obstructive pulmonary disease (COPD), heart failure, and left atrial volume index (LAVI) were identified as important predictors of AF development in patients with ACS.

DECLARATIONS

Ethics approval and consent to participate were obtained. Permission for this study was obtained from the Ethics Committee of the Universitas Sumatera Utara and Haji Adam Malik General Hospital.

CONSENT FOR PUBLICATION

The Authors agree to publication in Journal of Society Medicine.

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The authors declare that there is no conflict of interest in this report.

AUTHORS' CONTRIBUTIONS
All authors significantly contribute to the work reported execution, acquisition of data, analysis, and interpretation, or in all these areas. Contribute to drafting, revising, or critically reviewing the article. Approved the final version to be published, agreed on the journal to be submitted, and agreed to be accountable for all aspects of the work.

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