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Original Article

Evaluation of CHA_2DS_2-VASc Score to Predict No Reflow Phenomenon in Patients with St Elevated Myocardial Infarction Undergoing Primary Percutaneous Coronary Intervention

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ABSTRACT

Objective: To evaluate the prognostic efficacy of the CHA_2DS_2-VASc scoring system in predicting the incidence of the no-reflow phenomenon in patients diagnosed with ST-segment elevation myocardial infarction (STEMI) who are receiving primary percutaneous coronary intervention (PPCI).

Methodology: The study was a prospective observational analytical study conducted in the Department of Cardiology, National Institute of Cardiovascular Diseases, Karachi. It involved 124 patients between the age of 18 and 70 years with STEMI and treated with PPCI. The CHA_2DS_2-VASc score was assessed pre-procedure and angiographic evaluation revealed no-reflow when the post-intervention TIMI flow was less than grade III. Statistical analysis has been done on SPSS v26 by implementing ROC curve and Chi-square analysis with significance level of $p < 0.05$.

Results: Among a study group of 124 participants (mean age 55.8 ± 9.6 years; 81.5% male and 18.5% female), 22.6% demonstrated the occurrence of the no-reflow phenomenon subsequent to (PPCI). Patients with no-reflow had significantly higher CHA_2DS_2-VASc scores compared to those with reflow (3.60±1.49 vs. 2.18±1.12; $p<0.001$). Smoking showed a significant relationship with no-reflow. Receiver operating characteristic analysis demonstrated good predictive ability for the CHA_2DS_2-VASc score (AUC = 0.765, 95% CI: 0.670–0.860; $p < 0.001$).

Conclusion: The present study indicates that the CHA_2DS_2-VASc score serves as a useful clinical tool for anticipating the likelihood of no-reflow among individuals presenting with STEMI treated through PPCI. Elevated scores were associated with a greater probability of no-reflow, particularly in female and smoking patients, supporting its role in guiding early clinical decision-making.

Keywords: CHA_2DS_2-VASc score, No-reflow phenomenon, Percutaneous coronary intervention, ST-elevation myocardial infarction

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) continues to be a significant cause of cardiovascular mortality globally, and an overload in developing countries, including Pakistan, where the late presentation to the hospital and limited access to reperfusion therapies a significant contributor to poor clinical outcomes[1,2]. Primary percutaneous coronary intervention (PPCI) is now considered to be the best means of coronary blood flow restoration in STEMI, and its timely performance minimizes the size of infarcts, limits myocardial damage, and improves prognosis is better[3,4]. Although the infarct-related artery reopening is successful, a few patients develop the no-reflow phenomenon (NRP), defined by inappropriate myocardial perfusion without the presence of epicardial blockage that is associated with poor short- and long-term outcomes[5,6].

Reported incidence of NRP has been found to vary between 5% to 40%, based on patient factors and definition of the phenomenon. Its pathophysiology is complicated, and it involves microvascular dysfunction, distal embolization, ischemia-reperfusion injury, and inflammatory cascades[7,8]. The prediction of the development of NRP before the main intervention of PPCI may help clinicians design interventional approaches, allocate resources properly, and provide preventive treatment. Nonetheless, the existing predictive models are usually complex and are not well validated in other populations.

The CHA_2DS_2-VASc score, originally developed for stroke risk stratification in non-valvular atrial fibrillation, has been investigated in other cardiovascular contexts because it incorporates clinical risk factors such as age, hypertension, diabetes, and vascular disease, which also play a role in the pathophysiology of NRP[9,10]. Several recent studies have assessed its predictive value in STEMI patients undergoing PPCI. Zhang and colleagues reported that a modified CHA_2DS_2-VASc-HSF score, which included additional clinical variables, demonstrated moderate predictive accuracy with an area under the curve (AUC) of 0.755 and acceptable sensitivity and specificity at a cutoff of four[11]. Another study applying the $R_2CHA_2DS_2$-VASc variant, which incorporates renal impairment, reported a sensitivity of 52.6% and specificity of 73.1% for predicting NRP at a cutoff of three[12]. A systematic review summarizing five independent studies showed that a CHA_2DS_2-VASc score ≥2 had moderate predictive performance, with an average AUC of 0.70, sensitivity of 86%, and specificity of 44%[13]. Supporting this, evidence from a Pakistani registry indicated that the CHA_2DS_2-VASc score may help identify patients at elevated risk of NRP, particularly when combined with markers such as thrombus burden and endothelial dysfunction[14,15].

Considering the clinical significance of the NRP among patients with STEMI treated with PPCI and recognizing the practical advantages of using a simple and easily calculable bedside tool, the CHA_2DS_2-VASc score emerges as a potentially valuable predictor of this adverse outcome. Although prior studies conducted in various populations have reported its predictive value with differing cutoff points, there remains limited evidence from South Asian settings where variations in

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patient characteristics, comorbidities, and procedural timing may influence outcomes[11,13]. Therefore, the present research was designed to assess the predictive accuracy of the CHA_2DS_2-VASc score for identifying the risk of no-reflow in patients with STEMI undergoing PPCI at a major tertiary cardiac centre in Karachi. This study contributes region-specific data to validate the CHA_2DS_2-VASc score as a reliable predictor of no-reflow in a South Asian cohort, thereby addressing an existing gap in the global evidence base and supporting its broader clinical applicability.

METHODOLOGY

This prospective observational analytical investigation was undertaken within the Department of Cardiology at the NICVD in Karachi, spanning the period from September 2023 to December 2024, subsequent to obtaining authorization from the institutional ethics review committee. Written informed consent was procured from all participants prior to their enrolment in the study. Individuals of any gender, aged between 18 and 70 years, who presented with STEMI and underwent PPCI were included in the study cohort. STEMI was characterized by the presence of typical chest pain persisting for more than 20 minutes, accompanied by either ST-segment elevation of ≥1 mm in a minimum of two contiguous limb leads, ≥2 mm in two or more adjacent precordial leads, or the emergence of a new left bundle branch block as evidenced on the electrocardiogram. The no-reflow phenomenon has been characterized angiographically as insufficient myocardial perfusion, indicated by a Thrombolysis in Myocardial Infarction (TIMI) flow grade of less than III, notwithstanding the successful recanalization of the responsible epicardial artery. The CHA_2DS_2-VASc scoring system was determined prior to the initiation of PPCI for each subject, integrating clinical variables such as the presence of heart failure, hypertension, advanced age (≥75 years), diabetes mellitus, history of cerebrovascular accident or transient ischemic attack, vascular pathology, age range of 65 to 74 years, and female gender. Patients were excluded from the study if they had a prior history of PCI or CABG, presented outside the optimal timeframe for PPCI, exhibited non-significant coronary artery lesions that were not amenable to intervention, or possessed coronary anatomy that was more suitably addressed through surgical revascularization. The study enrolled 124 participants based on an anticipated area under the receiver operating characteristic (ROC) curve of (0.70)[13], considering a 95% confidence interval and expected sensitivity and specificity values of (86% and 44%)[13], respectively. Participants were enrolled using a non-probability consecutive sampling method during the study period. Demographic, clinical, and angiographic data were recorded using a structured proforma at presentation. All PPCI procedures were performed by experienced interventional cardiologists following standardized institutional protocols. The CHA_2DS_2-VASc score was documented pre-procedurally, and the presence or absence of no-reflow was assessed angiographically after the intervention. All gathered data were managed with strict confidentiality and employed exclusively for the purposes of academic research. A statistical analysis was performed using the SPSS software, version 26. Descriptive statistics were computed in terms of mean accompanied by standard deviation and frequency along with percentage. The Receiver Operating Characteristic (ROC) curve analysis was utilized to evaluate the predictive validity of the CHA_2DS_2-VASc score concerning the occurrence of no-reflow. The Chi-square test was applied, and a p-value of ≤ 0.05 was considered to be statistically significant.

RESULTS

Out of 124 patients included in the analysis, 96 (77.4%) exhibited reflow, while 28 (22.6%) demonstrated the no-reflow phenomenon. The mean age and body mass index exhibited no statistically significant differences between the two groups ($p = 0.858$ and 0.608, respectively). The mean CHA_2DS_2-VASc score was markedly elevated among patients demonstrating reflow in comparison to those experiencing no-reflow (3.60±1.49 vs. 2.18±1.12; $p < 0.001$). Male participants displayed a higher propensity for reflow relative to their female counterparts (88.7% vs. 69.0%; p=0.010). No statistically significant correlations were identified with respect to residential status, diabetes mellitus, or hypertension.

A positive family history of cardiovascular pathologies exhibited a significant association with the NRP, as all four subjects demonstrating such a medical history manifested this outcome (p=0.002). Moreover, the utilization of tobacco was recognized as possessing a significant relationship with the occurrence of no-reflow (35.3% vs. 17.8%; $p = 0.037$). Individuals diagnosed with triple-vessel coronary artery disease exhibited a propensity for elevated occurrences of no-reflow phenomena; however, this association did not achieve statistical significance (p=0.061). The culprit artery exhibited a statistically significant association with the reflow status; involvement of the left anterior descending (LAD) artery was observed more frequently in patients demonstrating reflow, whereas lesions of the right coronary artery (RCA) were more prevalent in the no-reflow cohort (p=0.002). The post-operative TIMI flow classification exhibited a statistically significant divergence between the two cohorts, with each patient attaining TIMI grades I–II manifesting reflow, whereas all individuals categorized with grade III demonstrated an absence of reflow ($p < 0.001$) **(Table I)**.

ROC analysis revealed that the CHA_2DS_2-VASc score exhibited a substantial predictive capacity for the identification of the NRP, as evidenced by AUC of 0.765 (95% CI: 0.670–0.860; $p < 0.001$), thereby indicating commendable discriminative efficacy. A threshold value of ≥ 3.5 yielded a sensitivity of 50.0% and a specificity of 92.9%, accompanied by a positive likelihood ratio of 7.04 and a negative likelihood ratio of 0.54 **(refer to Table I, Figure I)**.

Multivariable logistic regression analysis indicated that age did not exhibit a statistically significant association with the NRP, as evidenced in both the unadjusted model (OR=0.996; 95% CI: 0.959–1.036; p=0.857) and the adjusted model (OR=0.993; 95% CI: 0.954–1.034; p=0.723). In contrast, gender persisted as a notable predictor; females had a greater propensity for the occurrence of no-reflow both prior to adjustment (OR=3.517; 95% CI:1.310–9.441; p=0.013) & subsequent to adjustment (OR=3.557; 95% CI: 1.321–9.576; p=0.012) **(Table III)**.

Table I: Baseline Characteristics of Study Participants (n=124)

Baseline Characteristics		Re-Flow Phenomenon		P-Value
		Yes (n=96)	**No** (n=28)	
Age in years, Mean ± SD		57.99 ± 10.81	57.57 ± 11.15	0.858
Body mass index in kg/m , Mean ± SD		25.12 ± 2.57	24.85 ± 1.93	0.608
CHA_2DS_2-VASc Score, Mean ± SD		2.18 ± 1.12	3.60 ± 1.49	0.0001*
Gender	Male	47 (88.7)	6 (11.3)	0.010*
	Female	49 (69.0)	22 (31.0)	
Residential Status	Urban	79 (76.7)	24 (23.3)	0.459
	Rural	17 (81.0)	4 (19.0)	
Diabetes Mellitus	Diabetic	32 (80.0)	8 (20.0)	0.635
	Non-Diabetic	64 (76.2)	20 (23.8)	
Hypertension	Hypertensive	48 (80.0)	12 (20.0)	0.506
	Non-Hypertensive	48 (75.0)	16 (25.0)	
Family history of CVD	Positive	0 (0.0)	4 (100.0)	0.002*
	Negative	96 (80.0)	24 (20.0)	
Smoking Status	Smoker	22 (64.7)	12 (35.3)	0.037*
	Non-Smoker	74 (82.2)	16 (17.8)	
Type of CAD	SVD	38 (76.0)	12 (24.0)	0.061
	DVD	34 (89.5)	4 (10.5)	
	TVD	24 (66.7)	12 (33.3)	
Culprit Artery	LAD	79 (83.2)	16 (16.8)	0.002*
	LCX	4 (100.0)	0 (0.0)	
	RCA	13 (52.0)	12 (48.0)	
TIMI Grades	I	4 (100.0)	0 (0.0)	0.0001*
	II	92 (100.0)	0 (0.0)	
	III	0 (0.0)	28 (100.0)	

Applying Independent Sample t-test* & Chi-Square test*
"CAD = Coronary Artery Disease; SVD = Single Vessel Disease; DVD = Double Vessel Disease; TVD = Triple Vessel Disease; LAD = Left Anterior Descending artery; LCX = Left Circumflex artery; RCA = Right Coronary Artery; TIMI = Thrombolysis in Myocardial Infarction."

Figure 1: Receiver Operating Characteristic (ROC) Curve of CHA_2DS_2-VASc Score for Predicting No-Reflow

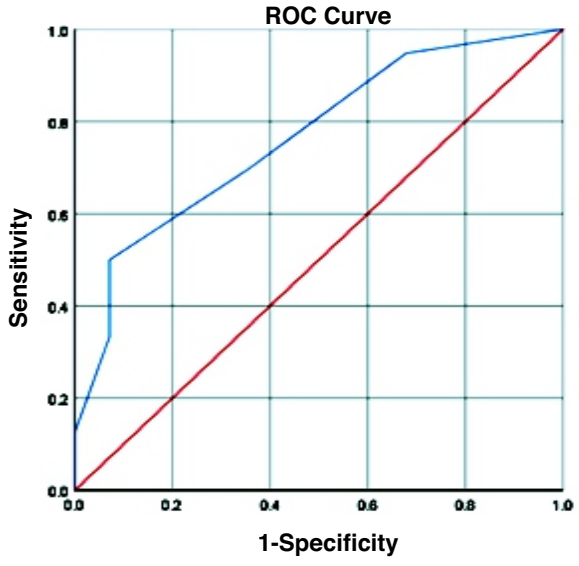

Table II: ROC Curve Analysis of CHADS2-VASC Score for Predicting No Re-Flow Phenomenon (n=124)

Area under the curve (AUC)	0.765
Std. Error	0.048
95% Confidence Interval	0.670----0.860
P-Value	0.0001
Cut off value	≥3.50
Sensitivity	50.0%
Specificity	92.9%
Positive Likelihood Ratio	7.04
Negative Likelihood Ratio	0.54

Table III: Multivariable Logistic Regression Model of Age and Gender as Predictors of the No-Reflow Phenomenon				
Predictor	**Unadjusted OR (95% CI)**	**P-value**	**Adjusted OR (95% CI)**	**P-value**
Age (years)	0.996 (0.959 – 1.036)	0.857	0.993 (0.954 – 1.034)	0.723
Gender	3.517 (1.310 – 9.441)	0.013	3.557 (1.321 – 9.576)	0.012*

DISCUSSION

This study examined the predictive capability of the CHA_2DS_2-VASc score in identifying patients at risk of developing the no-reflow phenomenon among those presenting with STEMI who underwent PPCI at a tertiary cardiac hospital in Karachi. The analysis revealed that patients who experienced no-reflow had significantly higher CHA_2DS_2-VASc scores than those who achieved optimal myocardial reperfusion. These findings support the use of this clinical scoring system as a practical and accessible tool to identify patients vulnerable to microvascular reperfusion failure during acute myocardial infarction. Clinical elements of the CHA_2DS_2-VASc score such as age, hypertension, diabetes, and vascular disease are known to trigger endothelial dysfunction, inflammation and microvascular blockage, which are central to no-reflow[5,7]. This association is further supported by recent work by Huang et al.[16] who found that a CHA_2DS_2-VASc score of three or greater was a significant predictor of phenomenon of slow-flow and no-reflow in patients with STEMI receiving PPCI. The demographic composition in the present investigation, defined by a predominance of middle-aged male subjects and a notable prevalence of conventional cardiovascular risk factors including hypertension, diabetes mellitus, and tobacco use, is congruent with previously reported findings in analogous cohorts. The no-reflow subgroup exhibited a higher representation of female patients and smokers, in addition to an increased incidence of right coronary artery (RCA) involvement, observations that are consistent with extant literature suggesting that these variables significantly contribute to compromised microvascular outcomes following PPCI[8,14,15].

The predictive efficacy demonstrated in this investigation aligns closely with the findings documented in prior research. Zhang and associates illustrated that a modified CHA_2DS_2-VASc-HSF score achieved an area under the receiver operating characteristic curve (AUC) of 0.755 within a Chinese demographic, a finding that is analogous to the AUC of 0.765 attained in the current analysis[11]. In a similar vein, Zhao and colleagues reported that an $R_2CHA_2DS_2$-VASc score, which included renal dysfunction, sustained a moderate predictive capability for no-reflow (AUC=0.74)[12]. Furthermore, Eldessouki and their team also established a significant correlation between heightened CHA_2DS_2-VASc scores and microvascular obstruction, thereby affirming its ability to reflect the systemic atherosclerotic load[13]. Furthermore, the research conducted by Rashed et al. within a South Asian cohort substantiated the prognostic significance of this scoring system across diverse regional and ethnic demographics[14]. In more contemporary investigations, Ashoori et al.[17] elucidated that an $R_2CHA_2DS_2$-VASc score of three or higher independently forecasted no-reflow phenomena and unfavourable in-hospital outcomes in patients experiencing STEMI following PCI, evidencing an AUC of 0.781. In a similar vein, Dönmez et al.[18] discerned that beyond risk scores, clinical determinants such as left ventricular ejection fraction, serum troponin levels, fasting glucose concentrations, and thrombus classification were significant predictors of no-reflow phenomena in STEMI, suggesting that both systemic and procedural factors play a role in its manifestation. Collectively, these investigations underscore the clinical importance of CHA_2DS_2-VASc–based models as straightforward, cost-effective, and proficient instruments for the identification of high-risk patients, especially in healthcare environments where access to more sophisticated risk assessment methodologies is constrained.

Clinically, it is significant to identify patients who have a high risk of no-reflow prior to PPCI. Patients with a greater CHA_2DS_2VASc are likely to receive specific procedural plans, intensive pharmacologic pre-procedural preparation, and increased post-procedural management. The present study's findings regarding the significant roles of smoking, female sex, and RCA involvement emphasize the multifactorial origin of the phenomenon and the need for individualized preventive approaches[1,2]. The association between RCA infarction and a greater incidence of no-reflow observed here is consistent with prior studies suggesting that the right coronary distribution is more susceptible to distal embolization and microvascular obstruction due to anatomical and perfusion-related factors[8,17]. These findings collectively highlight the clinical usefulness of incorporating the CHA_2DS_2-VASc score into pre-procedural evaluation frameworks to improve the prediction and management of no-reflow during PPCI.

While the study provides valuable insights, several methodological considerations should be acknowledged. It was performed at a single centre with a relatively small sample size, which may affect the generalizability of the results. The observational design prevents the establishment of causality, and the potential influence of unmeasured confounders cannot be ruled out. Moreover, reliance on angiographic criteria alone may have underestimated the true incidence of microvascular obstruction when compared with cardiac magnetic resonance or myocardial contrast echocardiography. The exclusion of late presenters and those with prior revascularization procedures could have introduced selection bias. Despite these constraints, the strengths of this work include a prospective approach, standardized interventional protocols, and rigorous statistical assessment using ROC curve and logistic regression analyses. Most importantly, it provides contemporary data from a South Asian population, addressing an underexplored regional context and contributing to the global understanding of no-reflow risk prediction in STEMI.

The evidence presented supports the CHA_2DS_2-VASc score as an effective, clinically feasible instrument for assessing no-reflow risk in STEMI patients undergoing PPCI. Its integration into pre-procedural evaluation can enhance early risk stratification, optimize procedural planning, and improve post-intervention outcomes. Future large-scale, multicentre investigations that incorporate advanced imaging and hemodynamic parameters are warranted to validate and refine predictive thresholds for broader clinical use.

CONCLUSION

The present study indicates that the CHA_2DS_2-VASc score serves as a useful clinical tool for anticipating the likelihood of no-reflow among individuals presenting with STEMI treated through PPCI. Elevated scores were associated with a greater probability of no-reflow, particularly in female and smoking patients, supporting its role in guiding early clinical decision-making.

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