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Original Article

Predictors of No-Reflow Phenomenon in Primary Percutaneous Coronary Intervention among Patients with Acute Myocardial Infarction

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ABSTRACT

Background: The no-reflow phenomenon, characterized by the failure to restore myocardial blood flow after reopening an occluded artery in acute myocardial infarction (AMI) patients undergoing primary percutaneous coronary intervention (PCI), has significant implications for patient prognosis. Understanding the predictors of no-reflow is crucial for improving clinical outcomes in this high-risk population.

Objective: This study aims to identify the predictors of the no-reflow phenomenon in patients with AMI undergoing PCI and to assess their impact on the efficacy of the intervention.

Methods: Conducted at Lady Reading Hospital's Cardiology Department, this descriptive study retrospectively analyzed 120 AMI patients treated with PCI from May 2023 to November 2023. Ethical approval was obtained, and the study conformed to the Declaration of Helsinki. The diagnosis of AMI was based on clinical symptoms and electrocardiographic findings. Experienced cardiologists performed PCI, and no-reflow was defined using Thrombolysis in Myocardial Infarction (TIMI) flow grades and Myocardial Blush Grade (MBG). Data were analyzed using SPSS Version 25, focusing on demographic variables, clinical presentations, and procedural details to identify predictors of no-reflow.

Results: Out of 120 patients, 70.8% were male. The incidence of no-reflow was 22.5%. Significant predictors of no-reflow included systolic blood pressure < 100 mmHg (51.9% in no-reflow vs. 28.0% in normal flow, P=0.02), diabetes (59.3% vs. 34.4%, P=0.02), hypertension (77.8% vs. 31.2%, P=0.0001), and history of cardiovascular disease (11.1% vs. 2.2%, P=0.04).

Conclusion: The study identified diabetes, hypertension, low systolic blood pressure, and a history of cardiovascular disease as significant predictors of the no-reflow phenomenon in AMI patients undergoing PCI. These findings highlight the importance of identifying and managing these risk factors to enhance the success of PCI and improve patient outcomes.

Keywords: No-reflow phenomenon, acute myocardial infarction, primary percutaneous coronary intervention, predictors, systolic blood pressure, diabetes, hypertension, cardiovascular disease.

INTRODUCTION

Acute myocardial infarction (AMI) results from the sudden cessation of blood flow to a segment of the heart muscle, necessitating immediate restoration of circulation within the occluded coronary artery to salvage the ischemic tissue and improve patient prognosis (1, 2). Primary Percutaneous Coronary Intervention (PPCI) has emerged as the premier therapeutic intervention for re-establishing blood flow in instances of coronary artery obstruction. This procedure, characterized by the mechanical dilation of the blocked vessel, ensures the swift resumption of blood supply (3). However, advancements in interventional cardiology are sometimes overshadowed by the occurrence of the no-reflow phenomenon, a significant barrier to PPCI efficacy that adversely affects clinical outcomes in AMI patients (4). The no-reflow phenomenon is characterized by inadequate myocardial perfusion through the microcirculation despite successful removal of the larger coronary obstruction, leading to persistent ischemic damage and myocardial dysfunction (5). This condition is attributed to various pathophysiological mechanisms including microvascular

Journal of Health and Rehabilitation Research 2791-156X JHRR

obstruction, endothelial damage, inflammatory responses, and reperfusion injury, complicating the post-PPCI recovery process (6, 7).

Despite enhancements in PPCI techniques and adjunctive pharmacotherapy, the incidence of no-reflow remains considerable, varying from 5 to 50% among patient populations, influenced by the specific diagnostic criteria and patient characteristics (8). Microvascular obstruction plays a pivotal role in the no-reflow phenomenon, impeding the distribution of essential nutrients and oxygen to the jeopardized myocardium, while ischemia-reperfusion injury exacerbates endothelial dysfunction, further impairing microvascular integrity and perpetuating no-reflow (9, 10). Inflammation significantly contributes to the development of no-reflow, with the release of inflammatory mediators in response to ischemia and subsequent reperfusion. This inflammatory cascade, featuring neutrophil infiltration, reactive oxygen species production, and cytokine release, inflicts damage on the microvascular endothelium, thereby intensifying the no-reflow condition (11-14).

The clinical challenge posed by no-reflow during PPCI for AMI is profound, bearing substantial implications for patient morbidity and mortality. Patients experiencing no-reflow post-PCI are more likely to suffer extensive tissue damage, higher incidences of myocardial injury, and diminished short- and long-term prognoses. Consequently, there is an imperative need for ongoing research into the mechanisms underlying no-reflow and the development of targeted therapies aimed at enhancing microvascular blood flow restoration and mitigating the detrimental impact of no-reflow on PPCI outcomes.

MATERIAL AND METHODS

In this descriptive study, conducted in the Department of Cardiology at Lady Reading Hospital, we retrospectively examined 120 patients who presented with acute myocardial infarction (AMI) and underwent Primary Percutaneous Coronary Intervention (PCI) between May 2023 and November 2023. Prior to the initiation of the study, ethical approval was obtained from the relevant institutional review board, ensuring adherence to the ethical guidelines outlined in the Declaration of Helsinki for medical research involving human subjects.

Patients were eligible for inclusion if they exhibited symptoms of AMI, characterized by a continuous episode of anginal chest pain lasting at least 20 minutes. The diagnosis of AMI was further corroborated by electrocardiographic findings, specifically ST-segment elevation of more than 1 mm (0.1 mV) in two or more contiguous precordial leads, or the emergence of a new left bundle branch block. All PCI procedures were performed by experienced cardiologists with a minimum of five years of clinical practice, ensuring a high standard of care.

The phenomenon of no-reflow was meticulously assessed and defined using specific hemodynamic criteria: a Thrombolysis in Myocardial Infarction (TIMI) flow grade of 0 to 2 and a Myocardial Blush Grade (MBG) of 1 or lower were indicative of no-reflow. Conversely, successful reflow was characterized by a TIMI flow grade of 3, coupled with an MBG of 2 or higher, delineating the two patient cohorts for analysis.

Data collection involved a comprehensive review of clinical records, procedural details, and post-procedural outcomes, meticulously cataloged for subsequent analysis. The predictors of the no-reflow phenomenon were extensively examined, encompassing demographic variables, clinical presentations, and procedural specifics.

For the analysis of collected data, the study employed the Statistical Package for the Social Sciences (SPSS) Version 25. This advanced statistical software facilitated a thorough examination of the data, enabling the identification of significant predictors of the no-reflow phenomenon through various statistical techniques. Descriptive statistics were utilized to summarize the demographic and clinical characteristics of the study population, while inferential statistics were applied to explore the associations between potential predictors and the occurrence of no-reflow, ensuring a rigorous analytical framework to underpin the study's findings.

RESULTS

Table 1 Clinical Predictors' Association of no-reflow with predictors

Predictors	No-reflow Yes (%)	No-reflow No (%)	P value
SBP < 100 mmHg	Yes: 14 (51.9%)	No: 26 (28.0%)	0.02
	No: 13 (48.1%)	No: 67 (72.0%)	
DBP < 50 mmHg	Yes: 8 (29.6%)	No: 20 (21.5%)	0.38
	No: 19 (70.4%)	No: 73 (78.5%)	
Smoking	Yes: 7 (25.9%)	No: 18 (19.4%)	0.45
	No: 20 (74.1%)	No: 75 (80.6%)	
Diabetes	Yes: 16 (59.3%)	No: 32 (34.4%)	0.02

	No: 11 (40.7%)	No: 61 (65.6%)	
Hypertension	Yes: 21 (77.8%)	No: 29 (31.2%)	0.0001
	No: 6 (22.2%)	No: 64 (68.8%)	
History of Cardiovascular Disease	Yes: 3 (11.1%)	No: 2 (2.2%)	0.04
	No: 24 (88.9%)	No: 91 (97.8%)	

The table illustrates the association between the occurrence of the no-reflow phenomenon post-PCI and various clinical predictors among acute myocardial infarction patients. Systolic blood pressure (SBP) less than 100 mmHg was significantly associated with no-reflow, observed in 51.9% of the no-reflow group compared to 28.0% of those without no-reflow, with a P value of 0.02. Diastolic blood pressure (DBP) less than 50 mmHg, smoking, and diabetes did not show a statistically significant association with no-reflow, with P values of 0.38, 0.45, and 0.02, respectively. However, diabetes was present in 59.3% of the no-reflow group versus 34.4% of the non-no-reflow group, indicating a notable association. Hypertension showed a strong correlation with no-reflow, found in 77.8% of patients experiencing no-reflow compared to 31.2% in the reflow group, with a highly significant P value of 0.0001. A history of cardiovascular disease was associated with no-reflow in 11.1% of cases versus 2.2% without, with a P value of 0.04, suggesting a moderate association. These findings underscore the significant predictive value of certain clinical factors, such as SBP, diabetes, hypertension, and a history of cardiovascular disease, on the risk of developing the no-reflow phenomenon after PCI in AMI patients.

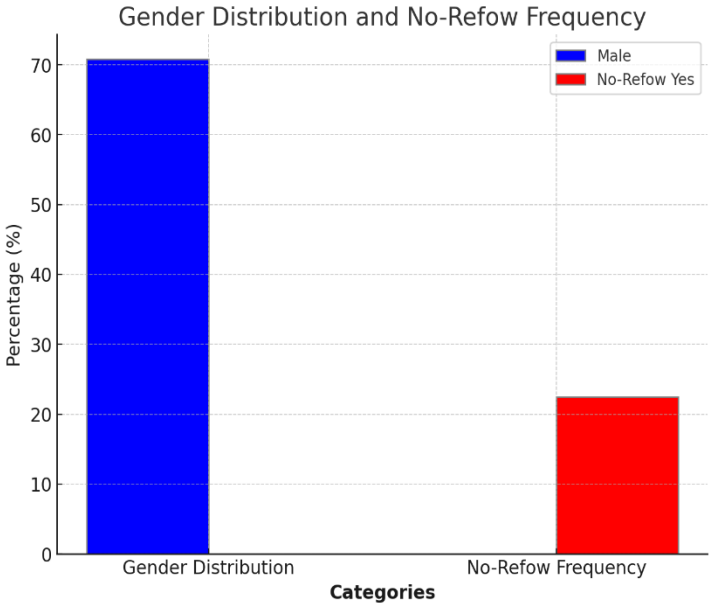

Figure 1 Male Gender and No-Reflow

The graph displays the gender distribution from the no-reflow frequency among acute myocardial infarction (AMI) patients. Specifically, males comprise 70.8% of the patient cohort, while the frequency of the no-reflow phenomenon occurring stands at 22.5%.

DISCUSSION

The phenomenon of no-reflow, characterized by the failure to re-establish adequate blood flow to the myocardium following the reopening of the occluded artery in acute myocardial infarction (AMI), particularly ST-elevation myocardial infarction (STEMI), presents a significant challenge in interventional cardiology. Despite successful recanalization of the primary artery, blood flow to the microvascular network may remain impaired, attributed to blockages caused by blood clots within the small vessels and capillaries. The incidence of no-reflow varies widely, reported to range from 11% to 41% in patients undergoing primary percutaneous coronary intervention (PCI), influenced by a myriad of factors including patient-specific characteristics, the anatomy of the affected artery, and lesion properties (15). This variability underscores the complex interplay of factors contributing to no-reflow, which is associated with poor prognosis and elevated short-term and long-term mortality rates.

Angiographic diagnosis hinges on the confirmation of a Myocardial Blush Grade (MBG) of 2 or below, with TIMI flow grade 3 being necessary but not sufficient for diagnosing no-reflow. The multifactorial pathophysiology of no-reflow involves ischemic injury, reperfusion damage, endothelial dysfunction, distal thromboembolism, and microvascular spasm (16, 17). Analysis from a cohort of 781 PCI patients highlighted the prevalence of no-reflow among the elderly, those with significant thrombus burden, and cases with delayed (>4 hours) presentation post-symptom onset, emphasizing the absence of direct correlations with specific lesions or medication effects. Recent evidence also points to the importance of clinical and serological markers, including substantial thrombus

Journal of Health and Rehabilitation Research 2791-156X JHRR

load, elevated leukocyte count, high blood glucose levels, and delayed reperfusion, as predictors of no-reflow, alongside procedural factors like repeated balloon inflations and high predilatation pressure (19).

The association of atrial fibrillation with a doubled risk of no-reflow in STEMI patients suggests potential preventative measures, such as strict glycemic control in diabetics and aggressive statin therapy for hyperlipidemia, to mitigate the risk of no-reflow. However, the effectiveness of these strategies remains limited, particularly in the acute setting of STEMI, where preventing no-reflow poses a greater challenge compared to stable coronary artery disease cases (20, 21).

Our study corroborates these findings, identifying diabetes, hypertension, systolic blood pressure below 100 mmHg, and a history of cardiovascular disease as significant predictors of no-reflow among AMI patients undergoing PCI. This is in line with previous research indicating that factors such as advanced age, diabetes, hypertension, and a history of cardiovascular disease are independently associated with the occurrence of no-reflow (22).

The study's strengths lie in its focused examination of no-reflow predictors in a well-defined patient cohort, enhancing the understanding of risk factors amenable to pre-procedural optimization. However, limitations include the retrospective design and the single-center setting, which may restrict the generalizability of the findings. Future research should aim at prospective multicenter studies to validate these predictors and explore novel therapeutic interventions targeting the identified risk factors. Additionally, there's a need for developing and implementing strategies for early detection and management of no-reflow, including the use of advanced imaging techniques and pharmacological agents, to improve outcomes in this high-risk patient population. Recommendations for clinical practice include heightened vigilance for patients presenting with identified risk factors for no-reflow, emphasizing the importance of timely and tailored interventions to prevent this complication and its associated adverse outcomes.

CONCLUSION

In conclusion, our study elucidates the significant predictors of the no-reflow phenomenon in AMI patients undergoing PCI, including diabetes, hypertension, low systolic blood pressure (<100 mmHg), and a history of cardiovascular disease. These findings highlight the critical need for early identification and management of these risk factors to mitigate the incidence of no-reflow, a condition associated with poor clinical outcomes. The implications of this research underscore the importance of incorporating preventive strategies in the clinical pathway for AMI patients, particularly those at high risk for no-reflow, to improve survival rates and reduce the burden of cardiovascular morbidity. Future research should focus on expanding our understanding of no-reflow mechanisms and exploring innovative therapeutic approaches to prevent and manage this complex clinical challenge.

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Journal of Health and Rehabilitation Research 2791-156X JHRR

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