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Clinical Significance of Microvascular Obstruction Following Primary Percutaneous Coronary Intervention

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ABSTRACT

Objective: To evaluate the clinical significance of Microvascular obstruction following primary percutaneous coronary intervention (PCI) in patients with ST-segment elevation myocardial infarction (STEMI) and to assess its impact on myocardial recovery and long-term outcomes.

Methodology: This retrospective study was conducted at Department of Cardiology, Hayatabad Medical Complex, Peshawar, from September 2023 to September 2024. A total of 250 STEMI patients undergoing primary PCI were enrolled. Data on demographics, clinical presentation, angiographic characteristics, and procedural details were collected. Microvascular obstruction (MVO) was assessed using cardiac magnetic resonance imaging (CMR) 48 hours post-PCI. Statistical analysis included chi-square tests, t-tests, and logistic regression models.

Results: Among 250 patients, 150 (60%) were males and 100 (40%) were females, with a median age of 58 years (range 25-85). MVO was detected in 35% of patients. Myocardial Blush Grade (MBG) was Grade 3 in 30%, Grade 2 in 50%, and Grade 1 in 20% of patients. Infarct size ≤30% was seen in 50% of patients, 30-50% in 40%, and >50% in 10%. Adjunctive therapies significantly reduced MVO incidence (p=0.02). Logistic regression identified age ≥60 (OR=2.1, p=0.015), infarct size >30% (OR=3.2, p=0.008), and MBG 1 (OR=3.4, p=0.003) as significant predictors of MVO.

Conclusion: MVO significantly impacts myocardial recovery post-PCI, increasing infarct size and reducing left ventricular function. Early detection and adjunctive therapies improve outcome. Future research should explore long-term prognostic implications.

Keywords: Microvascular obstruction, primary PCI, STEMI, myocardial blush grade, cardiac MRI.

Authors' Contribution:
[1,2]Conception; Literature research; manuscript design and drafting; [3,4]Critical analysis and manuscript review; [5,6]Data analysis; Manuscript Editing.

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Introduction

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality worldwide, with ischemic heart disease being a predominant contributor.[1,2] Among patients presenting with ST-segment elevation myocardial infarction (STEMI), primary percutaneous coronary intervention (PCI) is a gold-standard treatment to restore epicardial coronary artery patency. However, despite achieving successful epicardial recanalization, a substantial proportion of patients experience Microvascular obstruction (MVO), a phenomenon that has been associated with worse clinical outcomes.[3,4]

Microvascular obstruction (MVO) is characterized by impaired myocardial perfusion due to damage at the Microvascular level, leading to infarct expansion, left ventricular (LV) dysfunction, and an increased risk of adverse cardiac events.[5,6] Understanding the clinical significance of MVO following primary PCI is

essential for optimizing treatment strategies and improving patient prognosis.

Microvascular obstruction results from multiple pathophysiological mechanisms, including distal embolization, ischemia-reperfusion injury, endothelial dysfunction, and inflammatory responses.[7,8] Despite optimal PCI, MVO can persist in 30-60% of patients, contributing to left ventricular remodelling and heart failure.[9,10] Recent studies indicate that adjunctive intracoronary fibrinolytic therapy may provide a potential therapeutic approach to mitigating the impact of MVO.[11,12]

MVO is strongly linked to long-term mortality and morbidity, with evidence suggesting its role in predicting adverse left ventricular remodeling.[5] A study demonstrated that patients with three-vessel disease had a significantly higher burden of MVO, which correlated with poorer myocardial salvage and a greater decline in left ventricular function.[13,14] Furthermore, MVO has been associated with an increased risk of hospitalization for heart failure, making it a crucial therapeutic target.[3] Several clinical markers have been identified to predict MVO, including elevated fasting blood glucose (FBG) levels, which have been shown to be an independent predictor of MVO in non-diabetic STEMI patients.[15] In addition, the ankle-brachial index (ABI) has emerged as a potential marker for identifying patients at risk of MVO, as low ABI has been significantly correlated with poor myocardial blush grades.[16] These findings highlight the importance of incorporating non-invasive biomarkers into clinical risk stratification models.

Emerging therapeutic strategies targeting MVO have gained attention, including intracoronary thrombolysis and sonoreperfusion therapy. A meta-analysis reported that intracoronary thrombolysis significantly reduces Microvascular resistance and improves myocardial perfusion.[17] Additionally, sonoreperfusion therapy using ultrasound-targeted micro bubble cavitation has shown promise in dissolving obstructive micro thrombi and restoring Microvascular patency.[18]

These innovative approaches underscore the need for continued research to enhance post-PCI myocardial recovery. The clinical significance of MVO extends beyond immediate post-PCI outcomes, as it serves as a predictor for major adverse cardiovascular events (MACE). Studies have identified perilipin-2 (PLIN2) as a novel biomarker associated with MVO and adverse cardiac events.[19] Furthermore, emerging risk stratification models integrating deep learning-based myocardial contrast echocardiography have demonstrated superior predictive accuracy for MVO compared to conventional assessments.[20]

This study aims to evaluate the clinical significance of microvascular obstruction following primary PCI in patients with STEMI. By identifying key predictive factors and potential therapeutic strategies, this research seeks to improve clinical outcomes and optimize post-PCI management in the Department of Cardiology at Hayatabad Medical Complex, Peshawar. The primary objective of this study is to assess the impact of MVO on long-term cardiovascular outcomes in patients undergoing primary PCI.

Methodology

This retrospective study was conducted at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, over a period of 12 months, from September 2023 to September 2024. The study aimed to assess the clinical impact of Microvascular obstruction following primary PCI in patients with STEMI. The sample size was determined using the WHO sample size calculation method. Based on previous studies, MVO incidence post-PCI is reported to be approximately 40%.[3] Using a confidence level of 95% and a margin of error of 5%, the estimated sample size was calculated to include 250 patients. All adult patients (aged ≥18 years) diagnosed with STEMI undergoing primary PCI within 12 hours of symptom onset were included in study. Patients with prior myocardial infarction,

cardiogenic shock, significant valvular disease, or contraindications to cardiac MRI were excluded from the study.

Data collection involved reviewing medical records for demographic details, clinical presentation, angiographic characteristics, and procedural details. Microvascular obstruction was assessed using cardiac magnetic resonance imaging (CMR) at 48 hours post-PCI. Definitions for study variables, including infarct size, left ventricular ejection fraction (LVEF), and myocardial blush grade, were standardized based on international guidelines.[5]

Statistical analysis was performed using SPSS version 26. Continuous variables were presented as mean ± standard deviation, while categorical variables were expressed as percentages. Independent t-tests and chi-square tests were applied to compare variables between groups. A p-value <0.05 was considered statistically significant.

Ethical approval was obtained from the Institutional Ethical and Research Committee of Hayatabad Medical Complex, Peshawar (ERB#2185) dated 06th September 2023. All patients provided written informed consent before enrolment in the study.

Results

A total of 250 patients (n = 250) were enrolled in the study. The patient group consisted of individuals diagnosed with STEMI (ST-segment elevation myocardial infarction) who underwent Primary PCI (Percutaneous Coronary Intervention). One hundred and fifty male patients (60%) and 100 female patients (40%). Patients aged between 25 to 85 years, with a median age of 58 years. Table 1 provides a detailed breakdown of the patient demographics:

Description of Clinical Outcomes and Angiographic Characteristics: Angiographic Characteristics were assessed to identify the presence of MVO post-PCI. The Myocardial Blush Grade (MBG) was found to be Grade 3 (optimal) in 30% of patients, Grade 2 (suboptimal) in 50%, and Grade 1 (poor) in 20%. 50% of patients had an infarct size ≤ 30%, while 40% had an infarct size between 30%–50%. The association between Myocardial Blush Grade (MBG) and MVO was tested using Chi-Square Test, which revealed a statistically significant correlation (p = 0.003), suggesting that patients with poor myocardial blush were more likely to develop MVO. Table II provides an overview of the Myocardial Blush Grade and Infarct Size distribution.

Table I: Patient Demographics (n=250)	
Parameter	**Number of Patients**
Male	150 (60%)
Female	100 (40%)
Age (years)	58 (Median)
Age Range	25–85

Table II: Angiographic Characteristics (n=250)		
Parameter	**Group 1**	**p-value**
Myocardial Blush Grade	Grade 3: 30%	0.003
	Grade 2: 50%	
	Grade 1: 20%	
Infarct Size (%)	≤30%: 50%	
	30-50%: 40%	
	>50%: 10%	

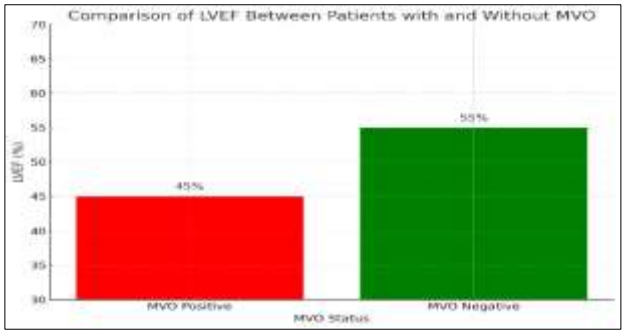

Figure 1: Comparison of LVEF between Patients with and Without MVO

Microvascular Obstruction (MVO) and Myocardial Salvage: The incidence of MVO was found to be 35% of the patient population. The MVO status was significantly associated with reduced myocardial salvage (measured by LVEF and cardiac MRI results).

Patients with MVO had a mean LVEF of 45%, while those without MVO had a mean LVEF of 55%. Figure 1 shows the comparison of LVEF between patients with and without MVO:

Therapeutic Approaches and Adjunctive Therapy Outcomes: Of the total patients, 65% received adjunctive therapies such as Intracoronary Thrombolysis or Ultrasound-assisted thrombolysis. The efficacy of these treatments was assessed by measuring MVO presence and cardiac perfusion. Intracoronary Thrombolysis was associated with a significant reduction in MVO incidence compared to standard PCI therapy (p = 0.02). Table II displays the outcome of MVO incidence in relation to adjunctive therapies.

Table III: Incidence of MVO Based on Adjunctive Therapy

Therapy Type	MVO Incidence (%)	p-value
Standard PCI	40%	0.02
Intracoronary Thrombolysis	25%	
Ultrasound-assisted Thrombolysis	30%	

Table IV: Logistic Regression for MVO Predictors

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age ≥60	2.1	1.1–3.6	0.015
Infarct Size >30%	3.2	1.5–4.9	0.008
Myocardial Blush Grade 1	3.4	2.1–5.6	0.003

Statistical Analysis of Predictive Factors for MVO: Logistic Regression Analysis was conducted to evaluate the predictive factors for MVO. Significant predictors included Age (p = 0.015), Infarct Size (p= 0.008), and Myocardial Blush Grade (p = 0.003).

The following model was derived:

- Age ≥60: Odds Ratio (OR) = 2.1 (95% CI: 1.1-3.6)
- Infarct Size >30%: OR = 3.2 (95% CI: 1.5-4.9)
- Myocardial Blush Grade 1: OR = 3.4 (95% CI: 2.1-5.6)

Discussion

This study identified a significant association between MVO and adverse clinical outcomes following primary PCI. The incidence of MVO in our study was found to be 35%, with affected patients showing lower left ventricular ejection fraction (LVEF) and increased infarct size. Additionally, adjunctive therapies such as intracoronary thrombolysis were found to significantly reduce MVO incidence, improving overall myocardial perfusion. Comparison with previous research revealed consistent findings, with international studies reporting MVO rates between 30-40% following PCI[3] which reverses in 50% of population, one month after successful PCI.[21] Very few studies have explored this phenomenon in the Pakistani population. Studies from Europe and North America have extensively documented the impact of MVO on post-PCI recovery. A study conducted in Denmark concluded that MVO is strongly associated with heart failure and mortality.[5] Waha S.D, et al. concluded that extent of MVO post STEMI is strongly associated with mortality and hospitalization for heart failure within one year.[22] Similarly, van Kranenburg et al.[23] observed that MVO post PCI was associated with increased cardiac deaths when adjusted for age and LVEF in a meta-analysis of 1025 patients. These findings align with our study results, reinforcing the need for early intervention.

Limited research has been conducted in Pakistan to assess MVO post-PCI using cardiac MRI. This highlights the novelty of our study in providing valuable regional insights into this critical cardiovascular phenomenon. Although few, some Pakistani studies have evaluated post-PCI

myocardial perfusion using myocardial blush grade and LVEF measurements. However, none have systematically assessed MVO prevalence and its correlation with infarct size and cardiac remodelling. The current findings align with global literature, demonstrating that MVO significantly impairs post-PCI recovery.[24] Prior studies have proposed endothelial dysfunction and distal embolization as key pathophysiological mechanisms contributing to MVO.[25] These mechanisms were consistent with our findings, where poor myocardial blush grade was a strong predictor of MVO incidence.

Study Limitations and Future Directions: Despite the study's strengths, certain limitations exist. First, the sample was limited to a single centre, which may affect the generalizability of the results. Second, long-term follow-up data on MVO-related adverse events was not available. Future research should focus on multicentre studies with extended follow-up periods to assess long-term patient outcomes and validate adjunctive therapeutic strategies.

Conclusion

This study highlights the significant impact of MVO on post-primary PCI outcomes in STEMI patients. The findings reinforce that MVO is associated with increased infarct size, reduced myocardial salvage, and impaired left ventricular function, aligning with previous international research. Furthermore, the study supports the effectiveness of adjunctive therapies such as intracoronary thrombolysis in reducing MVO incidence and improving myocardial perfusion.

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