Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Cardiology

Clinical Outcomes in Non-ST Elevation Myocardial Infarction Patients with High Coronary Calcium Burden

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DOI: https://doi.org/10.36347/sjams.2025.v13i04.015 | **Received:** 18.02.2025 | **Accepted:** 23.03.2025 | **Published:** 18.04.2025

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Abstract **Original Research Article**

Background: Coronary artery calcification significantly impacts stent expansion and clinical outcomes in patients undergoing percutaneous coronary intervention (PCI). However, data on its effects in non-ST elevation myocardial infarction (NSTEMI) patients remain limited. ***Objective:*** This study aimed to evaluate the impact of coronary calcium burden on stent expansion and procedural outcomes in NSTEMI patients undergoing intravascular ultrasound (IVUS)-guided PCI. ***Methods:*** This cross-sectional observational study was conducted at the National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh, from May 2019 to April 2020. A total of 109 NSTEMI patients with calcified lesions were enrolled and divided into two groups: Group I (calcium arc 0–180°; n = 73) and Group II (calcium arc 181–270°; n = 36). IVUS parameters, including calcium arc, length, and stent expansion metrics, were analyzed. Data were processed using SPSS version 23.0. ***Results:*** In this study, 109 NSTEMI patients with calcified coronary lesions were analyzed. Group II (calcium arc 181–270°) had significantly higher IVUS parameters, including calcium arc, length, and reference diameters ($p < 0.05$). Greater calcium burden was associated with poorer stent expansion and higher post-PCI stenosis. Stent expansion showed a moderate negative correlation with calcium arc ($p < 0.001$). ***Conclusion:*** Higher coronary calcium burden (181–270°) is associated with poorer stent expansion and greater post-PCI stenosis in NSTEMI patients. IVUS-guided PCI and tailored strategies for calcified lesions are essential to optimize outcomes in this high-risk population.

Keywords: Coronary calcium burden, Calcified lesions, Intravascular ultrasound, Non-ST elevation myocardial infarction, Percutaneous coronary intervention, Stent expansion.

INTRODUCTION

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide, with non-ST elevation myocardial infarction (NSTEMI) representing a significant proportion of acute coronary syndromes [1]. Percutaneous coronary intervention (PCI) is a cornerstone in the management of NSTEMI, particularly in patients with high-risk features or refractory ischemia [2]. However, the presence of coronary artery calcification poses a significant challenge to PCI, often leading to suboptimal stent expansion and increased risk of adverse outcomes [3]. Coronary calcification is a marker of advanced atherosclerosis and is associated with older age, diabetes, chronic kidney disease, and other cardiovascular risk factors [4]. The extent of calcification, often quantified by the calcium arc on intravascular ultrasound (IVUS), has been shown to influence stent deployment and expansion [5]. Specifically, a higher calcium burden (calcium arc >180°) is associated with greater stent under-expansion, which can lead to higher rates of in-stent restenosis and target lesion revascularization (TLR) [6]. Despite advancements in PCI techniques, calcified

lesions remain difficult to manage, often requiring specialized approaches such as rotational atherectomy or cutting balloons [7]. Intravascular ultrasound (IVUS) has emerged as a valuable tool in guiding PCI, providing detailed insights into plaque morphology, calcium distribution, and stent expansion [8]. Studies have demonstrated that IVUS-guided PCI improves procedural outcomes, particularly in complex lesions, by optimizing stent sizing and deployment [9]. However, data on the impact of calcium burden on stent expansion and clinical outcomes in NSTEMI patients remain limited, especially in populations with a high prevalence of risk factors for coronary calcification, such as those in South Asia [10]. In Bangladesh, the burden of CAD is rising, with NSTEMI accounting for a significant proportion of acute coronary syndromes [11]. Despite the increasing use of PCI, there is a lack of local data on the impact of coronary calcification on procedural outcomes. Understanding the relationship between calcium burden and stent expansion in this population is critical for optimizing PCI strategies and improving patient outcomes [12]. This study aimed to evaluate the impact of coronary calcium burden on stent expansion and procedural outcomes in NSTEMI patients undergoing IVUS-guided PCI at the National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh. By analyzing IVUS parameters and stent expansion metrics, this research seeks to provide insights into the challenges of managing calcified lesions and inform strategies to improve PCI outcomes in this high-risk population.

METHODOLOGY

This cross-sectional observational study was conducted at the National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh, from May 2019 to April 2020. A total of 110 patients with non-ST elevation myocardial infarction (NSTEMI) undergoing intravascular ultrasound (IVUS)-guided percutaneous coronary intervention (PCI) for calcified lesions were enrolled. After exclusions, 109 patients were divided into two groups based on calcium arc: Group I (0–180°; n = 73) and Group II (181–270°; n = 36). Patients with cardiogenic shock, congestive heart failure, STEMI lesions, inaccessible imaging devices, insufficient image quality, stent thrombosis, in-stent restenosis, coronary artery bypass grafting (CABG), or a calcium arc ≥270° were excluded. IVUS parameters, including calcium arc, calcium length, proximal and distal reference diameters, lesion length, and stent expansion metrics (minimal lumen diameter, minimal lumen area, and acute luminal gain), were measured. Procedural data, such as maximal balloon size and pressure, were also recorded. Data were analyzed using SPSS version 23.0, with descriptive statistics, t-tests, and correlation analyses performed. The study was approved by the NICVD ethical committee, and informed consent was obtained from all participants.

RESULT

In this study, a total of 109 NSTEMI patients with calcified coronary lesions were analyzed. Among them, 73 patients were categorized as Group I (calcium arc 0–180°) and 36 as Group II (calcium arc 181–270°). Key findings are presented below. Older patients tended to have a higher degree of coronary calcification ($p = 0.03$). No significant difference in the location of calcification was found between the groups. Key IVUS parameters such as calcium arc, calcium length, proximal reference diameter, and average reference diameter were significantly higher in Group II ($p < 0.05$). Higher calcium burden was associated with poorer stent expansion and greater post-PCI stenosis in Group II. A moderate negative correlation was observed between stent expansion (by MLD and MLA) and calcium arc ($p < 0.001$), as well as superficial calcium arc ($p < 0.001$). The correlation between stent expansion and the length of calcification was negligible ($p = 0.36$). These findings underscore the importance of IVUS-guided PCI strategies for patients with high coronary calcium burden to optimize procedural outcomes and minimize post-PCI stenosis.

Table 1: Age distribution of participants (N=73)

Age (Years)	Group-I (n=73)	Group-II (n=36)	Total (n=109)	p-value
< 50	36 (49.3%)	13 (36.4%)	49 (45.0%)	0.03s
≥ 50	37 (50.7%)	23 (63.9%)	60 (55.0%)	
Mean ± SD	51.9 ± 9.7	56.4 ± 9.7	53.4 ± 9.8	

Table 2: Distribution of cases by location of calcification (N=73)

Location	Group-I	Group-II	Total	p-value
Superficial	67 (91.8%)	33 (91.7%)	100 (91.7%)	0.98ns
Deep	4 (5.5%)	0 (0.0%)	4 (3.7%)	0.15ns
Both	2 (2.7%)	3 (8.3%)	5 (4.6%)	0.18ns

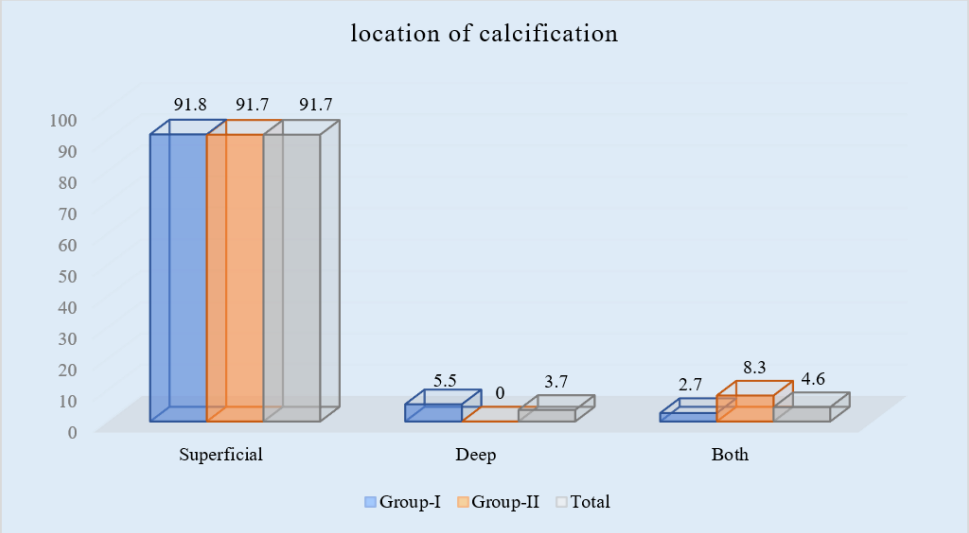

Figure I: Column chart showed location of calcification among cases (N=73)

Table 3: Comparison of pre-PCI intravascular ultrasound measurements between two groups (N=73)

IVUS Characteristics	Group-I (Mean ± SD)	Group-II (Mean ± SD)	p-value
Arc of calcium (°)	106.7 ± 38.4	221.7 ± 30.7	<0.001s
Arc of superficial calcium (°)	99.8 ± 45.0	219.4 ± 31.3	<0.001s
Length of calcification (mm)	7.3 ± 4.6	9.9 ± 6.3	0.01s
Proximal reference diameter (mm)	3.6 ± 0.4	3.8 ± 0.3	0.002s
Distal reference diameter (mm)	3.2 ± 0.4	3.2 ± 0.4	0.76ns
Average reference diameter (mm)	3.3 ± 0.3	3.5 ± 0.3	0.002s
Reference CSA (mm²)	8.6 ± 1.9	9.8 ± 1.4	0.002s
Lesion length (mm)	29.6 ± 8.5	32.0 ± 7.0	0.14ns

Table 4: Comparison of post-PCI intravascular ultrasound measurements between two groups (N=73)

IVUS Characteristics	Group-I (Mean ± SD)	Group-II (Mean ± SD)	p-value
Stent length (mm)	33.6 ± 8.7	35.9 ± 7.3	0.16ns
Acute luminal diameter gain (mm)	1.5 ± 0.4	1.4 ± 0.3	0.03s
Acute luminal CSA gain (mm²)	5.8 ± 1.2	5.3 ± 1.0	0.04s
Stent expansion by MLD (%)	95.6 ± 2.9	89.6 ± 3.3	<0.001s
Stent expansion by MLA (%)	92.7 ± 5.1	81.3 ± 6.4	<0.001s
Maximal balloon size (mm)	3.6 ± 0.4	3.9 ± 0.3	0.002s
Maximal balloon pressure (atm)	15.1 ± 1.3	18.5 ± 1.4	<0.001s

Table 5: Comparison of intravascular ultrasound measurements in patients pre- and post-PCI (N=73)

IVUS Characteristics	Pre PCI	Post PCI
Minimal Lumen Diameter (mm)	1.9 ± 0.3 (G-I)	3.4 ± 0.5 (G-I)
	1.8 ± 0.3 (G-II)	3.0 ± 0.2 (G-II)
p-value	0.23ns	0.03s
Lumen CSA (mm²)	2.8 ± 0.8 (G-I)	8.2 ± 1.7 (G-I)
	2.6 ± 0.8 (G-II)	7.9 ± 1.0 (G-II)
p-value	0.30ns	0.33ns
CSA stenosis (%)	71.9 ± 6.7 (G-I)	7.1 ± 5.1 (G-I)
	76.2 ± 7.1 (G-II)	18.7 ± 6.6 (G-II)
p-value	0.002s	<0.001s

DISCUSSION

Coronary artery calcification (CAC) is a major challenge in percutaneous coronary intervention (PCI), particularly in patients with non-ST-elevation myocardial infarction (NSTEMI). Intravascular ultrasound (IVUS) has proven to be a valuable imaging tool for assessing calcium burden and optimizing PCI

outcomes [13]. This study aimed to evaluate the impact of coronary calcification on post-PCI outcomes, focusing on stent expansion and luminal gain. The results showed that patients in Group II (calcium arc 181–270°) had significantly higher calcium burden compared to Group I (calcium arc 0–180°). This finding aligns with previous studies that have reported a direct association between increased calcium arc and procedural complexity, including difficulty in achieving optimal stent expansion [14,15]. Stent under-expansion is a known predictor of restenosis and adverse cardiovascular events, emphasizing the need for effective calcium modification techniques before stent deployment [16]. Pre-PCI IVUS measurements revealed that Group II had significantly greater calcium arc, length of calcification, and reference diameters. These findings suggest that more extensive calcification is associated with larger but more rigid plaques, potentially limiting the effectiveness of conventional balloon angioplasty and stent deployment [17]. Similar observations have been reported in other studies where severe coronary calcification was linked to suboptimal acute luminal gain post-PCI [18]. Post-PCI IVUS analysis demonstrated that patients in Group II had significantly lower stent expansion percentages, both in terms of minimal lumen diameter (MLD) and minimal lumen area (MLA). The negative correlation between calcium arc and stent expansion highlights the mechanical limitations imposed by extensive calcification on balloon and stent expansion [19]. It has been suggested that rotational atherectomy, intravascular lithotripsy, and cutting balloons may improve stent expansion in heavily calcified lesions by modifying plaque rigidity before stent placement [20,21]. Additionally, our study observed that acute luminal gain was significantly lower in Group II, reinforcing the impact of extensive calcification on procedural outcomes. Prior research has indicated that the presence of superficial calcium arc exceeding 180° is a strong predictor of stent under-expansion and increased risk of in-stent restenosis [22]. Given these findings, the role of advanced imaging techniques, such as optical coherence tomography (OCT) and IVUS, is crucial in guiding lesion preparation strategies and optimizing PCI outcomes [23].

LIMITATIONS

This study was conducted in a single center with a relatively small sample size, which may limit generalizability. Long-term clinical outcomes were not assessed, and the impact of different calcium modification strategies was not evaluated. Further multicenter studies with larger cohorts and extended follow-up are necessary for validation.

CONCLUSION

In conclusion, our study underscores the negative impact of high coronary calcium burden on PCI success in NSTEMI patients. The findings highlight the importance of IVUS-guided PCI strategies and calcium modification techniques to improve stent expansion and reduce post-procedural complications. Future research should focus on comparative studies involving different calcium modification techniques to determine the most effective approach for managing severely calcified lesions.

RECOMMENDATION

Based on our findings, we recommend the use of IVUS-guided PCI to optimize stent expansion in patients with high coronary calcium burden. Adequate lesion preparation, including calcium modification techniques, should be considered to improve procedural outcomes. Further large-scale studies are needed to validate these findings and refine treatment strategies.

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