University Heart Journal
Vol. 21, No. 1, January 2025

ORIGINAL ARTICLE

Short-Term Outcomes of Intravascular Ultrasound Guided Percutaneous Coronary Intervention for Patients with Long Coronary Artery Lesions

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Abstract

***Introduction:** Percutaneous coronary intervention (PCI) for long coronary artery lesions requires precise assessment to optimize outcomes. Intravascular ultrasonography (IVUS) provides detailed information on lesion morphology, length, and vascular diameter, enhancing stent placement accuracy. Compared to angiography, IVUS-guided stenting has been associated with a significant reduction in major adverse cardiac events (MACE).*

***Objective:** To observe short-term outcomes of IVUS-guided PCI for patients with long coronary artery lesions.*

***Methodology:** This prospective observational study was conducted from July 2022 to June 2024 in the Department of Cardiology at National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh. A total of 100 patients who met the inclusion criteria were enrolled in the study by purposive sampling. The patients were then divided into two groups: IVUS-guided group (n=50) and angiography-guided group (n=50). The occurrence of major adverse cardiac events (MACE): myocardial infarction, target vessel revascularizations and death were recorded after three months of follow-up.*

***Results:** After 3-month follow-up, the incidence of composite MACE in the IVUS guided group was lower than the angiography-guided group (4% vs. 8%, P=.678). The risk of death (group I vs. group II: 2% vs. 4%, P=1.00), MI (group I vs. group II: 2% vs. 2%, P=1.00), TVR (group I vs. group II: 0.0% vs. 2%, P=1.00) did not differ significantly among the groups. Kaplan-Meier Curves analysis showed that the incidence of 3-months MACE in the IVUS guided group compared to angiography guided group was not statistically significant (P=.340).In-hospital outcomes were not different between angiography-guided and IVUS-guided PCI groups.*

***Conclusion:** IVUS-guided PCI offers favorable short-term outcomes to angiography-guided PCI for long coronary artery lesions, suggesting its potential for enhancing procedural precision and patient care. However, further larger study is recommended.*

***Keywords:** IVUS: Intravascular ultrasonography, MACE: Major adverse cardiac events, TVU: Target vessels revascularization*

University Heart Journal 2025; 21(1): 24-30
DOI: https://doi.org/10.3329/uhj.v21i1.83469

Introduction

Coronary artery disease (CAD) is a significant medical and public health concern because it is one of the most common causes of death worldwide. There has been an epidemiological transition in Bangladesh from communicable to non-communicable diseases (NCD). Over the past several decades, there has been a notable decline in the total mortality rate. However, the number of deaths from chronic illnesses is rising alarmingly, particularly from the “fatal four,” which are diabetes, cancer, chronic respiratory disorders, and cardiovascular disease (CVD).[1]

Received: 25 November, 2024 **Accepted:** 17 December, 2024

Patients who have long coronary artery stenosis are a challenging subgroup to consider for percutaneous intervention. An increased incidence of restenosis following conventional percutaneous transluminal coronary angioplasty (PTCA) has been linked to long lesions.[2] A long coronary artery lesion is a major blockage or narrowing that spans a considerable length of the coronary artery, usually more than or equal to 20 mm.[3] The rates of target lesion failure have significantly dropped since the advent of the second-generation drug-eluting stent(DES).[4]

In spite of using DES Percutaneous coronary intervention (PCI) of diffuse long coronary lesions is still difficult since the prevalence of stent thrombosis and in-stent restenosis is substantially higher than for short coronary lesions.[5]

Coronary angiography has limitations in case of determining the proper stent expansion, apposition, or lesion coverage. Intravascular ultrasound (IVUS), in contrast to two-dimensional angiography, has a higher tissue penetration rate and can evaluate the lumen and characteristics of the arterial wall.[6]

IVUS gives anatomical details about the coronary artery lumen, plaques and can identify under-expansion inappropriate adhesion, or stripping following stent implantation. It can also asses complications associated with PCI. So, stent optimization can be accomplished based on these IVUS results, leading to better clinical outcomes.[7]

Atherosclerotic plaque is categorized into four categories based on visual appearence: soft plaque (echogenicity less than that of adventitia), fibrotic plaque (echogenicity equal to that of adventitia), calcified plaque (lesion echogenicity greater than that of adventitia), and mixed plaque (containing elements of soft, fibrotic, and calcified plaque).[8]

Now a days, IVUS is frequently used in conjunction with coronary angiography to improve the identification and characterization of plaque morphology, assess reference luminal dimensions, and optimize stent size, placement, and deployment.[9]

Outcomes following PCI are measured using procedural success and complication rates. (MACE) Major adverse cardiac event are death, post procedural myocardial infarction and target vessel revascularization (TVR). Other adverse events are heart failure, cardiogenic shock, significant arrhythmia, stent thrombosis, transient ischemic attacks, vascular complications, major bleeding, contrast-induced nephropathy, and angiographic complications.[10]

Previous study showed When a DES is implanted in a complex coronary artery lesion under IVUS guidance, cardiac death, myocardial infarction, stent thrombosis, and in-stent restenosis have all been shown to decrease.[11] IVUS-guided treatment of long coronary lesion with a drug-eluting stent was linked to a significant reduction in one-year MACE when compared to angiography guidance. (IVUS-guided 2.9% versus angiography-guided 5.8%)[12]

There are some studies regarding IVUS has been conducted in our country. Prior research indicates that high-pressure balloon inflations can be employed with a low clinical event rate when stent implantation is performed in calcified lesions under IVUS guidance. (Barman, 2020).[13] Also IVUS guidance intervention in LMCA has a trend to decrease MACE.[14] (Rashid et al., 2022).

So, intravascular ultrasonography (IVUS) facilitates the evaluation of coronary plaque features in vivo and optimizes the placement, size, and deployment of stents. The purpose of this study was to see short-term outcomes of intravascular ultrasound guided percutaneous coronary intervention for patients with long coronary artery lesions.

Methods

This prospective observational study was conducted at the Department of Cardiology, National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh, over a period of two years, from July 2022 to June 2024. The study population consisted of patients admitted to NICVD with an indication for percutaneous coronary intervention (PCI) for long coronary artery lesions, based on predefined inclusion and exclusion criteria. The sample was selected using a purposive sampling method. The study included a total of 100 patients, who were divided into two groups. Group I comprised 50 patients who underwent IVUS-guided PCI for long coronary artery lesions, while Group II included 50 patients who underwent angiography-guided PCI for long coronary artery lesions. The inclusion criteria for the study were patients aged ≥18 years who were undergoing ad-hoc or elective percutaneous coronary intervention (PCI) for unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI), or chronic coronary syndrome

(CCS), with stenosis of ≥20 mm in length in a native coronary artery. The exclusion criteria included patients with primary PCI, multivessel disease, cardiogenic shock, left main coronary artery (LMCA) lesions, bifurcation lesions, chronic total occlusion, a history of coronary artery bypass grafting (CABG), left ventricular ejection fraction (LVEF) < 35%, cardiomyopathy, valvular or congenital heart disease, or serum creatinine levels greater than 2 mg/dl. The independent variables in this study include demographic, confounding, angiographic, IVUS, and PCI-related variables. Demographic variables include age and sex. Confounding variables encompass hypertension, diabetes mellitus, smoking status, dyslipidemia, and a family history of coronary artery disease. Angiographic variables include vessel involvement and the length of the lesion. IVUS-related variables are plaque morphology, plaque burden, lesion length, minimal luminal diameter (MLD), minimal luminal area (MLA), minimal stent area (MSA), stent apposition, medial dissection, and optimal stent expansion. PCI-related variables include the number of stents used, stent diameter, and stent length. The dependent variables in this study include outcome variables related to PCI and major adverse cardiovascular events (MACE). PCI-related outcome variables are angiographic success and procedural success. MACE includes death, post-procedural myocardial infarction (MI), and target vessel revascularization (TVR). Other outcome variables include left ventricular failure (LVF), cardiogenic shock, major bleeding, and arrhythmia.Patients undergoing ad-hoc or PCI who met the inclusion and exclusion criteria for long coronary lesion PCI were included in the study. Prior to enrollment, each patient provided written informed consent.A thorough history and clinical examination were conducted, with the results documented in a predesigned, structured questionnaire. Information about age, sex, was recorded. Coronary angiography was performed using either the transradial, transfemoral, or distal transradial route. The study involved interventional cardiologists skilled in long lesion PCI who frequently performed high-definition intravascular ultrasonography (HD-IVUS). HD-IVUS was conducted based on the operator's judgment. Intracoronary nitroglycerin (100–200 mcg) was administered before doing HD- IVUS. HD- IVUS was performed using a commercially available HD-IVUS equipment (iLAB, Boston Scientific Corporation, USA). Patients in the study were assigned to either the HD-IVUS-guided group or the angiography-guided group. When coronary artery imaging was done both before and after PCI, the process was referred to as HD-IVUS-guided. Patients receiving angiography-guided stent implantation were placed in the angiography-guided group. If the stenosis was angiographically significant (≥70%), ad hoc PCI was performed on the affected artery. Every patient received a Drug-Eluting Stent (DES) and standard dual antiplatelet therapy (DAPT) consisting of aspirin plus ticagrelor, prasugrel, or clopidogrel. Angiographic success was defined as TIMI grade 3 and residual stenosis <20%.

Patients were monitored during their hospital stay to identify any significant complications after PCI. Within three months following PCI, all patients were requested to follow up. For individuals unable to attend in person, a telephone interview was used for the follow-up examination, and all parameters were recorded. Finally, a comparison of the short-term outcomes of the two groups was performed.

Data Processing and Analysis:

After the collection of all required data, tabulated using SPSS version 26 (IBM Corp., Armonk, NY). Frequencies and percentages were calculated as summary measures for qualitative variables. For quantitative variables, the arithmetic mean and standard deviation were used. The Student's t-test was applied to compare symmetrically distributed continuous variables, while the Chi-square test was used to compare categorical variables. A p-value of < 0.05 was considered statistically significant..

Ethical consideration

The study was approved by the Ethical Review Committee, and informed consent was obtained from participants, ensuring confidentiality and their right to withdraw.

Results

Baseline characteristics of these participants were mentioned in Table I. The study compared two groups of patients undergoing PCI (Group I: HD-IVUS guided, Group II: Angiography guided) with 50 patients each. Both groups had similar demographic and clinical profiles, with an average age of around 50-52 years, a male predominance (72% in Group I, 78% in Group II), and comparable rates of hypertension, smoking, dyslipidemia, and diabetes. Hemoglobin and serum creatinine levels, as well as ejection fraction, were nearly identical between the groups. Diagnosis categories included Unstable angina (10% in both), NSTEMI (slightly higher in Group I at 32%), and CCS (slightly higher in Group II at 64%). No statistically significant differences were observed between the two groups in any of the measured variables, indicating comparable baseline characteristics.

Table-I

Baseline characteristics of the participants (n=100)

Age distribution	Group I N=50 n (%)	Group II N=50 n (%)	*P* value
Age (Years)	50.00±8.99	52.54±11.59	.224
Male	36 (72)	39 (78)	.488
Female	14 (28)	11 (22)	
Hypertension	29 (58)	32 (64)	.539
Smoking	18 (36)	23 (46)	.309
Dyslipidaemia	17 (34)	24 (48)	.155
Diabetes mellitus	11 (22)	17 (34)	.181
Family H/O CAD	8 (16)	7 (14)	.779
Hemoglobin (gm/dl)	11.17 ± 1.63	11.03 ± 1.72	.661
S. Creatinine (gm/dl)	1.28 ± 0.27	1.33 ± 0.30	.367
Ejection Fraction (%)	56.13 ± 6.26	56.95 ± 6.11	.511
UA	5(10)	5(10)	.795
NSTEMI	16(32)	13(26)	
CCS	29(58)	32(64)	

Table-II

Procedural characteristics among the study subjects (n=100)

Variables	Group I (N=50)	Group II (N=50)	*P*- value*
Target Vessel LAD	28(56%)	27(54%)	
LCX	5(10%)	6(12%)	
RCA	17(34%)	17(34%)	
Access site	29(58%)	26(52%)	
Trans radial	18(30%)	20(34%)	
Trans femoral	3(12%)	4(14%)	
Trans distal radial			
Length of lesion, mm	23.68 ± 4.00	22.60 ± 3.26	.142
Stent number (mean ± SD)	1.10 ± 0.30	1.06 ± 0.24	.466
Stent diameter, mm (mean ± SD)	3.35 ± 0.48	3.12 ± 0.41	.011
Stent length, mm (mean ± SD)	27.70 ± 4.08	26.22 ± 3.24	.047
Balloon size, mm (mean ± SD)	3.88 ± 0.45	3.62 ± 0.22	<0.001
Balloon pressure, atm1 (mean ± SD)	15.64 ± 2.24	14.56 ± 1.40	.005

Procedural characteristics among the study subjects were mentioned in Table II.In this study, both groups have similar angiographic characteristics, including a preference for radial artery access and the selection of target vessels. Left anterior descending (LAD) artery (56% and 54%) was the common target of both groups. The groups had comparable lesion lengths (23.68 mm vs. 22.60 mm, $p = 0.142$) and stent numbers (1.10 vs. 1.06, $p = 0.466$). However, significant differences were observed in stent diameter (larger in Group I at 3.35 mm vs. 3.12 mm, $p = 0.011$), stent length (longer in Group I at 27.70 mm vs. 26.22 mm, $p = 0.047$), balloon size (larger in Group I at 3.88 mm vs. 3.62 mm, $p < 0.001$), and balloon pressure (higher in Group I at 15.64 atm vs. 14.56 atm, $p = 0.005$). These results indicate that Group I required slightly larger stents and balloons with higher inflation pressure.

Table III summarizes the clinical events.During in-hospital follow-up, the incidence of composite major adverse cardiovascular events (MACE) did not show a significant difference between the angiography-guided long coronary artery lesion PCI group (10%), and the IVUS-guided PCI group (2%) (P=.204) .The risk of myocardial infarction (MI), target vessel revascularization (TVR), left ventricular failure (LVF), major bleeding, and cardiogenic shock was similar across both groups.There was no statistically significant difference in the incidence of 3-month composite MACE rate between the angiography-guided long coronary artery lesion PCI group (8%), and the IVUS-guided PCI group (4%). (P=.678).

Table IV , binary logistic regression was performed to assess the impact of several factors on thelikelihood three

Table-III

Clinical Events(n=100)

Variable		Group I N=50 n(%)	Group II N=50 n(%)	*P* value*
In-hospital				
MACE	1(2)	5(10)	.204	
	Cardiac death	1 (2)	1 (2)	1.00
	MI	0(0)	3 (6)	.242
	TVR	0 (0)	1 (2)	1.00
Cardiogenic shock			1 (2)	2 (4)
1.00				
LVF		1 (2)	3 (6)	.617
Major bleeding		2 (4)	3 (6)	1.00
Arrythmia		2 (4)	3 (6)	1.00
3 Months				
MACE		2 (4)	4 (8)	.678
	Cardiac death	1(2)	2(4)	1.00
	MI	1(2)	1(2)	1.00
	TVR	0(0)	1(2)	1.00
LVF		2(4)	5(10)	.436

Table-IV

Binary logistic regression analysis of MACE outcome after 3 months of follow-up with confounding variables (n=100)

Variable	*P* value	OR	95% CI
Male	.164	0.306	0.058-1.623
Hypertension	.572	1.611	0.308-8.418
Diabetes mellitus	.144	3.476	0.653-18.508
Dyslipidemia	.646	1.474	0.282-7.692
Smoking	.646	1.474	0.282-7.692
Family history of CAD	.215	3.115	0.517-18.763

months composite MACE. Among the variables did not exhibit significant associations (P> 0.05). Figure- I Kaplan-Meier Curves analysis showed the incidence of 3 months composite MACE in angiography guided group was statistically not significantly higher compared to IVUS guided group (P value=.340).

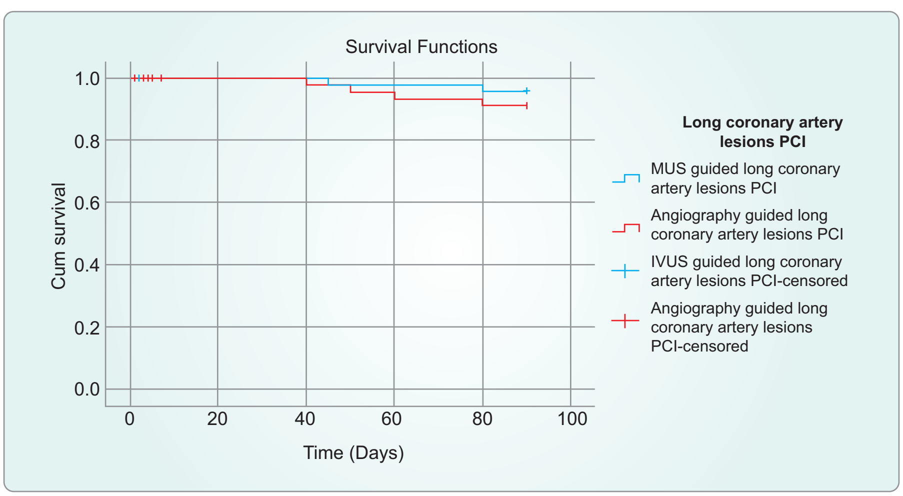

Figure 1 : *Kaplan-Meier Curves of 3-months composite MACE study*

Discussions

Long lesions are a challenging subset because they are traditionally associated with poor outcome after balloon angioplasty or stenting.[2]

The study involved mostly male participants with a mean age of around 50-52 years, with the majority falling in the 51-60 age range. This age distribution differs from studies by Kim et al. (2021), where participants were older, possibly reflecting the earlier onset of atherosclerotic diseases in South Asians.[15,16] Both groups exhibited similar cardiac risk factors.[3] Angiographic characteristics were also similar, with a preference for radial access and targeting the left anterior descending artery (LAD).[12] No significant differences were noted in hemoglobin, serum creatinine levels, or left ventricular ejection fraction (LVEF).[17]

The study found no significant differences between Group I (IVUS-guided PCI) and Group II (Angiography-guided PCI) in lesion length or stent number . However, Group I used larger stent diameters, longer stents, larger balloons , and higher balloon pressure. IVUS guidance enabled more precise assessment and optimization of stent deployment. This approach helps detect procedural complications early and improves clinical outcomes by optimizing stent expansion and symmetry.[18]

This study found no significant difference in in-hospital or 3-month composite MACE between angiography-guided and IVUS-guided PCI. The results contrast with previous studies done by Oemrawsingh et al. possibly due to the shorter follow-up and smaller sample size.[3] A meta-analysis by Wang et al. suggested IVUS reduced MACE, but no significant differences were found in mortality.[19]

Limitations

The study's limitations include a small, single-center sample and the lack of randomization due to purposive sampling, which may introduce bias.

Conclusion

In patients with long coronary artery lesions, this study showed that IVUS-guided PCI yields statistically non-significant results compared to angiography-guided PCI. Although statistically non-significant, PCI of long coronary artery lesions with IVUS guidance has numerically lowered MACE than angiography guided PCI which may be beneficial in long coronary artery lesion in term of short-term outcomes.

Funding

No funding was received for this work.

Conflict of Interest

None

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