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Clinical Outcome of Single Vessel Versus Multi-Vessels Percutaneous Coronary Intervention In Patient With Non-St Elevation Myocardial Infarction Having Multivessel Disease

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Abstract
Background: *Coronary artery disease (CAD) is the leading cause of mortality in Bangladesh. One of the emergency manifestations of CAD is non-ST-elevation MI (NSTEMI). Percutaneous Coronary Intervention (PCI) is frequently used to revascularize infarct related arteries; however, its efficacy for treating other non-culprit significant coronary artery stenosis is still unclear.* ***Objective:*** *The aim of this study was to determine the comparative clinical outcome of single vessel revascularization (SVR) and multi-vessels revascularization (MVR) by PCI in patients with NSTEMI and multi-vessel disease (MVD).* ***Methods****: Department of Cardiology, BSMMU undertook this quasi-experimental study from Jan 2023 to August 2024. Using inclusion and exclusion criteria, this study included 98 patients with NSTEMI and MVD who were revascularized by PCI (SVR 48; MVR 50). All participants gave informed consent. Basic clinical data (angina with Canadian Cardiovascular Society-CCS class, shortness of breath with New York Heart Association-NYHA class, functional capacity by Metabolic Equivalents-METs), biochemical data (serum creatinine), Electrocardiography-ECG, and echocardiographic data (Left Ventricular Ejection Fraction-LVEF) were recorded at baseline and 6months after PCI. Major adverse cardiovascular and cerebrovascular events (MACCE) were diagnosed by patient's or legal guardian's history, investigations (Troponin I-TnI, Creatinine Kinase CK-MB, ECG, Echocardiography), and invasive coronary angiography from PCI to 6 months following the procedure. Data was collected on a predesigned, semi-structured collection sheet. Final intra and inter-group comparisons were made between single vessel and multi-vessel PCI.*
Results: *MVR group demonstrated superiority in term of MACCE (Composite of Death or Myocardial Infarction and composite of Death, MI or any revascularization, non-Target vessel revascularization) over SVR in NSTEMI*

with multi-Vessel disease. Both MVR and SVR in NSTEMI with multi vessel disease was associated with not only symptomatic benefits regarding angina, shortness of breath and functional capacity but also improvement of left ventricular systolic function although difference between two groups were not significant except shortness of breath by NYHA class. ***Conclusion****: Multi-Vessel revascularization is more preferred compared to single culprit only revascularization in NSTEMI patient having multi-vessel disease due to symptomatic as well as mortality benefit.*

Key words: *SVR, MVR, NSTEMI, MVD, MACCE, PCI.*

Introduction

Non-ST-elevation myocardial infarction (NSTEMI) is a major sub type of acute coronary syndrome (ACS) associated with significant morbidity and mortality worldwide. The management of NSTEMI includes pharmacological therapy, risk stratification, and coronary revascularization. Percutaneous coronary intervention (PCI) is a widely used revascularization strategy; however, for patients with multi-vessel coronary artery disease (CAD), the optimal approach remains controversial. Single-vessel PCI (SV-PCI) focuses on treating only the culprit lesion, while multi-vessel PCI (MV-PCI) aims to revascularize multiple significantly diseased arteries either during the same procedure or in a staged manner [1,2]. The choice between these strategies is influenced by factors such as patient stability, anatomical complexity, and long-term cardiovascular risk [3].

Recent studies have explored the comparative outcomes of MV-PCI and SV-PCI in NSTEMI patients with multi-vessel disease, yielding conflicting results. Some evidence suggests that MV-PCI provides better long-term benefits by reducing major adverse cardiovascular events (MACE), including recurrent myocardial infarction (MI), repeat revascularization, and cardiovascular mortality, by restoring complete myocardial perfusion [4,5]. A meta-analysis reported that complete revascularization in NSTEMI patients resulted in lower MACE rates compared to culprit-only PCI [6]. Another study found that MV-PCI significantly reduced the risk of future cardiovascular events, thereby improving long-term survival[7].

However, MV-PCI is associated with higher procedural risks, including increased contrast-induced nephropathy, prolonged procedure time, and a greater incidence of peri-procedural complications such as bleeding and stent thrombosis [8,9]. The COMPLETE trial demonstrated that complete revascularization resulted in better long-term outcomes but came at the cost of higher short-term procedural risks [10]. Additionally, in hemodynamically unstable patients, culprit-only PCI is often preferred to minimize immediate complications [11].

On the other hand, SV-PCI, by targeting only the culprit lesion, minimizes procedural risks and reduces intervention time. Some studies have suggested that this approach is safer, particularly in high-risk patients with renal dysfunction or advanced age [12]. However, residual ischemia from untreated non-culprit lesions may increase the likelihood of recurrent ischemic events, necessitating additional interventions in the future [13]. The PRAMI trial demonstrated that preventive PCI of non-culprit lesions significantly reduced MACE compared to culprit-only PCI, further supporting the potential benefit of MV-PCI in selected patients [14].

Given these conflicting findings, the decision between MV-PCI and SV-PCI in NSTEMI patients remains a matter of clinical judgment. This study aims to compare the short-term and long-term outcomes of MV- PCI versus SV-PCI in NSTEMI patients with multivessel disease. By analyzing parameters such as mortality, recurrent MI, revascularization rates, and heart failure incidence, this research seeks to provide further insights into the optimal revascularization strategy. Understanding these differences is crucial for optimizing treatment decisions, improving patient prognosis, and reducing cardiovascular morbidity and mortality [15].

Materials & Methods

This quasi-experimental study was conducted at the department of cardiology, Bangabandhu Sheikh Mujib Medical University (BSMMU). Shahbag, Dhaka, Bangladesh from January 2023 to August 2024. Purposively selected previously diagnosed 98 NSTEMI patient having multi vessel disease who underwent either MVR (50) or SVR (48) were included in this study. Patients with NSTEMI with single vessel disease, STEMI, Unstable angina, Individuals with a history of coronary bypass grafts, isolated left main coronary artery disease (CAD), or chronic total occlusions; those who experienced cardiogenic shock prior to intervention and those who underwent planned staged intervention following discharge from the initial hospitalization; Cardiomyopathy Atrial Fibrillation Valvular Heart Disease; Systemic diseases, such as cancer, collagen vascular diseases or amyloidosis were excluded from the study. Ethical clearance was obtained from Institutional review board of BSMMU (Ref no –BSMMU/2020/3024, date-02/03/2020). Written informed consent was taken from the patient. All the baseline data including history (chest pain by CCS class, dyspnea by NYHA class, functional capacity with METs determined by the subjective experiences of daily activities), clinical examination of the patients, ECG, echocardiography (2D and M mode), laboratory findings (serum creatinine), angiography and PCI related data were collected and recorded on a predetermined sheet. All PCI were executed by using established interventional methodologies. The operators were full liberty in choosing either single or multi vessel revascularization. The type of drug-eluting stent, pre-dilation, post-stent adjunctive balloon inflation and delivery of glycoprotein IIb/IIIa receptor antagonists adhered to conventional practice. Post PCI antiplatelets were given as per DAPT guidelines.

All patient were received standard medical care in accordance with current guideline for managing NSTEMI undergoing PCI. During hospitalization, peri-procedural data were collected. Follow up was done after 6 months of PCI to record all relevant history (angina by CCS class, shortness of breath by NYHA class, functional capacity with METs determined by the subjective experiences of daily activities), ECG and echocardiography (LVEF) findings. Any incidence of major adverse cardiovascular or cerebrovascular events like death, stroke, MI, any repeat revascularization (target and non-target vessels) was also recorded during intervention, peri-procedural time and within 6 months of post intervention period. Finally, intra and inter group comparative outcome of single vessel and multi vessel PCI was determined in patient with non-STEMI having multi vessel disease undergoing PCI. By using Cox proportional hazards model the clinical outcomes of SVR versus MVR PCI were assessed. Hazards ratios both unadjusted and risk-adjusted along with 95% confidence intervals were computed while controlling for age, gender, DM, HTN, prior PCI, LVEF, the SYNTAX score and total stent length. Sub-group analysis were conducted based on SYNTAX score values. Data processing and analyses were done using Statistical Package for Social Sciences (SPSS) version 23. A value of $p < 0.05$ was considered as statistically significant.

Results

Table I: Baseline Demographic variables, distribution of Risk factors & co-morbidity and angiographic variable of the patients enrolled in the two groups:

	MVR group (N=50)	SVR group (N=48)	*p* value
Risk Factors and Co-morbidity			
Age (Y)	57.4 ± 4.7	56.7 ± 5.4	[a]0.09[ns]
Male	39(51.3)	37(48.7)	[b]0.913[ns]
Female	11 (50)	11 (50)	
DM	28(50.9)	27(49.1)	[a]0.980[ns]
HTN	44(53.7)	38(46.3)	[a]0.237[ns]
Current Smoker	28(54.9)	23(45.1)	[a]0.423[ns]
Dyslipidemia	18(43.90)	23(56.10)	[a]0.1644[ns]
Family history of CAD	29(46.8)	33(53.2)	[a]0.270[ns]
PAOD	1 (33.3)	2 (66.67)	[a]0.972[ns]
Previous MI	5(50.0)	5(50.0)	[a]0.916[ns]
Previous CVA	1(25)	3(75)	[a]0.288[ns]
Prior PCI	2(66.7)	1(33.3)	[a]0.582[ns]
CHF	9(45)	11(55)	[a]0.546[ns]
CKD	6 (46)	7 (54)	[a]0.903[ns]
SYNTAX score	21.09 ± 2.213	20.479± 2.0454	[a] 0.1595[ns]
DVD	34 (50.75%)	33 (49.25%)	[a]0.9372[ns]
TVD	16 (51.61%)	15 (48.39%)	[a]0.9372[ns]
Number of Stents	2.12±0.76	1.15±0.64	[a]<0.01[s]
Total stent length (mm)	65.72±3.85	36.46±2.35	[a]<0.01[s]

Both groups show similarities in demographic characteristics. The mean age of the MVR group was 57.4 ± 4.7, while that of the SVR group was 56.7 ± 5.4. A male predominance was noted in both groups. The majority of patients exhibited numerous comorbidities and risk factors within each category. Hypertension, diabetes mellitus, a familial predisposition to coronary artery disease, dyslipidemia, and a history of smoking were the predominant risk variables present in both groups. Table I also showing similar coronary lesion complexity (SYNTAX score-MVR 21.09 ± 2.213 and SVR 20.479± 2.0454; p=0.1595) and vessel score (vessel involvement; DVD 32% in MVR and 31% in SVR; TVD 68% in MVR and 69% in SVR) in both of the groups.

But number stents (MVR 2.12±0.76; SVR 1.15±0.64l p<0.01) and length of stents (MVR 65.72±3.85; SVR 36.46±2.35; p <0.01) were significantly higher in Multi vessel-PCI group compared to single vessel-PCI group.

Table II: Comparison of six-months MACCE between study groups:

MACCE	MVR group (n-50)	SVR group (n-48)	UNADJUSTED HR (95% CI)	p value	ADJUSTED HR (95% CI)	p value
Death	2 (4%)	4 (8.33%)	1.031 [0.320, 2.941]	0.874	0.874 [0.190, 2.234]	0.813[ns]
MI	1 (2%)	4 (8.33%)	0.751 [0.411, 1.876]	0.699	0.732 [0.395, 1.687]	0.657[ns]
TVR	1	1	1.105 [0.594, 2.457]	0.956	0.985 [0.710, 2.013]	0.882[ns]
Non-TVR	0	8	1.812 [1.123, 2.471]	0.035	1.697 [1.012, 1.934]	0.047[S]
Any revascularization	1	9	1.725 [1.237, 3.14]	0.012	1.462 [1.173, 2.624]	0.045[s]
Composite of death, MI or Any Revascularization	3 (6%)	14 (29.17%)	1.575 [1.108, 3.482]	0.027	1.428 [1.121, 2.925]	0.029[S]
Composite of death or	2 (4%)	7 (14.58%)	0.882	0.043	0.902	0.048[S]

MI	[0.227, 1.573]	[0.342, 1.487]

4% people died after Multi vessel revascularization and 8.33% patient died after single vessel revascularisation. On the other hand, 2% patient who underwent MVR and 8.33% patients who were treated by Single vessel revascularization had suffered from MI. However, no statistically significant difference was observed between the two study groups. Neither group experienced any incidence of stroke or TIA following revascularization. The rate of non-target vessel revascularization was notably greater in the single vessel revascularization group when compared to the multi vessel revascularization group in cases of non-ST elevated myocardial infarction with multi vessel disease (p 0.047). However, there was no statistically significant difference between the two groups when it came to target vessel revascularization. It is important to highlight that the rate of any revascularization was greater in the single vessel revascularization group when compared to the multi vessel revascularization group (p=0.045). No incidence of stent thrombosis or in-stent re-stenosis noted during this study period in any of the study groups. We have evaluated the composite of death, MI or revascularization and composite of death or MI in both groups. Multi vessel revascularization group showed significantly lower evidence of MACCE in term of composite of death, MI or revascularization and composite of death or MI compared to single vessel revascularization (p=0.029 and 0.048 respectively). MVR showed its superiority over SVR in Non-ST elevated MI with multi vessel disease patients.

Figure I: Kaplan-Meier survival curve for any revascularization:I

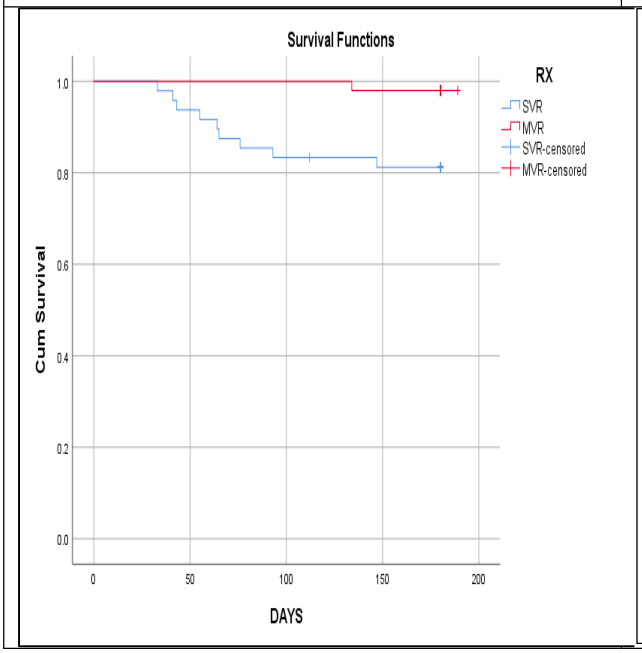
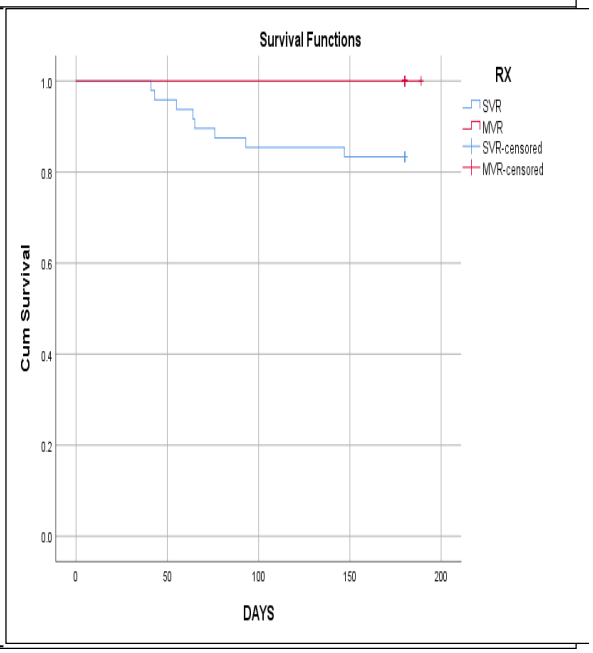


Figure II: Kaplan-Meier survival curve for non-Target vessel revascularization:



Kaplan-Meier survival curve for any revascularization (Figure-I) depicting time interval in days showing in the horizontal axis and cumulative survival rate is showing in the vertical axis. Here, MVR curve is flatter, few events are noted. On the contrary, SVR curve is steeper and more occurrence of any revascularization is seen. Divergence of both of the curve indicating statistically significant differences is executed in this curve. MVR group shows less occurrence of any revascularization and more event free survival.

Kaplan-Meier survival curve for non-target vessel revascularization (Figure-II), time interval in days showing in the horizontal axis and cumulative survival rate is showing in the vertical axis. Here, MVR curve is flatter, no events are noted. On the contrary, SVR curve is steeper and more occurrence of non-target vessel revascularization is seen. Divergence of both of the curve indicating statistically significant differences is revealed in this curve.

Figure III: Kaplan Meier survival curve composite outcome for the composite outcome of death or myocardial infarction:

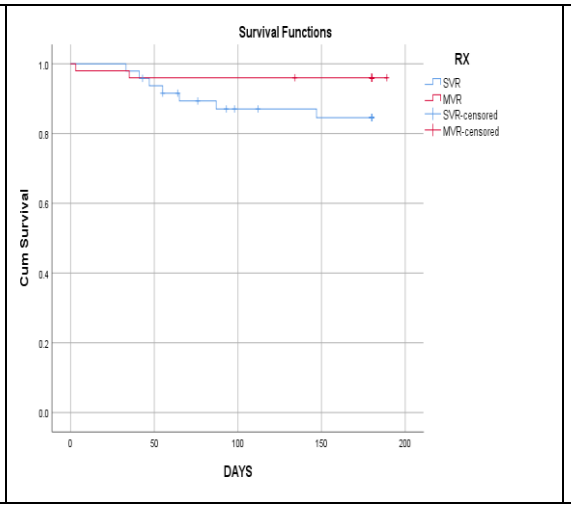
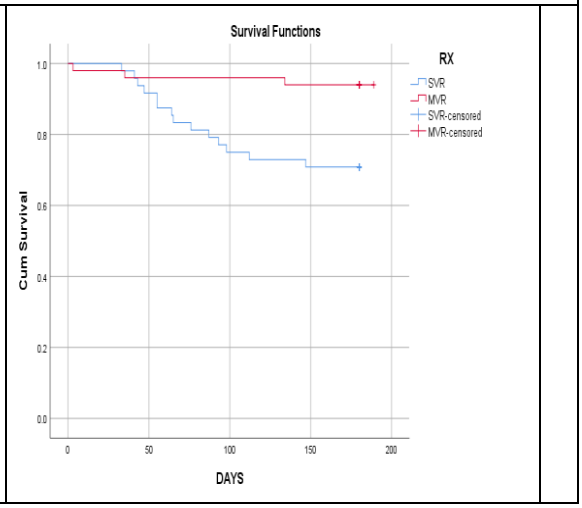


Figure IV: Kaplan Meier survival curve composite outcome of death, myocardial infarction or any revascularization:



The composite outcome of death or myocardial infarction is more prevalent in the SVR group than in the MVR group. Again, Diverge and crossed curve of SVR and MVR group indicating there is significant differences seen in between two group in terms of composite of death, or myocardial infarction (Figure III).

The composite outcome of death, myocardial infarction, or any revascularization (Figure IV) is observed more frequently in the SVR group than in the MVR group. The diverging and intersecting curves of the SVR and MVR groups indicate significant differences observed between the two groups regarding the composite outcomes of death, MI (myocardial infarction), or any revascularization procedures.

Table III: Intra-group and Inter-group Comparison of functional outcome in the term of METs in both SVR and MVR group:

Intra-group comparison of METs						
	METs	**Before PCI**		**6 months after PCI**		**P VALUE**
SVR	<4	42 (87.5%)		2 (4.17%)		<0.01[s]
	4-7	5 (10.42%)		17 (35.42%)		
	>7	1 (2.08%)		25 (52.08%)		
MVR	<4	45 (90%)		1 (2%)		<0.01[s]
	4-7	4 (8%)		15 (30%)		
	>7	1(2%)		32 (64%)		
Inter-group Comparison of METs						
METs	**Before PCI**			**After PCI**		
	SVR	**MVR**	**P value**	**SVR**	**MVR**	**P value**
<4	42 (87.5%)	45 (90%)	0.949[ns]	2 (4.17%)	1 (2%)	0.454[ns]
4-7	5 (10.42%)	4 (8%)		17 (35.42%)	15 (30%)	
>7	1 (2.08%)	1 (2%)		25 (52.08%)	32 (64%)	

Baseline functional capacity (METs) was similar between two study groups (p=0.949). Six months post-revascularization, there was no statistically significant difference in functional capacity (METs) between the SVR and MVR groups (p=0.454).

Table IV: Intra and Inter group comparison of Angina before and after PCI:

Intra group Comparison of Angina before and After PCI				
Angina	**CCS class**	**Before PCI**	**After PCI**	**p value**
SVR (n=48)	IV	27 (56.25%)	0(0)	<0.01
	III	21 (43.75%)	1 (2.08%)	<0.01
	II	0 (0)	7 (14.58%)	0.074
	I	0 (0)	12 (25%)	<0.01
	No chest pain	0 (0)	24 (50%)	<0.01
MVR (n=50)	IV	33 (66%)	0 (0)	<0.01

	III	17 (34%)	0 (0)	<0.01
	II	0 (0)	1 (2%)	0.981
	I	0 (0)	9 (18%)	0.023
	No chest pain	0 (0)	38 (76%)	<0.01

Inter-group comparison of Angina before and after PCI

CCS class	**Before PCI**			**After PCI**		
	SVR (n=48)	**MVR (n=50)**	**p value**	**SVR (n=48)**	**MVR (n=50)**	**p Value**
IV	27 (56.25%)	33 (66%)	0.433^{ns}	0	0	0.066^{ns}
III	21 (43.75%)	17 (34%)		1 (2.08%)	0	
II	0	0		7 (14.58%)	1 (2%)	
I	0	0		12 (25%)	9 (18%)	
No chest pain	0	0		24 (50%)	38 (76%)	

Comparison showed, Both the SVR and MVR groups demonstrated a noteworthy enhancement in anginal symptoms, as assessed by CCS class, following 6 months of PCI. These changes were statistically significant. On the other hand, inter group comparison showed, similar baseline CCS class or anginal symptoms before PCI (p=0.433) and 6-months after revascularization did not reveal any statistical differences between two groups (p=0.066).

Table V: Intra-group and Inter-group changes of NYHA class before and after PCI:

Intra group changes of NYHA class before and after PCI

	NYHA class	Before PCI	After PCI	p value
SVR	IV	0	0(0)	--
	III	0	1 (2.08%)	--
	II	7 (14.58%)	6 (12.5%)	0.937^{ns}
	I	32 (66.67%)	17 (35.42%)	0.008^{s}
	No dyspnea	9 (18.75%)	20 (41.67%)	0.037^{s}
MVR	IV	0	0	--
	III	0	1 (2%)	--
	II	12 (24%)	1 (2%)	0.002^{s}
	I	38 (76%)	5 (10%)	$<0.001^{s}$
	No dyspnea	0	41 (82%)	$<0.001^{s}$

Inter group comparison of NYHA class before and after PCI

NYHA	Before PCI			After PCI		
	SVR	MVR	p value	SVR	MVR	p value
IV	0	0	0.075^{ns}	0	0	$<0.01^{s}$
III	0	0		1 (2.08%)	1 (2%)	
II	7 (14.58%)	12 (24%)		6 (12.5%)	1 (2%)	
I	32 (66.67%)	38 (76%)		17 (35.42%)	5 (10%)	
No Dyspnea	9 (18.75%)	0		20 (41.67%)	41 (82%)	

SVR and MVR both group of patients showed significant improvement of dyspnea in NYHA class and it is statistically significant in both groups (P<0.05). Prior to revascularization, the MVR and SVR study group exhibited no notable differences regarding NYHA class (Dyspnea); the level of significance was 0.075. After 6 months of revascularization, Patient with multi vessel PCI suffer less from dyspnea compared to single vessel PCI in NSTEMI with multi vessel disease and it was statistically significant (p<0.01).

Discussion

This study explored the comparative safety, efficacy, and outcomes of multi vessel revascularization (MVR) versus single-vessel revascularization (SVR) in patients with non-ST-elevation myocardial infarction (NSTEMI) and multi vessel disease (MVD) undergoing percutaneous coronary intervention (PCI) with drug-eluting stents (DES). It assessed the incidence of major adverse cardiac and cerebrovascular events (MACCE) and examined clinical and functional outcomes over six months.

Patient Demographics and Characteristics

The mean age of patients in the MVR and SVR groups was comparable, with MVR patients averaging 57.4 years and SVR patients 56.7 years. These findings align with prior research which reported similar age distributions among patients undergoing MVR and SVR[18-19]. The study also confirmed that males were predominantly affected by NSTEMI with MVD, consistent with earlier studies indicating a male-to-female ratio of 3:2 in acute coronary syndrome (ACS) cases.

Multi vessel coronary artery disease is a common condition in NSTEMI patients, affecting one-third to one-half of those with ACS. This prevalence is attributed to the rupture of atherosclerotic plaques, which leads to intermittent ischemia and myocardial damage. Double vessel disease (DVD) was more frequent in this study, with nearly equal distribution between MVR (50.75%) and SVR (49.25%) groups, though the results varied compared to earlier studies [19,20].

Stent Usage and Procedural Metrics

The study highlighted that MVR procedures required a greater number of stents and longer total stent lengths compared to SVR. On average, the MVR group used 2.12 stents per patient, while the SVR group used 1.15 stents, with statistically significant differences ($p < 0.01$). The total stent length in the MVR group was 65.72 mm compared to 36.46 mm in the SVR group, findings consistent with prior research[18,21].

Left Ventricular Function and Clinical Outcomes

Both MVR and SVR improved left ventricular ejection fraction (LVEF) post-revascularization, as determined by Transthoracic echocardiography. Intra-group comparisons revealed significant improvements in LVEF for both groups, while inter-group comparisons showed no statistically significant differences either at baseline or six months post-PCI. These results align with earlier studies[22,23].

Functional capacity, measured in metabolic equivalents (METs), also improved significantly in both groups, with no discernible differences between MVR and SVR. These findings are consistent with previous research[24,25].

The study noted significant improvements in angina symptoms, functional capacity, and dyspnea (NYHA class) within each group after PCI. However, the MVR group demonstrated greater progress in NYHA class compared to the SVR group six months post-revascularization.

Peri-procedural Complications and Renal Dysfunction

Peri-procedural renal dysfunction was evaluated in both groups, showing similar patterns regardless of whether patients underwent MVR or SVR. These findings are consistent with earlier studies[3].

MACCE and Mortality

The study assessed the incidence of MACCE, which includes death, myocardial infarction (MI), stent thrombosis, stent restenosis, and target lesion revascularization. MVR demonstrated a reduced need for repeat revascularization and a lower composite rate of death, MI, or revascularization compared to SVR. However, there were no significant differences between the groups in terms of all-cause mortality or target vessel revascularization.

Earlier studies presented conflicting findings regarding the superiority of MVR or SVR in terms of mortality and MI outcomes. Some studies[18,20] suggested MVR yielded better results, while other favored SVR[26]. This study aligns with those highlighting the benefits of MVR in reducing MACCE, particularly with the use of DES.

Comparison with Previous Research

The study's findings align closely with earlier research on the efficacy of revascularization strategies in NSTEMI patients with MVD. It confirmed that MVR using DES improves clinical outcomes by reducing MACCE incidence[27,28].

However, conflicting evidence exists in the literature regarding the optimal revascularization strategy. Studies favored SVR for lower mortality[29,30,31], while others demonstrated no significant differences between MVR and SVR[19].

Conclusion

The study found that multi vessel revascularization (MVR) showed better outcomes compared to single-vessel revascularization (SVR) in term of reducing major adverse cardiovascular and cerebrovascular events (MACCE). In MVR group had significantly fewer composite events of death or MI and events of death, MI, or any revascularization than the SVR group. SVR had a higher rate of revascularization for non-targeted vessels than MVR. MVR and SVR showed similar improvements in symptoms (angina, dyspnea) and functional capacity. Both groups had similar rates of peri-procedural renal dysfunction.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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