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FREQUENCY OF IMPROVEMENT IN LEFT VENTRICULAR FUNCTION FOLLOWING PRIMARY PERCUTANEOUS CORONARY INTERVENTION IN PATIENTS WITH ST-ELEVATION MYOCARDIAL INFARCTION AND LEFT VENTRICULAR DYSFUNCTION

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Abstract

Background: *ST-elevation myocardial infarction (STEMI) significantly compromises left ventricular function, contributing to long-term morbidity and mortality. Early revascularization with primary percutaneous coronary intervention (PCI) plays a crucial role in preserving myocardial function and improving outcomes.*

Objective: *To assess the improvement in left ventricular ejection fraction (LVEF) three months after primary percutaneous coronary intervention (PCI) in patients presenting with ST-elevation myocardial Infarction and Left Ventricular Dysfunction.*

Methodology: *A descriptive cross-sectional study was conducted on 199 patients presenting with STEMI who underwent primary PCI. Baseline clinical, demographic, and angiographic data were recorded. Left ventricular ejection fraction (LVEF) was measured at admission and reassessed after 3 months to evaluate improvement. Associations between LVEF recovery and various clinical factors were statistically analyzed. All data were analyzed using SPSS version 26. Continuous variables such as age, height, weight, BMI, door-to-balloon time, and LVEF values were expressed as means ± standard deviations. Categorical variables such as gender, presence of comorbidities, and STEMI type were presented as frequencies and percentages. Inferential statistics were applied to determine associations between clinical variables and LVEF improvement. The chi-square test was used for categorical data, and a p-value of <0.05 was considered statistically significant.*

Result: *Out of 199 STEMI patients, 75.3% showed ≥10% improvement in LVEF at 3 months. Anterior wall MI (69.8%) and LAD involvement (69.8%) were the most common. LVEF improvement was significantly associated with the absence of hypertension (p=0.015), anterior STEMI (p=0.0001), and absence of no-reflow phenomenon (p=0.0001). Diabetes and smoking showed no significant*

association.

Conclusion: *Patients who had primary PCI for STEMI experience meaningful improvement in left ventricular ejection fraction (LVEF) within three months of intervention. The most notable predictors of poor LVEF recovery were hypertension, anterior STEMI, and the presence of no-reflow or distal embolism. These findings underscore the critical importance of early identification and aggressive management of high-risk STEMI patients, particularly those with anterior infarctions or hemodynamic instability post-PCI.*

INTRODUCTION

ST-segment elevation myocardial infarction (STE-MI) remains a major cause of death and morbidity worldwide, despite well-established treatment strategies including direct revascularization with primary percutaneous coronary intervention (PPCI).(1) The prognostic factors after STEMI depend upon the extent of myocardial damage and left ventricular (LV) systolic function, which in turn is affected by several components including the myocardial area at jeopardy, the time duration between ischemia onset, and restoration of coronary blood flow.(2) PPCI remains the mainstay for the treatment of STEMI and can decrease the risk of long-term major adverse cardiac events.(3)

In a recent study, the prevalence of LVEF <40% was low and after primary percutaneous coronary intervention and with optimal medical therapy, LVEF normalized in 39% of patients at 6 months follow-up.(4) Myocardial infarction either causes permanent myocardial damage when it is prolonged and severe or can be transient when brief or mild as in the case of stunned myocardium.(5) Current guidelines recommend early echocardiography after STEMI for risk stratification to estimate LV systolic function in the acute setting after PPCI. If LV dysfunction at presentation, it is recommended to reassess three months after the acute MI.(5) Nevertheless, a substantial proportion of patients after STEMI remain with reduced LV systolic function.(6)

There is scant regional data available regarding the proportion of patients with STEMI treated with primary percutaneous coronary intervention who had left ventricular systolic dysfunction at baseline (within 48 hours) of admission and exhibited LVEF recovery under optimal guideline-based medical treatment. Therefore, our study aims to evaluate the improvement of LVEF in patients after STEMI who underwent PPCI and were discharged on guideline-based medical therapy. So, this study is designed to measure the frequency of left ventricular (LV) function improvement in patients admitted with ST-elevation myocardial infarction (STEMI) and LV dysfunction after primary percutaneous coronary interventions.

METHODS & MATERIELS

Study Design, Setting & Duration:

The study was a descriptive cross-sectional study conducted in the inpatient department of Cardiology at Tabba Heart Institute, Karachi. The duration of the study spanned six months, from October 2023 to March 2024. The sample size was calculated based on a 39% (7) Frequency of improvement in left ventricular (LV) function, using a 95% confidence level and a 7% margin of error. Applying the formula $n = z^2 \times p(1-p) / d^2$, the calculated sample size was 199 patients who presented with STEMI and underwent diagnostic catheterization and revascularization via PCI. Participants were recruited using a non-probability consecutive sampling technique from the cardiology department of a tertiary care hospital. Informed consent was obtained from all patients before inclusion and ethical approval for the study was secured from the institutional review board.

Demographic data including age, gender, height, weight, and BMI were recorded. Comorbid conditions such as dyslipidemia, hypertension, diabetes mellitus, and tobacco use (including cigarette smoking and smokeless tobacco) were documented. A family history of premature coronary artery disease (CAD) was also noted. Diabetic patients were further categorized based on the mode of glycemic control, i.e., dietary management, oral

hypoglycemics, insulin therapy, or combination therapy.

Clinical and procedural details were carefully recorded. These included symptom-to-balloon time and door-to-balloon time, type of myocardial infarction (anterior, inferior, or posterior wall), and the culprit vessel involved. The presence of multivessel disease and the incidence of complications such as no-reflow phenomenon or distal embolism during PCI were also noted. All patients underwent diagnostic angiography, with PCI being performed in all individuals.

Left ventricular ejection fraction (LVEF) was assessed via echocardiography at the time of admission and repeated at a 3-month follow-up to evaluate cardiac function recovery. An improvement in LVEF was defined as a ≥10% increase from baseline. Data were stratified based on age (<60 years vs. ≥60 years), gender, diabetic and hypertensive status, smoking status, culprit vessel involvement, infarct location, and presence of complications to identify associations with LVEF recovery.

Data Analysis:

All data were analyzed using SPSS version 26. Continuous variables such as age, height, weight, BMI, door-to-balloon time, and LVEF values were expressed as means ± standard deviations. Categorical variables such as gender, presence of comorbidities, and STEMI type were presented as frequencies and percentages. Inferential statistics were applied to determine associations between clinical variables and LVEF improvement. The chi-square test was used for categorical data and a p-value of <0.05 was considered statistically significant.

RESULTS

The study included 199 patients, of which 155 (77.9%) were male and 44 (22.1%) were female. The mean age of the patients was 55.46 ± 10.3 years. The average height was 164.18 ± 6.42 cm, weight was 74.96 ± 13.05 kg, and BMI was 27.9 ± 5.1 kg/m^2. Dyslipidemia was present in 44 (22.1%) patients, while 155 (77.9%) had no such history. Hypertension was reported in 96 (48.2%) individuals, and 103 (51.8%) were normotensive. A positive family history of premature coronary artery disease (CAD) was seen in 45 (22.5%) participants. Diabetes mellitus was present in 77 (38.7%) patients, whereas 122 (61.3%) were non-diabetic. Among the diabetic population, 6 (3%) were managed by diet, 47 (23.6%) were on oral hypoglycemics, 4 (2%) were using insulin, and 16 (8%) were on a combination of insulin and oral therapy. Tobacco use was prevalent among 55 (27.6%) patients, while 144 (72.3%) were non-users. Cigarette smoking was noted in 68 (34.2%) individuals, while 131 (65.8%) did not smoke. Additionally, 12 (6%) used smokeless tobacco, whereas 187 (94%) did not. (Table 1)

The mean door-to-balloon time was 66.22 ± 26.8 minutes, while the mean symptom-to-balloon time was 256.0 ± 155 minutes. Diagnostic catheterization and Percutaneous coronary intervention (PCI) were performed in all 199 (100%) patients. Multivessel disease requiring PCI was observed in 46 (23.1%) patients. Among STEMI types, anterior wall myocardial infarction was the most common, affecting 139 (69.8%) patients, followed by inferior wall MI in 59 (29.6%) and posterior wall MI in 1 (0.5%). The left anterior descending (LAD) artery was the most frequently involved culprit vessel in 139 (69.8%) patients. Right coronary artery (RCA) involvement was noted in 37 (18.6%) patients, left circumflex artery (LCX) or obtuse marginal artery (OM) in 22 (11.1%), and diagonal artery in 1 (0.5%) patients. No flow or distal embolism was observed in 63 (31.7%) patients, while 136 (68.3%) had no such complications. (Table 2)

The mean baseline LVEF at the time of admission was 34.0 ± 4.9%, which improved significantly to 46.5 ± 9.4% at the 3-month follow-up. Overall, 150 (75.3%) patients showed significant improvement in LVEF (≥10% increase), while 49 (24.6%) did not demonstrate such improvement. (Table 3)

On subgroup analysis, male patients showed higher improvement in LVEF compared to females (80.7% vs. 69.4%), although this difference was not statistically significant ($p = 0.075$). Patients aged below 60 years were more likely to show improvement (52.2%) compared to those aged 60 and above (23.1%), with a p-value of 0.482. Diabetic status was not significantly associated with LVEF improvement ($p = 0.172$), with 36.0% of improved patients being diabetic compared to 48.9% in the non-improved group. However, hypertension was significantly associated with poor LVEF recovery, as

63.3% of non-improved patients were hypertensive compared to 43.3% of those who improved (p = 0.015). Smoking status was not significantly associated with LVEF improvement (p = 0.545). (Table 4)

Time to balloon inflation also showed a non-significant trend (p = 0.070), where only 1.5% of improved patients had a time <90 minutes, while 73.8% had ≥90 minutes. STEMI type was significantly associated with outcome; patients with anterior wall STEMI showed greater LVEF improvement (49.7%) than those with inferior/lateral STEMI (25.6%) (p = 0.0001). LAD involvement, although more common among patients who improved (66.0%), did not reach statistical significance (p = 0.107). A strong association was noted between no-reflow phenomenon and poor recovery; 18.5% of patients in the non-improved group had no-reflow/distal embolism compared to only 13.0% in the improved group (p = 0.0001). (Table 5).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (n = 199)

Variable	(n)% / Mean ± SD
Gender	
Male	155 (77.9%)
Female	44 (22.1%)
Age (years)	55.46 ± 10.31
Height (cm)	164.18 ± 6.42
Weight (kg)	74.96 ± 13.05
BMI	27.9 ± 5.1
Dyslipidemia	
Yes	44 (22.1%)
No	155 (77.9%)
Hypertension	
Yes	96 (48.2%)
No	103 (51.8%)
Family History of Premature CAD	
Yes	45 (22.5%)
No	154 (77.4%)
Diabetes Mellitus	
Yes	77 (38.7%)
No	122 (61.3%)
Diabetes Therapy	
Diet	6 (3.0%)
Oral	47 (23.6%)
Insulin	4 (2.0%)
Insulin + Oral	16 (8.0%)
Tobacco Use	
Yes	55 (27.6%)
No	144 (72.4%)
Cigarette Use	
Yes	68 (34.2%)
No	131 (65.8%)
Smokeless Tobacco	

Yes	12 (6.0%)
No	187 (94.0%)

Table 2: Clinical and Procedural Details

Parameter	Mean ± SD / n (%)
Door to Balloon Time (minutes)	66.22 ± 26.84
Symptom to Balloon Time (minutes)	256.0 ± 155.0
PCI Performed	199 (100%)
Diagnostic Catheterization Only	199 (100%)
PCI for Multivessel Disease	46 (23.1%)
STEMI Type	
Anterior	139 (69.8%)
Inferior	60 (30.2%)
Culprit Stenosis Location	
LAD	139 (69.8%)
LCX/OM	22 (11.1%)
RCA	37 (18.6%)
Diagonal	1 (0.5%)
No Reflow / Distal Embolism	
Present	63 (31.7%)
Absent	136 (68.3%)
Abbreviations: **PCI:** Percutaneous Coronary Intervention **STEMI:** ST-Elevation Myocardial Infarction **LAD:** Left Anterior Descending artery **LCX:** Left Circumflex artery **OM:** Obtuse Marginal artery **RCA:** Right Coronary Artery	

Table 3: Left Ventricular Ejection Fraction (LVEF) Comparison

Timepoint	Mean LVEF (%) ± SD
Baseline (Admission)	34.0 ± 4.9
After 3 Months (Follow-up Echo)	46.5 ± 9.4

Table 4: Frequency of Left Ventricular Function Improvement After 3 Months

LVEF Improvement Status	n (%)
Improved (≥10% increase)	150 (75.3%)
Not Improved (<10% increase)	49 (24.6%)

Table 5: Association of Clinical Factors with LV Function Improvement

Clinical Factors	Improved n (%)	Not Improved n (%)	p-value
Gender			
Male	121 (80.7%)	34 (69.4%)	0.075
Female	29 (19.3%)	15 (30.6%)	
Age Group			
<60 years	104 (52.2%)	28 (12.5%)	0.482

≥60 years	46 (23.1%)	21 (10.5%)	
Diabetes Mellitus			
Yes	54 (36.0%)	23 (48.9%)	0.172
No	96 (54.0%)	26 (53.1%)	
Hypertension			
Yes	65 (43.3%)	31 (63.3%)	**0.015***
No	85 (56.7%)	18 (36.7%)	
Smoking Status			
Yes	53 (35.3%)	15 (30.6%)	0.545
No	97 (64.7%)	34 (69.4%)	
Time to Balloon			
<90 minutes	3 (1.5%)	2 (1.0%)	0.070
≥90 minutes	147 (73.8%)	47 (23.6%)	
STEMI Type			
Anterior	99 (49.7%)	40 (20.1%)	**0.0001***
Inferior/Lateral	51 (25.6%)	9 (4.5%)	
Culprit Vessel			
LAD	99 (66.0%)	40 (81.6%)	0.107
Others	51 (34.0%)	9 (18.4%)	
No Reflow / Distal Embolism			
Present	26 (13.0%)	37 (18.5%)	**0.0001***
Absent	124 (62.3%)	12 (6.0%)	

Note: The chi-square test was applied to determine the p-values.
* Indicates a statistically significant association ($p < 0.05$).
Abbreviations:
LAD: Left Anterior Descending artery

Discussion

This study evaluated the improvement in left ventricular ejection fraction (LVEF) three months after percutaneous coronary intervention (PCI) in patients presenting with ST-elevation myocardial infarction (STEMI), along with assessing associations between various clinical factors and LV functional recovery. Our findings showed that 75.3% of the patients experienced significant improvement in LVEF (≥10%), while 24.6% did not show such improvement. The mean LVEF improved from 34.0 ± 4.9% at baseline to 46.5 ± 9.4% after three months, indicating that timely PCI can lead to substantial improvement in cardiac function. This aligns with results reported by Dauw J et al. (2021), who also found a significant rise in LVEF after revascularization in anterior STEMI patients, highlighting the importance of myocardial salvage through timely intervention.(8)

Gender did not show a statistically significant association with LVEF improvement (p = 0.075), although male patients constituted a greater proportion of those who improved (80.7%). Similar findings were reported by Li S et al. (2024), who found no significant gender difference in LVEF recovery post-STEMI, suggesting that gender alone may not predict recovery of ventricular function.(9) Hypertension was significantly associated with poor improvement in LV function (p = 0.015), with 63.3% of non-improvers being hypertensive. This finding is supported by Pavlidis G. et al. (2024), who reported that hypertensive patients had increased myocardial stiffness and adverse remodeling, contributing to limited functional recovery.(10) Interestingly, diabetes mellitus, although biologically plausible as a limiting factor for myocardial recovery, was not significantly associated with improvement in LVEF in our cohort (p = 0.172). However, a study by Hathaway QA et al. (2022), has found diabetes to be a predictor of poor ventricular remodeling.(11) The discrepancy may be due to differences in glycemic control, diabetes duration, or sample characteristics.

No significant association was observed between age groups and LVEF improvement (p = 0.482), though patients younger than 60 years showed better recovery trends. This is consistent with Wang NJ, et al. (2023), who observed that age had limited predictive value for LV function recovery when confounding variables such as comorbidities and treatment delays were controlled.(12) Smoking status and time to balloon (≥90 minutes vs. <90 minutes) were not significantly associated with improvement, though early revascularization is still emphasized in guidelines for better myocardial salvage. Our findings are in contrast with those of Schiphorst et al. (2024), who demonstrated that delayed reperfusion was associated with larger infarct size and worse functional outcomes.(13) In our cohort, despite the mean door-to-balloon time being 66.22 ± 26.8 minutes, the mean symptom-to-balloon time was much longer (256 ± 155 minutes), which might have diluted the impact of door-to-balloon performance alone.

A highly significant association was found between STEMI type and LVEF improvement (p = 0.0001), with anterior STEMI more commonly associated with poor functional recovery. This is consistent with findings by Sen G et al. (2021), who stated that anterior wall infarctions involve a larger myocardial territory and hence have greater potential for post-infarction dysfunction.(14) The culprit artery (LAD vs. others) showed no significant association with LVEF improvement (p = 0.107), although the LAD was the most commonly affected vessel (69.8%). This may be due to prompt reperfusion in most patients, limiting myocardial damage. However, studies such as that by Yildiz et al. (2022) have found that LAD involvement in anterior STEMI is a strong predictor of reduced LVEF, especially if not treated within the golden hour.(15)

Another important finding in our study was the strong association between the no-reflow/distal embolism phenomenon and the lack of improvement in LV function (p = 0.0001). Among patients who did not improve, 18.5% experienced no flow, while only 13.0% of those who improved had this complication. This confirms the detrimental impact of microvascular obstruction on myocardial recovery, as highlighted in the study by Refaat H et al. (2021), where no flow was associated with larger infarct size and adverse remodeling.(16) Overall, our study reinforces the importance of early reperfusion therapy in STEMI patients and identifies hypertension, anterior infarct location, and the no-reflow phenomenon as key factors associated with poor LV function recovery. Although some traditional risk factors such as age, diabetes, and smoking did not reach statistical significance, they still warrant close attention in the comprehensive management of STEMI patients.

Conclusion

This study demonstrates that a significant proportion of patients (75.3%) who undergo primary PCI for STEMI experience meaningful improvement in left ventricular ejection fraction (LVEF) within three months of intervention. The most notable predictors of poor LVEF recovery were hypertension, anterior STEMI, and the presence of no-reflow or distal embolism. These findings underscore the critical importance of early identification and aggressive management of high-risk STEMI patients, particularly those with anterior infarctions or hemodynamic instability post-PCI. Optimizing time to reperfusion and addressing procedural complications such as no-reflow may further enhance myocardial salvage and long-term outcomes.

Limitations

The study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to broader populations with varying healthcare settings. Assessment of LVEF was limited to three months post-PCI. A longer follow-up could provide deeper insights into long-term ventricular remodeling and functional outcomes. Although data collection was systematic, some information—particularly symptom onset times—may be subject to recall bias or documentation inaccuracies. The study relied on echocardiography for LVEF measurement, whereas cardiac MRI could have provided more precise data on myocardial viability and infarct size. Variables such as medication adherence, lifestyle modification, revascularization completeness, and socioeconomic status were not assessed, though they may influence LV recovery.

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