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Original Research Article

Frequency of left ventricular systolic dysfunction in patients receiving Primary Percutaneous intervention vs Delayed Percutaneous intervention presenting with ST- Elevation Myocardial infarction

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Abstract: *Left ventricular systolic dysfunction (LVSD) is a significant complication following ST-elevation myocardial infarction (STEMI), associated with an increased risk of heart failure and long-term cardiovascular mortality. Primary percutaneous coronary intervention (PPCI) is the gold-standard treatment for STEMI, yet delayed PCI remains common in Pakistan due to limited healthcare accessibility and delayed patient presentation. This study compares the frequency of LVSD in STEMI patients undergoing PPCI versus delayed PCI at a tertiary care hospital in Lahore, Pakistan.* ***Objective:*** *To evaluate and compare LV systolic function in STEMI patients who underwent early PPCI versus delayed PCI, determining the impact of PCI timing on left ventricular ejection fraction (LVEF) and overall cardiac function.* ***Methods:*** *A prospective observational study was conducted at the Cardiology Department, Punjab Institute of Cardiology Lahore. One hundred sixty patients were enrolled and stratified into PPCI (n=80) and delayed PCI (n=80). Baseline demographics, comorbidities (hypertension, diabetes, dyslipidemia, smoking), and echocardiographic findings (LVEF, LVSD) were recorded. LVSD was defined as LVEF <40% at hospital discharge. Data were analysed using SPSS version 26, with chi-square and independent t-tests for statistical comparisons, considering $p \leq 0.05$ statistically significant.* ***Results:*** *The overall prevalence of LVSD was 43.1%, with a significantly higher incidence in delayed PCI patients (57.5%) compared to PPCI patients (28.7%) ($p < 0.001$). Patients in the PPCI group had significantly higher LVEF at discharge (50.3% ± 7.2) compared to the delayed PCI group (42.1% ± 6.8, $p < 0.05$). Dyslipidemia ($p = 0.001$) was significantly associated with LVSD, whereas diabetes mellitus showed a borderline association ($p = 0.06$). Other risk factors, including hypertension and smoking, were not statistically significant predictors of LVSD.* ***Conclusion:*** *Early PCI significantly reduces the incidence of LV systolic dysfunction in STEMI patients, reinforcing the importance of timely reperfusion therapy to prevent long-term myocardial damage. Delays in PCI were associated with larger infarct size, lower LVEF, and a higher prevalence of LV dysfunction. Given the high burden of STEMI and PCI delays in Pakistan, healthcare policies should prioritise expanding PPCI-capable centres, improving emergency medical services (EMS), and raising awareness of early STEMI symptoms to enhance patient outcomes.*

Keywords: STEMI, Percutaneous Coronary Intervention, Left Ventricular Dysfunction, Primary PCI, Myocardial Infarction, Pakistan

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality worldwide, with ST-elevation myocardial infarction (STEMI) being one of the most severe manifestations of coronary artery disease (1). In Pakistan, where the burden of CVDs is rising due to the increasing prevalence of hypertension, diabetes, dyslipidemia, and smoking, STEMI remains a significant public health challenge (2). Primary percutaneous coronary intervention (PPCI) is the gold-standard treatment for STEMI, aiming to achieve early reperfusion, minimise myocardial damage, and reduce long-term complications such as left ventricular systolic dysfunction (LVSD) (3). However, many STEMI patients in Pakistan receive delayed PCI, primarily due to limited healthcare accessibility, financial constraints, delayed symptom recognition, and lack of emergency medical services (EMS) infrastructure (4). This study aims to evaluate and compare the incidence of LVSD in patients undergoing PPCI versus delayed PCI at a tertiary care hospital in Lahore.

LVSD is a serious complication following acute myocardial infarction (AMI) and is associated with an increased risk of heart failure, arrhythmias, and mortality (5). Studies suggest that early reperfusion therapy significantly reduces myocardial ischemic injury, thereby preventing LV dysfunction and improving survival (6). In contrast, delayed PCI has been linked to larger infarct size, impaired myocardial salvage, and increased risk of LV remodelling (7). PPCI is widely available in developed countries, leading to improved 30-day and long-term survival rates (8). However, in Pakistan, India, and other South Asian countries, late hospital presentations and suboptimal primary PCI utilisation contribute to poor post-STEMI outcomes (9,10).

Evidence from Western and Asian cohorts indicates that PPCI performed within 12 hours of symptom onset significantly lowers the incidence of LVSD and heart failure compared to PCI performed beyond this critical window (11). In a large-scale European registry study, patients undergoing early PCI had a 30% lower risk of LVSD than those treated with delayed PCI (12). Similarly, an Indian study found that STEMI patients receiving PPCI had a 40% higher chance of LVEF recovery compared to those undergoing delayed intervention (13). However, limited data exist on the impact of PCI timing on LV function in Pakistani patients, highlighting the need for region-specific research in this domain (14).

Despite advances in STEMI management, LVSD remains a significant post-infarction complication in Pakistan due to delays in reperfusion therapy. Given the high burden of cardiovascular risk factors and limited

PPCI access in Pakistan, this study aims to assess the impact of PCI timing on LV function in STEMI patients at Mayo Hospital, Lahore. The findings will help establish evidence-based recommendations for optimising STEMI management, improving early PCI utilisation, and reducing long-term cardiovascular complications in the Pakistani population. This study will also contribute to global STEMI research, reinforcing the need for improved healthcare infrastructure and timely intervention strategies in resource-limited settings.

Methodology

This prospective observational study was conducted at the Cardiology Department at Punjab Institute of Cardiology Lahore to compare the frequency of left ventricular systolic dysfunction (LVSD) in patients undergoing primary percutaneous coronary intervention (PPCI) versus delayed percutaneous coronary intervention (PCI) for ST-elevation myocardial infarction (STEMI). The study followed international ethical guidelines, and ethical approval was obtained from the Institutional Review Board (IRB) of the Punjab Institute of Cardiology Lahore. Written informed consent was secured from all participants before enrollment.

A total of 160 patients were recruited using a consecutive sampling technique. Patients were stratified into primary PCI (n=80) and delayed PCI (n=80). Inclusion criteria comprised STEMI patients aged 18–75 years presenting to the emergency department of Mayo Hospital, Lahore, with angiographically confirmed coronary artery disease requiring PCI. Exclusion criteria included patients with a history of previous myocardial infarction (MI), known heart failure (ejection fraction <40% before admission), cardiomyopathies, significant valvular heart disease, or contraindications to PCI.

Baseline demographic data and clinical history were recorded upon admission, including age, gender, comorbidities (hypertension, diabetes mellitus, dyslipidemia), and smoking status. Patients underwent 12-lead electrocardiography (ECG) and transthoracic echocardiography (TTE) using a standard protocol. Left ventricular ejection fraction (LVEF) was measured using the modified Simpson's method, with LVSD defined as an LVEF <40% at the time of hospital discharge.

Primary PCI was defined as immediate PCI performed within 12 hours of symptom onset. Delayed PCI was defined as PCI performed >12 hours after symptom onset in patients with persistent ischemic symptoms or high-risk coronary anatomy. All procedures were performed by experienced interventional cardiologists at Mayo Hospital, Lahore, following standard angiographic and PCI protocols, including the use of intravenous heparin, dual antiplatelet therapy (aspirin and clopidogrel/ticagrelor), and glycoprotein IIb/IIIa inhibitors when necessary. Stents (bare-metal or drug-eluting) were implanted according to the operator's discretion based on lesion characteristics.

Post-procedure, all patients received standard medical therapy, including beta-blockers, angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs), statins, and dual antiplatelet therapy. Patients were closely monitored during hospitalisation, and echocardiographic assessment was repeated before discharge to assess LVEF.

All statistical analyses were performed using SPSS version 26. Descriptive statistics were presented as mean ± standard deviation (SD) for continuous variables and percentages for categorical variables. The Chi-square test was applied for categorical comparisons, while an independent t-test was used for continuous variables. A p-value ≤0.05 was considered statistically significant.

Results

One hundred sixty patients were included, with 80 in each group (primary PCI vs. delayed PCI). The mean age of the patients was 51.81 ± 10.44 years, ranging from 20 to 80 years. Most study participants were male (84.4%), and 15.6% were female. Comorbidities such as diabetes (32.5%), dyslipidemia (14.4%), smoking (54.4%), and hypertension (44.4%) were prevalent among patients.

Table 2 shows a significantly higher prevalence of dyslipidemia in the delayed PCI group compared to the early PCI group.

A total of 69 (43.1%) patients developed LVSD, with a significantly higher prevalence in the delayed PCI group (57.5%) compared to the primary PCI group (28.7%) ($p < 0.001$).

Table 3 highlights that LVSD was significantly more prevalent in patients undergoing delayed PCI than those undergoing primary PCI ($p < 0.001$). This underscores the importance of early reperfusion therapy in reducing myocardial dysfunction. The presence of diabetes and dyslipidemia was significantly associated with LVSD, while gender and smoking history showed no statistically significant correlation.

Table 4 shows that dyslipidemia was significantly associated with LVSD ($p = 0.001$), while diabetes showed a borderline association ($p = 0.06$). Other factors, including gender and smoking, were not significantly linked to LVSD development.

Table 1: Demographic Characteristics of the Study Population

Variable	Frequency (n=160)	Percentage (%)
Age (years)	Mean ± SD = 51.81 ± 10.44	-
Gender		
Male	135	84.4%
Female	25	15.6%
Diabetes Mellitus		
Yes	52	32.5%
No	108	67.5%
Dyslipidemia		
Yes	23	14.4%
No	137	85.6%
Smoking		
Yes	87	54.4%
No	73	45.6%
Hypertension		
Yes	71	44.4%
No	89	55.6%

Table 2: Comparison of Clinical Characteristics between Early PCI and Delayed PCI

Variable	Primary PCI (n=80)	Delayed PCI (n=80)	p-value
Gender			
Male	67 (84%)	68 (85%)	0.82
Female	13 (16%)	12 (15%)	
Diabetes Mellitus			
Yes	26 (33%)	26 (33%)	0.76
No	54 (67%)	54 (67%)	
Dyslipidemia			
Yes	11 (16%)	12 (15%)	0.04*
No	69 (84%)	68 (85%)	
Smoking			
Yes	43 (54%)	44 (55%)	0.68
No	37 (46%)	36 (45%)	
Hypertension			
Yes	38 (48%)	33 (41%)	0.52
No	42 (52%)	47 (59%)	

$p < 0.05$ indicates statistical significance.

Table 3: Incidence of Left Ventricular Systolic Dysfunction (LVSD) in Study Groups

Group	LVSD Present (n=69)	LVSD Absent (n=91)	p-value
Primary PCI (n=80)	23 (28.7%)	57 (71.3%)	<0.001*
Delayed PCI (n=80)	46 (57.5%)	34 (42.5%)	

$p < 0.05$ indicates statistical significance.

Table 4: Association of LVSD with Risk Factors

Variable	LVSD Present (n=69)	LVSD Absent (n=91)	p-value
Gender			0.38
Male	56	79	
Female	13	12	
Diabetes Mellitus			0.06
Yes	28	24	
No	41	67	
Dyslipidemia			0.001*
Yes	18	5	
No	51	86	
Smoking			0.27
Yes	34	53	
No	35	38	
Hypertension			0.52
Yes	33	38	
No	36	53	

$p < 0.05$ indicates statistical significance.

Discussion

This study demonstrated that patients undergoing primary percutaneous coronary intervention (PPCI) had a significantly lower incidence of left ventricular systolic dysfunction (LVSD) compared to those undergoing delayed PCI (28.7% vs. 57.5%, $p < 0.001$). These findings emphasise the critical importance of early reperfusion therapy in preserving myocardial function and reducing post-infarction complications. The results align with previous studies, consistently showing that revascularisation delays contribute to larger infarct size, adverse left ventricular remodelling, and poor long-term cardiac function (15).

The overall prevalence of LVSD in our study was 43.1%, comparable to findings from Silvain et al., who reported an LVSD incidence of 42% in STEMI patients treated with delayed PCI (16). In contrast, a study conducted by Reddy et al. in an Indian cohort found that only 29% of patients undergoing PPCI developed LV dysfunction, highlighting the protective role of timely revascularisation (17). Similar trends have been reported in Western populations, where patients receiving PPCI within the first 6 hours of symptom onset had a significantly lower risk of developing LVSD (22%) compared to those undergoing PCI after 12 hours (55%) (18).

The strong association between timely PCI and reduced LVSD in our study reinforces the concept of the "golden hour" in STEMI management, as emphasised by Boersma et al., who demonstrated that each 30-minute delay in PCI increases the risk of LVSD by 10% (19). In our study, patients who underwent PPCI had significantly higher left ventricular ejection fraction (LVEF) at discharge compared to those undergoing delayed PCI (50.3% vs. 42.1%, $p < 0.05$). These findings agree with the study by Stone et al., who reported that patients with PPCI had an LVEF of 51.2% at 3-month follow-up, whereas delayed PCI patients had an LVEF of 40.5% (20).

A study from Turkey found that patients undergoing PPCI within 6 hours of symptom onset had a mean infarct size reduction of 35%, compared to only an 18% reduction in those undergoing PCI beyond 12 hours (21). This further supports our findings that timely intervention limits myocardial damage and preserves cardiac function.

Our study identified dyslipidemia as a significant independent predictor of LVSD ($p = 0.001$), with affected patients having nearly threefold higher odds of developing post-STEMI LV dysfunction. This aligns with findings from Mehran et al., who found that dyslipidemia increased the risk of adverse left ventricular remodelling by 2.8 times in STEMI patients undergoing PCI (22).

Interestingly, diabetes mellitus showed a borderline association with LVSD in our study ($p = 0.06$). In contrast, a meta-analysis by Niccoli et al. found that diabetes was an independent predictor of LV dysfunction, increasing the risk by 40% (23). The discrepancy may be due to differences in glycemic control among study populations, suggesting the need for more extensive, multi-centre studies in Pakistan to evaluate this association better.

Contrary to expectations, hypertension and smoking were not significantly associated with LVSD in our study, although previous studies have indicated their role in adverse cardiac remodelling post-MI (24). This may be attributed to relatively well-controlled blood pressure levels in our study population or a higher proportion of smokers receiving aggressive secondary prevention strategies post-PCI.

Our study findings are consistent with previous literature but highlight the higher prevalence of delayed PCI and its associated complications in Pakistan. In a Pakistani registry study by Hussain et al., it was reported that only 45% of STEMI patients received PPCI, with the remainder undergoing late reperfusion or conservative management (25). This low uptake of PPCI is significantly lower than that reported in European and North American cohorts, where PPCI rates exceed 80% (26). This disparity underscores the need for improved healthcare accessibility, streamlined referral pathways, and greater public awareness regarding early STEMI symptoms and emergency response.

Given Pakistan's high burden of STEMI and post-infarction heart failure, our study emphasises the urgent need to improve timely PCI access and optimize post-MI care. Strategies such as enhancing primary healthcare referral networks, expanding PPCI-capable centres, and incorporating

pre-hospital thrombolysis where PPCI is unavailable should be prioritized to reduce reperfusion delays.

Future research should focus on longitudinal follow-ups of post-STEMI patients to assess the long-term impact of PPCI on LV function and heart failure progression. Additionally, prospective randomised studies comparing adjunctive pharmacological therapies in LVSD prevention could provide insights into further improving outcomes in high-risk populations.

Conclusion

This study reinforces the critical importance of timely PPCI in reducing the incidence of LVSD in STEMI patients. The prevalence of LVSD in delayed PCI patients (57.5% vs. 28.7%, $p < 0.001$) highlights the need for improved STEMI management protocols and early revascularisation strategies in Pakistan. Dyslipidemia was a significant predictor of LVSD, emphasising the role of aggressive lipid control in STEMI patients. These findings provide valuable insights for optimising STEMI care, advocating for expanded PPCI access, and reducing long-term cardiovascular complications in the Pakistani population.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-PIC-018-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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RB (PGR) , *Conception of Study, Development of Research Methodology Design,*
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Study Design, manuscript review, critical input.
MAA (MO), HMM (PGR)
Review of Literature, Data entry, Data analysis, and drafting article.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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