Original Article

OPEN ACCESS

Correlation of Post-Primary PCI Left Ventricular End-Diastolic Pressure and Myocardial Blush Grade with Improvement in Left Ventricular Ejection Fraction

Sumaira Altaf[1], Muhammad Abair Ul Haq[2], Muhammad Umar Farooq[3], Khawar Naeem Satti[4], Mujaddid Mudassir[5], Ali Farahe[6] , Asim Javed[7]

Rawalpindi Institute of Cardiology, Rawalpindi

Author`s Contribution

[1,3,6]Substantial contributions to the conception or design of the work; or the acquisition, Data Analysis [2,4]Drafting the work or revising it critically for important intellectual content, [4,7]Final approval of the version to be published

Funding Source: None
Conflict of Interest: None

Received: Jan 28, 2026
Revised: May 22, 2026
Accepted: June 02, 2026

Address of Correspondent
Dr. Sumaira Altaf
Rawalpindi Institute of Cardiology, Rawalpindi
sumaira.altaf.abbasi@gmail.com

ABSTRACT

Objectives: To evaluate the relation between post-primary percutaneous coronary intervention (P-PCI) left ventricular end diastolic pressure (LVEDP) and myocardial blush grade (MBG) with left ventricular ejection fraction (LVEF).

Methodology: This cross-sectional analytical study was conducted at Rawalpindi Institute of Cardiology from June 2025 to November 2025.One hundred and ten STEMI patients who underwent P-PCI were included by convenience sampling. Patients were divided into two groups: LVEDP <19mmHg and >19mmHg with 55 participants in each group. The P-PCI of the target vessel was performed by the Interventional Cardiologist. The pre & post LVEDP and pre and post LVEF were measured. After achieving TIMI grade 3 flow, the myocardial blush grade was assessed and noted on the angiogram. The patients were allocated into 3 groups according to the ejection fraction: EF 25–40%, 41–50%, and >50%. The MBG ≥2 and <2 were categorized as high and low grade, respectively. The data analysis was carried out using the Statistical Package for the Social Sciences version 26.

Results: Pre-PCI LVEDP was 20.59+3.78 mmHg, and post-PCI LVEDP was 18.16+3.29 mmHg. Our results showed that 25.5% of the patients with post-PCI LVEDP <19mmHg had EF <40% than 52.7% of the patients with LVEDP>19mmHg, with a significant p-value. Our study reported better EF (>50%) in 36.4% of the patients with MBG >2 versus 18.2% in those with MBG <2, with statistical significance.

conclusion: Left ventricular end diastolic pressure and myocardial blush grade are reliable, inexpensive and feasible indicators of left ventricular ejection fraction after primary percutaneous coronary intervention in STEMI patients. The post-PCI LVEDP <19 mmHg and MBG >2 are associated with improvement in the ejection fraction of patients.

Keywords: Percutaneous coronary intervention, PCI, Ventricular dysfunction

Cite this article as: Altaf S, Haq MAU, Farooq MU, Satti KN, Mudassir M, Farahe A, Javed A. Correlation of Post-Primary PCI Left Ventricular End-Diastolic Pressure and Myocardial Blush Grade with Improvement in Left Ventricular Ejection Fraction. Ann Pak Inst Med Sci. 2026; 22(3):250-254. doi. 10.48036/apims.v22i3.1655.

Introduction

ST-segment elevation myocardial infarction (STEMI) is a global health problem and a major contributor to morbidity & mortality. The frequency of disease is highly variable across different regions. The disease prevalence ranges from 33 to 138 patients per 100,000 populations in Asia.[1] Around 29.1% of the deaths are attributed to ischemic heart disease in Pakistan. After an acute episode of STEMI, remodeling of the ventricles occurs, which further impairs heart function and predisposes to arrhythmias and heart failure. Cardiac remodeling occurs in 30% and 17% of the patients who had anterior wall and non-anterior wall myocardial infarction, respectively. Following STEMI, left ventricular end diastolic pressure increases within seconds, leading to myocardial motion abnormalities and decreased ejection fraction.[2,3] The standard treatment of STEMI is Primary percutaneous coronary intervention (P-PCI). Despite its great success rate, the major challenges after P-PCI are higher in-hospital deaths and heart failure.[4]

Around one-third of patients undergoing PCI for STEMI develop persistent no-reflow, characterized by thrombolysis in myocardial infarction [TIMI] flow grade ≤2. These patients are more likely to have high LVEDP and lower EF.[5] Left ventricular end-diastolic pressure after PCI is related to significant mortality and morbidity. A study reported that the incidence of adverse outcomes was much greater in patients with LVEDP >22mmHg than in those with LVEDP<22mmHg. These figures were even higher in patients having a lower ejection fraction.[6] The myocardial blush grade (MBG) shows cardiac perfusion, and low MBG is related to lower ejection fraction and increased mortality.[7]

Left ventricular end diastolic pressure is considered a prognostic factor after P-PCI. Because LVEDP can be measured easily and inexpensively during PCI without the need for additional equipment, establishing its prognostic value may provide interventional cardiologists with a simple bedside tool for early risk stratification. Myocardial blush grade is an indicator of myocardial perfusion and can also be used to determine prognosis after PCI. Most of the studies have seen the association of LVEDP or MBG with major adverse cardiovascular events and mortality without evaluating the relation between LVEDP/MBG and LVEF.[7,8] Our study aimed to evaluate the relation between LVEDP and myocardial blush grade after P-PCI and left ventricular ejection fraction.

Methodology

This cross-sectional analytical study was approved by the Institutional ethical committee (RIC/RERC/05/2025) from 1st June 2025 to 30th November 2025. The sample size of 110 was calculated taking 95% confidence interval, 5% margin of error and EF <40% in 31.9% versus 57.6% of the patients with LVEDP <19 and ≥19mmHg.[9] Patients were divided into two groups: LVEDP <19mmHg and ≥19mmHg with 55 participants in each group.

All the patients who presented with STEMI in the emergency department of Rawalpindi Institute of Cardiology within 12 hours of the onset of symptoms and underwent P-PCI were included in the study. The patients were recruited after taking informed consent by nonprobability sampling. Patients with established renal disease, cardiogenic shock and ischemic cardiomyopathy were excluded.

The patients were loaded with 300 mg of aspirin and 180 mg of ticagrelor before the procedure. The P-PCI of the target vessel was performed by the Interventional Cardiologist. The pre and post LVEDP were measured at the end of diastolic filling, just prior to systole. Similarly, the pre and post LVEF were determined on echocardiography. The changes in pre and post LVEDP and LVEF were noted. After revascularization, the TIMI score was determined. After achieving TIMI grade 3 flow, the myocardial blush grade was assessed and noted on the angiogram. The myocardial blush grade ranges from 0 to 3, 0 = myocardial perfusion, 1 = minimal perfusion, 2 = partial perfusion and 3 = normal perfusion. A cutoff value of ≥19mmHg was taken as elevated LVEDP.[10] The patients were allocated into 3 groups according to the ejection fraction: EF 25–40%, 41–50%, and >50%. Based on LVEDP, patients were divided into two categories: <19 mmHg and ≥19mmHg. The MBG ≥2 and <2 were categorized as high and low grade, respectively.[11] The demographic information, co-morbidities, MBG, pre- and post P-PCI LVEF and LVEF were noted on a proforma.

The data analysis was carried out using the Statistical Package for the Social Sciences version 26. Qualitative and quantitative variables were expressed using frequency (percentage) and mean (standard deviation), respectively. The relation between LVEDP & LVEF and MBG & LVEF was assessed using the Pearson Chi-square test. The significant p-value was <0.05.

Results

The mean age of the patients was 57.6±8.72, with the majority of the patients 51-60 (60%) and 61-70 years (22.7%) old. Most of the patients were males (79.1%), and 20.9% were females. In our study, 65.5% of the patients had hypertension (HTN), 79.1% had diabetes mellitus (DM), 27.3% were smokers, and 15.5% had a positive family history of IHD. Out of 110 patients, the majority of the patients had DVCAD (41%), 33.6% had TVCAD, and 25.4% of them had SVCAD. The culprit artery was the left anterior descending artery (LAD) in 65.5% of the patients, followed by the right coronary artery (27.3%) and the left circumflex artery (7.2%). The demographic variables and co-morbidities of the study participants in the two groups are given in Table I, with no significant difference between the two groups (p-value > 0.05).

There was a significant difference in the pre-LVEDP between the two groups. Similarly, the post-LVEDP also differed significantly. The pre-LVEF was <40% in 41.8% versus 61.8% of the patients with LVEDP <19mmHg and

≥19mmHg. But the difference in pre-LVEF between the two groups was not statistically significant. When the post-LVEF was compared between the two groups, 25.5% of the patients with LVEDP <19mmHg had EF <40% than 52.7% of the patients with LVEDP≥19mmHg, with a significant p-value (Table II).

The comparison of myocardial blush grade with LVEF showed that a greater percentage of patients with MBG<2 had pre- and post-LVEF <40%. The difference in both pre- and post- ejection fraction was significant. These results are shown in Table II.

Table I: Demographic Variables and Co-morbidities of the Study Participants.

Variable		LVEDP < 19mm Hg (n = 55)	LVEDP ≥ 19mm Hg (n = 55)	Total	Chi-Square/t-Statistic	p-value
Age (Years)				57.6±8.72		
			Age Groups (Years)			
31-40		5(9.1%)	2(3.6%)	7(6.4%)		
41-50		6(10.9%)	6(10.9%)	12(10.9%)	2.191	0.53
51-60		30(54.5%)	36(65.5%)	66(60%)		
61-70		14(25.5%)	11(20%)	25(22.7%)		
Total		**55(100%)**	**55(100%)**	**110(100%)**		
			Gender			
Male		38(69.1%)	41(74.5%)	87(79.1%)		
Female		17(30.9%)	14(25.5%)	23(20.9%)	0.401	0.52
Total		**55(100%)**	**55(100%)**	**110(100%)**		
			Co-morbidities			
HTN	Present	38(69.1%)	34(61.8%)	72(65.5%)	0.637	0.42
	Absent	17(30.9%)	21(38.2%)	38(34.5%)		
Total		**55(100%)**	**55(100%)**	**110(100%)**		
DM	Present	42(76.4%)	45(81.8%)	87(79.1%)	0.490	0.48
	Absent	13(23.6%)	10(18.2%)	23(20.9%)		
Total		**55(100%)**	**55(100%)**	**110(100%)**		
Smoking	Present	16(29.1%)	14(25.5%)	30(27.3%)		
	Absent	39(70.9%)	41(74.5%)	80(72.7%)	0.181	0.66
Total		**55(100%)**	**55(100%)**	**110(100%)**		
Family History of IHD	Present	8(14.5%)	9(16.4%)	17(15.5%)		
	Absent	47(85.5%)	46(83.6%)	93(84.5%)	0.068	0.79
Total		**55(100%)**	**55(100%)**	**110(100%)**		
			Type of Disease			
SVCAD		16(29.1%)	12(21.8%)	28(25.4%)	2.095	0.35
DVCAD		24(43.6%)	21(38.2%)	45(41%)		
TVCAD		15(27.3%)	22(40%)	37(33.6%)		
Total		**55(100%)**	**55(100%)**	**110(100%)**		
			Coronary Artery Involved			
LAD		39(70.9%)	33(60%)	72(65.5%)		
RCA		13(23.6%)	17(30.9%)	30(27.3%)	1.533	0.46
LCX		3(5.5%)	5(9.1%)	8(7.2%)		
Total		**55(100%)**	**55(100%)**	**110(100%)**		

Table II: Relation of Left Ventricular End Diastolic Pressure with Left Ventricular Ejection Fraction.

Variable	LVEDP < 19mm Hg	LVEDP ≥ 19mm Hg	Total	Chi-Square/t-Statistic	p-value
Pre-LVEDP (mmHg)	16.47±4.31	24.72±3.25	20.59±3.78	11.334	<0.0001*
Post-LVEDP (mm Hg)	14.20±2.35	22.13±4.23	18.16±3.29	12.154	<0.0001*
		Pre-LVEF (%)			
25-40%	23(41.8%)	34(61.8%)	57(51.8%)		
41-50%	13(23.6%)	8(14.5%)	21(19.1%)	4.438	0.108
>50%	19(34.6%)	13(23.7%)	32(29.1%)		
Total	**55(100%)**	**55(100%)**	**110(100%)**		
		Post-LVEF (%)			
25-40%	14(25.5%)	29(52.7%)	43(39.1%)		
41-50%	18(32.7%)	11(20%)	29(26.4%)	8.606	0.01*
>50%	23(41.8%)	15(27.3%)	38(34.5%)		
Total	**55(100%)**	**55(100%)**	**110(100%)**		

Table III: Relation of Myocardial Blush Grade with Left Ventricular Ejection Fraction.

Variable	MBG < 2	MBG ≥ 2	Total	Chi-Square/t-Statistic	p-value
Pre-LVEF (%)					
25-40%	30(54.5%)	18(32.7%)	48(43.6%)	6.309	0.04*
41-50%	18(32.7%)	22(40%)	40(36.4%)		
>50%	7(12.8%)	15(27.3%)	22(20%)		
Total	**55(100%)**	**55(100%)**	**110(100%)**		
Post-LVEF (%)					
25-40%	23(41.8%)	5(9.1%)	28(25.5%)	16.135	0.0003*
41-50%	22(40%)	30(54.5%)	52(47.3%)		
>50%	10(18.2%)	20(36.4%)	30(27.2%)		
Total	**55(100%)**	**55(100%)**	**110(100%)**		

Discussion

ST-segment elevation myocardial infarction is a leading cause of cardiac remodeling that badly affects the systolic as well as diastolic function of the left ventricle. The low ejection fraction is linked to poor prognosis. Left ventricular end-diastolic pressure, estimated during PCI, can be used as a marker to predict patient outcomes. Elevated LVEDP is a contributor to low LVEF, heart failure and mortality.[8] Similarly, myocardial blush grade achieved after PCI also has a predictive role in determining patient prognosis. Low MBG is associated with worse outcomes.[12]

In our study, the average age of the patients was 57.6±8.72 years, and 79.1% were males. The average age was 55.7±10.52 years, with the majority of male (81.1%) patients in a study.[10] Similarly, patients had an average age of 59.5±12.71 years in another study, and 75% were males.[11] In a study by Malik et al., the mean age was 54.78 ± 11.84 years with 83.2% males.[9] In our study, 79.1% of the patients were diabetic, 65.5% were hypertensive, 27.3% were smokers, and 15.5% had a positive family history of IHD. In a study by Bhatti et al., 54.7% of the patients had HTN, 37.7% had DM, 29.6% were smokers, and 11.3% had a family history of IHD.[10] In another study, 85% of the patients were diabetic, 91% were hypertensive, and 48% were smokers.[11] Our results showed that the majority of the patients had DVCAD (41%), 33.6% had TVCAD, and 25.4% of them had SVCAD. In a study, there were 34.6% of the patients with SVCAD, 33.3% with DVCAD and 32.1% with TVCAD.[11] The culprit artery was the left anterior descending artery (LAD) in 65.5% of the patients, followed by the right coronary artery (27.3%) and the left circumflex artery (7.2%) in our study. Bhatti et al. revealed that in most of the cases, LAD was involved (52.8%), followed by RCA (30.8%) and LCX (14.5%).[10] Left anterior descending artery was the culprit in 52%, RCA in 35%, and LCX in 13% of the cases in a study by Parvithra et al.[11]

In our study, pre-PCI LVEDP was 20.59±3.78 mmHg, and post-PCI LVEDP was 18.16±3.29 mmHg. Bhatti et al. reported pre-PCI LVEDP of 17.25±5.97 mmHg, and post-PCI LVEDP was 15.59±5.15 mmHg. The post-PCI LVEDP decreased by 1.65 ± 4.35 mmHg.[10] Our results showed that 25.5% of the patients with post-PCI LVEDP <19mmHg had EF <40% than 52.7% of the patients with LVEDP≥19mmHg, with a significant p-value. In another study from Pakistan, post-PCI LVEDP was 18.71 ± 4.67 mmHg. The post-PCI EF was less than 40% in 31.9% of the patients with LVEDP <19mmHg and 57.5% of the patients with LVEDP ≥19mmHg. These results showed a significant association of post-PCI LVEDP with LVEF.[9]

Another study reported lower EF (<40%) and higher mortality in patients with LVEDP >20 mmHg.[13] Zhou et al. reported that higher LVEDP was linked to lower EF, complex lesions and higher rates of adverse events & mortality.[14] According to Bhatti et al, there was a significant difference in LVEF in patients with LVEDP < 19 mmHg and ≥19mmHg. Ejection fraction >50% was achieved in 21.3% versus 0% and 22.6% versus 19.6% of the patients with LVEDP < 19mmHg and ≥19mmHg at 1 month and 3-month follow-up.[10]

Our study reported better EF (>50%) in 36.4% of the patients with MBG ≥2 versus 18.2% in those with MBG <2. A study reported a significant relation between higher MBG and improved post-PCI LVEF and less complications.[15] Hoffmann et al. reported that patients with normal MBG after P-PCI had improved EF (53.7 ± 11.1) as compared to patients with low MBG (37.4 ± 9.7%).[16] On the other hand, pre-PCI and post-PCI EF were 46.42 ±7.08 and 47.59±9.9, respectively, with no statistical difference with MBG grade.[11]

Our study evaluated the relation between LVEDP and myocardial blush grade with post-PCI LVEF at 3 months.

But we did not evaluate the association of LVEDP and MBG with other adverse outcomes, such as mortality and major adverse cardiovascular events (MACE).

Conclusion

Left ventricular end diastolic pressure and myocardial blush grade are reliable, inexpensive and feasible indicators of left ventricular ejection fraction after primary percutaneous coronary intervention in STEMI patients. The post-PCI LVEDP ≤19 mmHg and MBG ≥2 are associated with improvement in the ejection fraction of patients.

References

1. Elendu C, Amaechi DC, Elendu TC, Omeludike EK, Alakwe-Ojimba CE, Obidigbo B, et al. Comprehensive review of ST-segment elevation myocardial infarction: understanding pathophysiology, diagnostic strategies, and current treatment approaches. *Medicine (Baltimore).* 2023 Oct 27;102(43):e35687. https://doi.org/10.1097/MD.0000000000035687
2. Sadiq MW, Siddique MB, Farhan S, Ahmed I, Haider R, Shahzad MMK. Clinical and biological factors affecting left ventricular end-diastolic pressure in ST-segment elevation myocardial infarction. *Pak Armed Forces Med J.* 2025;75(Suppl 3):S390-S396. https://doi.org/10.51253/pafmj.v75i-SUPPL-3-12776
3. Ali S, Samore NA, Ahmed I, Khan MN, Alam F, Mustafa A, et al. Association of acute change in left ventricular end diastolic pressure with in-hospital mortality after primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. *Pak Armed Forces Med J.* 2023;73(Suppl 3):S505-S509. https://doi.org/10.51253/pafmj.v73iSUPPL-3.10560
4. Zuccarelli V, Andreaggi S, Walsh JL, Kotronias RA, Chu M, Vibhishanan J, et al. Treatment and care of patients with ST-segment elevation myocardial infarction: What challenges remain after three decades of primary percutaneous coronary intervention? *J Clin Med.* 2024 ;13(10):2923. https://doi.org/10.3390/jcm13102923
5. Hanson L, Noaman S, Vogrin S, Zheng W, Al-Mukhtar O, Ho F, et al. Association of left ventricular end-diastolic pressure with angiographic reflow and short-term clinical outcomes in patients presenting with ST-elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (P-PCI). *Heart Lung Circ.*2023;32:S423. https://doi.org/10.1016/j.hlc.2023.06.611
6. Pipitone K, Cao JJ, Weber J, Bressler K, Tarantino C, Sandhovel K, et al. The impact of left ventricular end diastolic pressure on adverse clinical outcome between subjects with preserved and reduced left ventricular ejection fraction. *J Cardiovasc Magn Reson.* 2025;27(1):101463. https://doi.org/10.1186/s12968-025-01075-2
7. Khan SW, Ahtesham M, Azim FE, Sajid M, Fayyaz A, Ullah I, et al. Prognostic value of myocardial blush grade in patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PCI): association with reperfusion success and in-hospital outcomes. *Cureus.* 2025;17(11):e96717. https://doi.org/10.7759/cureus.96717
8. Khan AA, Williams T, Ray M, Al-Omary MS, Taylor J, Collins N, et al. Impact of left ventricular end-diastolic pressure on clinical outcomes in patients with ST-elevation myocardial infarction (Hunter LVEDP Study): a prospective, single-centre study. *BMJ Open.* 2025 Jul 5;15(7):e090465. https://doi.org/10.1136/bmjopen-2024-090465
9. Malik AI, Abbas T, Tariq H, Ashfaq A. Impact of postprocedural left ventricular end-diastolic pressure on microvascular perfusion and myocardial function after primary percutaneous coronary intervention in acute myocardial infarction. *Pak Heart J.* 2025;58(Suppl 3):263-270.
10. Bhatti UH, Naseeb K, Khan MN, Mal V, Baqai MA, Karim M, et al. Improvement in LV end-diastolic pressure after primary PCI and its impact on patients' recovery. *Br J Cardiol.* 2023 Nov 29;30(4):43. https://doi.org/10.5837/bjc.2023.043
11. Pavithra L, Hegde AV, Prakash VS. Myocardial blush grade: association between post percutaneous intervention and left ventricular ejection fraction. *Eur J Cardiovasc Med.* 2024;14(6):566-571.
12. Vera Cruz P, Palmes P, Bacalangco N. Prognostic value of myocardial blush grade in ST-elevation MI: a systematic review and meta-analysis. *Interv Cardiol.* 2022 Jul 21;17:e10. https://doi.org/10.15420/icr.2022.01
13. Siano M, Jobanputra Y, Oliva A, Sartori S, Smith K, Kaur H, et al. Impact of left ventricular end-diastolic pressure on percutaneous coronary intervention outcomes. *J Soc Cardiovasc Angiogr Interv.* 2025 Nov 18;4(12):104017. https://doi.org/10.1016/j.jscai.2025.104017
14. Zhou X, Lei M, Zhou D, Li G, Duan Z, Zhou S, et al. Clinical factors affecting left ventricular end-diastolic pressure in patients with acute ST-segment elevation myocardial infarction. *Ann Palliat Med.* 2020 Jul;9(4):1834-1840. https://doi.org/10.21037/apm.2020.03.22
15. Rehman AU, Malik J, Javed N, Iftikhar I, Sharif H. Myocardial blush grade: a determinant of left ventricular ejection fraction and adverse outcomes in STEMI. *Scott Med J.* 2021 Feb;66(1):34-39. https://doi.org/10.1177/0036933020941260
16. Hoffmann R, Haager P, Arning J, Christott P, Radke P, Blindt R, et al. Usefulness of myocardial blush grade early and late after primary coronary angioplasty for acute myocardial infarction in predicting left ventricular function. *Am J Cardiol.* 2003 Nov 1;92(9):1015-1019. https://doi.org/10.1016/j.amjcard.2003.07.001