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Original Article

ADULT CARDIOLOGY

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

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ABSTRACT

Objective: To investigate the relationship between acute changes in Left Ventricular End Diastolic Pressure (LVEDP) and in-hospital mortality in patients with ST-segment Elevation Myocardial Infarction (STEMI) who underwent Primary Percutaneous Coronary Intervention (PPCI).

Study Design: Analytical Cross-sectional study.

Place and Duration of Study: Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi Pakistan, from Sep 2022 to Dec 2022.

Methodology: Patients (n=104) with STEMI who underwent primary PCI of the culprit coronary artery with deployment of drug eluting stent were recruited through consecutive sampling. Left ventricular end-diastolic pressure values were measured pre-and Post-Primary Percutaneous Coronary Intervention. Mean, median and standard deviation were obtained for continuous variables while percentages and frequencies for categorical variables. Chi square test was applied to check association. $p<0.05$ was considered significant.

Results: Out of 104 patients, Males were 62(59.6%) and mean age was 64.04±10.04 years. Hypertensive patients were 85(81.7%) and 67(64.4%) were diabetic. The median LVEDP was 21 mmHg while the mean pre- and post-intervention left ventricular end-diastolic pressure was 21.39±3.42mmHg and 13.54±4.50mmHg respectively, with mean reduction of 7.85±3.33 mmHg. Following Primary Percutaneous Coronary Intervention, patients who exhibited elevated LVEDP experienced an in-hospital mortality rate of 7(70%), (p<0.001).

Conclusion: Patients who did not exhibit a notable decrease in left ventricle end-diastolic pressure after intervention were at an increased risk of in-hospital mortality. This heightened risk was strongly associated with elevated levels of left ventricle end-diastolic pressure.

Keywords: In-hospital Mortality, Left Ventricular End Diastolic Pressure, Primary Percutaneous Coronary Intervention.

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INTRODUCTION

Despite significant advancements in the diagnosis and treatment of Coronary Artery Disease (CAD), Myocardial Infarction (MI) remains the primary cause of morbidity and mortality.[1,2] In 2015, CAD alone accounted for approximately 8.9 million deaths globally.[3] In Pakistan every 1 in 4 adult is a victim of this disease.[4] The etiology of MI is polygenic, with both modifiable and non-modifiable risk factors playing a role. Some of the most significant risk factors include cigarette smoking, hypertension, hyperlipidemia, obesity, and diabetes mellitus.[5]

ST-Elevation Myocardial Infarction (STEMI) is a prominent contributor to the development of Heart Failure (HF) and serves as a primary factor in the mortality associated with Acute Coronary Syndrome (ACS). Post-infarct remodeling is a critical factor in the development of HF and occurs in approximately 30% of patients with a previous anterior wall MI and 17% of patients with a non-anterior wall MI.[6] STEMI has a detrimental impact on both the diastolic and systolic functions of the left ventricle (LV). The LV systolic function is typically assessed through the measurement of Left Ventricular Ejection Fraction (LVEF), while LV compliance is indicated by LV End Diastolic Pressure (LVEDP). Following an acute STEMI, LVEDP increases due to myocardial edema caused by ischemic-induced myocardial wall stiffening and reduced LV compliance. Elevated LVEDP in

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patients with STEMI is strongly associated with higher rates of both in-hospital and remote mortalities.[7] According to Laplace's law, the wall stress of the left ventricle (LV) is determined by the product of LV pressure and radius, divided by twice the wall thickness. As a result, LVEDP is directly related to wall stress and serves as the primary mediator of LV remodeling following STEMI.[8] LV remodeling is a maladaptive process that occurs after myocardial insult and is typified by alterations in LV structure, shape and function.[6]

The timely implementation of Primary Percutaneous Coronary Intervention (PPCI) with the deployment of a drug eluting stent is an effective approach to restore unobstructed blood flow in the affected coronary artery. This intervention helps prevent post-infarction remodeling and significantly reduces the risk of developing HF. Furthermore, as LV filling pressures are remarkably elevated in STEMI patients, early PPCI not only ameliorates overall LV function but also reduces infarct size and hence, reduces mortality rate.[9] A recent meta-analysis reported that elevated LVEDP in patients with STEMI led to high incidence of HF and deaths.[10] Reperfusion therapy reestablishes free flow in epicardial vessels and improves overall survival rate as well. Therefore, it is important to obtain LVEDP value in such cases to predict prognostic outcomes, rectify treatment direction, identify and manage corresponding factors that influence LVEDP. Current study's main objective was to examine the relationship of acute changes in Left Ventricular End Diastolic Pressure with patients' mortality within the hospital, who presented with STEMI and underwent PPCI.

METHODOLOGY

This was Analytical Cross-sectional study, carried out at AFIC/NIHD, Rawalpindi, from September 2022 to December 2022 after obtaining approval from the Institutional Ethical Review Board. (IERB# 9/2/R&D/ 2022/208). Data was collected using Non-Probability Consecutive sampling technique.

Sample size of n=95 was calculated by taking prevalence of STEMI 6.6%,[11] by using WHO sample calculator taking 95% Confidence level and margin of error 5%. However, data was collected from 104 patients.

Inclusion Criteria: Patients who presented with chest pain duration less than 12 hours and ST elevation of equal to or more than 2 mm in two or more consecutive irrespective of age and gender and undervent PPCI were included in the study.

Exclusion criteria: Patients who fell outside the PPCI time window, those receiving inotropic support, individuals with unstable angina, and those diagnosed with Non-ST Elevation Myocardial Infarction (NSTEMI) were excluded from the study.

All patients received Aspirin 300mg PO stat, Ticagrelol 180mg PO stat, Heparin 5000IU IV stat, Atorvastatin 80mg PO stat, Glyceryl Trinitrate 0.5 mg SL stat, and Nalbuphine 5 mg IV stat on arrival at the Emergency Department. After obtaining written consent, all patients underwent PPCI. LVEDP was measured prior to and after the successful stenting of the culprit artery with drug elu-ting stent. LVEDP was measured without any complication. After successful PCI, all patients were kept on Aspirin 150mg PO OD, Ticagrelol 90 mg PO BD, Atorvastatin 40mg PO HS and Pantoprazole 40mg HS.

Statistical analyses of data was done by utilizing IBM Statistical Package for Social Sciences (SPSS) for windows 28.00 version. Mean, median and standard deviation were obtained for continuous variables while categorical variables were compared using the chi-square test and expressed as percentages and frequencies. *p*-value less than and equal to 0.05 was taken as statistically significant.

RESULTS

Out of total n=104 study participants, majority were males 62(59.6%). Mean age was 64.04±10.04 years. Majority of the participants were hypertensive 85(81.7%) and diabetic 67(64.4%). The mean decrease in LVEDP post-primary PCI was 7.85±3.33 mmHg. Overall mortality was 10(9.6%) in patients with no significant reduction in LVEDP post-primary PCI (Table-I).

Table-I: Baseline Clinical Characteristics of Study Participants (n=104)

Variables		values
Age (years) Mean±SD		64.04±10.04
Gender	Female	42(40.4%)
	Male	62(59.6%)
Hypertension		85(81.7%)
Diabetes Mellitus		67(64.4%)
Serum Creatinine (mg/dl) Mean±SD		1.30±0.17
LVEDP Pre-PPCI (mmHg) Mean±SD		21.39±3.42
LVEDP Post-PPCI (mmHg) Mean±SD		13.54±4.50
Mean Decrease in LVEDP post-PPCI (mmHg) Mean±SD		7.85±3.33

Mortality	10(9.6%)

**LVEDP=Left Ventricular End Diastolic Pressure, PPCI=Primary Percutaneous Coronary Intervention*

Table-II displayed the association between mortality and LVEDP value. The median LVEDP value was 21 mmHg. Mortality was high in patients with LVEDP ≥21 mmHg (p<0.001).

Table-II: Association LVEDP with In-Hospital Mortality (n=104)

LVEDP	Mortality		*p*-value
	Yes (n=10)	No (n=94)	
<21 mmHg	3(30.0%)	87(92.6%)	<0.001
≥21 mmHg	7(70.0%)	7(7.4%)	

The incidence of mortality in relationship to reduction in LVEDP below median LVEDP value is shown in Figure. The mortality was reported in 3 patients with a decrease in LVEDP below the median value while it was reported higher in 7 patients with no reduction in LVEDP below median value (p<0.001).

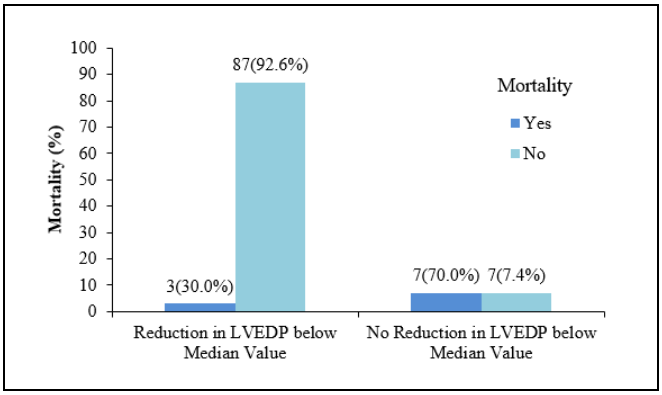

Figure: Incidence of Mortality According to the Reduction of LVEDP Value after PPCI (n=104)

DISCUSSION

In this study, we found that elevated LVEDP is a poor prognostic factor of STEMI and there is a significant relationship between LVEDP and mortality after PPCI. Elevated LVEDP was associated with high in-hospital mortality even after successful stenting of the culprit coronary artery (p<0.001).

In STEMI, LVEDP can be measured quickly during PPCI with low rate of complications. Though STEMI causes both systolic and diastolic dysfunction but diastolic dysfunction occurs too earlier than the former in periods of Ischemia. There were quite a high rates of death, cardiogenic shock and long term re-infarction events in patients who have had elevated LVEDP measured during PPCI. Moreover, a high incidence of HF was observed, which was attributed to a reduced left ventricular ejection fraction. Decrease in LVEDP following PPCI indicates a favorable prognosis, as it signifies improved myocardial reperfusion.[12] Furthermore, addition of nitrates and diuretics in patients with elevated LVEDP after PPCI for STEMI, reduces the LVEDP effectively without serious hazards.[8] Satiroğlu *et al*.[9] reported that PPCI resulted in improvements in both LVEDP and diastolic function among patients diagnosed with acute inferior and anterior STEMI. In most of the patients Thrombolysis in Myocardial Infarction (TIMI) grade-3 flow was established. Similar to our study, there was a significant reduction in post-PPCI LVEDP in most of the patients (21.39±3.42 vs 13.54±4.50).

Watanabe *et al*.[13] reported that there was a strong association between elevated LVEDP and Major Adverse Cardiovascular Events (MACE) and it is a better prognostic indicator than other clinically used analytical parameters such as infarct area, LVEF etc. Additionally, this information serves as a valuable supplement to the Global Registry of Acute Coronary Events (GRACE) risk score for accurately assessing the prognosis and predicting adverse cardiac events. The adverse effects are result of direct interrelation between LVEDP and succeeding LV remodeling. A meta-analysis demonstrated a substantial risk of 30-day mortality and HF among patients with STEMI who exhibited elevated LVEDP.[10] Sola *et al*.[14] found that the ratio of SBP/LVEDP, measured during primary PCI in patients with STEMI, has been found to offer similar prognostic information compared to established risk scores such as TIMI risk score, Killip class, and GRACE risk score. There exists an inverse relationship between the SBP/LVEDP ratio and in-hospital mortality, with higher mortality rates observed in patients with an SBP/LVEDP ratio of equal to or less than 3.

Zhou *et al*.[15] found that there was a positive correlation between elevated LVEDP and various factors, including cardiac enzymes, left ventricular end-diastolic diameter, left atrial end-diastolic diameter, Gensini score for Coronary Artery Disease, N-terminal pro B-type Natriuretic Peptide (BNP), uric acid, low-density lipoprotein cholesterol, and fasting blood glucose. Conversely, a negative correlation is observed with glomerular filtration rate and LVEF. The rate of HF is significantly high in patients with elevated LVEDP. These findings suggested that elevated LVEDP may serve as an indicator of more

severe and widespread cardiovascular pathology. Similarly, Maznyczka *et al*.[16] found that patients with elevated LVEDP of more than 18 mmHg and index of microcirculatory resistance of more than 32 during PCI were at high risk of heart failure related re-hospitalization, non-fatal MI and cardiac death at 1 year follow up. Similar to our study, Cap *et al*.[12] found that there was significant reduction in LVEDP after PPCI. Reduced LVEDP resulted in improved myocardial reperfusion denoted by settlement of ST segment elevations on ECG and better myocardial blush grade during angiography.

Kobayashi *et al*.[17] reported that LVEDP measurement exceeding 22 mmHg was strongly linked with high risk of HF and in-hospital mortality among patients diagnosed with NSTEMI. Analogously Azzalini *et al*.[18] reported that an elevated LVEDP greater than 26 mmHg found to be significantly associated with adverse in-hospital events, including death, in patients who required either urgent or elective PCI. Leistner *et al*.[19] found that LVEDP serves as a valuable tool during PCI in patients with ACS since it can be rapidly obtained in the catheterization laboratory. Additionally, elevated LVEDP in ACS patients has been strongly correlated with increased mortality rates and a higher likelihood of hospital admissions related to heart failure which corroborates with our study results. Therefore, LVEDP can be utilized as a risk stratification parameter in ACS patients, aiding in the assessment and management of their condition.

LIMITATIONS OF STUDY

This study had a few limitations that should be considered. Firstly, it was conducted at a single center, which may limit the generalizability of the findings to other settings or populations. Secondly, the sample size was relatively small, which could affect the statistical power and precision of the results. Thirdly, only in-hospital mortality was assessed, while long-term follow-up of patients was not done, limiting the understanding of the outcomes beyond the immediate hospitalization period. Fourthly, the study focused solely on in-hospital mortality and did not investigate other potential complications. Therefore, conducting a more comprehensive multi-centered study with a larger sample size, long-term follow-up, and evaluation of various outcomes is necessary to establish a more precise relationship between elevated LVEDP and mortality in STEMI patients undergoing PPCI.

CONCLUSION

STEMI is indeed a critical cardiac emergency, and PPCI is widely recognized as the most effective life-saving treatment available in catheterization laboratories. Hemodynamic measurements, including LVEDP, play a crucial role in providing valuable information in a timely manner during PPCI procedures. Furthermore, elevated LVEDP has been identified as a reliable prognostic factor for predicting in-hospital mortality in patients with STEMI. The findings of this study indicated that reduction in LVEDP secondary to PPCI improved the survival rate in STEMI patients.

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Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript:

SA, NAS & IA: Basic concept, Data management, critical review, Final approval, Manuscript writing, Data acquisition.

MNK, FA & AM: Critical review, Final approval, Data management, Proof reading, editing.

AM & MSM: Proof Reading, Data analysis, Data acquisition, Editing, Approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1 Brown JC, Gerhardt TE, Kwon E. Risk factors for coronary artery disease. PubMed. Treasure Island (FL): StatPearls Publishing; 2020. doi: 10.12669/pjms.38.8.6162.

2 Iliou A, Mikros E, Karaman I, Elliott F, Griffin JL, Tzoulaki I, et al. Metabolic phenotyping and cardiovascular disease: an overview of evidence from epidemiological settings. Heart 2021; 107(14): 1123–1129. https://doi: 10.1136/heartjnl-2019-315615.

3 Zhang G, Yu C, Zhou M, Wang L, Zhang Y, Luo L, et al. Burden of Ischaemic heart disease and attributable risk factors in China from 1990 to 2015: findings from the global burden of disease 2015 study. BMC Cardiovasc Disord 2018; 18(1): 1-3. https://doi: 10.1186/s12872-018-0761-0.

4 Jafar TH, Jafary FH, Jessani S, Chaturvedi N. Heart disease epidemic in Pakistan: Women and men at equal risk. Am Heart J 2005; 150(2): 221–226. https://doi: 10.1016/j.ahj.2004.09.025.

5 Gaudel P, Neupane S, Koivisto A-M, Kaunonen M, Rantanen A. Effects of a lifestyle-related risk factor modification intervention on lifestyle changes among patients with coronary artery disease in Nepal. Patient Educ Couns, j.pec 2020.11.030. https://doi: 10.1016/j.pec.2020.11.03.

6 Leanca SA, Crişu D, Petriş AO, Afrasanie I, Genes A, Costache AD, et al. Left Ventricular Remodeling after Myocardial Infarction: From Physiopathology to Treatment. Life 2022; 12(8): 1111. https://doi: 10.3390/life12081111.

7 Kobayashi A, Misumida N, Fox JT, Kanei Y. Prognostic value of left ventricular end-diastolic pressure in patients with non-st-segment elevation myocardial infarction. Cardiology Research 2015; 6(4-5): 301–5. https://doi: 10.14740/cr406w.

8 Khan AA, Davies AJ, Whitehead NJ, McGee M, Al-Omary MS, Baker D, et al. Targeting elevated left ventricular end-diastolic pressure following primary percutaneous coronary intervention for ST-segment elevation myocardial infarction - a phase one safety and feasibility study. Eur Heart J Acute Cardiovasc Care 2020; 9(7): 758–63. https://doi: 10.1177/2048872618819657.

9 Satıroglu O, Cicek Y, Bostan M, Cetin M, Bozkurt E. Acute change in left ventricle end-diastolic pressure after primary percutaneous coronary intervention in patients with st segment elevation myocardial infarction. The American Heart Hospital Journal 2010; 8(2): 86.

10 Brienesse SC, Davies AJ, Khan A, Boyle AJ. Prognostic value of LVEDP in acute myocardial infarction: a systematic review and metaanalysis. J Cardiovasc TranslRes 2018; 11: 33-35. https://doi: 10.1007/s12265-017-9776-7.

11 Ary KA, Barward P, Bahl A, Sharma Y, Gupta H. Rotablation in complex ACS versus Non-ACS patients: Prospective follow up study from tertiary care centre in North India. Indian Heart J. 2022; 74(6): 510-512. https://doi: 10.1016/j.ihj.2022.

12 Cap M, Erdogan E, Karagoz A, Dogan C, Acar RD, Unkun T, et al. Acute change of left ventricular end-diastolic pressure during primary percutaneous coronary intervention and its relationship with early reperfusion parameters. Eastern Journal Of Medicine 2020; 25(2): 250–255. https://doi: 10.5505/ejm.2020.60252.

13 Watanabe I, Saito D, Noike R, Yabe T, Okubo R. Measurement of left ventricular end-diastolic pressure improves the prognostic utility of the global registry of acute coronary events score in patients with ST-segment elevation myocardial infarction. AsiaIntervention 2019; 5(2): 134-140. https://doi: 10.4244/AIJ-D-0132118-00051.

14 Sola M, Rayson R, Venkatesh K, Caughey M, Dai X, Stouffer G, et al. Ratio of systolic blood pressure to left ventricular end-diastolic pressure at the time of percutaneous coronary intervention predicts in-hospital mortality in patients with ST-elevation myocardial infarction. J Am Coll Cardiol 2016; 67(13): 54. https://doi: 10.1002/ccd.26963.

15 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. Annals of Palliative Medicine 2020; 9(4): 1834–1840. https://doi: 10.21037/apm.2020.03.22.

16 Maznyczka AM, McCartney PJ, Oldroyd KG, Lindsay M, McEntegart M, Eteiba H, et al. Risk stratification guided by the index of microcirculatory resistance and left ventricular end-diastolic pressure in acute myocardial infarction. Circ Cardiovasc Interv 2021; 14(2): e009529. https://doi:10.1161/120.009529.

17) Kobayashi A, Misumida N, Fox JT, Kanei Y. Prognostic value of left ventricular end-diastolic pressure in patients with non-st-segment elevation myocardial infarction. cardiology research 2015; 6(4-5):301–5. https://doi: 10.14740/cr406w.

18 Azzalini L, Seth M, Sukul D, Arora DS, Chattahi J, Osman A, et al. Impact of left ventricular end-diastolic pressure on the outcomes of patients undergoing percutaneous coronary intervention. Am J Cardiol 2022; 185: 107–114. https://doi: 10.1016/j.amjcard.2022.09.007.

19 Leistner DM, Dietrich S, Erbay A, Steiner J. Association of left ventricular end-diastolic pressure with mortality in patients undergoing percutaneous coronary intervention for acute coronary syndromes. Catheter Cardiovasc Interv 2020; 96(4): E439–46. https://doi:10.1016/ j.amjcard.2022.09.007.