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Acute Change of Left Ventricular End-diastolic Pressure during Primary Percutaneous Coronary Intervention and Its Relationship with Early Reperfusion Parameters

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ABSTRACT

Elevated left ventricular end-diastolic pressure (LVEDP) is associated with adverse outcomes among those patients with ST-elevation myocardial infarction (STEMI).We aim to investigate the acute change of LVEDP in patients with STEMI and the relationship between LVEDP and early reperfusion parameters, such as ST-segment resolution (STR%) and myocardial blush grade (MBG).
A total of 51 consecutive patients with STEMI who had undergone successful primary percutaneous coronary intervention (pPCI) with TIMI flow grade 3 were included in the study. LVEDP measurements were performed at the beginning (pre-pPCI LVEDP) and end of (post-pPCI LVEDP) the pPCI. MBG was defined after a successful pPCI; STR% was calculated 60 minutes after pPCI.
The mean pre-pPCI LVEDP was 22.1 ± 4.8 mmHg and the post-pPCI LVEDP was 19.4 ± 4.8 mmHg. There was a mean 2.7±1.8 mmHg decrease in LVEDP values after pPCI which was statistically significant (95% CI -3.2, -2.2, p value< 0.001). Post-pPCI LVEDP median value was 19 mmHg. The patients were divided into two groups according to median value: there were 26 (51%) patients with post-pPCI LVEDP≤ 19 mmHg and 25 (49%) patients with post-pPCI LVEDP> 19 mmHg. STR% and MBG were significantly different between the two groups (p= 0.03 and p= 0.01). Post-pPCI LVEDP had a moderate negative correlation with MBG (r= -0.438) and STR% (r= -0.501).
In this study, we demonstrated that primary PCI might substantially reduce the LVEDP level. Moreover, the LVEDP levels achieved after PCI might be associated with myocardial reperfusion, assessed by STR% on ECG and MBG during angiography.

Key Words: Left ventricular end-diastolic pressure, ST-segment elevation myocardial infarction, Myocardial blush grade, ST-segment resolution

Introduction

Acute myocardial infarction is associated with high mortality rates. Despite advances in diagnosis and treatment, mortality remains substantial in ST-elevation myocardial infarction (STEMI) patients (1). Although there are numerous studies on systolic functions, research on the invasive evaluation of the diastolic functions of the heart is limited. In STEMI patients, diastolic and systolic functions deteriorate consecutively. (2) Left ventricular end-diastolic pressure (LVEDP) reflects left ventricular compliance and is affected by acute conditions such as myocardial infarction. Parallel to this, LVEDP values frequently increases in acute myocardial infarction. (3,4,5) The results of the two large-scale studies on LVEDP among STEMI patients have shown that LVEDP is an independent predictor of poor outcomes. (3,6) In a recent meta-analysis, death and heart failure were observed to increase significantly in the STEMI

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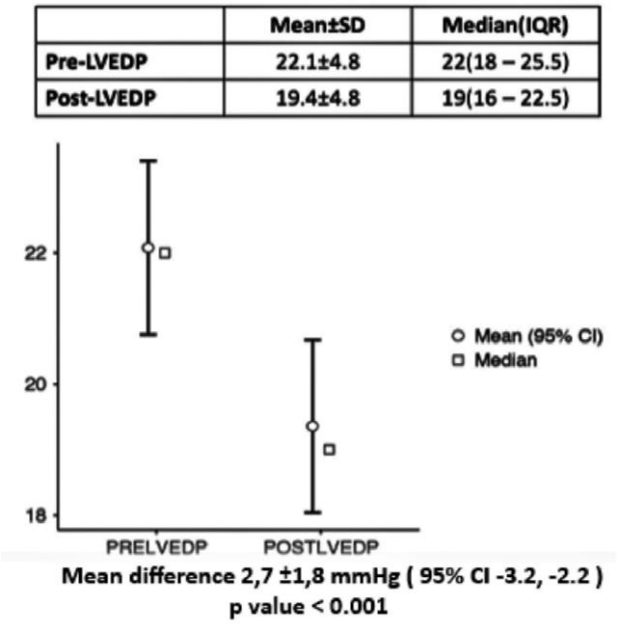

Fig. 1. LVEDP change after primary percutaneous coronary intervention

patients who suffer from high LVEDP levels. (7) Another study demonstrated the Left Ventricular Ejection Fraction (LVEF)/LVEDP ratio was independently associated with long term cardiac mortality. (8)

Myocardial blush grade (MBG) is an angiographic measure of myocardial perfusion and a strong angiographic predictor of mortality in patients with TIMI 3 flow after primary angioplasty (9). ST-segment resolution(STR%) is an electrocardiographic marker of reperfusion and an independent predictor of major adverse cardiovascular events in STEMI patients (10). There is limited information about early changes of LVEDP and its relationship with reperfusion parameters, such as MBG[9] and STR% in patients with STEMI (10). In a small-scale study, LVEDP has been found to significantly decrease after successful revascularization (11). In a separate study, it was found that those patients with high LVEDP values after fibrinolytic treatment tend to have lower TIMI flow grades and have insufficient myocardial perfusion. (12)

In our study, we aimed to investigate the acute change of LVEDP during the primary percutaneous coronary intervention (pPCI) and the relationship between LVEDP and early period reperfusion parameters, such as STR% and MBG.

Material and Methods

Fifty-one patients who were diagnosed with symptoms of the first episode of acute STEMI and underwent successful primary percutaneous coronary intervention (pPCI) with TIMI grade flow 3 were recruited for this study. They were examined within 12 hours after the onset of symptoms. STEMI was defined as the presence of typical chest pain and ST-segment elevation in at least two contiguous leads ≥ 1 mm in the absence of left ventricular hypertrophy or left bundle branch block (LBBB). (13) Informed consent for invasive coronary angiography was obtained from all the participating patients. The patients who had atrial fibrillation, cardiogenic shock, LBBB, cardiomyopathy, myocardial infarction with nonobstructive coronary artery, mechanical complications of myocardial infarction, pacemaker rhythm, prior myocardial infarction or coronary artery bypass grafting and coronary occlusions unsuitable for PCI were excluded from the study.

Angiographic Examination and Definition: Coronary angiography, primary PCI, and periprocedural care conformed to the current guidelines. The wire was crossed off the culprit lesion within the first 60 minutes of admission to the hospital in all the participating patients. LVEDP measured at the beginning (pre-pPCI) and end of (post-pPCI) the pPCI. LVEDP measurement was performed using pressure tracing just after the atrial contraction and during the simultaneous ECG recording; the pressure measurement point corresponded to the top of the R wave. (14) TIMI flow grade was defined as TIMI 0, no perfusion; TIMI 1 penetration without perfusion; TIMI 2 partial reperfusion; and TIMI 3 complete reperfusion. (15)

MBG has been defined as follows: 0 with no myocardial blush(MB) or contrast density (CD); 1 with minimal MB or CD; 2 with moderate MB or CD; 3 with normal MB or CD comparable with that obtained during angiography of a non-infarct-related coronary artery. (9) Coronary angiography was performed with Siemens Artis Zee Floor angiography machine.

St Segment Resolution (STR%): Electrocardiography(ECG) was performed on all patients upon admission to the hospital before the procedure and 60 minutes after pPCI. The sum of ST-segment elevation was measured 20 milliseconds after the end of QRS complex and ST resolution was calculated as a percentage and millimetric reduction of the absolute STE evaluation in the single lead, which is associated with the infarct territory with maximum STE on the baseline ECG. (16) ECG was performed with Nihon Kohten Electrocardiograph (model ECG 2350)

Echocardiographic evaluation was performed 24 hours after admission, and the LVEF was measured

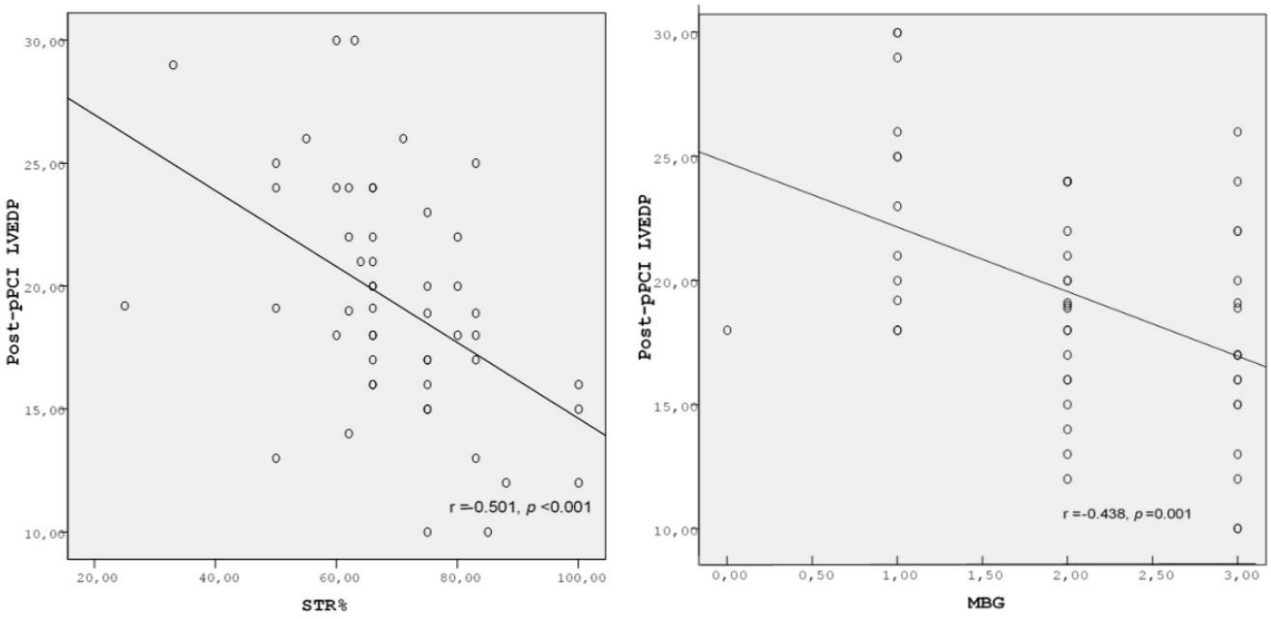

Fig. 2. Correlation Graphics between Post-pPCI LVEDP and ST-segment resolution % (STR%), Miyocardial Blush grade (MBG)

by modified Simpson method. The study was approved by the local institutional ethics committee.

Statistics: Data was expressed as median (interquartile range) and mean ± standard deviation for the continuous variables. After evaluating normality with the Kolmogorov Smirnov test, continuous variables compared by Mann-Whitney U test or Student's T test. Categorical variables were expressed as percentage and compared by the chi-square test.

The relationship between the two continuous and ordinal variables was assessed by Pearson or Spearman correlation coefficients. All the statistical analyses were performed by IBM SPSS Statistic for Windows ,Version 21.0

Results

The mean age was 56±8 years in the study population. 8(16%) patients were female and 17(33%) patients had anterior STEMI. The mean pre-pPCI LVEDP was 22.1 ± 4.8 mmHg and the post-pPCI LVEDP was 19.4 ± 4.8 mmHg. There was a mean 2.7±1.8 mmHg decrease in LVEDP values after successful pPCI which was statistically significant (95% CI -3.2, -2.2 p value < 0.001) Figure 1.

The post-pPCI LVEDP median value was 19 mmHg. Patients were divided into two groups according to the median LVEDP value. There were 26 (51%) patients with post-pPCI LVEDP ≤ 19 mmHg and 25 (49%) patients with post-pPCI LVEDP > 19 mmHg. The median STR% value was 66% ($62^{\%25}$-$80^{\%75}$) and median MBG was 2 ($1^{\%25}$- $3^{\%75}$). Anterior MI ratio was significantly higher in LVEDP > 19 mmHg group (p = 0.001). LVEF% values were significantly different between the two groups (p = 0.004). The mean LVEF% was 55 ± 7% in the patients with LVEDP ≤ 19 mmHg and 49 ± 6% in the patients with LVEDP > 19 mmHg. Baseline characteristics of the patients were given in Table 1.

There was a moderate positive correlation between the post-pPCI LVEDP levels and the time of the symptom onset since admission at the hospital (r =0.399). STR% and MBG values were significantly different between the groups (respectively p = 0.03 and p = 0.01) and were lower in post-pPCI LVEDP > 19 mmHg group. Post-pPCI LVEDP had a moderate negative correlation with MBG (r = -0.438), STR% (r = -0.501). Correlation graphics of post-pPCI LVEDP with STR% and MBG are shown in Figure 2.

Discussion

The main findings of this study are as follows: 1) Significantly decrease was observed in LVEDP after successful pPCI 2) Reperfusion parameters such as MBG and STR% were found to be low in patients with high post-pPCI LVEDP levels. Although the patients with TIMI-III flow were included in the study, LVEDP elevation was associated with low blood supply at tissue level.

In a previous small scale study, it was found that LVEDP difference before and after pPCI was substantial. (11) Supporting these findings, in our study, it was observed that LVEDP decrease after successful pPCI was statistically significant. This was

Table 1. Baseline Characteristics

	Post-pPCI LVEDP<19 mmHg n=26	Post-pPCI LVEDP≥19mmHg n=25	p value
Age(years)	54±7	58±10	0.184[b]
Gender (Woman)	4 (%15.3)	4 (%16)	0.95[c]
Diabetes	5 (%19.2)	6 (%24)	0.67[c]
Hypertension	9 (%34)	12 (%48)	0.33[c]
Hyperlipidemia	2 (%7.6)	4 (%16)	0.35[c]
Smoking	16 (%61.5)	16 (%64)	0.86[c]
Anterior infarction localisation	3 (%11.5)	14 (%56)	0.001[c]
LVEF%(biplane)	55±7	49±7	0.004[b]
Creatinine(mg/dl)	0,75±0,17	0,75±0,20	0.946[b]
Hemoglobin(gr/dl)	14.1 (13.4-14.7)	14.5 (13.1-15.1)	0.988[b]
Platelet(10^3/ μg)	221±46	221±55	0.725[b]
Time to admission interval (h)	2 (2-3)	4 (2.5-4.5)	<0.001[a]
MBG	2 (2-3)	2 (1-2)	0.01[a]
ST segment resolution (%)	75 (66-83)	66 (57-68)	0.03[a]
LVEDP Change(mmHg)	2,6±1,6	2,9± 2,1	0.589[b]
Pre-pPCI LVEDP mmHg	18,3± 2,9	26± 2,8	<0.001[b]
Systolic blood pressure (mmHg)	124±19	132±20	0.173[b]
Mitral E/A	1.13 (0.86-1.26)	0.96 (0.78-1.33)	0.758[a]
DT(msn)	186 (151-216)	190 (165-219)	0.593[a]
Mitral E/e' septal(TDI)	10.5 (8.1-12.8)	9.6 (7.3-12)	0.457[a]
Mitral E/e' lateral(TDI)	7 (5.6-9.8)	7.2 (5.9-10.7)	0.601[a]

Continuous variables are expressed as mean±SD or median (25-75 percentile), Categorical data are presented as absolute (percentage). Two groups compared by Mann-Whitney U test(a) or Student's T test for continuous variables and chi-square test(c) for categorical variables. MBG, Myocardial blush grade; LVEF, Left ventricular ejection fraction; pPCI, Primary percutaneous coronary intervention; LVEDP, Left ventricular end diastolic pressure; TDI,Tissue doppler image; DT, deceleration time.

thought to be due to the improvement of impaired diastolic functions after revascularization. In the previous large scale studies that assessed prognostic importance of LVEDP, the timing for measurement of the LVEDP was at the discretion of the operator or not specified. LVEDP measurement was performed pre or post-pPCI and the timing of measurement were unknown in some patient (3,6). Depending at the time of the measurement (i.e. before or after pPCI), the LVEDP values may change and this situation may affect the study outcomes. Considering that the decrease in LVEDP after revascularization was significant, it was predicted that the pre-pPCI measurement without knowing the outcome of the pPCI may affect the results, so that post-pPCI measurement of LVEDP might be more accurate. Hence, we used post-pPCI LVEDP values in our study.

Invasive LVEDP measurement can be performed rapidly with low complication rates in STEMI

patients undergoing pPCI. (11) While both systolic and diastolic functions of the left ventricle are impaired in STEMI, diastolic functions are affected earlier than systolic functions during ischemia.[2] Previous large-scale studies have shown that increased LVEDP is an independent predictor of adverse outcomes in terms of death, cardiogenic shock, and reinfarction in long-term follow-up. (3,6) Furthermore, in patients who suffer from high LVEDP values LVEF% has been found to be low and heart failure rates have been observed to be high. (18) The results of a recent study showed in patients with STEMI, elevated LVEDP was correlated with the extent of myocardial ischemia and increased risk of long-term cardiac mortality. Consistent with these findings, in our study, LVEF% was significantly lower in patients with LVEDP > 19 mmHg. (19) In another study performed on STEMI patients treated with fibrinolytic therapy, high LVEDP level was associated with both an occluded infarct-related artery and impaired myocardial perfusion. (12) Although the patients who participated in our study had TIMI-III grade flow, the blood flow at tissue level—assessed by MBG—was lower in the group with higher LVEDP values. Parallel to this, the patients with high LVEDP levels had significantly lower STR% values within the first hour after successful pPCI. Similar to the previous studies, anterior MI ratio was higher in these patients and the time from symptom onset to hospital admission was longer. We hypothesize that the decrease in LVEDP may indicate a better prognosis by improving tissue level blood flow after primary PCI. However, even if the TIMI-III flow is established after primary PCI, a high LVEDP can still be measured.

Considering the significant decrease in LVEDP, the optimal timing of LVEDP measurement was thought to be after reperfusion. Due to the relationship between high LVEDP values with reperfusion parameters, LVEDP values may be used as a guide in the selected patient groups for closer monitoring, and application of intensive treatment in terms of poor prognosis.

In this study, we demonstrated that primary PCI might substantially reduce the LVEDP level. Moreover, the LVEDP levels achieved after PCI might be associated with myocardial reperfusion, assessed by STR% on ECG and MBG during angiography.

Limitations: The small number of participants may have undermined the possibility of extrapolating the results of this study to a wide range of patients; this was mainly because of the broad exclusion criteria, which allowed only patients with TIMI-III grade flow to take part in this research. Further comprehensive studies are needed for long-term surveillance of these patients.

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