The Egyptian Journal of Hospital Medicine (April 2022) Vol. 87, Page 1027-1033

Short Term Evolution of Left Ventricular Diastolic Function Following Primary Percutaneous Coronary Intervention

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ABSTRACT

Background: It is well established fact that acute coronary occlusion leads to diastolic dysfunction, followed by systolic dysfunction when myonecrosis occurs. It is also proven that primary percutaneous coronary intervention (PPCI) is an excellent therapy for ST elevation myocardial infarction (STEMI) to improve outcomes. However there is a paucity of information on efficacy of PPCI in improving diastolic function. Evaluation of the role of PPCI in improving diastolic dysfunction is required. **Objective:** To evaluate diastolic dysfunction recovery following successful PCI in STEMI patients according to the occluded artery including Left Anterior Descending (LAD) group and Non-LAD group including Left Circumflex Artery (LCX) and Right Coronary Artery (RCA).

Patients and methods: The study included sixty one patients who were presented to emergency room with STEMI and underwent primary PCI. Echocardiographic evaluation was performed within 24 h of PPCI and then on 3 months after PPCI. We evaluated the prevalence of diastolic dysfunction after PPCI and its recovery during 3 months.

Results: There was a significant difference between grading of degree of diastolic dysfunction before PCI and after 3-months follow up with significant improvement after PCI. **Conclusion**: We concluded that primary PCI improves diastolic dysfunction in patients with anterior wall STEMI over a period of 3 months.

Keywords: Diastolic dysfunction, Primary percutaneous coronary intervention, ST elevation myocardial infarction.

INTRODUCTION

An acute ST-elevation myocardial infarction (STEMI) is an event in which transmural myocardial ischemia results in myocardial injury or necrosis. Although the incidence of STEMI has decreased over the past decade, it remains a common and morbid diagnosis [(1)]. It is a life-threatening situation, rapid and correct decision making for life saving of patients in emergency room is very important [(2)].

MI damages the regional myocardium that undergoes ischemia and necrosis, resulting in impairment of both systolic and diastolic functions of the heart. Ischemia of myocardial cells, interstitial edema, and regional wall motion abnormalities resulting from MI affect active and passive relaxation of ventricles. Left ventricular (LV) function and myocardial infarct size both serve as the main determinants of patients' outcome after MI [(3)].

Currently, the primary strategy for treating MI is based on pharmacological thrombolytic or percutaneous coronary intervention (PCI) reperfusion therapy. PCI has progressed from balloon angioplasty to drug-eluting stents and now bioabsorbable stents. Now it is a very powerful tool to preserve ischemic myocardium and reduce mortality as the sooner the ischemic myocardium gets reperfused by PCI, the better the patient's LV function recovers [(4)].

Acute myocardial infarction (AMI) is a leading cause of heart failure, despite significant treatment advancements in recent years. Development of new onset heart failure in patients with AMI is a poor prognostic sign with higher in hospital mortality [(5)]. A number of studies have indicated that both mortality and morbidity rates can be reduced in ST elevation myocardial infarction (STEMI) patients who receive timely primary percutaneous coronary intervention (PPCI) [(6)]. Although LV (left ventricle) systolic function is a well-known prognostic factor in patients with AMI, a growing body of evidence indicates that left ventricular diastolic dysfunction (LVDD), as assessed by Doppler echocardiography, is also an important predictor of patient outcomes after AMI [(7)]. A normal LV filling pattern illustrating cardiac diastolic function was seen in only one third of patients in the acute phase of MI, and an abnormal pattern usually indicated patients having higher risk of developing permanent heart failure [(8)].Two-dimensional echocardiography (2D Echo) is the technique of choice to assess and monitor remodeling after AMI, enabling a precise definition of magnitude and timing of the process. In addition, Doppler echocardiography has provided evidence that serial changes in diastolic filling pattern may parallel the evolutionary changes in LV dimensions after AMI [(9)]. Previous studies on primary PCI showed that coronary reperfusion caused an immediate improvement in diastolic function by increasing LV compliance and in systolic function by increasing apical contractility in STEMI patients [(10)].

On the other hand, **Chen and colleagues** [(11)] concluded that STEMI patients receiving early myocardial reperfusion had no better diastolic functions compared with late re-perfused patients within the acute phase.

The aim of the present study was to evaluate diastolic dysfunction recovery following successful PCI in STEMI patients according to the occluded artery including Left Anterior Descending (LAD) group and Non-LAD group including Left Circumflex Artery (LCX) and Right Coronary Artery (RCA).

PATIENT AND METHODS

The study was done in Cardiology Department, Zagazig University Hospitals and National Heart

Received: 24/09/2021
Accepted: 22/11/2021

Institute and included sixty one patients who were presented to ER with STEMI and underwent primary PCI .

Inclusion criteria: Patient with acute STEMI who meets the following criteria: age: 18 - 60 years, give a written informed consent to be enrolled in the study, presented to the emergency unit within 12 hours of chest pain onset with ST-segment elevation myocardial infarction amenable to PCI, had ECG done on admission or at acute onset of chest pain, had cardiac biomarker done on admission or 12 hours from acute onset of chest pain and indicated for invasive coronary angiography done.

Exclusion criteria: patients refused to give a consent to participate in the study, age > 60 years, patients with multi vessel disease, patients with cardiogenic shock, prior history of myocardial infarction (MI)/coronary artery bypass graft (CABG) or PCI and significant stenosis (>50%) of any other coronary arteries, patients with ST elevation on electrocardiogram (ECG) without obvious coronary artery diseases such as acute myocarditis, early repolarization, or Takotsubo cardiomyopathy, valvular Heart disease, pericardial disease such as acute pericarditis and pericardial effusion and patients with atrial flutter, atrial fibrillation or complete heart block.

Study design:

Detailed history, demographic characteristics and physical examination findings were recorded with special attention to the coronary risk factors like smoking, dyslipidemia, hypertension, diabetes and family history of ischemic heart disease. Routine biochemical investigations were done and pharmacotherapy started as per department's protocol. Primary PCI with stenting was done by standard technique on all eligible consenting patients as per department's protocol. 2D echocardiography with colour Doppler assessment was done within 24 h after PPCI on Philips SONOS 5500 Echo machine, USA.

Assessment of diastolic dysfunction:

The following parameters were assessed:

Pulsed wave (PW) Doppler was performed in the apical 4 chamber view within 3 mm sample volume at the tip of the mitral leaflets to obtain mitral inflow velocities to assess LV filling.

E (early diastolic)/A (late diastolic) - Using PW Doppler the peak E and A velocities were recorded, then ratio of E/A was calculated.

Deceleration time (DT) - from peak of E wave to baseline .

E/e'- PW tissue Doppler imaging (TDI) was performed in the apical views to acquire mitral annular velocities. The sample volume was positioned at or 1 cm within the septal site of the mitral leaflet.

Left atrial volume and left atrial volume index (LAVI) - The maximal left atrial (LA) volume was measured from the apical four-chamber view by using the modified Simpson method in end-systole before mitral valve opening. The LAVI was obtained for all patients by dividing the LA volume by the body surface area.

TR velocity.

Left atrial volumes.

Left ventricular ejection fraction by modified Simpson's method.

Regional Wall Motion Abnormality (RWMA).

Then grading of degree of Diastolic dysfunction according to the American society of echocardiography [(12)].

Follow up:

A clinical follow-up was also performed at 3 months. We evaluated the occurrence of major adverse cardiac events (MACE) [cardiac death, Q and non-Q wave MI, target vessel revascularization] at 3 months. We also assessed the incidence of stent thrombosis indicated as ''definite,'' ''probable,'' and ''possible'' according to the Academic Research Consortium (ARC) definition.

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance to be enrolled in the study. The patient had the right to withdraw from the study at any time without any negative consequence on the treatment plane. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for the Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Wilk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) was used to compare independent qualitative data while marginal homogeneity test was used to compare paired qualitative data. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data) and Mann-Whitney U test was used to compare nonparametric data. P value < 0.05 was considered significant and P≤ 0.0001 was considered highly significant.

RESULTS

Table 1 shows that there was no statistically significant difference between both studied groups as regard demographic characteristics. While there was a significant difference between LAD group and non-LAD group regarding presence of thrombus and dyslipidemia,

non-LAD group had higher percent of dyslipidemia.
LAD group had higher percent of thrombus.

Table (1): Comparison of demographic characteristics and risk factors in the two groups

Variable	Studied groups		p-value
	LAD (n. 39) n. (%)	non LAD (n. 22) n. (%)	
Age in years Mean ±SD Range	52.08±5.16 42-59	54.5±4.43 43-59	0.070
gender Males Females	 22 (56.4) 17 (43.6)	 10 (45.5) 12 (54.5)	 0.41
Smoking habit	17 (43.6)	10 (45.5)	0.89
Family history	24 (61.5)	13 (59.1)	0.85
Hypertension	18 (46.2)	13 (59.1)	0.33
Diabetes mellitus	23 (59.0)	10 (45.5)	0.31
Dyslipidemia	17 (43.6)	16 (72.7)	0.03(S)
Obesity	20 (51.3)	12 (54.5)	0.81
Presence of thrombus	7 (17.9)	0 (0.00)	0.04 (S)

Table (2) shows that there was a significant difference between LAD and non-LAD group as regard RWMA before PCI. Also, there was significant difference between the 2 groups at baseline data as regard, E/A ratio, DT, E/e', LAVI, TR velocity, septal e' velocity, left atrial volumes and LV ejection fraction.

Table (2): Comparison of grading of RWMA and echocardiographic data in the two groups at the baseline

Variables	Studied groups		p-value
	LAD (n. 39)	non LAD (n. 22)	
RWMA (anterior) (inferior) (septal, anterior, lateral) (lateral) (infero lateral)	 17 (43.6%) 2 (5.1%) 20 (51.3%) 0 (0.0%) 0 (0.0%)	 0 (0.0%) 17 (77.3%) 0 (0.0%) 3 (13.6%) 2 (9.1%)	 0.0001
E/A Mean ±SD	1.08±0.41	0.6±0.13	0.0001
DT Mean ±SD	189.97±27.04	214.77±13.97	0.0001
E/e' Mean ±SD	9.64±2.35	7.73±1.35	0.001
LAVI Mean ±SD	38.51±2.16	36.73±1.93	0.002
TR velocity Mean ±SD	2.87±0.37	2.56±0.24	0.001
Septal e' velocity Mean ±SD	7.01±0.52	7.4±0.38	0.003
Left atrial volumes Mean ±SD	55.46±7.13	49.09±4.71	0.0001
LV ejection fraction (%) Mean ±SD	43.56±7.01	54.91±5.02	0.0001
Diastolic dysfunction No. (%)	39 (%)	22 (%)	1.00

Table (3) shows that there was a significant difference between LAD and non-LAD group as regard grading of degree of diastolic dysfunction.

Table (3): Comparison of grading of degree of Diastolic dysfunction in the two groups at the baseline

	Studied groups				p-value
	LAD (n. 39)		non LAD (n. 22)		
	No.	%	No.	%	
Grading of degree of Diastolic dysfunction					
Grade I	13	33.3	18	81.8	0.001
Grade II	22	56.4	4	18.2	
Grade III	4	10.3	0	0.0	

Table (4) shows that there was no significant difference between the two groups regarding 3 moths clinical outcome.

Table (4): Incidence of 3 months clinical outcome in the two groups

	Studied groups				p-value
	LAD (n. 39)		non LAD (n. 22)		
	No.	%	No.	%	
Major bleeding	6	15.4	2	9.1	0.48
Re-infarction	3	7.7	4	18.2	0.22
3 MFU cardiac death	2	5.1	0.0	0.0	0.28
Stent thrombosis	7	17.94	0.0	18.2	0.04

Table (5) shows that there was a significant difference between LAD and non-LAD group as regard grading of degree of diastolic dysfunction after 3-months follow up.

Table (5): Comparison of grading of degree of diastolic dysfunction in the two groups after 3months follow up

	Studied groups				p-value
	LAD (n. 39)		non-LAD (n. 22)		
	No.	%	No.	%	
Grading of degree of Diastolic dysfunction after follow up	.	.	.	.	
Normal	4	10.3	8	36.4	0.01
Grade I	12	30.8	10	45.4	
Grade II	19	48.7	4	18.2	
Grade III	4	10.3	0	0.0	

Table (6) shows that there was significant difference between the 2 groups at 3-month follow up as regard, E/e', TR velocity, septal e' velocity, left atrial volumes and LV ejection fraction.

Table (6): Comparison between LAD and non-LAD regarding the 3-month follow up echocardiographic data

3-month follow up echocardiographic data	Studied groups		p-value
	LAD (n. 39) Mean ±SD	non LAD (n. 22) Mean ±SD	
E/A	0.8±0.35	0.7±0.32	0.256
DT	192.26±31.47	197.64±20.94	0.428
E/e'	9.39±2.43	7.86±1.12	0.001
LAVI	36.72±2.7	35.27±2.96	0.058
TR velocity	2.75±0.39	2.36±0.498	0.00
Septal e' velocity	7.36±0.78	7.96±1.18	0.02
Left atrial volumes	53.97±7.46	47.09±6.24	0.001
LV ejection fraction	47.56±6.56	55.91±5.44	0.0001

Table (7) shows that there was a significant difference between grading of degree of diastolic dysfunction before PCI and after 3-months follow up.

Table (7): Comparison of grading of degree of diastolic dysfunction before PCI and 3 months follow up after PCI among studied patients (n .61)

	Time				p-value
	Before PCI		After PCI		
	No.	%	No.	%	
Grading of degree of Diastolic dysfunction	.	.	.	.	
Normal	0	0.0	12	19.7	
Grade I	31	50.8	22	36.0	0.0001
Grade II	26	42.6	23	37.7	
Grade III	4	6.6	4	6.6	

DISCUSSION

In the current study there was no statistically significant difference between both studied LAD and non LAD groups as regard demographic characteristics as age in years was 52.08±5.16 and males were affected with 56.4 % in LAD groups. This came in agreement with **Achong *et al.*** [13] who found that most patients were male, had cardiac risk factors and revealed that age in years was 62.3±4.14 and males were affected with 70.5 % in LAD groups.

In the current study in LAD group, the hypertension patients were 18 of 39 with percent of 46.2% while, **Achong *et al.*** [13] revealed that the hypertension patient were 64 of 95 with percent of 67.4%. In disagreement with our study, **Lalande and Johnson** [14] found that an antecedent history of hypertension is common in patients presenting with diastolic heart failure. This difference may be due to our small sample size.

In our study we found that there was significant difference between the 2 groups at baseline data as regard, E/A ratio, DT, E/e', LAVI, TR velocity, septal e' velocity, left atrial volumes and LV ejection fraction. **Chen *et al.*** [15] found that reduced LVEF was more common in STEMI patients with LAD as culprit vessel. They confirmed the occurrence of reduced LVEF (LVEF < 55 %) in non-LAD related MI patients, although this prevalence was lower than that in LAD related MI group (P < 0.01).

In the current study, mean LVEF at the baseline was 43.56±7.01, which was improved to 47.56±6.56 in LAD group with a significant difference. This came in agreement with **Subramaniyan *et al.*** [7] who found that the mean LVEF at the baseline were 41.92 ± 4.82, which was improved to 46.19 ± 5.52 (p value < 0.001). This finding is similar also to study by **Remmelink *et al.*** [10]**.** They have shown that LVEF improved from 40 ± 17% to 54 ± 15% in patients presenting with first anterior wall STEMI within 6 hours of chest pain. Another prospective study has shown that LVEF improved from 48.8 ± 11.6% to 52.5 ± 11.5% at 6 months stenting to LAD [16]**.**

In the present study, there was significant difference regarding E/A, LAVI, septal e' velocity and LV ejection fraction at baseline and 3-months follow up in LAD group while there was no significant difference regarding other parameters. And there was significant difference regarding E/A, DT and septal e' velocity at baseline and 3-months follow up in non-LAD group while there was no significant difference regarding other parameters. This came in agreement with **Subramaniyan *et al.*** [7] who found that some diastolic function echocardiographic parameters improved significantly from baseline to follow up. One of the recent study in acute coronary syndrome (ACS) patients, who had diastolic dysfunction at baseline, showed that in 82% diastolic dysfunction become normal after PCI [17]**.**

Shacham *et al.* [18] **and Prasad *et al.*** [19] found that early evaluation by echo done within 24 h of primary PCI and follow up done by echo up to 6 months, all these factors potentially reduce the confounding factor causing diastolic dysfunction.

Hashemi *et al.* [20] found that not all the diastolic parameters will improve after PCI. They evaluated diastolic echocardiographic findings before PCI and 3 months after PCI. Only there was significant difference regarding E/A and e' velocity. **Cosson and Kevorkian** [21] found that E/A ratio constitutes specially the most significant parameters for an analysis of diastolic dysfunction.

It has been demonstrated that left ventricular diastolic dysfunction in CAD patients begins sooner and improves earlier than systolic dysfunction after treatment [22]**.** Utilizing strain rate imaging, **Tanaka *et al.*** [23] showed that myocardial diastolic function improved in CAD patients after PCI. They suggested that the improvement in left ventricular early diastolic function after PCI might be associated with the degree of improvement in impaired regional myocardial relaxation. **Derumeaux *et al.*** [24] reported that regional diastolic function was impaired during PCI and improved in the early period after PCI. **Cayly *et al.*** [25] posited that regional diastolic function improved at 3 months after successful elective PCI.

There are several possible explanations for persistently impaired diastolic function (DF). First, diastolic dysfunction might not have improved in some

patients because of residual ischemia resulting from incomplete revascularization, development of new ischemia from restenosis of treated lesions, or progression of atherosclerosis in non-culprit lesions [(26)].

A second explanation is that procedural complications, including distal embolization of microemboli or a lack of reflow during PCI, might have resulted in persistently impaired DF. Importantly, both distal embolization and lack of reflow during PCI are associated with adverse outcomes [(27)].

Our data suggested that monitoring diastolic dysfunction before and after revascularization is an important method of predicting long-term clinical outcomes and selecting patients who require more intensive risk factor modification. Previous data showed that the use of echocardiography lowers the risk of death among patients with CAD [(28)].

In the current study, there was a significant difference between grading degree of diastolic dysfunction before PCI and after 3-months follow up. This came in agreement with **Subramaniyan *et al.*** [(7)] who found that diastolic dysfunction improved after follow up. Most of the patients who had impaired relaxation and all grades of diastolic dysfunction improved from baseline to follow up.

CONCLUSION

We concluded that left ventricular diastolic dysfunction occurs more commonly in patients with anterior wall STEMI. Doppler echocardiography is a simple and useful non-invasive method for assessing left ventricular diastolic dysfunction and recovery of diastolic dysfunction in anterior wall STEMI after primary PCI. Primary PCI improves diastolic dysfunction in patients with anterior wall STEMI over a period of 3 months.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

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