Original Article

Effect of Primary Percutaneous Coronary Intervention on Diastolic Dysfunction Recovery in Patients With ST-Segment Elevation Myocardial Infarction

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ABSTRACT

Background: ST-elevation myocardial infarction (STEMI) is a major cause of heart failure, with left ventricular diastolic dysfunction being a key predictor of adverse outcomes. Primary percutaneous coronary intervention (PCI) is the preferred reperfusion strategy for improving both systolic and diastolic functions. This study aimed to determine the effect of primary PCI on the recovery of diastolic dysfunction in patients with STEMI.

Methods: This prospective observational study included 100 patients with STEMI at Misr University for Science and Technology Hospital between September 2023 and February 2024. Key echocardiographic metrics, including deceleration time (DT), E/A ratio, and left atrial volume index (LAVI) were documented at three time points: baseline, immediately following PCI, and at the 3-month follow-up.

Results: At baseline, 58% of patients had diastolic dysfunction. Post-PCI left ventricular ejection fraction (LVEF) improved significantly from 34.8% to 51.9% at 3 months ($P < 0.001$). LA volume and LAVI decreased significantly at 3 months ($P < 0.001$). DT and isovolumic relaxation time showed significant reductions after PCI ($P < 0.001$). E/A ratio improved significantly at 3 months ($P < 0.001$), and 32% of patients demonstrated improvement in diastolic function. The prevalence of diastolic dysfunction was significantly higher among patients who experienced chest pain for a period exceeding 4 hours ($P = 0.010$).

Conclusions: Patients with STEMI demonstrated a significant enhancement in diastolic function after undergoing primary PCI, with notable enhancements in echocardiographic parameters, such as LVEF, E/A ratio, and LAVI. Timely intervention is crucial for optimizing diastolic function recovery. *(Iranian Heart Journal 2026; 27(1): 63-70)*

KEYWORDS: STEMI; primary PCI; echocardiography; diastolic dysfunction; left ventricular function

According to the 2017 ESC guidelines, ST-elevation myocardial infarction (STEMI) occurs when myocardial injury, defined as an elevated cardiac troponin level (>99th percentile upper reference limit), is observed in the context of myocardial ischemia. This ischemia is indicated by persistent chest discomfort, other symptoms, and ST-segment elevation in at least two contiguous ECG leads.[1] Acute myocardial infarction (AMI) continues to represent a leading factor in the development of heart failure, even with the considerable progress achieved in treatment strategies.

The most effective reperfusion approach for patients with STEMI is primary PCI, provided it is performed by an experienced team within 120 minutes of diagnosis and within the first 12 hours after the onset of symptoms.[1] For patients presenting more than 12 hours after symptom onset, PCI is recommended if there are ongoing ischemic symptoms, hemodynamic instability, or life-threatening arrhythmias.[2]

While left ventricular (LV) systolic performance is a widely recognized prognostic indicator in individuals with AMI, emerging studies suggest that LV diastolic dysfunction, as assessed through Doppler echocardiography, plays an equally pivotal role in forecasting post-AMI prognosis.[3] Research indicates that alterations in diastolic filling patterns may mirror the progression of LV dimensions in the aftermath of AMI.

Prompt reestablishment of blood circulation is crucial in preventing LV remodeling and improving diastolic function, given the well-established association between diastolic dysfunction and negative clinical outcomes. Delayed reperfusion increases myocardial stiffness, thus raising the incidence of diastolic dysfunction [4].

This study aims to determine the effect of primary PCI on diastolic dysfunction recovery in patients with STEMI by echocardiography.

METHODS

Study Design and Population
This prospective observational study was conducted on 100 adolescent patients with STEMI. They were selected from the Coronary Catheterization Laboratory of the Cardiology Department at Misr University for Science and Technology (MUST) Hospital during the period from September 2023 through February 2024. The study commenced after receiving approval from the Ethics Committee of the MUST Faculty of Medicine. Informed written consent was obtained from all participants' parents.

Patient Selection Criteria
The selection criteria included both inclusion and exclusion factors. Inclusion criteria were age older than 18 years and presentation with ST-segment elevation myocardial infarction within 48 hours of chest pain onset. Exclusion criteria were presentation more than 48 hours after pain onset without evidence of ongoing ischemia, receipt of thrombolytic reperfusion therapy, resuscitation from cardiac arrest, known heart failure with reduced ejection fraction before the event, pulmonary embolism, significant valvular or congenital heart disease, and moderate to severe pulmonary hypertension.

Patient Procedures and Data Collection
All patients underwent the following:
A thorough history was taken, focusing on coronary artery disease (CAD) risk factors-including age, sex, smoking status, diabetes, hypertension, dyslipidemia, family history of premature CAD, chronic kidney disease, peripheral vascular disease, cerebrovascular disease, and sedentary lifestyle. Clinical examination and laboratory tests-including complete blood count, cardiac enzymes, and serum creatinine-were conducted with attention to patient confidentiality.

Assessment of Diastolic Dysfunction
Echocardiographic data for left ventricular ejection fraction (LVEF) and diastolic function (before primary percutaneous coronary intervention [PCI] and after 3 months) were recorded, including the following parameters[5]:

Pulsed wave Doppler was performed in the apical four-chamber view to assess LV filling, recording the E/A ratio, deceleration time (DT), and E/e′ ratio. Tissue Doppler imaging was used to measure mitral annular velocities, and the left atrial volume index (LAVI) was calculated using the modified Simpson method. Other parameters included tricuspid regurgitation velocity, LA volume, LVEF, and regional wall motion abnormalities. Diastolic function was classified based on the grading system established by the American Society of Echocardiography.

The primary PCI procedure followed guidelines by Subramaniyan et al, [6] where patients received a loading dose of aspirin and a P2Y12 inhibitor, and a high-intensity statin (atorvastatin or rosuvastatin). PCI was performed by experienced cardiologists, with details such as access route, door-to-balloon time, infarct-related artery, stent use, and Thrombolysis in Myocardial Infarction (TIMI) flow grade recorded. Full anti-ischemic medication was administered post-PCI according to the 2017 European Society of Cardiology STEMI guidelines.

Clinical evaluation was performed at the 3-month follow-up.

Statistical Analysis
SPSS, version 23.0, was utilized for statistical analysis of the data. Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. For parametric variables, descriptive statistics were presented as mean (SD) and range (minimum–maximum). For nonparametric data, the median and interquartile range were calculated. Categorical data were summarized as frequencies and percentages.

RESULTS

Baseline characteristics and relevant risk factors are presented in Table 1.

Table 1. Baseline characteristics and risk factors of the studied patients

		Total (No. =100)
Age (y)	Mean (SD)	54.2 (13.06)
	Range	35 - 79
Sex	Male	68 (68%)
	Female	32 (32%)
Weight (kg)	Mean (SD)	78.8 (9.79)
	Range	61 - 95
Height (m)	Mean (SD)	1.7 (0.05)
	Range	1.6 - 1.76
BMI (kg/m^2)	Mean (SD)	27.8 (3.82)
	Range	19.92 - 34.72
Smoking	No. (%)	36 (36%)
Diabetes mellitus	No. (%)	54 (54%)
Hypertension	No. (%)	69 (69%)
Dyslipidemia	No. (%)	38 (38%)
Family history of premature CAD	No. (%)	14 (14%)
Peripheral vascular disease	NO. (%)	6 (6%)
Chronic kidney disease	No. (%)	7 (7%)

BMI: body mass index; CAD: coronary artery disease; MI: myocardial infarction

Regarding the baseline grading of diastolic dysfunction, 42 patients (42%) were categorized as grade 0, 35 patients (35%) as grade I, 13 patients (13%) as grade II, and 10 patients (10%) as grade III. Additionally, 54 patients (54%) presented with anterior MI, 31 patients (31%) with inferior MI, 10 patients (10%) with lateral MI, and 5 patients (5%) with posterior MI (Table 2).

Table 2. Baseline diastolic dysfunction grading and myocardial infarction in the studied patients

		Total (No.= 100)
Baseline Diastolic Dysfunction	Grade 0	42 (42%)
	Grade I	35 (35%)
	Grade II	13 (13%)
	Grade III	10 (10%)
Anterior MI		54 (54%)

Inferior MI		31 (31%)
Lateral MI		10 (10%)
Posterior MI		5 (5%)

MI: myocardial infarction

Clinical examinations and laboratory investigations are mentioned in Table 3.

Table 3. Clinical examination of vital signs, clinical data, and laboratory investigations of the studied patients

		Total (No. =100)
HR (bpm)	Mean (SD)	84.2 (8.38)
	Range	70 - 100
SBP (mm Hg)	Mean (SD)	137.0 (8.35)
	Range	120 - 150
DBP (mm Hg)	Mean (SD)	71.3 (5.8)
	Range	60 - 80
Duration of chest pain (h)	Mean (SD)	8.4 (4.34)
	Range	1 - 15
Door-to-balloon time (min)	Mean (SD)	66.6 (13.56)
	Range	41 - 90
Hb (g/dL)	Mean (SD)	12.4 (0.89)
	Range	11 - 13.9
Platelets (*10^9/L)	Mean (SD)	261.6 (50.09)
	Range	181 - 349
WBCs (*10^9/L)	Mean (SD)	5.8 (0.85)
	Range	4.6 - 7.3
Serum creatinine (mg/dL)	Mean (SD)	0.8 (0.23)
	Range	0.6 - 1.8
Urea (mg/dL)	Mean (SD)	41.2 (9.61)
	Range	25 - 59
INR	Mean (SD)	1.1 (0.11)
	Range	0.9 - 1.2
PT (s)	Mean (SD)	12.2 (0.74)
	Range	11.1 - 13.5
Troponin (ng/mL)	Mean (SD)	2.6 (1.15)
	Range	0.5 - 4.5

DSB: diastolic blood pressure; SBP: systolic blood pressure; HR: heart rate; PT: prothrombin time; Hb: hemoglobin; INR: international normalized ratio; WBCs: white blood cells

Lesions were located in the left main (LM) (4%), left anterior descending (70%), left circumflex (10%), and right coronary (16%) arteries. Baseline TIMI flow was 0 in 40%, 1 in 42%, 2 in 12%, and 3 in 6% of patients. Mean stent length was 39.9 (9.98) mm; patients received one stent (32%), two stents (34%), or three stents (34%) (Table 4).

Table 4. Angiographic and procedural findings of the studied patients

		Total (No. = 100)
Lesion Location	LM	4 (4%)
	LAD	70 (70%)
	LCX	10 (10%)
	RCA	16 (16%)
Baseline TIMI Flow	TIMI 0	40 (40%)
	TIMI 1	42 (42%)
	TIMI 2	12 (12%)
	TIMI 3	6 (6%)
Stent Length (mm)	Mean (SD)	39.9 (9.98)
	Range	23 - 56
No. of Stents	1	32 (32%)
	2	34 (34%)
	3	34 (34%)

LAD: left anterior descending coronary artery; LM: left main coronary artery; LCX: left circumflex artery

EF improved significantly immediately after PCI and at 3 months compared with baseline ($P = 0.007$; $P < 0.001$) and was greater at 3 months than immediately after PCI ($P < 0.001$). LA volume decreased significantly at 3 months compared with baseline and post-PCI ($P < 0.001$; $P = 0.022$). LAVI was lower post-PCI and at 3 months compared with baseline ($P = 0.023$; $P < 0.001$), with a further decrease at 3 months ($P = 0.013$). DT and isovolumic relaxation time (IVRT) dropped significantly post-PCI and at 3 months ($P < 0.001$), with DT further reduced at 3 months ($P < 0.001$). Peak early diastolic velocity (E) and E/A ratio increased at 3 months ($P < 0.001$), whereas peak late diastolic velocity (A) decreased significantly at 3 months ($P < 0.001$) (Table 5). GP IIb/IIIa inhibitors were received by 65 (65%) patients. Discharge medications included aspirin (45 [45%]), clopidogrel (43 [43%]), ACEI/ARB (32 [32%]), β-blockers (26 [26%]), and diuretics (19 [19%]). Longer chest pain duration was associated with a greater incidence of diastolic dysfunction ($P = 0.01$) (Table 6). Diastolic dysfunction was present in 58 (58%) patients, of whom 32 (32%) showed improved diastolic function.

Table 5. Echocardiography for diastolic function at baseline and 3 months after PCI in the studied patients

		Total (No.=100)			
		Baseline	Immediately After PCI	At 3 Months	Δ Change
LVEF (%)	Mean (SD)	34.8 (3.45)	36.2 (3.59)	51.9 (4.7)	17.2 (5.78)
	Range	30 - 40	30 - 42	43 - 60	4 - 30
	P	P1=0.007*, P2<0.001*, P3<0.001*			
LA volume (mL)	Mean (SD)	55.1 (6.38)	53.5 (7.77)	50.7 (6.5)	-4.4 (8.63)
	Range	45 - 65	40 - 65	41 - 63	-21 - 17
	P	P1=0.107, P2<0.001*, P3=0.022*			
LAVI (mL/m²)	Mean (SD)	30.2 (6.36)	32 (4.57)	28.1 (4.4)	-2.04 (8.1)
	Range	20 - 40	25 - 40	22 - 35	-18 - 11
	P	P1=0.023*, P2=0.013*, P3<0.001*			
DT (ms)	Mean (SD)	198.5 (9.3)	187.5 (7.47)	176.9 (11.2)	-21.6 (16.1)
	Range	185 - 215	175 - 200	155 - 200	-57 - 10
	P	P1<0.001*, P2<0.001*, P3<0.001*			
IVRT (ms)	Mean (SD)	95.7(15.1)	84.9 (7.71)	85.9 (9.08)	-9.8 (18.54)
	Range	70 - 120	71 - 99	70 - 100	-46 - 25
	P	P1<0.001*, P2<0.001*, P3=0.363			
E (m/s)	Mean (SD)	0.584 (0.08)	0.586 (0.07)	0.639 (0.11)	0.055 (0.12)
	Range	0.5 - 0.7	0.5 - 0.7	0.5 - 0.8	-0.2 - 0.3
	P	P1=0.853, P2<0.001*, P3<0.001*			
A (m/s)	Mean (SD)	0.761 (0.11)	0.772 (0.11)	0.704 (0.08)	-0.057 (0.15)
	Range	0.6 - 0.9	0.6 - 0.9	0.6 - 0.8	-0.3 - 0.2
	P	P1=0.466, P2<0.001*, P3<0.001*			
E/A ratio	Mean (SD)	0.78 (0.17)	0.77 (0.15)	0.92 (0.21)	0.13 (0.27)
	Range	0.56 - 1.17	0.56 - 1.17	0.63 - 1.33	-0.45 - 0.61
	P	P1=0.585, P2<0.001*, P3<0.001*			

LA: left atrium; LVEF: left ventricular ejection fraction; LAVI: left atrial volume index; DT: declaration time; IVRT: isovolumic relaxation time; E/A ratio: early to atrial filling velocity ratio
*: statistically significant at $P < 0.05$, P1: *P* value between baseline and immediately after PCI; P2: *P* value between baseline and at 3 months; P3: *P* value between immediately after PCI and at 3 months

Table 6. Correlation between the duration of chest pain and baseline diastolic dysfunction

Duration of Chest Pain	Diastolic Dysfunction			
	Present	Absent	Total	*P*
<4 h	25	29	54	0.010*
>4 h	33	13	46	
Total	58	42	100	

*: statistically significant at $P < 0.05$

DISCUSSION

Diastolic dysfunction significantly impacts outcomes in patients with STEMI. Primary PCI, the standard reperfusion treatment, improves diastolic function, which is essential for recovery and long-term cardiac health. [6] Therefore, 100 patients with STEMI were included to evaluate the effect of primary PCI on recovery from diastolic dysfunction.

Among the 100 patients, 68 were male, and 32 were female, with a mean age of 54 (SD, 13) years. This finding chimes with those reported by Al-Ghamedi et al,[7] whose study of 242 patients with CAD in Saudi Arabia between June 2018 and June 2019 found a mean age of 58 (SD, 12) years, with 66.1% being male. Similarly, the Cardiovascular Disease Statistics 2014 report for the United Kingdom, reviewed by Bhatnagar et al,[8] found that in 2013, the prevalence of MI in males was nearly 3 times that in females, based on data from the CPRD GOLD database.

Ischemic heart disease is more common in males, likely because of hormonal

differences. Premenopausal females have higher estrogen levels, particularly estradiol, which raises high-density lipoprotein, lowers low-density lipoprotein, and offers a cardioprotective effect. Estradiol enhances angiogenesis and vasodilation and reduces oxidative stress and fibrosis. [9] Further, lifestyle factors, such as higher rates of smoking in males, contribute to their increased risk of coronary artery disease. [9]

In the study cohort, body mass index (BMI) ranged from 19.92 to 34.72 kg/m^2, with a mean of 28 (SD, 4) kg/m^2, which is within the overweight category. This finding is concordant with a study by Joshy et al,[10] which examined the relationship between BMI and cardiovascular disease risk and found that for every 5-kg/m^2 increase in BMI, the hazard ratio for ischemic heart disease hospitalization increased by 23%. That study, part of the 45 and Up Study in Australia, included 158,546 individuals with no prior cardiovascular disease and highlighted that even small BMI increments increased risk.[10] Similarly, Qiu et al[11] found that high BMI directly contributed to cardiovascular disease risk factors such as diabetes, hypertension, and hypercholesterolemia, which are key pathways linking BMI to increased risk.

The most common risk factors reported in the present study cohort were hypertension, diabetes mellitus, smoking, and dyslipidemia. Corroborating these results, Mons et al[12] conducted an analysis on the influence of smoking and its cessation on cardiovascular mortality and adverse events in individuals aged 60 years and older. Their meta-analysis of 25 cohorts within the CHANCES consortium found that smoking remained a strong independent risk factor for cardiovascular events, advancing cardiovascular mortality by more than 5 years. Likewise, Butler et al[13] studied 482 patients with CAD in South Africa and found that hypertension was the leading risk factor, followed by smoking and obesity, in a predominantly male population (66%) with a mean age of 58 (SD, 11) years, aligning with the present results. Moreover, Muneeb et al[14] reported a high prevalence of dyslipidemia among 101 patients with acute coronary syndrome, with dyslipidemia more frequent in overweight individuals.

In the current study, grade I diastolic dysfunction was observed in 35 patients (35%). Consistent with this, Hashemi et al[15] explored the effects of PCI on LV diastolic function in 30 patients with CAD and EF greater than 40%. Echocardiographic evaluations were performed before the procedure and at 48 hours and 3 months after. They found that most patients had grade I diastolic dysfunction.

Similarly, Subramaniyan et al[6] evaluated 61 patients with anterior wall STEMI after PCI and found that grade I diastolic dysfunction was the most prevalent. In the present study, anterior MI was the most common type among patients. These findings are in concordance with those of a prospective cohort study by Qamar et al,[16] which examined characteristics, practices, outcomes, and sex-related differences in patients with STEMI in India. The study included 3,635 patients treated at tertiary care centers and concluded that anterior wall MI was the most prevalent type, occurring in 54% of cases.

In the current study, on angiography, the lesion location was most frequent in the left anterior descending artery (70%), followed by the right coronary artery (16%) and the left circumflex artery (10%). Similarly, Al-Ghamdi et al[7] reported that left anterior descending artery lesions were the most common, with 68.6% of patients in their study having a lesion in this artery.

According to our results, the following echocardiographic variables improved from baseline to 3 months after PCI: EF, LA dimension, LAVI, DT, IVRT, mitral early diastolic velocity (E wave), and the E/A ratio. Likewise, Tanaka et al[17] studied 27 patients

and found that PCI improved peak early diastolic transmitral flow velocities, particularly in those with greater improvement in strain rate in ischemic segments, suggesting a link between enhanced early diastolic filling and regional myocardial relaxation. In contrast, Hashemi et al[15] reported minimal changes in IVRT, DT, and the E/e′ ratio after PCI, with only the mitral E/A ratio, septal e′ velocity, and A wave velocity showing significant improvement after 3 months.

In addition, Subramaniyan et al[6] demonstrated that diastolic parameters- including the E/A ratio, A wave velocity, E wave velocity, IVRT, DT, LA volume, and LVAI-improved significantly from baseline to 6 months, except for the mitral E/e′ ratio. This finding was corroborated by a study by Farooq et al, [18] which assessed the residual SYNTAX score as a measure of the complexity and severity of residual stenosis after PCI. The authors proposed that persistent impairment of diastolic function might result from unresolved ischemia due to restenosis in treated arteries, incomplete revascularization, or the progression of atherosclerosis in nonculprit vessels, thereby hindering recovery in some patients. Diastolic dysfunction was significantly more prevalent in patients with chest pain persisting more than 6 hours. Similarly, Subramaniyan et al [6] reported comparable findings, showing that 81.3% of patients with chest pain duration exceeding 6 hours exhibited diastolic dysfunction.

Limitations

Study limitations include the single-center design, 90-day follow-up period, and small cohort (approximately 100 patients), which may limit the generalizability of the findings. Further multicenter studies with larger samples and longer follow-up are required.

CONCLUSIONS

The present study found that primary PCI led to significant improvement in diastolic function in patients with STEMI, with notable changes in echocardiographic parameters-including LVEF, E/A ratio, and LAVI. Timely intervention is important for optimizing recovery of diastolic function.

Conflict of Interest
Non.

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