Original Article

# Evaluation of the Effect of Elective Percutaneous Coronary Intervention as a Treatment Method on the Left Ventricular Diastolic Dysfunction in Patients with Coronary Artery Disease

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## Abstract

***Background:*** *Although percutaneous coronary intervention (PCI) is an excellent therapy for coronary artery disease, there is a paucity of information on the efficacy of PCI in improving diastolic function, especially in Iran. Because of the high prevalence of left diastolic dysfunction in coronary artery disease patients and its probable progression to heart failure, an evaluation of the role of PCI in improving diastolic function is required.*

***Methods:*** *Thirty patients scheduled for elective PCI were enrolled in this study providing that their systolic ejection fraction was > 40%. Before PCI and 48 hours and 3 months after PCI, echocardiography was done to evaluate some diastolic values in these patients.*

***Results:*** *The mean age of all the patients was 54 ± 10 year, and 20 patients were male. All the patients had a low degree of left ventricular diastolic dysfunction. Isovolumic relaxation time (115 ± 10 before treatment versus 120 ± 1 and 119 ± 3 respectively 48 hours and 3 months after treatment), mitral E wave velocity in septal (0.70 ± 0.05 before treatment vs. 0.71 ± 0.15 and 0.72 ± 0.12 respectively 48 hours and 3 months after treatment), and the peak velocity of late filling due to atrial contraction (mitral A wave velocity) in septal (0.74 ± 0.02 before treatment vs. 0.73 ± 0.01 and 0.68 ± 0.16 respectively 48 hours and 3 months after treatment) showed improvement after PCI. It is notable that early diastolic mitral annulus velocity (E') wave velocity in the septal part of the mitral annulus improved significantly 48 hours and 3 months after PCI ($p$ value < 0.05). The early-to-late diastolic tissue velocity ratio of the mitral annulus (E/A) ratio of the mitral inflow improved 48 hours after PCI; it was statistically significant ($p$ value = 0.05). Also, mitral A wave velocity in septal and the E/A ratio of the mitral inflow improved significantly 3 months after PCI ($p$ value < 0.05).*

***Conclusion:*** *Improvement in some of values related to left ventricular diastolic function followed by PCI shows that this method can be used to improve cardiac diastolic function in patients with symptomatic coronary artery disease.*

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## Introduction

Half of heart failure causes are related to left ventricular diastolic dysfunction, and heart failure is one of the important causes of mortality in heart disease patients.[1, 2] Because of the increase in left ventricular diastolic filling pressure in diastolic dysfunction, the patients suffer from congestion symptoms.[3, 4] Diastolic dysfunction has different causes such as ischemia, hypertension, diabetes mellitus, and age.[5, 6] Development of left ventricular diastolic dysfunction is a frequent complication after acute myocardial infarction (AMI), and it is associated with an increased risk of heart failure.[7, 8] Even if left ventricular systolic function is well preserved,[3, 4] therapeutic strategies for patients with diastolic dysfunction or diastolic heart failure remain poorly defined.[9] Nowadays, percutaneous coronary intervention (PCI) is recommended as an experimental treatment method in these patients.

Today, because of improvement in equipment and interventionists' expertise, PCI is one of the most common treatment strategies. Studies show that between the years 1989 and 1999, the number of patients who underwent PCI increased four times in the United States. Annually, PCI is done in one million cases in the United States and two million around the world.[10] However, because the role of PCI in asymptomatic patients is not clear yet, further studies in this area seem necessary. Diastolic failure is determined by the evaluation of the transmitral inflow pattern (E/A) and pulmonary vein flow with Doppler echocardiography.[11] Although PCI is a known excellent therapy for ischemic symptoms at short term, the efficacy of this method in the treatment of diastolic failure has yet to be evaluated precisely in coronary artery disease (CAD) patients, especially in Iran. Given the high prevalence of left ventricular diastolic dysfunction in CAD patients and the probable progression of diastolic dysfunction to heart failure, an evaluation of PCI effectiveness in improving left ventricular diastolic function in symptomatic patients seems necessary.

In this study, we examined the effect of PCI on the left ventricular diastolic function in CAD patients through computing echocardiography parameters pre PCI and 48 hours and 3 months post PCI (using routine echocardiography and tissue Doppler imaging).

## Methods

Thirty patients who were known cases of CAD with an ejection fraction (EF) > 40% were enrolled in this study by randomization. The study population underwent an echocardiographic study for an evaluation of diastolic dysfunction prior to PCI and 48 hours and 3 months after that. All the patients had left ventricular EF > 40%, mild diastolic dysfunction (grade 1), and some degree of exertional dyspnea.

The exclusion criteria were diabetes, thyroid disease, high creatinine, heart valve dysfunctions, uncontrolled hypertension, heart block or atrial fibrillation, and hypertrophic or idiopathic restrictive cardiomyopathy. Informed written consent was obtained from all the patients prior to the study commencement.

Ventricular diastolic function echocardiographic parameters were assessed at baseline. Echocardiography was performed with the ECO SYSTEM FIVE echocardiographic machine. At follow-up, echocardiographic examinations were performed 48 hours and 3 months after PCI.

The echocardiographic techniques and calculations of the cardiac dimensions were carried out in accordance with the recommendations of The American society of echocardiography. Left ventricular diastolic function was assessed using the following echocardiographic parameters: deceleration time (DT) (ms), isovolumic relaxation time (IVRT) (ms), peak transmitral early diastolic flow velocity (E wave), peak transmitral late diastolic flow velocity (A wave), and mitral E/A ratio.

Tissue Doppler imaging was performed in the apical four-chamber view, and the following parameters were recorded: peak myocardial early diastolic flow velocity (E' wave), peak myocardial late diastolic flow velocity (A' wave), and E/E′ in the medial annulus.

In the next step, all the patients underwent PCI with stenting in the catheterization laboratory of Shahid Modarres Hospital via the three methods of left anterior descending artery (LAD) exclusively, LAD and right coronary artery (RCA), and LAD and left circumflex coronary artery (LCX).

The same patients underwent echocardiography 48 hours and 3 months after PCI as follow-up in order that their left ventricular diastolic function could be reassessed. (The previous parameters were assessed again) All the echocardiographic assessments were conducted in five consecutive cardiac cycles, and the average results were analyzed. The patients were followed up during their hospital stay for major adverse cardiac events (MACE).

All the calculations were performed with SPSS 10.0 (statistical package for social sciences 10.0) software. The comparisons between the baseline and follow-up variables were made using paired samples t-test. A p value of $\leq 0.05$ was considered statistically significant.

## Results

Twenty men and 10 women at a mean age of 54±10 years were enrolled in this study. All the patients had a mild degree of diastolic dysfunction (grade 1). Each patient underwent elective PCI on one or two major coronary arteries. Table 1 depicts the patients' demographic characteristics and Table 2 demonstrates the patients' echocardiographic data at the beginning of the study.

Table 1. Demographic characteristics of patients*

| | |
|---|---|
| Age (y) | 54±10 |
| Female/Male | 10/20 |
| Smoking | 13 (43.33) |
| Positive family history | 12 (40) |
| Hypercholesterolemia | 12 (40) |
| Body mass index (kg/m²) | 30.1±2 |

*Data are presented as mean±SD or n (%)

All the patients underwent successful PCI, and no complication was observed during hospital stay. Thrombolysis in Myocardial Infarction (TIMI) flow grade 3 was achieved in all the patients.

Forty-eight hours and 3 months after PCI, all the patients were assessed again with further echocardiography. IVRT (115 ± 10 before treatment versus 120 ± 1 and 119 ± 3 respectively 48 hours and 3 months after treatment), deceleration time (270 ± 28 before treatment versus 271 ± 26 and 268 ± 34 respectively 48 hours and 3 months after treatment), and E/E′ ratio in the medial annulus (12.07 ± 1.5 before treatment versus 11.45 ± 1.8 and 9.72 ± 3.3 respectively 48 hours and 3 months after treatment) exhibited little change post PCI. None of the left ventricular diastolic parameters showed significant difference before and after elective PCI (both 48 hours and 3 months after PCI), except for mitral E/A ratio (0.94 ± 0.15 before treatment versus 0.97 ± 0.15 and 1.05 ± 0.18 respectively 48 hours and 3 months after treatment) (p value ≤ 0.053), mitral E’ septal velocity (0.058 ± 0.005 before treatment versus 0.062 ± 0.008 and 0.074 ± 0.018 respectively 48 hours and 3 months after treatment) (p value < 0.05), and mitral A wave velocity (0.74 ± 0.02 before treatment versus 0.73 ± 0.01 and 0.68 ± 0.16 respectively 48 hours and 3 months after treatment), all of which improved significantly 3 months after PCI (p value < 0.05) (Table 3).

Table 4 shows the echocardiographic results of the patients 48 hours and 3 months after elective PCI.

Table 2. Echocardiographic findings in patients before elective PCI

| | |
|---|---|
| Deceleration time (ms) | 270.34±28.05 |
| IVRT (ms) | 115.45±10.15 |
| Mitral E velocity (cm/s) | 0.70±0.05 |
| Mitral A velocity (cm/s) | 0.74±0.02 |
| Mitral E/A ratio | 0.94±0.15 |
| Mitral E′ septal velocity (cm/s) | 0.058±0.01 |
| Mitral A′ septal velocity (cm/s) | 0.08±0.01 |
| E/E′ ratio in medial annulus | 12.07±1.05 |

*Data are presented as mean±SD

PCI, Percutaneous coronary intervention; IVRT, Isovolumic relaxation time; E velocity, Peak mitral flow velocity of early rapid filling (cm/s); A velocity, Peak velocity of late filling were due to atrial contraction (cm/s); E′, Early diastolic mitral annulus velocity (cm/s); A′, Late diastolic mitral annulus velocity (cm/s); Mitral E/A ratio, The early-to-late diastolic tissue velocity ratio of the mitral annulus

Table 3. P value obtained from comparison of parameters before elective PCI vs. 48 hours and 3 months after elective PCI

| | 48 hours after PCI | 3 months after PCI |
|---|---|---|
| Deceleration time (ms) | NS | NS |
| IVRT (ms) | NS | NS |
| Mitral E velocity (cm/s) | NS | NS |
| Mitral A velocity (cm/s) | NS | 0.02 |
| Mitral E/A ratio | 0.05 | 0.04 |
| Mitral E′ septal velocity (cm/s) | 0.05 | 0.03 |
| Mitral A′ septal velocity (cm/s) | NS | NS |
| E/E′ in medial annulus | NS | NS |

PCI, Percutaneous coronary intervention; NS, Non-significant; IVRT: Isovolumic relaxation time; E velocity, Peak mitral flow velocity of early rapid filling (cm/s); A velocity, Peak velocity of late filling were due to atrial contraction (cm/s); E′, Early diastolic mitral annulus velocity (cm/s); A′, Late diastolic mitral annulus Velocity (cm/s); Mitral E/A ratio, The early-to-late diastolic tissue velocity ratio of the mitral annulus

Table 4. Echocardiographic results of patients 48 hours and 3 months after elective PCI*

| | 48 hours after PCI | 3 months after PCI |
|---|---|---|
| Deceleration time (ms) | 271.40±26.05 | 268.35±34.15 |
| IVRT (ms) | 120.45±1.20 | 119.25±3.05 |
| Mitral E velocity (cm/s) | 0.71±0.15 | 0.72±0.12 |
| Mitral A velocity (cm/s) | 0.73±0.01 | 0.68±0.16 |
| Mitral E/A ratio | 0.97±0.15 | 0.10±81.05 |
| Mitral E′ septal velocity (cm/s) | 0.06±0.01 | 0.07±0.01 |
| Mitral A′ septal velocity (cm/s) | 0.08±0.01 | 0.08±0.01 |
| E/E′ in medial annulus | 11.45±1.8 | 9.72±3.30 |

*Data are presented as mean±SD

PCI, Percutaneous coronary intervention; IVRT, Isovolumic relaxation time; E velocity, Peak mitral flow velocity of early rapid filling (cm/s); A velocity, Peak velocity of late filling were due to atrial contraction (cm/s); E′, Early diastolic mitral annulus velocity (cm/s); A′, Late diastolic mitral annulus velocity (cm/s); Mitral E/A ratio, The early-to-late diastolic tissue velocity ratio of the mitral annulus

## *Discussion*

Diastolic heart failure has been reported in more than 35-42% of patients with signs and symptoms of heart failure.[1, 2] These patients have left ventricular abnormal diastolic function in the sense of a disturbed relaxation detectable by mitral valve Doppler examination.[12] Meanwhile, 30-40% of patients with heart failure, despite enjoying an acceptable EF, continue to suffer from clinical symptoms of heart failure. It should be mentioned that this group of patients, like patients with a low EF (EF < 45%) are at risk of complications and symptoms of heart failure.[13] That is why only patients with EF > 40% were recruited in the present study.

Diastolic left ventricular parameters are assessed with non-invasive techniques such as routine echocardiography and TDI.[14, 15] TDI has high quality and safety in comparison with other methods such as radionuclide angiography[14] and cineangiography[16] in the evaluation of diastolic failure.

For all the studies in the existing literature probing into changes in regional myocardial velocities with TDI in the early period post PCI, there is a dearth of data on the assessment of these items late after PCI.[17] The present study, therefore, investigated the effects of PCI on diastolic dysfunction in CAD patients early and late after PCI. It is deserving of note that IVRT, the interval from the peak of (E) velocity to its extrapolation to baseline (DCT), and specially E/A ratio constitute the most significant parameters for an analysis of diastolic dysfunction.[18]

It has been demonstrated that left ventricular diastolic dysfunction in CAD patients begins sooner and improves earlier than systolic dysfunction after treatment.[19] Previous studies have suggested that balloon angioplasty and stenting augment the statistical parameters related to left ventricular diastolic function even 48 hours after elective PCI.[20] Utilizing strain rate imaging, Tanaka et al. 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.[21] Derumeaux et al. reported that regional diastolic function was impaired during PCI and improved in the early period after PCI.[22] Cayly et al. posited that regional diastolic function improved at 3 months after successful elective PCI.[17]

In this study, PCI was performed safely in CAD patients, resulting in a significant improvement in mitral E/A ratio and mitral E′ septal velocity (cm/s) early after PCI. Moreover, a significant increase was achieved in mitral A velocity (cm/s) 3 months after PCI by comparison with that prior to PCI. Our results showed a few changes in the echocardiographic parameters early and late after PCI.

## Conclusion

The present study sought to assess improvement in diastolic function after elective PCI in CAD patients in an Iranian university-affiliated tertiary medical center and compare the results with those previously published in the medical literature from other countries.

Improvement in diastolic function was detected especially 3 months after elective PCI. The increase in some of the values related to diastolic function by this method suggests that PCI can be employed to enhance diastolic function in CAD patients.

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