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Evaluation of the early effect of elective percutaneous coronary intervention on left ventricular diastolic and systolic function

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Original Article

Abstract

BACKGROUND: Percutaneous coronary intervention (PCI) is an effective treatment for coronary artery disease. Previous studies have demonstrated the delayed effects of PCI on left ventricular diastolic and systolic function. However, the early impact on these parameters has not been systematically examined. Moreover, no study has compared the impact of revascularization on the global longitudinal (GLS) and circumferential (GCS) strains of the left ventricle. Using echocardiographic parameters, the present study aimed to investigate the reversibility of diastolic and systolic abnormalities in patients with significant coronary artery stenosis within 1 to 2 days after PCI. Additionally, this study will compare the effects on both global and longitudinal strains.

METHODS: This study included 80 consecutive patients admitted to the angiography department for elective PCI with normal left ventricular function. Echocardiography was performed before PCI and 1 to 2 days post-procedure to assess left ventricular diastolic and systolic function indices in these patients.

RESULTS: The mean age of the patients was 58.0±11.9 years, with a predominantly male cohort (65%). All the patients exhibited normal left ventricular systolic function and various degrees of diastolic dysfunction. One to 2 days after revascularization, significant improvements were observed in all diastolic function indices and GLS. However, no significant improvement was found in GCS.

CONCLUSION: Revascularization of a significantly stenotic coronary artery can enhance diastolic function and systolic longitudinal strain of the left ventricular myocardium as early as 1 to 2 days, with no significant impact on GCS.

Keywords: Left ventricular function; PCI; Strain; Systolic; Diastolic

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Introduction

Outcomes in patients with coronary artery disease (CAD) are associated with left ventricular (LV) function and remodeling. Improving LV function is crucial for a better prognosis. Previous studies have highlighted the significance of monitoring changes in various LV function parameters using echocardiographic data, comparing them with baseline measurements. These studies have demonstrated the additional prognostic value of such monitoring[1].

While left ventricular ejection fraction (LVEF) is traditionally used to assess LV function, it is not an ideal method due to its dependence on factors such as preload and afterload, as well as inter- and intraobserver variabilities. Other echocardiographic parameters, such as fractional shortening, LV volume and dimensions, cardiac output, dp/dt (the ratio of

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pressure change in the ventricular cavity during the isovolumic contraction period), Global Longitudinal Strain (GLS), and Global Circumferential Strain (GCS), can provide indirect assessments of global LV function[2].

GLS and GCS are emerging methods for detecting subtle disturbances in global and circumferential LV systolic function. These techniques have been shown to be more predictive than EF and are less operator-dependent.

Speckle-tracking echocardiography (STE), independent of the ultrasound beam's angle of insonation, enables the assessment of myocardial strains in spatial directions: circumferential, longitudinal, and radial. Among these, longitudinal strains are most commonly used in clinical practice[3].

Strain echocardiography has the potential to play a significant role in diagnosing subtle myocardial dysfunction across a range of conditions that impact the myocardium, as well as in the detection of ischemic heart disease. This is because ischemia predominantly affects the longitudinal mechanics of the myocardium. Ischemia may impair longitudinal LV function at rest, which may not be detectable by visual assessment of LV function alone[4-6].

Although stress echocardiography is the only echocardiographic method for detecting ischemia in patients with suspected CAD without regional wall motion abnormalities at rest, several studies have demonstrated that resting GLS has comparable accuracy to stress echocardiography in predicting obstructive CAD[7]. Additionally, some studies have shown that GLS improves several months after revascularization[8-10]. Nonetheless, little is known about the early effects of revascularization on segments with obstructive CAD. Therefore, we aimed to assess the effect of percutaneous coronary intervention (PCI) on a vessel with significant obstruction within 1 to 2 days after revascularization and compare the changes in both GLS and GCS.

Materials and Methods

Study Population

In this cross-sectional study, 80 consecutive patients, with a mean age of 58 ± 11.9 years (range: 39-59 years), including 52 males (65%) and 28 females (35%), were admitted to the Cardiology Department of Doctor Shariati Hospital for elective PCI between April 2020 and March 2021. The inclusion criteria required patients to have normal LV systolic function on 2D echocardiography. The exclusion criteria were patients with symptomatic heart failure, segmental wall motion abnormalities, poor echocardiographic windows, significant arrhythmias, significant valvular heart disease, and nonobstructive CAD.

Coronary Angiography

Coronary angiography and elective PCI were performed by interventional cardiologists in accordance with the European Society of Cardiology guidelines for PCI[11]. PCI was considered successful upon achieving thrombolysis in myocardial infarction (TIMI) flow grade III and residual stenosis of less than 20% as per the guidelines[12].

Echocardiography

Two-dimensional echocardiographic examinations were performed twice to assess LV systolic and diastolic function. The first examination was conducted the day before coronary angiography for all eligible patients, and the second was performed 1 to 2 days after PCI. The examinations were performed using standard parasternal and apical views with an EPIQ 7 (Philips Medical System, Andover, MA, USA) equipped with a 5-1 MHz sector transducer. Images were obtained by a specialist echocardiographer who was blind to the clinical data, following the recommendations of the American Society of Echocardiography guidelines[13].

LV systolic function was assessed in terms of conventional parameters, including EF (via the Simpson method), GLS, and GCS, using 2D-STE. LV diastolic function was assessed using tissue Doppler evaluation of mitral valve inflow velocity to measure E- and A-wave peak velocities, the E/A velocity ratio, dt, and tissue velocity assessment to calculate e-wave velocity, E/e ratio, and isovolumic relaxation time (IVT). All images were stored digitally, and offline analysis of all echocardiographic data was performed later using commercially available software. For 2D-STE, the LV myocardial surface was manually traced, and the whole LV wall thickness was covered by adjusting the speckle-tracking width.

Apical 4-, 3-, and 2-chamber views were stored to obtain GLS, while parasternal short-axis views at the base, mid, and apex levels were stored to obtain GCS (Figure 1).

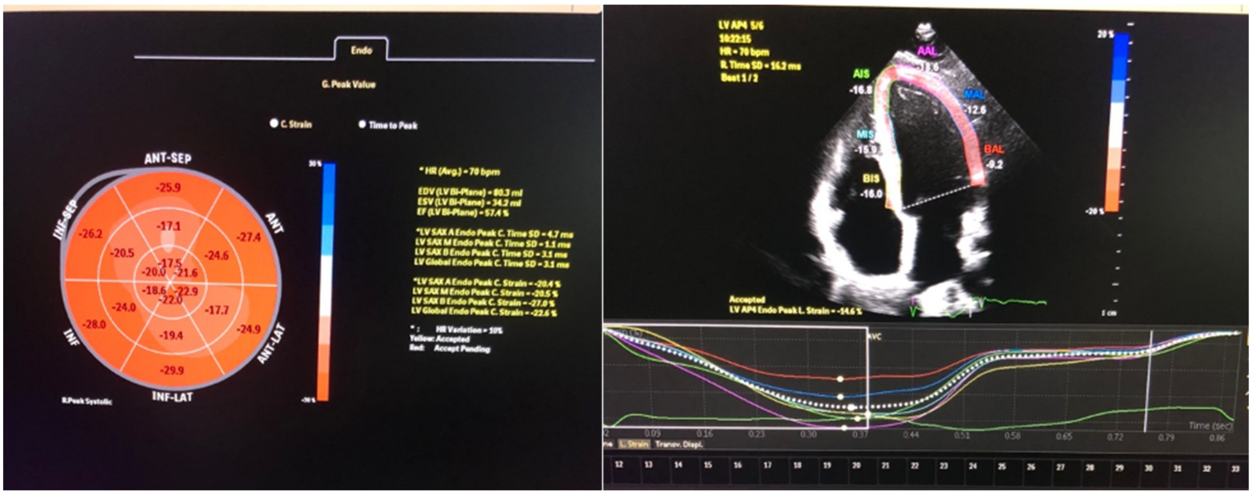

Figure 1. The images show endocardial and epicardial border tracing throughout the cardiac cycle (left) and the bull's-eye plot of strain curves and color-coded 17 segments.

Table 1. Patient characteristics

Characteristic	
Variable	Value
Age, y	58 ± 11.9 (39-59)
Sex, male / Female ratio	52/28
history of HTN, n, %	44 (55%)
History of DM, n, %	36 (45%)
Current smoking, n, %	28 (35%)

DM: diabetes mellitus, HTN: hypertension

Table 2. Variables of diastolic function before and after PCI

Variable	Before PCI	After PCI	*P* value
dt	195.67 ± 38.92	172.97 ± 23.85	0.024
IVRT	55.6 ± 16	52.3 ± 13	0.007
E/A ratio	1.226 ± 0.463	1.588 ± 0.38	0.001
E/e ratio	7.5 ±3.602	6.91 ± 2.95	0.035

dt: deceleration time, IVRT: isovolumic relaxation time

Analysis of the samples was performed by a single echocardiographer. A random selection of images was later reanalyzed by the same echocardiographer to evaluate interobserver variability.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 19.0). The Kolmogorov-Smirnov test was applied to assess the normality of the data distribution. For normally distributed data, paired sample t-tests were used to compare echocardiographic parameters (e.g., EF, GLS, GCS, and diastolic function indices) before and after PCI. In cases where the data did not follow a normal distribution, the Wilcoxon Signed-Rank test was employed. Descriptive statistics were reported as mean ± standard deviation. A p-value of less than 0.05 was considered statistically significant.

Results

The clinical characteristics of the study population are listed in Table 1, and variables related to LV diastolic function before and after revascularization are listed in Table 2. Comparisons of patient characteristics and diastolic function before and after PCI revealed significant improvements in all diastolic function indices following revascularization.

Table 3 presents the EF and GLS values of the studied patients before and after PCI. The 2D-STE

Table 3. Comparisons of EF and GLS before and after PCI

Variable	Before PCI	After PCI	*P* value
EF	56±1.7	58±2.9	0.04
Apical 2Ch	-15.00 ± 2.78	-17.56 ±1.78	0.04
Apical 3Ch	-15.75 ± 1.34	-18.25 ± 1.45	0.024
Apical 4Ch	-14.71 ± 2.88	-17.37± 1.34	0.045
Global GLS	-15.20 ±1.33	-18.45 ± 1.67	0.01

EF: ejection fraction, PCI: percutaneous coronary intervention, Ch: chamber, GLS: global longitudinal strain

Table 4. Comparisons of GCS before and after PCI

Variable	Before PCI	After PCI	*P* value
GCS	-20.02±3.62	-22.1±3.88	0.31

GCS: global circumferential strain, PCI: percutaneous coronary intervention

examination revealed that EF and GLS were significantly improved as early as 1 to 2 days after PCI (Table 3).

Table 4 shows the mean ± standard deviation of GCS before and after successful revascularization. The evaluation of GCS revealed that revascularization of a stenotic coronary artery did not result in significant improvements in the circumferential shortening of the LV myocardium. Rather, the greatest benefit was observed in longitudinal shortening.

Discussion

The present study demonstrated that PCI for significant coronary stenosis significantly improved the diastolic function and systolic longitudinal strain of the LV. Nevertheless, systolic circumferential shortening (GCS) remained unaffected. Several studies have shown the positive effects of revascularization for chronic total occlusion on LVEF and GLS[14-16].

In our study, improvement occurred as early as 1 to 2 days after revascularization of the affected artery. This finding is supported by a 2019 study conducted by Wang et al[14], in which patients with chronic total occlusion of the epicardial coronary artery showed improvements in GLS just 1 day after successful PCI.

Data on the early effects of PCI for vessels with significant stenosis on GLS remain scarce. Chbini et al[17] demonstrated improvements in GLS in patients 1 week after PCI, while Ionac et al[18] assessed this variable during a 4-6 weeks follow-up of patients who experienced acute myocardial infarction. Previous studies have evaluated primarily the effects of PCI on EF and GLS. Our study uniquely assessed the effects of PCI on GLS and GCS within 1 to 2 days after revascularization and found that revascularization had no significant early effect on GCS.

Several mechanisms contribute to clinical or subclinical myocardial damage in patients with stable CAD. Key factors include reduced coronary blood flow, endothelial dysfunction, and chronic ischemia, leading to myocardial hibernation[19]. According to the literature, among the 3 layers of myocardial fibers, the subendocardial layer, which has an oblique clockwise orientation and longitudinal direction, is most vulnerable to ischemic damage. In the presence of epicardial coronary artery stenosis, the subendocardial layer receives less blood flow than the subepicardial layer[10], potentially explaining the differences observed in GLS and GCS in 2D-STE.

As demonstrated in our study, reperfusion of the stenotic-related artery improved GLS but had no significant impact on GCS. In a study by Román-Fernández et al[20] involving 55 patients with significant and nonsignificant coronary artery stenosis, there was no difference in GCS based on the number of significantly diseased arteries. The authors concluded that using GCS to discriminate between the presence or absence of significant CAD was not justified.

The early and late effects of revascularization on diastolic function variables have been confirmed in several studies[21-24]. Our results align with these findings, further supporting the benefits of revascularization on the diastolic properties of the LV myocardium.

Conclusion

Revascularization of significantly stenotic coronary arteries led to improvements in diastolic function and systolic longitudinal strain of the LV myocardium within 1 to 2 days, with no significant impact on GCS.

Limitations

The primary limitation of our study is its small sample size.

Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

All co-authors contributed and participated in the main design and revision of the manuscript.

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