European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Post PCI Systolic Evaluation In Patients With Coronary Artery Disease Using Tissue Doppler Echocardiography and Tei index (MPI)

Article History:

Name of Author:
Zahraa Hassan Hmood[1], Prof. Shukri Faez Alsaad[2]

Affiliation: *[1]University of Babylon, college of medicine*
[2] Prof University of Babylon, college of medicine

***Received**:* 12-05-2026
***Revised**:* 05-06-2026
***Accepted**:* 20-06-2026
***Published**:* 04-07-2026

Abstract: ***Background:*** Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide. Percutaneous coronary intervention (PCI) is an established therapeutic procedure for restoring coronary blood flow and improving myocardial function. Tissue Doppler Imaging (TDI) and Myocardial Performance Index (MPI/Tei index) are valuable echocardiographic tools used to assess left ventricular systolic performance. ***Aim of the Study:*** To evaluate changes in left ventricular systolic function in patients with CAD before and after PCI using Tissue Doppler Echocardiography and Tei index. ***Methods:*** This prospective cohort study included 50 patients with coronary artery disease undergoing PCI at Merjan Medical City, Babylon, Iraq. Echocardiographic assessment including ejection fraction (EF), left ventricular end-diastolic diameter (LVEDD), Tissue Doppler systolic velocities (S′), and Tei index measured by both TDI and pulsed-wave Doppler were performed before PCI and repeated after the procedure. Statistical analysis was used to compare pre- and post-PCI findings. ***Results:*** The mean EF improved from 45.86 ± 4.71% before PCI to 50.40 ± 3.56% after PCI, while LVEDD showed a reduction from 55.78 ± 3.17 mm to 51.86 ± 7.32 mm; however, these changes were not statistically significant. Similarly, Tei index values measured by both TDI and PW Doppler showed numerical improvement without statistical significance. In contrast, regional myocardial systolic velocities (S′) demonstrated significant improvement in all examined myocardial segments after PCI ($p \leq 0.001$). Significant negative correlations were observed between Tei index and regional systolic velocities, particularly in anterior and anterolateral walls. ***Conclusion:*** PCI was associated with significant improvement in regional left ventricular systolic function assessed by Tissue Doppler Imaging despite nonsignificant changes in global echocardiographic parameters. Tissue Dopplerderived systolic velocities appear to be more sensitive than conventional EF in detecting early myocardial functional recovery after PCI.

Keywords: Post PCI Systolic, Coronary Artery Disease, Tissue Doppler Echocardiography, Tei index (MPI).

INTRODUCTION

Coronary artery disease (CAD) was defined as one of the most prevalent cardiovascular disorders and is occure due to progressive deposition of atherosclerotic plaques in the coronary arteries. The process causes a reduction in the lumen of the artery and the flow of coronary blood. This causes an insufficient supply of oxygen to the myocardial tissue. Coronary heart disease (CHD), also known as ischemic heart disease (IHD), includes a range of clinical manifestations, such as stable angina, silent myocardial ischemia , and acute coronary syndromes (ACS). Most cases of deaths from CHD are due to underlying coronary artery disease. Acute coronary syndromes are usually symptomatic and include unstable angina and myocardial infarction[1]. Ischaemic heart disease is the most common form of cardiovascular disease and continues to be a leading cause of death for both men and women worldwide [2]. The identification of cardiovascular risk factors was initiated by the landmark Framingham Heart Study (FHS) which started in 1948 and laid the foundation for understanding the determinants of cardiovascular disease . Later, several largescale studies (e.g., the FINRISK study in Finland [1972], the Uppsala cohorts in Sweden [ULSAM, PIVUS, POEM, EpiHealth, and SCAPIS], the INTERHEART study with participants from 52 countries, and the PREDICT Cardiovascular Disease Cohort in New Zealand) added to the understanding of coronary artery disease (CAD) risk assessment. These investigations have resulted in the classification of CAD risk factors in two groups: the first group is modifiable factors, while the other is non-modifiable factors. The modifiable factors are hypercholesterolemia, cigarette smoking, diabetes mellitus, elevated systolic blood pressure, and physical inactivity; nonmodifiable factors are advancing age, sex, and positive family history of CAD [3]. Atherosclerosis is a chronic inflammation of the intimal layer of medium-sized arteries. Several established cardiovascular risk factors promote its development including hypertension, hypercholesterolemia, cigarette smoking, diabetes mellitus, and genetic predisposition. The disease progresses slowly in the coronary circulation by intimal thickening and plaque formation with variable degrees of luminal narrowing. With time, these structural changes can severely compromise coronary blood flow. Lesions of acute myocardial infarction (AMI) and sudden cardiac death (SCD) are predominantly located in the proximal parts of the large coronary arteries, especially at sites of arterial branching where flow patterns are disturbed [4]. Coronary thrombosis can occur through three main pathological mechanisms: plaque rupture, plaque erosion and calcified nodules. Of these, rupture of plaque is the most common reason. It is characterized by disruption of the fibrous cap exposing the underlying necrotic core to circulating blood and promoting thrombus formation in the vessel lumen. Plaque erosion is the second most common mechanism and is characterized by endothelial denudation accompanied by a matrix rich in proteoglycans and collagen, with a predominance of smooth muscle cells below the affected surface. Calcified nodules are the least common cause of coronary thrombosis. They are seen in severely calcified arteries. These lesions are characterized by fragmentation of calcified deposits that extend into the fibrous cap, often resulting in deposition of fibrin and formation of a platelet-rich thrombus. The calcified nodules are usually eccentrically located and accompanied by a non occlusive thrombus [5].

Study Design

In this particular investigation, a prospective cohort design was utilized. Those patients who were receiving percutaneous coronary intervention and had coronary artery disorder were recruited in this research and observed throughout the course of time. Clinical and echocardiographic parameters, including tissue Doppler imaging (TDI) and myocardial performance index (Tei index), were assessed before and after PCI to evaluate changes in left ventricular function.

2.2 Data Setting and Collection Time

This prospective cohort study was conducted at the echocardiography unit of Merjan Medical City, Directorate of Health of Babil, Babylon, Iraq. Individuals who had been diagnosed with coronary artery disorder and were selected for treatment with percutaneous coronary intervention were included in the study in a sequential manner. As a whole, there were fifty patients that participated in the research. Clinical and echocardiographic data, including tissue Doppler imaging (TDI) and myocardial performance index (Tei index), were collected at baseline (pre-PCI) and reassessed one month after the procedure (post-PCI). In the span of five months, beginning on the first of December 2025 and ending on the twentieth of May 2026, data collecting was carried out.

2.3 Study sample and sample size

The study sample comprised 50 consecutive CAD patients undergoing PCI. Each of patients were assessed pre- and post-procedure using tissue Doppler echocardiography and myocardial performance index to evaluate systolic function. In order to improve the study's validity and reliability, participants were recruited according to various criteria that had been established beforehand.

2.4 Selection Criteria

2.4.1 Inclusion Criteria

Patients who satisfied the following criteria were considered to be eligible for participation in the study:

• Adults who are at least 18 years old.
• Diagnosed with CAD and scheduled for percutaneous coronary intervention.
• Systolic function of Left ventricle of varying degrees, including preserved, mildly reduced, and reduced ejection fraction.
• Sinus rhythm at the time of echocardiographic examination.
• Ability to undergo echocardiographic assessment using tissue Doppler imaging (TDI).

2.4.2 Exclusion Criteria

Patients were not allowed to participate if they have any of the following conditions:

• Significant valvular heart disease (moderate to severe).
• Cardiac arrhythmias affecting the accuracy of TDI measurements (e.g., atrial fibrillation).
• Congenital heart disease. • Poor echocardiographic image quality.

• Hemodynamic instability or severe systemic illness.

2.5 Data collection methods

2.5.1 Questionnaire

The self-constructed questionnaire includes demographic characteristics for all patient's history (age, sex, weight, height and medical history). The equation below is used to calculate of Body mass index and body surface area: BMI (Kg / m ²) = Weight (Kg) / Height ² (m) as recommended by control disease and prevention (CDC) and world health organization(WHO). [18]

2.5.2 Echocardiography assessment. Transthoracic echocardiographic(TTE) examination with the patient first attached to ECG and then laying on left lateral decubitus position with left hand extended below the head. 2D-echocardiography,EF,LVEDD, tissue doppler image (TDI),Myocardial performance index done by(VIVID9 GE),with a(3.5-MHz transducer). Made in Norway by GE Vingmed Ultrasound, 2012

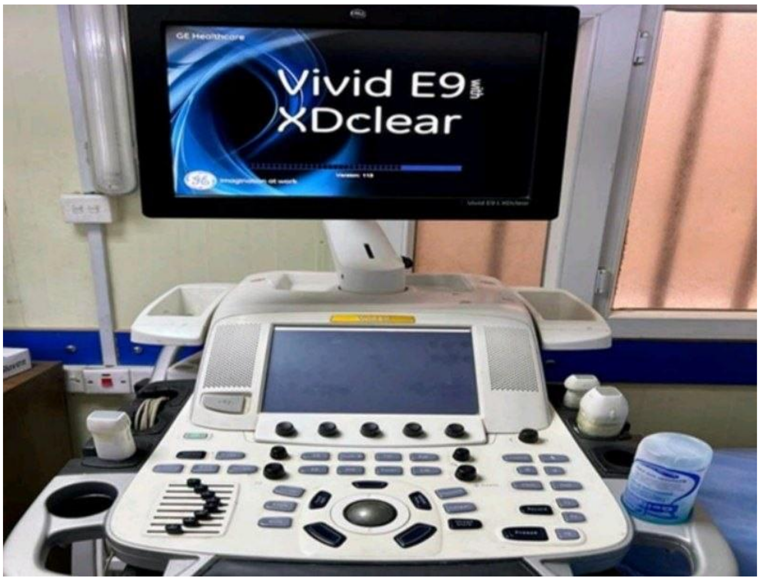


Fig (2.1): Echocardiography Vivid E9 Xdclear GE device


Fig (2.2) M5Sc probe for 2D image

The left ventricle dimensions measured at the mitral valve leaflet tips level in a direction that is aligned perpendicular to the ventricular longitudinal axis during end-diastole. Normal LVID for male = 37_56mm, and for female =35_51mm.[19]

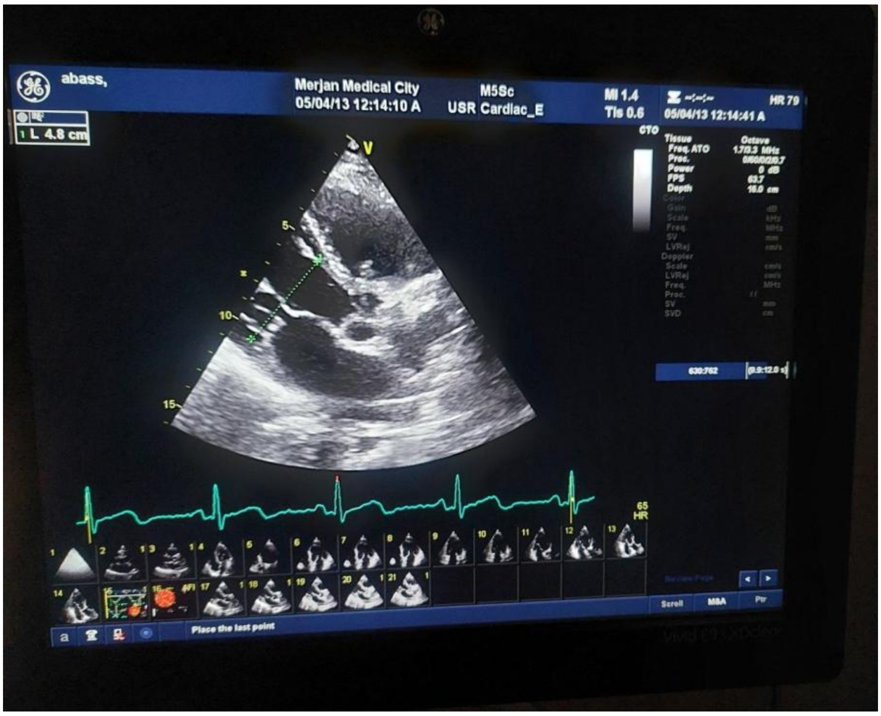


Fig (2.3) Measurement of LVDD at the end of diastole from the perspective of the parasternal long axis.

LV functional assessment was defined by measuring LV ejection fraction through 2D echocardiography. Both LVESV and LVEDV were established in the 4 chamber and 2 chamber apical views.[20].

The sum of a series of elliptical discs of identical height that are evenly spaced along the ventricular longitudinal plane is the basis for this approach, which is based on the idea of calculating the entire LV volume at the same time [16]. The cross-sectional area in ideal conditions is based on both diam-eters, obtained from the A2C and A4C views. A4C and A2C views are utilized in order to determine LVEDV and LVESV. The following formula used for calculating LVEF as EF:

$EFA4C=(LVEDVA4C-LVESVA4C/LVESA4C)/LVEDVA4C\times100$ $EFA2C=(LVEDVA2C-LVESVA2C)/LVEDVA2C\times100$

The mean EF is calculated by taking the average of the EF values for both A4C and A2C. Normal EF=55% in both males and females[21]

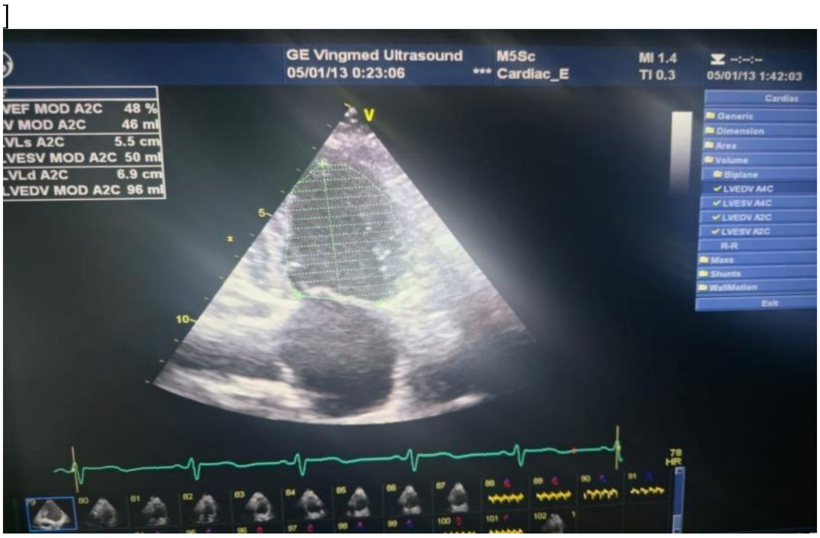


Fig (2.4) Evaluation of the LVEF by using of Simpson technique in the two chamber apical view

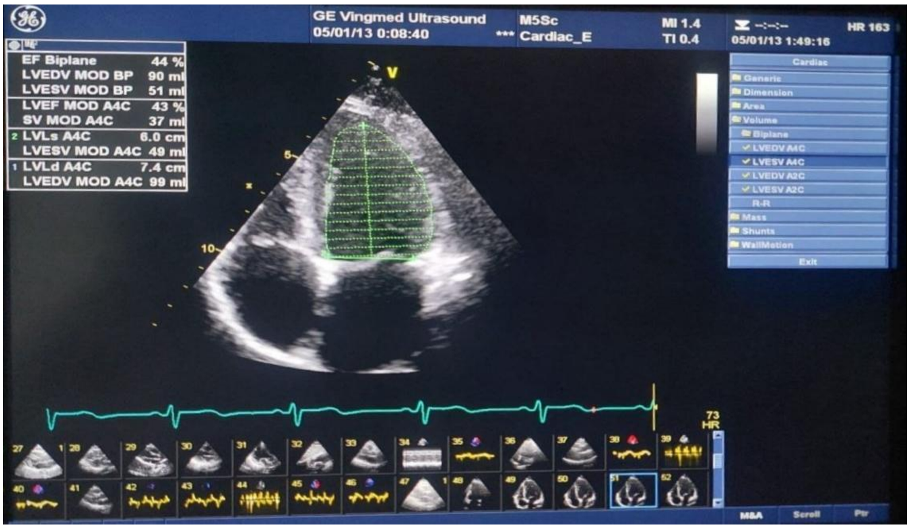


Fig (2.5) Evaluation of LVEF by using Simpson technique in the four chamber apical view

2.5.3 Tissue Doppler Imaging

This technique, PW-TDI, allows a quantitative assessment of the myocardial motion in a selected region of the heart with an excellent temporal resolution. The Doppler sampling volume was positioned at a site in the myocardium where tissue velocities could be accurately measured during image acquisition. The evaluation of the longitudinal left ventricular systolic function is generally done by positioning the sample volume within the myocardial tissue adjacent to the mitral annular plane. This is usually performed at less than 1 cm of the attachment of the leaflets of mitral valve on the septal or lateral aspect of four chamber apical view. The obtained velocity waveform after the completion of cardiac cycle reflects the mobility of the myocardium. During systole, mitral annulus moves towards the cardiac apex resulting in a positive deflection called the S' wave. This wave is the longitudinal shortening of the ventricles. The tissue velocities at the septal and lateral annular sites may both be used to assess LV function. Moreover, average of these data can give an average global value providing a more extended estimate of the longitudinal systolic performance [19].

The anterior and inferior walls was assessed TDI and PW obtained from the 2 chamber apical view [22]

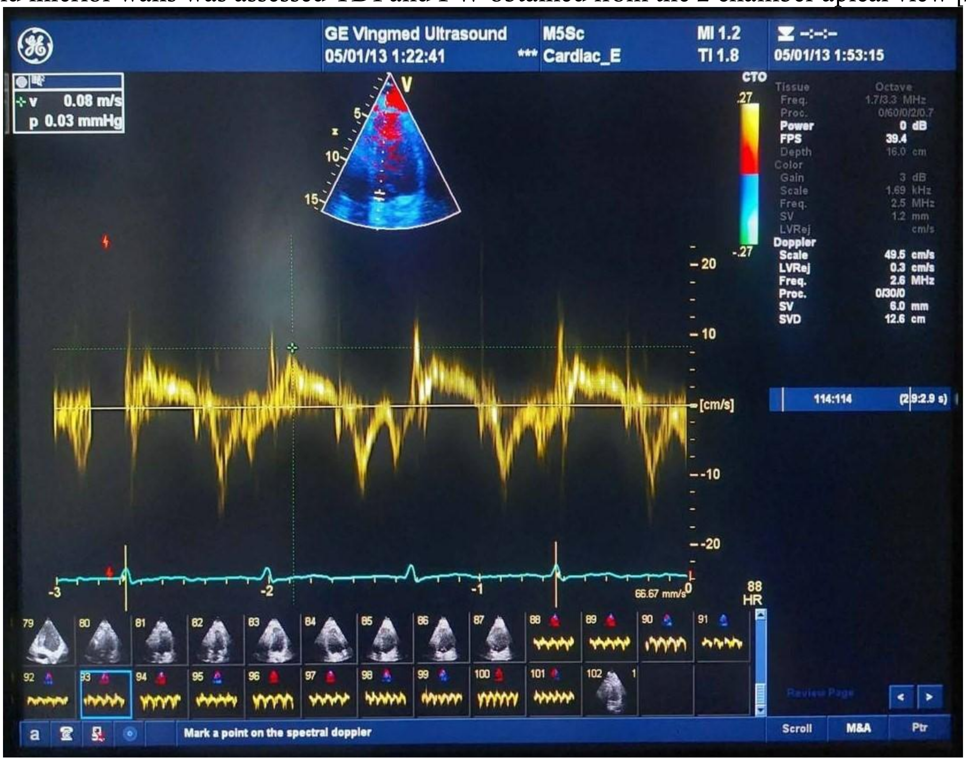


Fig (2.6) measurement of S^ of inferoseptal wall using TDI and PW in 4 - chamber apical view

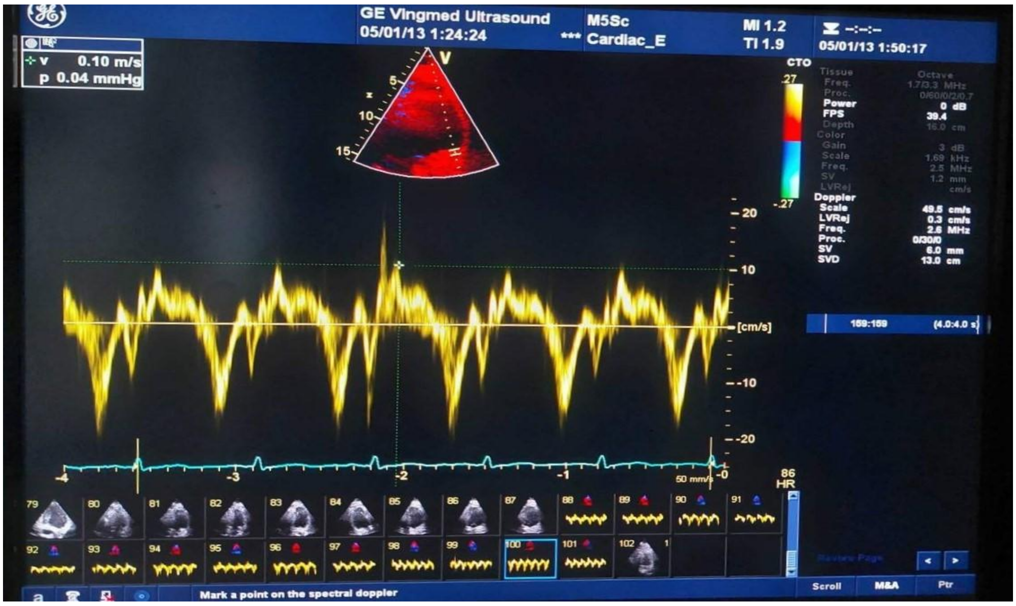


Fig (2.7) measurement of S^of anterolateral wall using TDI and PW in apical 4 - chamber view

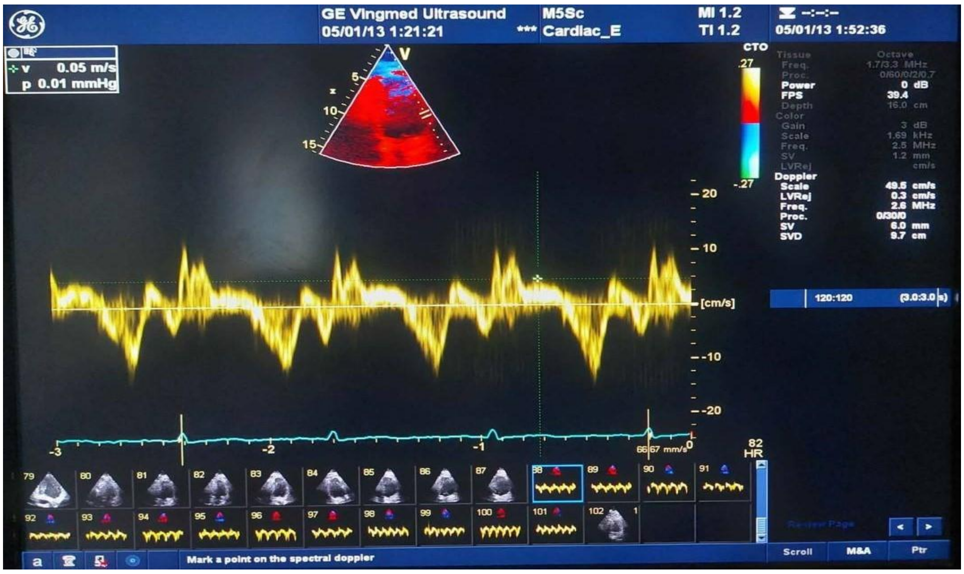


Fig (2.8) measurement of S^ of anterior wall using TDI and PW from apical 2 chamber view

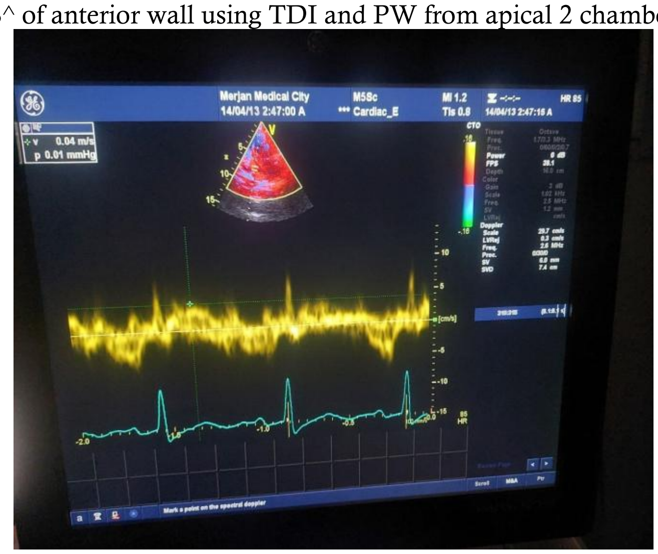


Fig (2.9) measurement of S^ of inferior wall using TDI and PW from apical 2 chamber view

Table 2.1Normal ranges for pulsed tissue Doppler peak systolic velocity[23]

Parameter	Inferoseptal	Anterolateral	Inferior	Anterior
Pulsed TDI peak systolic velocity (cm/s)	5.6–10.4	5.2–12.4	5.8–11.4	4.5–12.1

2.6 MPI by TDI
MPI can be calculated using both PWD and TDI. In TDI-based assessment, myocardial velocity signals are recorded in general at the septal (medial) mitral annulus in the 4 chamber apical view where the sample volume of doppler is placed.

The recordings are made with about 100 mm/s speed to improve the accuracy of time-interval measurements. For Doppler-derived measurements, IVRT was determined as the period extending between the end flow of aortic valve and the mitral inflow initiation, whereas IVCT was determined as the time extending from mitral valve closure to the aortic ejection onset. Left ventricular ejection time is the period extending between valve opening and its subsequent closure of the aortic valve by the left ventricular outflow tract velocity profile.

MPI is then derived by the equation:
MPI = (IVCT + IVRT) / ET

This parameter integrates both systolic and diastolic features of ventricular performance in one single variable and provides a global measure of myocardial function. The mean Tei Index of the left ventricle in normal individuals has been reported to be in the order of 0.39 ± 0.05.[17,24]

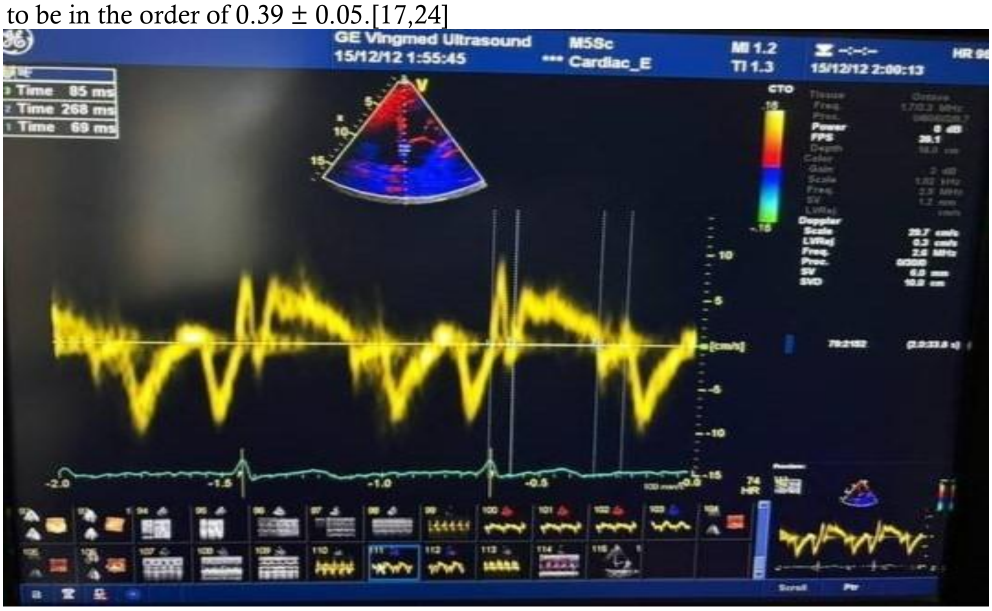


Fig (2.10) meaurement of myocardial performance index by TDI

2.7 MPI by PW
The Myocardial Performance Index (MPI) obtained by conventional pulsed-wave Doppler echocardiography is calculated from time intervals obtained from recordings of transmitral inflow and left ventricular outflow velocities. IVRT is the period from the aortic valves closure to the mitral valves opening. While IVCT is the time from closure of mitral valve to the opening of aortic valve.

LV ejection time is the period between the beginning of forward flow across aortic valve to the aortic valve closure on the outflow of LV.

Another parameter is MCOT (Mitral Valve Closure Opening Time) which is the total time period including IVCT , ET , and IVRT. So, the Myocardial Performance Index can be defined as:

MPI = (MCOT – ET) ET
or, equivalently:
MPI = (IVCT + IVRT) / ET
This index is a global assessment of the ventricular performance[25].

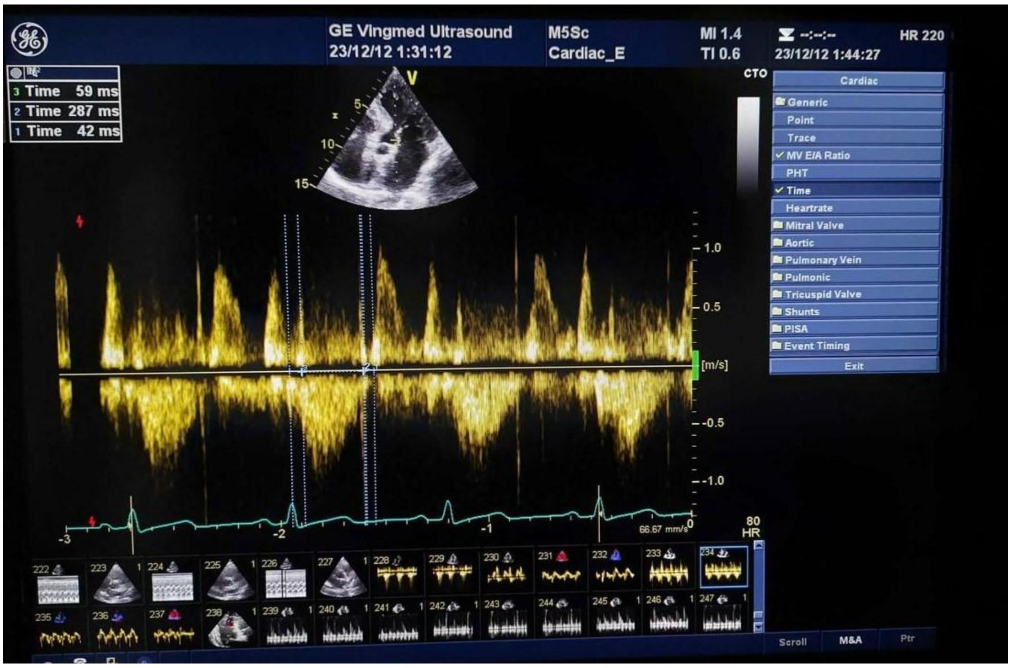
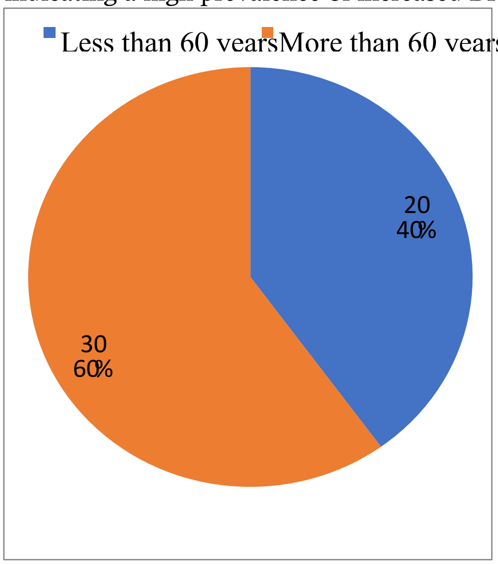


Fig (2.11) measurement of myocardial performance index by PW

RESULT

The present study involved 50 CAD patients who underwent PCI. The majority of patients were older than 60 years (60%), 40% were younger than 60 years. Regarding sex distribution, males predominated the study population, accounting for 80%, whereas females represented 20%. In terms of body mass index (BMI), no patients were classified as underweight or normal weight. More than half of the patients (52%) were overweight, while 48% were obese, indicating a high prevalence of increased BMI among the studied cohort.(As shown in figure 1,2,3)



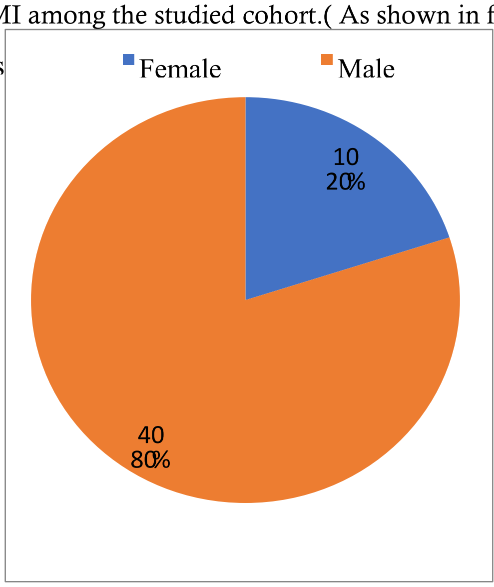


Figure 3-1: distribution among age group

Figure 3-2: distribution among gender group

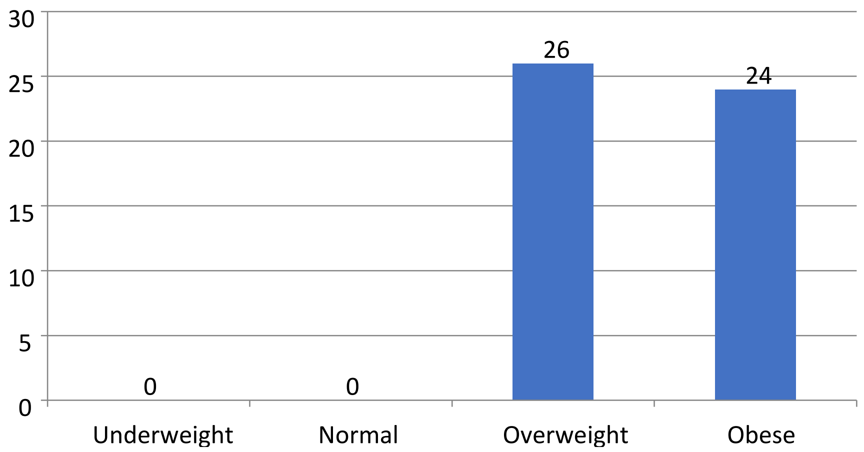


Figure 3-3 : bar chart of Distribution among age group

Table 3-1 showed Comparison of echocardiographic parameters before and after PCI. There was an observed enhancement of LV systolic function following PCI; however, this did not reach statistical significance. The mean ejection fraction (EF) increased from 45.86 ± 4.71% before PCI to 50.40 ± 3.56% after PCI, with a mean difference of +4.54 ± 6.28%, however this improvement is statistically nonsignificant (p = 0.345). Similarly, LVEDD showed a reduction from 55.78 ± 3.17 mm to 51.86 ± 7.32 mm, with a mean change of −3.92 ± 7.19 mm, which also did not reach statistical significance (p = 0.071).

Regarding myocardial performance index (Tei index), both tissue Doppler imaging (TDI) and pulsed-wave (PW) measurements demonstrated slight reductions after PCI. The Tei index (TDI) decreased from 0.59 ± 0.054 to 0.515 ± 0.057, while the Tei index (PW) decreased from 0.55 ± 0.090 to 0.487 ± 0.056. These changes are statistically non-significant (p = 0.932 , p = 0.997).

Table3-1: Comparison of echocardiographic parameters before and after PCI

Parameters	Pre-PCI (man ±SD)	Post-PCI (mean ±SD)	Mean difference (mean ±SD)	p-value
EF (%)	45.86±4.71	50.40±3.563	4.540 ±6.28	0.345
LVEDD	55.78±3.17	51.86±7.32	-3.920 ±7.19	0.071
Tei index(TDI)	0.59±0.054	0.515±0.057	-0.080 ±0.08	0.932
Tei index (PW)	0.55±0.090	0.487±0.056	-0.068 ±0.11	0.997

In contrast to global parameters, tissue Doppler imaging demonstrated a significant improvement in regional systolic function across all examined myocardial segments following PCI. The inferoseptal S′ velocity increased significantly from (6.61 ± 1.03 cm per second) to (7.44 ± 0.99 cm per second) (p < 0.001). Similarly, the inferior segment showed a significant increase from 6.52 ± 0.43 cm per second to (6.79 ± 0.31 cm per second) (p < 0.001). Noticeable enhancement was also showed in the anterolateral segment, its values rising from (6.98 ± 1.03 cm per second) to (7.96 ± 1.13 cm per second) (p < 0.001), and in the anterior segment from (7.01 ± 0.99 cm per second) to (7.78 ± 0.93 cm per second) (p = 0.001). The results show that the regional myocardial systolic function improves significantly after PCI, although global indices don't show significant changes. (See Table 3.2) Table3.2: Tissue Doppler systolic velocities before and after PCI

Parameters	Pre-PCI (mean ±SD)	Post-PCI (mean ±SD)	Mean difference (mean ±SD)
S′ inferoseptal	6.61 ±1.03	7.44 ±0.99	0.83±0.978
S′ inferior	6.52 ±0.43	6.79 ±0.31	0.27±0.18
S′ antrolateral	6.98 ±1.03	7.96 ±1.13	0.97±0.99
S′ anterior	7.01 ±0.99	7.78 ±0.93	0.77 ±1.01

Table 3.3 presented the relationship between the parameters of echocardiography and systolic velocities. Negative relationship of Tei index (TDI) with anterolateral
(r= -0.317, p=0.025) and anterior
(r= -0.434, p= 0.002) S′ velocities was showed. This suggests that higher Tei index values (worse global function) are associated with lower regional systolic velocities.

Similarly, Tei index (PW) presented a significantly negative relationship with velocity of anterior wall (r = -0.389, p = 0.005), reinforcing of inverse relationship between myocardial performance index and systolic function. On the other hand, ejection fraction demonstrated positive relationship with anterolateral S′ velocity (r = 0.300, p = 0.034), indicating that improved global systolic function is associated with higher regional myocardial velocities. nonsignificant relationships were observed between EF and other segments or between Tei indices and inferoseptal/inferior segments.

Table3.3: correlation between echocardiographic parameters and s'of each wall.

Variable		R	P value
MPI TDI	S′ inferoseptal	-0.235	0.101
	S′ inferior	-0.125	0.387
	S′ antrolateral	-0.317	0.025
	S′ anterior	-0.434	0.002
MPI PW	S′ inferoseptal	-0.222	0.121
	S′ inferior	-0.070	0.629
	S′ antrolateral	-0.236	0.099
	S′ anterior	-0.389	0.005
EF	S′ inferoseptal	0.269	0.059
	S′ inferior	0.160	0.268
	S′ antrolateral	0.300	0.034
	S′ anterior	0.263	0.065

DISCUSSION

In the present study, most patients undergoing PCI were older than 60 years (60%). This result is in line with those of other research that demonstrated that CAD development increase with advancing age due to the progressive nature of atherosclerosis and the accumulation of cardiovascular risk factors over time. Recent evidence has shown that patients undergoing PCI are predominantly elderly, with a higher burden of comorbidities and cardiovascular risk factors.[26]. Regarding sex distribution, males represented 80% of the study population, whereas females accounted for only 20%. This finding is consistent with earlier reports that the most patients who go through PCI are men. Khawaja et al. reported that about 80% of PCI patients were male, which is consistent with the higher occurrence of obstructive CAD in men at younger ages than women.[27]. The current study is supported by modern studies of PCI populations reporting a predominance of male patients . Zhang et al. showed that only 29.8% of the patients who underwent PCI were women, and the rest were men. Such differences could be explained by sex differences in cardiovascular risk profiles, hormonal protection in premenopausal women and differences in disease presentation[28]. None of the patients in the present study was underweight or normal weight with respect to body mass index (BMI). >50% (52%) of participants were overweight and 48% were obese. The results indicate that a considerable share of patients with CAD subject to PCI had a higher BMI. This finding is consistent with the study by Li et al. (2024) who studied the effect of BMI on outcomes after PCI and reported that most PCI patients had BMI above the normal range [26].

In the present study we observed a numerical improvement of LV Ejection Fraction (EF%) after percutaneous coronary intervention (PCI) from 45.86 ± 4.71% at baseline to 50.40 ± 3.56% post procedure with a mean difference of 4.54 ± 6.28%.

This increase indicates a favorable trend towards enhancement in LV systolic function but was statistically non-significant (p=0.345). This lack of statistical significance may be explained by the relatively limited sample size and the considerable variability in individual responses to myocardial revascularization. The findings of the present study showed a similar trend to those reported by Jason et al (2022)in the restore EF study, which evaluated left ventricular functional recovery after high-risk PCI.

Their study demonstrated a important enhancement in the ejection fraction of left ventricular at 90-day follow-up, with EF increasing from 35 ± 15% at baseline to 45 ± 14% after PCI. Although statistical significance was achieved in their study, likely due to the larger sample size and longer followup duration, the numerical improvement observed in the current study (4.54%) supports the concept that PCI may contribute to recovery of ventricular systolic function after myocardial revascularization.[29]

Furthermore, variability in EF recovery among patients may be attributed to differences in myocardial viability. Erberto Carluccio et al(2012) demonstrated that ventricular functional recovery after coronary revascularization is strongly associated with myocardial viability, with patients possessing viable myocardium showing greater improvement in systolic function following PCI. Therefore, the heterogeneous response observed in EF improvement in the present study may reflect differences in the extent of viable myocardial tissue among participants.[30] Although the post-PCI increase in EF did not achieve statistical significance in the present study, the observed numerical improvement remains clinically meaningful. Previous data suggests that time for statistically significant improvement in left ventricular systolic recovery after PCI may be longer especially in patients with different degrees of myocardial dysfunction .

In the present study, analysis of LVEDD showed significant numerical reduction after percutaneous coronary intervention (PCI) from 55.78 ± 3.17 mm at baseline to 51.86 ± 7.32 mm post intervention with mean difference of −3.92 mm. This finding suggests a positive trend toward left ventricular reverse remodelling and that restoration of coronary blood flow may contribute to partial reversal of pathological ventricular dilatation.

LVEDD was reduced at a borderline level of statistical significance ($p=0.071$). There was a clear tendency toward improvement (though not at the conventional level of statistical significance $p<0.05$). This finding may be explained, at least in part, by the relatively small sample size and the individual variation in structural response of the heart after revascularization, as suggested by the relatively high standard deviation in the measurements performed after intervention.

The present results are reliable with earlier observations of Batra et al. (2022) that successful percutaneous coronary intervention results in favorable LV reverse remodeling with reductions in LV dimensions and volumes at follow-up. Their study also backs the idea of functional improvement and recovery of the left ventricle over time after myocardial reperfusion.[31] . Çelik et al (2017) also stated that left ventricular remodeling is clinically important. Left ventricular structural remodeling is a strong prognostic marker in cardiovascular diseases.

Their findings highlighted that changes in size and geometry of LV are closely related to chronic disorders, where even modest reductions in ventricular dilation are linked to improved prognosis and reduced cardiovascular events. Therefore, the observed reduction in LVEDD in the present study, although not statistically significant, may still represent an early indicator of favorable reverse remodeling following PCI.[32]

In the current study, the Tei index measured via Tissue Doppler Imaging (TDI) showed a numerical improvement, decreasing from 0.59 ± 0.054 pre-PCI to 0.515 ± 0.057 post-PCI. A similar trend was observed in the Pulse Wave (PW) measurements, which decreased from 0.55 ± 0.090 to 0.487 ± 0.056. While these decreases physiologically signify an improvement in the combined systolic and diastolic efficiency of the left ventricle, they did not reach statistical significance in this specific patient cohort, as indicated by p-values of 0.932 and 0.997, respectively

Comparison with Ragab et al. (2020) Our findings are consistent with the shortterm results reported by Ragab et al. (2020) . They evaluated the Tei index five days after PCI. They observed that the mean MPI (Tei index) changed only slightly from 0.41 ± 0.05 to 0.4 ± 0.06, which was statistically insignificant ($p = 0.4$). Ragab et al. concluded that the Myocardial Performance Index might not add significant diagnostic benefit for this specific group of patients in the immediate post-procedural phase[33].

Comparison with Sikora-Frac et al. (2021) In contrast, a more pronounced and significant improvement was documented by Sikora-Frac et al. (2021) at a longer follow-up interval of three months . Their study of 66 patients demonstrated that the Tei index improved significantly in the entire group, dropping from 0.57 ± 0.09 to 0.42 ± 0.08 ($p < 0.001$) . Notably, Sikora-Frac et al. found that diabetic patients had a significantly worse baseline Tei index compared to non-diabetics (0.6 ± 0.1 vs. 0.53 ± 0.06, $p = 0.0006$), but they also experienced a more evident improvement after revascularization ($p = 0.002$). This highlights the Tei index as a sensitive "enhanced echocardiographic" tool capable of assessing subtle, subclinical changes in myocardial function that standard measures might overlook[34]

While the current results demonstrate a numerical trend toward improved global cardiac efficiency, they mirror the findings of Ragab et al. (2020) regarding shortterm follow-up. However, when viewed alongside the research by Sikora-Frac et al. (2021), it is evident that the Tei index remains a valuable and comprehensive parameter. The discrepancy in statistical significance between these studies suggests that the functional recovery of the myocardium, as captured by the Tei index, may require a longer duration to manifest fully after successful coronary revascularization

The assessment of regional systolic function through Peak Systolic Myocardial Velocity (S') using Tissue Doppler Imaging (TDI) yielded the most clinically and statistically significant findings in this study. Following the PCI procedure, a robust and highly significant increase in S' velocities was observed across the analyzed myocardial segments. Specifically, the S' velocity in the inferoseptal wall increased from 6.61 ± 1.03 cm per second to 7.44 ± 0.99 cm per second (p=0.000) , while the anterolateral segment showed a substantial improvement from 6.98 ± 1.03 cm per second to 7.96 ± 1.13 cm per second (p=0.000),S' inferior Increased from 6.52 ± 0.43 to 6.79 ± 0.31 (p = 0.000) Additionally, a highly significant improvement was documented in the anterior wall, rising from 7.01 ± 0.99 cm per second to 7.78 ± 0.93 cm per second (p= 0.001)

The high statistical significance ($p \leq 0.001$) across these segments demonstrates that TDI-derived parameters are exceptionally sensitive in detecting the early recovery of regional contractility after revascularization. This is consistent with recent clinical research by Al Khashab et al , which suggests that longitudinal myocardial velocities (S') are superior to global parameters like Ejection Fraction (EF) in capturing subtle improvements in myocardial performance during the immediate post-PCI phase. Such findings imply that the restoration of blood flow directly enhances the contractile reserve of segments previously compromised by ischemia[35].

Furthermore, our results align with the functional recovery patterns described by Bytyçi et al. (2022). Although Bytyçiet al. emphasize long-term reverse remodeling, they highlight that early increases in myocardial systolic velocities serve as critical physiological precursors to global structural recovery.[36]

The present study demonstrated a significant inverse correlation between myocardial performance index (MPI) and systolic velocity (S′) that derived by tissue doppler, particularly in the anterior and anterolateral left ventricular walls. MPI measured by tissue Doppler imaging (TDI) showed statistically significant negative correlations with anterior wall S′ ($r = -0.434$, $p = 0.002$) and anterolateral wall S′ ($r = -0.317$, $p = 0.025$). Similarly, pulsed-wave Doppler MPI demonstrated a significant negative relationship with anterior wall S′ ($r = -0.389$, $p = 0.005$). These results shows that impaired global myocardial performance is associated with reduced regional longitudinal systolic function, particularly in myocardial regions vulnerable to ischemic damage.

The present findings are supported by the study of Omar A.M.S. Omar et al. (2022), who reported that tissue Doppler-derived myocardial velocities are closely associated with myocardial mechanical performance and can provide valuable information regarding myocardial functional status. Their study emphasized that myocardial velocity abnormalities may reflect subtle myocardial dysfunction before overt deterioration in conventional cardiac performance parameters becomes evident.[37].

Furthermore, the current results are in agreement with the study conducted by Khaled A. Al Khashab et al (2020), who assessed systolic myocardial function in patients undergoing PCI using tissue Doppler echocardiography. The authors demonstrated that tissue Doppler parameters, particularly longitudinal systolic myocardial velocities, are sensitive tools for identifying early myocardial functional changes following PCI, even in patients with preserved ejection fraction. This finding may explain the stronger relationship observed in the current study between S′ velocities and myocardial performance index compared with conventional EF measurements.[35]

Additionally, recent evidence from a study conducted by Begrregaard(2024) supports the current findings, demonstrating that advanced echocardiographic myocardial performance indices and tissue Doppler-derived parameters are valuable in detecting subtle regional and global left ventricular dysfunction. This supports the role of S′ velocity as a sensitive marker of regional myocardial performance beyond conventional ejection fraction assessment.[38]

Regarding ejection fraction (EF), only the anterolateral wall presented a important liner relationship with S′ velocity ($r=0.300$, $p=0.034$), while the remaining myocardial walls showed non-significant correlations. This finding suggests that EF, as a global marker of left ventricular systolic function, may be less sensitive in identifying subtle regional myocardial abnormalities than tissue Doppler-derived indices. Therefore, S′ velocity may represent a more sensitive parameter for evaluating regional myocardial recovery and systolic performance after ischemia and revascularization.The absence of statistically significant correlations in inferoseptal and inferior walls may reflect differences in coronary perfusion territories, regional myocardial recovery, and heterogeneity in ischemic burden after PCI.

4.2 Recommendations

1.Tissue Doppler Imaging should be incorporated routinely in the echocardiographic assessment of patients undergoing PCI because of its high sensitivity in detecting early myocardial functional recovery.

2.Longer follow-up periods are recommended in future studies to evaluate delayed development in function of the left ventricle
3.Larger multicenter studies with a greater sample size are needed to confirm the present findings and improve statistical power.
4.Future research should investigate the prognostic value of Tissue Doppler parameters and Tei index in predicting long-term cardiovascular outcomes after PCI.
5.Assessment of myocardial viability before PCI is recommended, as it may influence the degree of functional recovery after revascularization.
6.Combining conventional echocardiography with advanced myocardial functional indices may improve the evaluation of CAD patients

4.3 Limitations.
1-The study sample size was relatively small, which may have influenced the ability to detect statistically significant changes in some global echocardiographic parameters.
2- The follow up period was relatively short and more prolonged observation may be required to identify more marked improvement in LV remodeling and global systolic function.
3- Variability in myocardial viability and extent of coronary artery disease among patients may have affected the degree of recovery after PCI.
4- The study was mainly concerned with echocardiographic functional parameters and did not evaluate long term clinical outcomes as mortality, recurrent ischemia or hospitalization.
5-Inter- and intrareader variability in Tissue Doppler measurements could not be entirely eliminated even with standardized echocardiographic assessment.

REFERENCES

1. Shahjehan RD, Sharma S, Dababneh E, et al. Coronary Artery Disease. [Updated 2024 Oct 9]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from:https://www.ncbi.nlm.nih.gov/sites/books/NBK564304/
2. H. Ali, K. Alrekaby, The correlation between hypertension and risk factors among ischemic heart disease patients in Babylon governorate, 6 (2022) 3854–3863.
3. L.I. Butnariu, L. Florea, M.C. Badescu, E. Țarcă, I.I. Costache, E.V. Gorduza, Etiologic Puzzle of Coronary Artery Disease: How Important Is Genetic Component?, Life 12 (2022). https://doi.org/10.3390/life12060865.
4. J.A. Ambrose, M. Singh, Pathophysiology of coronary artery disease leading to acute coronary syndromes., F1000Prime Rep. 7 (2015) 8. https://doi.org/10.12703/P7-08.
5. H. Jinnouchi, F.D. Kolodgie, M. Romero, R. Virmani, A. V Finn, Pathophysiology of Coronary Artery Disease BT - Vessel Based Imaging Techniques : Diagnosis, Treatment, and Prevention, in: C. Yuan, T.S. Hatsukami, M. Mossa-Basha (Eds.), Springer International Publishing, Cham, 2020: pp. 211–227. https://doi.org/10.1007/978-3-030-25249-6_11.
6. R. Pranavchand, B.M. Reddy, Current status of understanding of the genetic etiology of coronary heart disease, J. Postgrad. Med. 59 (2013). https://journals.lww.com/jopm/fulltext/2013/59010/current_status_of_understanding_of_the_genetic.8.aspx.
7. J.C. Brown, T.E. Gerhardt, E. Kwon, Risk Factors for Coronary Artery Disease., in: Treasure Island (FL), 2026.
8. M.M. Kadhim, S.F. AL-Saad, H.S. Al-Jumaily, Z.F. Hassan, Role of Dobutamine Stress Test and Speckle Tracking in Ischemic Heart Disease, Comparative Study, Med. J. Babylon 21 (2024) 621–626. https://doi.org/10.4103/MJBL.MJBL_1300_23.
9. B.K. Sheel, M. Badiuzzaman, T. Haque, H. Rahman, A.K. Biswas, Association between Myocardial Performance Index (Tei- Index) and Severity of Coronary Artery Disease in Patients with Non-ST Segment Elevation Acute Coronary Syndrome, (2020).
10. L.G. Klaeboe, T. Edvardsen, Echocardiographic assessment of left ventricular systolic function, J. Echocardiogr. 17 (2019) 10–16. https://doi.org/10.1007/s12574-018-0405-5.
11. P. Ponikowski, A.A. Voors, S.D. Anker, H. Bueno, J.G.F. Cleland, A.J.S. Coats, V. Falk, J.R. González-Juanatey, V.-P. Harjola, E.A. Jankowska, M. Jessup, C. Linde, P. Nihoyannopoulos, J.T. Parissis, B. Pieske, J.P. Riley, G.M.C. Rosano, L.M. Ruilope, F. Ruschitzka, F.H. Rutten, P. van der Meer, 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)Developed with the special contribution o, Eur. Heart J. 37 (2016) 2129–2200. https://doi.org/10.1093/eurheartj/ehw128.
12. E.S. Lane, J. Jevsikov, M.J. Shun-Shin, N. Dhutia, N. Matoorian, G.D. Cole, D.P. Francis, M. Zolgharni, Automated multi-beat tissue Doppler echocardiography analysis using deep neural networks., Med. Biol. Eng. Comput. 61 (2023) 911–926. https://doi.org/10.1007/s11517-022-02753-3.
13. K.K. Kadappu, L. Thomas, Tissue Doppler Imaging in Echocardiography: Value and Limitations, Hear. Lung Circ. 24 (2015) 224–233. https://doi.org/10.1016/J.HLC.2014.10.003.

14. L. Askin, E.İ. Yuce, O. Tanriverdi, Myocardial performance index and cardiovascular diseases, Echocardiography 40 (2023) 720–725. https://doi.org/https://doi.org/10.1111/echo.15628.
15. Y. Ibrahim, I.E.Y. Ibrahim, CORRELATION OF MYOCARDIAL PERFORMANCE INDEX ASSESSED BY, 94 (2023) 1450–1462.
16. M. Oliveira, J.P. Dias, L. Guedes-Martins, Fetal Cardiac Function: Myocardial Performance Index., Curr. Cardiol. Rev. 18 (2022) e271221199505. https://doi.org/10.2174/1573403X18666211227145856.
17. R.M. e. al Lang, ASE ' s Comprehensive Echocardiography THIRD EDITION, 2021.
18. About Body Mass Index (BMI) | BMI | CDC, (n.d.). https://www.cdc.gov/bmi/about/index.html (accessed June 3, 2026).
19. A.R. Houghton, MAKING SENSE of Echocardiography, 2013. https://doi.org/10.1201/b15360.
20. D. Zamfir, D. Pitic, G. Tamaşescu, S. Onciul, O. Tăutu, C. Angelescu, R. Onuţ, M. Stoian, M. Dorobanţu, Prognostic Value of Right Ventricular Function Assessed by Echocardiography in Patients Presenting With a First Acute ST Elevation Myocardial Infarction Treated By Primary PCI, Rev. Med. Chir. Soc. Med. Nat. Iasi 120 (2016) 824–833.
21. O.F. Cardiology, The EACVI Textbook of Echocardiography, 2016. https://doi.org/10.1093/med/9780198726012.001.0001.
22. R.M. Lang, L.P. Badano, M.A. Victor, J. Afilalo, A. Armstrong, L. Ernande, F.A. Flachskampf, E. Foster, S.A. Goldstein, T. Kuznetsova, P. Lancellotti, D. Muraru, M.H. Picard, E.R. Retzschel, L. Rudski, K.T. Spencer, W. Tsang, J.U. Voigt, Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging, J. Am. Soc. Echocardiogr. 28 (2015) 1-39.e14. https://doi.org/10.1016/j.echo.2014.10.003.
23. Echocardiography, (n.d.). https://www.perlego.com/ereader/1506768 (accessed June 4, 2026).
24. S. Yadav, R.M. Gajurel, C.M. Poudel, R. Khanal, N. Shah, R. Ghimire, L. Yadav, Relationship between Myocardial Performance Index (Tei Index) and angiographic severity of coronary artery disease in patients with Acute ST Elevation Myocardial Infarction, Nepal. Hear. J. 21 (2024) 5–11. https://doi.org/10.3126/nhj.v21i2.70862.
25. E.A.E. Ibrahim, M.M. Ahmed, M.A. Abd-Elghaffar, A. El Tayeb, Impact of percutaneous coronary intervention on critical proximal lesion of left anterior descending artery on left ventricular function by echocardiography and tissue doppler, Int. J. Health Sci. (Qassim). 6 (2022) 6684–6696. https://doi.org/10.53730/ijhs.v6ns4.10113.
26. C. Rao, Q. Zhong, R. Wu, Z. Li, Y. Duan, Y. Zhou, C. Wang, X. Chen, R. Wang, K. He, Impact of body mass index on long-term outcomes in patients undergoing percutaneous coronary intervention stratified by diabetes mellitus: a retrospective cohort study, BMC Cardiovasc. Disord. 24 (2024) 1–11. https://doi.org/10.1186/s12872-024-03770-w.
27. Khawaja, F. J., Rihal, C. S., Lennon, R. J., Holmes, D. R., & Prasad, A. (2011). Temporal trends (over 30 Years), clinical characteristics, outcomes, and gender in patients ≤50 years of age having percutaneous coronary intervention. American Journal of Cardiology, 107(5), 668-674. https://doi.org/10.1016/j.amjcard.2010.10.044
28. J. Zhang, J. Jiang, X. Hu, Y. Sun, C. Li, L. Zhu, F. Gao, L. Dong, Y. Liu, J. Shen, C. Ni, K. Wang, Z. Chen, H. Chen, S. Li, S. Yang, J. Kang, D. Hwang, J.Y. Hahn, C.W. Nam, J.H. Doh, B.K. Lee, W. Kim, J. Huang, F. Jiang, H. Zhou, P. Chen, L. Tang, W. Jiang, X. Chen, W. He, S.G. Ahn, M.H. Yoon, U. Kim, J.M. Lee, Y.J. Ki, E.S. Shin, C.H. Kim, S.J. Tahk, B.K. Koo, J. Wang, Sex Differences in Fractional Flow Reserve– or Intravascular Ultrasound–Guided Percutaneous Coronary Intervention, JACC Cardiovasc. Interv. 16 (2023) 2426–2435. https://doi.org/10.1016/j.jcin.2023.08.017.
29. J. Wollmuth, M.P. Patel, T. Dahle, A. Bharadwaj, T.E. Waggoner, J.W. Chambers, E. Ruiz-Rodriguez, E. Mahmud, C. Thompson, D.L. Morris, Ejection Fraction Improvement Following Contemporary High-Risk Percutaneous Coronary Intervention: RESTORE EF Study Results., J. Soc. Cardiovasc. Angiogr. Interv. 1(2022) 100350. https://doi.org/10.1016/j.jscai.2022.100350.
30. E. Carluccio, P. Biagioli, G. Alunni, A. Murrone, C. Zuchi, E. Biscottini, R. Lauciello, P. Pantano, F. Gentile, R.A. Nishimura, G. Ambrosio, Improvement of myocardial performance (Tei) index closely reflects intrinsic improvement of cardiac function: assessment in revascularized hibernating myocardium., Echocardiography 29 (2012) 298–306. https://doi.org/10.1111/j.1540-8175.2011.01575.x.
31. M.K. Batra, M.A. Malik, K.A. Khan, L. Rai, R. Kumar, J.A. Shah, J.A. Sial, T. Saghir, N. Khan, M. Karim, Left Ventricular Functional Remodeling after Primary Percutaneous Coronary Intervention., J. Cardiovasc. Echogr.

32 (2022) 12–16. https://doi.org/10.4103/jcecho.jcecho_64_21.
32. A. Celik, N. Kalay, H. Korkmaz, O. Dogdu, O. Sahin, D. Elcik, S. Karacavus, A. Dogan, T. Inanc, I. Ozdogru, A. Oguzhan, R. Topsakal, Short- Term Left Ventricular Remodeling After Revascularization in Subacute Total and Subtotal Occlusion With the Infarct-Related Left Anterior Descending Artery., Cardiol. Res. 2 (2011) 229–235. https://doi.org/10.4021/cr83w.
33. T.M. Ragab, K. Ahmed, A. Khashab, S. Al, Effect of PCI on Cardiac Function in Chronic Stable Angina Patients with " Normal " Ejection Fraction : A Tissue Doppler Study, (2020).
34. M. Sikora-Frac, B. Zaborska, P. Maciejewski, A. Budaj, B. Bednarz, Improvement of left ventricular function after percutaneous coronary intervention in patients with stable coronary artery disease and preserved ejection fraction: Impact of diabetes mellitus, Cardiol. J. 28 (2021) 923–931. https://doi.org/10.5603/CJ.A2019.0066.
35. K.A. Al Khashab, T.M. Ragab, S.M. Agiz, Post PCI Systolic Evaluation In Patients With Coronary Artery Disease Using Tissue Doppler Echocardiography, Fayoum Univ. Med. J. 5 (2020) 61–70. https://doi.org/10.21608/fumj.2020.77481.
36. I. Bytyçi, L. Alves, O. Alves, C. Lopes, G. Bajraktari, M.Y. Henein, Left Ventricular Myocardial and Cavity Velocity Disturbances Are Powerful Predictors of Significant Coronary Artery Stenosis, J. Clin. Med. 11 (2022). https://doi.org/10.3390/jcm11206185.
37. A.M.S. Omar, D.M.R. Botero, J.A. Caraballo, G.H. Kim, Y. Khachatoorian, J. Kliewer, M.A.A. Rahman, O. Rifaie, J.N. Bella, E. Argulian, J. Contreras, Tissue Doppler derived biphasic velocities during the pre and post-ejection phases: patterns, concordance and hemodynamic significance in health and disease, Cardiovasc. Ultrasound 20 (2022) 1–14. https://doi.org/10.1186/s12947-022-00287-0.
38. C.L. Bjerregaard, F.J. Olsen, K.G. Skaarup, P.G. Jørgensen, S. Galatius, S. Pedersen, A. Iversen, T. Biering-Sørensen, Association between cardiac time intervals and incident heart failure after acute coronary syndrome, Int. J. Cardiovasc. Imaging 40 (2024) 2145–2155. https://doi.org/10.1007/s10554024-03206-8.

