Section: Cardiology

Original Research Article

A STUDY OF TISSUE DOPPLER IMAGING FOR ASSESSMENT OF LEFT VENTRICULAR DYSFUNCTION IN CORONARY ARTERY DISEASE

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ABSTRACT

Background: Coronary artery disease (CAD) remains the leading cause of morbidity and mortality worldwide. Early detection of left ventricular (LV) systolic and diastolic dysfunction is crucial for prognostic stratification and therapeutic decision-making. Conventional Doppler echocardiography assesses LV function using parameters such as transmittal E/A ratio and left ventricular ejection fraction (LVEF). However, Tissue Doppler Imaging (TDI) provides direct quantitative assessment of myocardial velocities and may detect subclinical dysfunction earlier. The objective is to determine left ventricular mitral annular systolic (Sa) and early diastolic (Ea) velocities using TDI and compare them with conventional Doppler echocardiographic parameters in patients with CAD.

Materials and Methods: This hospital-based observational study included 60 patients (39 males, 21 females) with newly or previously diagnosed CAD admitted to Khaja Banda Nawaz Teaching and General Hospital, Kalaburagi. All subjects underwent standard two-dimensional echocardiography, conventional pulsed-wave Doppler, and pulsed-wave TDI using a GE LOGIQ F8 system. Mitral annular velocities were recorded from the lateral annulus in the apical four-chamber view. Peak systolic (Sa), early diastolic (Ea), and late diastolic (Aa) velocities were measured and compared with conventional parameters including LVEF and transmitral E/A ratio. Statistical significance was defined as $p < 0.05$.

Results: TDI-derived Ea detected diastolic dysfunction in 75% of CAD patients compared to 60% detected by conventional E/A ratio ($p < 0.001$). For systolic dysfunction, conventional LVEF identified 83.3% of cases, whereas Sa velocity detected 61.7%. Ea showed superior sensitivity in identifying diastolic dysfunction, while LVEF remained a stronger predictor of systolic dysfunction.

Conclusion: TDI-derived Ea is a more sensitive parameter for detecting LV diastolic dysfunction in CAD patients compared to conventional Doppler E/A ratio. However, LVEF remains superior to Sa velocity in identifying systolic dysfunction. TDI parameters (Ea and Sa) provide valuable complementary diagnostic and prognostic information in CAD patients.

Keywords: Coronary artery disease; Tissue Doppler Imaging; Left ventricular dysfunction; Mitral annular velocity; Ejection fraction.

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality worldwide. According to the World Health Organization (WHO), cardiovascular diseases (CVDs) account for approximately 20.5 million deaths annually, with ischemic heart disease being the largest contributor.[1] The Global Burden of Disease (GBD) Study 2021 further confirms that ischemic heart disease continues to be the leading cause of death globally, with rising prevalence in low- and middle-income countries.[2]

India is currently experiencing a rapid epidemiological transition, with non-communicable diseases surpassing communicable diseases as the

primary cause of mortality. Recent data suggest that CAD prevalence in India ranges between 7–13% in urban populations and 3–7% in rural populations, with an earlier age of onset compared to Western populations.[3,4] The age-standardized cardiovascular mortality rate in India is significantly higher than the global average, underscoring the urgent need for early detection and risk stratification strategies.[2,4]

Left ventricular (LV) dysfunction is a major determinant of prognosis in CAD. Both systolic and diastolic dysfunction may result from ischemia, myocardial fibrosis, and adverse remodelling. Conventional echocardiography evaluates LV systolic function using left ventricular ejection fraction (LVEF) and diastolic function using transmitral Doppler parameters such as E wave, A wave, E/A ratio, deceleration time (DT), and isovolumetric relaxation time (IVRT).[5] However, these parameters are preload-dependent and may fail to detect early myocardial dysfunction.

Tissue Doppler Imaging (TDI), introduced in the late 1980s, measures myocardial tissue velocities rather than blood flow velocities and provides quantitative assessment of longitudinal ventricular function.[6] Mitral annular peak systolic velocity (Sa or S′) reflects longitudinal systolic performance, while early diastolic velocity (Ea or E′) reflects myocardial relaxation and is relatively less influenced by preload.[7] Studies have demonstrated that Ea correlates well with invasive measures of LV relaxation and filling pressures, particularly when combined with transmitral E velocity (E/Ea ratio).[8]

In CAD, longitudinal myocardial fibres are affected early in the ischemic cascade, often leading to reduced mitral annular velocities before significant reduction in global LVEF occurs.[9] Therefore, TDI may allow earlier detection of subclinical LV dysfunction compared to conventional Doppler parameters.

Given the increasing burden of CAD and the clinical importance of early ventricular dysfunction detection, this study aims to evaluate left ventricular mitral annular systolic (Sa) and early diastolic (Ea) velocities using TDI and compare them with conventional Doppler echocardiographic parameters in patients with coronary artery disease.

MATERIALS AND METHODS

Study Design and Setting: This was a hospital-based, observational, cross-sectional study conducted in the Department of General Medicine at Khaja Banda Nawaz Teaching and General Hospital, Kalaburagi. The study included both inpatient and outpatient participants.

Study Population: A total of 60 patients diagnosed with coronary artery disease (CAD) were enrolled in the study. Among them, 39 were males and 21 were females. Patients were either newly diagnosed or previously diagnosed cases of CAD.

Inclusion Criteria

- Age ≥ 18 years
- Patients with clinically diagnosed or previously documented CAD
- Patients willing to provide informed consent

Exclusion Criteria

- Significant valvular heart disease
- Congenital heart disease
- Cardiomyopathy unrelated to ischemic aetiology
- Severe arrhythmias interfering with Doppler assessment
- Poor echocardiographic window

Data Collection: Detailed clinical history including symptoms such as chest pain, dyspnea, sweating, and risk factors including diabetes mellitus, hypertension, dyslipidemia, and smoking was recorded. Physical examination was performed for all participants.

Baseline investigations included:

- Electrocardiogram (ECG)
- Two-dimensional echocardiography (2D ECHO)
- Conventional Doppler echocardiography
- Tissue Doppler Imaging (TDI)

Echocardiographic Assessment

All echocardiographic examinations were performed using a GE LOGIQ F8 ultrasound system equipped with a phased-array transducer.

Conventional Echocardiography

Two-dimensional echocardiography was performed in standard parasternal long-axis, short-axis, and apical views.

Left ventricular ejection fraction (LVEF) was calculated using standard methods.

Transmitral flow velocities were obtained using pulsed-wave Doppler with the sample volume placed at the tips of the mitral valve leaflets in the apical four-chamber view. The following parameters were measured:

- Peak early diastolic velocity (E wave)
- Peak late diastolic velocity (A wave)
- E/A ratio
- Deceleration time (DT)

Diastolic dysfunction was graded based on established Doppler criteria.

Tissue Doppler Imaging (TDI)

Pulsed-wave TDI was performed in the apical four-chamber view.

The sample volume was placed at the lateral mitral annulus, at the junction of the left ventricular wall and the mitral annulus.

The following myocardial velocities were recorded:

- Sa (S′): Peak systolic velocity
- Ea (E′): Peak early diastolic velocity
- Aa (A′): Peak late diastolic velocity

All measurements were obtained during quiet respiration and averaged over three cardiac cycles.

Outcome Measures

The primary objective was to compare:

- TDI-derived Sa with conventional LVEF for assessment of systolic dysfunction
- TDI-derived Ea with transmitral E/A ratio for assessment of diastolic dysfunction

Statistical Analysis

Data were entered and analyzed using appropriate statistical software. Continuous variables were

expressed as mean ± standard deviation, and categorical variables were expressed as percentages. Comparisons between TDI parameters and conventional echocardiographic parameters were performed using appropriate statistical tests. A p-value < 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted in accordance with ethical principles for medical research. Institutional ethical approval was obtained prior to commencement of the study (KBNIMS/IEC/19-20/41). Written informed consent was obtained from all participants.

RESULTS

Demographic Characteristics: A total of 60 patients with coronary artery disease (CAD) and left ventricular dysfunction were included in the study.

Gender Distribution: A total of 60 patients with coronary artery disease (CAD) and left ventricular dysfunction were included in the study. Among them, 39 patients (65.0%) were males, and 21 patients (35.0%) were females, demonstrating a male predominance in the study population. [Table 1].

Table 1: Gender Distribution of Study Population (n = 60)

Gender	No. of Patients	%
Female	21	35.0
Male	39	65.0
Total	60	100.0

Age Distribution: The majority of patients were in the 50–60 years age group (35.0%), followed by 61–70 years (31.7%). Patients aged <50 years and >70 years each accounted for 16.7% of the study cohort. These findings indicate that CAD with LV dysfunction was most prevalent among middle-aged and elderly individuals. [Table 2].

Table 2: Age Distribution of Study Population (n = 60)

Age in Years	No. of Patients	%
<50	10	16.7
50-60	21	35.0
61-70	19	31.7
>70	10	16.7
Total	60	100.0

Clinical Presentation

Presenting Symptoms: Chest pain was the most common presenting symptom, reported in 42 patients (70.0%). Shortness of breath was observed in 8 patients (13.3%), while 7 patients (11.7%) were asymptomatic. Gastrointestinal symptoms were present in 3 patients (5.0%). [Table 3].

Table 3: Presenting Symptoms of Patients (n = 60)

Presenting Symptoms	No. of Patients	%
Chest pain	42	70.0
Shortness of breath	8	13.3
Asymptomatic	7	11.7
GI symptoms	3	5.0
Total	60	100.0

Risk Factor Profile: Hypertension was the most prevalent risk factor, observed in 31 patients (51.7%). Diabetes mellitus was present in 14 patients (23.3%), dyslipidemia in 8 patients (13.3%), and smoking in 7 patients (11.7%). [Table 4].

Table 4. Risk Factors Among Study Population (n = 60)

Risk Factors	No. of Patients (n=60)	%
HTN	31	51.7
DM	14	23.3
Dyslipidemia	8	13.3
Smoking	7	11.7

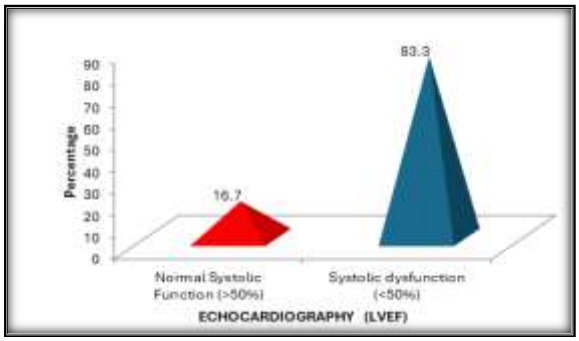

Figure 1: Study of LV Systolic Function by Conventional Echocardiography (LVEF)

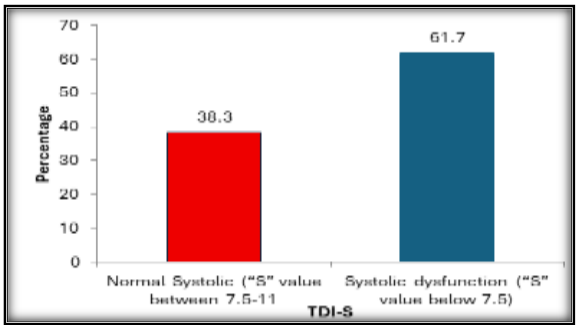

Figure 2: LV Systolic Function by TISSUE DOPPLER IMAGING

Left Ventricular Systolic Function

Conventional Echocardiography (LVEF): Assessment of systolic function using conventional echocardiography showed that 50 patients (83.3%) had systolic dysfunction (LVEF <50%), whereas 10 patients (16.7%) had preserved systolic function. [Figure 1]

Tissue Doppler Imaging (Sa): Tissue Doppler Imaging demonstrated systolic dysfunction (Sa <7.5 cm/s) in 37 patients (61.7%), while 23 patients (38.3%) had normal systolic velocities. [Figure 2]

Comparative Analysis of Systolic Function: Conventional echocardiography detected a significantly higher proportion of systolic dysfunction compared to TDI (83.3% vs 61.7%). The difference between the two modalities was statistically significant ($\chi^2 = 19.43$, $p < 0.001$). [Figure 3]

Pearson correlation analysis showed a moderate positive correlation between LVEF and TDI-S values ($r = 0.496$, $p < 0.001$), indicating that longitudinal systolic velocity reflects global systolic performance.

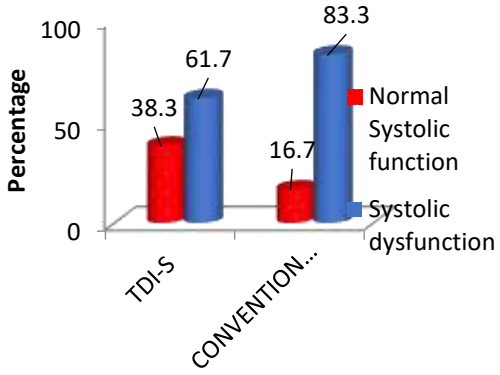

Figure 3: Compare the study of LV Systolic Function by TDI & Conventional Echocardiography.

Correlation Between LVEF and TDI-S

Table 5: Pearson correlation analysis demonstrated

ECHOCARDIOGRAPHY EF VS TDI-S	
r Value	0.496
P Value	<0.001**

This shows a moderate positive correlation between LVEF and TDI-S, indicating that longitudinal systolic velocity reflects global systolic function.

Left Ventricular Diastolic Function

Conventional Echocardiography (E/A Ratio): Conventional Doppler assessment demonstrated abnormal diastolic function in 36 patients (60.0%), while 24 patients (40.0%) had normal diastolic function. [Figure 4]

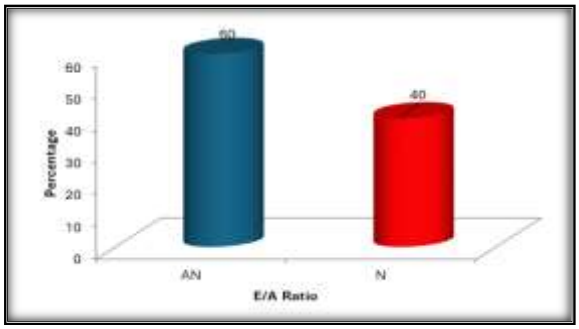

Figure 4: LV Diastolic Function by Conventional ECHO CARDIOGRAPHY (E/A)

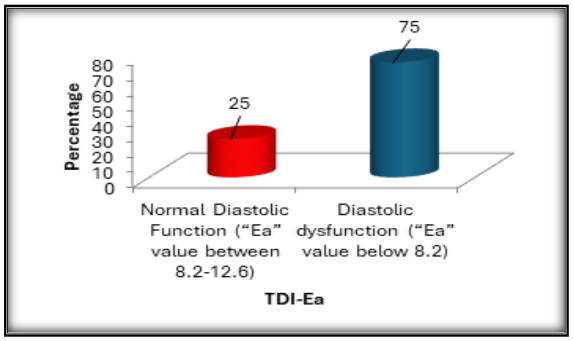

Figure 5: Study of LV Diastolic Function by TDI

Tissue Doppler Imaging (Ea): TDI-derived Ea identified diastolic dysfunction in 45 patients (75.0%), whereas 15 patients (25.0%) had normal diastolic parameters. [Figure 5]

Comparative Analysis of Diastolic Function: TDI detected a significantly greater proportion of diastolic dysfunction compared to conventional echocardiography (75.0% vs 60.0%). The difference was highly statistically significant ($\chi^2 = 30.0$, $p < 0.001$). [Figure 6]

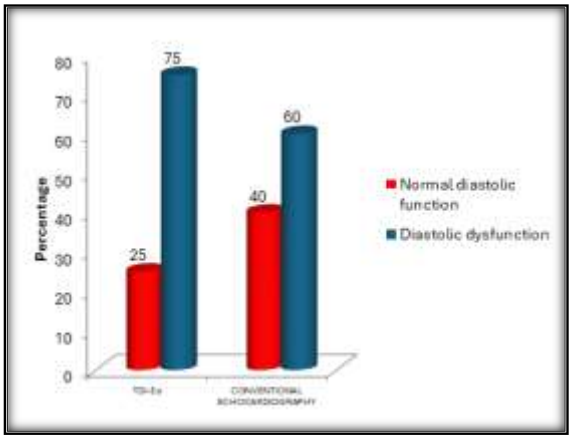

Figure 6: Compare the study of LV Diastolic Function by TDI & Conventional Echocardiography

Coronary artery disease with left ventricular dysfunction was observed predominantly in males and middle-aged individuals in the present study. Conventional echocardiography using left ventricular ejection fraction (LVEF) identified a greater proportion of systolic dysfunction cases compared to Tissue Doppler Imaging–derived systolic velocity

(TDI-S). In contrast, Tissue Doppler Imaging using early diastolic velocity (Ea) detected significantly more cases of diastolic dysfunction than the conventional transmitral E/A ratio. Furthermore, a moderate positive correlation was observed between LVEF and TDI-S values (r = 0.496), indicating that longitudinal systolic myocardial velocity reflects global left ventricular systolic function.

DISCUSSION

The present study evaluated the role of Tissue Doppler Imaging (TDI) in assessing left ventricular (LV) systolic and diastolic dysfunction in patients with coronary artery disease (CAD), and compared its diagnostic performance with conventional Doppler echocardiographic parameters. The principal findings demonstrate that TDI-derived early diastolic velocity (Ea) detected a significantly greater proportion of diastolic dysfunction cases compared to conventional transmitral E/A ratio, whereas conventional left ventricular ejection fraction (LVEF) remained superior in identifying systolic dysfunction. Additionally, a moderate positive correlation was observed between LVEF and TDI-derived systolic velocity (Sa), supporting the association between longitudinal myocardial velocity and global ventricular function.

In the present study, CAD with LV dysfunction was predominantly observed in males and middle-aged individuals. This demographic pattern aligns with contemporary data indicating higher CAD prevalence and earlier disease manifestation in males, particularly in South Asian populations.[10] The INTERHEART study highlighted that modifiable risk factors such as hypertension, diabetes, and dyslipidemia contribute significantly to earlier CAD presentation in developing countries.[11] The high prevalence of hypertension and diabetes observed in our cohort likely contributed to the burden of ventricular dysfunction.

Conventional echocardiography detected systolic dysfunction in 83.3% of patients, whereas TDI-derived Sa identified 61.7%. Although Sa reflects longitudinal fiber shortening, LVEF measures global volumetric systolic performance and incorporates contributions from longitudinal, circumferential, and radial fibers.[12] In established ischemic heart disease, systolic impairment often involves multiple myocardial layers; thus, LVEF may better represent advanced systolic dysfunction.

Previous studies have demonstrated that longitudinal systolic velocities decline early in ischemic states, sometimes preceding reduction in LVEF.[13] However, in patients with established systolic dysfunction, LVEF remains the reference parameter for global systolic assessment.[14] The moderate positive correlation observed in our study (r = 0.496, P < 0.001) is consistent with findings reported by Wang et al., who showed significant correlation between mitral annular systolic velocity and ejection fraction in patients with ischemic cardiomyopathy.[15] Therefore, while TDI-S reflects longitudinal mechanics and provides useful adjunctive information, it should not replace LVEF for evaluation of overt systolic dysfunction.

A major finding of this study was the higher detection rate of diastolic dysfunction using TDI-derived Ea (75%) compared to conventional E/A ratio (60%). This difference was statistically significant ($\chi^2 = 30.0$, $P < 0.001$).

Transmitral flow patterns are influenced by loading conditions, heart rate, and left atrial pressure, which may result in pseudonormalization of E/A ratio in intermediate stages of diastolic dysfunction.[16] In contrast, TDI-derived Ea reflects intrinsic myocardial relaxation and is relatively preload-independent.[17]

Bruch et al. demonstrated that Ea provides superior discrimination of impaired relaxation compared to conventional Doppler indices in patients with ischemic heart disease.[18] Furthermore, Dokainish et al. reported that TDI parameters detect early diastolic abnormalities even in patients with preserved ejection fraction.[19] The superior detection of diastolic dysfunction observed in our study supports these findings and reinforces the role of TDI in early identification of impaired myocardial relaxation.

In CAD, ischemia primarily affects subendocardial longitudinal fibers, which are highly sensitive to oxygen deprivation. Since these fibers play a crucial role in active relaxation, early impairment of Ea may occur before transmitral flow abnormalities become evident.[20] This pathophysiological mechanism likely explains the higher detection rate of diastolic dysfunction using TDI in our study.

Diastolic dysfunction often precedes systolic impairment and is independently associated with adverse cardiovascular outcomes, including heart failure with preserved ejection fraction (HFpEF).[21] Early detection of diastolic abnormalities in CAD patients may allow earlier therapeutic intervention and improved risk stratification.

The findings of this study suggest that TDI should be incorporated into routine echocardiographic evaluation of CAD patients, particularly for identification of subclinical diastolic dysfunction. However, conventional echocardiography remains essential for assessment of global systolic performance.

Limitations: The study was conducted at a single center with a relatively small sample size, which may limit generalizability. Long-term follow-up was not performed, and invasive hemodynamic validation was not available. Future large-scale prospective studies are warranted to establish the prognostic significance of TDI parameters in CAD.

CONCLUSION

The present study demonstrates that Tissue Doppler Imaging (TDI) provides valuable additional information in the assessment of left ventricular dysfunction in patients with coronary artery disease.

While conventional echocardiography using left ventricular ejection fraction (LVEF) remains superior for detecting established systolic dysfunction, TDI-derived early diastolic velocity (Ea) identifies a greater proportion of patients with diastolic dysfunction compared to conventional transmitral E/A ratio.

The significant difference observed in diastolic dysfunction detection (75% vs 60%, $P < 0.001$) highlights the enhanced sensitivity of TDI in identifying impaired myocardial relaxation. Furthermore, the moderate positive correlation between LVEF and TDI-S ($r = 0.496$, $P < 0.001$) confirms that longitudinal systolic velocity reflects global ventricular performance.

These findings suggest that TDI should be incorporated as a complementary tool alongside conventional echocardiography in the routine evaluation of CAD patients, particularly for early detection of subclinical diastolic dysfunction. Early identification of ventricular dysfunction may improve risk stratification and guide timely therapeutic intervention.

Further large-scale prospective studies are warranted to establish the long-term prognostic implications of TDI parameters in coronary artery disease.

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