RESEARCH ARTICLE

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Comparison of Mitral Annular Plane Systolic Excursion to 2D Speckle Tracking and Tissue Doppler Imaging in Patients with Type 2 Diabetes and Normal Subjects for Prediction of Subclinical Left Ventricular Systolic Dysfunction

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Abstract

Background and Aim: Type 2 diabetes mellitus (T2DM) is a significant risk factor for cardiovascular diseases, leading to subclinical left ventricular systolic dysfunction (LVSD). Early detection is crucial to prevent progression. To assess the utility of mitral annular plane systolic excursion (MAPSE) in detecting subclinical LVSD in asymptomatic T2DM patients and its correlation with 2D speckle-tracking echocardiography and tissue Doppler imaging (TDI) parameters.

Materials and Methods: A cross-sectional comparative study involving 200 participants (100 with T2DM and 100 controls) was conducted. Echocardiographic parameters, including MAPSE, global longitudinal strain (GLS), and TDI, were analysed. Statistical tests included t-tests and Pearson correlation analyses.

Results: T2DM patients showed significantly reduced MAPSE (1.2±0.3 cm vs. 1.4±0.2 cm, $P < 0.001$), GLS (-17.2±3.1% vs. -22.6±2.7%, $P < 0.001$), and TDI (0.08±0.02 m/s vs. 0.10±0.01 m/s, $P < 0.001$) compared with controls. MAPSE correlated positively with GLS (r=0.699, $P = 0.001$) and TDI [r=0.04, $P = 0.03$; 95% confidence interval (CI): 0.01-0.07] and negatively with HbA1c (r=-0.018, $P = 0.02$; 95% CI: -0.04-0.00) and diabetes duration (r=-0.117).

Conclusion: MAPSE <1.2 cm, a value supported by previous echocardiographic studies, identifies subtle impairment of longitudinal systolic function in asymptomatic T2DM patients. MAPSE demonstrates strong agreement with GLS and TDI and provides a simple, reproducible, and accessible marker for detecting subclinical LVSD, particularly in resource-limited settings.

Keywords: Diabetes mellitus, MAPSE, GLS, tissue doppler imaging, subclinical LVSD

INTRODUCTION

Diabetes mellitus (DM) constitutes an ongoing metabolic dysfunction that has emerged as a critical global health issue, contributing significantly to cardiovascular morbidity and mortality. Subclinical left ventricular systolic dysfunction (LVSD), an early manifestation of diabetic cardiomyopathy,[1] often remains undiagnosed until overt heart failure develops. Advanced imaging techniques, such as 2D speckle-tracking echocardiography (STE) and tissue Doppler imaging (TDI), are of primary importance in diagnosing subclinical LVSD.[2,3] DM represents a chronic metabolic disorder that has emerged as a

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major global public health challenge, contributing substantially to cardiovascular morbidity and mortality. Among its cardiac manifestations, subclinical LVSD is recognized as an early hallmark of diabetic cardiomyopathy, often preceding clinically overt heart failure.[4]

Subclinical LVSD can remain undetected on conventional echocardiography, as left ventricular ejection fraction (LVEF) may appear preserved in the early stages. Advanced imaging modalities such as two-dimensional STE and TDI have been instrumental in detecting subtle myocardial deformation abnormalities. However, these methods may be technically demanding, cost-intensive, or not universally available in resource-constrained settings.[2]

Mitral annular plane systolic excursion (MAPSE), a simple M-mode echocardiographic measurement, reflects longitudinal left ventricular function and can serve as a practical surrogate marker for global systolic performance. Prior studies have demonstrated its correlation with both LVEF and global longitudinal strain (GLS), suggesting potential for early LVSD identification.[3,5]

Despite growing interest in MAPSE, limited data exist regarding its performance compared with GLS and TDI-derived systolic (S') velocities in asymptomatic patients with type 2 diabetes mellitus (T2DM). Therefore, this study aimed to evaluate the diagnostic value of MAPSE for detecting subclinical LVSD in T2DM patients with preserved LVEF and to examine its correlation with and to examine its correlation with GLS and TDI-derived systolic velocities.

METHODS

Study Design and Study Population

This was a cross-sectional comparative study conducted at a tertiary care medical centre between May 2024 and March 2025. The study included 200 patients divided into two groups: 100 asymptomatic patients with T2DM and 100 age- and sex-matched healthy controls. Inclusion criteria for the diabetic group included patients aged 18-70 years with a confirmed T2DM diagnosis. The control group consisted of healthy individuals without diabetes, cardiovascular disease, or other metabolic disorders. Exclusion criteria were overt heart failure, significant valvular disease, coronary artery disease, atrial fibrillation, poor echocardiographic windows, acute illness, or inability to provide informed consent. In addition to obtaining the patient history, a baseline electrocardiogram (ECG) evaluation and a review of medical records were performed to exclude occult ischemic heart disease.

Data Collection

Comprehensive demographic, anthropometric, and clinical data were collected, including age, sex, body mass index (BMI), duration of diabetes, HbA1c levels, comorbidities (hypertension, dyslipidaemia), and medication history (antihypertensives, statins). All patients underwent a thorough physical examination, including assessment of vital signs. Transthoracic echocardiography was performed by experienced cardiologists using standardized protocols and high-resolution ultrasound systems, with patients in the left lateral decubitus position. Echocardiographic measurements included standard 2D, M-mode, pulsed-wave Doppler, and TDI imaging. MAPSE was measured in M-mode at both septal and lateral mitral annular sites. The mean MAPSE was calculated as the arithmetic average of the septal and lateral values for each subject. LVEF was obtained using the biplane Simpson's method. TDI S', early diastolic, and late diastolic velocities were recorded at the septal and lateral annuli. GLS was assessed using vendor-independent software (EchoPAC, GE Healthcare) by analyzing apical 2-, 3-, and 4-chamber views.[6] All echocardiographic measurements were averaged over three consecutive cardiac cycles to minimize beat-to-beat variability. To assess measurement reproducibility, intra- and inter-observer variabilities were calculated for 20 randomly selected subjects, yielding intraclass correlation coefficients of 0.92 and 0.89, respectively. All echocardiographic and statistical analyses were performed by personnel blinded to the participants' group allocation, with all data anonymized prior to analysis. Laboratory parameters, such as HbA1c, were also assessed.

Ethics Committee Information

Ethical approval for this study was obtained from the Institutional Ethics Committee of Jawaharlal Nehru Medical College (references no: MDC/JNMCIEC/300, date: 13.05.2024). The study was conducted in accordance with the principles of the Declaration of Helsinki (2013 revision). Each patient provided written informed consent before the start of the study.

Statistical Analysis

All statistical analyses were performed using SPSS software version 22.0 (IBM Corp., Armonk, NY). Quantitative variables are expressed as mean ± standard deviation, and qualitative data are expressed as frequencies and percentages. Group comparisons (T2DM vs control) were performed using independent-samples t-tests for continuous variables and chi-square tests for categorical variables. Correlations between MAPSE and GLS, TDI S', HbA1c, and diabetes duration were assessed using Pearson's correlation coefficients with corresponding 95% confidence intervals (CIs). Statistical significance was set at $P < 0.05$.

RESULTS

A total of 100 T2DM patients and 100 age-matched healthy controls were included. As shown in Table 1, the mean age was slightly higher in the T2DM group than in controls (57.0±6.2

Table 1. Comparison of echocardiographic parameters between type 2 diabetes mellitus patients and healthy controls

Variable	T2DM (n=100)	Controls (n=100)	t-value	*P*-value	95% CI for mean difference
Age (years)	57.0±6.2	54.0±5.8	2.09	0.038	(0.17, 5.83)
Gender (M/F)	54/46	52/48	χ^2=0.65	0.42	-
HbA1c (%)	8.65±1.78	5.85±0.63	12.89	<0.001	(2.36, 3.24)
LVEF (%)	58.0±2.9	62.5±3.2	9.89	<0.001	(3.59, 5.41)
Septal MAPSE (cm)	1.10±0.25	1.30±0.20	6.12	<0.001	(0.13, 0.27)
Lateral MAPSE (cm)	1.30±0.25	1.50±0.20	6.48	<0.001	(0.14, 0.26)
Mean MAPSE (cm)	1.20±0.30	1.40±0.20	5.73	<0.001	(0.13, 0.27)
GLS (%)	-17.2±3.1	-22.6±2.7	12.00	<0.001	(4.61, 6.39)
TDI S' (m/s)	0.08±0.02	0.10±0.01	8.24	<0.001	(0.014, 0.026)
E/e' ratio	8.7±1.9	7.1±1.6	6.18	<0.001	(1.09, 2.11)
E/A ratio	0.9±0.2	1.1±0.2	5.28	<0.001	(0.12, 0.28)

LVEF: Left ventricular ejection fraction, MAPSE: Mitral annular plane systolic excursion, GLS: Global longitudinal strain, TDI: Tissue Doppler imaging, S': Derived systolic, CI: Confidence interval
Values are presented as mean ± standard deviation unless otherwise indicated. Independent-sample t-tests were used for continuous variables; χ^2 test for gender distribution

vs. 54.0±5.8 years; P = 0.038). The gender distribution was similar across groups (P = 0.42). T2DM patients demonstrated significantly lower MAPSE, GLS, and TDI S' values compared with controls (P < 0.001 for all measures), indicating early impairment of longitudinal systolic function despite a preserved ejection fraction.

MAPSE exhibited a strong positive association with GLS, supporting its use as a surrogate marker of global longitudinal systolic function [r=0.699, 95% CI: (0.58, 0.78); P < 0.001] (Figure 1). The weak or absent relationships with HbA1c and diabetes duration suggest that structural myocardial dysfunction may occur independently of glycaemic status or disease chronicity.

MAPSE demonstrated a small, statistically significant negative correlation with HbA1c [r=-0.018, 95% CI: (-0.04, 0.00); P = 0.02], as shown in Figure 2, suggesting that poorer glycemic control is associated with reduced longitudinal systolic displacement. No significant correlation was found between MAPSE and duration of diabetes (P = 0.24).

A weak but statistically significant positive correlation was identified between MAPSE and TDI S' velocity [r=0.04, 95% CI: (0.01, 0.07); P = 0.03], as shown in Table 2 and Figure 3, highlighting that reduced MAPSE reflects subtle impairments in tissue-level systolic function.

DISCUSSION

In this study, we evaluated the diagnostic value of MAPSE for detecting subclinical LVSD in patients with T2DM and compared its performance with GLS and TDI. The findings demonstrate that diabetic patients exhibit significant reductions in MAPSE, GLS, and S' velocities despite a preserved ejection fraction, indicating early subclinical myocardial dysfunction.

Demographic and Baseline Characteristics

The mean age and distribution between diabetic and control groups were comparable (P = 0.038 for age; P = 0.42 for gender), validating the matching process. The diabetic cohort had significantly higher HbA1c levels, consistent with impaired glycaemic control. The mean disease duration was 8.2 years, with a moderate prevalence of hypertension and dyslipidaemia, aligning with prior epidemiological data for middle-aged T2DM populations.

MAPSE as a Marker of Longitudinal Systolic Function

The observed reduction in both septal and lateral MAPSE among diabetic patients compared with controls (1.2±0.3 cm vs. 1.4±0.2 cm; P < 0.001) supports previous evidence that longitudinal myocardial fibres, located subendocardially, are

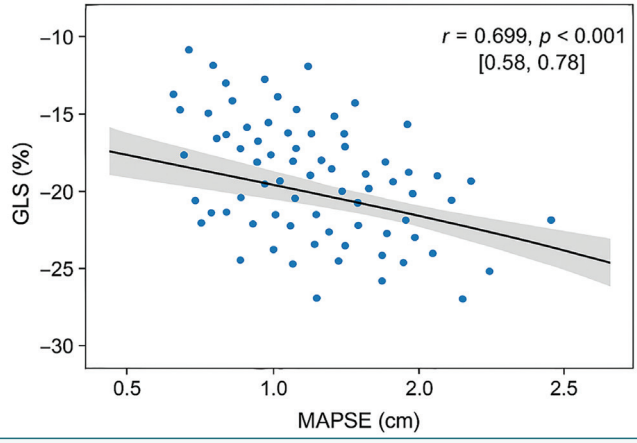

Figure 1. Correlation between mitral annular plane systolic excursion (MAPSE) and global longitudinal strain (GLS) in type 2 diabetes mellitus patients

Table 2. Correlation between MAPSE and clinical or echocardiographic parameters in T2DM patients

Parameter	Pearson's r	95% CI for r	*P*-value
GLS (%)	0.699	(0.58, 0.78)	<0.001
TDI S' (m/s)	0.04	(0.01, 0.07)	0.03
HbA1c (%)	-0.018	(-0.04, 0.00)	0.02
Duration of diabetes (years)	-0.117	(-0.28, 0.05)	0.24

T2DM: Type 2 diabetes mellitus, MAPSE: Mitral annular plane systolic excursion, GLS: Global longitudinal strain, TDI: Tissue Doppler imaging, S': Derived systolic, CI: Confidence interval
Pearson correlation coefficients computed for continuous variables. All tests two-tailed; significance level set at $P < 0.05$

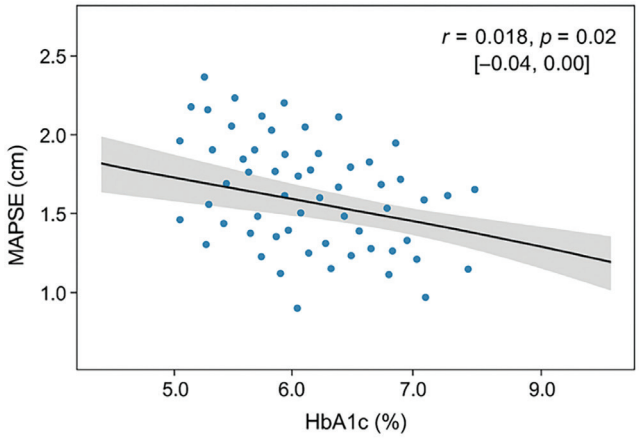

Figure 2. Correlation between mitral annular plane systolic excursion (MAPSE) and HbA1c in type 2 diabetes mellitus patients

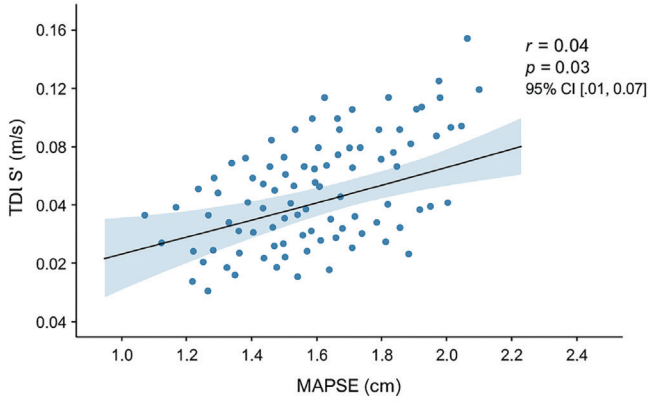

Figure 3. Correlation between mitral annular plane systolic excursion (MAPSE) and tissue Doppler imaging derived systolic (TDI S') velocity in type 2 diabetes mellitus patients

particularly vulnerable to hyperglycaemia-induced injury. These findings are consistent with Hu et al.[5] and Matos et al.,[3] who established that reduced MAPSE correlates strongly with global systolic dysfunction even when LVEF is preserved.

The strong positive correlation between MAPSE and GLS (r=0.699, $P < 0.001$) further supports the use of MAPSE as a simple surrogate measure of myocardial strain, particularly when advanced imaging modalities such as speckle-tracking are not available.

Correlations with TDI and Metabolic Variables

The relationship between MAPSE and TDI S' was statistically significant (r=0.04, $P = 0.03$), although the magnitude of the correlation was minimal, indicating limited clinical relevance. This weak association may reflect technical variability in annular velocity measurements or the influence of regional motion abnormalities that can affect TDI values independently of global longitudinal function.

The correlation between MAPSE and HbA1c (r=-0.018, $P = 0.02$) was statistically significant, but extremely weak. This suggests that while poor glycaemic control is associated with myocardial dysfunction, MAPSE may be influenced by multiple overlapping pathophysiological mechanisms, including microangiopathy, oxidative stress, and myocardial fibrosis, rather than glycaemia alone.[1]

No significant correlation was observed between MAPSE and disease duration, implying that myocardial changes may occur early in the course of diabetes, potentially independent of clinically apparent disease duration.

The present findings are consistent with prior reports by Ernande and Derumeaux[1] and Mondillo et al.,[2] which emphasized that GLS and MAPSE both detect early myocardial dysfunction in people with diabetes before a decline in ejection fraction. Unlike previous studies, our analysis highlights the relative simplicity and reproducibility of MAPSE measurement, which can be particularly valuable in resource-limited clinical environments where STE software may not be available. This reinforces MAPSE as a feasible, low-cost tool for initial screening of diabetic cardiomyopathy.

These results confirm that diabetic patients can exhibit subclinical LVSD despite preserved LVEF. A MAPSE value <1.2 cm, supported by prior literature,[2] identified this impairment with reasonable sensitivity. Given its simplicity, MAPSE can serve as an early screening tool to identify patients who may benefit from closer echocardiographic surveillance or from lifestyle and

pharmacologic optimization.[3] Although the correlations with metabolic control were weak, the overall trend underscores that diabetic cardiomyopathy is multifactorial, involving metabolic, structural, and microvascular components rather than glycaemia alone.[1]

Study Limitations

Its cross-sectional design precludes causal inferences about relationships among diabetes duration, glycaemic control, and LV function. The sample size was moderate and determined by feasibility rather than by a formal power calculation, which potentially limited the ability to detect smaller effects. Subclinical coronary artery disease could not be entirely excluded without angiography, although clinical screening and ECG were used to minimize this risk. No multivariate regression analysis was performed due to sample size constraints; hence, confounding by variables such as BMI and blood pressure cannot be fully excluded. Finally, this was a single-center study, and the results may not be generalizable to all diabetic populations. Despite these limitations, the study provides robust evidence that MAPSE is an effective parameter for early detection of LVSD.

CONCLUSION

This study demonstrates that patients with T2DM exhibit a significant reduction in MAPSE, GLS, and tissue Doppler S' velocities compared to healthy controls, despite a preserved ejection fraction. A MAPSE value below 1.2 cm was indicative of subclinical LVSD and correlated strongly with GLS and moderately with TDI S'. These findings suggest that MAPSE is a simple, reproducible, and cost-effective echocardiographic parameter that can serve as a practical alternative for the early detection of subclinical LV dysfunction, particularly in resource-limited clinical settings where advanced strain analysis may not be available. Although the correlations between MAPSE and metabolic indices (HbA1c, disease duration) were weak, the overall data underscore that myocardial dysfunction in diabetes is multifactorial, reflecting the cumulative effects of metabolic, microvascular, and structural remodelling processes.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from the Institutional Ethics Committee of Jawaharlal Nehru Medical College (references no: MDC/JNMCIEC/300, date: 13.05.2024).

Informed Consent: Each patient provided written informed consent before the start of the study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.B., K.C., Concept: V.H., Design: M.B., S.P., Data Collection or Processing: S.P., K.C., Analysis or Interpretation: V.H., Literature Search: M.B., S.P., Writing: V.H., M.B., S.P., K.C.

Conflict of Interest: No conflict of interest was declared by the authors.

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