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Using Mitral Annular Plane Systolic Excursion (MAPSE) and Tissue Doppler Imaging Systolic Velocity (TDIS') As Surrogates of Left Ventricular Systolic Function

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Abstract

Purpose: Echocardiography has become a useful method for assessing structural diseases of the heart. MAPSE and TDI S' have also been shown to be reproducible assessments of longitudinal heart changes as LVEF is ineffective in cases of sub-optimal echocardiographic imagery caused by artefacts or air trapping.

Methodology: One hundred patients referred for echocardiography at the cardiac laboratory of DELSUTH, Oghara, Nigeria was recruited for the study. All patients had trans-thoracic echocardiography done with M-Mode, 2D and Spectral Doppler and Tissue Doppler echocardiographic images acquired. Data obtained was analyzed using IBM-SPSS version 22. A p-value of ≤ 0.05 was considered significant for all comparisons.

Findings: Hypertension was the commonest indication for an echocardiogram. The prevalence of abnormal left ventricular function was 13%, 24% and 28% as determined using LVEF, TDI S' and MAPSE. MAPSE had a higher specificity than TDI S' with statistically significant correlations found between TDI S' ($p<0.001$); MAPSE ($p=0.032$) and LVEF. Multiple linear and binomial logistic regression analysis showed significant relationships (beta=0.423; $p <0.001$) and odd ratios [OR(CI) = 10.80(2.56- 49.07)] respectively between TDI S' and LVEF.

Unique Contribution to Theory, Policy and Practice: MAPSE's specificity allows for diagnosis of longitudinal heart functional changes even in cases where the LVEF may be within normal limits. A combination of both MAPSE and TDI S' offer a greater prognostic significance. The correlation between MAPSE and TDI S' were good. Thus, MAPSE and TDI S' can serve as

surrogates for LVEF in assessing left ventricular systolic function and prognosticating cardiac disease

Keywords: *Echocardiography, Mitral Annular Plane Systolic Excursion, Tissue Doppler Imaging Systolic Velocity, Left Ventricular Ejection Fraction*

INTRODUCTION

Echocardiography has become a useful method for assessing structural diseases of the heart over the past few decades. It is known to give an understanding of the structure as well as functionality[1,2]. Until recently Doppler assessment has also been incorporated into modern day echocardiography[2].

Before now, the contractile function of the heart was largely assessed using the left ventricular ejection fraction[3], as well as fractional shortening. This assesses the fraction of blood that is ejected from the heart during the systolic phase of the cardiac cycle. These parameters can be measured using M-Mode echocardiography[4]. Tissue Doppler imaging can also be used to assess systolic function of the heart and has been shown to be a more sensitive way of assessing contractile as well as relaxation properties of the left ventricle[5].

Several echocardiographic parameters have been shown to correlate well with left ventricular systolic function. They include mitral annular plane systolic excursion (MAPSE) and tissue Doppler imaging systolic velocity (TDI S'). The complexity of the mitral annulus has been noted in various studies as well as its usefulness in assessing left ventricular function.[6]

It has been shown from studies that assessing longitudinal function of the heart using MAPSE is more reproducible and less error prone as opposed to using it for radial myocardial function assessment.[7] S' velocity using tissue Doppler imaging is also known to be independent of loading conditions of the heart as opposed to normal 2D echocardiographic assessment which is more subject to haemodynamic changes[6].

It may appear difficult in some instances to assess left ventricular function using M-Mode or 2D assessment largely due to suboptimal echocardiographic images caused by air trapping and artefacts. Therefore, using a simple tool such MAPSE or TDI S' velocity for assessing left ventricular systolic function may help to circumvent this challenge. It will also be relevant to determine which surrogate (MAPSE and TDI S') correlates better with indices of left ventricular systolic function (LVEF).

Aims

1. To determine if MAPSE and TDI S' correlate with left ventricular systolic function parameters.
2. To compare correlation abilities of the surrogates (MAPSE and TDI S') with LVEF.

Methodology

This study was carried out in the Cardiology unit of The Delta State University Teaching Hospital (DELSUTH) a University Teaching Hospital located in Oghara. Oghara is a town in Ethiope West Local Government area of Delta State (one of the major clans of the Urhobo ethnic group), Nigeria with geographic coordinates at 5035'20"N606'1"E.96. It is the tertiary health institution in Delta State, Nigeria. The hospital receives referral cases from within the state and from neighboring states (Edo, Bayelsa and Anambra).

Study design was a descriptive cross sectional. A total of 100 patients visiting the cardiology clinic with varying indications for echocardiography were recruited consecutively for the study. All patients had a transthoracic echocardiogram (Xario diagnostics ultrasound system model SSA-660A, Toshiba Medicals) with ECG gating performed according to established recommendations.

The M-mode, two-dimensional (2D) and spectral Doppler and tissue Doppler echocardiographic images were acquired from standard echocardiographic views (parasternal, apical and subcoastal) with subjects in the left lateral decubitus position. The left ventricular ejection fraction was calculated automatically by the echocardiograph machine in all patients, Displacement of the mitral annulus was measured in millimeters (mm) by MME by apical 4 chamber view.

TDI S' of the mitral annulus was taken from the apical 4 chamber view. The following measurements were made from the recordings: Peak Systolic Velocity (Sm), Early (Em) and Late (Am) diastolic velocities[6].

Data Management

Data was analysed with the Statistical Package for Social Sciences version 22. Categorical data are presented as frequencies and percentages. Continuous data are presented as means (Standard Deviation). Frequencies were compared using the Pearson's Chi Square test. The Pearson's Correlation test was used to correlate Left ventricular systolic function with MAPSE and TDI S'. A p-value of ≤ 0.05 was considered statistically significant for all comparisons/associations. Results are presented as Tables and Charts.

Results

The mean (SD) age of the patients was 54.83(16.51). The mean (SD) left ventricular ejection fraction was 67.04 (17.27) while the mean MAPSE was 14.85 (10.81) and the mean TDI S' being 7.46 (2.35). (Table 1)

The prevalence of abnormal left ventricular function was 13% (reduced ejection fraction) using LVEF; 28% using MAPSE and 24% using TDI S'. both surrogates had a specificity of 82.8%

with MAPSE being more sensitive (100%) than TDI S' (69.2%). MAPSE also showed a higher positive predictive value than TDI S'. (Tables 2 & 3)

There was a statistically significant association between the MAPSE ($p<0.001$), TDI's ($p<0.001$) and LVEF. Logistic regression analysis showed a significant odds ratio for comparison between LVEF and TDI S'. (Tables 2 & 3)

In addition, there was a positive significant correlation between TDI S' ($r=0.45$; $p<0.001$), MAPSE ($r=0.21$; $p=0.032$) and LVEF.(Figure 1 & 2) Multiple linear regressions also showed statistically significant relationship between TDI S' and LVEF.(Table 4)

Table 1: Age and LV Function Parameters of Patients

	Mean	Standard deviation
AGE (years)	54.83	16.51
LVEF (%)	67.04	17.27
MAPSE	14.85	10.81
S' VELOCITY	7.46	2.35

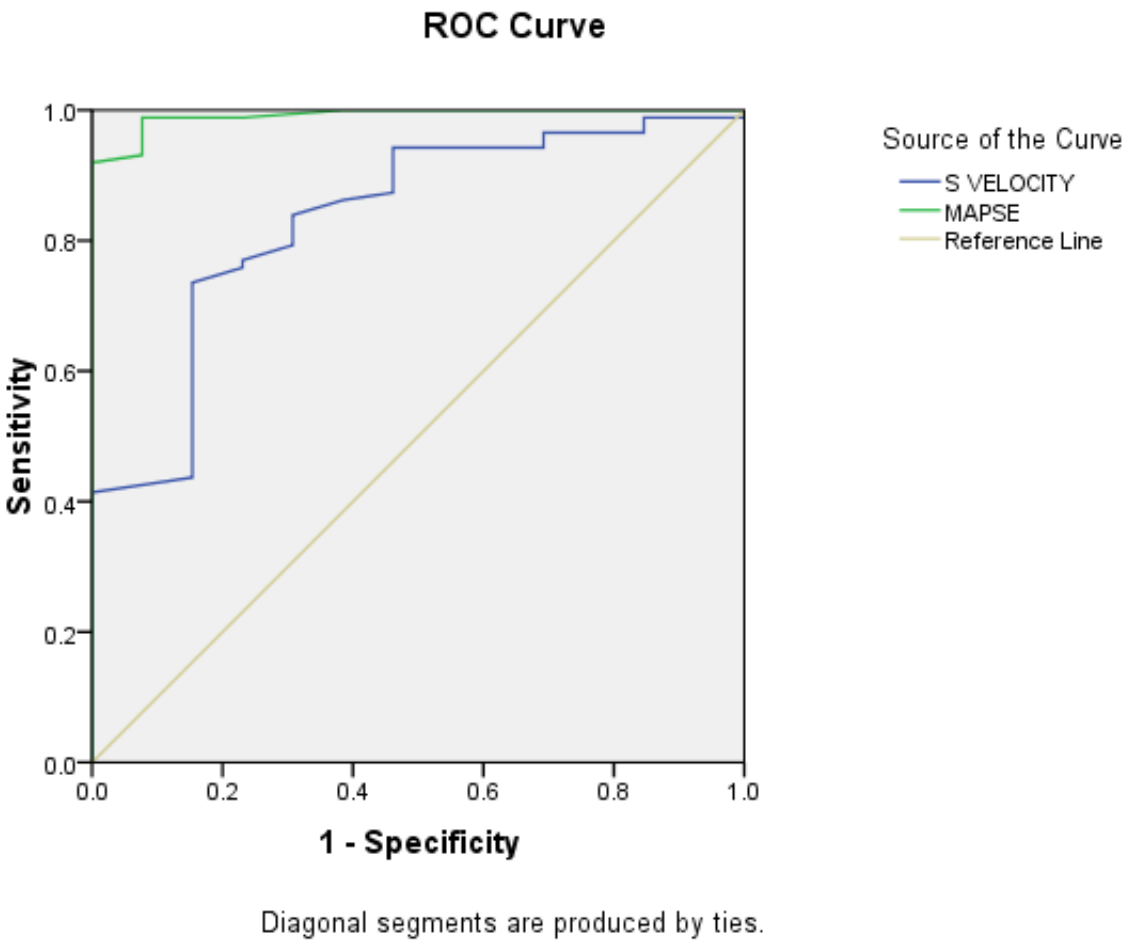
Table 2a: Comparison of LVEF by TDI S' Categories

	TDI S'			
	Abnormal n=24 mean (SD)	**Normal n=76 mean (SD)**	**t**	**p-value**
LVEF	50.73 (21.61)	72.20 (11.76)	-6.25	<0.001

MAPSE	12.14 (4.31)	15.70 (12.06)	-1.41	0.161
Median (IQR)	13.40 (6.57)	13.55 (3.80)		

Table 2b: Comparison of LVEF by MAPSE categories

	MAPSE			
	Reduced	**Normal**		
	n=28	**n=72**	**t**	**p-value**
	mean (SD)	**mean (SD)**		
LVEF	53.38 (24.89)	72.36 (8.82)	-5.65	<0.001
Median (IQR)	59.90 (50.45)	73.80 (12.90)		
TDI S'	6.85 (2.34)	7.69 (2.33)	-1.62	0.108



Area under the curve: TDI S' = 0.833 ; MAPSE = 0.992

Figure 1: ROC of MAPSE AND TDI S'

Table 3a: Relationship between MAPSE and LVEF

		LVEF			
		Reduced n(%)	**Normal n(%)**	**Total N(%)**	
MAPSE	**Reduced**	13 (46.4)	15 (53.6)	28 (100)	χ^2=34.43

					P < 0.001
	Normal	0 (0.0)	72 (100)	72 (100)	

Sensitivity = 100%; Specificity = 82.8%; PPV =46.4%; NPV = 100%

Table 3b: Relationship between TDI's and LVEF

		LVEF			
		Reduced n(%)	**Normal n(%)**	**Total N(%)**	
TDI's	**Reduced**	9 (37.5)	15 (62.5)	24 (100)	χ^2= 16.76 P < 0.001
	Normal	4 (5.3)	72 (94.7)	76 (100)	OR (CI)= 10.80 (2.56-49.07)

Sensitivity = 69.2%; Specificity = 82.3%; PPV =37.5%; NPV = 94.7%

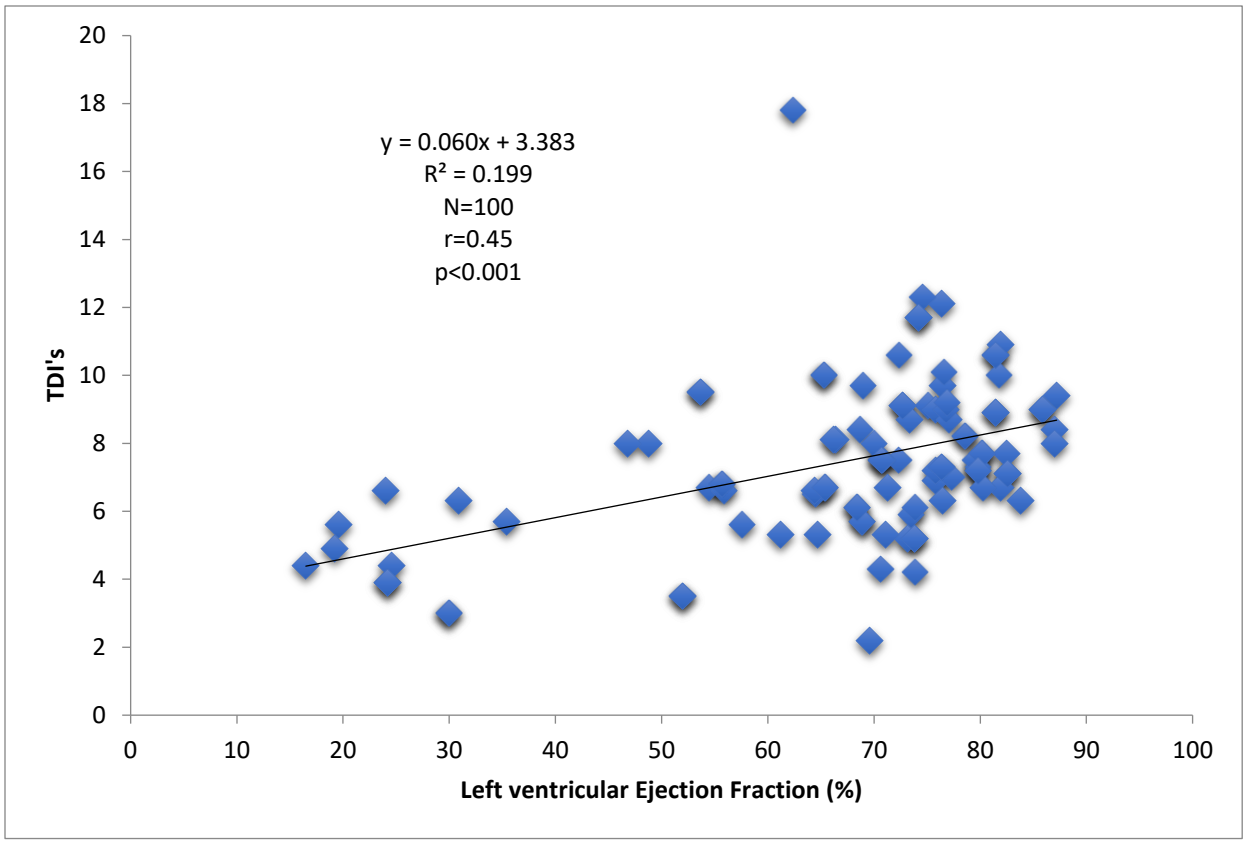


Figure 2: Correlation between TDI's and LVEF

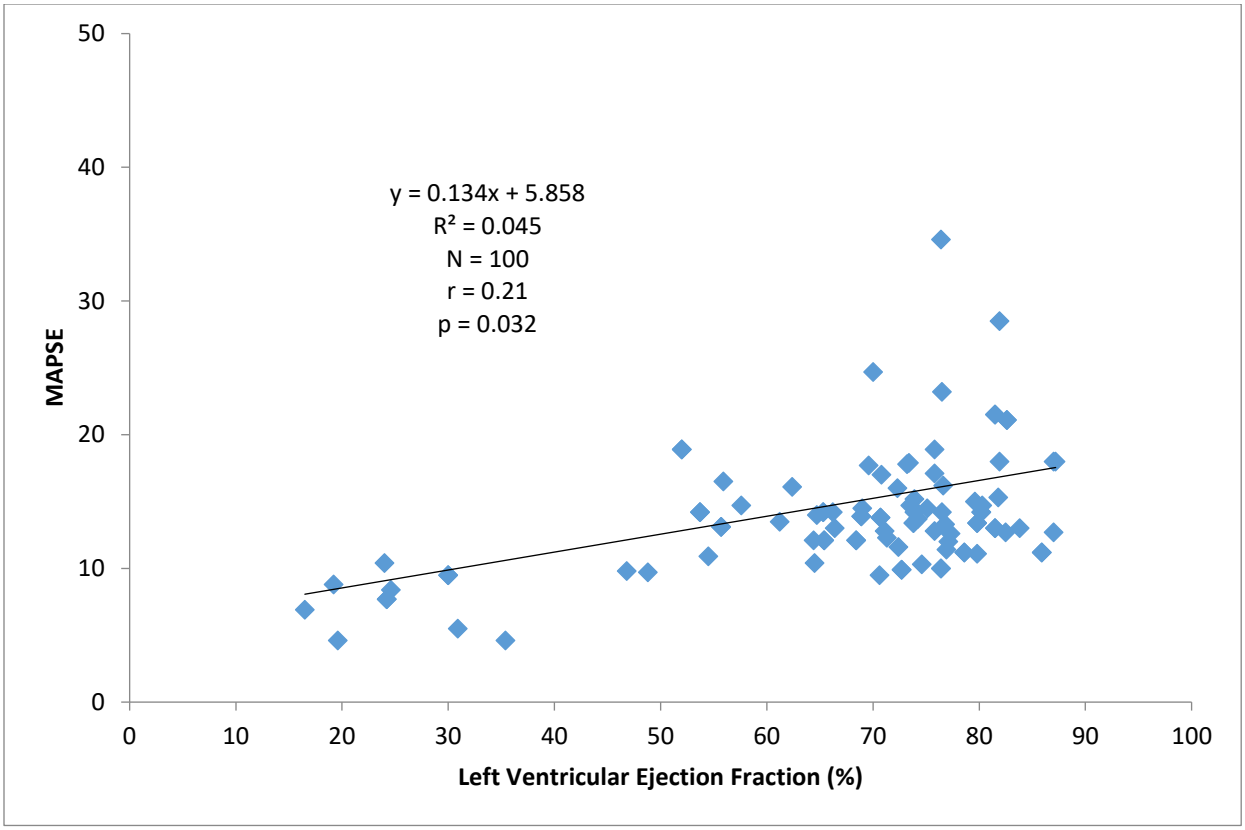


Figure 3: Correlation between MAPSE and LVEF

Table 4: Multiple Linear Regression of MAPSE, TDI and LVEF

	UNSTANDARDIZED COEFFICIENTS		**STANDARDIZED COEFFICIENTS**	**t**	Sig.
	B	Std. Error	Beta		
(Constant)	40.417	5.323		7.593	< 0.001
MAPSE	0.233	0.145	0.146	1.602	0.112
TDI's	3.108	0.668	0.423	4.654	< 0.001

Dependent variable: left ventricular ejection fraction

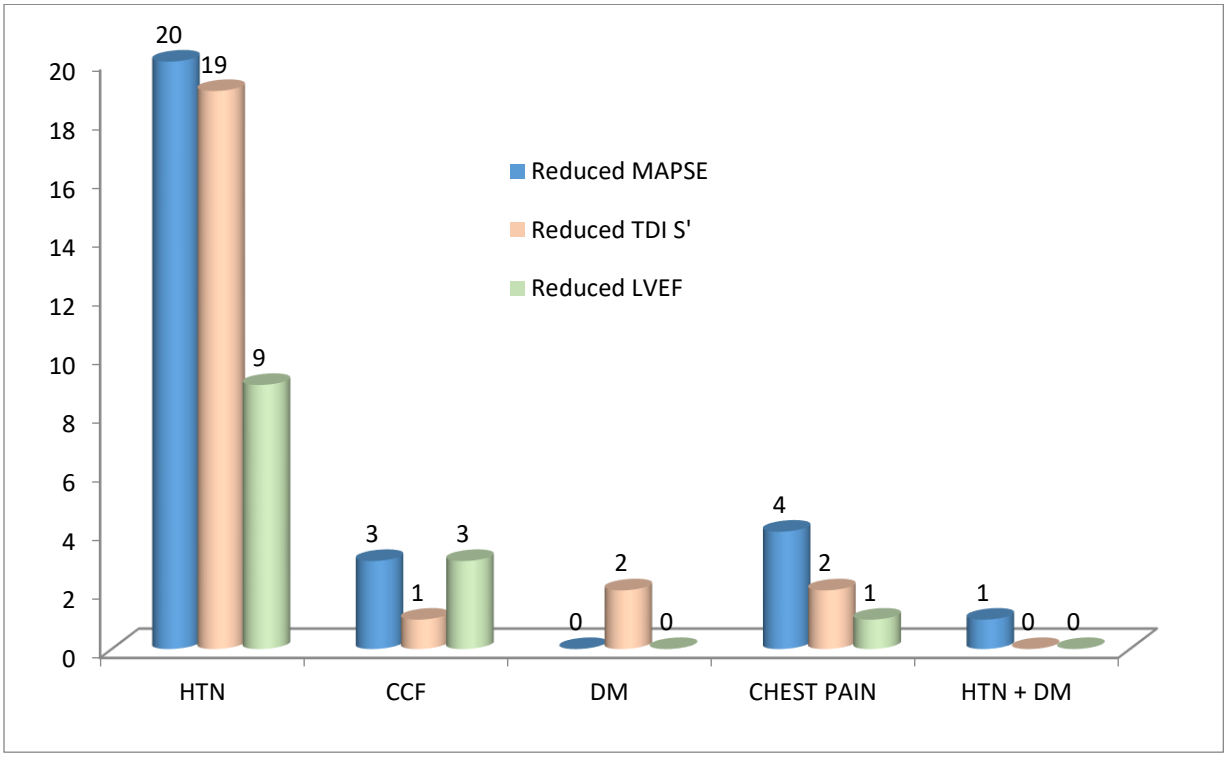


Figure 4: Indication for Echocardiography and presence of abnormal findings.

DISCUSSION

Mitral annular plane systolic excursion is a measure of longitudinal cardiac function[8]. It is also notable that the use of left ventricular ejection fraction as a measure of cardiac systolic function is not cast in stone[9]. TDI S' and MAPSE are two other methods for measuring systolic function. These methods become much more beneficial in the event of poor echocardiographic imaging quality. The average MAPSE ranges between 12 and 15mm[10]. The mean (SD) MAPSE in this study was 14.85 (10.81) which was within normal limits. MAPSE is a measure of global longitudinal function[11,12] while TDI permits a measure of regional and global LV systolic function,[13] with both methods being non-invasive techniques.

This study showed a sensitivity of 100% and a specificity of 82.8% for MAPSE and a sensitivity of 69.2% and specificity of 82.3% for TDI S' in determining abnormal myocardial function. Also, a higher prevalence of abnormal myocardial function was found when MAPSE (28%) or TDI S' (24%) was used. Similar findings in previous studies by Simonson et al, showed sensitivity of 98% and specificity of 82%[10] while Khorshid et al, found a sensitivity of 85.5% and specificity of 97.7%[14] meanwhile TDI S' showed an 18% prevalence of determining left ventricular diastolic dysfunction[15]. MAPSE predicts early heart disease such as changes in

concentric hypertrophy as some early cardiac diseases cause longitudinal functional changes which can be determined using MAPSE even when the LVEF remains within normal limits[16,17]. Thus, this may in part account for a higher number of patients with reduced MAPSE than reduced LVEF in this study. Similarly, TDI S' allows for long term prognosis and diagnosis of cardiac diseases e.g. coronary artery disease and cardiac dyssynchrony[18-20].

This study also showed a positive significant correlation between MAPSE, TDI S' and LVEF suggesting that MAPSE and TDI S' can be used as surrogates to LVEF. Lang et al, and Bellenger et al, found close significant correlations between MAPSE , TDI S' and LVEF[21,22] While Heinen et al, Molgevang et al, and Willenhiemer et al, further demonstrated that MAPSE and TDI S' can be used as surrogates for LVEF in addition to offering prognostic significance[23-25].

A combination of both methods has been found to offer a greater prognostic significance especially in view of poor image quality. These methods also offer the benefit of proper categorization of at-risk patients with cardiac diseases even in the face of a preserved ejection fraction.[9,26,27].

Conclusion

MAPSE and TDI S' show a good correlation with LVEF, can serve as surrogates for LVEF and are beneficial in assessing prognosis of cardiac diseases.

Recommendation

Mitral annular plane systolic excursion and or Tissue doppler imaging systolic velocity can be used to assess left ventricular systole function

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