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Mitral Annular Plane Systolic Excursion (MAPSE) as a Simple Index for Assessing Left Ventricular Function: An Observational Study

Jayanti Venkata Balasubramaniyan [a*], Ashutosh Prasad Tripathi [a] and J. S. Satyanarayana Murthy [a]

[a] Department of Cardiology, Sri Ramachandra Institute of Higher Education and Research Porur ; Chennai, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Mitral annular plane systolic excursion (MAPSE) has been proposed as a parameter for assessing left ventricular function. The assessment of LVF has major diagnostic and prognostic implications in patients with cardiovascular diseases. LVF is measured by Left Ventricular Ejection Fraction, however the accuracy of LVEF estimation by two dimensional echocardiography is limited especially in patients with poor image quality. Mitral annular plane systolic excursion (MAPSE) measurement predicts left ventricular function even in conditions with suboptimal echo window.
Objective: To assess the correlation of MAPSE derived LVEF with LVEF measured by Modified Simpson's method.
Methods: This is a cross sectional study which included 279 patients admitted at our tertiary care hospital from December 2019 to March 2020 and the patients were divided in two groups. Group A – Patients with LVEF>= 50% and Group B – Patients with LVEF<50%. All patients underwent 2D echocardiographic examination using Modified Simpsons' method and MAPSE measurement. The VIVID E9, VIVID T8, VIVID E95 and PHILIPS echocardiography machine was used for the non-invasive measurements. MAPSE was recorded at medial and lateral mitral annuli in the apical four-chamber approach.
Results: On analysis, a cut off value for average MAPSE-S (medial mitral annuli) was 8.5 was

**Corresponding author*

obtained, denoting preserved LV function with sensitivity of 81.7%, specificity of 84.9%, positive predictive value of 91.6% and negative predictive value of 84.9%. The AUC for MAPSE-S was 0.822. Similarly, the cut off value of average MAPSE-L (lateral mitral annuli) was 7.5 denoting impaired LV functions with an AUC of 0.826, sensitivity of 82.8%, specificity of 72.0%, positive predictive value of 85.6% and negative predictive value of 72.0%. The AUC of 82.6% was observed for MAPSE-L.

Conclusion: MAPSE reflects longitudinal myocardial shortening. MAPSE is a rapid and sensitive echocardiographic parameter for assessing normal LV function and global LV systolic dysfunction.

Keywords: MAPSE; left ventricular function; 2D echocardiography; ejection fraction.

ABBREVIATIONS

LVEF : Left Ventricular Ejection Fraction;
MAPSE : Mitral Annular Plane Systolic Excursion;
LVF : Left ventricular function

1. INTRODUCTION

Left Ventricular Ejection Fraction (LVEF) is a robust and most reliable criterion for assessing Left Ventricular Systolic Function [1-2]. LVEF plays a critical role in assessment of myocardial functioning and is also a strong prognostic indicator. LVEF can be assessed by several methods. The most common method widely used for assessing left ventricular systolic function is Two Dimensional Echocardiography. There is no well established method for determination of systolic function and unfortunately there are certain limitations pertinent to the available diagnostic modalities [3-4]. Recent advancements in technology have enhanced the use of echocardiography and its applications. Echocardiography is a simple and authentic method for assessment of LV systolic function and also in stratification of cardiac function [5]. Echocardiography has its own limitations. Good endocardial border precision is essential for echocardiography in quantifying LVEF. Poor quality image is attributed to poor endocardial border visibility and many studies reported a prevalence of poor image quality of about 23-31%. [6]. Similarly in aged populations, nearly one-third of the patients have technically difficult images that affect the precise calculation of Ejection Fraction [7-8].

Mitral annular plane systolic excursion (MAPSE) is a parameter derived from M-mode measurement which can assess abnormality in regions of myocardium [9]. Mitral annular plane systolic excursion (MAPSE) measurement is a simple and reproducible method for evaluation of left ventricular (LV) function. It has been established that MAPSE correlates well with Left Ventricular Ejection Fraction (LVEF) [10–14]. The amount of systolic long- axis direct displacement of the mitral annular plane towards is denoted by MAPSE measurement. Thereby the global change in size of the LV cavity is assessed. This can be elucidated as the change in volume during the phase of ejection. So therefore there exists a significant association between the long-axis shortening and ejection fraction, and it has been reported among several patient groups with normal or reduced LV function [15–19]. The normal average value of MAPSE ranges between 12-15 mm, a value of ≥ 10 mm denotes preserved EF (≥ 55%) function, a value of MAPSE < 8 mm is associated with a depressed LV EF (< 50%) function and a MAPSE value of < 7 mm represents an EF < 30% [16].

The aim of this study was to evaluate and validate MAPSE derived Left Ventricular Ejection Fraction with the Left Ventricular Ejection Fraction derived from 2D Echocardiography using modified Simpson’s method.

2. MATERIALS AND METHODS

This is a cross sectional study conducted at our tertiary care centre in Chennai, Tamil Nadu. This study included 279 patients admitted at our Institute between December 2019 to March 2020. Adult patients with age ranging from more than 18 years and patients with clinical conditions in normal sinus rhythm were included in our study. All patients underwent a detailed echocardiographic assessment using Modified Simpson’s method. Patients with valvular heart disease,diastolic dysfunction were excluded from the study. All the patients included in the study were divided in two groups: Group A – Patients with LVEF>= 50% and Group B – Patients with LVEF<50%.

The patients were subjected to detailed history taking and underwent clinical examination. Two-dimensional echocardiography was performed on all patients using GE vivid 7 machine and measurements were obtained following the current American Society of Echocardiography guidelines. Echocardiography was performed in the left lateral decubitus position of the patients. The standard parasternal long-axis and apical 4-chamber two-dimensional imaging views were adopted for evaluation. To improve signal-to-noise ratio and to provide optimal endocardial definition, optimization was performed using harmonic imaging, gain, dynamic range, frequency and sector width.

2.1 Determination of LVEF

LVEF was measured by Modified Simpson`s method at A4C and A2C views; biplane traced average End Diastolic Volume (EDV) and End Systolic Volume (ESV) (from endocardial border) then equated and transformed to volume measuring LVEF% equal to (EDV-ESV)/EDVx100.

2.2 Determination of MAPSE

MAPSE was measured with M-mode at the medial and lateral mitral annulus; images were obtained in A-4C view, longitudinal curser along lateral and medial walls of LV cutting MV annuli trace line at level of MV MAPSE at this level from end-diastole (lowest point) to end- systole (highest point), and average MAPSE value was calculated (mm).

2.3 Statistical Analysis

Data were coded and analyzed using the SPSS software version 20 (Statistical Package for Social Sciences, IBM, Armonk, NY, USA). Representation of Qualitative data was done using the frequency and percentage. The quantitative data were reported as mean and standard deviation. Student's t-test and Chi-square test was used to analyse baseline characteristics of study groups (age, gender and risk factors). P value less than or equal to 0.05 ($P \leq 0.05$) were considered statistically significant. Correlation between average MAPSE assessed by M–mode and LV EF measured by modified Simpson's rule was performed using the Pearson correlation coefficient test. A receiver-operating characteristic curve (ROC) was used to identify the cut off points and the area under the curve (AUC) was calculated. Average MAPSE were obtained using cut off points with the highest balanced sensitivity and specificity for the different EF measured by the Simpson's rule.

3. RESULTS

A total of 303 patients were identified and 24 patients were excluded from the study. Among the 279 patients, Group A comprised of 186 patients, whereas group B had 93 patients. (Fig 1) The mean age of study group A was 49.1±13.2 years and the mean age of the study group B was 60.7±13.6 years. Males 175 (62.5%) were observed to be predominantly high when compared to females 104 (37.1%). On analysis, there was no statistical significance detected between gender and study groups (p=0.662) whereas age and morbidity had statistical significance was present (p<0.001) between study groups. A major proportion of patients with co-morbidities were predominantly found in study group B (LVEF was <50%) where the mean age observed was higher than group A as shown in Table 1. Majority of patients in group A belonged to age group of 40-69 years, meanwhile in Group B 50-69 years age group was prominent as shown in Table 2.

Table 1. Baseline characteristics and prevalence of risk factors in study groups

Variables		Group A	Group B	p value
Age (years)		49.1±13.2	60.7±13.6	<0.001
Gender	Male	115(61.8%)	60(64.5%)	0.662
	Female	71(38.2%)	33(35.5%)	
Morbidity	DM	20(10.8%)	4(4.3%)	<0.001
	HTN	8(4.3%)	0(0.0%)	
	Co-morbidity	77(41.4%)	89(95.7%)	
	No Co-morbidity	81(43.5%)	0(0.0%)	

DM: Diabetes Mellitus; HTN: Hypertension

Table 2. Age wise distribution of patients in the study

Age (in years)	Group A n (%)	Group B n (%)
20-29	12 (4.3)	1 (0.4)
30-39	39 (14)	5 (1.8)
40-49	41 (14.7)	10 (3.6)
50-59	43 (15.4)	25 (9)
60-69	42 (15.1)	27 (9.7)
70-79	8 (2.9)	16 (5.7)
80-89	1 (0.4)	9 (3.2)

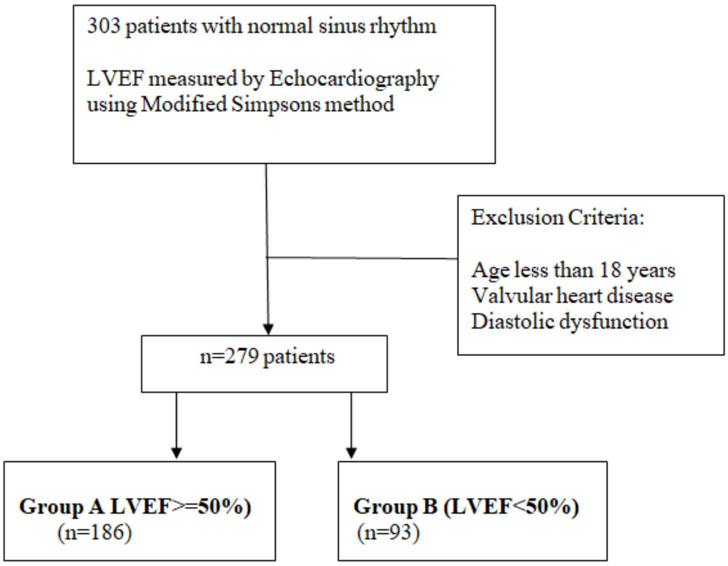

Fig. 1. Flowchart on identification of patients in the study

Analysis was performed between EF-Simpson with MAPSE-S, EF-Simpson with MAPSE-S and MAPSE-S with MAPSE-L of both study groups. In group A, MAPSE S and MAPSE L had strong positive correlation (p<0.001) and predicted each other at 87.4%. In group B, EF Simpson had positive statistical significant correlation with MAPSE-S (p<0.001) and predicted at 56.6%. We observed a positive statistical significant correlation with EF Simpson and MAPSE L (p<0.001) and determined a 52.3% prediction. The MAPSE-S had positive correlation with MAPSE-L (p<0.001) and predicted 59.8% each other as demonstrated in Table 3. The ROC and the Dot diagram of MAPSE-S revealed an optimal cut off value for detecting LVEF >=50 was 8.5. The ROC and the Dot diagram of MAPSE-L showed that the optimal cut off value for detecting LVEF >=50 were 7.5 (Fig 2).

The cut of values observed for MAPSE-S and MAPSE-L were 8.5 and 7.5 respectively. The AUC of MAPSE-S and MAPSE-L was 82.2% and 82.6% respectively. The sensitivity for MAPSE-S was 81.7%, specificity was 84.9%, Positive Predictive Value 91.6% and Negative Predictive Value was 84.9%. Similarly, the sensitivity for MAPSE-L was 82.8%, specificity was 72.0%, the positive predictive value was 85.6% and negative predictive value was 72.0% as illustrated in Table 4.

4. DISCUSSION

Our study showed a positive correlation between MAPSE and EF derived from Modified Simpsons' method. The most sensitive parameter reflecting cardiac systolic function is longitudinal shortening of LV which contributes to about 60% of the LV stroke volume [10,15,20]. Primarily due to the location of fibers which is subendocardial, the longitudinal fibers are more sensitive to various diseases and pathologies. A reduced MAPSE signifies longitudinal function impediment and which is reflected on the ejection fraction [16].

Table 3. Correlation of EF with MAPSE-M and MAPSE-L method

Group	Variables	"r"	p value	r^2	r^2 (%)	%
A	EF Simpson X MAPSE S	-0.039	0.600	NS	-	-
	EF Simpson X MAPSE L	-0.010	0.895	NS	-	-
	MAPSE S X MAPSE L	0.935	<0.001	0.874	87.4	MAPSE S determined MAPSE L 87.4%
B	EF Simpson X MAPSE S	0.752	<0.001	0.566	56.6	EF Simpson determined MAPSE S 56.6%
	EF Simpson X MAPSE L	0.723	<0.001	0.523	52.3	EF Simpson determined MAPSE L 52.3%
	MAPSE S X MAPSE L	0.773	<0.001	0.598	59.8	MAPSE S determined MAPSE L 59.8%

MAPSE: Mitral Annular Plane Systolic Excursion; S: Medial; L: Lateral

Table 4. The Echocardiographic measures assessed among the study groups

	Cut-off value	AUC (%)	Sensitivity	Specificity	PPV	NPV
MAPSE-S(mm)	8.5	82.2	81.7	84.9	91.6	84.9
MAPSE-L(mm)	7.5	82.6	82.8	72.0	85.6	72.0

MAPSE: Mitral Annular Plane Systolic Excursion; S: Medial; L: Lateral

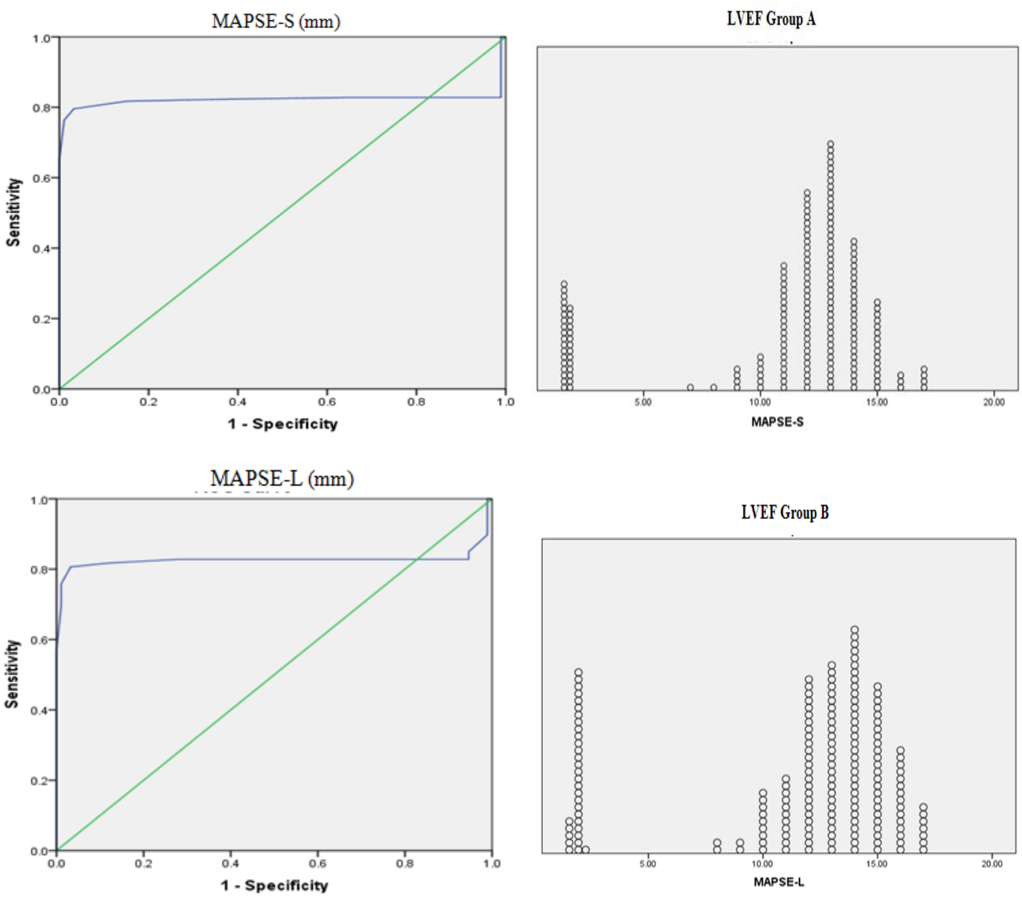

Fig. 2. The ROC curve for optimal cut off point and dot diagram of LVEF of study groups at medial and lateral mitral annulus

MAPSE: Mitral Annular Plane Systolic Excursion; S: Medial Mitral Annulus; L: Lateral Mitral Annulus
LVEF: Left Ventricular Ejection Fraction

4.1 MAPSE

EF derived from MAPSE has been reported as a measurement for LVEF [21]. MAPSE has been reported to be functionally effective in assessing LV systolic function in patients with myocardial infarction, heart failure, atrial fibrillation and critically ill patients with shock [22–24]. The study conducted by Adel et al in Adult patients reported a validated mitral annular plane systolic excursion (MAPSE)–derived formula for formulating the ejection fraction where EF = 4.8 x MAPSE (mm) + 5.8 in adult males with left ventricular (LV) dysfunction [24]. Willenheimer R et al study demonstrated that MAPSE has very strong correlation with one-year mortality and the mortality was 36% in patients with MAPSE < 6.4 mm as compared to mortality of patients with MAPSE >10 mm [21]. Similar results were reported in study done by Nikitin NP et al. [25].

In post-myocardial infarction patients with MAPSE <8 mm, the incidence of hospitalization and mortality was reported to be 43.8% [26]. Significant correlation was also reported between MAPSE and serum BNP levels [27]. In a 10-year follow-up study, MAPSE was reported to be a strong risk predictor of long-term survival in patients with heart failure [28].

The results of our study revealed the cut of value of MAPSE-S was 8.5, the AUC was 0.822, sensitivity of 81.7%, specificity of 84.9%, positive predictive value of 91.6% and negative predictive value of 84.9%.

Similarly, the cut of value of MAPSE-L was 7.5. The AUC was 0.826, the sensitivity 82.8% and specificity was 72.0%. The positive predictive value was 85.6% and the negative predictive value was 72.0%. The results are in concordance with the results of previous studies which revealed that mean MAPSE of ≥10 mm was linked with normal EF (≥55%) with a sensitivity of 90–92% and a specificity of 87% [10,29]. Likewise, a MAPSE value of <8 mm was associated with LVEF <50% with a specificity of 82% and a sensitivity of 98% which was similar to the study conducted by Simonson JS et al. [29]. The values of lateral MAPSE were generally higher than those of septal MAPSE and this was consistent with the study conducted by Carlhall C et al. [30].

5. CONCLUSION

We confer from the present study that by combining the measurement of both MAPSE-S and MAPSE-L the sensitivity and specificity for predicting the EF is being augmented. Further research on application of MAPSE-S and MAPSE-L combined indices on different subsets of population is recommended. Therefore, we conclude that a combination of these two simple measurements provides a more rapid and reliable information on the LV systolic function in normal patients and in patients with poor echogenicity.

6. LIMITATION

We studied the accuracy of MAPSE only in adult population and not in pediatric population. In our study population, there was presence of male predominance among MAPSE derived LV measurements unlike to the reports of study conducted by Matos et al where a female predominance of patient with depressed LV function and normal mitral valve was observed. Future studies on effect of diastolic dysfunction on accuracy of MAPSE derived EF measurements is recommended.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

This study was approved by the Institutional Research Ethics Committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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