Original Research Article

"MEASUREMENT OF MITRAL ANNULAR PLANE SYSTOLIC EXCURSION TO ESTIMATE LEFT VENTRICULAR EJECTION FRACTION IN PATIENTS WITH LEFT VENTRICULAR SYSTOLIC DYSFUNCTION"

ABSTRACT

Backgrounds and Aims: Left Ventricular Ejection Fraction (LVEF) serves as an important prognostic tool for managing patients with heart failure. Mitral annular plane systolic excursion (MAPSE) can be used for the calculation of LVEF as an easy, reproducible, reliable and cost-effective method.

Method: This was a hospital-based observational study. Patients, above 18, from OPD and wards in Bir Hospital and Shahid Gangalal National Heart Centre referred for echocardiographic assessment, who were found to have systolic dysfunction (LVEF $\leq$ 50%), were enrolled in the study. Patients with primary valvular disease, congenital heart disease, any type of arrhythmia, acute coronary syndrome, hemodynamic instability and history of recent (≤6weeks) cardioversion were excluded from the study. Mean of lateral and medial MAPSE values were taken; and LVEF derived from biplane apical (2- and 4-chamber) views using the modified Simpson' s rule algorithm was used in the study for comparison.

Results: 155 patients were enrolled in the study, out of which, 81 were males and 74 were females. Gender-wise regression analysis between LVEF-Simpson and MAPSE-Mean showed a strong positive correlation ($R^2 = 0.614$) for males and a fair positive correlation ($R^2 = 0.310$) for females. In both, the regression model was significant ($p \leq 0.05$). From the Regression analysis, the

gender-specific formulae for predicted LVEF from MAPSE for our population were calculated as:

- ***LVEF for Male*** *= 3.6 x MAPSE + 7*
- ***LVEF for Female*** *= 2.4 x MAPSE + 12.5*

Conclusions: The use of MAPSE is helpful to calculate LV systolic function in case of poor echocardiographic windows and for non-cardiologist and novice practitioners. There is a fair correlation between LVEF derived from modified Simpson method and the average MAPSE value.

Key words: *Mitral annular plane systolic excursion (MAPSE), Left ventricular systolic dysfunction (LVSD) and left ventricular ejection fraction (LVEF)*

Introduction

Left ventricular ejection fraction serves as an important prognostic tool for managing patients with heart failure. Among patients with heart failure, higher the values of LVEF, lesser will be the mortality in a linear decrement up to an LVEF of 45%[1]. Moreover, treatment of heart failure with low ejection fraction is different from that with normal ejection fraction. The prognostic value of LVEF in heart failure should, however, be interpreted in a holistic way in the context of other established cardiovascular risk factors.[2] LVEF has stood as the primary criterion for intracardiac defibrillator placement and cardiac resynchronization therapy. All these facts highlight the importance of correct LVEF measurement in clinical practice.

Many modalities of assessment can be used for the evaluation of LVEF, cardiac MRI being the gold standard. It can be assessed by 2D-echocardiography by eye-balling, Teichholz's, Simpson's and Speckle Tracking methods. 3D-echocardiography is being increasingly used. Other modalities include computed tomography (CT), Gated equilibrium radionuclide angiography (multiple-gated acquisition [MUGA] scan), Gated myocardial perfusion imaging with either single photon emission computed tomography (SPECT) or positron emission tomography (PET). Left ventricular contrast ventriculography, in contrast to others, is the only invasive method of LVEF measurement.[2] Among others, LV systolic dysfunction can be graded into mild (LVEF: 40%-49%), moderate (LVEF: 30%-39%) and severe (LVEF<30%).[3]
The major benefit of using MAPSE for left ventricular functional assessment lies in its simplicity even for novice practitioners with little training in echocardiography. Also, its value is much less dependent on endocardial resolution and can be performed with fair accuracy even in technically

challenging studies.[4] MAPSE as a surrogate of LVEF was first tried to use in 2012. The initial analysis included 300 studies in the calibration cohort which showed that MAPSE values greater or equal to 13 mm in men and 11 mm in women invariably predicted a normal or increased EF. Similarly, in the same study, it was found that a MAPSE value less than 6 mm (for both men and women) predicted an appropriate cut-off for severely depressed EF (≤30%).[4] The average human heart size is different for both sexes, so the same formula doesn't hold true for both of them.

Methodology

This was a hospital-based observational study. The objective of the study was to assess LVEF in patients with left ventricular systolic dysfunction (LVEF < 50%) in relation to MAPSE. The study population was the patients from OPD and wards in Bir Hospital and Shahid Gangalal National Heart Centre, from October 2019 to March 2020, referred for echocardiographic assessment, who were found to have systolic dysfunction. Ethical clearance was taken from the Institutional Research Board (IRB), National Academy of Medical Sciences, Bir Hospital. Total of 155 cases above 18 years, who had left ventricular systolic dysfunction were enrolled in the study. Patients with primary valvular disease, congenital heart disease, any form of arrhythmia, acute coronary syndrome, hemodynamic instability and history of recent (≤6weeks) cardioversion were excluded from the study.

2D-imaging examination was performed in the standard fashion in parasternal long- and short-axis views and apical 4- and 2- chamber views. Echocardiograms were assessed by careful visual analysis to detect regional and global contractile abnormalities. LV systolic and diastolic volumes and ejection fraction were also derived from biplane apical (2- and 4-chamber) views using the modified Simpson' s rule algorithm. Displacement of the mitral annulus was measured in the apical four-chamber view. The measurements were taken with M-mode beam positioned on the medial and lateral mitral annuli, in line with the left ventricular long axis. Maximum systolic plane excursions of the medial and lateral mitral annuli were taken in mm. The longitudinal motion of the mitral annulus was depicted over time as a sine wave. The nadir of the sine wave corresponds to the mitral annular position at end-diastole, and the peak occurs at end-systole. The height of the peak relative to the nadir is MAPSE. MAPSE was averaged from the septal and lateral mitral annuli.[5, 6]

Sometimes in patients with mitral valve disease, the mitral ring is extremely calcified. In these patients, the direct MAPSE measurement at the mitral ring was not possible and longitudinal functional assessment was done, by convention, slightly more above in the myocardium.

Collected data was entered into and analyzed with SPSS 23 for Mac-OS. Qualitative data were presented using the frequency and related percentage, while quantitative data would have the mean and standard deviation. The LVEF obtained from Simpson's method was tabulated and the LVEF derived from Simpson's method was correlated with MAPSE-mean.

Results

In this study, age range of the patients varied from 18 years to 92 years, the mean age being 60.82 years. Of the total 155 patients involved, 81 were males and 74 were females. In both sexes, the number of patients with left ventricular systolic dysfunction was maximum in the age range of 50 to 70 years.

Table 1:Age-group and Sex-wise distribution of LVSD

	Sex		
Age Group(Years	Male	Female	Total
18-30	9	2	11
31-40	2	8	10
41-50	9	4	13
51-60	16	15	31
61-70	17	27	44
71-80	21	13	34
81-90	5	4	9
>91	2	1	3
Total	81	74	155

Clinical heart failure was evident in 40.65% of patients, 22.58% in males and 18.06% in females.

The mean of MAPSE was correlated with LVEF derived from Simpson's method for both sexes but the correlation was stronger in male patients.

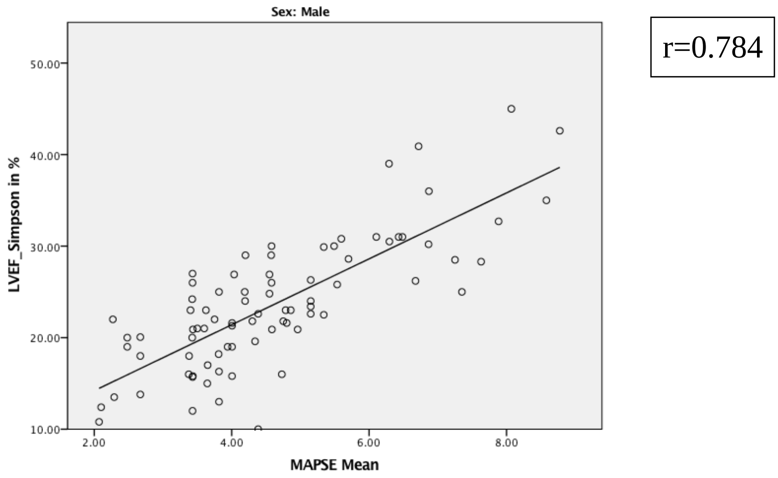

Figure 1: Linear scarplot showing positive correlation between MAPSE-Mean in Males and the LVEF by Simpson's Method

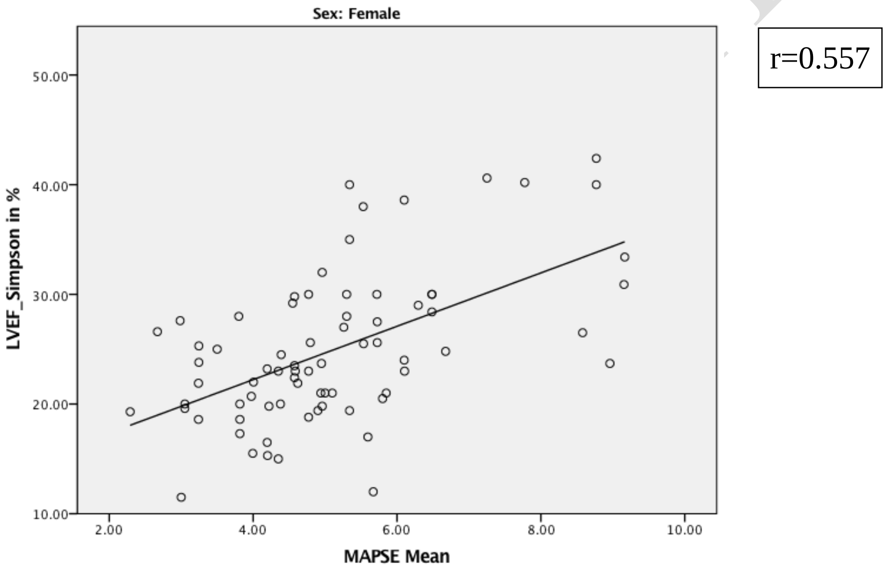

Figure 2: Linear scarplot showing positive correlation between MAPSE-Mean and the LVEF by Simpson's Method in Female Patients

Pearson correlation analysis between LVEF derived from Simpson's method and MAPSE-Mean was significant. The correlation coefficient was more strongly positive in males (r = 0.784) than in females (r = 0.557) [Table: 2].

Table 2: Correlation Between LVEF_Simpson and MAPSE-Mean

Sex			LVEF-Simpson in %	MAPSE Mean
Male	LVEF_Simpson in %	Pearson Correlation	1	.784**
		Sig. (2-tailed)		.000
		N	81	81
	MAPSE Mean	Pearson Correlation	.784**	1
		Sig. (2-tailed)	.000	
		N	81	81
Female	LVEF_Simpson in %	Pearson Correlation	1	.557**
		Sig. (2-tailed)		.000
		N	74	74
	MAPSE Mean	Pearson Correlation	.557**	1
		Sig. (2-tailed)	.000	
		N	74	74

**. Correlation is significant at the 0.01 level (2-tailed).

From the Regression analysis, the gender-specific formula for LVEF from MAPSE for our population was found to be [Table:3].

- **LVEF for Male** = 3.6 x MAPSE + 7
- **LVEF for Female** = 2.4 x MAPSE + 12

Table 3: Regression Analysis between LVEF-Simpson and MAPSE

Sex	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
			B	Std. Error	Beta			Lower Bound	Upper Bound
Male	1	(Constant)	7.007	1.563		4.483	.000	3.896	10.118
		MAPSE Mean	3.601	.321	.784	11.220	.000	2.962	4.239
Female	1	(Constant)	12.493	2.288		5.460	.000	7.932	17.055
		MAPSE Mean	2.433	.428	.557	5.688	.000	1.580	3.286

a. Dependent Variable: LVEF-Simpson in %

Receiver-operating characteristic curve analysis was used to predict MAPSE cutoff value for both gender with the highest balanced sensitivity and specificity to ascertain LVEF < 30% that was derived from the modified Simpson's rule. In males, an average MAPSE cutoff value of less than or equal to 4.57mm fulfilled the best-balanced sensitivity (100%) and specificity (58.2%) to predict

LVEF < 30%. The area under the ROC curve for this cutoff value was 0.674 (Figure: 3). In females, an average MAPSE cutoff value of less than or equal to 5mm provided the best-balanced sensitivity (80%) and specificity (60%) to foretell the EF < 30%. The area under the ROC curve for this cutoff value was 0.714 (Figure: 4).

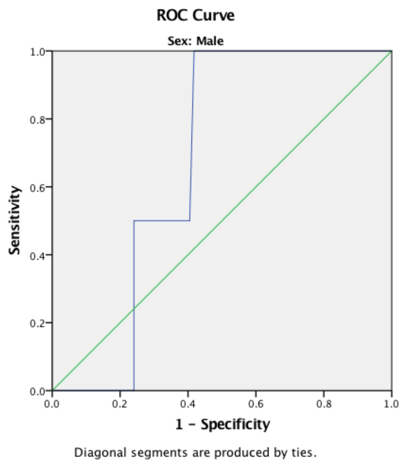

Figure 3: Receiver-operating characteristics curve for males. Average MAPSE cutoff value of less than or equal to 4.57mm in males fulfilled the best-balanced sensitivity (100%) and specificity (58.2%) to predict EF < 30% (area under the curve = 0.674).

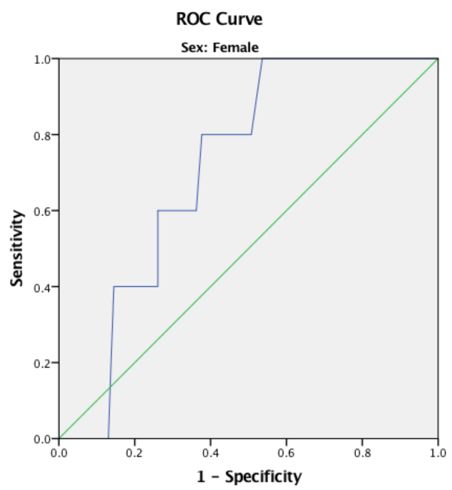

Figure 4: Receiver-operating characteristics curve for females. Average MAPSE cutoff value of less than or equal to 5mm in females satisfied the best-balanced sensitivity (80%) and specificity (60%) to predict patients with EF < 30% (area under the curve = 0.714).

Discussions

Mitral annular plane systolic excursion (MAPSE) has been found to correlate with and is advocated as a surrogate measurement for left ventricular function. Matos et al designed a study to find out the accuracy of MAPSE taken by novice examiners for foretelling left ventricular ejection fraction (EF). The study concluded that MAPSE measurement by an untrained observer was a fairly accurate predictor of LVEF.[4] They propounded formulae for LVEF for males(4.8x MAPSE + 5.8) and females(4.2 x MAPSE + 20) who had LVEF in the range of 30-50%.

After the publication of this study, a number of studies were carried out to test the accuracy of the predicted LVEF from MAPSE, including those with severe left ventricular systolic dysfunction. One of those is the study done by Adel W et al which showed that MAPSE-derived left ventricular ejection fraction using the equation- LVEF = 4.8 × MAPSE (mm) + 5.8 was yet a valid and reproducible technique in adult males with severely impaired LV EF.[7]

Studies on female patients are scarce. A study done by Mohamed Nabil revealed that anticipated ejection fractions in females using MAPSE formula generated by Matos et al. gave higher mean values than the ones measured by M-mode, Simpson's method and eye-balling.

The present study aimed to correlate the left ventricular ejection fraction with the mean value of lateral and septal MAPSE taken in M-mode in 2D-Echocardiography. 155 patients were taken in the sample, out of which, 81 were males and 74 were females. The mean age of the patients was (60.82 $\pm$ 16.56) years which was similar to the study done by Adel W et al in which the mean age of the study group was 60.6 ± 9.8 years.[7] In both sexes, the number of patients with left ventricular systolic dysfunction was maximum in the age range of 50 to 70 years. Clinical heart failure was evident in 40.65% of patients (22.58% of males and 18.06% of females). This study had larger sample size than similar study done by Angel Lopez-Candales et al who studied 100 patients (mean age 54 ± 14) with male being 53.[8]

Among the patients, most were diagnosed to have dilated cardiomyopathy. Second most common cause of LVSD was ischemic cardiomyopathy followed by alcoholic cardiomyopathy. Myocarditis was the least common diagnosis. This was different from the study by Adel W where ischemic cardiomyopathy (61.2%) was the most common pathology followed by dilated cardiomyopathy (38.8%).

Gender-wise regression analysis between LVEF-Simpson and MAPSE _Mean showed a strong positive correlation (R^2 = 0.614) for males and a fair positive correlation (R^2 = 0.310) for females. In both, the regression model was significant ($p \leq 0.05$). Pearson correlation analysis between LVEF derived from Simpson's method and MAPSE-mean was significant. In males, the correlation coefficient (r = 0.784) was strongly positive while in females, it was fairly

positive (r= 0.557).
From the Regression analysis, the gender-specific formulae for LVEF from MAPSE were calculated. Receiver-operating characteristic curve analysis was utilized to generate MAPSE cutoff value for both gender with the highest balanced sensitivity and specificity to predict LVEF less than 30% as determined by the modified Simpson's rule. In males, the cutoff value of less than or equal to 4.57mm provided the best-balanced sensitivity (100%) and specificity (58.2%). The area under the ROC curve for this cutoff point was 0.674. In females, an average MAPSE cutoff value of less than or equal to 5mm provided the best-balanced sensitivity (80%) and specificity (60%). The area under the ROC curve for this cutoff point was 0.714.

Conclusions

Newer and more advanced echocardiographic technologies such as strain-rate imaging, 3D echocardiography are routinely practiced in many centers. The use of MAPSE measurement still finds a place to evaluate LV systolic function in case of poor sonographic windows. An average MAPSE cutoff value of $\leq$ 4.57mm satisfied the best-balanced sensitivity (100%) and specificity (58.2%) in males, and a value of 5mm provided the best-balanced sensitivity (80%) and specificity (60%) in females to predict EF $\leq$ 30%.

Further study with large number of patients ~~are~~ is necessary to validate the gender-specific formulae for predicted LVEF from MAPSE.

Limitations

- The effect of specific disease entities on MAPSE measurements was not examined. Localized wall motion abnormalities due to coronary artery disease, significant mitral annular calcifications, prosthetic valves can definitely affect MAPSE values, irrespective of global EF.
- Whether or not diastolic dysfunction could affect MAPSE-derived measurements remains another area of future research. It was not addressed in this study.
- The study was done in a limited number of patients over a specified time period.

Recommendations

- The effect of specific disease entities on MAPSE measurements should be assessed and the formulae for MAPSE-derived LVEF should accordingly be tested.

- ❖ Effect of diastolic dysfunction on MAPSE, if any, should be incorporated in the formula.

- ❖ Comparing MAPSE-derived EF with CMR or 3DTTE-derived LVEF should be considered in future studies as these modalities represent the gold standard for quantification of LV function and are sought to be much more accurate than the current 2D quantification methods.

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