Original Research Paper
Volume - 11 | Issue - 04 | April - 2021 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar
Clinical Research

MITRAL ANNULAR PLANE SYSTOLIC EXCURSION-DERIVED FORMULA TO CALCULATE THE EJECTION FRACTION: A SIMPLE, EASY AND RAPID ECHOCARDIOGRAPHY PARAMETER TO ASSES LEFT VENTRICLE SYSTOLIC DYSFUNCTION

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ABSTRACT **Aims & Objectives** - MAPSE DERIVED EJECTION FRACTION CAN BE USED AS AN ALTERNATIVE TO THE CONVENTIONAL ECHOCARDIORAPHIC MEASUREMENTS OF EJECION FRACTION IN EVERY DAY CLINICAL PRACTICE WITH PATIENTS WITH LV SYSTOLIC DYSFUNTION & VALIDATION OF MITRAL ANNULAR PLANE SYSTOLIC EXCURSION DERIVED FORMULA TO CALCULATE THE EJECTION FRACTION IN PATIENTS WITH LV SYSTOLIC DYSFUNCTION EF=4.8XMAPSE(mm)+5.8 in adult male & 4.2X MAPSE(mm)+20 in adult female. **Material and Method-** Our study is observational, prospective study with cross sectional data collection done in a period of nov 2018 to nov 2019, The study included 151 adult male and female patients with LV systolic dysfunction fulfilling all inclusion criteria, LVEF measured by average MAPSE and LVEF measured by visual inspection, M–mode, and modified Simpson's rule was statistically correlated to know the validity of MAPSE derived ejection in case of LVsystolic dysfunction. **Result** - The current study showed a significant positive correlation between average MAPSE and EF measured by M-mode ($r = 0.980$, $P < 0.001$), EF measured by Simpson's rule ($r = 0.968$, $P < 0.001$), and EF measured by visual inspection($r = 0.960$, $P < 0.001$). The mean differences in the EF derived by MAPSE formula between the inter-observer was(-0.14 ± 3.18). **Conclusion** - MAPSE-derived EF using the equation EF = 4.8 × MAPSE (mm) + 5.8 for male and EF = 4.2×MAPSE (mm)+20 for female, is a valid echocardiographic parameter in adult males and females with impaired LV systolic function to asses global LV longitudinal function with minimal interobserver variability.

KEYWORDS :

INTRODUCTION

Left ventricular (LV) longitudinal shortening plays an important role in cardiac pump function and can be evaluated by measuring long axis, (1-3) m-mode-derived, mitral annular plane systolic excursion (MAPSE) . MAPSE has been proposed as a well-established clinically useful echocardiographic parameter for the assessment of LV longitudinal (4,5) function and correlates with global systolic function of the LV . Echo- derived mitral annular plane systolic excursion (MAPSE) offers an advantage as it can be performed in most patients because it does not rely on optimal endocardial definition or proper visualization of the LV apex and the mitral annulus can often be visualized and tracked even when there is poor LV image quality with inadequate endocardial visualization. The other major advantage of MAPSE is the simplicity of its measurement. Being a simple one-dimensional measurement, it can be even performed with least interobserver variability.

MATERIALS AND METHODS

It is a prospective observational study. After obtaining approval from ethics committee The study carried out in the cardiology department of IMS & SUM HOSPITAL.The study population comprised of 151 patients which included all adult patients with Dilated cardiomyopathy (Ischaemic/non ischaemic etiology) starting from FEB 2019 ending FEB 2020 and who have LV systolic dysfunction defined as EF < 50% measured by Modified Simpsons method .

The Inclusion criteria for this study wasAll adult Patients (age>18years) having ischaemic/dilated cardiomyopathy having ejection fraction less than 50% measured by modified simpsons Rule, Exclusion criteria for this study was Mitral valve disease (Degenerative mitral valve Disease or calicified mitral annulus) or prosthetic mitral valve,Any form of arrhythmia, Acute coronary syndrome, Decompensated heart failure, and Constrictive pericarditis, moderate to large pericardial effusion,LVH secondary to any cause.

All patients were subjected to echocardioraphic examnation using echocardioraphic system(philips healthcare CX-50,USA) with a broadband 1-5 MHz transducer standard views were taken following the recommendations of the American society of echocardiography.

MAPSE is measured as displacement of the mitral annulus, measurment were taken with M-mode beam positioned on the medial and lateral mitral annuli in the apical4Ch view and Systolic planeexcursion of the medial and lateral mitral annuli was measured in mm.The longitudinal motion of the mitral annulus is 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 [6-9]. systole. The height of the peak relative to the nadir is MAPSE.

The average MAPSE values were used in obtaining MAPSE-derived EF on the basis of the formula previously generated by matos et al. where ejection fraction equals for (Male = 4.8×mapse(mm)+5.8) & (Female=4.2xmapse(mm)+20)[10-12]).LVEF measured by average MAPSE and LV EF measured by visual inspection, M–mode, and modified Simpson's rule was Statistically correlated to know the validity of MAPSE derived ejection in case of LVsystolic dysfunction. Medial and lateral MAPSE measurements were taken and averaged for each patient by 2 different operators blinded to results of each other. The average MAPSE values were used in obtaining MAPSE-derived EF. Inter-observer variabilities in MAPSE measurements were then tested by comparing the results of the 2 different operators blinded with the result of each other.

Statistical Evaluation

Data were analyzed using the SPSS program24 Software. Qualitative data were presented using the frequency and its related percentage, while quantitative data were presented using the mean and standard deviation.Comparison of mean EF calculated by MAPSE and by other methods(eyeballing,teichholz formula, Simpson's method) was done by using paired sample 't' test. Correlation between average MAPSE and LV EF measured by visual inspection, M–mode, and modified Simpson's rule was performed using the Pearson correlation coefficient. Interobserver variabilities for MAPSE measurements were assessed using paired t-test and Bland–Altman analysis. A P-value of <0.05 was chosen as the level of significance.

RESULT

The study included 151 adult male and female patients with LV systolic dysfunction who were referred for elective echocardiographic study in the Cardiology Department of SUM MEDICAL COLLEGE & HOSPITAL.(TABLE 15 and 15.1) showing the various baseline characteristics and Echocardiographic variables of the study group.

Table :

Table 15 Baseline characteristics of the study group

Variable	Range	Mean ± SD
Age in year	40-85	66.2 ± 9.1
Weight in kg	46-90	67.2 ± 10.3
Height in cm	150-180	162.9 ± 7.9
Diabetes	20 (13%)	----
Dyslipidemia	35(23%)	
Hypertension	40 (26%)	----
Smoking	25 (17%)	----
COPD	20 (13%)	----

Table 15.1 Echocardiographic variables of the study group		
Variable	Range	Mean±SD
End diastolic diameter in mm	47-70	58.0 ± 5.4
End diastolic volume in ml	100-262	169.2 ± 35.7
End systolic diameter in mm	32-61	47.2 ± 5.5
End systolic volume in ml	59-188	106.4 ± 28.7
Ejection fraction in Simpsons method in %	20-45	33.2 ± 6.9
Ejection fraction Teichholz formula in %	20-48	35.8 ± 7.4
Ejection fraction eyeballing in %	20-48	33.3 ± 6.7

Table 5.6 present linear relationship between ejection fraction measured by simpson'smethod, teichholz formula, eye balling and MAPSE derived formula. It is found the KARL pearson correlation coefficient is extremely high between all the four methods of measuring EF. MAPSE derived EF has extremely high positive correlation with EF measure by simpson method, teichholz formula and eye balling with correlation coefficients 0.968, 0.980 and 0.960 respectively.

Table :

Table 5.6 Correlation of Ejection Fraction evaluated with different methods				
	Ejection fraction in simpson's method in %	Ejection fraction Teichholz formula in %	Ejection fraction eyeballing in %	MAPSE (derived ejection fraction)
Ejection fraction in simpson's method in %	1	.964**	.966**	.968**
Ejection fraction Teichholz formula in %		1	.962**	.980**
Ejection fraction eyeballing in %			1	.960**
MAPSE (derived ejection fraction)				1
** Correlation is significant at the 0.01 level (2-tailed).				

Table 5.8 compares the mean of EF by simpson method, Teichholz formula, and eye balling vrs. EF derived by MAPSE formula with the help of paired't' test. The mean difference of EF between simpsons method and MAPSE (derived ejection fraction) was (–0.35 ± 1.73%) with 95% CI (3.04 to -3.74) and difference was not statistically significant (p= 0.13). The mean difference of EF between Teichholz formula and MAPSE derived ejection fraction was (-2.28 ± 1.59 %) with 95 % CI (5.40 to -0.84) and the difference was not statistically significant (p= 0.20). The mean difference of EF between eyeballing and MAPSE (derived ejection fraction was (-0.27 ± 1.89 %) with 95 % CI(3.43 to -3.97) and the difference was not statistically significant (p= 0.084).

The analysis suggested extremely high degree of direct linear relationship between EF by Simpson's method, teichholz formula, eye balling with that of EF by MAPSE derived formula. But this high positive correlation is indicative of movement of EF by the pairs of methods in the same direction but not necessarily the agreement, but certainly an indication for analysing agreement. Similarly the statistically significant difference between the two means of EF by two methods is not necessarily lack of agreement, because the statistically significant may not imply clinical significant.

Table 5.9 presents details of descriptive statistics of mean difference of EF between pairs of observations Simpsons and MAPSE, teichholz and MAPSE and eye balling and MAPSE.

Table 5.9 Comparison of mean difference EF by different methods and MAPSE			
Descriptive Statistics	Difference EF simpson's-MAPSE (derived ejection fraction) (n=151)	Difference EF Teichholz-MAPSE (derived ejection fraction) (n=151)	Difference EF eyeballing-MAPSE (derived ejection fraction) (n=151)
Mean	-0.35	2.28	-0.27
SD	1.73	1.59	1.89
Q1(1st Quartile)	-2	1.8	-2
Q2 (Median)	0	2.4	0
Q3 (3rd Quartile)	0.8	3	1
Minimum	-5	-4	-5
Maximum	4	5.1	4

Table 5.10 Percentage difference between MAPSE Ejection fraction and Ejection fraction by other methods			
Percentage difference EF by MAPSE EF	Variation	No.	%
Simpson EF	0 to ±5	88	58.3
	± 5.01 to ± 10	54	35.8
	> ±10	9	6
Teichhlolz EF	0 to ±5	34	22.5
	± 5.01 to ± 10	93	61.6
	> ±10	24	15.9
Eyeballing EF	0 to ±5	84	55.6
	± 5.01 to ± 10	61	40.4
	> ±10	6	4
	Total	151	100

Table 5.11 present analysis of agreement between the interobserver MAPSE EF. The lateral and medial MAPSE as well as average MAPSE was measured for all patients by 2 different operators blinded to result of each other, there was strong positive correlation between average MAPSE measurements even measured by 2 different operators at different time.

The mean differences in the EF derived by MAPSE formula between the inter-observer was (-0.14 ± 1.18) and the difference was nonsignificant (p=0.148). The mean ± 1.96 SD was in the range of (2.17 and -2.45).

The Bland-Altaman plot revealed that the difference between the interobservers lies between the 95% CI and the limit of difference is within the clinically permissible limit. This ensures the validity of MAPSE derived EF.

Correlation of MAPSE derived EFwith othermethods by gender

Within male and female, significantly extremely high correlation was found between MAPSE derived ejection fraction and other methods of ejection fraction (Table 5.13). It is found that from table (5.14) the MAPSE average as a marker of EF <30% with reference to Simpson method as gold standard found a MAPSE average cut off value of ≤ 4.5 for male that produced extremely high sensitivity (96, 95% CI 94.3 to 100%) and specificity (100, 95% CI 90.2 to 99.8%) and similarly a cut off value ≤ 2.0 for females also produced extremely high sensitivity and specificity of 92.31, 95% CI (64.0 99.8%)and 100, 95% CI (92.9 to 100.0)respectively.

DISCUSSION

The current study showed a significant positive correlation between average MAPSE and EF measured by M-mode ® =0.980, P < 0.001), EF measured by Simpson's rule (r =0.968, P< 0.001), and EF measured by visual inspection(r =0.960, P < 0.001).The mean difference between the MAPSE-derived EF and EF measured by eye balling was (-0.27 ± 1.89 %) and the difference was not statistically significant (p= 0.084). The mean difference between MAPSE-derived EF and EF measured by M-mode was (-2.28 ± 1.59 %) the difference was not statistically significant (p= 0.20). The least mean difference was present between MAPSE derived EF and EF measured by Simpsons method was (0.35 ± 1.73%) and difference was not statistically significant (p= 0.13). The analysis suggested extremely high degree of direct linear relationship between EF by simpsons method, teichholz formula, eye balling With that of EF by MAPSE derived formula. But this high positive correlation is indicative of movement of EF by the pairs of methods in the same direction but not necessarily the agreement, but certainly an indication for analysing agreement.

The mean differences in the EF derived by MAPSE formula between the inter-observer was(-0.14 ± 3.18)and the difference was nonsignificant (p=0.148). The Bland-Altaman plot revealed that the difference between the inter-observers lies between the 95% CI and the limit of difference is within the clinically permissible limit. This ensures the validity of MAPSE derived EF.

The current study showed that an average MAPSE cutoff value of less than or equal to 4.5 with reference to Simpsons method as gold standard for male was found to have an optimum sensitivity 97.37% and specificity 72.57% as a marker of LV ejection fraction less than 30%. The positive predictive value was 54.4 and negative predictive value was 98.8.

Similarly a cut off value ≤ 2.0 for female with reference to Simpsons method was found to have an also produced extremely high sensitivityand specificity of 92.31 and 100 respectively as a marker of LV ejection fraction less than 30%.The positive predictive value was 70 and negative predictive value was 99.5.

As we know that the values of MAPSE derived ejection fraction differs between male and female previous work has shown that a larger heart size correlates with a larger MAPSE for a given EF.Because females heart are typically smaller than male, the mitral annulus has a shorter distance to travel toward the apex during systolic motion.[11-13] This could account (at least partially) for the observed differences between male and female and explain why the threshold for a normal MAPSE for female should be lower than that of male.

Our results were consistent with those of Matos etal.6. Who stated that a MAPSE cutoff point of <6 served as an appropriate cutoff point to predict severely depressed EF less than or equal to 30.Two major limitations of this study were stated by the authors themselves who stated that they relied on comparison of MAPSE-derived values against the visually estimated EF not with worldwide accepted simpsons method and second that they did not studied patients with specific disease entities to determine validity of MAPSE derived ejection formula.[14-15]

WAALAAdel et al. demonstrated validity of MAPSE derived ejection formula in dialted cardiomyopathy but he taken only adult male patient in his study..Limitation of this study was the number of female patients with depressed LV function and normal mitral valve during the period of the study was not sufficient to confirm the gender-specific differences in MAPSE measurements as postulated by Matos et al.

In the current study, we tried to overcome these limitations and at the same time validated the equation derived by Matos et al. in another cohort of patients namely adult males and females with impaired LV functions secondary to ischemic heart disease or dilated myopathy.

MAPSE derived EF is especially helpful in patients with increasing age, myocardial hypertrophy or diastolic dysfunction with preserved ejection fraction (HFpEF) where long axis function of the heart is already impaired while the radial function can be preserved or even increased . Thus by using LVEF the long axis function of the heart is not necessarily considered while using MAPSE derived ejection fraction can helpful in such situation to asses LV global longitudinal function.[16-17]

Clearly, there is no way to replace a comprehensive expert echocardiographic examination with a one dimensional measurement that is a surrogate for left ventricular EF. However, in clinical settings, sometimes a rough estimate of EF is urgently required, and we believe that having the option to accurately estimate it with such a simple method can be very valuable. In these situations, this assessment should be regarded as a preliminary result, to be followed by a complete expert evaluation of the echocardiogram.

STUDYLIMITATION & RECOMMENDATION

1) One of the limitations in this study was small sample size.

2) We did not attempt to examine the effect of specific disease entities on MAPSE measurements. For example, localized wall motion abnormalities due to coronary artery disease.

3) We did not attempt to see the validity of MAPSE derived ejection fraction in specific disease entities in pediatric & child age group population. Whether or not diastolic dysfunction could affect MAPSE-derived measurements remains another area of future research.

Comparing MAPSE-derived EF with CMR or 3DTTE-derived LVEF by volumes 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.

CONCLUSION

Despite of the routine use of newer and more refined echocardiographic technologies, MAPSE measurement is still helpful to evaluate LV systolic function during daily routine echocardiography in case of poor sonographic windows as this measurement demands very little of image quality on account of the high echogenicity in the atrioventricular annulus while most advanced echocardiographic techniques requires very good image quality with minimal interobserver variability.

MAPSE-derived EF using the equation EF = 4.8 × MAPSE (mm) + 5.8 for male and EF = 4.2×MAPSE (mm)+20 for female is a valid echocardiographic parameter in adult males and females with impaired LV systolic function to asses global LV longitudinal function .The mean differences in the EF derived by MAPSE formula between the interobserver was(-0.14 ± 3.18),which indicate there is least variation in the value of MAPSE derived ejection fraction when it is measured by two different observer.

Average MAPSE cutoff value of less than or equal to 4.5 for male that produced extremely high sensitivity 96%,and specificity 100%.The positive predictive value was 54.4 and negative predictive value was 98.8and similarly a cut off value ≤ 2.0 for females also produced extremely high sensitivity and specificity of 92.31%and 100% respectively as a marker of LV ejection fraction of less than 30 or severe LV systolic dysfunction. The positive predictive value was 70 and negative predictive value was 99.5.

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