Original Article

Determination of Values of the Tricuspid Annular Plane Systolic Excursion (TAPSE) in Bangladeshi Adult Patient with or without LV Dysfunction

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Abstract:

Background: Tricuspid annular plane systolic excursion (TAPSE) is an Echocardiographic measure that allows us to assess right ventricular systolic function and it correlates well with reference techniques like Cardiac Magnetic Resonance Imaging. TAPSE measurement is common in adults.

Objective: Our objective was to determine values of TAPSE in Bangladeshi adults with or without LV systolic dysfunction and to determine the relationship of these values with age, sex, RVIDd, LVEF & EPSS.

Method: This was an prospective observational study in patients undergoing comprehensive transthoracic echocardiography for any indication. From April 2022 to April 2023 we prospectively enrolled 100 adult (from 30 to age 80 years) of both sexes who presented to the Cardiology Clinic of LABAID Cardiac Hospital. We performed a complete transthoracic echocardiography study. We measured TAPSE in 2-dimensional M-mode echocardiograms from the apical 4- chamber view, positioning the cursor on the lateral tricuspid annulus near the free RV wall and aligning it as close as possible to the apex of the heart . The mean values were taken by at least 2 measurements for reducing interobserver and intraobserver variability's. Patients with confirmed congenital & valvular heart disease were excluded.

Results: Mean TAPSE values were 19.15±3.87cm irrespective of LVEF, with no significant differences between sexes, 18.45±3.801 in male , 19.94±3.853 in female (P=.056). TAPSE value was 22.00±1.581 in person with normal LVEF & 16.77±2.455 in person with reduced LVEF (P<.001) A statistically significant positive correlation of LVEF (r=.813) and significant negative correlation of EPSS (r=-.639) were observed with TAPSE (p<0.001). But no significant correlation of TAPSE was found between age (r=-.185)).), gender (r=.192) & RVIDd (r= -.063) (p >0.05). Multivariate analysis confirmed these correlations and the interactions between variables (LVEF & EPSS). Graphs of estimated population-based TAPSE values adjusted by age and LV function are provided.

Conclusion: We determined values of TAPSE in Bangladeshi adult population with or without LV systolic dysfunction and assessed relationship of these values with age, sex, RVIDd, LVEF & EPSS. The TAPSE measurement was reproducible and associated directly with LV systolic function. These reference values could guide decision making in daily clinical practice.

Keywords: Left Ventricular Ejection Function, E Point Septal Separation, Tricuspid Annular Plane Systolic Excursion.

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Introduction

Cardiovascular disease remains a leading cause of death. Right ventricular (RV) function is a strong predictor of outcome in many cardiovascular diseases, but its significance is often neglected. Little is known about the

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prognostic value of RV systolic function in the general population. Therefore, we aimed to determine the value of RV systolic function, evaluated by tricuspid annular plane systolic excursion (TAPSE), in patient with or without LV systolic dysfunction.

The complex geometry of the right ventricle (RV) makes systolic function evaluation difficult. The thick trabeculae in the endocardial surface and muscular elongated outflow tract—located in a different plane to that of the inflow tract—prevent us from adopting the theoretical volumetric models that can be applied in the left ventricle.[1, 2, 3, 4, 5] interventions. The RV functional situation can condition therapeutic management and clinical course in certain diseases. [6,7] Hence, in daily clinical practice, we need a means to reliably, reproducibly measure RV systolic function.[8, 9]

In M-mode echocardiography, tricuspid annular plane systolic excursion (TAPSE) measures the variation during the cardiac cycle, in the situation of the lateral portion of the annulus of the tricuspid valve, from the apical 4-chamber view. TAPSE is an echocardiographic parameter that estimates RV systolic function adequately and correlates well with reference techniques like cardiac magnetic resonance imaging.[10] Recommendations for echocardiographic evaluation of RV and TAPSE values in the adult population can be found in the literature.[11, 12]

The principle objective of the present study was to determine baseline TAPSE values in Bangladeshi adult patient with or without LV dysfunction and to assess the influence of age, sex , RVIDd & LV systolic function variables on those values.

Material & Methods:

This was an prospective observational study in patients undergoing comprehensive transthoracic echocardiography for any indication. From April 2022 to April 2023, we prospectively enrolled 100 adult (from 30 to age 80 years) of both sexes who had been referred to the cardiology service of LABAID Cardiac Hospital for routine health check up. We performed a complete transthoracic echocardiography study . M-mode and 2D echocardiograms were recorded on a Vivid ^{TM} E 95 with cSound ^{TM} ultrasound system (GE Medical System) with M5sc-D (GE) multifrequency transducer. We followed a standard protocol, evaluated left ventricular function, The modified Simpson rule was used for calculating the LVEF . In addition to routine echocardiographic measurements, EPSS was measured by M-mode in the para-sternal long axis view (PLAX) of the heart. We additionally measured TAPSE in 2-dimensional M-mode echocardiograms from the apical 4-chamber view, positioning the cursor on the lateral tricuspid annulus near the free RV wall and aligning it as close as possible to the apex of the heart (Figure 1). To prevent systematic errors in obtaining or interpreting the echocardiograms, 2 different cardiologists performed the echocardiograms and the mean values were taken by at least 2 measurements for reducing interobserver and intraobserver variability's. We excluded patients with congenital & valvular heart disease.

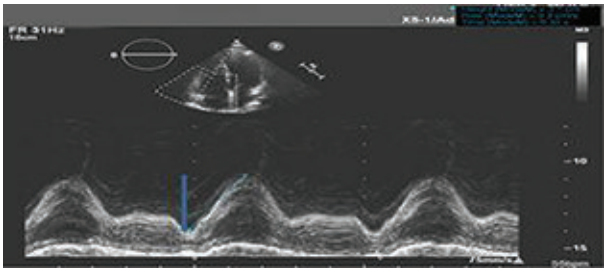


Fig.-1 : *Standard technique for measuring tricuspid annular plane systolic excursion using two-dimensional M mode echocardiography.*

Statistical Analysis : Numerical data obtained from the study were analyzed and significance of difference was estimated by using statistical method. The statistical data were analyzed using IBM SPSS 25.0. The continuous data were expressed as frequency, the mean±standard deviation, and the categorical data were expressed as percentages. Significance of difference between groups was evaluated by unpaired student t test. Graphical representation, Correlation test & Pearson correlation coefficient were used to measure the relationship between TAPSE & other variables. Stepwise simple & multiple linear regression analysis were used to estimate the relation between different variables and TAPSE and also to identify best predictor of TAPSE. Probability values ($P<0.05$) were considered statistically significant in the analyses.

Results:

Echocardiographic tracings of sufficient quality for analysis were obtained in all patients.

Fig 2 & 3 showed sex and age distribution of study patients. In total, 100 patients were enrolled in the study. We examined 53 male (53%) and 47 female (47%) Age range 30 – 103yrs, majority of the cases (>60%) are in between 41-to 70 yrs of age . Age - Mean ±SD (58.7±11.66 yrs), Male and Female ratio 1.1: 1 Majority of male patient are in between 51-70 yrs of age and majority of female patient are in between 61 to 70 yrs of age.

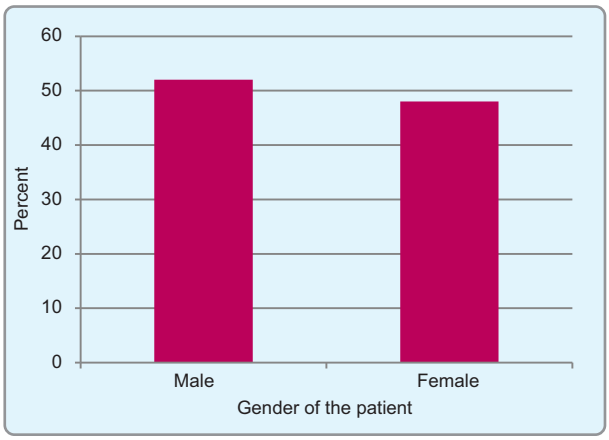


Fig.-2: *Sex distribution of the study patients.*

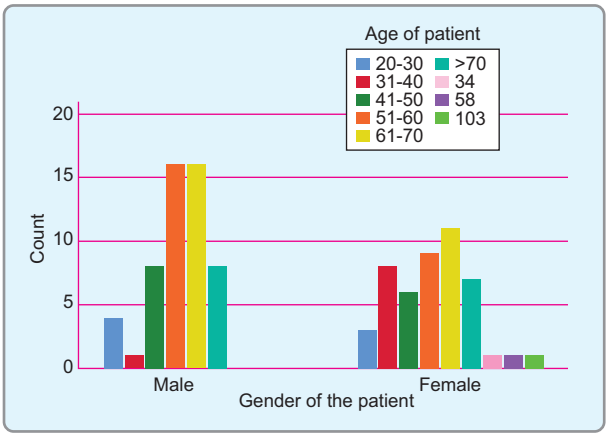


Fig.-3: *Age and sex distribution of the study patients*

Table I showed Distribution of Echocardiography parameters. The LVEF ranged from 20% to 68% (mean±SD 47.14±15.77), the EPSS ranged from 4 to 28 mm (mean ±SD 9.26±5.60), the LVIDd ranged from 30 to 72 mm (mean ±SD 50.43±8.97), LVIDs ranged from 12mm to 62 mm (mean ± SD 34.77±12.32) ,. TAPSE ranged from 12 to 25 mm (mean ±SD =19.15± 3.878) , RV Dimension ranged from 17 to 34 mm (mean ±SD =24.28± 3.975).

Table II showed that TAPSE declined with increasing age.

Table III showed mean TAPSE value in the study population in relation to Gender. TAPSE value was 19.94±3.853 (mean±SD) in female & 18.45± 3.801 (mean±SD) in male. There was only a small gender difference but correlation is insignificant (r=.192 P=.056).

Fig 4 showed Distribution of TAPSE in respect of gender

Table IV showed correlation of TAPSE value to other variables .TAPSE declined with increasing age but the correlation with age was not significant (r=-.185 , P=.065). Correlation with RVIDd was negative but not significant (r =.-.063, P=.533) . Very significant positive correlations of TAPSE was found with LVEF (r =.813, P=.000) & significant negative correlation was found with EPSS (r =-.639, P=.000).

Table V showed that an LVEF > 50% is evidence of TAPSE >20 mm, (P<.001). Of note, LVEF <40% correlates with decreased TAPSE value with an estimated TAPSE of <17 mm. (P<.001) suggestive of reduced RV systolic function.

Table VI showed Pearson Correlation between different variables & TAPSE. A statistically significant negative correlation of EPSS (r=-.639) and very significant positive correlation of LVEF (r=.813) were observed with TAPSE (p<0.001). But no significant correlation of TAPSE was found with age (r=-.185)), gender (r=.192) & RVIDd (r= -.063)) (p >0.05). In the analysis, LVEF presented the best positive correlations with TAPSE values (r=0.813 ; *P*<.001), whereas EPSS maintained a negative correlation (r=–0.639; *P*<.001).

Table I

Distribution of Echocardiography parameters

Echocardiographic Parameters	N	Minimum	Maximum	Mean	Std Deviation
Left Ventricle Diastolic Dimension	100	30	72	50.43	8.976
Left Ventricle Systolic Dimension	100	12	62	34.77	12.321
Left Ventricular Ejection Fraction	100	20	68	47.14	15.777
E Point Septal Seperation	100	4	28	9.26	5.601
Tricuspid Annular Plane Systolic Excursion	100	12	25	19.15	3.878
Right Ventricle Dimension	100	17	34	24.28	3.975

Data presented as Mean± SD

Table-II
Age related Values of TAPSE

Age (in yrs)	TAPSE in mm (mean±SD)
20-30	23±1.000
31-40	22±3.333
41-50	18±3.759
51-60	18±3.845
61-70	18±3.965
>70	18±3.135

Data presented as Mean± SD

Table-III
Correlation of mean TAPSE value with gender

Gender	N	Mean TAPSE (mm)	SD	Correlation (r value)	Sig (P value)
Male	53	18.45	3.801	.192	.056
Female	47	19.94	3.853		

P value reached from Paired sample t test,*p- value significant at <0.05.

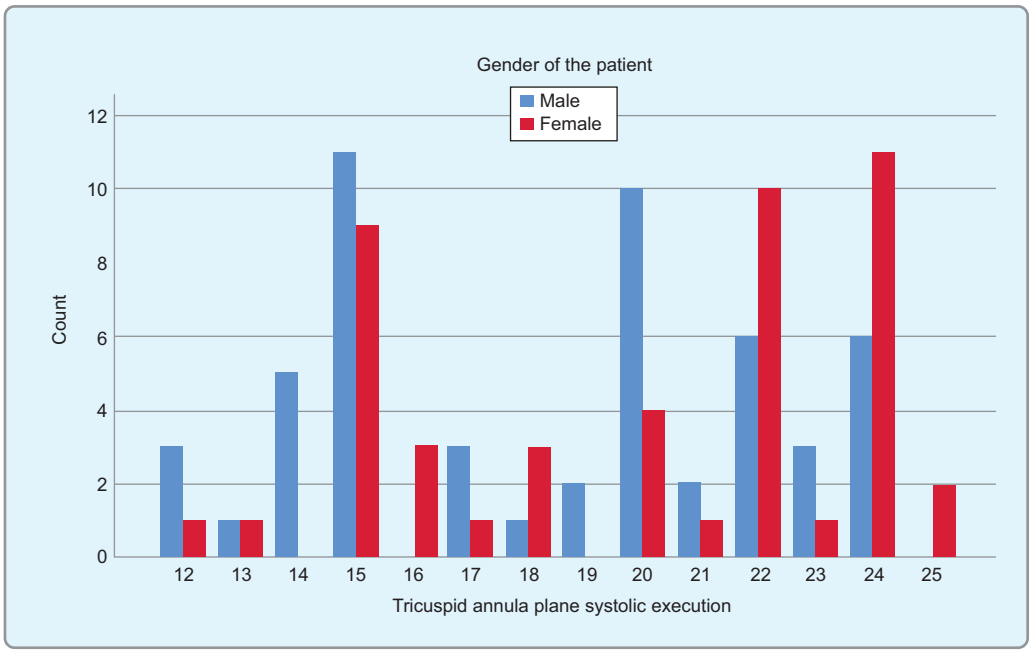


Fig 4: *Distribution of TAPSE in respect of gender*

Table-IV
Correlation of mean TAPSE with other variables

		Mean	SD	N	Correlation	Sig
	TAPSE	19.15mm	3.878	100	(r value)	(p value)
Pair -1	Age	58 yrs	11.663	100	-.185	.065
Pair -2	RVIDd	24.28mm	3.975	100	-.063	.533
Pair- 3	LVEF	47.14%	15.777	100	.813	.000
Pair -4	EPSS	9.26mm	5.601	100	-.639	.000

P value reached from Paired sample t test , p- value significant at<0.05.

Table-V

Prediction of TAPSE in respect of LVEF

LVEF (%)	TAPSE (mm)	Std Deviation	N	P value
55	22	1.581	5	.000[s]
35	16	2.455	13	.000[s]

*P value reached from unpaired student t test, S = significant, P 0<.01

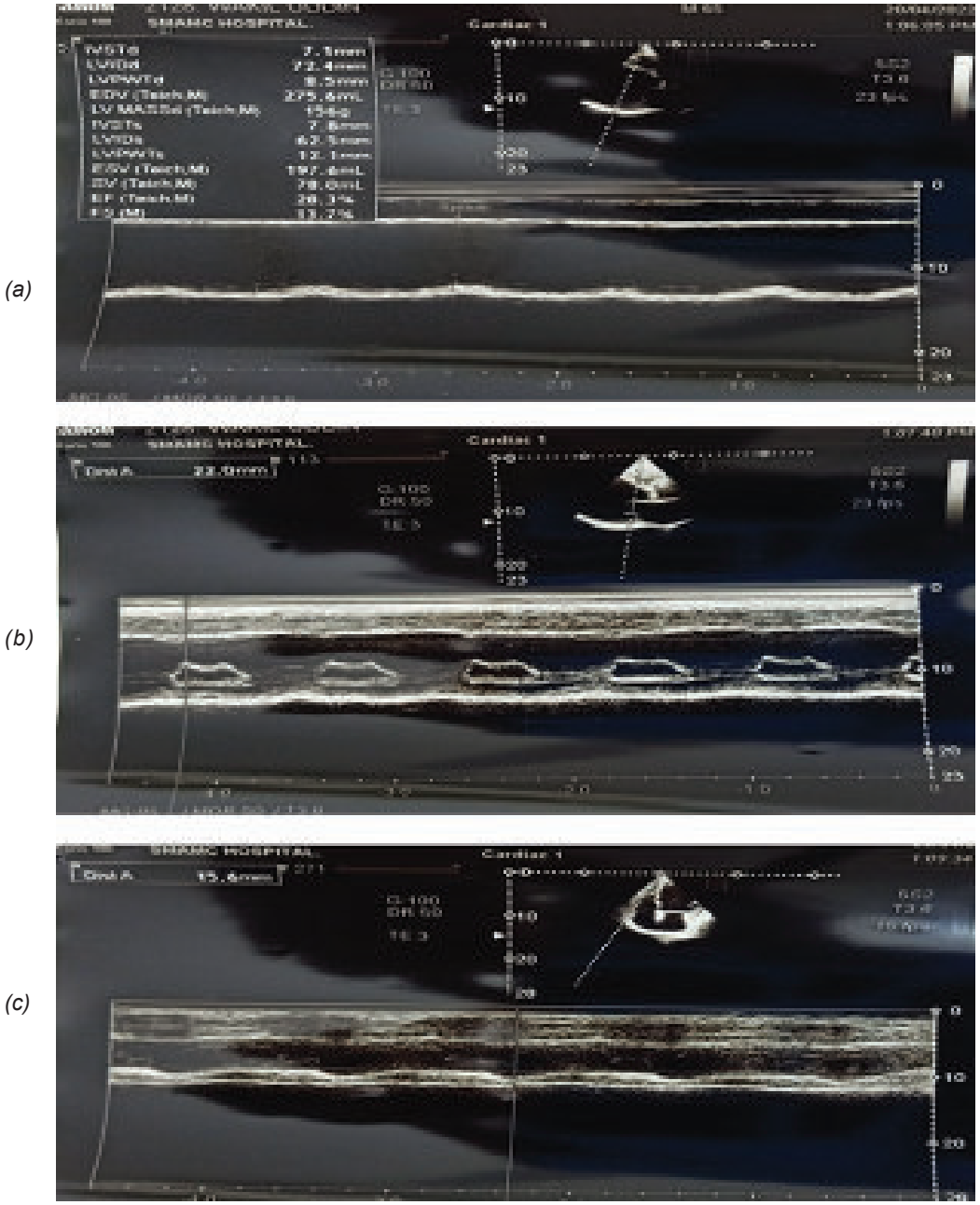


Fig 5 : *Measurement of LVEF In the image above (a) , EPSS in the image middle (b) & TAPSE in the image below (c). LVEF is ~28% , EPSS is ~22 mm & TAPSE is ~15 mm indicating both LV & RV systolic dysfunction.*

Table VI
Pearson Correlation between different variables & TAPSE

Variable vs. TAPSE	Pearson Correlation Co-efficient (r value) (N=100)	Sig (P value)
EPSS	-.639**	.000s
LVEF	. 813**	. 000s
Age	-.185	.065
Gender	.192	.056
RVIDd	-.063	.533

P value reached from Correlation test. **. Correlation is significant at the 0.01 level (2-tailed). S =significant

Table VII showed Simple Linear Regression analysis. In linear regression analysis with all of the variables only LVEF & EPSS were significant predictor of TAPSE. Most important determinant of TAPSE was LVEF (R=.813, p<0.001) followed by EPSS (R=.639, p<0.001)

Table-VII
Simple Linear Regression analysis.

Simple Linear Regression analysis	R value	R Square	P value
LVEF	.813	.662	.000s
EPSS	.639	.408	.000s
Gender	.192	.037	.056
Age	.185	.034	.065
RVIDd	.063	.004	.533

Dependent Variable: TAPSE, Predictor: LVEF, EPSS, Age, Gender, & RVIDd . P value derived from Pearson correlation, S= significant, **. Correlation is significant at the 0.01 level (2-tailed).

In Table VIII by combining different variables in stepwise multiple linear regression analysis an attempt for predicting TAPSE was done. When other variables were included with the variable LVEF into multiple linear regression analysis the resultant correlation coefficient was ((R=.818, P < .001). So it was observed that contribution of other variables is very insignificant & LVEF was the best independent predictor of TAPSE (R=.813, P<.001).

Table IX showed Pearson Correlation between TAPSE and Calculated LVEF. It was found that TAPSE has highly significant positive correlation with calculated LVEF (r=.813, p<0.001)

Fig 6. Scatter plots showed the relationships of TAPSE with LVEF (Fig 6a) & EPSS (Fig 6b) , indicating their sample distribution. Plots showed TAPSE is directly proportionate to LVEF & inversely proportionate to the EPSS

Table VIII
Stepwise Multiple linear regression analysis:

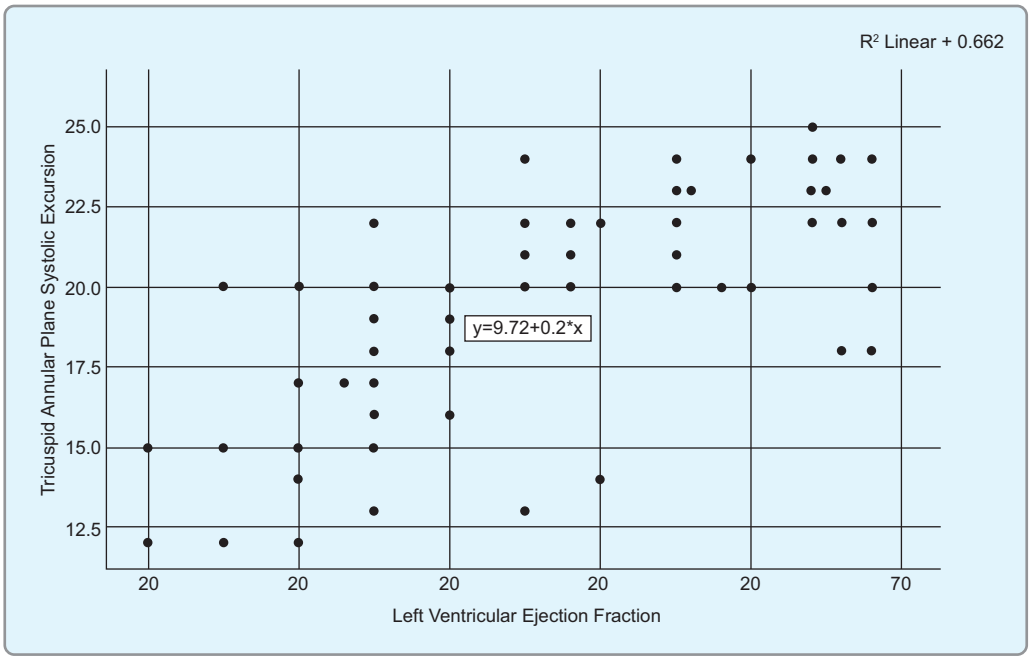
Stepwise Multiple Linear regression analysis	R value	R square	P value
LVEF	.813	.662	.000s
LVEF+EPSS	.814	.662	.000 s
LVEF+EPSS+Age	.816	.667	.000 s
LVEF+EPSS+Age+ Gender	.817	.667	.000 s
LVEF+EPSS+Age+ Gender +RVIDd	.818	.669	.000 s

P value derived from Pearson correlation, S= significant, **. Correlation is significant at the 0.01 level (2-tailed). A). Dependent Variable: TAPSE
B) Predictors: (Constant), LVEF, EPSS, Age, Gender & RVIDd

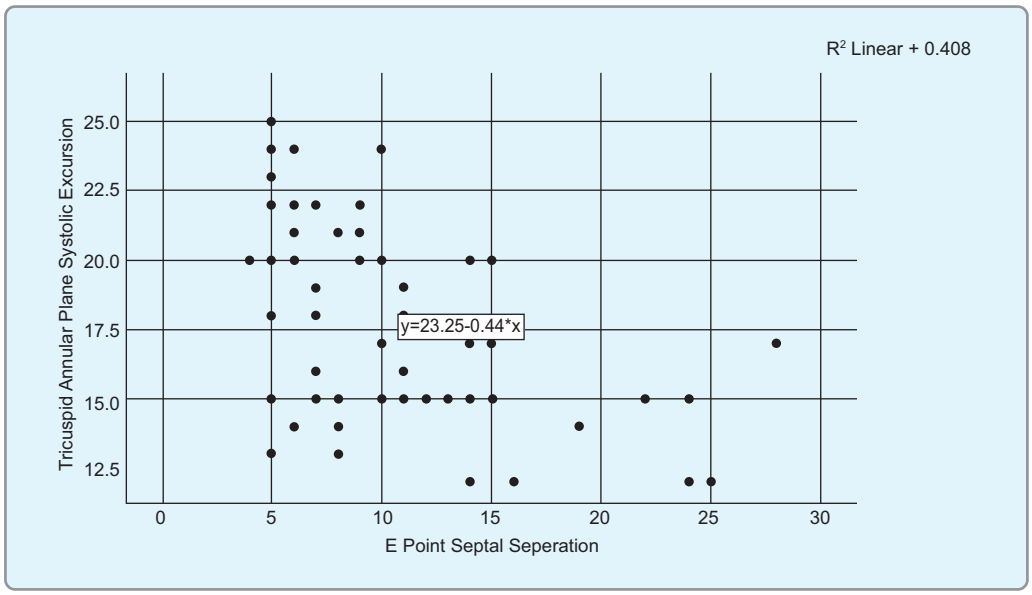
Table IX
Pearson Correlation between TAPSE and Calculated LVEF

LVEF	Pearson Correlation Co –efficient (r value) (N=100)	P value
TAPSE	. 813**	. 000s

P value derived from Pearson correlation, S= significant, **. Correlation is significant at the 0.01 level (2- tailed).



(a)



(b)

Fig.-6: *(a) Scatter plot (BIVAR) = LVEF with TAPSE. (b) Scatter plot (BIVAR)=EPSS with TAPSE*

Discussion:

We present the values for TAPSE in a sample of adult with or without LV systolic dysfunction. TAPSE is a measure of RV systolic function. Assessment of the RV systolic function may be beneficial for risk stratification of individuals from the general population. This may be because of TAPSE's simplicity, ease of measurement, and good reproducibility.[13] It does not require state of the art image quality or high frame rate conditions for optimal measurement,[13]as is the case for other measures of RV systolic function, such as 2 dimensional speckle tracking of the RV free wall.[13] In addition, it can often be hard to acquire high quality images of the entire RV free wall, whereas imaging only the RV base and

tricuspid annular plane is much more feasible. Despite its simplicity, TAPSE correlates well with RV ejection fraction determined by radionucleotide angiography.[13,14]

Current guidelines define the normal range of RV systolic function determined by TAPSE in the general population as a mean±SD of 24±3.5 mm.[15] and abnormal RV systolic function is defined as TAPSE <17 m*m.[15]*

In our sample values of TAPSE were maximum 25 mm, minimum 12 mm , mean±*SD* 19.1 ± 3. 878. Mean TAPSE value was 19.94±3.853 in female & 18.45± 3.801 in male. There was only a small gender difference but insignificant (r=.192, P=.056). The reason for lower mean value in our study was the inclusion of patients with or without LV systolic dysfunction. In our study mean value of TAPSE was 22±1.581 in person with normal LVEF (P<.001) & 16 ±*2.455* in person with reduced LVEF*(P<.001).* LV systolic function is a significant determinant of RV systolic function through mechanical interventricular dependence.[16] In our study, decreasing LV systolic function, was significantly associated with decreasing RV systolic function, as determined by TAPSE. It was found that TAPSE has very significant positive correlation with calculated LVEF (r=.813, p<0.001)

In our study LVEF > 50% is evidence of TAPSE >20 mm, (P<.001). Of note, LVEF <40% correlates with decreased TAPSE value with an estimated TAPSE of <17 mm. (P<.001) suggestive of reduced RV systolic function. TAPSE value of d"17 mm was significantly associated with a reduced LV systolic function (LVEF<40%) which is predictive of CVD as shown in Table V. RV function, determined by TAPSE, remained a strong predictor of CVD. However, more research is needed to validate our findings.

In other study , the relationship between TAPSE and age was positive. On the other hand, relation between TAPSE and HR was linear and negative. Although not all studies have found HR has a clear influence of on tricuspid annular plane movement.[17] In our study we found TAPSE declined with increasing age but the correlation with age was not significant ((r=-.185, P=.065). And we did not correlate HR with TAPSE.

In this study , a statistically significant negative correlation of EPSS (r=-.639) and significant positive correlation of LVEF (r=.813) were observed with TAPSE (p<0.001). But no significant correlation of TAPSE was found with age (r=-.185)).), gender (r=.192) & RVIDd (r= -.063)) (p >0.05). In the analysis, LVEF presented the best positive correlations with TAPSE values (r=0.813; *P*<.001). In linear regression analysis with all of the variables only LVEF & EPSS were significant predictor of TAPSE. Most important determinant of TAPSE was LVEF (R=.813, p<0.001) .

Measuring TAPSE as a parameter to evaluate RV systolic function was reproducible. In our study, we found good concordance for TAPSE[18], in the line with published recommendations [19]and in parallel with other studies conducted in different circumstances.[20] The same conclusion about reproducibly has been reached by other methods.[21.] Moreover, in contrast to other less readily available MRI- (Magnetic resonance imaging) or more invasive diagnostic right heart catheterization tech niques , this method is accessible in any Echocardiography laboratory . Future large scale studies will probably needed to determine the clinical role of TAPSE measurement in adult.

Study Limitations

A limitation of the present study is the lack of information on RV systolic pressure. It would be interesting to assess whether the prognostic value of RV systolic function is independent of RV afterload. Unfortunately, information on RV systolic pressure was not available in this study. Another limitation is the number of patients. Our result could not be generalized because we included patient with or without LV systolic dysfunction which was associated with variability of mean value of TAPSE.

Conclusion:

We presented TAPSE reference values of Bangladeshi adult male and female with or without LV systolic dysfunction. TAPSE was directly proportional to LV systolic dysfunction & age. But relation to age was not found statistically significant in this study. TAPSE was found inversely proportionate to EPSS & RVIDd. Though relation to RVIDd was not statistically significant in accordance with our study.A statistically significant positive correlation of LVEF & significant negative correlation of EPSS were observed with TAPSE. This result could be used to help with decision making in daily clinical practice. RV systolic function as assessed by TAPSE, is associated with CVD in general population. In the general population assessment of RV systolic function as evaluated by TAPSE may provide novel prognostic information about the risk of CVD. In concordance with other pioneering studies, we presented reference values to guide diagnostic, prognostic and therapeutic decision making.

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