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Original Article

E-Point Septal Separation: A Bedside Tool for Emergency Physician Assessment of Left Ventricular Ejection Fraction

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Abstract:

Introduction: *Rapid assessment of left ventricular ejection fraction (LVEF) may be critical among emergency department (ED) patients. This study examined the predictive relationship between bedside mitral-valve E-point septal separation (EPSS) measurements to the quantitative calculated LVEF.*

Objective: *The aim of this study was to investigate the ability of a new index, namely the mitral valve E-Point Septal Separation (EPSS) to predict the left ventricular (LV) systolic function.*

Methods: *A prospective observational study was conducted on a sequential convenience sample of patients, receiving comprehensive Transthoracic Echocardiography (TTE). The current study recruited 100 patients who presented to the Cardiology Clinic of Lab Aid Cardiac Hospital. Echocardiographic examinations were performed to obtain 2D guided M-mode measurements of the EPSS in addition to calculation of conventional, quantitative LVEF. All the measurements were done in the Para-sternal long-axis view. A linear regression analysis was conducted to examine the relation of EPSS to the calculated LVEF from the comprehensive TTE.*

Results: *Total 100 patients were enrolled in the study. It was found that there was a very significant negative correlation of EPSS with Calculated LVEF (r=--.766, p<0.001). An EPSS ≥ 7 mm was evidence of reduced LVEF <40%, (p<0.01). Of note an EPSS ≥ 12 mm correlates with severely decreased LV function, with an estimated LVEF of ≤ 30% (p<0.01). As was shown by the results of the linear regression analysis, EPSS was a significant determinant of calculated LVEF (R=.766, p<0.001). The results of the linear regression analysis indicated that the EPSS was an independent predictor of the LVEF.*

Conclusions: *Measurements of EPSS were significantly associated with the calculated measurements of LVEF from comprehensive TTE. An EPSS measurement of >7 mm was uniformly sensitive at identifying patients with reduced LVEF & >12 mm was uniformly sensitive at identifying patients with severely reduced LVEF. EPSS may allow certain clinicians, especially beginners and emergency department physicians, to assess the LVEF when other methods are not available or questionable.*

Key Words: *EPSS, LVEF, E-Point Septal Separation, Left Ventricular Ejection Fraction*

Introduction:

Transthoracic Echocardiography is the method of choice for the assessment of the LV myocardial systolic function. The best approach to evaluate the cardiac function in the emergency department setting has not been determined. Measures for the calculation of the LVEF are difficult to perform and time-consuming, which limits their use in the emergency department.[1] Most emergency department physicians are not trained in the quantitative calculation of the LVEF. A limited number of studies in the literature suggest that visual prediction by emergency department physicians correlates with the quantitative and semi-quantitative methods of estimating the cardiac function.[2] The major limitations of visual prediction for evaluating the LVEF are observer dependency and subjectivity. [3] However, there is still value in a quick and easy quantitative measurement of the LVEF. Objective measurements can be helpful for early learners who aren't yet confident in visual LVEF estimation.

An alternate method for estimating the LVEF is the mitral valve E-Point Septal Separation (EPSS). The E-Point Septal Separation (EPSS) is an easy measurement to obtain that is accurate in estimating the LVEF.

Similar to the left ventricular internal dimension at end-diastole (LVIDd), the EPSS is a simple linear M-mode measurement obtained from the parasternal long-axis view. The amount of separation between the valve leaflet and the septum in early diastole is defined as the EPSS.[4]

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The mitral valve waveform on M-mode contains two peaks. The first, larger peak is called the "E-point" and corresponds to the maximal mitral valve opening in early LV diastole. The second, smaller peak is called the "A-point" and corresponds to atrial contraction later in LV diastole. In a normally functioning heart, the mitral valve should open with the leaflet hitting or coming very near to the inter-ventricular septum at the E-point. Thus, a healthy heart will have a very small distance between the E-point and the inter-ventricular septum, and this distance is called the E-Point Septal Separation (EPSS). Therefore, EPSS is negatively correlated with LVEF.

The EPSS can generate a rapid quantitative measure of the LV function, especially when the acquisition of multiple breath-hold short-axis images proves difficult.[5]

Objective:

In this study, we aimed to investigate the ability of a new index, namely the mitral valve E-Point Septal Separation (EPSS) to predict the left ventricular (LV) systolic function and secondarily, we aimed to determine whether the EPSS measurements correlate with the calculated LVEF from comprehensive Transthoracic Echocardiography (TTE).

Materials & Methods:

This was an prospective observational study of the association between the EPSS and the LVEF in patients undergoing comprehensive Transthoracic Echocardiography for any indication.

The current study recruited 100 consecutive patients who presented to the Cardiology Outpatient Clinic of Lab Aid Cardiac Hospital, Dhaka, and were followed between the period of November 2020 to October 2021.

An LVEF > 50% was considered as normal, an LVEF between 40% and 49% was considered heart failure with a midrange ejection fraction (HFmrEF), an LVEF<40% was classified as Heart failure with a reduced ejection fraction HFrEF, and an LVEF≤30% was defined as advanced Heart failure (AHF). In addition to routine Echocardiographic measurements, the EPSS was measured by 2D guided M-mode in the para-sternal long-axis view. The EPSS were compared with LVEF in various groups. This study was approved by the local institutional ethics committee and conducted in accordance with the Declaration of Helsinki. M-mode and 2D echocardiograms were recorded on a Vivid ™ E 95 with cSound ™ ultrasound system (GE Medical System) with M5sc-D (GE) multifrequency transducer. To prevent systematic errors in obtaining or interpreting the Echocardiograms, 2 noninvasive Cardiologists obtained the Echocardiograms. EPSS is measured in the para-sternal long axis view (PLAX) of the heart, which gives a view of the left ventricle and is often used to assess its function. EPSS is obtained by placing the M-mode tracer over the distal tip of the anterior leaflet of the mitral valve, as in the image below (Fig-1a). The EPSS was measured in millimeters (mm) as the minimum separation distance between the mitral valve anterior leaflet and interventricular septum in M-mode echocardiography (Fig 1b)

The modified Simpson rule was used for calculating the LVEF. Patients who had atrial fibrillation, asymmetric septal hypertrophy, severe LV hypertrophy, severe valve diseases were excluded from the study.

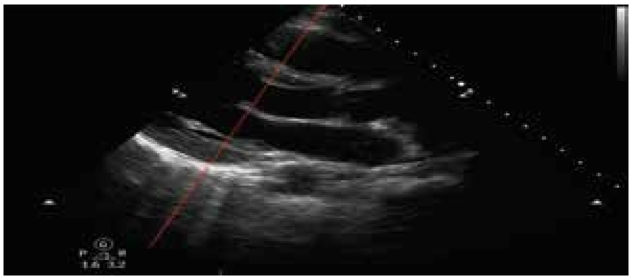

Figure 1a: Red line showing correct M-mode cursor placement in PLAX view

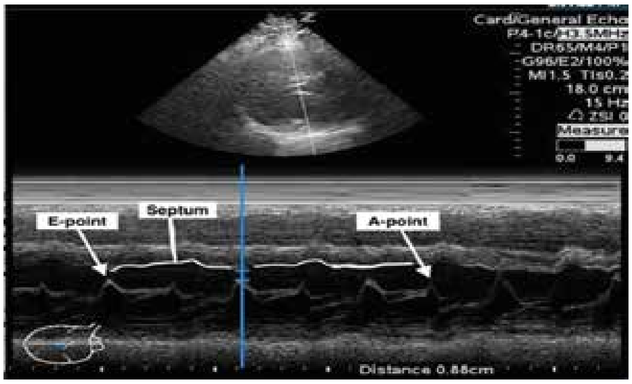

Figure 1b: Measurement of EPSS (blue calipers) with labels of E-point, A-point and partial tracing of septal wall In the image above, EPSS is 8.8 mm, indicating abnormal systolic function.

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 EPSS & LVEF. Stepwise simple linear regression analysis was used to estimate the relation between echocardiographic variables and calculated LVEF and also to identify best predictor of LVEF. 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 showed age and sex 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 - 103, majority of the cases (>60%), of 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.

Table I showed mean distribution of Echocardiographic 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), LVIDd ranged from 30 to 72 mm (mean ±SD 50.43±8.97), LVIDs ranged from 12 mm to 62 mm (mean ± SD 34.77±12.32) LA ranged from 26 to 59 mm (mean ±SD 40.73± 5.51).

Fig -3 showed mean distributions of EPSS in respect of gender. When the groups were evaluated according to sex, there were differences in the EPSS. EPSS was higher in the male patients.

Table II showed prediction of LVEF in respect of EPSS. An EPSS ≥ 7 mm is evidence of reduced LVEF < 40%, (P<.01). Of note, EPSS ≥ 12 mm correlates with severely decreased function, with an estimated LVEF of ≤ 30%. (P<.01)

Table III showed correlation of mean EPSS & LVEF. The results of the analysis of the patients with an EPSS > 7 revealed a significant association between the LVEF and the EPSS (*r*=-0.766; P<0.001) and EPSS >7 is strongly predictive of reduced LVEF<50%.

Table IV showed Correlation between different Echocardiographic Variables & LVEF. A statistically significant negative correlation of EPSS (r=-.766) and significant positive correlation of LVIDd (r=.717)) were observed with calculated LVEF (p<0.01). But Correlation was higher with EPSS.

Table V showed Simple Linear Regression analysis. As was shown by the results of the linear regression analysis most important determinant of LVEF was EPSS (R=.766, p<0.001)) followed by LVIDd (R=.613, p<0.001).

In Table VI, it was confirmed that LVEF determined by EPSS has very significant negative with correlation with calculated LVEF (r= -.766**, p<0.001)

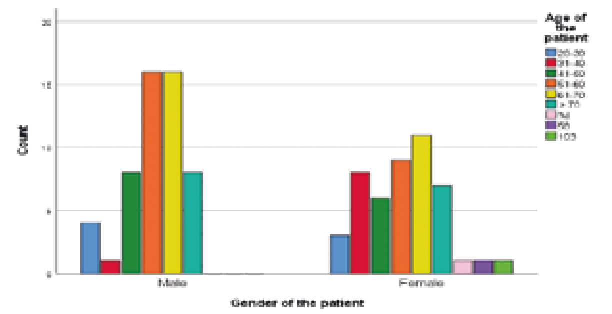

Fig 2: Age and sex distribution of the study patients

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
Fractional Shortening	100	10	34	23.64	7.872
Left Atrium Dimension	100	26	59	40.73	5.517
E Point Septal Seperation	100	4	28	9.26	5.601

Data presented as Mean± SD

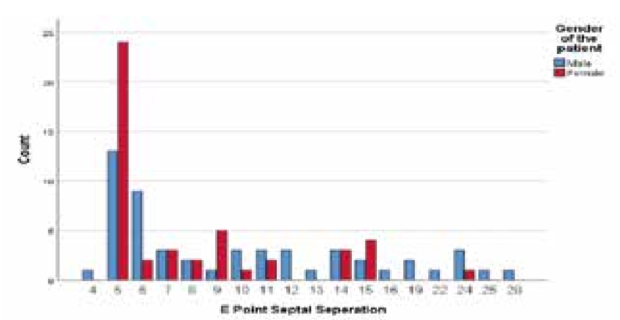

Fig 3: Mean distribution of EPSS in respect of gender

Table II: Prediction of LVEF in respect of EPSS

EPSS (mm)	LVEF (%)	Std Deviation	N	P value
05	63	6.88	37	.000s
06	52	8.84	11	.001s
07	39	5.845	06	.001s
08	33	11.64	04	.000s
12	30	2.541	06	.001s
14	30	2.582	06	.000s
16	20	2.55	06	.001s

*P value reached from unpaired student t test/Independent sample t test,

S = significant, P 0<.01

Table III: Correlation of mean EPSS & LVEF

Parameter	Mean	N	Std deviation	Correlation	P value
LVEF	47	100	15.77	-.766	.000[s]
EPSS	9.26	100	5.601		

P value reached from Paired sample t test, **.

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

Table IV: Pearson Correlation between different Echocardiographic variables & LVEF

Echocardiographic Variable vs. Calculated LVEF	Pearson Correlation Co-efficient(r value) (N=100)	P value
EPSS	-.766	.000[s]
LVIDd	.717	.000[s]

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

Table V: Simple Linear Regression

Simple Linear Regression analysis	R value	R Square	Standardized Co-efficient Beta	P value
EPSS	.766	.586	-.766	.000[s]
LVIDd	.613	.376	-.613	.000[s]

P value derived from Pearson correlation, S= significant, **.

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

Table VI: Pearson Correlation between EPSS and Calculated LVEF

LVEF	Pearson Correlation Co –efficient (r value) (N=100)	P value
EPSS	-.766**	.000[s]

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

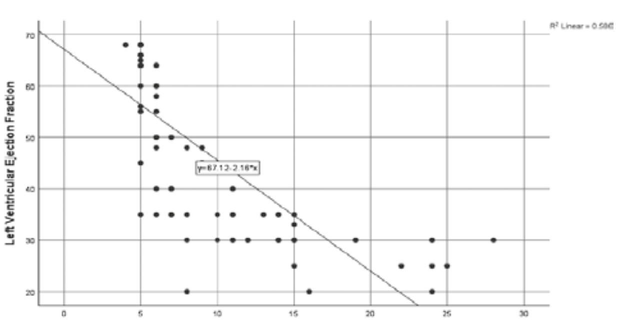

Fig-4: Scatter plot showing correlation between Calculated LVEF & EPSS

Figure 6 depicts the scatter plot of the LVEF versus the EPSS with a regression line. There was a highly significant negative correlation between the LVEF and the EPSS (r= -.766 ; P<0.001).*LVEF, Left ventricular ejection fraction; EPSS, mitral valve E-point septal separation*

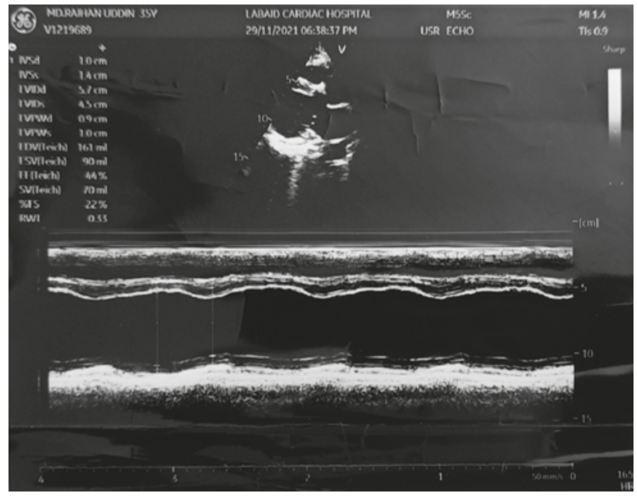

Fig 5a : Measurement of LVEF In the image above(LVEF is ~44%) indicating abnormal systolic function

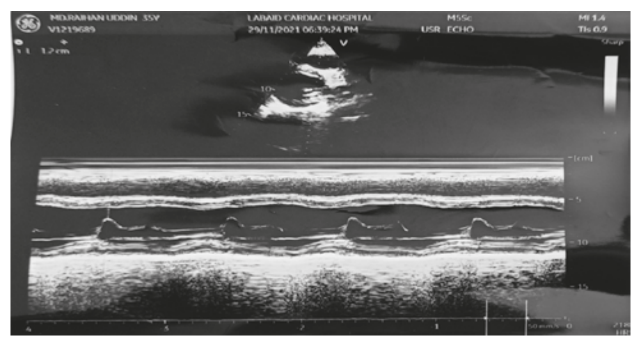

Figure 5b : Measurement of EPSS in the image above and EPSS is (~12 mm), indicating abnormal systolic function.

Discussion:

The present study conducted on patients attended to the Cardiology outpatient clinic. The results revealed that there was a correlation between the LVEF and the EPSS, EPSS was an independent predictive marker of HFrEF. Previous studies have demonstrated a high negative correlation between the EPSS and the LVEF, with the EPSS measurements of >7 mm indicating a poor LV function.[6]

Our results demonstrated a significant correlation between the LVEF and the EPSS in patients with HFmrEF HFrEF & AHF. This is the study to suggest that the EPSS may predict the LVEF using linear regression. An EPSS ≥ 7 mm is evidence of reduced LVEF < 40%, (P<.01) Of note, EPSS ≥ 12 mm correlates with severely decreased function, with an estimated LVEF of ≤ 30%. (P<.01)

Another study suggested that An EPSS > 7 mm is evidence of reduced LVEF. Of note, EPSS ≥ 13 mm correlates with severely decreased function, with an estimated LVEF of ≤ 35%.[7] For most patients, EPSS gives a good estimation of heart function. One study derived the following equation: LVEF = 75.5 – (2.5 x EPSS) with a correlation of(r= 0.80).[8] A second study derived a similar equation and correlation and demonstrated 100% sensitivity of an EPSS measurement > 7mm for detecting severely reduced EF (<30%).[9]

Secko et al.[10] showed that junior emergency physicians could readily obtain the EPSS measurements that correlated with the visual estimates of the LVEF. The E-Point Septal Separation (EPSS) is an easy measurement to obtain that is accurate in estimating the LVEF.

There are some patient populations in which EPSS may give an inaccurate estimate of cardiac function. Patients with mitral stenosis have poor opening of their mitral valve even with otherwise adequate cardiac function, and may have a falsely high EPSS measurement despite normal function. Similarly, patients with aortic regurgitation may also have poor forward anterior leaflet movement and will have a falsely high EPSS measurement while possibly having a preserved LVEF. Patients with atrial fibrillation will lack an A-point due to lack of coordinated atrial contraction, and will have beat-to-beat variability in EPSS due to the same discoordination.[11] To improve estimations in these patients averaging several measurements of EPSS is required.

Limitations:

This study was based on data from a single centre. Another weakness of this study is its relatively small sample size. In future studies, it may be more appropriate to include healthy individuals as well as patients suffering from HF (AHF, HFrEF, HFmrEF, and HFpEF) in wide spectrum and multicentre.

Conclusion:

In the present study, the EPSS predicted systolic dysfunction. Measurements of EPSS were significantly associated with the calculated measurements of LVEF from comprehensive TTE. An EPSS measurement greater than 7 mm was uniformly sensitive at identifying patients with reduced LVEF & EPSS >12 mm was uniformly sensitive at identifying patients with severely reduced LVEF. EPSS, which can easily be measured, appears to be quite useful for the prediction of systolic dysfunction, especially for beginners and emergency department physicians, when it is not possible to determine visually whether there is systolic dysfunction or not. In the absence of some conditions, like MS, AR & AF, EPSS gives a reliable, fast, quantitative measure of cardiac function that can help verify emergency physicians' visual estimations and be used to communicate the degree of cardiac dysfunction to other consultants and colleagues. The role of the EPSS in the prediction of systolic dysfunction requires further investigation in studies with a larger patient population.

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