

Utility of E Point Septal Separation as Screening Tool for Left Ventricular Ejection Fraction in Perioperative Settings by Anesthetists

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ABSTRACT

Background and Aims: Left ventricular (LV) systolic dysfunction is a common cause of hemodynamic disturbance perioperatively and is associated with increased morbidity and mortality. Echocardiographic evaluation of left ventricular systolic function (LVSF) has great clinical utility. This study was aimed to test the hypothesis that LVSF assessed by an anesthetist using mitral valve E Point Septal Separation (EPSS) has a significant correlation with that assessed using modified Simpson's method perioperatively.

Methods: This prospective observational study included 100 patients scheduled for elective surgeries. Transthoracic echocardiography (TTE) was performed preoperatively within 24 hours of surgery by an anesthetist as per American Society of Echocardiography (ASE) guidelines. EPSS measurements were obtained in parasternal long-axis view while volumetric assessment of LV ejection fraction (EF) used apical four-chamber view. Bivariate analysis of EPSS and LV EF was done by testing Pearson correlation coefficient. Receiver Operating Characteristic (ROC) curve constructed to obtain area under curve (AUC) and Youden's Index.

Results: The mean value of mitral valve EPSS was 7.18 ± 3.95 mm. The calculated mean LV EF value using volumetric analysis was $56.31 \pm 11.92\%$. LV dysfunction as per ASE guidelines is present in 28% of patients. EPSS was statistically significantly related to LV EF negatively with a Pearson coefficient of -0.74 ($P < 0.0001$). AUC of ROC curve 0.950 ($P < 0.0001$) suggesting a statistically significant correlation between EPSS and LV EF. Youden's index of EPSS value 7 mm was obtained to predict LV systolic dysfunction.

Conclusion: Mitral valve EPSS shows a significant negative correlation with gold standard LVEF measurement for LVSF estimation. It can very well be used to assess LVSF perioperatively by anesthetists with brief training.

Keywords: E point septal separation (EPSS), focused transthoracic echocardiography (FTTE), left ventricular systolic dysfunction, point of care ultrasound (POCUS)

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INTRODUCTION

Perioperative unanticipated cardiopulmonary complications are well described during surgery and anesthesia. Cardiac diseases are established independent predictors of

mortality.^[1] Unreliable medical history, incomplete medical records, exercise limitations due to non-cardiac reasons like morbid obesity, joint pathology, leading to inadequate patient

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evaluation. Conventional methods for the diagnosis of cardiac condition like clinical assessment have limited practical utility when compared with ultrasonographic evaluation. Focused transthoracic echocardiography (FTTE) has established its fundamental role in clinical application for rapid assessment of cardiac condition and can be lifesaving.^[2]

Left ventricular (LV) systolic dysfunction, being one of the common causes of hemodynamic disturbance perioperatively, has a direct impact on clinical management of patients. Commonly practiced method of eyeballing for evaluation of LV systolic function, being observer-dependent has great subjectivity. Recommended LV systolic function (LVSF) assessment by LV ejection fraction (EF) is calculated from a volumetric assessment using modified Simpson's rule.^[3] This method requires adequate training, experience, excellent images for volume estimation and is time-consuming.

The mitral valve (MV) E Point Septal Separation (EPSS) easy to obtain, quicker method which has been described in various previous studies and various settings and shown to effectively estimate LVSF.^[4,5] It is the amount of separation between 'E' point of anterior MV leaflet and interventricular septum in early diastole. EPSS has not largely been studied in perioperative practice and needs to be validated against the gold standard modified Simpson's method of LVSF assessment.

Our objective was to test a hypothesis that LVSF assessed using MV EPSS has a significant correlation with that assessed using modified Simpson's method when performed by anesthetists in perioperative settings.

Methods

This was a prospective observational study evaluating consecutive patients posted for various elective surgeries in a tertiary care center. The institutional review board approved this study and informed consent from all the patients was obtained.

All the consecutive adult patients aged >18 years, of either sex, admitted to the hospital for various elective surgeries during December 2019 to March 2020 for whom preoperative transthoracic echocardiography (TTE) was done by anesthetist were considered for inclusion in the study. The exclusion criteria consisted of patients with a known history of MV disease, MV repair or replacement, patients with aortic valve regurgitation, inability to obtain adequate echocardiographic view due to poor imaging windows, patients with arrhythmia. The TTE was performed preoperatively within 24 h of surgery. All examinations

were performed by a single board-certified anesthetist in advanced focus assessed transthoracic echo (FATE). All TTE exams were performed on GE Vivid™ T8 echo machine manufactured by GE Healthcare, Norway, as per American Society of Echocardiography (ASE) guidelines.^[3]

Ultrasound examination was done with the patient lying down supine or in the left lateral position whichever allowed best views. Demographic data like age, sex and ultrasound data consisting MV EPSS, LV end-diastolic volume (LVEDV) and LV end-systolic volume (LVESV) measurements were collected. All echocardiographic images were recorded in a raw Digital Imaging and Communications in Medicine (native DICOM format) and analyzed offline using EchoPAC software (version 203, GE Healthcare, Norway).

Mitral valve EPSS measurements were done using M-mode in the parasternal long-axis (PS-LAX) window. M-line was positioned perpendicular to the long axis of the LV at the tip of the mitral leaflet and minimum distance between anterior leaflet of MV and interventricular septum was measured during early diastole in millimeter.^[6] Mitral valve EPSS measurement in a study patient is shown in Figure 1.

Apical four-chamber (A4C) view was obtained in the same exam to quantify LVEDV and LVESV. Volume measurements were based on tracings of the blood tissue interface. At MV level, the contour was closed by connecting the two opposite sections of the mitral ring with a straight line.^[3] End diastole was defined as the first frame after MV closure or the frame in the cardiac cycle in which the respective LV dimension or volume measurement is the largest. End-systole was defined as the frame after aortic valve closure or the frame in which the cardiac dimension or volume is smallest.^[3]

EF was calculated from LVEDV and LVESV measurements, using the following formula: $EF = (LVEDV - LVESD) / LVEDV$.

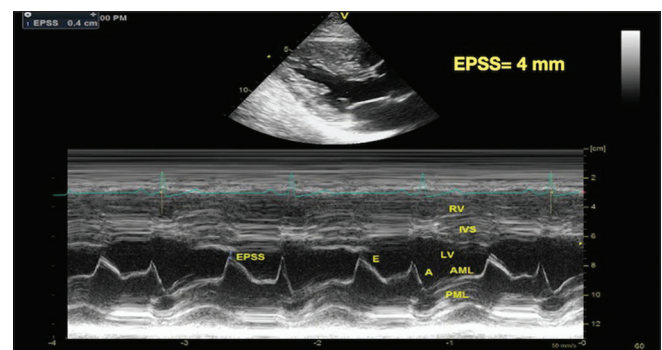


Figure 1: Shows MV EPSS measurement in PS LAX view where minimum distance between E point of anterior mitral leaflet (AML) and interventricular septum (IVS) is measured as 4 mm

Example of LVEF calculation in a study patient is shown in Figure 2.

LV EF values <52% for men and <54% for women were suggestive of abnormal LVSF as per ASE guidelines.^[3]

Descriptive statistics calculated using mean (Standard Deviation) for continuous variables and counts, while percentages and proportions for categorical variables. Correlation and linear regression analysis were carried out to examine the relation between MV EPSS and calculated LVEF. Pearson correlation coefficient was tested. Bivariate relation among these variables was assessed. Receiver Operating Characteristic (ROC) curve was constructed between variables EPSS and LV EF. Area under curve (AUC) was obtained and Youden's Index (Value of EPSS with best possible sensitivity and specificity) was obtained. $P < 0.05$ was considered statistically significant. Statistical Package for Social Sciences version 11 was used for statistical analysis.

RESULTS

During study period 105 patients were considered for inclusion in the present study. Five patients were excluded for reasons - two patients had moderate mitral regurgitation while three patients had poor A4C view to calculate LV EF. No image was excluded for inability to obtain PS-LAX view. Final analysis included 100 patients with various surgical categories. Twenty-eight were general surgery patients, 12 were orthopedic, 28 for urological procedures and 32 patients were cardiac surgical patients. The mean age of the present study population was 60 years with 21% female patients. The mean value of LVEDV and LVESV was 101.43 ml and 45.84 ml respectively, resulting in calculated mean LV EF value of 56.31 ± 11.92 . (LVEF range 28% to 74%). There were 28% of patients with LV dysfunction as per ASE guidelines. The mean value of mitral valve EPSS was 7.18 ± 3.95 with a range 3 to 21 mm.

EPSS was statistically significantly related to LV EF negatively with Pearson coefficient of -0.74 (Confidence Interval C.I. -0.82 to -0.64) and $P < 0.0001$ as illustrated in Figure 3.

Figure 4 demonstrates AUC of ROC curve 0.950 (C.I. 0.887 to 0.984) with $P < 0.0001$, suggesting a statistically significant correlation between EPSS and LV EF. Youden's index of EPSS value 7 mm (C.I. 0.01-0.2) was obtained with 95.83% sensitivity and 85.71% specificity to predict LV systolic dysfunction.

In a sample patient with LV systolic dysfunction with LVEF 31%, MV EPSS was measured as 20 mm as shown in Figure 5.

DISCUSSION

The main findings of the study were EPSS measured by an anesthetist during preoperative evaluation with TTE correlates significantly negatively with LVEF and EPSS value more than 7 mm can significantly diagnose LV systolic dysfunction.

Rising trend of patients being admitted on the day of surgery as well as patients coming for emergency surgeries poses challenge to anesthetists. LV systolic dysfunction, regional wall motion abnormalities are amongst the established risk factors for post-operative mortality. Goldman and colleagues have proposed various independent correlates of life-threatening cardiac complications postoperatively using prospective multivariate discriminant analysis which includes preexisting cardiac ailments.^[7] Similarly, another two studies predicted preoperative risk factors as well as intraoperative hemodynamic variables for perioperative cardiac adverse events.^[8,9] Therefore, perioperative LVSF assessment is extremely important as it allows anesthetists to categorize the risk profile of the patient leading to appropriate management.



Figure 2: Shows LV EF calculation in apical 4 chamber view and apical two chamber view. On the left, apical 4 chamber view obtained while on the right apical two chamber view is obtained to calculate LV EF by tracing endocardial borders in diastolic and systolic frame each

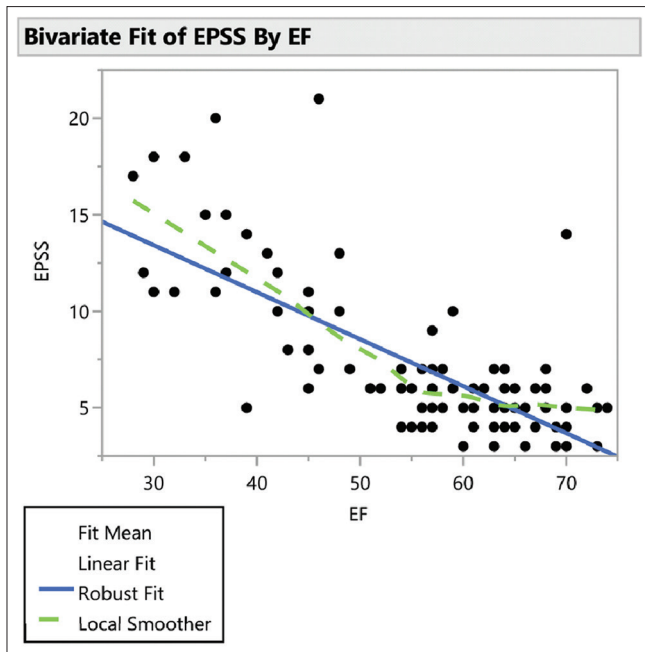


Figure 3: Shows scatter diagram of EPSS and LV EF showing significant negative correlation of EPSS to LV EF

A recent study describing “Start-Up” experience of perioperative TTE practice by anesthetist reported major impact of TTE on step-down (avoidance of extensive monitoring like pulmonary artery catheter, surgery decision time delay, cancellation, cardiology consultation) or step-up (inotropic/vasopressor therapy, volume infusion, additional monitoring, cardiology consultation) management decisions in a significant number of patients perioperatively.^[10] Early and appropriate preoperative diagnosis of cardiac condition in high-risk patients using FTTE reduces mortality by altering management in substantial proportion of patients undergoing emergency non-cardiac surgery.^[11] It is reported that in critically ill patients, lower mortality and complications, rather improved outcomes are observed when limited echocardiography-based patient management is practiced as compared to standard management.^[12] A systematic review of eighteen studies reporting topic of focused echocardiography in anesthesia and critical care, highlighted its impact on clinical decision making and diagnosis. Only two of them reported lower complications and mortality with use of FTTE. This review concluded with the need of randomized trials in future.^[13] A very recent article dealt with clinical importance of perioperative point of care TTE and also emphasized the need of ultrasound training inclusion in foundation years of anesthesia curriculum.^[14]

In contemporary practice, gold standard for LV EF measurement remains volumetric assessment using modified Simpson’s method.^[3] This method requires

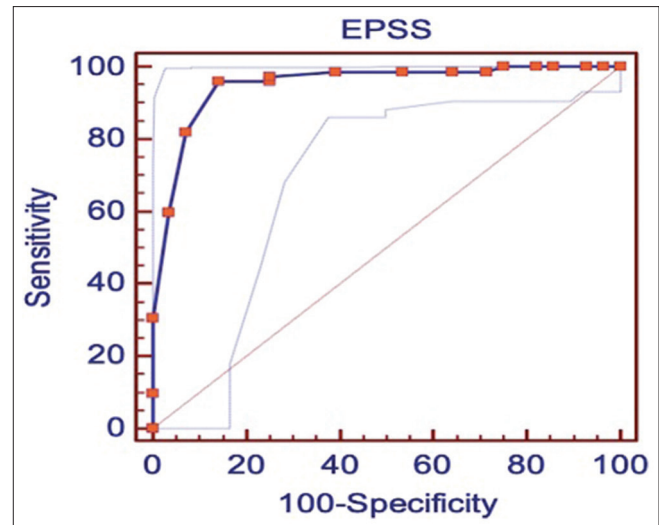


Figure 4: Shows receiver operating characteristic (ROC) curve with statistically significant area under curve (AUC)

trained and experienced clinician. The comprehensive echocardiography measurements are technically challenging as well as time-consuming, occupying crucial time in a busy preoperative period. Also, poor imaging windows in patients with respiratory pathology, obese patients, don’t allow accurate volumetric assessment.

Qualitative estimate of LV systolic function using eyeballing has been shown to be accurate in several studies when performed by experienced echocardiographer. Potential limitations of this method are the need of training and observer dependency.^[15]

Alternative echocardiographic index of LV function, MV EPSS was studied by Lew and colleagues in which they concluded that an abnormal EPSS is useful for identifying depressed LV function in patients with acute myocardial infarction and chronic ischemic heart disease.^[16] Mitral valve EPSS utility has also been demonstrated in pediatric echocardiography as a simple, practical and accurate means of separating normal from abnormal LV function.^[17]

Although underutilized, M-mode ultrasonographic imaging provides the most reliable temporal resolution in ultrasonography and provides clinically relevant information in TTE.^[6] Cardiac magnetic resonance imaging (CMR) modality is accurate being characterized by superior endocardial border definition and better spatial resolution as compared to echocardiography. A study conducted at Washington hospital center including 143 patients revealed correlation and regression coefficients to be very strong between EPSS and LVEF by Simpson’s method, both obtained using cardiac magnetic resonance imaging (CMR).^[18] Another study using CMR by Silverstein

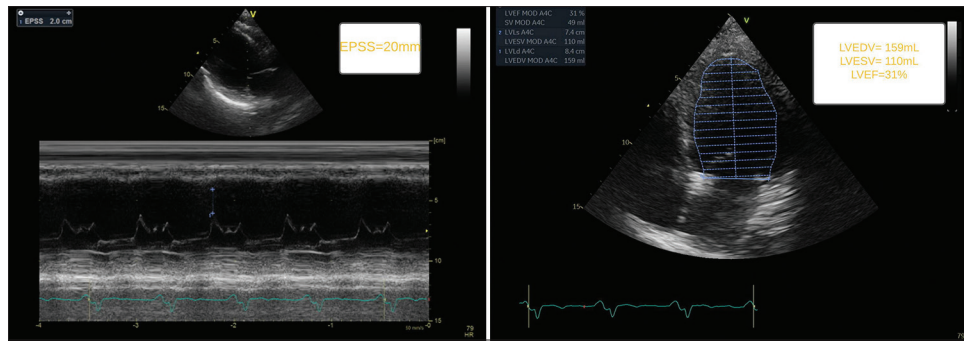


Figure 5: Shows measurement of EPSS as 20 mm in a patient with LV systolic dysfunction and corresponding LV EF calculation as 31% in the same patient

and colleagues, concluded clinically useful quantitative prediction of the LV EF as a continuous variable can be obtained from the EPSS with a simple linear regression equation in a substantial portion of patients and may be a useful adjunct for assessment of LV function.^[19] Hence, present study was conducted to assess correlation of mitral valve EPSS as a single most measure obtained in a single view of LV systolic function estimation with that obtained from LV EF using TTE in perioperative settings.

EPSS has been studied as a bedside tool for LVEF assessment in emergency departments by emergency physicians in 71 patients by McKaigney and associates.^[5] This prospective observational study demonstrated EPSS measurements strongly correlated with calculated LVEF from comprehensive TTE by Teichholz method using linear chamber measurements.^[5] Another prospective randomized study proved the hypothesis that MV EPSS correlates with contemporaneous fractional shortening (FS) measurements of LV systolic function when performed by emergency physicians. They concluded EPSS and FS had a moderate negative correlation.^[20] Similarly, the calculated Pearson correlation coefficient between EPSS and LV EF measured by modified Simpson's method obtained was -0.74 , $P < 0.0001$, suggesting statistically significant negative correlation, in present study.

In a previous study, EPSS accurately estimated abnormal ejection fractions with a sensitivity and specificity of 100% in a combined anterior and inferior myocardial wall infarction. They found an abnormal EPSS (more than 7 mm) to be more sensitive (87%) and specific (75%) in detecting individuals with reduced EF (EF less than 50%) as compared to other echocardiographic indices like percentage fractional shortening, EF calculated by Teichholz method and LV diastolic dimension.^[21]

S.C. Boon and authors published the Point of Care Ultrasound (POCUS) series highlighting use of EPSS as

a quick, easy, crude but reliable and suitable method to objectivize reduced LV EF (50%) in ICU POCUS scenarios. They described EPSS as a surrogate measure of LV remodeling in significant systolic dysfunction.^[22] In a prospective observational study including emergency department patients with acute dyspnea; significant correlation was found between novice physicians' EPSS measurements and visual estimation of LVEF by experienced emergency physicians.^[4] Prior studies also have indicated reasonable concordance to estimate LV EF with minimum training requirements in comparison to formal echocardiography by trained intensivists.^[23,24] A study conducted at University hospital including 105 patients for non-cardiac thoracic surgery, demonstrated feasibility and success of intraoperative TTE imaging, even in unconventional positions, high risk, unstable patients and its impact on anesthetic management.^[25]

Present study is the one to compare EPSS measurement with gold standard modified Simpson's method for LV function assessment. This study was carried out in perioperative settings, by anesthetists, in patients posted for various cardiac and non-cardiac surgical procedures. In a prospective investigator blinded study of focused bedside TTE in surgical intensive care patients, PS-LAX view was found to be the most preferred, commonly obtained, useful and highly reproducible view for non-calculative LV EF estimation.^[26] This view was less affected by lung pathology and body habitus.^[26] LV EF estimation using PS-LAX view has shown strong interobserver agreement with need of minimum patient cooperation.^[26] Similarly, para-sternal LAX view could be obtained in all present study patients. None of the patients in present study were excluded due to inability to acquire PS-LAX view due to poor imaging windows. In contrast, in three patients apical 4C view was not obtained satisfactorily to measure LVEF.

Stenberg and associates evaluated three point of care tests, EPSS, Mitral Annular Plane Systolic Excursion (MAPSE) and tissue Doppler Imaging peak systolic myocardial

velocities (TDISm) to discriminate LV Systolic dysfunction in 100 ambulatory surgical patients and all three tests did reasonably well in identifying LV systolic dysfunction. EPSS test efficiency was highest, MAPSE was more feasible while TDISm was found inferior in differentiating LV systolic dysfunction in this very recent study. They too focused on proactive risk stratification by anesthetist performed TTE to optimize surgical flow.^[27]

Present study has some notable limitations like EPSS measurements being unreliable in certain mitral, aortic valve pathology and asymmetric septal hypertrophy, inability of EPSS to monitor effect of given treatment and thus is not useful for serial evaluation.

Exclusion of regional wall motion abnormality, apical aneurysm would have added great significance to this study as linear methods have limitations. Interobserver and intraobserver variability could not be commented upon in our study. As EPSS and LVEF both are dependent on preload and afterload, measurement of preload using IVC collapsibility index, would have added significantly to present study. Since number of patients was limited, impact of EPSS on clinical outcome was not demonstrated.

CONCLUSION

Mitral valve EPSS shows significant negative correlation with gold standard LV EF measurement for LV systolic function estimation. It can very well be used to assess LV systolic function perioperatively in busy operating rooms during odd hours by anesthetists with brief FTTE training.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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