How do Mitral Annular Plane Systolic Excursion (MAPSE) and E-Point Septal Separation (EPSS) performed by Emergency Physicians (EPs) to measure Ejection Fraction in the Emergency Department compare to gold standard echocardiograms by Cardiology?

Benjamin E. Fombonne MD, Kristopher Bianconi MD, Daniel Singer, MD, Gina Polizzo, MD, Jiten Patel MD, Michael Secko MD

Stony Brook Medicine

Department of Emergency Medicine

BACKGROUND

- Point Of Care Ultrasound (POCUS) has become an invaluable tool for emergency physicians (EP), enabling rapid and non-invasive assessment of various clinical conditions.
- EPs must assess cardiac function and ejection fraction (EF) in patients with chest pain and dyspnea using visual estimation, as well as by using objective advanced echo measurements, including Mitral Annular Plane Systolic Excursion (MAPSE), and E-Point Septal Separation (EPSS).
- The Simpson Biplane Method of Discs remains the gold standard for measuring EF%, but it is time consuming and operator dependent.
- MAPSE is an objective and surrogate measurement, which reflects left ventricular systolic function by measuring the motion of the mitral valve annulus during systole.
- Reduced MAPSE (< 1.0 cm or 10 mm) indicates impaired left ventricular function, potentially suggestive of reduced ejection fraction. Studies have demonstrated the reliability of MAPSE as an indicator of ejection fraction and its application in the Emergency Department (Bahl et al., 2021).
- E-Point Septal Separation (EPSS) is another parameter used for the rapid assessment of ejection fraction which measures the distance between the tip of the anterior mitral valve leaflet and the intraventricular septum during early diastole.
- An EPSS (>0.7 cm or 7mm), or a greater distance between the tip of the anterior leaflet and the septum, is suggestive of a reduced ejection fraction, and is associated with conditions like congestive heart failure.
- Point of care ultrasound is a bedside imaging modality that allows for real time visualization of anatomical structures and assessment of cardiac function, helping clinicians make swift and informed decisions and provide goal directed care. Our aim is to standardize the use of these parameters in the rapid assessment of critically ill patients and to emphasize their accuracy and reliability when compared to the gold standard of formal echocardiogram.

OBJECTIVES

- Investigate how EPs EF estimation via EPSS/MAPSE values during POCUS in the ED compares to the EF reported on formal echo obtained during the same hospitalization.
- Examine if EPSS and MAPSE correlate to EF.
- Compare the accuracy of EPSS vs MAPSE in predicting formal Echo EF.
- Does accuracy in predicting EF improve when EPSS and MAPSE are combined?

METHODS

Study Design:
- Observational Retrospective Electronic Chart Review Study
- Institutional Review Board approval with waiver of informed consent

Patients and Setting:
- All ER Cardiac POCUS exams performed on patients from Stony Brook University Hospital, a suburban level 1 Trauma Center located on Long Island in New York with approx. 130,000 adult and pediatric visits per year from August 2023 to February 2024
- Estimate approx. 400 patients will meet criteria for inclusion and a subset of these (20-25%) are likely to have same admission ECHOs performed.
- Inclusion in the study will depend solely on whether patient had received POCUS cardiac exam as a part of their routine care during their ER stay, in addition to formal echos to serve as a basis for comparison.

Data Source and Collection
- Observational Retrospective Chart review and data collection by trained research staff
- ED EF Interpretation quantified by visual estimation and EPSS/MAPSE measurements and EF % obtained via formal echocardiogram while inpatient during the same hospitalization will be collected along with demographic data
- Ultrasound operators included Ultrasound Boarded EM Physicians, Ultrasound EM Fellows, Critical Care EM Fellows, Emergency Medicine Attending Physicians, and Emergency Medicine Resident Physicians supervised by US Fellow or US Trained
- All ultrasounds were obtained with a Mindray M9 or ME8 ultrasound machine using the phased array probe (1.1–4.7 MHz frequency). Patient position was at the discretion of the study investigator; patients were in the supine position if able, semi-recumbent position if unable, and left lateral decubitus position if needed.

Study Outcomes
- Primary Outcomes: Demonstrate the accuracy and utility of EF interpretation by visual estimation, MAPSE and EPSS collected by ER Physicians during POCUS as compared to formal echo.
- Compare MAPSE vs EPSS ability to accurately predict EF%.

Statistical Analysis
- Achieved using SPSS statistical software suite
- Analysis of Variance (ANOVA) of ED Interpretation to Formal EF %
- Chi-Square with Kappa Coefficient of ED Interpretation to Formal Echo Category
- Coefficient Correlation of MAPSE to EF
- Coefficient Correlation of EPSS to EF
- Multiple Linear Regression of EPSS, MAPSE with EF on Formal Echo

RESULTS

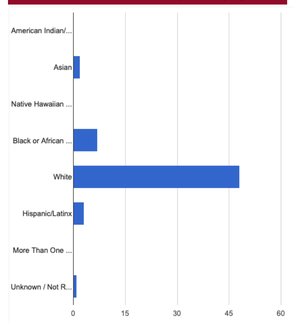
Table 1.1 Cohort Sex and PMHx Data

% Male	% with Preexisting CHF	% with Preexisting CAD
63.90%	35.00%	56.90%

Table 1.2 Age and BMI Distribution

	Mean	Standard Deviation
Age	72.5	14.8
BMI	27.41	6.19

Table 1.3 Race and Ethnicity Demographics



Counts/frequency: American Indian/Alaska Native (0, 0.0%), Asian (2, 3.3%), Native Hawaiian or Other Pacific Islander (0, 0.0%), Black or African American (7, 11.5%), White (48, 78.7%), Hispanic/Latinx (3, 4.9%), More Than One Race (0, 0.0%), Unknown / Not Reported (1, 1.6%)

Table 2.1 Summary Statistics of the Data

		EPSS	Septal	Lateral	Average	MAPSE Imputed	Echo
N	Valid	33	31	56	25	61	62
	Missing	30	32	7	38	1	1
Mean		0.96	0.9855	1.043	1.0492	1.0116	49.69%
Std. Deviation		0.63758	0.39038	0.39644	0.37373	0.35183	17.40%

Table 3.1 ER vs Echo Crosstabulations

		Formal Echo Normal >50%	Formal Echo Depressed 30-50%	Formal Echo Severely Depressed <30%	Total	Percentages
ER Interpretation	Normal >50%	29	4	0	33	87%
	Depressed 30-50%	7	12	1	20	60%
	Severely Depressed <30%	0	2	8	10	80%
Total		36	18	9	63	

Crosstabulation is a method to summarize the relationship between two or more categorical variables by creating a matrix (table) that displays the frequency distribution of the variables. The data here conveys that when formal echo determines someone has either a normal EF, or severely depressed EF (the extremes), we are quite accurate in our assessments (>87% and 80% respectively.) However, when EF is only moderately depressed, we are less accurate, and often likely instead interpret moderately reduced EF (30-50%) as either normal or severely depressed. In particular this tends to happen when the EF is very close to the cutoffs for Normal or Severely depressed. For example, some patients with an EF% on formal echo of 29% are technically in the severely depressed category, however we may have called them moderately depressed on our assessment. However, the ability to detect normal vs severely depressed in the ED is more likely to impact clinical decision making and treatment plans.

Table 4.1 Cohen's Kappa

	Value	Asymptomatic Standard Error[a]	Approximate Tb[b]	Approximate Significance
Measurement of Agreement	0.622	0.89	6.585	<0.001
N of Valid Cases	63			

The kappa coefficient, specifically Cohen's kappa, is a measure of inter-rater agreement for categorical items. It is calculated based on observed and expected agreements between raters. Cohen's kappa is especially useful in situations where you want to account for the possibility of agreement occurring by chance. This p value <0.001 suggests the data collected measuring agreement between formal echo and ED echo interpretations are unlikely to have resulted by chance.

Table 5.2 – Analysis of Variance of EF interpretation to Formal Echos (ANOVA)

	Sum of Squares	df	Mean Square	F	Significance
Between Groups	11082.841	2	5541.421	44.251	<0.001
Within Groups	7388.336	59	125.226		
Total	18471.177	61			

For table 4.2, if the calculated F is greater than the critical value, reject the null hypothesis. If the F-statistic is significant, it indicates that at least one group mean is different from the others.

Table 6.1 – Pearson Correlation Analysis of EPSS, MAPSE (septal, lateral, average, and all) to Formal Echo EF%

		EPSS	Septal MAPSE	Lateral MAPSE	Average MAPSE	All MAPSE
EPSS	Pearson Correlation	---	---	---	---	---
	N	33	---	---	---	---
Septal MAPSE	Pearson Correlation	-0.679**	---	---	---	---
	Significance (2-tailed)	.005	---	---	---	---
	N	15	31	---	---	---
Lateral MAPSE	Pearson Correlation	-.579**	.603**	---	---	---
	Significance (2-tailed)	<0.001	0.001	---	---	---
	N	30	25	56	---	---
Average MAPSE	Pearson Correlation	-.746**	.887**	.903**	---	---
	Significance (2-tailed)	.003	<0.001	<0.001	---	---
	N	13	25	25	25	---
All MAPSE	Pearson Correlation	-.611**	.896**	.940**	1.000	---
	Significance (2-tailed)	<0.001	<0.001	<0.001	<0.001	---
	N	32	31	56	25	62
Formal Echo EF	Pearson Correlation	-.714**	.285	.666**	.549**	.603**
	Significance (2-tailed)	<0.001	.127	<0.001	.005	<0.001
	N	33	30	55	24	61

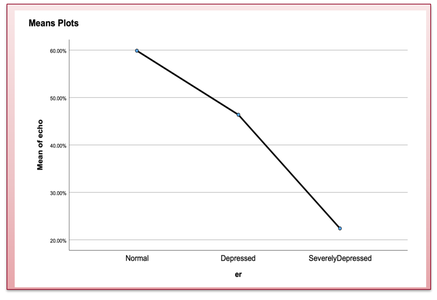
The Pearson correlation coefficient, denoted as *r*, is a measure of the linear relationship between two continuous variables. It quantifies the strength and direction of this relationship on a scale from -1 to 1. The closer to +1 or -1, stronger the correlation. A positive relationship suggests that as one variable goes up, so does the other; MAPSE and EF, for example should follow. Negative relationship indicates as one goes down, the other should go up. For example, a low EPSS measurement is indicative of a normal or high EF%, so ie. EPSS value to EF% would correlate negatively.

Table 5.1 – Analysis of Variance of EF interpretation to Formal Echos (ANOVA) Descriptive Statistics

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Lower Bound	95% Confidence Interval for Upper Bound
Normal EF >50%	33	59.879%	11.101%	1.932%	55.943%	63.815%
Depressed EF 30-50%	19	46.368%	12.659%	2.904%	40.267%	52.470%
Severely Depressed EF <30%	10	22.400%	7.891%	2.495%	16.755%	28.045%
Total	62	49.694%	17.401%	2.210%	45.274%	54.113%

Analysis of Variance is a statistical method used to compare means among three or more groups to determine if at least one group mean is significantly different from the others. It helps in identifying whether variations in data are due to actual differences among the groups or just random chance. Null hypothesis assumes all group means are equal. Alternate hypothesis suggests at least one group mean is different. Table 4.1 compares how the qualitative EF interpretation (Normal vs Depressed vs Severely Depressed) compares to the % EF measured on formal echo. For example, this data reflects that when we determine and EF is normal, the mean % EF value on formal echo was 59%. This suggests that our descriptive statistic of "Normal" correlated to a mean EF of 59%, with a standard deviation of +/- 11, which is quite accurate given that Normal EF= >50%. The standard deviation in the EF % increases when ED Echo stated "Depressed", which fortifies the crosstabulation data in table 2.2. This again suggests we are more accurate when the EF% is either very, or very low, and that we become less accurate when the EF is moderately reduced.

Graph 1.1 ED Categorical Interpretation vs Echo EF %



This graph offers a visual representation of the relationship between our categorical assessment of EF and the mean % measured on formal Echo. This information is also seen in table 5.1. The Y axis is the % EF on formal Echo, and the X axis is our categorical ED interpretation. As can be seen, when categorizing patients as "Severely Depressed" the average EF % for these patients was approximately 22%, which is appropriate.

RESULTS

Table 7.1- Descriptive Statistics for Multivariable Regression Model Analysis of EPSS, All MAPSE and Formal Echo EF% (N=32)

	Mean	Std. Deviation	N
Formal Echo	46.375%	14.462%	32
All MAPSE	0.9734	0.38449	32
EPSS	0.9681	0.64604	32

Table 7.2 - Linear Regression Analysis of EPSS and Formal Echo EF% (N=32)

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Significance
EPSS	0.714	0.51	0.493	10.294%	0.51	31.187	1	30	<0.001

Table 7.3 - Linear Regression Analysis of All MAPSE and Formal Echo EF% (N=32)

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Significance
All MAPSE	0.632	0.4	0.38	11.390%	0.4	19.976	1	30	<0.001

Table 7.4 - Multivariable Regression Model Analysis of EPSS, All MAPSE and Formal Echo EF% (N=32)

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	R Square Change	F Change	df1	df2	Significance
All MAPSE AND EPSS	0.756	0.571	0.541	9.794%	0.571	19.298	2	29	<0.001

A linear regression model is a statistical method used to examine the relationship between two or more variables. The primary purpose of linear regression is to model the relationship between a dependent variable (also called the response variable) and one or more independent variables (also called predictor variables) by fitting a linear equation to observed data. R-squared (R^2): Indicates the proportion of the variance in the dependent variable that is predictable from the independent variable(s). Ranges from 0 to 1. I.e. an R^2 of 1 states that MAPSE or EPSS perfectly predicts Echo EF. Closer to 1, the better. This data suggests that EPSS is slightly more accurate than MAPSE at predicting EF, (0.51 vs 0.4) however the most accurate measurements are derived from a combination of MAPSE and EPSS as suggested by the R of 0.571, which is closer to 1 than either variable independently (and R of 0.51 for EPPS and 0.4 for MAPSE).

CONCLUSIONS

It is important to emphasize that we are very much in the early phases of data collection for this study, and these results represent only a small portion of the anticipated final cohort. Despite our limited data set due to low sample size, these preliminary data already demonstrate statistical significance, which suggest the following conclusions:

- ER Physicians are good at estimating EF % based on echo, especially in cases of the extreme i.e.. normal vs severely depressed, which may be more important for clinical decision making.
- EPSS and MAPSE correlate to formal echo EF %.
- EPSS appears to be slightly more predictive of EF than MAPSE, however MAPSE was also significant enough.
- In our multiple regression model, both EPSS and MAPSE can be used to predict EF independently, however the model shows combining both EPSS and MAPSE measurements increases accuracy.

FUTURE

- Continue data collection to increase sample size and power to further validate our preliminary conclusions demonstrated thus far.
- Investigate how the operator of the ultrasound machine (ie. PGY-1/2/3, vs Fellows, Attending Physicians, and Ultrasound trained ER faculty) influences the accuracy in the collection of EPSS and MAPSE, and thus the ability to accurately predict EF.
- How the addition of EPSS and MAPSE measurements can increase reliability and accuracy of EF% Estimation in the Emergency Department.
- How frequently an abnormal EF determined by initial POCUS predicts admission.