DOI: 10.21088/ijaa.2349.8471.12325.6

Indian Journal of Anesthesia and Analgesia
Volume 12 Number 3 July - September 2025

ORIGINAL ARTICLE

Comparison of Tricuspid Annular Systolic Excursion Measurement between Transthoracic and Transesophageal Ecocardiography in the Perioperative setting

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HOW TO CITE THIS ARTICLE:

Gayatri Balabantaray, Chaitali SenDasgupta. Comparison of Tricuspid Annular Systolic Excursion Measurement between Transthoracic and Transesophageal Ecocardiography in the Perioperative setting. Ind J Anesth Analg. 2025; 12(3): 207-215.

ABSTRACT

Introduction: Tricuspid Annular Plane Systolic Excursion (TAPSE) is measured in apical 4-chamber (4CH) view in transthoracic echocardiography (TTE). In Transesophageal echocardiography (TEE), it is measured by Mid esophageal 4 chamber view (ME 4CH) and modified deep transgastric (dTG) view. The aim of our study was tocompare different methods of TAPSE measurement.

Materials and methods: Patients posted for elective Off Pump Coronary Artery Bypass Graft Surgery (OPCAB) were included in the study. TAPSE was measured after induction by TTE (4CH) view preoperatively and by TEE (ME 4CH and dTG) both preoperatively and postoperatively.

Result and analysis: Measurements in dTG RV view at 0° showed best agreement with standard TTE measurements with intraclass-correlation 0.987 and 95% confidence interval 0.917-0.995. In Mid Esophageal Four Chamber (ME 4CH) view showed agreement of measurements with intraclass-correlation 0.904 and 95% confidence interval - 0.096-0.977 and on average estimated TAPSE values 1.54 mm lower than TTE. TAPSE by pre-operative Mid Esophageal Four Chamber (ME 4CH) view and Deep Transgastric Right Ventricular view suggested strong positive correlation by intraclass-correlation 0.945 with a 95% confidence interval of -0.013 to 0.987. In post-operative period Mid Esophageal Four Chamber (ME 4CH) view and Deep Transgastric Right Ventricular view suggested intraclass-correlation 0.945 and 95% confidence interval -0.015 to 0.987.

Conclusion: Evaluation of RV function by means of TAPSE measurement in TEE can be performed with an excellent level of agreement compared to TTE.

KEYWORDS

• TAPSE • TTE • TEE • OPCAB

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➤ **Received:** 24-02-2025 ➤ **Accepted:** 30-05-2025

INTRODUCTION

The right ventricle (RV) plays an important role in the morbidity and mortality of patients with cardiac disease. The incidence of RV dysfunction while weaning from cardiopulmonary bypass and its negative prognostic impact on postoperative outcome[1-4], calls for an accurate evaluation of RV function in the perioperative setting using transesophageal echocardiography (TEE). The complex shape of the RV makes accurate evaluation of the RV ejection fraction (EF) difficult; it is not uncommon to use qualitative visual assessment.[5] Therefore, importance of assessment of RV function by quantitative methods in the intraoperative periodis increasing. TAPSE is one of the recommended methods for the quantitative assessment of RV function[6,7]. It measures the longitudinal systolic displacement of the base of RV free wall towards the apex,[14] which is assumed to represent the global right ventricular function.[8] Indeed, most of the RV muscular fibers lie in a base-to-apex direction. So, longitudinal shortening is more responsible for RV ejection rather than transverse shortening.[9-11] TAPSE measurement is done in apical 4-chamber (4CH) view in transthoracic echocardiography (TTE) by M mode. The cursor is placed at the junction of the tricuspid valve annulus and the RV free wall. The most important limitation of this method is its angle dependence.[6-8] The mid esophageal 4-chamber (ME 4CH) view in TEE is a less suitable view to measure TAPSE using M-mode because here the M-mode line is almost perpendicular to the lateral aspect of the tricuspid annulus, which makes the acquisition of M-mode impossible. There are different methods to overcome the flaw of TEE in measuring TAPSE. Mid RV ejection Esophageal 4 Chamber view is used to evaluate TAPSE. The difference between systolic and diastolic excursion of the lateral tricuspid annulus to the right ventricular apex[12] is measured by M-mode.[15] The steerable line can be used if available to adjust the cursor freely to the direction of the annular motion to correct any undesirable angle.[13-15] Alternatively, TAPSE is also measured in modified Deep Transgastric (dTG) RVviews[16-18] by M-mode. The M-mode cursor is properly aligned with the lateral tricuspid annular plane.

The aim of this study was to evaluate the correlation between different methods of measuring TAPSE. Nowadays, off-pump coronary artery bypass surgery (OPCAB) on beating heart is accepted as a procedure of choice in many centres[19,20] as it is safe and effective as well as long-term survival rate do not differ than on-pump CABG.[21]

Although cardio-pulmonary bypass (CPB) is one of the possible causes of reduced right ventricular function, several studies have reported decreased right ventricular function after OPCAB also. The rate of decline in RV function immediately after surgery is similar to that of on-pump CABG.[22] So, in this study RV function was observed after OPCAB surgeries by different methods of Echocardiography.

MATERIAL AND METHODS

The study was done in Cardiothoracic OT in a state run University affiliated tertiary care hospital and teaching institution. Fifty patients aged 30 years to 75 years in sinus rhythm scheduled for elective OPCAB with a class I indication for intra operative echocardiography were included for the study. Patients with contraindications to TEE, atrial fibrillation, tricuspid regurgitation greater than grade 1 and prior tricuspid valve surgery were excluded.

Being an observational study, involving the comparison of two diagnostic modalities, that are not radically different, considering the time and logistics available, fifty (n=50) patients were included in the study.

All echocardiographic data sets were obtained with the Philips HD7XE imaging platform. For transthoracic examination a S4-2-TTE probe and for transesophageal examinations a T6H Omni III -TEE probe was used.

Patients were anesthetised as per institutional protocol. Oxygen saturation, two-lead electrocardiogram (leads II and V5), arterial blood pressure, CVP, PA Pressure, urine output, temperature also were monitored continuously. The TEE probe was inserted after intubation. All the echocardiographic examinations was performed by one senior Cardiac Anaesthesiologist.

The echocardiographic measurements were done under GA in stable hemodynamic conditions in the following order:

(a) Before skin incision:

i. TTE apical 4CH view with TAPSE M-Mode.

ii. TEE ME4CH view - The probe was adjusted to provide best possible visualisation of the RV endocardial border.

iii. Deep TG position to obtain the deep - Trans-gastric view at 0° (dTG at 0°). The cursor was aligned with the direction of tricuspid annular motion.

The cursor was adjusted to achieve a parallel intercept angle with the tricuspid annular movement in M mode.

Post-operatively after sternal closure TAPSE was measured by:

i. TEE 4CH view

ii. dTG view at 0°

TAPSE was measured as the distance between the systolic and diastolic excursion of the tricuspid valve. The acquisition of Figures required for the study was followed by a comprehensive 2D TEE examination in all patients according and following our routine standard protocol.

Postoperatively, the patients were shifted to Cardio-thoracic intensive care unit and were electively ventilated and managed by intensive care unit team and extubated on following day as per institutional protocol.

RESULTS

The study data was recorded on a master sheet and was summarized as mean and standard deviation for normally distributed numerical variables, median and interquartile range for skewed numerical variables. P<0.05 was considered as statistically significant. This cross-sectional, observational study included fifty patients. All variables are normally distributed by Kolmogorov-Smirnoff goodness-of-fit test, other than angiographic data. Comparison of values obtained through two different modalities and two different times (pre and post) were done by Student's paired t-test. Extent of agreement between paired measurements (between TTE and TEE views) was done by construction of Bland-Altman plots and calculation of intraclass correlation coefficient. Key variables were expressed along with 95% confidence intervals. Software used were Statistica version 6 [Tulsa, Oklahoma: Stat Soft Inc., 2001] and MedCalc version 11.6 [Mariakerke, Belgium: MedCalc Software 2011]

TAPSE Measurements:

In both TTE and TEE appropriate echocardiographic Figures were obtained to get appropriate measurements in all patients. Mean values of TAPSE ranged between 17.1 to 19.1mm in different views. Details of TAPSE in different views have been shown in Table 1.

Agreements in TAPSE measurements:

TAPSE measurements obtained by TEE were compared with TTE measurements by Student's paired t-test and showed **p <0.001** which implies the values are not identical. However, the intra-class coefficient correlation between the TAPSE values in TEE showed a very good reproducibility for measurements with the correlation coefficients >0.900. All the measurements have reasonable agreement. The same is plotted in Bland-Altman plots.

Table 1:

Measurement	TTE_ 4CHV_ PreOp	TEE_ 4CHV_ PreOp	TTE_ 4CHV_ PreOp	TEE_ dTG_ PreOp	TEE_ 4CHV_ PreOp	TEE_ dTG_ PreOp	TEE_ 4CHV_ PostOp	TEE_ dTG_ PostOp
Mean	19.1±2.6	17.5±2.7	19.1±2.6	18.7±2.7	17.5±2.7	18.7±2.7	17.5±2.7	18.6±2.7
p	< 0.001		< 0.001		< 0.001		< 0.001	

Table 2:

Measurements	Average Measures	
	Intraclass correlation	95% Confidence Interval
TEE_4CHV_PreOp TTE_4CHV_PreOp	0.9045	-0.09635 to 0.9773
TTE_4CHV_PreOp TEE_dTG_PreOp	0.9876	0.9171 to 0.9957
TEE_4CHV_PreOp TEE_dTG_PreOp	0.9452	-0.01335 to 0.9871
TEE_4CHV_PostOp TEE_dTG_PostOp	0.945	-0.01530 to 0.9871

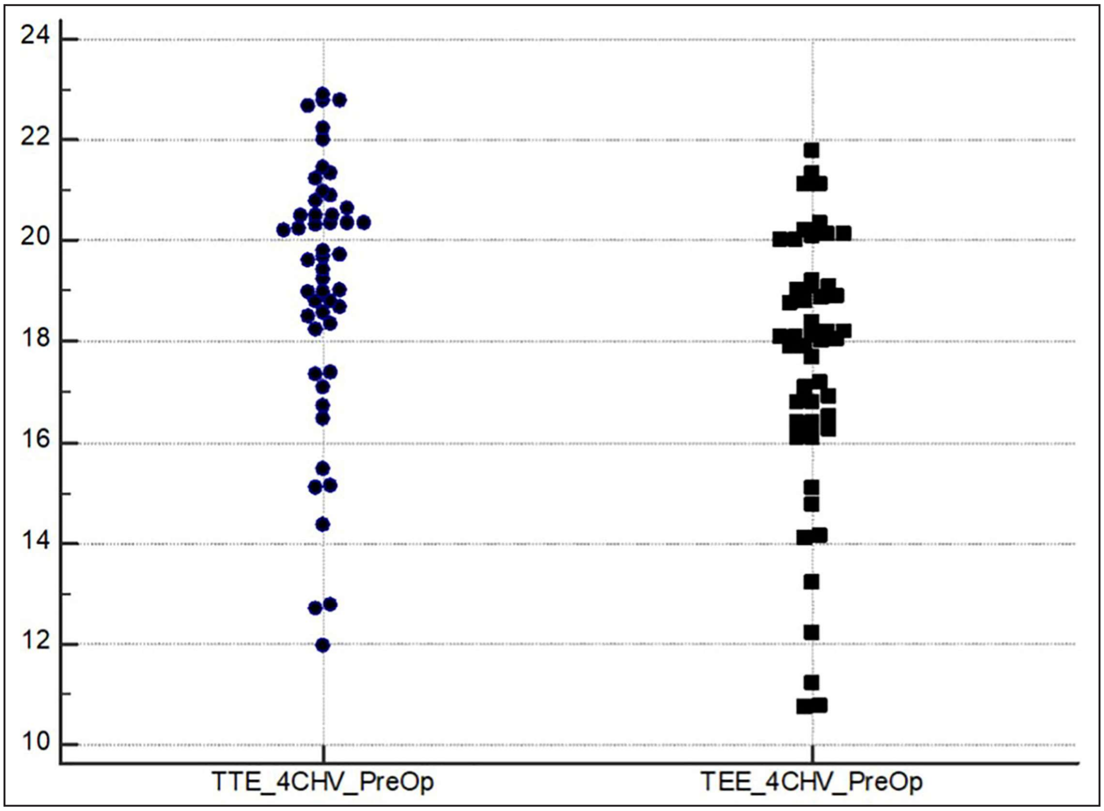


Figure 1:

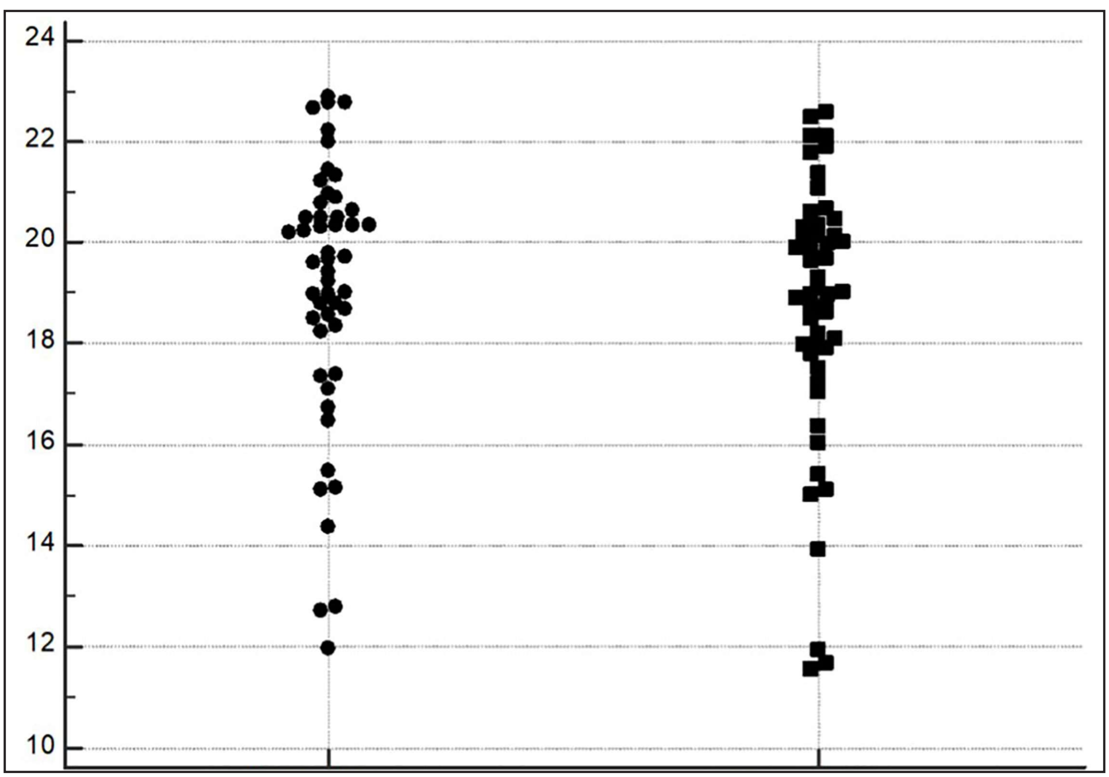
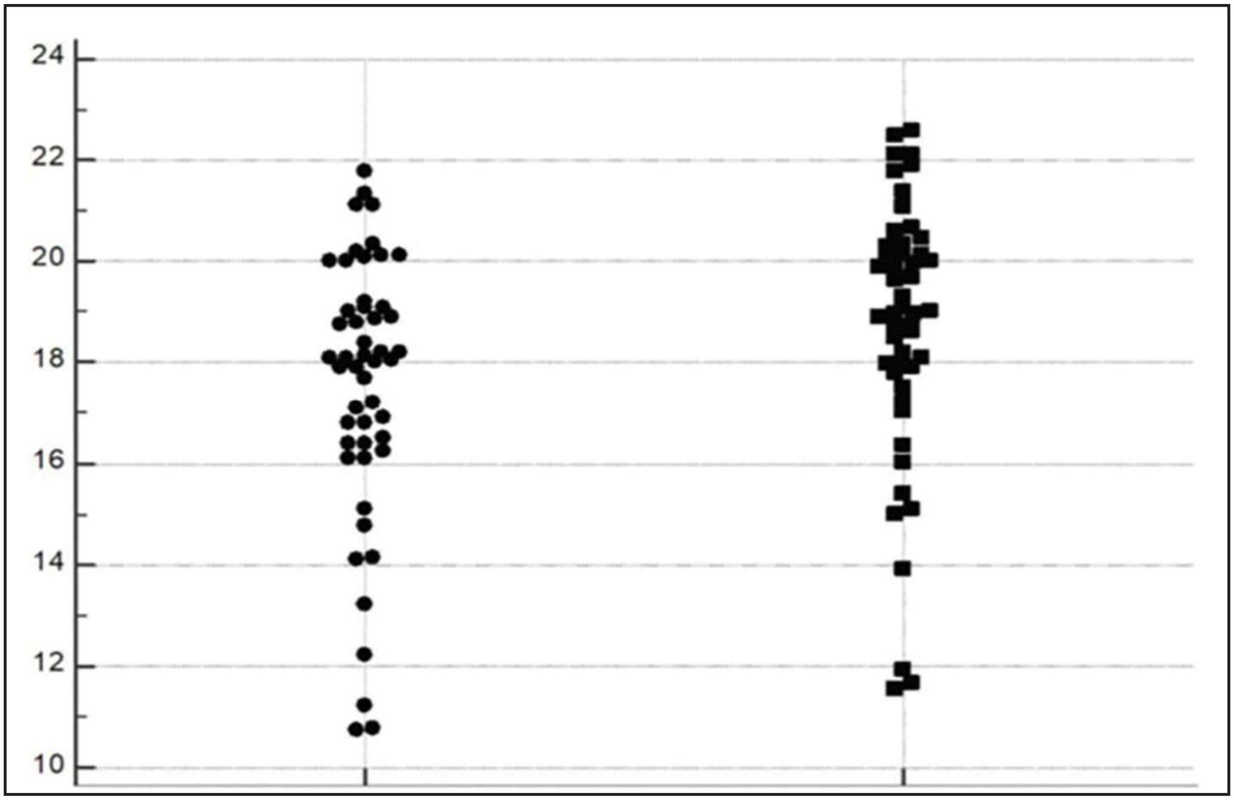


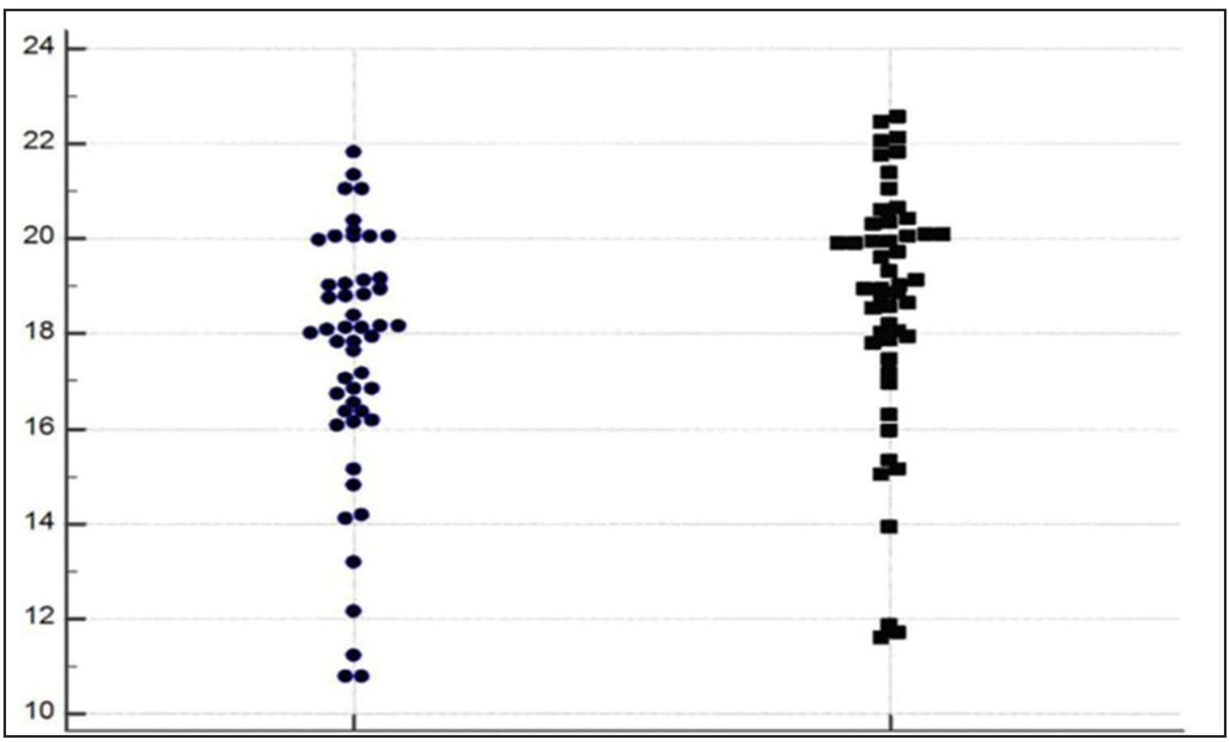
Figure 2:

TTE 4CH Preop TEE dTG



TEE 4CHV Pre OP TEE dTGPreOp

Figure 3:



TEE 4CHV Post OP TEE dTG Post Op

Figure 4:

ABBREVIATION

TTE 4CHV Pre-op: Transthoracic Echocardiography Apical 4 chamber view preoperatively;

TEE 4CHV Pre-op: Transesophageal Echocardiography midesophageal 4 chamber view preoperatively;

TEE dTG Pre-op: Transesophageal Echocardiography Deep Transgastric view preoperatively;

TEE 4CHV Post-op: Transesophageal Echocardiography midesophageal 4 chamber view postoperatively;

TEE dTG Post-op: Transesophageal Echocardiography Deep Transgastric view postoperatively

DISCUSSION

The need for quantitative assessment of RV systolic function in the perioperative setting makes TAPSE a valuable tool for quick evaluation. This cross-sectional observational study compared TAPSE measured by different methods of TEE and TTE. Since it is not possible to measure TAPSE by M-mode in the ME 4CH view in TEE, alternative ways like 2D method and the use of M-mode in the modified deep trans gastric RV views have been proposed and hence in our study these views are considered to measure TAPSE by TEE.

The parameters measured are:

I. TAPSE in TTE 4 chamber view, using M-mode (pre-op).
II. TAPSE in 2D TEE 4 chamber view at 0° (pre-op).
III. TAPSE in deep-trans gastric view at 0° (dTG at 0°) aligning the cursor with the direction of tricuspid annular motion using M-mode (pre-op).
IV. TAPSE in 2D TEE 4 chamber view at 0° (post-op).
V. TAPSE in deep-trans gastric view at 0° (dTG at 0°) aligning the cursor with the direction of tricuspid annular motion using M-mode (post-op).

In pre-op, after induction of anaesthesia, TAPSE was measured with M-mode in TTE and using this as the standard reference we found our measurements in TEE ME-4CH view at 0° showed an average mean difference of - 1.54 mm with intraclass-correlation 0.904 and 95% CI - 0.096 to 0.977.

The measurements in TAPSE in deep-trans gastric view at 0° showed an average mean difference of 0.40mm with intraclass-correlation 0.987 and 95% CI 0.917-0.995. The study showed that TEE measurements of TAPSE are of high agreement with TTE measurements of the same and can be used to measure TAPSE especially intra-operatively. The level of agreement between TAPSE measurements in TEE compared to TTE however dependent upon the specific view used. The measurements in TAPSE in deep-trans gastric view at 0° (aligning the cursor with the direction of tricuspid annular motion using M-mode) showed excellent agreement with TTE measurements. We also observed that there exists a reasonable degree of agreement between TAPSE measurements obtained by pre-op 2D 4CH view at 0° and M-mode in dTG RV view at 0° with intraclass-correlation 0.945 and 95% CI - 0.013 to 0.987. Same is true for both the post-op values with intraclass-correlation 0.945 and 95% CI - 0.015 to 0.987.

Anna Flo Forner *et al*[23] found a good agreement for TAPSE measured by TTE and in the ME 4CH and dTG RV at 0° viewsby TEE[23] through Bland–Altman analysis.The agreement between TAPSE measured in TTE and TEE (in ME 4CH view with M-mode, in dTGRV 0° by M-mode and in dTG RV LAX view by anatomical M-mode) showed a significant systematic underestimation of the measurements in their study. We found reasonable agreement for TAPSE measured using M-mode in TTE and dTG RV at 0° views or 2D 4CH mid-esophageal view at 0°.

According to above study, interrogation of the tricuspid annular movement can be done by the anatomical M-mode technology irrespective of the angle of interrogation. Anatomical M-mode Figures are reconstructed from 2D Figures unlike conventional M-mode and this leads to the loss of characteristic high temporal resolution of M-mode.[13] It did not affect the confidence Interval of TAPSE measurement done by AM-modein this study. In spite of the promising characteristic of AM-mode, we could find only one study[28] that described its feasibility for estimation of TAPSE by TEE. They compared different TAPSE measurement methods in TEE (M-mode, speckle tracking and tissue tracking) to the stroke volume, however the authors did not compare these measurements with TTE.

The 2D method is an alternative method to measure TAPSE in TEE. We found few studies utilizing this method for assessment of TAPSE[29,30] in correlation with outcome or the overall RV function. We could not find any study validating 2D measurement compared to the standard method in TTE. Yasir Qureshi *et al.*[26] studied TAPSE assessment in TTE using 2D compared to M-mode in children. They also found a systematic underestimation of 1 mm in 2D values, which is consistent with our results, indicating that it could be a good alternative for measurement of TAPSE.

The inherent lower frame rate and lower temporal resolution of 2D technology challenges the observer for correct recognition of endocardial borders and accurate identification of the RV apex. This may be the reason for the slightly higher variability observed in our study compared to the M-mode measurements although it remained within very good agreement.

Due to difficulty in RV assessment by TEE, new standard and non-standard RV views[16-18] have been introduced over last few years for measurement of TAPSE. In deep TG RV inflow-outflow view at 0° good visualization of the tricuspid valve, tricuspid annulus and RV free wall motion is feasable. This view is a small modification in standard TG RV inflow–outflow view at 0°; it is made by advancing the probe until the RV free wall lies as parallel to the cursor as much as possible.

Anna Flo Forner *et al*[24] could demonstrate that the use of M-mode in TAPSE measurements showed no differences to that of the standard TTE measurement. Similarly, the deep TG RV inflow-outflow view at 120–160° allows good visualization of the right ventricular structures.[17] Another study showed showed the feasibility of measuring tricuspid annular motion and velocity in dTG RV LAX but they did not compare the values with TTE.[31] However, we limited our TAPSE measurements to deep-transgastric view at 0° aligning the cursor with the direction of tricuspid annular motion (using M-mode view) as we faced some limitations as we experienced more difficulty aligning the cursor to the free wall in other views.

TAPSE with TTE and TEE were compared immediately before and after cardiac surgery.[25] They showed TAPSE measured from 2D had a poorer performance compared to the AM- and M-mode.[28] TAPSE from trans gastric view demonstrated high performance throughout surgery and a good agreement with TAPSE by TTE; whereas our study showed both 2D and M-mode show high agreement with TTE measurements.

Adrian Fischl *et al*[27] found right ventricular function measurement of TAPSE by TEE agree to TTE measurements obtained and they are in close temporal proximity under similar hemodynamic conditions with normal RV function.[27] In our study we observe excellent agreement of TEE TAPSE measurements with that of TTE measurements, most of the patients having right ventricular size and function in normal range.

Limitation of the study:

- The quality of 2D Figures is essential for accurate 2D measurements as correct recognition of endocardial borders and accurate identification of the RV apex is essential for the same.
- AM-mode technology we lacked in our study for TAPSE.
- Most of the patients in our study had right ventricular size and function in normal range therefore we do not know if the good agreement between the different methods remains true in severely compromised right ventricles.
- Our study is done by a single observer.
- Our study is limited to a single centre.

CONCLUSION

This study demonstrates that the evaluation of RV function by means of TAPSE measurement in TEE comparable to that of TTE. The most accurate and precise measurements can be achieved with the use of M-mode in the d deep-trans gastric view at 0° (dTG at 0°) aligning the cursor with the direction of tricuspid annular motion using M-mode. It is recommendeduse of TEE views to measure TAPSE peri-operatively whenever TTE is not feasible, though none of the views are replaceable with each other.

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