Transesophageal Speckle-Tracking Echocardiography Improves Right Ventricular Systolic Function Assessment in the Perioperative Setting

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Background: Perioperative evaluation of right ventricular (RV) systolic function is important to follow intraoperative changes, but it is often not possible to assess with transthoracic echocardiographic (TTE) imaging, because of surgical field constraints. Echocardiographic RV quantification is most commonly performed using tricuspid annular plane systolic excursion (TAPSE), but it is not clear whether this method works with transesophageal echocardiographic (TEE) imaging. This study was performed to evaluate the relationship between TTE and TEE TAPSE distances measured with M-mode imaging and in comparison with speckle-tracking TTE and TEE measurements.

Methods: Prospective observational TTE and TEE imaging was performed during elective cardiac surgical procedures in 100 subjects. Speckle-tracking echocardiographic TAPSE distances were determined and compared with the TTE M-mode TAPSE standard. Both an experienced and an inexperienced user of the speckle-tracking echocardiographic software evaluated the images, to enable interobserver assessment in 84 subjects.

Results: The comparison between TTE M-mode TAPSE and TEE M-mode TAPSE demonstrated significant variability, with a Spearman correlation of 0.5 and a mean variance in measurement of 6.5 mm. There was equivalence within data pairs and correlations between TTE M-mode TAPSE and both speckle-tracking TTE and speckle-tracking TEE TAPSE, with Spearman correlations of 0.65 and 0.65, respectively. The average variance in measurement was 0.6 mm for speckle-tracking TTE TAPSE and 1.5 mm for speckle-tracking TEE TAPSE.

Conclusions: Using TTE M-mode TAPSE as a control, TEE M-mode TAPSE results are not accurate and should not be used clinically to evaluate RV systolic function. The relationship between speckle-tracking echocardiographic TAPSE and TTE M-mode TAPSE suggests that in the perioperative setting, speckle-tracking TEE TAPSE might be used to quantitatively evaluate RV systolic function in the absence of TTE imaging. (J Am Soc Echocardiogr 2016;■:■-■.)

Keywords: Transthoracic echocardiography, Transesophageal echocardiography, Speckle-tracking echocardiography, Right ventricular function quantification

Assessment of right ventricular (RV) systolic function can be challenging because of the nonstandard geometric shape of the right ventricle, and in the perioperative setting, the use of transthoracic echocardiographic (TTE) imaging is limited. Transesophageal echocardiographic (TEE) imaging is used as a monitoring tool to evaluate cardiac structure and function during cardiac surgical procedures. Although many left ventricular quantitative assessment techniques translate well between TTE and TEE imaging, methods of quantifying RV systolic function with TEE are not as well described. The American Society of Echocardiography offers guidelines for quantitative measurement of RV systolic function that include tricuspid annular plane systolic excursion (TAPSE), tissue Doppler motion of the tricuspid annulus (S′), and fractional area change; RV ejection fraction remains difficult to assess using conventional echocardiographic methods.[1,2] Certain measurements are favored, such as TAPSE, which is a reliable and reproducible measurement of RV function, even in the setting of limited apical imaging. Guidelines indicate that the measurement is performed from the apical four-chamber window during TTE imaging, with a distance of ≥17 mm considered normal.[1]

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Abbreviations

CMQ = Cardiac Motion Quantification

LV = left ventricle

ME4C = Midesophageal four-chamber

mm = millimeter

RV = Right ventricle

STE = Speckle-tracking echocardiographic

TAPSE = Tricuspid annular plane systolic excursion

TEE = Transesophageal echocardiographic

TMAD = Tissue motion annular displacement

TTE = Transthoracic echocardiographic

2D = Two-dimensional

Perioperative measurements of RV systolic function are performed with TEE imaging because TTE imaging is often not possible because of constraints of the sterile surgical field. M-mode TAPSE obtained during perioperative TEE imaging has been used clinically but can result in nonparallel alignment of the M-mode cursor with motion of the tricuspid annulus toward the apex. This study was performed because TTE methods of assessing RV function are not available during most surgical procedures, and determining a method of quantifying RV systolic function, using either TEE M-mode TAPSE or speckle-tracking echocardiographic (STE) imaging, would add to the quantification of the right ventricle in the perioperative setting. STE imaging allows the tracking of a specific location in the myocardium or strain rates of the myocardium.[3] It is hypothesized that STE imaging could be used to determine the longitudinal displacement of the tricuspid annulus during systole, when the motion of the annulus is not parallel to the ultrasound beam, as seen during TEE imaging.

A prior study in which the investigators compared TTE M-mode TAPSE distance with speckle-tracking TTE distance values demonstrated the validity and reliability of STE imaging to measure TAPSE distance,[4] but no relationship between TTE and TEE measurements of RV function has been published. There were two aims of this study. The first was to determine if TTE M-mode TAPSE measurements are the same as the TEE M-mode TAPSE measurements. The second aim was to determine if STE TAPSE values for both transthoracic and transesophageal echocardiography are the same as the TTE M-mode TAPSE distances.

METHODS

Study Population

After approval was obtained from our institutional review board, and using departmental funding, consent for intraoperative study image collection was sought from subjects undergoing elective cardiac surgical procedures. Associated cardiac surgical procedures are summarized in Table 1. To be included in this prospective, observational study, subjects had to be scheduled for elective cardiac surgical procedures in which general endotracheal anesthesia was the planned anesthetic technique and TEE imaging would be performed as per our institutional standard for surgical management. Subjects would be excluded if TTE or TEE images could not be obtained. Sample size calculations suggested that 100 subjects would result in 81% power to detect a difference of 25%. A total of 249 elective cardiac surgical procedures were performed during the data collection period. Of these, 112 subjects provided consent, and images were collected from 102. Ten subjects granted consent but did not undergo imaging, because of an inability to acquire study images without interrupting the operating room schedule.

Table 1 Frequency of cardiac surgical procedures performed during the associated TTE and TEE imaging in this study

Procedure	Number of subjects
CABG	45
CABG + AVR	10
CABG + CEA	3
CABG + MVR	2
CABG + ascending aortic replacement	1
AVR	9
AVR + ascending aortic replacement	5
AVR + MVR	1
MVR	2
MVR + TVR	2
TVR	1
Ascending aortic replacement	5
LVAD	10
LVAD + MVR	1
RV-to-PA conduit	2
Pericardiectomy	1

AVR, Aortic valve replacement; *CABG*, coronary artery bypass graft; *CEA*, carotid endarterectomy; *LVAD*, left ventricular assist device; *MVR*, mitral valve replacement; *PA*, pulmonary artery; *RV*, right ventricle; *TVR*, tricuspid valve replacement.

Image Acquisition

Following the induction of general endotracheal anesthesia with the subject in the supine position, the TEE probe was placed before TTE imaging. All subjects were imaged while in a supine position without lateral tilt, and study TTE and TEE images were collected using an iE33 echocardiographic machine with an X5 TTE probe and an X7 TEE probe (Philips Medical Systems, Andover, MA). Imaging was performed after the induction of general endotracheal anesthesia to eliminate the possibility that variation observed between TTE and TEE imaging was the result of changes in cardiac function after the administration of anesthetic medications and/or the use of positive pressure ventilation.[5-7] Two TTE images and two TEE images constituted the study examination; for TTE imaging, an apical four-chamber two-dimensional (2D) two-beat clip and a TTE M-mode TAPSE measurement from this position were obtained,[1,2] and for TEE imaging, a midesophageal four-chamber (ME4C) 2D two-beat clip with the apex in a nonforeshortened position and rotated to keep the lateral tricuspid annulus within the scanning sector throughout the entire cardiac cycle and a TEE M-mode TAPSE measurement with the probe in the same position were obtained.

STE Image Analysis

All four study-related images were exported to a portable hard drive, and the two 2D clips were in a native data set Digital Imaging and Communications in Medicine format for postprocessing in a stand-alone QLAB (Philips Medical Systems) package with STE software. Using the tissue motion annular displacement (TMAD)