Review Article

Practice guidelines for perioperative transesophageal echocardiography: Recommendations of the Indian association of cardiovascular thoracic anesthesiologists

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The IACTA guideline committee acknowledges that it followed the international guidelines, especially the ASE and SCA principles wherever necessary and modified the strategy to suit local requirements.

ABSTRACT

Transoesophageal Echocardiography (TEE) is now an integral part of practice of cardiac anaesthesiology. Advances in instrumentation and the information that can be obtained from the TEE examination has proceeded at a breath-taking pace since the introduction of this technology in the early 1980s. Recognizing the importance of TEE in the management of surgical patients, the American Societies of Anesthesiologists (ASA) and the Society of Cardiac Anesthesiologists, USA (SCA) published practice guidelines for the clinical application of perioperative TEE in 1996. On a similar pattern, Indian Association of Cardiac Anaesthesiologists (IACTA) has taken the task of putting forth guidelines for transesophageal echocardiography (TEE) to standardize practice across the country. This review assesses the risks and benefits of TEE for several indications or clinical scenarios. The indications for this review were drawn from common applications or anticipated uses as well as current clinical practice guidelines published by various society practicing Cardiac Anaesthesia and cardiology . Based on the input received, it was determined that the most important parts of the TEE examination could be displayed in a set of 20 cross sectional imaging planes. These 20 cross sections would provide also the format for digital acquisition and storage of a comprehensive TEE examination. Because variability exists in the precise anatomic orientation between the heart and the esophagus in individual patients, an attempt was made to provide specific criteria based on identifiable anatomic landmarks to improve the reproducibility and consistency of image acquisition for each of the standard cross sections.

Received: 13-02-13
Accepted: 07-07-13

Key words: Guidelines; Perioperative; Transoesophageal echocardiogrphy

Access this article online
Website: www.annals.in
DOI: 10.4103/0971-9784.119175
Quick Response Code:

INTRODUCTION

Perioperative transesophageal echocardiography (TEE) is a diagnostic and monitoring imaging tool with widespread applications in the operating rooms and intensive care settings.[1] This modality is being used in both government institutions and private hospitals all across India. In view of increasing application of TEE in Indian context, it has become imperative to establish protocol/guidelines for the practice of TEE. This document is expected to assist physicians to help appropriate application of TEE and improve the perioperative management

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of surgical patients. These recommendations may be adapted and modified according to the local institutional policies, circumstances and expertise; and are not intended to be absolute regulatory requirements. Further, these recommendations are subject to the availability of TEE facility in a given hospital and its availability is not binding for carrying out surgical procedures [Table 1]. The guidelines do not address training, certification, establishing credentials and quality assurance.

INDICATIONS FOR PERIOPERATIVE TEE

The American Society of Anesthesiologists and Society for Cardiovascular Anesthesiologists in its updated report on TEE recommends the use of TEE for all adult open-heart and thoracic aortic procedures and transcatheter intracardiac procedures.[2] However, the Indian Association of Cardiovascular Thoracic Anesthesiologists recommendations are categorized as follows:

Technique for insertion of a TEE probe in an anesthetized individual: The following steps are followed for insertion of TEE probe in anesthetized and intubated patients:

1. Mouth is examined for abnormalities and loose teeth
2. An informed consent from the patient is obtained prior to the procedure
3. A suitable general anesthesia is administered
4. A nasogastric/orogastric tube is inserted to decompress the stomach and is removed prior to the passage of the TEE probe
5. A bite-guard is inserted to prevent injury to the probe by the patient's teeth
6. The probe is lubricated generously with jelly
7. The probe is inserted by displacing the mandible anteriorly and advancing the probe gently in the midline; manipulation of the neck by flexion of the neck will help in some cases; if blind insertion of the probe is not easy, a laryngoscope may be used to expose the posterior pharynx and permit direct passage of the probe into the esophagus; undue force should never be applied at any stage during insertion of the probe;[4] once in the esophagus, the transducer should never be forced through a resistance
8. The tip of the transducer is allowed to return to the neutral position before advancing or withdrawing the probe and undue force is never applied when flexing the tip with the control wheels
9. Cleaning and decontamination of the probe should be performed after each use based on hospital practice
10. It is recommended to have an electrocardiogram trace on the echocardiographic imaging screen.

Table 1: Perioperative TEE guidelines

Category-I	Category-II
Conditions for which there is evidence and/or general agreement that a given procedure or treatment is useful and effective	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment
Mitral valve repair	
Aortic valve repair	Myocardial ischemia and coronary artery disease (off-pump CABG inclusive)
Acute aortic dissection	Heart valve replacement
Acute unstable aortic aneurysm	Intracardiac mass/foreign body
Thoracic aortic trauma	Pulmonary embolism
Before balloon mitral valvuloplasty[3]	Aortic atherosclerotic disease
LA thrombus	Air embolism
Endocarditis/vegetation	Interventional procedure in cardiology
Complex congenital heart disease	Cardiomyopathy
Hemodynamic instability	Pericarditis
Minimally invasive cardiac surgery	Placement of IABP, PA catheter
LVAD insertion	Administration of cardioplegia especially retrograde
Critical care: Persistent hypotension, unexplained hypoxemia	Orthopedic surgery

LVAD: Left ventricular assist device, CABG: Coronary artery bypass graft, LA: Left atrium, IABP: Intra-aortic balloon pump, PA: Pulmonary artery

Complications associated with TEE (rare)[5]

1. Esophageal ulceration/injury/bleeding
2. Esophageal perforation
3. Esophageal hematoma
4. Laryngeal palsy
5. Dysphagia
6. Dental injury
7. Accidental tracheal extubation
8. Cardiac arrhythmia (especially supraventricular tachycardia in children)
9. Airway obstruction and increased ventilatory pressure
10. Hypoxia/unintentional endobronchial intubation
11. Distraction from anesthetic care
12. Death.

Contraindications to TEE:[6]

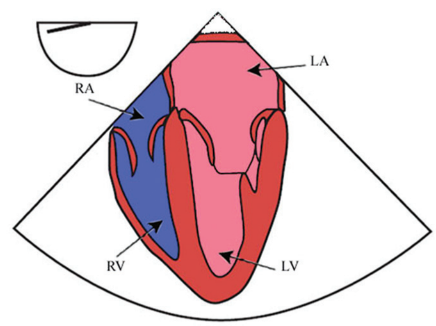
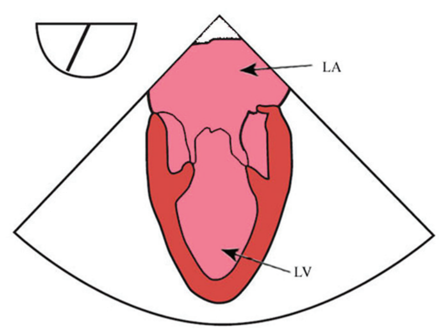
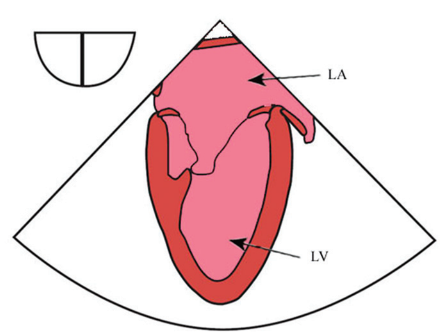
Absolute	Relative
Refusal of patient consent	Esophageal stricture
Previous esophagectomy	Esophageal diverticulum
Previous esophagogastrectomy	Tracheoesophageal fistula
Previous bariatric surgery	Hiatus hernia
Suspected/actual neck injury	Large descending thoracic aortic aneurysm
	Unilateral vocal cord paralysis
	Esophageal varices
	Post-radiation therapy

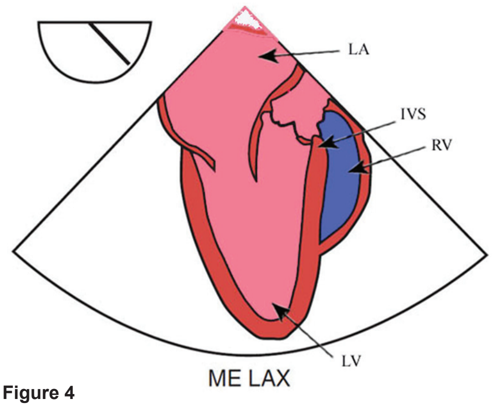
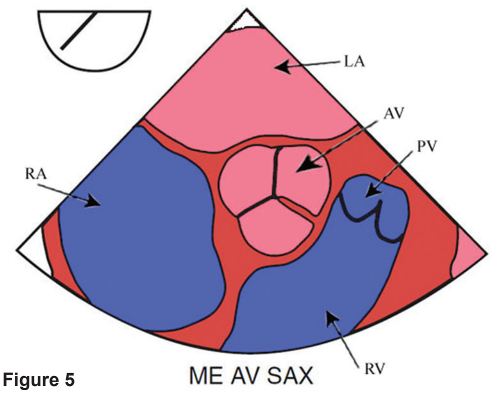
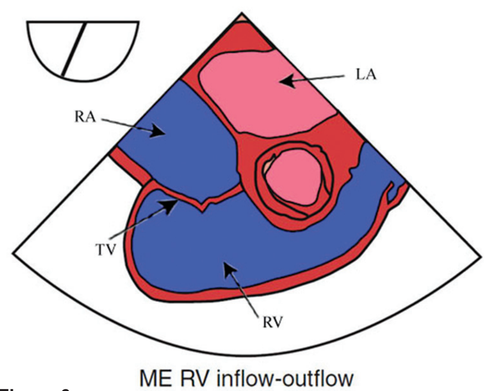
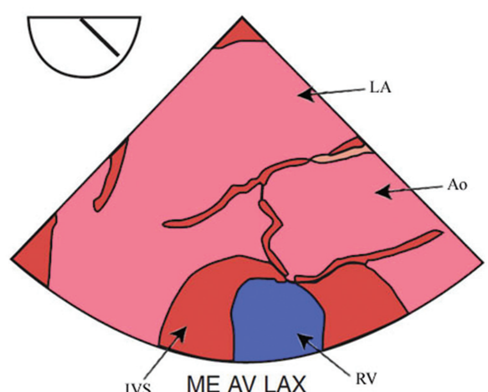
TERMINOLOGY FOR MANIPULATION OF PROBE

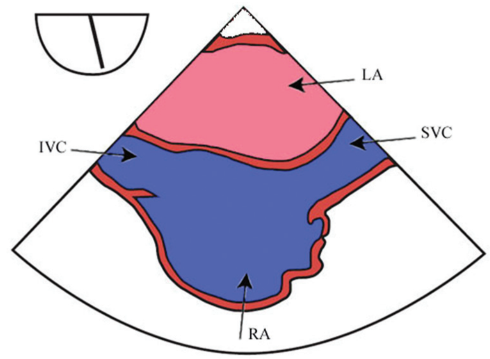
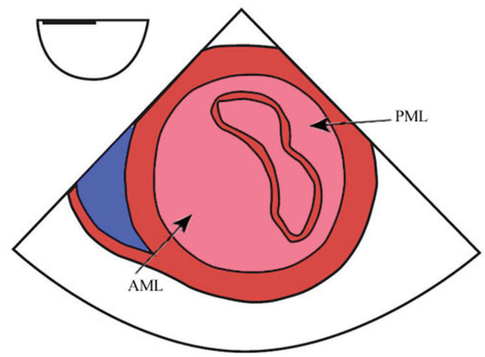
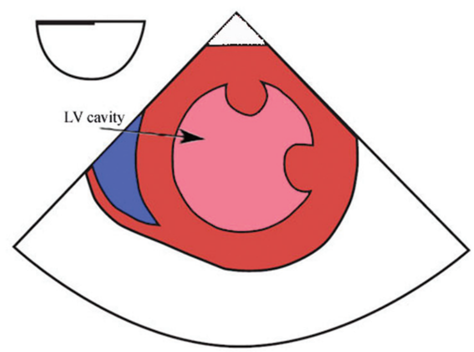
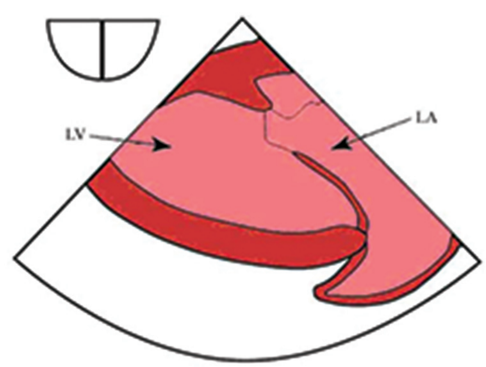
The terminology used to describe manipulation of the probe and transducer during image acquisition is described here.[7] With the patient supine, the imaging plane is directed anteriorly from the esophagus through the heart. With reference to the heart, superior means toward the head, inferior means toward the feet, posterior means toward the spine and anterior means toward the sternum. The terms right and left denote the patient's right and left sides, except when the text refers to the image display.

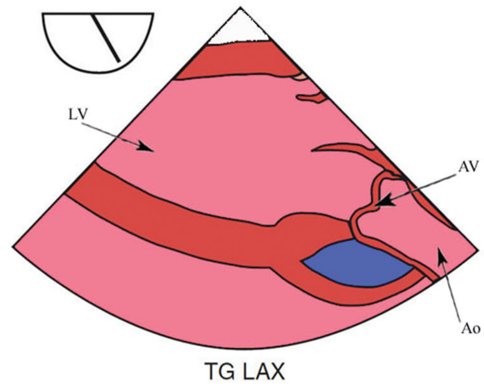
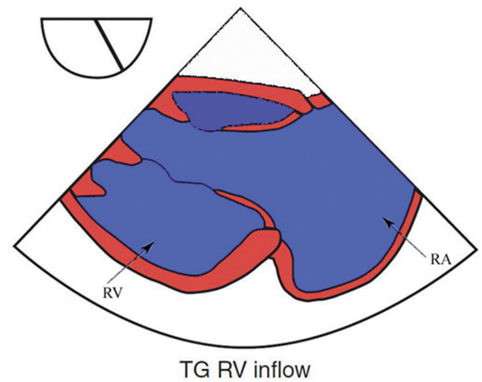
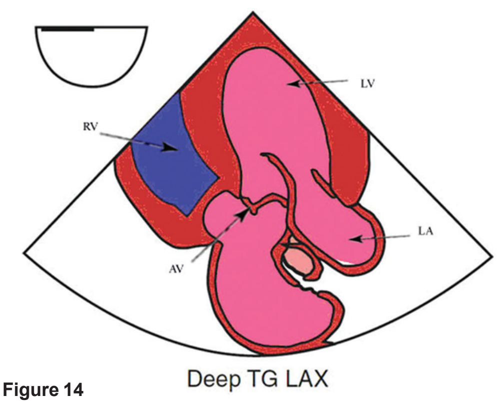
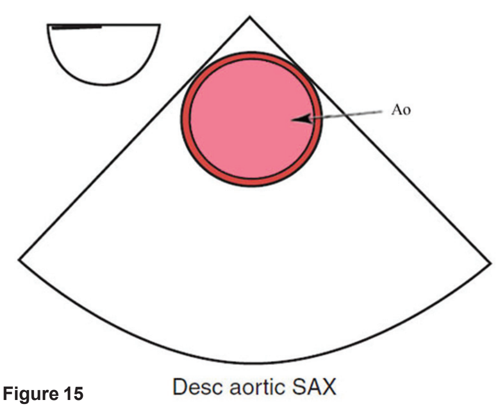
"Advancing:" pushing the tip of the probe distally into the esophagus or the stomach; "withdrawing:" pulling the tip in the opposite direction proximally; "turning to the right;" rotating the anterior aspect of the probe clockwise within the esophagus toward the patient's right; "turning to the left:" rotating the probe counterclockwise. Flexing the tip of the probe anteriorly with the large control wheel is called "anteflexing" and flexing it posteriorly is called "retroflexing." Flexing the tip of the probe to the patient's right with the small control wheel is called "flexing to the right," and flexing it to the patient's left is called "flexing to the left." Finally, axial rotation of the

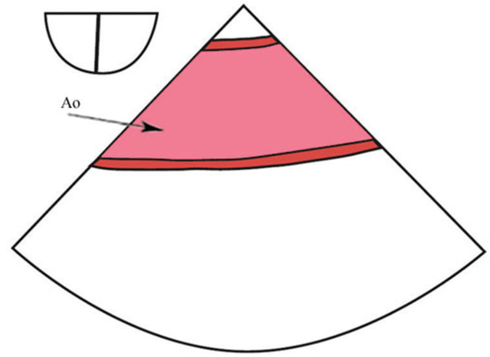
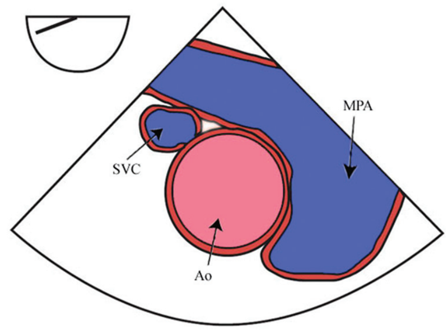
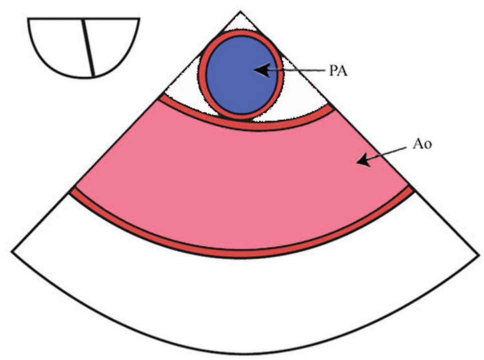
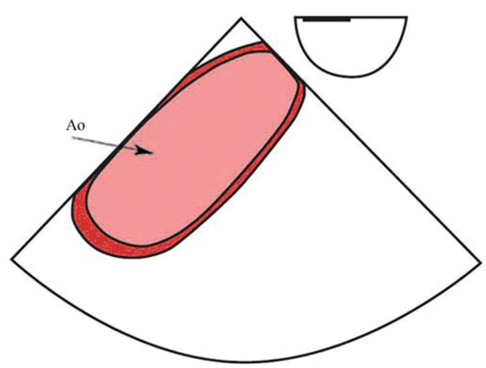
TWENTY STANDARD VIEWS + ADDITIONAL VIEWS [FIGURES 1-26]

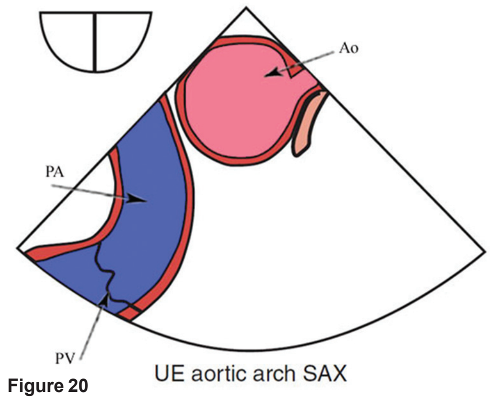
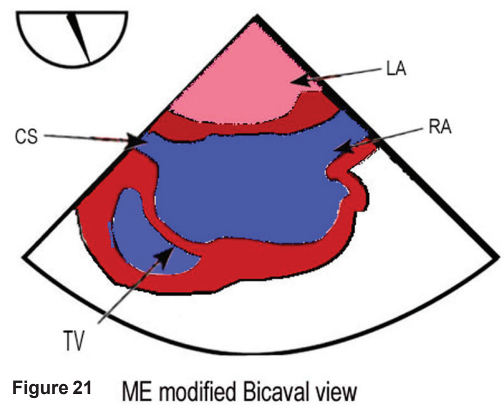
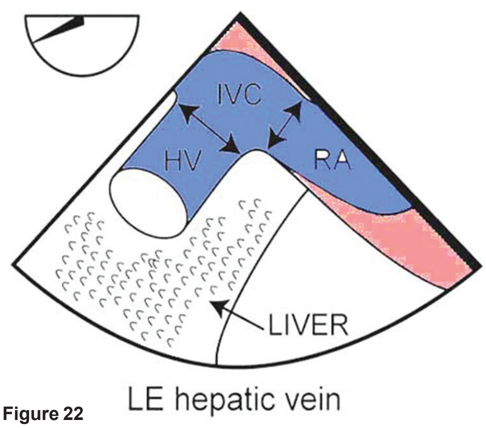
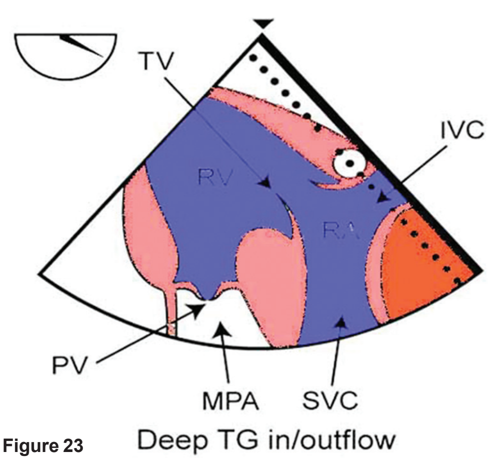
ME four-chamber view Image settings: • Angle: ~ 0-10° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral – retroflexed. Required structures: • Left atrium (LA) • LV • Right atrium • Right ventricle (RV) • Mitral valve • TV	Primary diagnostic uses: • Chamber enlargement/dysfunction • Left ventricular (LV) regional wall motion (inferoseptal and anterolateral walls) • Mitral valve disease • Tricuspid valve (TV) disease • Detection of intracardiac air/mass including thrombus and atrial septal defect.	 ME four chamber **Figure 1**
ME mitral commissural view Required structures: • LA • LV • Mitral valve • Papillary muscles. Image settings: • Angle: ~60-75° • Sector depth: ~12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • LV regional wall motion • Mitral valve disease.	 ME mitral commissural **Figure 2**
ME two-chamber view Required structures: • Left atrial appendage • Mitral valve • LV apex (maximum LV length). Image settings: • Angle: ~80-100° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Left atrial appendage mass or thrombus • LV apex pathology • LV systolic dysfunction • LV regional wall motion (anterior and inferior walls).	 ME two chamber **Figure 3**

ME LV long axis (LAX) view Required structures: • LA • Mitral valve • LV • LV outflow tract • Aortic valve (AV) and proximal ascending (ASC) aorta. Image settings: • Angle: ~110-130° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Mitral valve pathology • LV outflow tract pathology • LV ventricular wall motion (anteroseptal and inferolateral walls) • Systolic anterior motion of anterior mitral leaflet.	 **Figure 4**
ME AV short-axis (SAX) view Required structures: • AV leaflets • Commissures • Coaptation point. Image settings: • Angle: ~25-45° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • AV morphology • Aortic stenosis/regurgitation • Coronary arteries • Air in the roof of LA.	 **Figure 5**
ME RV inflow-outflow Required structures: • PV • TV • Main PA (atleast 1cm distal to the PV) • RV wall from TV to PV. Image settings: • Angle: ~50-70° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Pulmonic valve (PV) disease • Pulmonary artery (PA) pathology • Right ventricular outflow tract (RVOT) pathology (e.g., subvalvular stenosis).	 **Figure 6**
ME AV LAX view Required structures: • LVOT (at least 1 cm proximal to the AV) • AV (visualized cusps approximately equal in size) • ASC aorta (at least 1 cm distal to the sinotubular junction). Image settings: • Angle: ~115-130° • Sector depth: ~8-10 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • AV pathology • Aortic pathology (ASC and root) • Left ventricular outflow tract (LVOT) pathology.	 **Figure 7**

ME bicaval view Required structures: ● Right atrial free wall and appendage ● Superior vena cava ● Interatrial septum ● Inferior vena cava (IVC) ● LA. Image settings: ● Angle: ~100-110° ● Sector depth: ~8-10 cm. Probe adjustments: Probe rotated toward right.	Primary diagnostic uses: ● Atrial septal defect ● patent foramen ovale ● Right atrial tumor.	 **Figure 8** ME bicaval
TG basal SAX view Required structures: ● Mitral leaflets ● LV (basal segments). Image settings: ● Angle: ~0° ● Sector depth: ~12 cm. Probe adjustments: ● Neutral and anteflexed.	Primary diagnostic uses: ● LV systolic dysfunction (basal segments) ● Mitral valve pathology	 **Figure 9** TG basal SAX
TG midpapillary SAX view Required structures: ● LV cavity ● LV walls (at least 50% of the circumference with visible endocardium) ● Papillary muscles (approximately equal in size and distinct from ventricular wall). Image settings: ● Angle: ~0° ● Sector depth: ~12 cm. Probe adjustments: ● Anteflexed.	Primary diagnostic uses: ● Hemodynamic instability ● LV enlargement ● LV hypertrophy ● LV preload, volume status of the patient ● LV systolic dysfunction ● LV regional wall motion (mid-segments).	 **Figure 10** TG mid SAX
TG two-chamber view Required structures: ● Mitral leaflets ● Mitral subvalvular apparatus ● LV (anterior and inferior walls: Basal and mid segment). Image settings: ● Angle: ~90° ● Sector depth: ~12 cm. Probe adjustments: ● Neutral.	Primary diagnostic uses: ● LV systolic dysfunction (anterior and inferior walls). ● Mitral subvalvular pathology	 **Figure 11** TG two chamber

TG LAX view Required structures: ● Mitral leaflets ● Mitral subvalvular apparatus ● LV (anteroseptal and inferolateral wall) ● LV outflow tract ● AV and proximal ASC aorta. Image settings: ● Angle: ~110-130 cm. ● Sector depth: ~12 cm. Probe adjustments: ● Neutral to leftward.	Primary diagnostic uses: ● LV systolic dysfunction (anteroseptal and inferolateral walls) ● Doppler interrogation of AV.	 **Figure 12**
TG RV inflow view Required structures: ● Right atrium ● TV ● Tricuspid subvalvular apparatus ● RV. Image settings: ● Angle: ~110-130° ● Sector depth: ~12 cm. Probe adjustments: ● Neutral-rightward.	Primary diagnostic uses: ● RV systolic dysfunction ● TV pathology.	 **Figure 13**
Deep TG LAX view Required structures: ● LV ● AV ● ASC aorta. Image settings: ● Angle: ~0° ● Sector depth: ~16 cm. Probe adjustments: ● Anteflexed.	Primary diagnostic uses: ● AV pathology ● LVOT pathology ● Doppler interrogation of aortic outflow.	 **Figure 14**
Descending (DESC) aorta SAX view Required structures: ● DESC aorta in cross-section in the transverse plane (0°). Image settings: ● Angle: ~0° ● Sector depth: ~6 cm. Probe adjustments: ● Probe turned toward left until DESC aorta is seen in SAX.	Primary diagnostic uses: ● Aortic atherosclerosis ● Aortic dissection.	 **Figure 15**

DESC aorta LAX view Required structures: • DESC aorta in LAX in the longitudinal plane (90°). Image settings: • Angle: ~90° • Sector depth: ~6 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection • Intra-aortic balloon pump placement.	 **Figure 16** Desc aortic LAX
ME ASC aortic SAX view Required structures: • Aorta in cross-section in the transverse plane • PA (main and proximal right). Image settings: • Angle: ~10-30° • Sector depth: ~12 cm. Probe adjustments: • Withdraw probe slowly by 1-2 cm from the AV SAX view.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection/aneurysm • PA pathology (emboli, dilatation, etc.).	 ME asc aortic SAX **Figure 17:** Nomenclature of 17 segments of left ventricle for transesophageal echocardiography (modified from Corqueria *et al*. Circulation 2002; 105:539-42)
ME ASC aortic LAX view Required structures: • ASC aorta in LAX • Right PA in cross-section. Image settings: • Angle: ~100° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection • ASC aortic aneurysm.	 **Figure 18** ME asc aortic LAX
UE aortic arch LAX view Required structures: • Distal ASC aorta/aortic arch. Image settings: • Angle: ~0° • Sector depth: ~10 cm. Probe adjustments: • Withdraw probe slowly from the DESC aorta SAX view until aorta becomes oblong, slight manipulation of the transducer toward the right and lowering the probe handle help.	Primary diagnostic uses: • Aortic athrerosclerosis • Aortic dissection • Aortic regurgitation • Measurement of distal ASC aortic diameter • Visualization of aortic cannulation site.	 **Figure 19** UE aortic arch LAX

UE aortic SAX view (Looking down view) Required structures: ● Aortic arch in cross-section ● Main PA. Image settings: ● Angle: ~90° ● Sector depth: ~10 cm. Probe adjustments: ● Neutral.	Primary diagnostic uses: ● Aortic atherosclerosis ● Aortic dissection ● Diagnosis of patent ductus arteriosus ● Measurement of gradient across the pulmonary valve.	 **Figure 20**
ADDITIONAL VIEWS ME modified bicaval view Primary diagnostic uses: ● TV pathology ● Doppler interrogation of TV. Image settings: ● Angle: ~110° ● Sector depth: ~8-10 cm. Probe adjustments: ● Probe rotated toward right as in bicaval view.	Required structures: ● Right atrium ● LA ● Interatrial septum ● Coronary sinus ● TV.	 **Figure 21**
Lower esophageal (LE) hepatic view Primary diagnostic uses: ● Inferior venacava collapsibility and diameter ● Hepatic venous flow velocity. Image settings: ● Angle: ~20° Probe adjustments: ● Rightward.	Required structures: ● Right atrium ● Hepatic vein ● IVC.	 **Figure 22**
Deep TG RV LAX Primary diagnostic uses: ● Doppler assessment across RVOT ● RVOT. Image settings: ● Angle: ~110-130° ● Sector depth: ~16 cm. Probe adjustments: ● Rightward.	Required structures: ● RV ● Pulmonary valve ● PA.	 **Figure 23**

<table>
<tr><td>Deep TG RV inflow-outflow view
Primary diagnostic uses:
● Doppler assessment of PA flow.

Image settings:
● Angle: ~120-140°
● Sector depth: ~16 cm.

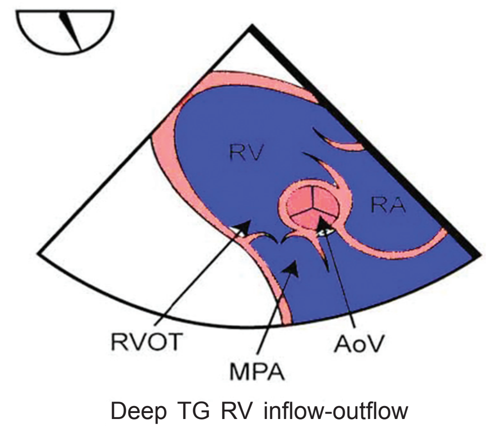
Probe adjustments:
● Rightward.</td><td>Required structures:
● RV
● Pulmonary valve
● PA.</td><td>Figure 24</td></tr>
<tr><td>ME 5-Chamber view
Primary diagnostic uses:
● LVOT
● Aortic regurgitation/stenosis by color flow Doppler.

Image settings:
● Angle: ~0-10°
● Sector depth: ~12-14 cm.

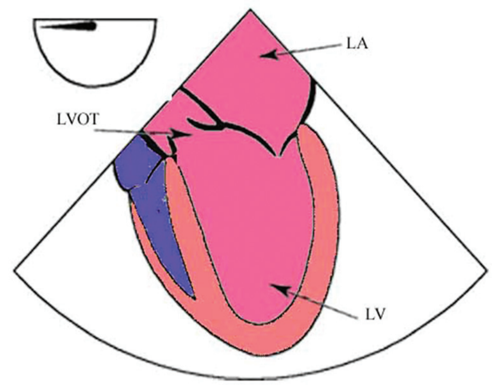
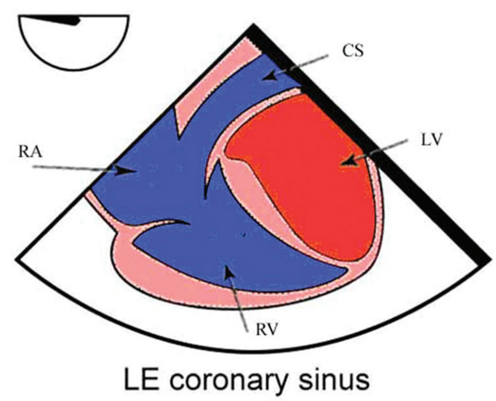
Probe adjustments:
● Neutral – retroflexed.</td><td>Required structures:
● LA
● LV outflow tract
● LV
● Right atrium
● RV
● Mitral valve
● TV.</td><td>Figure 25</td></tr>
<tr><td>Lower esophageal coronary sinus view
Primary diagnostic uses:
● Placement of retrograde cardioplegia cannula.

Image settings:
● Angle: ~0-10°
● Sector depth: ~12-14 cm.

Probe adjustments:
● Retroflexed.</td><td>Required structures:
● Coronary sinus in LAX.
● TV (septal and posterior leaflets)</td><td>Figure 26</td></tr>
</table>

multiplane angle from 0° toward 180° is called "rotating forward," and rotating in the opposite direction toward 0° is called "rotating back."

The images displayed at the top of the screen are in the near field and structures in the far field are at the bottom of the screen. At a multiplane angle of 0° (the horizontal or transverse plane), with the imaging plane directed anteriorly from the esophagus through the heart, the patient's right side appears in the left of the image display and vice versa. Rotating the multiplane angle forward from 0° to 90° moves the left side of the display inferiorly (caudad) and right side of the display superiorly (cephalad). Rotating the multiplane angle to 180° places the patient's right side to the right of the display, will be a mirror image of 0°. Approximately distance of the probe tip from lips is 20-25 cm for upper esophageal (UE) views, 30-40 cm for midesophageal (ME) views and 40-45 cm for transgastric (TG) view in an average sized adult male; however, placement of the transducer into desired location is primarily accomplished by waiting the image to develop as the probe is manipulated rather than depth markers on the probe.

THE 17-SEGMENT MODEL FOR REGIONAL LV ASSESSMENT AND CORONARY ARTERIAL DISTRIBUTION

From base to the apex, the LV is divided into basal, mid and apical thirds corresponding to the proximal, middle and apical segments of the coronary arteries. The scheme divides the ventricle into 17 segments [Figure 27], six segments both in the basal and mid portions (anteroseptal, inferoseptal, anterior, anterolateral, inferolateral and inferior walls) and five at the apex (septal, anterior, lateral, inferior and apical).[8] As these segments can be recorded from three SAX and several longitudinal views, it is possible (and useful) to evaluate a segment from more than one view [Figure 27].

The ME four-chamber view (transducer at 0°, posterior to the LA) allows simultaneous imaging of the LV and RV. It is advisable to retroflex the probe to avoid foreshortening of the left and RV cavities. In this view, the segmental function of the infero septal, antero-lateral walls and apex can be assessed. With the transducer at 90°, the ME two-chamber view allows visualization of the inferior and anterior walls and adjacent portions of the apex. Further transducer rotation up to 120-150° will result in a LAX view and visualization of the anterior septum and inferolateral wall on the right and left respectively. Using the trans-gastric approach, a series of SAX views can be obtained at 0-20° by modifying probe depth and anteflexion. For example, maximal anteflexion will generally allow visualization of the basal ventricular segments and the mitral valve. A lesser degree of ante-flexion or slight probe advancement will result in SAX views at the high and low papillary muscle levels. In these SAX views, the inferior wall is seen at the top of the screen, the anterior wall at the bottom, the inferolateral and anterolateral walls to the right and the anterior and inferior septal walls to the lower left and upper left of the screen. Further probe advancement will often result in a SAX view of the LV apical segments. Because ventricular segments perfused by each of the three major coronary arteries are represented in the SAX view at the mid-papillary muscle level, it is commonly used intraoperatively to evaluate global and segmental function.[9] Transducer rotation to 90° yields a two-chamber view, with the inferior and anterior walls at the top and bottom of the screen, respectively. Further rotation to 120-150° will result in a LAX view, with the inferolateral wall on top and the anterior septum at the bottom of the screen [Figure 28].

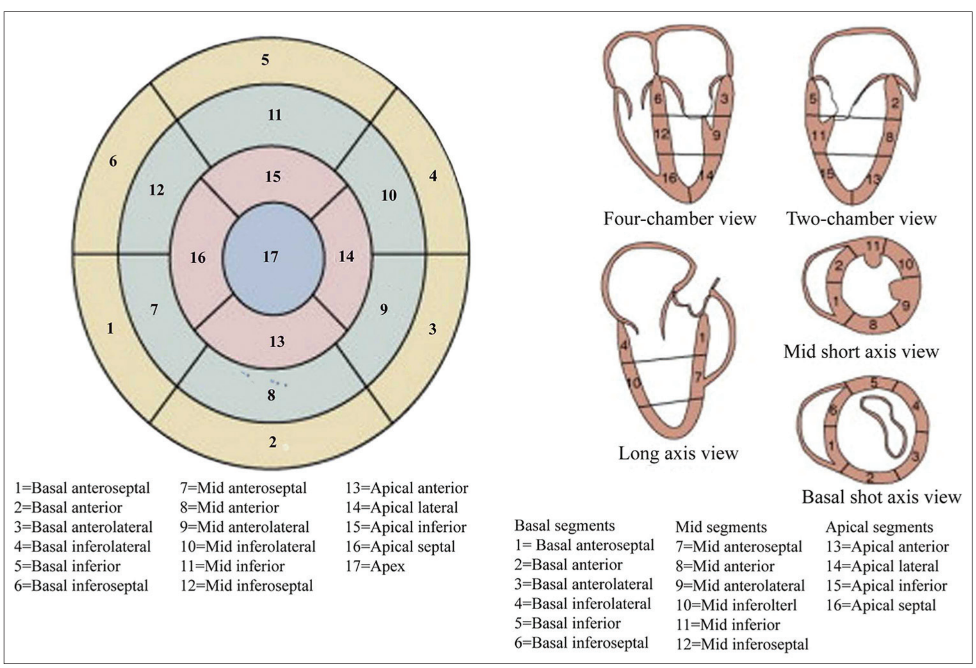


Figure 27: Nomenclature of 17 segments of the left ventricle for transesophageal echocardiography (modified from Corqueria *et al*. Circulation 2002; 105:539-42)

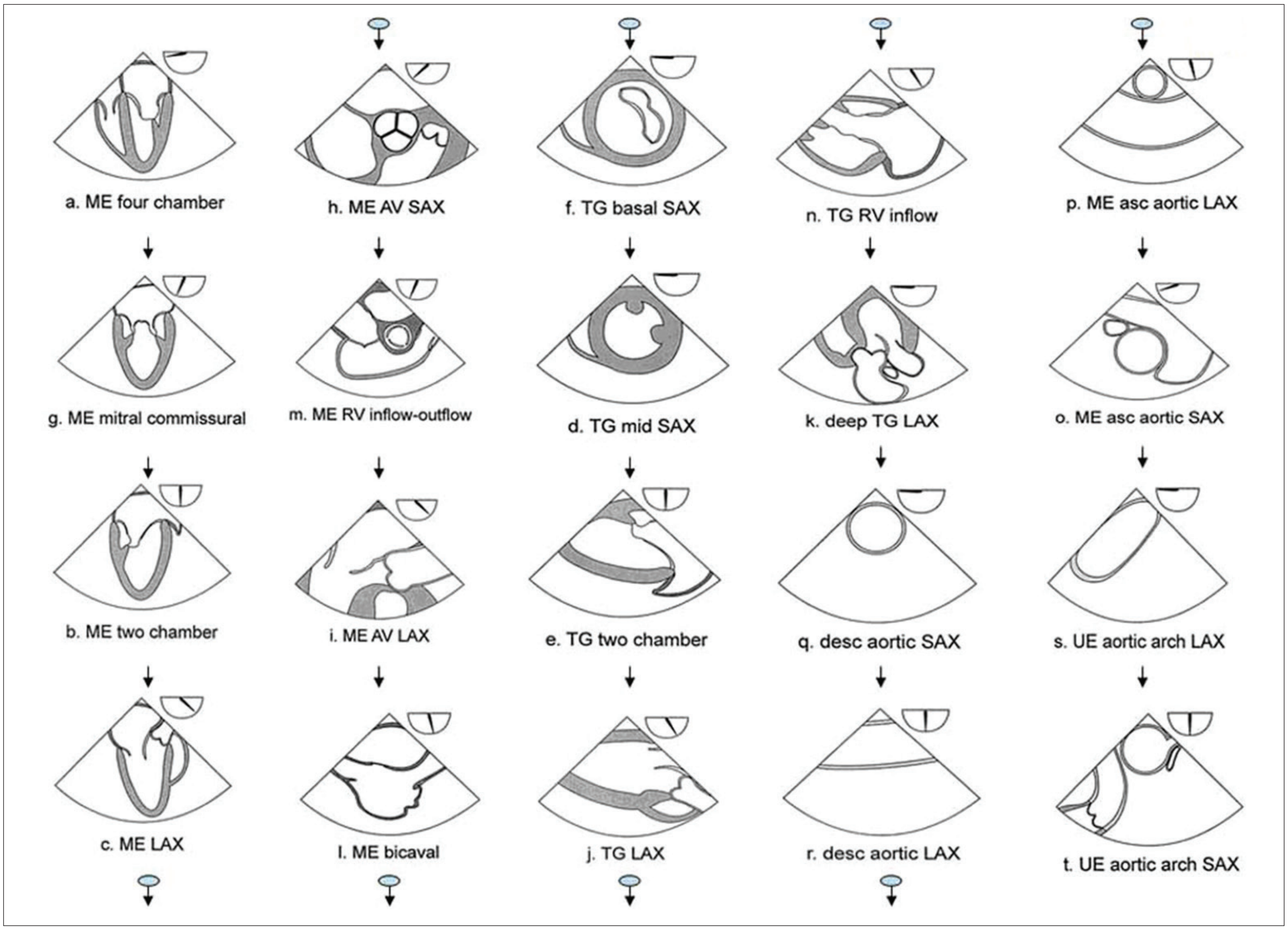


Figure 28: Recommended sequence of transesophageal echocardiography (TEE) examination. Cross-sectional views of the recommended comprehensive TEE examination: Approximate multiplane angle is indicated by the icon adjacent to each view. ME = Mid esophageal, LAX = Long axis, TG = Transgastric, SAX = Short-axis, AV = Aortic valve, RV = Right ventricle, ASC = Ascending, DESC = Descending, UE = Upper esophagea

ACKNOWLEDGMENTS

The authors are deeply indebted to Dr. Navin C Nanda and Dr. PK Neema for making valuable suggestions in writing of this manuscript.

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Cite this article as: Muralidhar K, Tempe D, Chakravarthy M, Shastry N, Kapoor PM, Tewari P, *et al*. Practice guidelines for perioperative transesophageal echocardiography: Recommendations of the Indian association of cardiovascular thoracic anesthesiologists. Ann Card Anaesth 2013;16:268-78.

Source of Support: Nil, **Conflict of Interest:** None declared.

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