Transesophageal Echocardiography

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Transesophageal echocardiography (TEE) is an ultrasound technique used to visualize the heart. A multicrystal phased-array or single crystal mechanical ultrasonic transducer is incorporated into a flexible gastroscope-like device. This arrangement allows the imaging transducer to be advanced into the esophagus where it is positioned directly posterior to the heart.

Transthoracic two-dimensional echocardiography or sector scanning is the standard method of imaging the heart in which the transducer is placed directly on the chest. In TEE the same method is used to image the heart, but these images come from behind the heart, thereby circumventing image degradation by interposed ribs, lung, and subcutaneous tissue.

Different cross-sectional orientations of the heart can be obtained by advancement, rotation, and angulation of the TEE transducer (Figures 1 and 2). Four-chamber views (through the left atrium), various short-axis views of the cardiac base (also through the left atrium), and short-axis views of the left ventricle are commonly used. The four-chamber view allows both ventricles and atria and their respective atrioventricular valves to be imaged. The short-axis basal views allow imaging of the aortic valve and surrounding structures. The short-axis left ventricular views are the most useful for assessing left ventricular function in that they allow long-term monitoring at the papillary muscle level of the left ventricle. At these levels all major coronary artery beds are usually represented, and major changes in regional wall motion, global function, and left ventricular filling volume can generally be detected. Short- and long-axis views of the ascending, transverse, and descending thoracic aorta are also frequently employed to assess aortic disease such as dissection and aneurysm.

It is recommended that practitioners employ a uniform view orientation. To this end the four-chamber view should appear with apex down (sector apex up) and the left ventricle to the viewer's right (Figures 1 and 2). All other views are to be displayed as they arise from the transducer element or crystal orientation and firing sequence required to generate this four-chamber view. To encourage image orientation uniformity, we recommend that instruments default to this beam orientation when first powered.

TEE can be performed in the conscious or anesthetized patient. In awake subjects the following procedure is used for insertion. The room should be equipped with a positive pressure oxygen delivery system (bag and mask), suction, crash cart, and blood pressure cuff. After securing peripheral venous access, the oropharynx is anesthetized with topical agents such as viscous lidocaine (Xylocaine and/or Cetacaine spray) so that the gag reflex is suppressed. Just before insertion of the probe, the patient is placed in the left decubitus position with the head flexed slightly forward. With the controls of the TEE transducer in the unlocked position, the transducer is inserted to the level of the cricopharyngeal cartilage. With gentle pressure the patient is asked to swallow, helping to advance the transducer tip into position behind the heart. In the awake patient the probe should pass with minimal discomfort.

In the anesthetized patient the unlocked transducer is advanced into the esophagus after the placement of the endotracheal tube. A laryngoscope may be used to facilitate insertion. Once in the esophagus, advancing the transducer requires minimal force. If any unusual resistance is encountered, the procedure should be abandoned. As the transducer is advanced,

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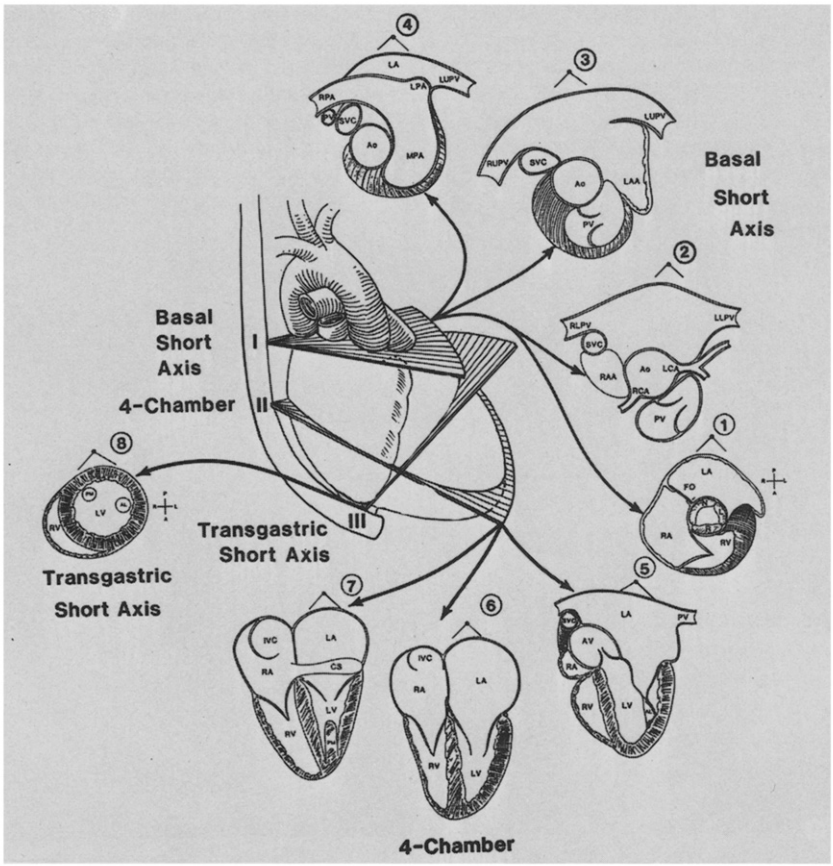

Figure 1 Diagram of common scan planes: basal short-axis *(I)*, four-chamber (frontal long-axis) *(II)*, and transgastric short-axis *(III)*; resultant tomographic planes of section (1 through 8). Basal short-axis sections: aortic root *(1)*, coronary arteries *(2)*, left atrial appendage *(3)*, and pulmonary artery bifurcation *(4)*. Four-chamber sections: left ventricular outflow view *(5)*, four-chamber view *(6)*, and coronary sinus view *(7)*. Transgastric short-axis section; ventricular short-axis view *(8)*. *AL*, Anterolateral papillary muscle; *Ao*, aorta; *AV*, aortic valve; *CS*, coronary sinus; *FO*, fossa ovalis; *IVC*, inferior vena cava; *L*, left coronary cusp; *LA*, left atrium; *LAA*, left atrial appendage; *LCA*, left coronary artery; *LLPV*, left lower pulmonary vein; *LPA*, left pulmonary artery; *LUPV*, left upper pulmonary vein; *LV*, left ventricle; *MPA*, main pulmonary artery; *N*, noncoronary cusp; *PM*, posteromedial papillary muscles; *PV*, pulmonary valve or pulmonary vein; *R*, right coronary cusp; *RA*, right atrium; *RAA*, right atrial appendage; *RCA*, right coronary artery; *RLPV*, right lower pulmonary vein; *RPA*, right pulmonary artery; *RUPV*, right upper pulmonary vein; *RV*, right ventricle; *SVC*, superior vena cava. Directional axes: *A*, anterior; *L*, left; *P*, posterior; *R*, right. (From Seward JB, Khandheria BK, Oh JK, et al. Transesophageal Echocardiography: technique, anatomic correlations, implementation, and clinical applications. Mayo Clin Proc 1988;63:649-80.)

the echocardiographic image on the video monitor is used to judge the transducer's position. In general, long-axis four-chamber and basal views are obtained at about 30 to 35 cm and short axis-views of the left ventricle at about 40 to 45 cm. At this level images are often obtained distal to the gastroesophageal junction from the gastric fundus.

In awake patients the use of intravenous sedation is widely employed but considered optional by many laboratories. These agents contribute slightly to the risk of the procedure. Short-acting agents such as midazolam are generally used.

In awake or sedated patients the more common indications for TEE are (1) technically inadequate transthoracic image, (2) evaluation of mitral and aortic prosthesis, (3) evaluation of native valves for disruption and/or vegetation, (4) identification and assessment of masses and tumors. In most cases TEE should not be done before completing a comprehensive transthoracic echocardiographic examination.

In the operating room this device can be used as

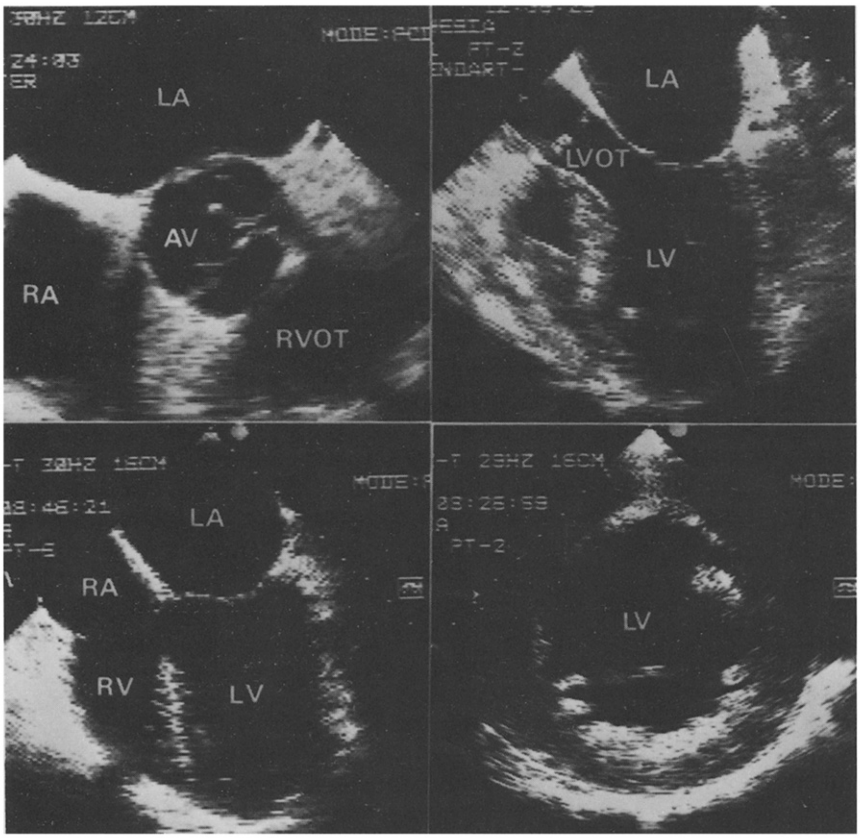

Figure 2 Transesophageal images from 5 MHz 64-element phased-array system. *Upper left*, Short-axis view through base showing three cusps of aortic valve *(AV)* in partly opening systolic position. *Upper right*, Long-axis view of left ventricle *(LV)* and left ventricular outflow tract *(LVOT)*. *Lower left*, Four-chamber view images of left and right atria *(LA, RA)* separated by interatrial septum and left and right ventricles *(LV, RV)* separated by interventricular septum. Orientation of this four-chamber view defines orientation of other views. *Lower right*, Short-axis view of left ventricle at papillary muscle tips. Right ventricle is just out of the sector to the viewer's left. Inferior wall is at top of image, septum to the left, free anterior wall at bottom and posteroinferior wall to the right.

an on-line monitor. In this capacity it is particularly valuable in patients at high risk for cardiovascular complications. In particular, patients undergoing coronary artery bypass grafting and those undergoing major abdominal, peripheral, and carotid vascular reconstructive procedures when there is a high risk for intraoperative ischemia as a result of the high prevalence of coronary heart disease in these groups. During operation TEE supplements or independently provides information typically obtained from the flow-directed wedge catheter for detecting changes in left ventricular filling, is more sensitive than the electrocardiogram for detecting ischemia, and is the most sensitive method for assessing the contractility of the left ventricle. Additionally, TEE can easily detect intravascular air embolism. This application is particularly important when patients are being weaned from extracorporeal circulation or when they are undergoing procedures carrying a high risk of air embolism such as craniotomies performed with the patient in the sitting position. When this is done care must be taken to avoid injury to the recurrent laryngeal nerve because the patient's cervical spine is flexed and the gastroscope can be "wedged" against the posterior aspect of the larynx by the chin. It remains to be determined whether TEE is contraindicated in this patient group.

TEE is becoming a standard method of assessing the success of mitral valve repair procedures and complex congenital heart disease surgery in the

adult. TEE is also valuable in the perioperative period and during the time that critically ill patients are in the intensive care unit. As in the operating room, direct visualization of cardiac performance and filling can provide rapid, accurate assessment of cardiac status.

TEE is relatively contraindicated in patients with esophageal disease such as stricture, varices, schleroderma, esophagitis, and may pose a risk to patients with coagulopathies or a history of prior esophageal surgery.

Complications of TEE have been rare. Occasional patients complain of a sore throat or lip laceration after operation, but these could have been caused by endotracheal intubation. In two cases of TEE performed with the patient in the sitting position with the head flexed, transient vocal cord paralysis was reported. Potential complications of this procedure include esophageal tear or abrasion and esophageal burn from transducer heating. It is recommended that the temperature of the transducer be checked before insertion. It is also recommended that minimal adequate power output of the ultrasonic instrument be used and that the power be turned off when actual imaging is not necessary. With electrocautery, strict electrical isolation of the TEE probe, its ultrasonogram, and the cautery apparatus is mandatory.

Although learning to perform TEE is relatively simple, it is recommended that potential users learn the technique in an experienced institution; a busy gastroenterologic endoscopy service is an asset for learning safe methods of introducing this device and providing institutional guidelines for upper gastrointestinal instrumentation. Mastery of basic echocardiography is essential for the use of transesophageal echocardiography in the comprehensive diagnosis of cardiovascular disease. Finally, TEE has passed its initial clinical trials and can now be considered a routine clinical method.

SUGGESTED READING

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