TRANSESOPHAGEAL ECHOCARDIOGRAPHY:

WHAT IS IT AND WHAT ARE THE INDICATIONS FOR ITS USE

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Transesophageal echocardiography (TEE) is a relatively new technique for ultrasound imaging of the heart and great vessels via a gastroscope modified to house an ultrasound transducer on its tip. Imaging of cardiac and vascular structures is performed from within the esophagus and stomach. TEE probes have Doppler and color-flow imaging capabilities to provide detailed information about cardiac structure and function. A review of the esophageal intubation technique, structures visualized, and indications for TEE in medical practice is presented.

Transesophageal echocardiography (TEE) is a relatively new cardiac ultrasound technique for high resolution imaging and blood-flow analysis of the heart and great vessels. TEE utilizes a small 5 mHz ultrasound transducer mounted within a standard flexible gastroscope. Newer TEE probes make use of two ultrasound transducers, for both transverse and longitudinal imaging of cardiac structures.

Standard thoracic echocardiography many times is limited acoustically by the thorax (lungs, bony structures) and provides images at a relatively far distance from structures of interest. An ultrasound transducer in the esophagus or stomach is fairly close to the heart and great vessels, and therefore high frequency, high resolution probes can be used. Impediments from lungs or bony structures are not a problem.

In order to obtain the required imaging planes, the TEE probe is passed into the esophagus and stomach and is manipulated in a manner similar to that of upper gastrointestinal endoscopy.

PREPARATION FOR EXAMINATION

It has been recommended that the patient be NPO for at least 4 hours before the TEE procedure. The author prefers to keep patients NPO after supper for an AM case, and to have only clear liquids before 7 AM for an afternoon case. After informed consent has been obtained, the patient is made ready with an intravenous line, a finger pulse oximeter, an automatic blood pressure cuff, and oxygen per nasal cannula at two liters per minute. The patient then assumes the left lateral decubitus position. Topical anesthesia of the oropharynx and intravenous midazolam (Versed) and meperidine (Demerol) are given. Only patients with prosthetic heart valves need antibiotic prophylaxis.

After the procedure, which usually lasts 5-15 minutes, the patient is monitored in the endoscopy laboratory for 2 hours. Because of sedation, the patient should not drive until the following day.

TEE ANATOMY

There are three basic planes used for evaluation of the cardiac structures (Figure 1). The basal short axis view provides images of the aortic valve, proximal aorta, atrial septum, right and left atria and their appendages, and the proximal coronary arteries (Figure 2).

The midesophageal four-chamber view is analogous to the transthoracic apical four-chamber view. This provides images of the atria, ventricles, tricuspid and mitral valves, and left ventricular outflow tract (Figure 3). ▶

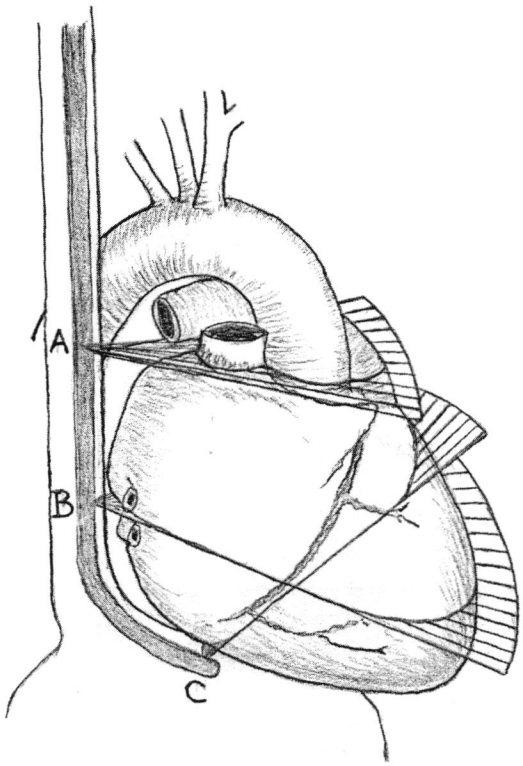

Figure 1. Transesophageal echocardiographic standard imaging planes. (A) Basal short Axis view, (B) Midesophageal view, (C) Transgastric view.

The transgastric view provides a short axis cross-sectional image of the left ventricle (Figure 4).

If the TEE probe is rotated 180 degrees, the descending thoracic aorta may be visualized.[1]

INDICATIONS FOR USE

TEE has been used both outside of the operating room and within the operating room. Outside the operating room, hospitalized patients and outpatients can be studied in the endoscopy laboratory. Critically ill patients are studied in the intensive care setting at the bedside. Within the operating room, TEE is used during both cardiac and noncardiac surgery, for both evaluation of cardiac structures and monitoring of left ventricular function and hemodynamic parameters.

Embolic Events (CVA, Peripheral). TEE has been shown to be superior to thoracic echocardiography as a means of evaluating patients with unexplained

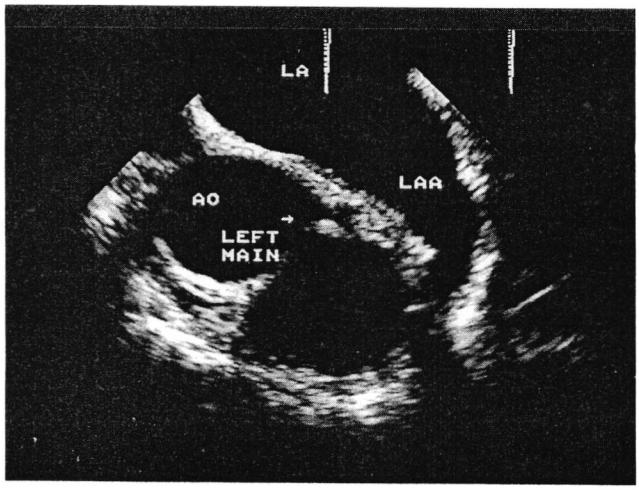

Figure 2. Basal short axis view with left atrium (LA), left atrial appendage (LAA), proximal aorta (AO), left main coronary artery with its bifurcation into left anterior descending and circumflex coronary arteries.

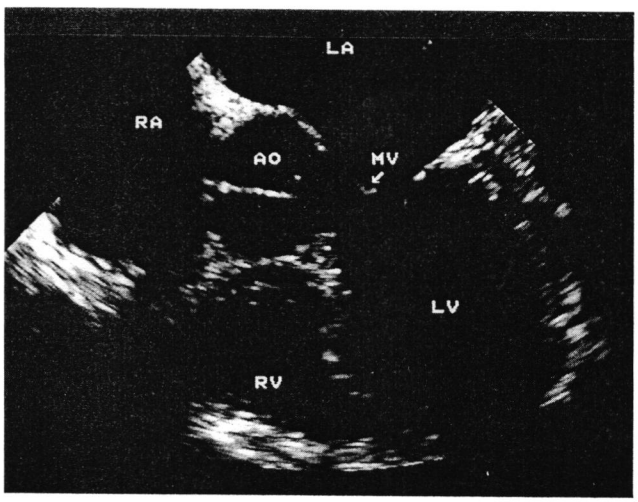

Figure 3. Midesophageal four-chamber view with left atrium (LA), anterior leaflet mitral valve (MV), aortic valve (AO), right atrium (RA), right ventricle (RV), left ventricle (LV).

embolic events. With the use of TEE, several sources of potential emboli have been found when a routine neurologic and cardiac workup is unfruitful.[2]

The left atrial appendage, which only rarely can be seen by thoracic echocardiography, has been found by TEE to be very sensitive for detection of thrombus

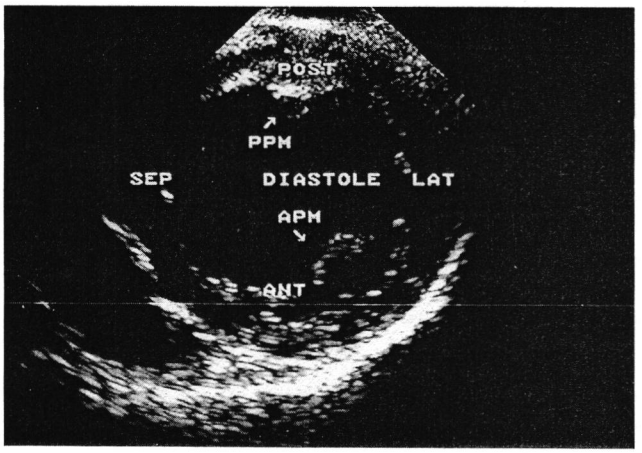

Figure 4. Transgastric view with septum (SEP), anterior wall (ANT), lateral wall (LAT), posterior wall (POST), posteromedial papillary muscle (PPM), and anterolateral papillary muscle (APM).

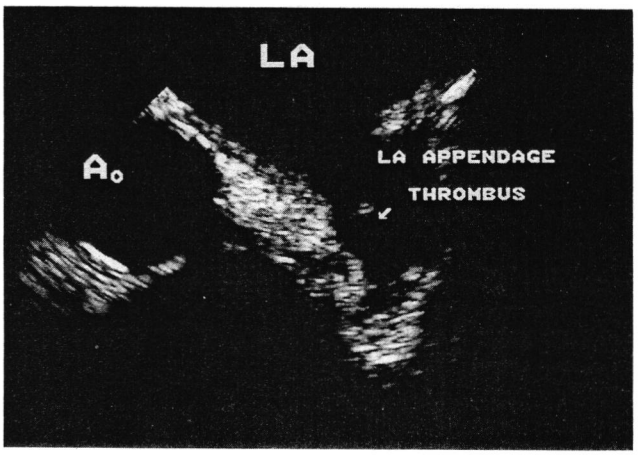

Figure 5. Demonstration of pedunculated thrombus within the left atrial appendage.

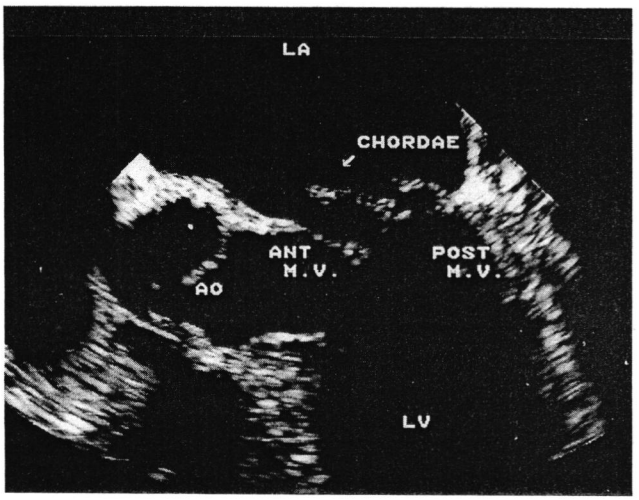

Figure 6. Ruptured chordae of posterior leaflet mitral valve.

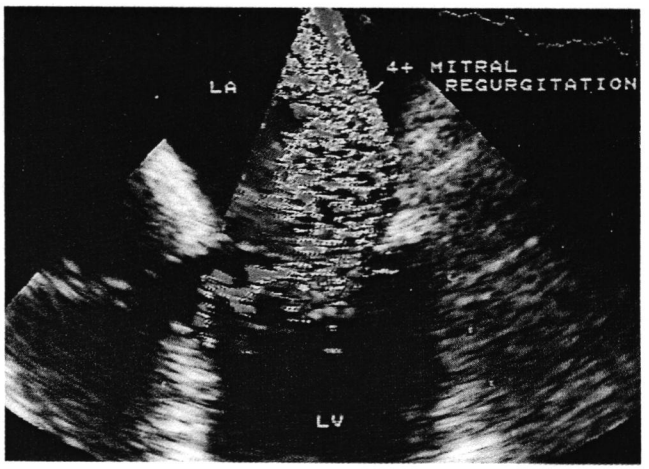

Figure 7. Color flow Doppler of Figure 6 demonstrating 4+ mitral regurgitation.

(Figure 5). A study of 21 patients with mitral stenosis, who had a clot in the left atrial appendage by TEE, were documented to have such at surgery. None of these patients could be diagnosed by thoracic echocardiography as having thrombus.[3]

TEE demonstrates spontaneous echo contrast ("swirling") in the left atrium, usually associated with mitral valve stenosis, prosthetic heart valves, or large fibrillating atria. This swirling is felt to be circulating aggregated erythrocytes. Swirling is essentially never seen in the left atrium by thoracic echocardiography. Several investigators have found a high correlation of ▶

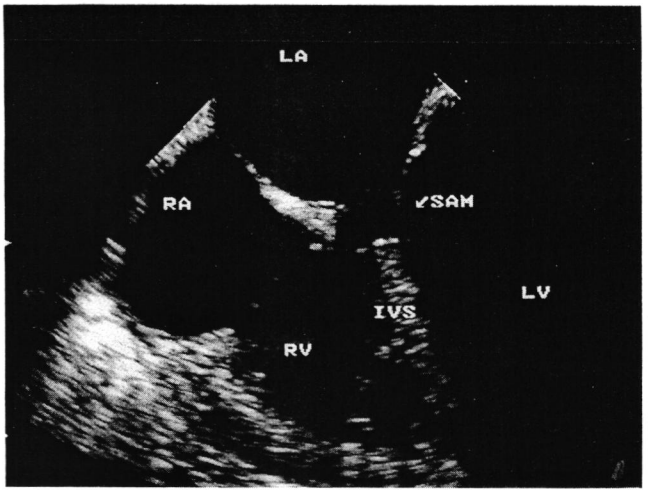

Figure 8. Hypertrophic obstructive cardiomyopathy demonstrating systolic anterior motion (SAM) of the anterior leaflet of the mitral valve.

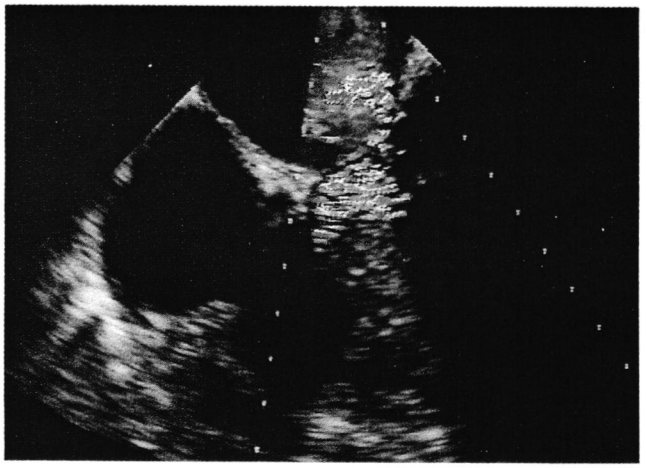

Figure 9. Color flow Doppler of Figure 8 demonstrating flow acceleration in left ventricular outflow tract with coexistent mitral regurgitation.

left atrial swirling with left atrial thrombus or a history of arterial embolism.[4]

Several studies have reported an increased incidence of patent foramen ovale in patients with unexplained ischemic neurologic events. The postulated mechanism is right to left shunting of small venous ▶

thrombi. Most of these studies were performed with thoracic echocardiography.[5] Recent studies have shown an increased sensitivity of TEE over that of thoracic echocardiography for detection of patent foramen ovale.[2, 6, 7]

Atrial septal aneurysm has been associated with unexplained embolic neurologic events. TEE demonstrates this abnormality of the atrial septum better than thoracic echocardiography.[8, 9]

Abnormalities of the ascending thoracic aorta, particularly protruding atheroma, have been associated with unexplained neurologic events. TEE has reliably detected this intraaortic debris.[10]

Endocarditis and Myocardial Abscess. TEE has been shown to be helpful in the diagnosis of vegetations of infective endocarditis when clinically suspected but thoracic echocardiography has been unfruitful. TEE has been very helpful in changing a possible or probable diagnosis to a definite diagnosis. TEE detects vegetations and other complications (valvular regurgitation, abscess formation) more frequently than thoracic echocardiography.[11, 12]

In patients with prosthetic valve endocarditis, diagnosis of endocarditis has been particularly difficult with thoracic echocardiography. TEE has been shown to be very helpful. In a series of autopsy or surgery-proven cases of prosthetic valve endocarditis, Mugge reported a definite vegetation in only 6 of 22 cases using thoracic echocardiography, as compared to 17 of 22 cases diagnosed by TEE.[13]

Native Valve Disorders. Thoracic echocardiography with Doppler and color-flow imaging provides good information about valvular disorders. TEE almost uniformly is superior for anatomical imaging of the valvular structures. Close evaluation of both leaflets of the mitral valve is possible, helping to quantitate and identify the etiology of mitral regurgitation (Figures 6 and 7). TEE has been invaluable when deciding to repair or replace the insufficient mitral valve.[14, 15] Continuous wave Doppler will be introduced on new TEE probes; therefore calculating the valve area of mitral stenosis will be possible. Evaluation of the mitral valvular and subvalvular structures and the left atrium, for feasibility of the balloon valvuloplasty procedure, is excellent using TEE.[16, 17]

Application of TEE for assessment of the tricuspid valve has been mostly to evaluate for endocarditis. However, the tricuspid valve, as with the mitral valve, can be evaluated for the etiology of insufficiency. TEE helps determine if the insufficient tricuspid should be repaired or replaced.[18]

Evaluation of the aortic valve structure is readily accomplished by TEE. Estimation of valve area for stenosis, by planimetry, has been attempted with limited success. Addition of continuous wave Doppler to new probes will help valve area calculation. Evaluation of the aortic root, and also the aortic valve for insufficiency, is excellent.[1] The left ventricular outflow tract is also readily imaged, and evaluation for abnormal anatomical structures or subaortic stenosis can be made (Figures 8 and 9).[19]

Prosthetic Valve Disorders. Assessment of a mitral or tricuspid valve prosthesis for regurgitation by thoracic echocardiography is inherently difficult. The prosthetic device "masks" the ultrasound signal by serving as a strong reflector of ultrasound. Therefore, Doppler evaluation for regurgitation is difficult. Because the TEE probe is located within the esophagus, behind the atria, evaluation for regurgitation is improved. Regurgitation through the valve itself or a periprosthetic leak (through the structure ring) can be readily distinguished. Thrombus or vegetation can also be seen on the atrial side of the prosthetic valve.[20, 21]

Evaluation of a prosthetic aortic valve for insufficiency is difficult by TEE because of masking. However, an aortic annulus abscess and bioprosthetic valve vegetations are diagnosed with improved sensitivity, as compared to thoracic echocardiography.[22]

Pathology of the Aorta. An important application of TEE is in suspected aortic dissection. This situation requires a rapid diagnosis in that dissection of the ascending aorta requires emergency surgery. TEE has been a useful initial procedure for diagnosis of suspected dissection because it can be performed rapidly at the bedside. Evaluation of the proximal ascending aorta, transverse aorta, and descending aorta is made quickly.[23, 24] A multicenter European trial consisted of 164 consecutive patients with suspected aortic dissection. The diagnosis was proven in 82 patients. The sensitivity and specificity for dissection, as diagnosed by TEE, was 99% and 98% respectively.[25]

Congenital Heart Disease. TEE is important in evaluation of pediatric and adult patients with repaired or unrepaired congenital heart disease. With color-flow Doppler or saline contrast injections, shunts are readily diagnosed. TEE offers new information (as compared

to thoracic echocardiography) particularly in the following areas:

1. Systemic and pulmonary venous connections to the heart
2. Atrial abnormalities including diagnosis of type of atrial septal defect (primum, secundum, sinus venosus)
3. Atrial baffles
4. Evaluation of the Fonton procedure
5. Evaluation of tricuspid and mitral valve structure and function
6. Left ventricular outflow tract abnormalities
7. Supraortic stenosis
8. The aorta in Marfan's syndrome
9. Cardiac sidedness and situs[26-29]

*Critical Care.*Thoracic echocardiography has been a very useful tool for evaluation of cardiac structure and function in the critical care situation. Many times transthoracic imaging is inadequate due to poor patient positioning, surgical wounds and bandages, or mechanical ventilation. In this situation, TEE has been invaluable. TEE intubation of the esophagus is performed at the patient's bedside, and can be performed easily in the patient on a mechanical ventilator. The most frequent indication for TEE in this setting is for evaluation of unexplained hemodynamic compromise, in both medical and surgical intensive care units. TEE helps assess left ventricular function, right ventricular function, volume status, valvular function (native and prosthetic), subaortic outflow tract obstruction, cardiac tamponade, "localized" cardiac tamponade, and aortic dissection. TEE has been used to evaluate cardiac structure and function, for possible myocardial contusion, in the evaluation of a possible cardiac transplant donor.[30, 31]

Decompression Sickness. Several authors have reported an incidence of PFO of up to 60% in divers who have suffered Type II decompression sickness (neurologic, vestibular, or pulmonary injury). These have been diagnosed by thoracic echocardiography.[32, 33] A large autopsy series reported an incidence of 27% of PFO in the general population.[34] Others have compared thoracic echocardiography with TEE for detection of PFO in the general population and in patients with unexplained neurologic ischemic events. They found TEE more sensitive for detection of PFO.[2, 6, 7] The author is presently investigating thoracic echocardiography and TEE for diagnosis of PFO in a population of divers with Type II decompression sickness.

Coronary Artery Disease. The left main coronary artery and proximal left anterior descending and circumflex arteries are visualized by TEE in about 90% of patients. The proximal right coronary artery is visualized in only about 25% of patients. Stenosis of these segments of coronary arteries can be readily seen, and color-flow Doppler demonstrates coronary blood flow disturbance associated with significant stenoses. What the clinical utility will be in the future for this application of TEE is questionable.[35, 36]

Intraoperative Setting. TEE is used in the operating room for both noncardiac and cardiac surgical procedures. During noncardiac surgery, TEE is used for intraoperative evaluation of left ventricular filling and function, and also to detect myocardial ischemia. The transgastric cross-sectional view allows for monitoring of left ventricular function continuously. All three major epicardial coronary distributions are monitored with the TEE probe in this position. Should the patient develop ischemia during the operative procedure, this is noted as development of hypokinesis of a segment of the left ventricle. Many times the ECG monitor will not change during these ischemic events, even though myocardial infarction may result.[37, 38, 39]

During cardiac surgery, TEE is used to evaluate left ventricular filling and function, both before going on pump and after coming off pump. A great advantage of TEE is that the probe does not enter the sterile field. Previously, when echocardiography was required, the transducer was placed directly on the surface of the heart. An important application of TEE in this setting is to evaluate the mitral and tricuspid valves before surgery for possible repair. The valve is then assessed post pump for adequacy of the repair procedure.[14, 18, 40, 41] Other applications for intraoperative TEE include congenital heart disease and hypertrophic cardiomyopathy.[26-29]

SUMMARY

TEE is a relatively new ultrasound technique for evaluation of the heart and great vessels. A brief description of the intubation procedure and of the anatomy visualized is presented. Clinical indications for its use both outside and within the operating room are presented.

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