Echo for TEVAR: How Useful is TEE?

Madhav Swaminathan, MD, FASE, FAHA
Associate Professor of Anesthesiology
Director, Perioperative TEE Service
Duke University Medical Center

Background

Endovascular repair of the aorta (EVAR) has steadily gained popularity as a reliable alternative to conventional surgical repair of thoracic aortic aneurysms (TAA). The success of EVAR is critically dependent on demonstration of satisfactory graft deployment by various imaging modalities. Transesophageal echocardiography (TEE) is an ideal imaging tool for the thoracic and upper abdominal aorta and can supplement angiography in guiding placement of the endograft. The principal advantage of TEE is that it enables the anesthesiologist to identify aortic pathology, detect endoleaks and monitor cardiac performance with a single imaging tool. Indications of EVAR are expanding to include complex aortic diseases.

Endovascular repair of abdominal aortic pathology was first reported in 1991. Since then endovascular stents have been used to treat various conditions of the aorta at almost any level. The development of thoracic endografts has been slower than those for the abdominal aorta. Endografts in the thoracic aorta are subject to greater hemodynamic stress and therefore are at increased risk for short and long-term complications. Questions remain about the long-term durability of endovascular repair, and therefore the advisability of using this technology in younger, fit patients remains to be determined. A number of endografts are available in the market for use in the thoracic aorta. However, most have not been approved by the US Food and Drug Administration (FDA), and are limited to investigational use only. There are several studies reporting the use of endografts for thoracic aortic pathology and current evidence favors their use, especially in patients who are at high risk of complications with open repair.

Aortic Anatomy

The aorta shares a close relationship with the esophagus throughout its length in the thorax (figure 1). Echocardiographic views must keep this relationship in perspective at all times. The thoracic aorta can be divided into three anatomic segments, the ascending, arch and descending aorta. In adults, the ascending aorta is approximately five cm in length, and originates at the aortic valve annulus, extends rightward around the main pulmonary trunk, crosses the right pulmonary artery anteriorly, and ascends rightward and anteriorly until it meets the aortic arch at the origin of the innominate artery or level of the second intercostal space. The arch curves in a posterior and leftward direction with a cephalad convexity. The proximal portion of the arch is poorly visualized by TEE due to the anatomical interposition of the air-filled trachea between the esophagus and the aorta at this level. The three major vessels, the innominate, left common carotid and left subclavian arteries arise from the arch. The descending aorta begins just distal to the origin of the left subclavian artery, at the level of the fourth thoracic vertebral body. The descending aorta then

Figure 1: Anatomical relationship between the aorta and esophagus
courses slightly anteriorly and rightwards towards the diaphragm. It is therefore anterior and to the left of the esophagus at the level of the fourth thoracic vertebral body, becoming directly posterior at the level of the diaphragm. Therefore, at the lower esophageal position, the heart and aorta are on opposite sides of the esophagus or the TEE probe.

Branches of the intercostals arteries may be variably seen and blood flow may be imaged using color flow Doppler (CFD). Imaging the aortic branches assumes importance in assessment of branch vessel involvement in aneurysms, occlusion by endografts, or certain types of endoleaks.

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<tr>
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<th>Multiplane angle</th>
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<td>Upper esophageal (20-25 cm)</td>
<td>Aortic arch long axis</td>
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<td>Aortic arch</td>
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<td>Aortic arch short axis</td>
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<td>Mid-esophageal (30-45 cm)</td>
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<td>Descending aorta short axis</td>
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<td>Descending aorta, left pleural space</td>
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<td>Descending aorta long axis</td>
<td>90-110</td>
<td>Descending aorta, left pleural space</td>
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**Imaging Views**

Care must be exercised while inserting a TEE probe in a patient with known aneurysmal dilatation of the thoracic aorta. In cases where resistance to the TEE probe in the esophagus is encountered, it may be prudent to wait until sternotomy before attempting to advance the probe any further. This is especially true in cases where a preoperative history of dysphagia, hoarseness (recurrent nerve palsy) or stridor is present.

Since the thoracic aorta is in close proximity with the esophagus, views are usually obtained at an imaging depth of 5 to 7 centimeters. Excellent resolution is obtained with higher frequency transducers. According to the SCA/ASE guidelines, the six standardized views of the thoracic aorta provide a comprehensive assessment of most aortic pathology (Table 1).

The proximity of the esophagus to the aorta in the intrathoracic and upper abdominal regions makes TEE an attractive imaging modality for aortic diseases. The sensitivity and specificity of TEE in the diagnosis of aortic pathology is well known. In the endovascular setting, TEE is useful for confirming aortic pathology, guiding placement of the endograft, monitoring cardiac performance during and following aortic occlusion, and detecting endoleaks after endograft deployment.

**What to look for with TEE**

**Confirming aortic pathology**

Transesophageal echocardiography is a sensitive tool for diagnosing aortic dissections and aneurysms. However, patients presenting for endovascular repair in the operating room usually have already undergone a variety of imaging tests to determine the extent and severity of the aortic disease. The anesthesiologist therefore, has a limited role to play in contributing to the principal diagnosis. However, co-existing aortic pathology may be diagnosed by careful echocardiographic observation of the descending thoracic and upper abdominal aorta. Patients with thoracic aortic aneurysms (TAA) are prone to develop aneurysms at multiple sites. Co-existing aneurysms may be detected by TEE and may
potentially alter the course of the procedure. Since most TAAs result from degenerative changes caused by atherosclerosis, it is common to find widespread atheromatous plaques and calcified deposits. These findings are also important, as they may indicate where positioning of the endograft may be hazardous or result in detachment of atheromatous lesions. Aortic atheromatous disease is commonly implicated in patients with stroke. Identification of the extent and severity of aortic atherosclerosis by TEE can alert the surgical team to the increased risk of an adverse neurological event.

Guiding placement of the endograft

Precise placement of the endograft is essential to ensure exclusion of the aneurysmal sac from aortic flow. Fluoroscopy is performed to confirm size and length of the aneurysm and select the optimal landing zone. In aortic dissections, TEE can be invaluable in determining the placement of the guidewire in the true lumen. The endograft system can be clearly visualized in the aorta, from guidewire insertion, to balloon inflation and stent expansion. The guidewire is visible as a bright echodense structure, in both short and long axis views of the descending aorta. The sheath may be distinguished from the guidewire on the basis of its thickness and echodensity on the TEE image. The TEE probe also serves as a useful marker of aortic level on the fluoroscope without contrast injection (Fig 2).

Monitoring cardiac performance

Myocardial responses to aortic cross clamping are well known. The higher the level of the clamp, the greater is the hemodynamic disturbance. Unlike open aortic aneurysm repair, endovascular techniques do not involve extended periods of aortic occlusion. There is usually a brief period of aortic occlusion due to inflation of the endovascular balloon that enables fixation of the endograft to the aortic wall. The balloon is usually deflated within 15-20 seconds. Newer balloons that are loculated however, do not completely occlude the aorta, being constructed to allow minimal flow between inflated sections of the balloon. Patients with coronary artery disease or left ventricular dysfunction may respond poorly to these stresses and run a high risk of myocardial ischemia. Cardiac performance may be monitored by TEE during the acute hemodynamic disturbances of stent deployment and appropriate remedial action taken. Most echocardiography machines are capable of performing complex calculations and this feature enables rapid assessment of systolic and diastolic function of the left ventricle. Diastolic dysfunction may be the only manifestation of a perioperative myocardial injury that remains undetected by any other monitoring modality.3

Figure 2: Radiographic image of a thoracic aortic stent in situ with a TEE probe in close proximity

Figure 3: The presence of spontaneous echocardiographic contrast within the aneurysmal sac may indicate the absence of endoleak, especially if the contrast acquires the echodensity of surrounding tissue. However, an endoleak may cause the contrast to ‘swirl’ with reduced echodensity similar to blood flow.
Detecting endoleaks

The timely detection of endoleaks may be one of the most important benefits of TEE, especially during endovascular repair of TAAs. Type 1 endoleaks may occur in up to 24% of endovascular repairs of the thoracic aorta. Color flow Doppler is a sensitive technique for assessment of blood flow in any area. Even small endoleaks may be identified by CFD. In many instances, TEE may be able to detect an endoleak that angiography may not be able to confirm. The disadvantage of angiography in this setting is that it relies on a fixed volume of contrast to circulate within the endoleak. Small leaks may be missed because the volume of contrast within the leak may not be detectable by fluoroscopy or the imaging angle may not be accurate enough to detect the leak. TEE has been shown to be more sensitive than angiography in detecting endoleaks after endovascular TAA repairs.

Endoleak may also be indicated by the development of spontaneous echo contrast, or echocardiographic ‘smoke’ within the aneurysmal sac after endograft deployment. The sudden development of ‘smoke’ in a previously quiescent aneurysmal sac should alert the anesthesiologist to the possibility of an endoleak.\(^4\) A distinction should be made between swirling echo contrast in an aneurysmal sac and static contrast. Contrast that swirls around the sac may indicate an endoleak, while static contrast implies no movement or flow within the sac, signifying the absence of any endoleak (Fig 2). Type 2 endoleaks are less common than Type 1 leaks, but may also be detected by intraoperative TEE.

Comparison with other modalities

Intraoperative guidance of stent graft placement may be accomplished with cine-angiography, intravascular ultrasound, including phased array intravascular echo, and TEE. With each modality, the goal is satisfactory exclusion of the pathology (intimal flap or aneurysmal sac) by a stent in stable position without any endoleaks. At present, there are no specific guidelines for intraoperative imaging. However, the European Society of Cardio-Thoracic Surgery and the European Society of Cardiology recommend TEE as an ‘adjunctive’ technique with angiography as the gold standard. TEE remains an effective way to image the stent graft and its margins in the aorta. There are advantages and disadvantages of each different imaging modality and the goal is always to optimize the balance between the benefit of imaging and the risk of the imaging tool. The development of fusion imaging that incorporates TEE and fluoroscopy into one imaging paradigm may lead to more accurate stent deployment and detection of endoleaks.\(^5\)

When TEE is not useful

For stents that involve any portion of the ascending aorta or proximal arch, including hybrid procedures, TEE will be an inadequate imaging modality due to the ‘blind spot’. Most of the distal abdominal aorta is inaccessible for imaging by standard TEE probes. That makes assessment of infrarenal AAAs extremely difficult, if not impossible. If the aorta is tortuous along its length, imaging may become difficult and interpretation inaccurate because the aorta may disappear from view at crucial locations. The introduction of endograft hardware into the aorta may make imaging of the aneurysm difficult due to the high echodensity of the equipment. The ‘fallout’ due to the echodensity does not permit Doppler color evaluation and detection of endoleak may be difficult.

Summary

The importance of TEE in endovascular repair of TAAs is slowly emerging. As with any new technique, the utility of supportive technology, such as TEE will be better known only with experience.
Transesophageal echocardiography can supplement information obtained by angiography to enhance the accuracy of endovascular repair and potentially improve outcomes. The anesthesiologist is in a unique position to provide the endovascular team with vital information regarding stent positioning, endoleaks, and cardiac performance with a single imaging modality.

References


