Epiaortic and Epicardial Echocardiography

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TEE has become a valuable tool in the assessment of many cardiac and aortic disease states. Mitral valve repair relies on TEE to assess adequacy of repair, and to rule out systolic anterior motion of the mitral valve and left ventricular outflow tract obstruction. Thoracic aortic surgery and coronary artery revascularization via a left thoracotomy rely on TEE data to monitor cardiac function when most of the ventricle is out of view. TEE is contraindicated in patients with significant esophageal pathology, and image data is not adequate in others.

Epiaortic echocardiography

Epiaortic echocardiography has been in use as a diagnostic imaging modality for a decade longer than TEE has been available. This procedure involves direct application of a high-resolution transthoracic probe to the heart or ascending aorta for ultrasound evaluation of intracardiac or aortic structures. (See description of necessary equipment in Epiaortic section.) This technique is valuable for patients in whom TEE is contraindicated, or in whom adequate TEE images cannot be acquired. Guidelines for performing a Comprehensive Epiaortic Examination have been published recently. These guidelines describe 7 imaging planes using currently recognized TEE nomenclatures as reference points. This exam requires sterile technique for application of the ultrasound probe. The most practical method of performing this exam is for the echocardiographer to guide a member of the surgical team in acquisition of the images.

Epiaortic views:
- Aortic valve short axis (SAX)
- Aortic valve long axis (LAX)
- Left Ventriecle basal SAX
- Left Ventriecle mid SAX
- Left Ventriecle LAX
- 2-chamber
- Right Ventriecle (RV) Outflow Track

Corresponding TEE view:
- Midesophageal (ME) aortic valve SAX
- ME aortic valve LAX
- Transgastric basal SAX
- Transgastric mid SAX
- Transgastric LAX
- Transgastric 2 chamber
- ME RV inflow-outflow

The Aortic valve views are obtained by placing the probe on the Ascending Aorta as close to the annulus as possible, and angling the probe towards the valve. Slight angulation of the probe towards the shoulder is frequently necessary as well. 90-degree rotation of the probe will move the image between short and long axis views, with some movement distal along the aorta sometimes necessary for the long axis view. LV views are obtained by placing the probe on the RV surface, angling towards the LV, and moving apically. Orientation of the marker is very important in determining LV wall segment orientation. Transgastric LAX and 2-chamber views can be used for evaluation of the Mitral valve and left atrium. The RV view allows visualization of right ventricular outflow tract (RVOT), pulmonic valve and proximal Pulmonary artery. Image depth will vary based on the image being obtained. It is possible to apply Doppler techniques for evaluation of valvular disease in many of these views. Further description of these views is in the document.

Epicardial Echocardiography

Much more data is available regarding the use of epiaortic echocardiography (EA). First, we will review the literature detailing the reason and importance for these examinations, and then show our standardized views, and examples of normal and abnormal exams, in addition to technical concerns that make an exam easier and less likely to have artifacts. Guidelines for the performance of a comprehensive examination have been published in JASE and Anesthesia and Analgesia.

Perioperative CNS injury remains one of the biggest problems facing cardiac surgery today. A large, multi-center study of CABG patients found that there was a 3.1% incidence of type 1 injuries (focal lesions, stupor, or coma). The risk factors for these injuries were atherosclerosis of the ascending aorta detected by the surgeon, history of a previous neurological injury, and increasing age. Other studies have shown that the risk factors for stroke during heart surgery are risk factors for atherosclerosis: increasing age, hypertension, previous stroke and carotid bruits. An autopsy study of 221 patients dying after heart surgery found that atheroembolism occurred at an increasing incidence with time reaching over 48% in 1989, the last year of the study. The incidence of atheroembolism in the ascending aorta was 55.7% and found to increase dramatically with age, severe disease being present in almost 75% of the patients over 75 years of age. There was a high correlation between atheroembolism and severe atherosclerosis of the ascending aorta. Transcranial Doppler studies have shown that embolism to the brain occurs when the ascending aorta is manipulated (cannulated, clamped, unclamped, and decannulated) during surgery. Thus, it seems reasonable to assume that atheroembolism due to manipulation of the ascending aorta is an important cause of CNS injury during heart surgery.

Epiaortic echocardiography (EA) is the best way to diagnose and evaluate patients for ascending aortic atherosclerosis during heart surgery. With this technique, a high frequency ultrasound transducer is placed in a sterile sheath and passed onto the surgical field and placed directly on the ascending aorta by the surgeon after sternotomy. Transesophageal echocardiography (TEE) has difficulty imaging the distal portion of the ascending aorta and proximal aortic arch because the trachea comes between the esophagus and these regions of the aorta. In one study TEE missed over 70% and palpation 50% of moderate or severe lesions detected with EA.
The equipment needed to perform EA includes an ultrasound machine, and a high frequency transducer probe in a sterile sheath. Both linear and phased array probes are available for this purpose. The phased array probe, usually 7.5 to 12 MHz, requires a standoff. To create an interface through which the ultrasound may pass, sterile water or aquasonic gel is placed within the sheath and into the pericardial well. With a phased array probe, the transducer is held about 1 cm above the outer surface of the aorta to allow adequate visualization of the anterior wall of the aorta. This is most easily accomplished by using a standoff, a device that is fitted to the end of the transducer that leaves a gap between it and the anterior wall of the aorta. The depth of the image display is adjusted to center the aorta in the image; usually 8 cm. Linear array probes do not require a standoff device. The linear array probes are typically 15 MHz, and thus allow increased resolution of near field structures. However, due to ultrasound limitations, linear array probes typically do not allow visualization of all 4 walls of the aorta simultaneously. The individual performing the exam must sweep the probe side to side to perform a complete exam. For both devices, the focus of the instrument is placed at the middle of the aorta. The gain is adjusted so the echoes are just barely visible in the lumen of the aorta. Because the anterior and posterior walls of the aorta are perpendicular to the ultrasound, they will appear to be brighter than the sides, which are more parallel and less reflective. The intima is seen as a thin line less than 2 mm thick around the inner edge of the aorta. Various grading scales have been published related to evaluation of severity of disease, but no one scale has been shown to correlate directly with outcome. Most of the published data related to outcomes discusses medical, not surgical, populations. A five-grade scale is typically used to indicate the severity of the disease seen, and one example has been included. It appears that 3 mm thickness, 5 mm thickness, and mobile disease are the most important determinants of risk, as is overall atherosclerotic load as assessed by total plaque area. For surgical patients, location of disease along the ascending aorta should be documented utilizing the 12 regions discussed below. The scale below is one proposed option:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Severity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>Normal</td>
<td>Normal, no intimal thickening</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Mild</td>
<td>Intimal thickening ≤ 3 mm</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Moderate</td>
<td>Sessile atheroma &gt; 3 mm</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Severe</td>
<td>Sessile atheroma ≥ 5 mm</td>
</tr>
<tr>
<td>Grade 5</td>
<td>Mobile</td>
<td>Protruding atheroma with mobile components</td>
</tr>
</tbody>
</table>

In order to describe the location of lesions, the ascending aorta is divided into three regions longitudinally and four regions axially for a total of 12 segments. The proximal third of the ascending aorta is from the aortic valve to the inferior level of the right pulmonary artery (Fig 4). The mid third is that which lies over the right pulmonary artery. The distal third goes from the superior edge of the right pulmonary artery to the aortic arch. Each third is divided into four quadrants, anterior, posterior, and left and right (Fig 3). Right and left are most easily distinguished by identifying the superior vena cava, which is adjacent to the right side of the ascending aorta (Fig 2).

The examination of the ascending aorta should be thorough and systematic. Significant lesions are often very localized and may be adjacent to normal appearing aorta. Start by placing the probe over the proximal portion and rotate it until a circular, short axis image is seen. The transducer is then angled inferiorly until the aortic valve comes into view. Then the probe is slowly moved through the proximal, mid and distal thirds until the aortic arch is seen. The probe is then rotated 90 degrees until a long axis image of the aorta is seen and then the proximal, mid and distal thirds are imaged once again.

The location of lesions in relation to the four axial quadrants is determined with the short axis views and their location proximally or distally with the long axis. The planned locations for manipulation of the aorta (cannulation and clamping sites) are then each carefully examined in short and long axis. The surgeon can determine the location of lesions by noting the position of the probe when the lesion is in the image. Many lesions will also be palpable and can be located in this manner. Calcified lesions of the anterior wall of the aorta may obscure the posterior wall because of acoustic shadowing. Moving the transducer to one side or the other of such a lesion and then angling it to direct the imaging plane under the plaque may allow imaging of the posterior wall in these regions.

Of course, the hope of identifying atherosclerosis within the ascending aorta is that surgical technique can somehow be modified to prevent atheroembolism and stroke. Reported modifications range from simply changing the location of cannulation and clamping sites to replacing the entire ascending aorta when it is severely and diffusely diseased. Another approach is to find with EA a suitable location for cannulation, construct the distal anastomoses with cold fibrillatory arrest while cooling the patient, and then construct a proximal anastomosis without clamping the aorta using a brief period of circulatory arrest. The other vein grafts


