Thoracic Aorta

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Abbreviations

CT	Computed tomography
IABP	Intra-aortic balloon pump
MRI	Magnetic resonance imaging
TEE	Transesophageal echocardiography
TTE	Transthoracic echocardiography

Introduction

Basic perioperative transesophageal echocardiography (TEE) guidelines suggest that knowledge of echocardiographic manifestations of lesions of the great vessels is a necessary training objective. Therefore, a thorough understanding of the use of TEE in evaluating the thoracic aorta, including normal and pathologic presentations, is essential to the basic perioperative echocardiographer. This chapter will review the essential TEE and TTE views for evaluating the thoracic aorta, including potential pitfalls, and review the major aortic pathologies of aortic dissection, aortic aneurysms, aortic atheromatous disease, and thoracic aortic trauma. Evaluation of the abdominal aorta is discussed in further detail in Chap. 19.

Echocardiographic Views of the Thoracic Aorta

The aorta is a three-layered structure, with intimal, medial, and adventitial layers, that extends from the heart immediately beyond the aortic valve through the transverse aortic arch and descends toward the lower extremity vessel branches. It is described as having five anatomical sections (Fig. 13.1):

1. *Aortic Root*, which extends from the aortic valve to the sinotubular junction (which connects the root to the ascending tubular aorta). The aortic root contains three sinuses of Valsalva, two of which contain the left and right coronary artery ostia.
2. *Tubular Ascending Aorta*, which extends from the sinotubular junction to the aortic arch.
3. *Aortic Arch*, which is the transverse portion of the aorta, with typically three great vessel branches: innominate artery, left common carotid, and left subclavian artery.

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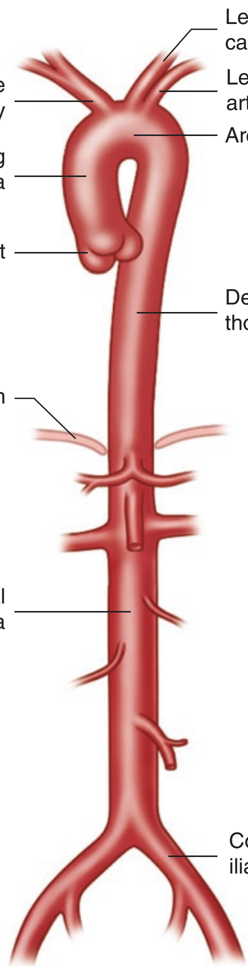


Fig. 13.1 Diagram of the entire aortic vascular system including its five anatomical components: 1. aortic root; 2. tubular ascending aorta; 3. aortic arch; 4. descending thoracic aorta; 5. abdominal aorta

4. *Descending Thoracic Aorta*, which extends from the distal edge of the left subclavian artery takeoff to the diaphragm.
5. *Abdominal Aorta*, which continues from the diaphragm to the lower extremity branch points (iliac arteries).

With TEE, the immediate proximity of the esophagus to the thoracic aorta allows excellent visualization and detection of disease states. However, limitations do exist. Because the trachea and left main bronchus are interposed between the esophagus and aorta, creating significant air-related artifact, imaging of the distal

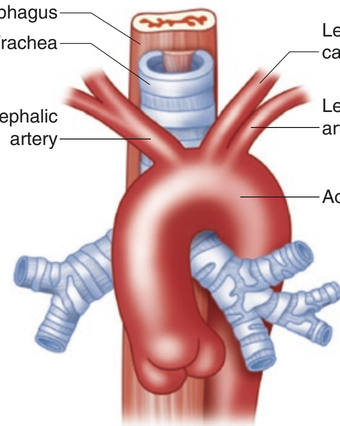


Fig. 13.2 Diagram of the distal ascending aorta, aortic arch, and proximal descending thoracic aorta, including its anterior relationship to the esophagus, with the trachea interposed. The air-filled trachea creates difficulty in TEE imaging the area is not depicted in red

ascending aorta and proximal arch is often challenging or impossible (Fig. 13.2). Alternative echocardiographic approaches to imaging these regions include epiaortic imaging intraoperatively with an opened chest or the use of saline-filled balloons placed in the trachea. However, each of these techniques is beyond the scope of this text. While TTE also allows visualization of the aortic root, it differs from TEE in that it provides imaging windows of the distal ascending aorta and aortic arch. However, due to the distance of the probe from the aorta as it descends posteriorly in the thorax, it is less helpful than TEE for evaluating the descending thoracic aorta. As such, the combined application of both TEE and TTE allows for a complete assessment of the thoracic aorta.

TEE Views

The relationship of the esophagus to the aorta changes from cranial to caudal. The esophagus is posterior to the aorta at the cranial aspect near the arch; however, the structures twist on themselves such that the esophagus is anterior to the aorta at the gastroesophageal junction. This makes description and location of pathology dif-

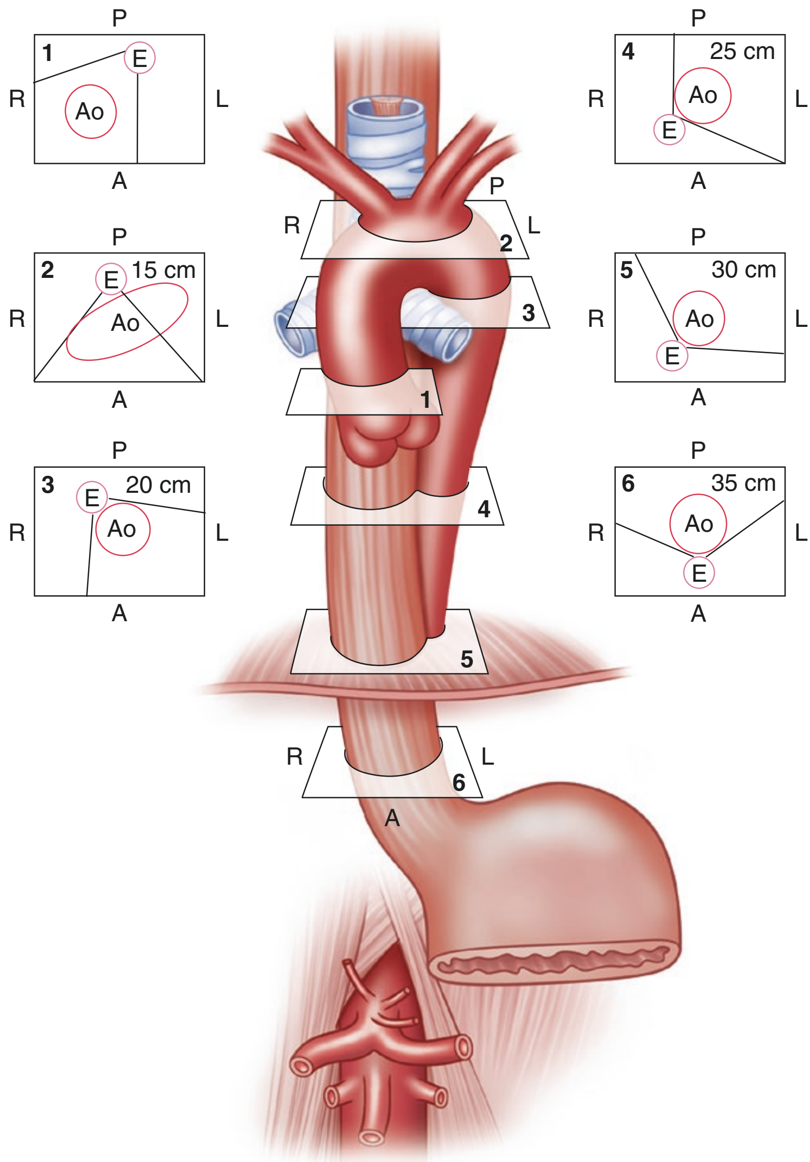
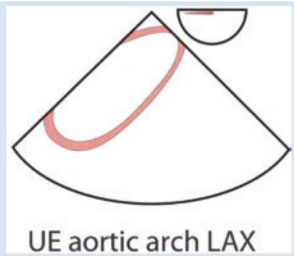
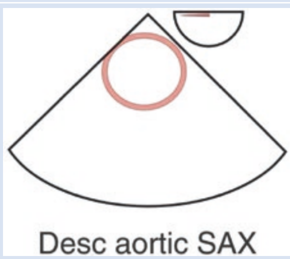
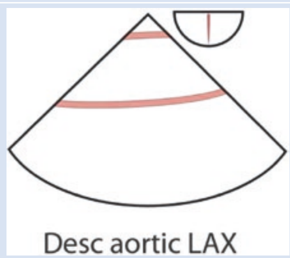


Fig. 13.3 Diagram of the thoracic aorta in relation to the esophagus. Note that when cephalad, the esophagus is positioned posterior to the aorta; however when moving caudally, the esophagus moves to an anterior position relative to the descending thoracic aorta. E esophagus

ficult because the echocardiographic imaging demonstrates a normally cylindrical shape (which appears circular in cross section) throughout the entire descending thoracic aorta (Fig. 13.3). The anterior, posterior, or lateral nature of a lesion is therefore difficult to identify. Lastly, when entering the stomach, the probe enters the intraperitoneal space *views*, while the aorta continues into the retroperitoneal space. Therefore, the probe is no longer opposing tissue near the aorta, and the abdominal aorta is not consistently imaged with TEE.

The TEE views of the aorta can largely be separated into a short- and long-axis view of each segment of the visible thoracic aorta (Table 13.1). When discussing the thoracic aorta, one must consider the aortic valve as disease of the aorta may affect the aortic valve and vice versa. The short- and long-axis views of the aortic valve provide an opportunity to evaluate the number, quality, and function of leaflets, to make appropriate measurements of left ventricular outflow tract (LVOT), aortic valve annulus, and sinotubular junction and to identify pathology such as aortic

Table 13.1 Transesophageal aortic views

Structure	Short axis	Long axis
Aortic valve		
Ascending aorta		
Aortic arch		
Descending aorta		

dissection or aneurysmal disease. The addition of color flow Doppler aids in the detection of valvular dysfunction. Withdrawing and advancing the probe at 0 and 90 degrees of multiplane allows the short- and long-axis examination, respectively, of the tubular ascending aorta. Obtaining the aortic arch views is easily achieved by rotating the TEE probe to the left until the circular descending thoracic aorta is identified and subsequently withdrawing the probe until the oval-shaped long-axis of the aortic arch is obtained. Increasing the multiplane angle to 90 degrees develops the short-axis view of the aortic arch. Of note, most commonly, the left subclavian artery takeoff is identified on the right side of the screen with the innominate vein noted *Views* distally. The left subclavian artery takeoff is an important structure for location identification in the descending aorta. As described above, determining the location of pathology in the descending aorta is difficult. Therefore, most commonly, the distance from the left subclavian artery takeoff to the pathology is used to communicate location. This technique is also utilized to properly place an intra-aortic balloon pump (IABP) within 1–2 cm distal to the left subclavian artery. Advancing the probe in both a 0- and 90-degree multiplane develops the short- and long-axis

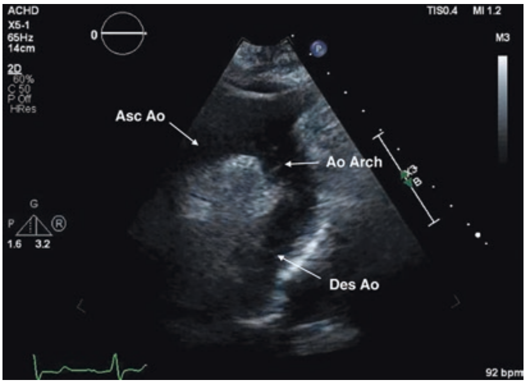


Fig. 13.4 Suprasternal view at the level of the aorta, demonstrating the distal ascending aorta (Asc Ao), aortic arch (Ao Arch), and proximal descending aorta (Des Ao). Here, the great vessels may be seen as they branch off the aortic arch

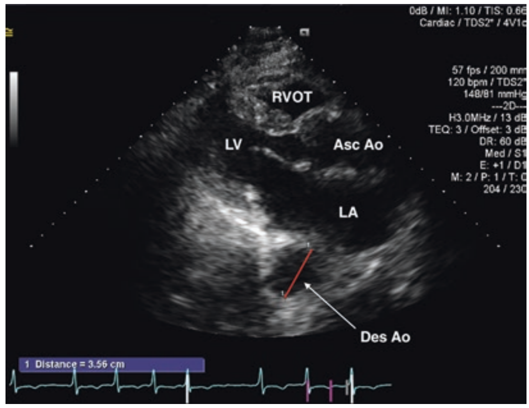


Fig. 13.5 Parasternal long-axis view with the descending aorta (Des Ao) in the fair field of the imaging sector. *RVOT* right ventricular outflow tract, *LV* left ventricle, *LA* left atrium, *Asc Ao* ascending aorta

views of the descending thoracic aorta, respectively.

TTE Views

While TEE is superior to TTE for assessment of the thoracic aorta, TTE provides the advantage of being a less-invasive, easily accessible screening modality and also allows the visualization of the TEE “blind spot” from the interposition of the trachea between the aorta and esophagus. Imaging of the aortic root and ascending aorta is best obtained through the parasternal windows, including parasternal long-axis and parasternal short-axis (right ventricular outflow tract level) views. As you follow the root to the ascending aorta, the parasternal short-axis view at the level of the pulmonary artery bifurcation allows the best assessment. From here, rotation of the probe 90 degrees or application of cross-plane imaging allows you to visualize the ascending aorta in long-axis. As you continue to follow the ascending aorta to the level of the aortic arch, the suprasternal long-axis view of the aorta provides a complete view of the aortic arch as it wraps around the right pulmonary artery. Unique to TTE, this view allows assessment of the distal ascending aorta, aortic arch with each of its three great vessels, and proximal descending aorta (Fig. 13.4). As mentioned, TTE is less helpful for evaluation of the descending aorta; however, it may be visualized in cross section in the far field of the imaging sector in the parasternal long-axis view (Fig. 13.5). Images of each of these TTE views can be found in Chap. 3.

Aortic Dissection (Highlight Box 13.1)

Highlight Box 13.1

Aortic dissection	
2D	• Large undulating mobile flap within aortic lumen • Ensure flap not due to imaging artifact • Differentiate true versus false lumen • SEC or thrombus in false lumen • Presence of pericardial or pleural effusion • Coronary artery involvement (wall motion abnormality)
CFD	• Differential flow patterns (true lumen = laminar; false lumen = sluggish) • Presence of aortic insufficiency
Spectral	• Evaluation of aortic insufficiency

Aortic dissection is typified by bleeding within the medial layer of the aorta, most commonly due to intimal tearing and separation. Propagation of bleeding within this layer separates the intima from the surrounding adventitial layer, yielding the classical dual-lumen appearance. The true lumen contains blood within the natural aortic lumen, while the false lumen is created by the force of blood ejecting through the intimal tear into the medial layer and contained by the adventitial layer.

This pathology carries a significant risk of morbidity and mortality with a 1–2% increased mortality *per hour* until definitive treatment [1]. Therefore, prompt diagnosis is of utmost concern. Patients at risk for developing an aortic dissection include those with long-standing hypertension, smoking, and connective tissue disorders [2]. Commonly-associated diseases include Marfan's syndrome, Ehlers-Danlos syndrome, bicuspid aortic valve, and coarctation of the aorta.

Two classification systems exist for classifying aortic dissections, DeBakey and Stanford [1]. The Stanford system separates any involvement of the ascending aorta into Stanford type A, which is a surgical emergency, while Stanford type B involves only the descending thoracic aorta below the left subclavian artery takeoff. Stanford type B dissections without complicating ischemia (paralysis, mesenteric ischemia, etc.) are often treated medically, while type A usually benefit from surgical treatment. The DeBakey system divides aortic dissections into three types: Type 1 involves the ascending and descending aorta, Type 2 involves the ascending aorta only, while Type 3 involves only the descending aorta below the left subclavian artery takeoff.

As mentioned above, prompt diagnosis is of paramount importance in such patients to reduce morbidity and mortality. The historical diagnostic gold standard involves angiography and the demonstration of contrast exiting the true lumen into the false lumen. The time-consuming process and increased risk of contrast-induced nephropathy have reduced this practice, being replaced by computed tomography (CT) and magnetic resonance imaging (MRI). The downside of each of these modalities is the continued need for patient transport, as well as being potentially time-consuming. While TTE may be of use as an initial screening modality, TEE also serves as an accessible portable modality while providing excellent sensitivity and specificity in the detection of aortic dissections. Shiga et al. demonstrated that TEE has a sensitivity of 98% and specificity of 95% and is comparable to CT or MRI [3]. Therefore, patients who are hemodynamically unstable and unable to be transported to an imaging suite may be evaluated by TEE in the emergency department, intensive care unit, or operating room.

The echocardiographic approach to an aortic dissection involves confirming the presence and the location of a dissection flap, as well as potentially identifying intimal tear entry/exit sites, differentiating the true versus false lumen, and identifying complicating pathologies, such as aortic insufficiency, pericardial and pleural effusions, coronary artery involvement, and ventricular dysfunction. Of note, the current basic perioperative TEE consensus statement suggests that in the setting of complex pathology such as an aortic dissection, appropriate consultation with an advanced echocardiographer or other imaging modalities is indicated [4].

Dissection Flap Identification

Identification of the intimal flap is the cornerstone of the aortic dissection diagnosis. Typically, the intimal flap is noted as a thin, undulating mobile structure that is entirely contained within the lumen of the aorta. Multiple multiplane angles should be utilized to ensure that there is a flap present, representing the separation of the true and false lumens, as occasionally artifacts can mimic a dissection flap (Figs. 13.6 and 13.7; Videos 13.1 and 13.2). With the cardiac cycle, systolic ejection into the aortic lumen causes true lumen expansion, while delayed entry of blood through the intimal tear into the false lumen causes delayed filling with sluggish or no flow. This cycling of expansion leads to the undulating mobile appearance of the intimal flap. Discussed below, the differential flow patterns may be detected with color flow Doppler to aid in identifying true versus false lumens. In addition to identifying the presence of the intimal flap, describing the location and extent of the dissection is important. Location within the ascending aorta or aortic arch denotes a surgical emergency. Dissection through adjacent structures or branches, such as the coronary arteries, great vessels, or aortic valves may also necessitate prompt surgical repair.

Echocardiography may identify not just the presence of an intimal flap but also the intimal tear site. The tear appears as an opening or communication in the intimal flap, with color flow Doppler documenting the presence of flow from the true to the false lumen (Fig. 13.8; Video 13.3). When a tear site is identified in the ascending aorta near the aortic valve, flow may be bidirectional between the true and false lumens because of pressure differentials near the aortic valve during systole and diastole. During systolic ejection, flow and pressure are higher in the true lumen with flow from true to false lumen through the tear site. During diastole, particularly with associated aortic insufficiency, the pressure is temporarily higher in the false lumen with a return of flow to the true lumen (Fig. 13.9; Video 13.4).

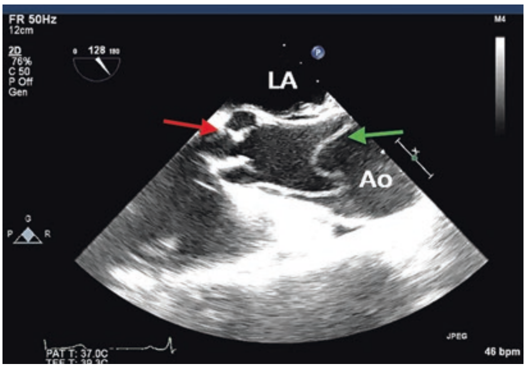


Fig. 13.6 Midesophageal aortic valve long-axis view with the probe slightly withdrawn to demonstrate more of the tubular ascending aorta. The *red arrow* points to a calcified aortic valve, while the *green arrow* indicates an undulating intimal flap within the aortic lumen. *LA* left atrium, *Ao* aorta

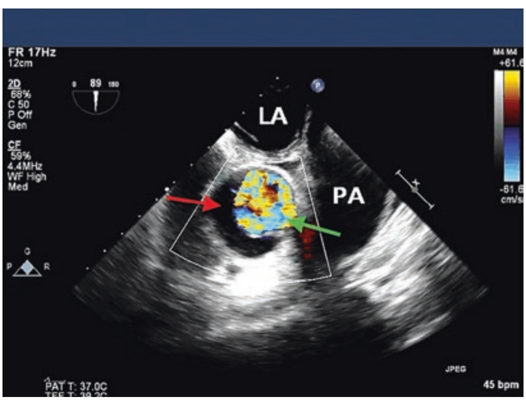


Fig. 13.7 Midesophageal view of the ascending aorta, developed by a slow withdrawal of the probe from an aortic valve short-axis view. The *green arrow* points to a true lumen with rapid early-systolic flow, while the *red arrow* indicates the false lumen with little to no flow demonstrated on color flow Doppler. *LA* left atrium, *PA* main pulmonary artery

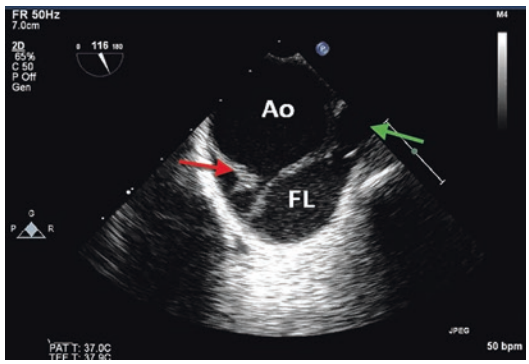


Fig. 13.8 Upper esophageal aortic arch short-axis view in a patient with an acute aortic arch dissection. The *red arrow* points to the tear site in the intimal flap. The *green arrow* indicates the left subclavian artery takeoff, which branches from the false lumen and has compromised flow. *Ao* aorta, *FL* false lumen

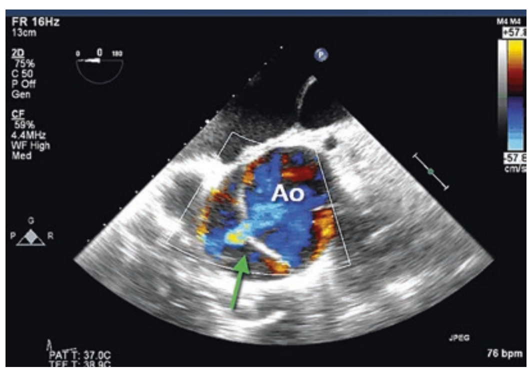


Fig. 13.9 Midesophageal ascending aortic short-axis view in a patient with an ascending aortic dissection. The *green arrow* indicates the tear site in the intimal flap with systolic flow demonstrated from the true lumen into the false lumen. *Ao* ascending aorta

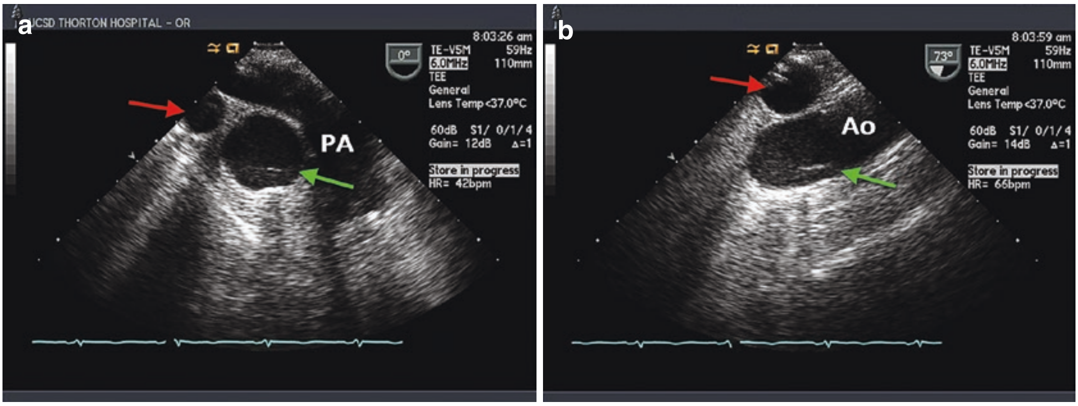


Fig. 13.10 (**a**) Midesophageal ascending aortic short-axis view, in a patient with a side lobe artifact. The *red arrow* indicates the superior vena cava. The *green arrow* indicates a side lobe artifact from a large out-of-plane specular reflector (such as a central line or pulmonary artery catheter). This linear density in the ascending aorta may be confused with an aortic dissection. (**b**) Midesophageal ascending aortic long-axis view of the same patient. The *red arrow* points to the right PA which contains a PA catheter. The *green arrow* points to a side lobe artifact which may be confused for an aortic dissection. *Ao* ascending aorta, *PA* pulmonary artery

Care must be taken to distinguish intimal flaps from imaging artifacts which, particularly in the ascending aorta, may appear as linear densities within the aortic lumen. Side lobe artifacts involve weak ultrasound beams emitted off-axis from the main imaging plane and returning from strong reflectors to the ultrasound probe. A common occurrence is a side lobe reflection from an off-plane central line or pulmonary artery catheter displayed as a linear echogenic density in the ascending aorta in the midesophageal ascending aortic short-axis view (Fig. 13.10a, b; Videos 13.5a and 13.5b). Again, it is emphasized that except in emergency situations, current consensus statement suggests that a basic echocardiographer consult an advanced echocardiographer when evaluating aortic dissections to confirm the diagnosis.

Differentiating True from False Lumens

The ability to differentiate true from false lumens serves to confirm the presence of an aortic dissection, rule out imaging artifacts, and, in the case of aortic surgery, allow the confirmation of surgical repair (lack of false lumen flow post-repair). There are several characteristics of true and false lumens that are fairly common: size, shape, systolic motion, and type or presence of flow (Table 13.2). With two-dimensional echocardiography, the true lumen is often the smaller and round-shaped lumen, while the false lumen tends to be the larger, irregularly shaped structure. The larger false lumen is often crescentic (“moon-like”), with concavity toward the true lumen. Systolic motion, as described above, involves the expansion of the true lumen with systolic ejection. Since the false lumen has delayed flow, the structure will compress during systole (Fig. 13.11a, b; Videos 13.6a and 13.6b). M-mode echocardiography may aid in identifying which structure is expanding during the systolic portion of the cardiac cycle. Lastly, color flow Doppler may be useful in differentiating if the true lumen has early-systolic laminar flow, while the false lumen has late-systolic turbulent flow. False

Table 13.2 Echocardiographic differentiation of aortic dissection true and false lumens

True lumen	False lumen
Smaller	Larger
Round	Irregular
Systolic expansion	Systolic compression
Early laminar flow	Late turbulent flow
	+/− Spontaneous contrast
	+/− Thrombus

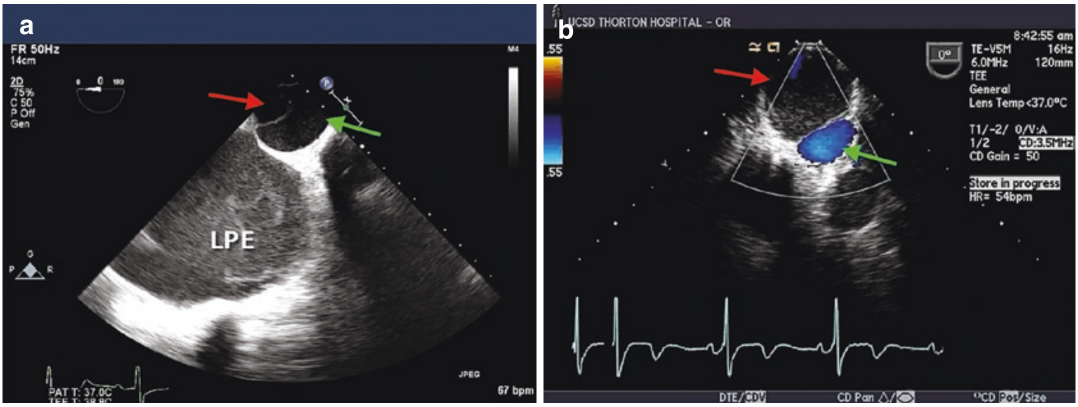


Fig. 13.11 (**a**) Descending thoracic aortic short-axis view in a patient with an aortic dissection. The *red arrow* indicates the true lumen. The *green arrow* indicates the false lumen, which contains spontaneous echo contrast. There is a large left-sided pleural effusion (LPE). (**b**) Descending thoracic aortic short-axis view with color flow Doppler in a separate patient with an aortic dissection. The *green arrow* indicates laminar flow in the true lumen and the *red arrow* indicates the false lumen with sluggish flow

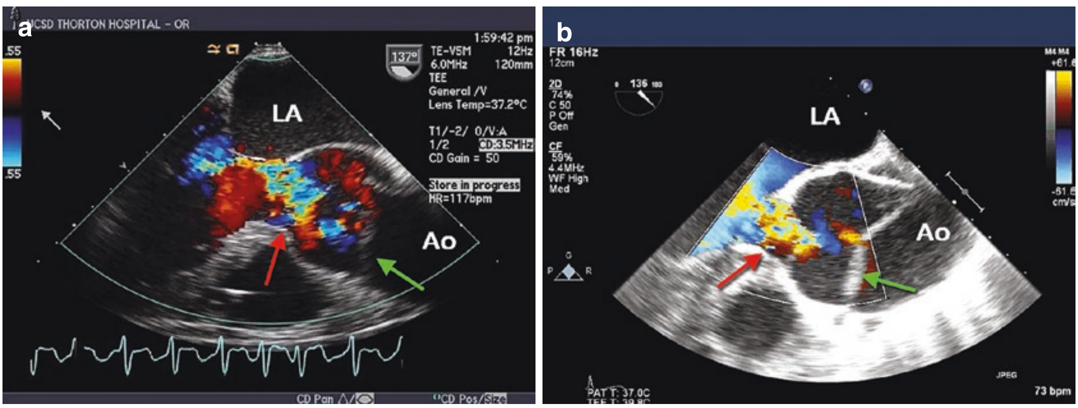


Fig. 13.12 (**a**) Midesophageal aortic valve long-axis view in a patient with an ascending aortic dissection. The *green arrow* indicates the intimal flap located near the sinotubular junction, while the red arrow indicates associated severe aortic insufficiency. (**b**) Midesophageal aortic valve long-axis view in a separate patient with an ascending aortic dissection. The *green arrow* indicates the intimal flap located near the sinotubular junction. Note the intimal tear with diastolic flow reversing back into the true lumen from the false lumen. The *red arrow* indicates associated severe aortic insufficiency. *LA* left atrium, *Ao* ascending aorta

lumens contain such sluggish flow that spontaneous echo contrast or frank thrombus may be identified.

Identifying Complicating Pathologies

The proximity of the aorta to several other anatomical structures, as well as the dependency of the branch vessels on an intact aorta, allows an aortic dissection to wreak havoc beyond just the damaged vessel itself. An advantage of echocardiography over other modalities includes its ability to evaluate surrounding structures and the effect of a dissection on those structures. As described above, the aortic valve is intimately connected to the aorta such that an aortic dissection may yield significant aortic valve dysfunction (Fig. 13.12a, b; Videos 13.7a and 13.7b). There are several mechanisms by which an ascending dissection may cause aortic insufficiency, such as the mobile flap itself impeding

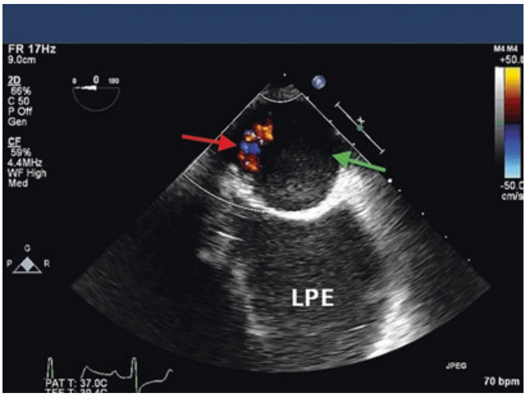


Fig. 13.13 Descending thoracic aortic short-axis view with color flow Doppler in a patient with an aortic dissection and a large left pleural effusion (LPE). The *red arrow* indicates the true lumen, while the *green arrow* indicates the false lumen

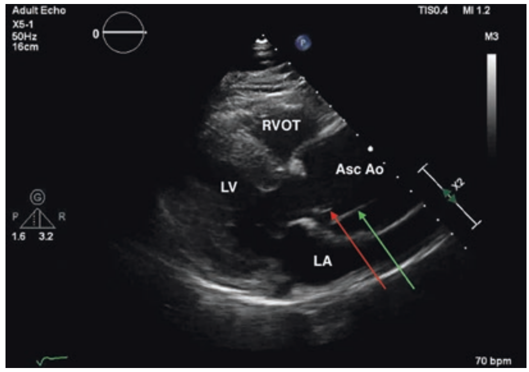


Fig. 13.14 Parasternal long-axis view in a patient with an ascending aortic dissection. The *green arrow* indicates the dissection flap extending to the aortic root with involvement of the coronary ostium. This can be distinguished from the aortic valve leaflet indicated by the *red arrow*. *RVOT* right ventricular outflow tract, *LV* left ventricle, *LA* left atrium, *Asc Ao* ascending aorta

valve closure or the large false lumen causing annular dilation or distortion and subsequent malcoaptation. A detailed evaluation of the mechanism is important in determining the need for concomitant valve replacement during aortic surgery; however this analysis is beyond the scope of this text.

In a normal state, the three layers of the aortic wall (intima, media, adventitia) contain the blood within the aortic lumen. During an aortic dissection, blood in the false lumen is now only contained by the adventitial layer, allowing a transudative process to leak into the surrounding spaces, such as the pericardial or left pleural space. An inflammatory component also appears to play a role in the development of pleural effusions [5]. Pericardial effusions are noted as an echolucent area surrounding the heart or great vessels in nearly any view, but commonly the midesophageal four-chamber or transgastric short-axis views with TEE and the apical four-chamber or parasternal short-axis (midpapillary level) with TTE. Determining tamponade physiology is discussed in the pericardium chapter (see Chap. 14). Left-sided pleural effusions are noted as an echolucent area anterior to the descending thoracic aorta in the descending aortic short-axis view (Fig. 13.13; Video 13.8). Frank rupture of the dissection into the pericardial or pleural space causes a hemorrhagic effusion, rapid accumulation of blood, and significant hemodynamic deterioration.

During evaluation of an ascending aortic dissection that is approaching the aortic root, careful evaluation should include the ostia of the main coronary arteries. The aortic root contains three sinuses of Valsalva, two of which contain coronary arteries (left and right). A proximal dissection through a coronary ostium and resultant reduction of its blood supply may result in significant myocardial ischemia or infarction (Fig. 13.14; Video 13.9). An evaluation for wall motion abnormalities should be included if coronary involvement is suspected (Fig. 13.15a, b; Videos 13.10a and 13.10b).

Lastly, aortic dissections may result in ventricular dysfunction through two major mechanisms. As previously described, acute ischemia may result in wall motion abnormalities and frank right ventricular or left ventricular dysfunction. In another fashion, acute aortic insufficiency causes abrupt volume overload to a ventricle that has not had the time to dilate and adapt to the volume overload (as in chronic aortic insufficiency). Therefore, an evaluation of biventricular function is important in the setting of ascending aortic dissections.

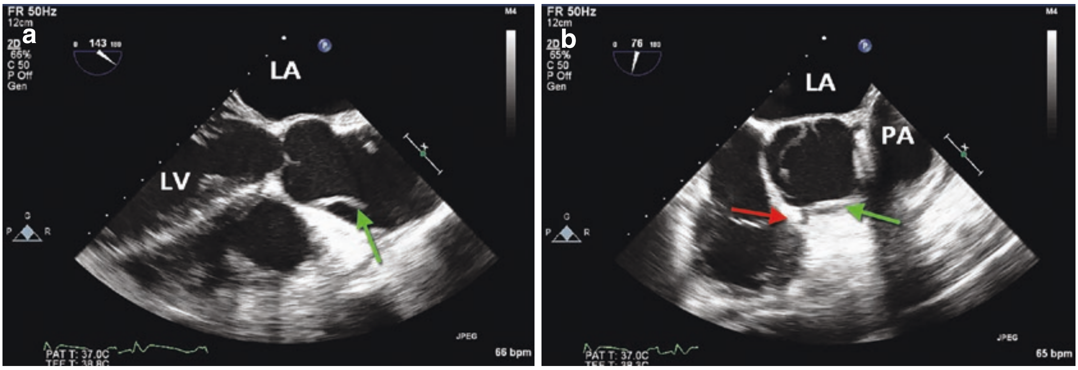


Fig. 13.15 (**a**) Midesophageal aortic valve long-axis view in a patient with an ascending aortic dissection. The *green arrow* indicates the intimal flap located near the sinotubular junction and extending into the right sinus of Valsalva. (**b**) Midesophageal aortic valve short-axis view in the same patient. The *green arrow* indicates the intimal flap located abutting the right coronary ostium (indicated by the *red arrow*). *LA* left atrium, *LV* left ventricle, *PA* pulmonary artery

Aortic Aneurysm
(Highlight Box 13.2)

Highlight Box 13.2

Aortic aneurysm	
2D	• Evidence of aortic dilation (linear measurements) • Branch involvement • Aortic root involvement (aortic valve malcoaptation)
CFD	• Presence of aortic insufficiency
Spectral	• Evaluation of aortic insufficiency

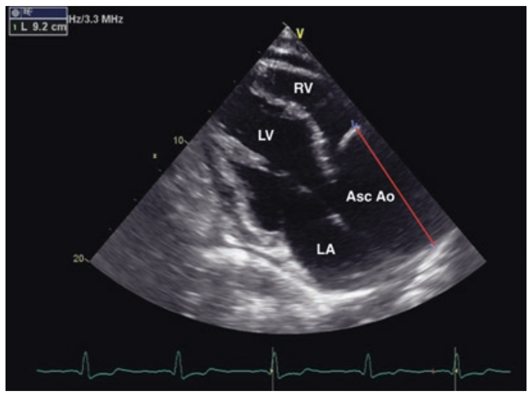


Fig. 13.16 Parasternal long-axis view in a patient with a large ascending aortic aneurysm. The *red line* indicates a dimension of 9.2 cm. *RV* right ventricle, *LV* left ventricle, *LA* left atrium, *Asc Ao* ascending aorta

Aortic dilation refers to the enlargement of the aorta beyond the upper limits of normal size. Normal adult thoracic aortic diameters are approximately 3.5–4.0 cm for the aortic root and less than 3.0 cm for the ascending and descending thoracic aorta. An aneurysm is classically described as a dilated segment of all three layers of an arterial wall with a vessel size that is beyond 150% of its normal size. Surgical repair is considered as the aorta dilates beyond 4.5–5.5 cm, taking into consideration the patients' history and risk factors [6]. Due to its noninvasive nature, TTE is often the imaging modality of choice for the screening of at-risk patients or for the serial follow-up imaging of patients with known ascending aortic aneurysms. However, as previously noted, TTE does not reliably image the descending aorta and is not used for serial assessment of this region (Fig. 13.16). Again, the close relationship of the esophagus to the aorta allows excellent TEE imaging of dilated and aneurysmal segments of the aorta. However, TEE does not carry the same potency in diagnosis of thoracic aortic aneurysm as it does in the setting of acute aortic dissection. As such, intermittent imaging by CT or MRI at longer time intervals is recommended in addition to echocardiography to allow for more accurate monitoring of the aortic diameter. In the setting of aortic aneurysms, proper surgical planning is essential to successful treatment and relies on preoperative imaging. Proper identification of tortuosity, anterior spinal arteries (including the artery of Adamkiewicz), and branch vessels may help guide management of cardiopulmonary bypass and neuroprotection strategies. Transesophageal echocardiography, however, still plays a role in the intraoperative management and in the setting of an unstable patient with an aneurysm rupture.

The echocardiographic approach to a patient with an aneurysm is similar to that of a dissection and includes determining the location and extent of disease, as well as identifying coexisting pathologies. Measurements in multiple planes may be helpful to identify the degree and extent of the aneurysm. In the setting of ascending aortic aneurysms, measurement of the aortic valve annulus and sinotubular junction may aid in assessing both the aneurysm and potential aortic valve involvement (Fig. 13.17). Care must be undertaken as proper cross-sectional measurements may be difficult in the setting of tortuosity.

Coexisting pathology with aortic aneurysm most often relates to the aorta's intimate structural relationship to the aortic valve. In the setting of aortic stenosis, the resultant post-stenotic turbulent flow in the ascending aorta leads to altered hemodynamics and an increased outward pressure. This results in post-stenotic aortic dilatation that may halt after aortic valve replacement in calcific aortic stenosis [7]. Bicuspid aortic valve disease may also progress toward aortic stenosis with attendant aortic dilatation. However, despite aortic valve replacement, aortic dilatation may continue in these patients. In addition, another group of patients with bicuspid aortic valve may present with annular dilation and aortic insufficiency without stenosis, potentially necessitating replacement of both the valve and ascending aorta (Fig. 13.18; Video 13.11). Lastly, the dilated aorta itself may have an impact on aortic valve function. As the aortic valve is crown-shaped, with attachments near the annulus at the base and the sinotubular junction at the top, dilation of the root may result in malcoaptation of the aortic valve leaflets and subsequent aortic regurgitation (Fig. 13.19; Video 13.12).

Aortic Atheroma

Transesophageal echocardiography is very sensitive to the detection of aortic atheromatous disease, and the presence of such plaque carries significant patient risk. While atheromatous disease may be detected with TTE from the suprasternal view of the aorta, it is less reliable and provides inferior visualization as compared to TEE. When atheromatous disease is noted to be

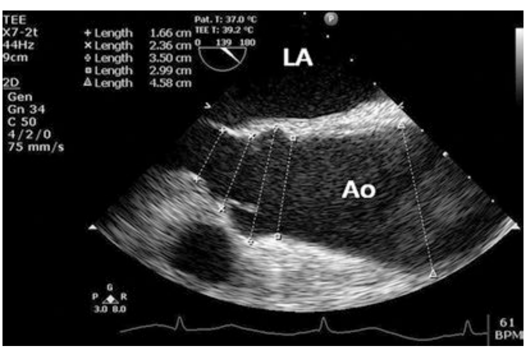


Fig. 13.17 Midesophageal aortic valve long-axis view in a patient with an ascending aortic aneurysm. Measurements of the left ventricular outflow tract, aortic annulus, sinuses of Valsalva, sinotubular junction, and ascending aorta note the presence of an ascending aortic aneurysm without significant involvement of the aortic root. *LA* left atrium, *Ao* ascending aorta

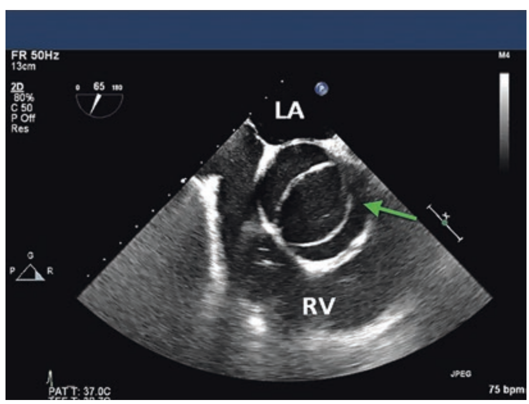


Fig. 13.18 Midesophageal aortic valve short-axis view in a patient with a bicuspid aortic valve and ascending aortic aneurysm. The *green arrow* indicates the bicuspid valve with a unified right and left coronary cusp. Note the dilated annulus. *LA* left atrium, *RV* right ventricle

greater than or equal to 4 mm in thickness, it is associated with increased risk of all vascular events, including stroke, myocardial infarction, peripheral emboli, and death [1]. The echocardiographic imaging approach includes noting severity, location, as well as mobility of the atheroma (Figs. 13.20 and 13.21a, b; Videos 13.13a and 13.13b). The grading of atheromatous disease is displayed in Table 13.3. In the setting of interventional vascular procedures, the presence of severe atheromatous disease, including plaque mobility, should be communicated to the surgical team to prevent inadvertent embolization.

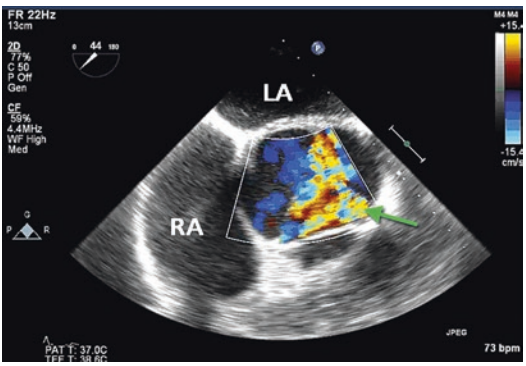


Fig. 13.19 Midesophageal aortic valve short-axis view with color flow Doppler in a patient with an ascending aortic aneurysm. The *green arrow* indicates the significant aortic insufficiency from the associated dilated annulus. *LA* left atrium, *RA* right atrium

Thoracic Aortic Trauma

The thoracic aorta has both relatively fixed and mobile portions. The junctions of these portions are often the site of injury in blunt aortic injury, mostly commonly the aortic isthmus (immedi-

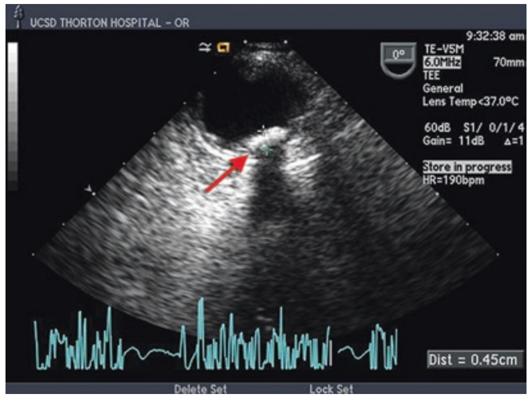


Fig. 13.20 Descending thoracic aorta short-axis view demonstrating an aortic atheroma measuring 4.5 millimeters, Grade III disease (*red arrow*)

Table 13.3 Echocardiographic grading of atheromatous disease

Grade	Description
1	Normal aorta; minimal intimal thickening
2	Extensive intimal thickening
3	Calcified aortic plaque less than 5 mm
4	Calcified aortic plaque greater than 5 mm
5	Mobile atheroma or ulcerated plaque

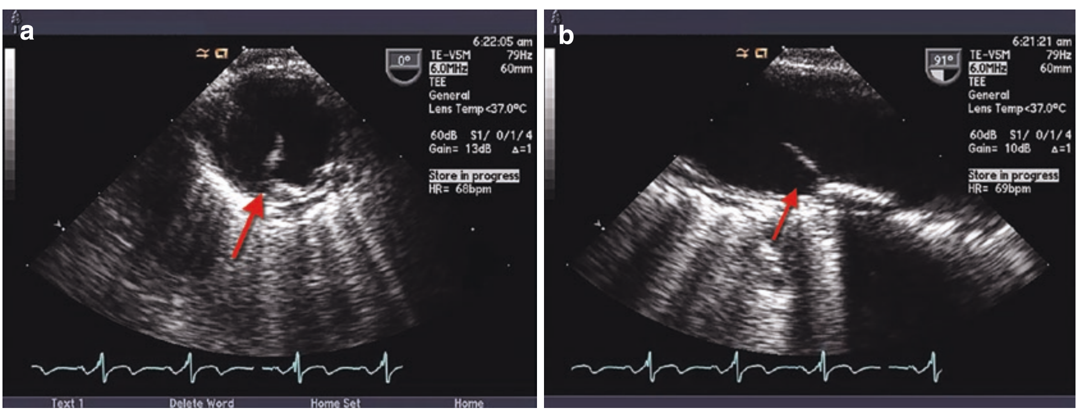


Fig. 13.21 (**a**) Descending thoracic aortic short-axis view demonstrating complex atheromatous disease. The *red arrow* indicates a large pedunculated mobile portion extending into the aortic lumen. (**b**) Descending thoracic aortic long-axis view of the same patient. The *red arrow* again points to the pedunculated mobile portion of the atheroma

ately distal to the left subclavian artery) and the ascending aorta (immediately distal to the aortic valve). The most common mechanism for this type of injury is a rapid deceleration, which transmits the sheer force between the relatively fixed and mobile portions. This usually involves damage to the aortic intima, with potential damage through the media and adventitia, including complete aortic transection [8].

Echocardiographically, aortic trauma may share characteristics of a spontaneous aortic dissection. However, on examination of a traumatic aortic injury, the medial flap tends to be thicker in appearance, the lesion is more often isolated without propagation, and there may be presence of an abnormal aortic contour, an aortic pseudoaneurysm, or a crescent-shaped intramural hematoma. A complete evaluation of the thoracic aorta in this setting should be in consultation with an advanced echocardiographer or confirmed with an alternative imaging technique.

Conclusion

Echocardiography is an excellent monitor for the diagnosis of several aortic pathologies, albeit with some limitations. Knowledge of these limitations allows this modality to be utilized in the setting of aortic dissection, aneurysm, atheroma, and trauma. The basic echocardiographer should have a sound understanding of thoracic aortic imaging with both TEE and TTE.

Questions

1. Which of the following is most true regarding distinguishing the true lumen from false lumen of an aortic dissection with echocardiography?

   (a) The false lumen has a higher systolic velocity.
   (b) The false lumen has echocardiographic evidence of stasis or thrombus.
   (c) The false lumen is often round in the short-axis view.
   (d) The true lumen has late turbulent flow in systole.

2. Which of the following is most true regarding distinguishing the true lumen from false lumen of an aortic dissection with echocardiography?

   (a) The true lumen is often crescentic in shape.
   (b) The true lumen is usually larger.
   (c) The true lumen has early laminar systolic flow on color flow Doppler.
   (d) The intimal flap moves toward the true lumen in systole.

3. Which of the following is *least* likely to be a consequence of aortic dissection?

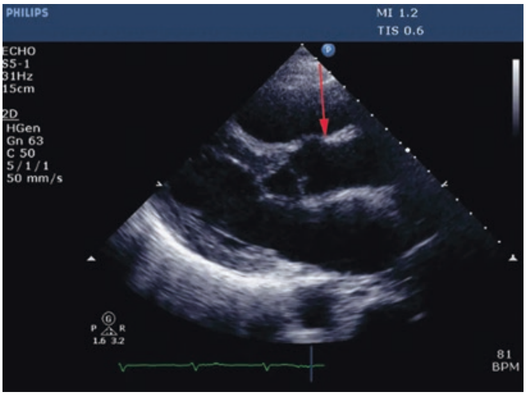
   (a) Aortic stenosis
   (b) Myocardial infarction
   (c) Pleural effusion
   (d) Aortic insufficiency

4. Which of the following is most true regarding the use of TTE versus TEE for the identification of aortic pathology?

   (a) TTE is more sensitive and specific than TEE for the detection of aortic dissections.
   (b) The "blind spot" of the aorta with TEE imaging exists due to the interposition of the trachea between the esophagus and the aorta.
   (c) TTE is more useful than TEE for imaging of the descending aorta.
   (d) The entire thoracic aorta may be visualized by TEE imaging alone.

5. Select the correct pairing for echocardiographic grading of atheromatous disease.

   (a) Grade 2 – Minimal intimal thickening
   (b) Grade 3 – Calcified aortic plaque measuring 6 mm
   (c) Grade 4 – Calcified aortic plaque measuring 7 mm and mobile
   (d) Grade 5 – Calcified aortic plaque measuring 1 mm and mobile



6. Which aortic section is indicated by the arrow in the figure below?

    (a) Aortic sinuses of Valsalva
    (b) Sinotubular junction
    (c) Aortic root
    (d) Tubular ascending aorta

7. A dilated segment of the aorta is considered aneurysmal when it exceeds what percent of its normal size?

    (a) 100%
    (b) 125%
    (c) 150%
    (d) 200%

8. Which of the following is most true regarding the classification systems for aortic dissections?

    (a) DeBakey Type 3 dissections are a surgical emergency.
    (b) Stanford A dissections when uncomplicated are often treated medically.
    (c) Stanford B dissections involve both the ascending and descending thoracic aorta.
    (d) DeBakey Type 2 dissections involve the ascending aorta only.

9. Which TTE view best images the “blind spot” encountered during imaging of the thoracic aorta with TEE?

    (a) Parasternal long-axis
    (b) Parasternal short-axis: pulmonary artery bifurcation level
    (c) Apical four-chamber
    (d) Suprasternal long-axis of the aorta

10. Which of the following is most true regarding the ability to distinguish artifact from a dissection flap?

    (a) Artifacts are often seen in multiple views.
    (b) Changing the angle of incidence will not affect the presence of artifacts.
    (c) A dissection flap has motion independent of the aorta.
    (d) Adjusting the imaging depth can move the artifact outside the aortic lumen.

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