TEE and TTE Assessment of Aortic Disease

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Normal aorta

CT reconstruction

segment I = aortic root

segment II = tubular ascending aorta (subdivided into IIa [STJ to the pulmonary artery level] and IIb [from the pulmonary artery level to the brachiocephalic artery])

segment III = aortic arch

segment IV = descending thoracic aorta (subdivided into IVa [from the left subclavian artery to the level of the pulmonary artery] and IVb [from the level of the pulmonary artery to the diaphragm])

segment V = abdominal aorta (subdivided into Va [upper abdominal aorta from the diaphragm to the renal arteries] and Vb [from the renal arteries to the iliac bifurcation])
TTE: Measurements of the aortic root and ascending aorta

1 = aortic valve annulus (hinge point of aortic leaflets), 2 = aortic root at sinuses of Valsalva (maximal diameter, usually midpoint), 3 = STJ, 4 = proximal tubular portion of the ascending aorta
Zoomed on aortic root and ascending aorta - measurement of the aortic root diameter at sinus of Valsalva level at end-diastole using the leading-edge-to-leading-edge method.

Aortic root diameter in relation to BSA

age: 1 to 15

20 to 39

≥40

To reliably evaluate patients with suspected aortic disease, the entire thoracic aorta must be imaged well. This is possible in some, but not all, patients on systematic TTE. TTE is particularly useful for evaluating the aortic root, and the ascending aorta and arch may also be adequately visualized in patients with good acoustic windows.

TTE is less helpful for evaluating the descending thoracic aorta.

However, TTE is an excellent screening tool for detecting aneurysms of the upper abdominal aorta.
(A) Angiography in the 90° LAO projection

(B) TTE (left) and 2D TEE (right) left ventricular outflow tract (LVOT) view of the aortic annulus

(C) Three-dimensional transesophageal echocardiographic cropped images of a sagittal (left) and coronal (right) view

(D) Dual-source computed tomographic (DSCT) reconstructed images of a sagittal (left) and coronal (right) view
TEE has two main advantages over TTE.
1) superior image quality can be obtained from the use of higher frequency transducers than are possible with TTE.
2) because of the close proximity of the esophagus to the thoracic aorta, TEE provides high-quality imaging of nearly all of the ascending and descending thoracic aorta.

TEE incorporates all the functionality of TTE, including 3D imaging, which can reliably interrogate cardiovascular anatomy, function, hemodynamics, and blood flow.
A portion of the distal ascending aorta and proximal aortic arch may not be visible because of interposition of the trachea. This “blind spot” can be partially resolved with longitudinal views. An additional view, the deep transgastric view, can sometimes image the entire ascending aorta and often the proximal arch.
Relatively new technology, with limited information regarding the clinical application to the thoracic aorta.

Like 2D TEE, it often fails to adequately visualize the distal ascending aorta and the aortic arch and its branches, because of interposition of the trachea.

In addition, spatial imaging of the thoracic aorta is limited because of the 90 deg image sector, which is too narrow to include long segments of the thoracic aorta.

65 yr with severe mitral regurgitation from flail MV. Incidental finding
Acute Aortic Syndrome

Spectrum of aortic pathologies including:
- classic aortic dissection
- IMH
- penetrating aortic ulcer (PAU)
- aortic aneurysm rupture (contained or not contained)

Common features:
- similar clinical presentation ("aortic pain")
- impaired integrity of the aortic wall
- potential danger of aortic rupture requiring emergency

Life-threatening nature → prompt and accurate diagnosis is paramount
Imaging is used to confirm or exclude the diagnosis, determine the site(s) of involvement, delineate extension, and detect complications to plan management / approach.
Comparison of 5 imaging modalities for diagnostic features of acute aortic syndrome

<table>
<thead>
<tr>
<th>Diagnostic performance</th>
<th>CTA</th>
<th>TTE</th>
<th>TEE</th>
<th>MRA</th>
<th>Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Specificity</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td>Ability to detect IMH</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>–</td>
</tr>
<tr>
<td>Site of intimal tear</td>
<td>+++</td>
<td>–</td>
<td>++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Presence of AR</td>
<td>–</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Coronary artery involvement</td>
<td>+</td>
<td>–</td>
<td>++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Presence of pericardial effusion</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>–</td>
</tr>
<tr>
<td>Branch vessel involvement</td>
<td>++</td>
<td>–</td>
<td>+</td>
<td>++</td>
<td>+++</td>
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Practical assessment of five imaging modalities in the evaluation of suspected AAS

<table>
<thead>
<tr>
<th>Advantages of modality</th>
<th>CTA</th>
<th>TTE</th>
<th>TEE</th>
<th>MRA</th>
<th>Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readily available</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Quickly performed</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Performed at bedside</td>
<td>−</td>
<td>+++</td>
<td>+++</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Noninvasive</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>−</td>
</tr>
<tr>
<td>No iodinated contrast</td>
<td>−</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>−</td>
</tr>
<tr>
<td>No ionizing radiation</td>
<td>−</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>−</td>
</tr>
<tr>
<td>Cost</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+++</td>
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Aortic Dissection

DeBakey –
Type I dissection originates in the ascending aorta and propagates distally to includes at least the arch and typically the descending aorta. Type II dissection originates in and is confined to the ascending aorta. Type III dissection originates in the descending thoracic aorta (usually just distal to the left subclavian artery) and propagates distally, usually to below the diaphragm.

Stanford –
2 categories: those that involve the ascending aorta, (type A) those beginning beyond the arch vessels (type B) The majority propagate beyond the diaphragm to the iliac arteries.
Management of aortic dissections

The appropriate management of aortic dissections depends not only on the location of the dissection but also on the time that has elapsed between onset of the process and the patient’s presentation.

There is a 24-hour “hyperacute” period during which dissections involving the ascending aorta carry a risk for rupture approaching 1% per hour.

Arbitrary - An aortic dissection is “acute” when the onset of symptoms was <2 weeks in duration at the time of diagnosis. The subsequent 2-month period was designated “subacute,” and beyond the second month, an aortic dissection was termed “chronic”.

TTE as screening tool

For the detection of type A dissection, the sensitivity of TTE has improved to approximately 85% due to new transducers with better resolution, harmonic imaging, and contrast enhancement.

Use for screening (e.g., in the emergency room) TTE provides assessment of LV contractility, pericardial effusion, aortic valve function, RV size and function, and pulmonary artery pressure, which may facilitate the diagnosis of other causes of chest pain and may identify dissection complications such as aortic regurgitation (AR) early. Negative results on TTE should not be considered definitive, and further imaging should follow.

TTE is less sensitive for the diagnosis of type B dissection, because the descending thoracic aorta (located farther from the transducer) is imaged less easily and accurately.

23yr old female

H/o Marfan’s – echo in May 2016
Not BAV
Sep 2016 – Neck pain X 4 days
Occur after eating mussels with friends
a/w left flank pain and vomiting
TTE - Arch
Mechanisms of AR in type A aortic dissection

1. Dilatation of the aortic root leading to incomplete aortic leaflet coaptation
2. Cusp prolapse (asymmetric dissection depressing cusp[s] below annulus)
3. Disruption of aortic annular support resulting in flail leaflet
4. Invagination/prolapse of dissection flap through the aortic valve in diastole
5. Preexisting aortic valve disease (e.g., bicuspid valve)
CTA – Standford type A aortic dissection extending from the aortic annulus @ right sinus of Valsalva up to the level of the renal arteries.

Underwent surgery – Bentall’s procedure with aortic root replacement (ATS) arch revision and hemiarch replacement and CABG
Use of contrast echo illustrates entry tear (arrow) by showing contrast emanating from true lumen (TL) to false lumen (FL)
Entry tear of a type B aortic dissection located in the proximal descending aorta. (Left) Live 3D image showing a large entry tear.
Another case?

55 yr Myanmese female

PMedHx – hypertension, dyslipidaemia, h/o PDA, AF, thyrotoxicosis

Known type A dissection diagnosed in Myanmar in 2006 (10 yrs)
Ascending aorta measures 10cm in dimension
TTE – Arch: True lumen vs false lumen
US Abdo aorta

Adult Echo
85-2
38Hz
20.0cm

2D
HGen
Gn 61
55
7/2/0
50 mm/s

83 BPM
Chronic vs Acute Aortic Dissection

In chronic dissection, the dissection flap tends to be thicker, more echodense, and relatively immobile.

In acute dissection, the flaps are ‘oscillating’.
Different imaging modalities in evaluating suspected aortic dissection

Sensitivity (left) and Specificity (right) of imaging modalities in evaluating suspected aortic dissection in a meta-analysis of 1,139 patients (MGH aortic center)
Echo findings in aortic dissection

- Diagnostic hallmark - mobile dissection flap that separates the true and false lumens
- Oscillation or motion that is independent of the aorta itself, visualization in more than one view
- The true and false lumens can almost always be differentiated
  In the descending thoracic aorta, the false lumen is usually larger than the true lumen.
- There is systolic expansion of the true lumen and diastolic expansion of the false lumen
- True lumen, rapid antegrade systolic flow. Flow in the false lumen is generally sluggish, may be absent or retrograde - spontaneous echo contrast, may contain thrombus.
## Role of echocardiography in detecting evidence of aortic dissection and echocardiographic definitions

<table>
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<th>Diagnostic goals</th>
<th>Definition by echocardiography</th>
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<tr>
<td>Identify presence of a dissection flap</td>
<td>Flap dividing two lumens</td>
</tr>
<tr>
<td>Define extension of aortic dissection</td>
<td>Extension of the flap and true/false lumens in the aortic root (ascending/arch/descending abdominal aorta)</td>
</tr>
<tr>
<td>Identify true lumen</td>
<td>Systolic expansion, diastolic collapse, systolic jet directed away from the lumen, absence of spontaneous contrast, forward systolic flow</td>
</tr>
<tr>
<td>Identify false lumen</td>
<td>Diastolic diameter increase, spontaneous contrast and or thrombus formation, reverse/delayed or absent flow</td>
</tr>
<tr>
<td>Identify presence of false luminal thrombosis</td>
<td>Mass separated from the intimal flap and aortic wall inside the false lumen</td>
</tr>
<tr>
<td>Localize entry tear</td>
<td>Disruption of the flap continuity with fluttering or ruptured intimal borders; color Doppler shows flow through the tear</td>
</tr>
<tr>
<td>Assess presence, severity and mechanisms of AR</td>
<td>Anatomic definition of the valve (bicuspid, degenerated, normal with/without prolapse of one cusp); dilation of different segments of the aorta; flap invagulation into the valve; severity by classic echocardiographic criteria</td>
</tr>
<tr>
<td>Assess coronary artery involvement</td>
<td>Flap invaginated into the coronary ostium; flap obstructing the ostium; absence of coronary flow; new regional wall motion abnormalities</td>
</tr>
<tr>
<td>Assess side-branch involvement</td>
<td>Flap invaginated into the aortic branches</td>
</tr>
<tr>
<td>Detect pericardial and/or pleural effusion</td>
<td>Echo-free space in the pericardium/pleura</td>
</tr>
<tr>
<td>Detect signs of cardiac tamponade</td>
<td>Classic echocardiographic and Doppler signs of tamponade</td>
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Few limitations of TEE

- **Blind spot** - Interposition of the trachea between the ascending aorta and the esophagus limits visualization of the distal ascending aorta and proximal arch. In a small no., the dissection may be limited to this area.

- In addition, the **cerebral vessels** (esp brachiocephalic and left common carotid arteries) can be difficult to image by TEE. Moreover, the celiac trunk and superior mesenteric artery cannot be consistently imaged by TEE, and CT is considered the gold standard for detecting complications below the diaphragm.

- Reverberation **artifacts**, especially in the ascending aorta, can mimic a dissection flap and result in a false-positive diagnosis. Knowledge of mediastinal and para-aortic tissues (e.g., the hemiazygos sheath, the thoracic venous anatomy and common anatomic variants) is essential.
**TEE to Guide Surgery for Type A Dissection**

- TEE should be performed in the OR in **all** patients during repair of type A aortic dissection.
- Intraoperative TEE is to **detail the anatomy of the dissection and to better define its physiologic consequences.**
- The origin and proximal extent of the dissection flap and the dimensions of the aorta at the annulus, sinuses of Valsalva, and STJ are important for determining whether to replace the ascending aorta alone or to also replace the root.
- TEE will also guide the management of complications from dissection.
Another aortic dissection?

65 yr old Chinese man from Indonesia

Phx – DM, hypt (stopped med X 1/52)
p/w h/o chest discomfort, radiating to back and neck
a/w SOB

ECG – T wave inversion lateral leads
Troponin – negative
CXR – widened mediastinum (9cm)
CT - ? Type A dissection with thrombosed false lumen

Monitor in CCU and keep SBP < 130mmHg
TEE 3 days later
Emergency aortic arch replacement performed but patient collapsed soon after op.
1. Focal aortic wall thickening (crescentic > concentric)
2. Preserved luminal shape with smooth luminal border
3. Absence of dissection flap and false lumen
4. Echolucent regions may be present in the aortic wall
5. Central displacement of intimal calcium
IMH represents hemorrhage into medial layer of aorta. Can progress to localized or frank dissection or rupture. IMH thickness and maximal aortic diameter predict risk for progression. Subtle wall thickening can be missed.
penetrating atherosclerotic ulcer

Lesion Location
Aortic diameter at the level of the lesion
Contrast extension
Pleural effusion

Lesion width, length, depth
Presence/absence/extent of IMH
Mediastinal hematoma
Presence and length of false lumen
Thoracic aortic aneurysm

1. Marfan syndrome
2. BAV-related aortopathy
3. Familial TAA syndrome
4. Ehlers-Danlos syndrome
5. Loeys-Dietz syndrome
6. Turner syndrome
7. Shprintzen-Goldberg syndrome
8. Noninfectious aortitis (e.g., GCA, TA,)
9. Infectious aortitis
10. Syphilitic aortitis
11. Trauma
12. Idiopathic
Echo of Massively Dilated Aortic Root and Ascending Aortic Aneurysm Secondary to Giant Cell Arteritis

A 77-year-old Indian man with h/o giant cell arteritis 12 years ago, p/w CCF

Echocardiogram showed severe aortic regurgitation with dilated aortic root and ascending aorta (with a diameter of 92 mm)

Chong E, …, Poh KK AAMS 2012, 41(7): 311-312
various shapes of aortic root and ascending aortic aneurysms

1. Confirm diagnosis
2. Measure maximal diameter of the aneurysm
3. Define longitudinal extent of the aneurysm
4. Measure the diameters of the proximal and distal margins of the aneurysm
5. Determine involvement of the aortic valve and arch vessel(s)
6. Detect periaortic hematoma or other sign of leakage
7. Differentiate from aortic dissection
8. Detect mural thrombus
Coarctation of aorta

41 yr old Sikh for follow-up echo
Echo: aortic arch w color
CW Doppler across coarctation
a/w with BAV
Conclusions

• Considerable advances in diagnostic imaging techniques have further our understanding of thoracic aortic diseases.

• TTE continues to be the technique most used in clinical practice for aortic root assessment.

• TEE is able to guide management of aortic emergencies including dissection and IMH.

• CT and MRI are very useful tools as well.

• Echo remains key for diagnosis, prognostication and management of patients with aortic diseases.
Thank you

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