Diseases Of The Aorta

A/Prof David Prior

St Vincent’s Hospital
What Happens To Aortas

- Grow
- Pop
- Tear
- Block
- Embolize
Outline

• Anatomy & nomenclature
• Aortic measurements
• Aortic aneurysm
• Acute aortic syndromes
  – aortic dissection and variants
• Aortic coarctation
• Atherosclerosis
• Anatomy & nomenclature
• Aortic measurements
• Aortic aneurysm
• Acute aortic syndromes
  — aortic dissection and variants
• Aortic coarctation
• Atherosclerosis
Anatomy

Size varies with:
- Age
- Gender
- Body size (height, weight and BSA)

Erbel, *EHJ* 2014 35:2873
Age, Gender and BSA

Goldstein JASE 2015 28:119
Clinical Case
Importance of Serial Measures

2006

Asc Ao Diam 5.5 cm

2016

5.4 cm

5.2 cm
Guidance On Imaging the Aorta

Multimodality Imaging of Diseases of the Thoracic Aorta in Adults: From the American Society of Echocardiography and the European Association of Cardiovascular Imaging
Endorsed by the Society of Cardiovascular Computed Tomography and Society for Cardiovascular Magnetic Resonance

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(J Am Soc Echocardiogr 2015;28:119-82.)

Goldstein JASE 2015 28:119
Measuring The Aorta

- End-diastole
- Leading edge to leading edge
- Perpendicular to the long axis
- Compare to previous images
- Measurements may be different to other modalities

Goldstein JASE 2015 28:119
## Normal Range

### Table 1
Normal aortic root diameter by age for men with BSA of 2.0 m²

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>15–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60–69</th>
<th>≥70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean normal (cm)</td>
<td>3.3</td>
<td>3.4</td>
<td>3.5</td>
<td>3.6</td>
<td>3.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Upper limit of normal (cm) (95% CI)</td>
<td>3.7</td>
<td>3.8</td>
<td>3.9</td>
<td>4.0</td>
<td>4.1</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Add 0.5 mm per 0.1 m² BSA above 2.0 m² or subtract 0.5 mm per 0.1 m² BSA below 2.0 m².\(^6\)

CI, Confidence interval.

### Table 2
Normal aortic root diameter by age for women with BSA of 1.7 m²

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>15–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60–69</th>
<th>≥70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean normal (cm)</td>
<td>2.9</td>
<td>3.0</td>
<td>3.2</td>
<td>3.2</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Upper limit of normal (cm)</td>
<td>3.3</td>
<td>3.4</td>
<td>3.6</td>
<td>3.6</td>
<td>3.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Add 0.5 mm per 0.1 m² BSA above 1.7 m² or subtract 0.5 mm per 0.1 m² BSA below 1.7 m².\(^6\)

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Goldstein JASE 2015 28:119
Comparison of methods for imaging the aorta

<table>
<thead>
<tr>
<th>Advantages/disadvantages</th>
<th>TTE</th>
<th>TOE</th>
<th>CT</th>
<th>MRI</th>
<th>Aortography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of use</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Diagnostic reliability</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Bedside/interventional use</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Serial examinations</td>
<td>++</td>
<td>+</td>
<td>+++(+)</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>Aortic wall visualization</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>
</tr>
<tr>
<td>Radiation</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nephrotoxicity</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

+ means a positive remark and — means a negative remark. The number of signs indicates the estimated potential value.

++(+) only for follow-up after aortic stenting (metallic struts), otherwise limit radiation.
Thoracic Aortic Aneurysm

- Familial / Genetic
  - Marfan syndrome
  - Bicuspid aortic valve-related aortopathy
  - Ehlers-Danlos syndrome (Type IV)
  - Loeys-Dietz syndrome
  - Thoracic aortic aneurysm syndrome

- Acquired
  - Hypertension
  - Infective (Syphilis, salmonella)
  - Atherosclerosis
  - Trauma

Will need echo for surveillance
May need echo for diagnosis
Thoracic Aortic Aneurysm

• Familial / Genetic
  – Marfan syndrome
  – Bicuspid aortic valve-related aortopathy
  – Ehlers-Danlos syndrome (Type IV)

Most common conditions requiring screening of patients & relatives

  – Atherosclerosis
  – Trauma
## Choice Of Imaging Modality

**Table 17: Recommendations for choice of imaging modality for TAA**

<table>
<thead>
<tr>
<th>Modality</th>
<th>Recommendation</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>First-line</td>
<td>First-line technique for staging, surveillance</td>
<td>Use of ionizing radiation and ICM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contrast enhanced CT and MRI very accurate for</td>
<td>Cardiac motion can cause imaging artifacts</td>
</tr>
<tr>
<td>TTE</td>
<td>Second-line</td>
<td>Usually diagnostic for aneurysms effecting aortic root</td>
<td>Distal ascending aorta, arch, and descending aorta not reliably imaged</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful for family screening</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful for following aortic root disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excellent reproducibility of measurements</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excellent for AR, LV function</td>
<td></td>
</tr>
<tr>
<td>TEE</td>
<td>Third-line</td>
<td>Excellent for assessment of AR mechanisms</td>
<td>Less valuable for routine screening or serial follow-up (semi-invasive)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excellent images of aortic root, ascending aorta, arch, and descending thoracic aorta</td>
<td>Distal ascending aorta may be poorly imaged</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Does not permit full visualization of arch vessels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Limited landmarks for serial examinations</td>
</tr>
<tr>
<td>Aortography</td>
<td>Third-line</td>
<td>Reserved for therapeutic intervention</td>
<td>Invasive; risk for contrast-induced nephropathy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Useful to guide endovascular procedures</td>
<td>Visualizes only aortic lumen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Does not permit accurate measurements</td>
</tr>
</tbody>
</table>

LV, Left ventricular.

Goldstein JASE 2015 28:119
Aortic Dissection
Chest Pain

- 82 Y.O. male
- Sudden onset chest pain in chest and scapula
- Presented to ED
- Minor T wave changes on ECG
- Echocardiogram requested - ?AMI
• Urgent CT scan
  — “complex dissection involving the aortic arch, ascending and descending aorta arising from the aortic root.....”

• Urgent surgery
  — AVR and repair of dissection
# Clinical data useful to assess the a priori probability of acute aortic syndromes

<table>
<thead>
<tr>
<th>High-risk conditions</th>
<th>High-risk pain features</th>
<th>High-risk examination features</th>
</tr>
</thead>
</table>
| Marfan syndrome (or other connective tissue diseases) | Chest, back, or abdominal pain described as any of the following:  
- abrupt onset  
- severe intensity  
- ripping or tearing | Evidence of perfusion deficit:  
- pulse deficit  
- systolic blood pressure difference  
- focal neurological deficit (in conjunction with pain) |
| Family history of aortic disease | | Aortic diastolic murmur (new and with pain) |
| Known aortic valve disease | | Hypotension or shock |
| Known thoracic aortic aneurysm | | |
| Previous aortic manipulation (including cardiac surgery) | | |
Role Of Echo in Dissection
TTE & TEE

• Identification of a dissection flap
• Determine the extent of dissection & location of entry point
• Complications
  — Aortic valve function
  — Pericardial effusion & tamponade
  — LV function and regional wall motion (dissection of coronary ostia)
Artifacts in Aortic Imaging

Bertrand JASE 2016 29:381
Dissection of Balloon

Appelbe JACC 1993 21:754
60 YO female with resistant hypertension

Ascending 5.2 cm

Arch
Admitted to Hospital for Ix of HPT & Aorta

- Pain during procedure with marked hypertension
- Subsequent chest pain and hypotension
Descending Thoracic Aorta

- Type A dissection
- True vs False Lumen
- Surgery
Chest Pain 3 Weeks Post CABG
Urgent TEE
Descending Aorta
CT scanning for dissection
MRI for Aortic Dissection
**Test Accuracy**

**TABLE 3  Sensitivity of the Four Imaging Modalities**

<table>
<thead>
<tr>
<th>Image Modality</th>
<th>Overall</th>
<th>Type A</th>
<th>Type B</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEE</td>
<td>88%</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>(170/193)</td>
<td>(144/158)</td>
<td>(28/35)</td>
</tr>
<tr>
<td>CT</td>
<td>93%</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td>(353/379)</td>
<td>(180/193)</td>
<td>(173/186)</td>
</tr>
<tr>
<td>MRI</td>
<td>100% (9/9)</td>
<td>100% (2/2)</td>
<td>100% (7/7)</td>
</tr>
<tr>
<td>Aortography</td>
<td>87% (21/24)</td>
<td>87% (13/15)</td>
<td>89% (8/9)</td>
</tr>
</tbody>
</table>

**Moore AmJCard 2002 89:1235**  
**Goldstein JASE 2015 28:119**
# Choice of Imaging Modality for Aortic Dissection

## Table 9: Recommendation for choice of imaging modality for aortic dissection

<table>
<thead>
<tr>
<th>Modality</th>
<th>Recommendation</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>First-line</td>
<td>- Initial test in &gt;70% of patients*&lt;br&gt;- Widely available, quickest diagnostic times&lt;br&gt;- Very high diagnostic accuracy&lt;br&gt;- Relatively operator independent&lt;br&gt;- Allows evaluation of entire aorta, including arch vessels, mesenteric vessels and renal arteries</td>
<td>- Ionizing radiation exposure&lt;br&gt;- Requires iodinated contrast material&lt;br&gt;- Pulsation artifact in ascending aorta (can be improved with ECG gating)</td>
</tr>
<tr>
<td>TEE</td>
<td>First- and second-line</td>
<td>- Very high diagnostic accuracy in thoracic aorta&lt;br&gt;- Widely available, portable, convenient, fast&lt;br&gt;- Excellent for pericardial effusion, and presence, degree and mechanism(s) of AR and LV function&lt;br&gt;- Can detect involvement of coronary arteries&lt;br&gt;- Safely performed on critically ill patients, even those on ventilators&lt;br&gt;- Optimal procedure for guidance in OR</td>
<td>- Operator dependent (depends on skill of operator)&lt;br&gt;- &quot;Blind spot&quot; upper ascending aorta, proximal arch&lt;br&gt;- Not reliable for cerebral vessels, celiac trunk, SMA, etc.&lt;br&gt;- Reverberation artifacts can potentially mimic dissection flap (can be differentiated from flaps in vast majority)&lt;br&gt;- Semi-invasive</td>
</tr>
<tr>
<td>TTE</td>
<td>Second-line</td>
<td>- Often initial imaging modality in ER&lt;br&gt;- Provides assessment of LV contractility, pericardial effusion, RV size and function, PA pressure&lt;br&gt;- Presence and severity of AR</td>
<td>- Sensitivity not sufficient distal to aortic root&lt;br&gt;- Descending thoracic aorta imaged less easily and accurately&lt;br&gt;- Misses IMH and PAU</td>
</tr>
<tr>
<td>MRI</td>
<td>Third-line</td>
<td>- 3D multiplanar, and high resolution&lt;br&gt;- Very high diagnostic accuracy&lt;br&gt;- Does not require ionizing radiation or iodinated contrast&lt;br&gt;- Appropriate for serial imaging over many years</td>
<td>- Less widely available&lt;br&gt;- Difficult monitoring critically ill patients&lt;br&gt;- Not feasible in emergent or unstable clinical situations&lt;br&gt;- Longer examination time&lt;br&gt;- Caution with use of gadolinium in renal failure</td>
</tr>
<tr>
<td>Angiography</td>
<td>Fourth-line</td>
<td>- Rarely necessary</td>
<td>- Often misses IMH (up to 10%-20% of ADs)&lt;br&gt;- Long diagnostic time&lt;br&gt;- Requires ICM&lt;br&gt;- Morbidity&lt;br&gt;- Less sensitivity than CT, TEE, and MRI</td>
</tr>
</tbody>
</table>

*AD, Aortic dissection; ECG, electrocardiographic; ER, emergency room; ICM, iodinated contrast media; IMH, intramural hematoma; LV, left ventricular; OR, operating room; PA, pulmonary artery; PAU, penetrating atherosclerotic ulcer; RV, right ventricular; SMA, superior mesenteric artery.
Intramural Haematoma

• A localized contained dissection
Admitted to Hospital for Ix of HPT & Aorta
Aortic Coarctation
Aortic Atheroma

• May be a source of systemic embolism
Summary

• Both TTE and TEE have a role in the investigation & management of aortic disease
• Often used in conjunction with other imaging modalities
• Consistent and accurate measurement is critical for serial studies
• Echo provides additional information about valve & ventricular function in aortic dissection