Echocardiographic Evaluation of the Aorta

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Professor of Medicine
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The Aorta: What to Evaluate

- Dimensions / shape
- Atherosclerotic disease
- Presence / absence of aneuysm
- Presence / absence of dissection
- Associated anatomy
  - Bicuspid aortic valve
The Aorta: When to Evaluate

- Symptoms suggestive of aortic disease
- Known predisposing factor for aortic disease
- Other test (CXR etc.) suggests aortic disease
- First degree relatives of patients with aortic disease
## Imaging Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Extent</th>
<th>Atheroma</th>
<th>Dissection</th>
<th>Associated Disease</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTE</td>
<td>AV, Proximal aorta &amp; arch</td>
<td>No</td>
<td>Limited</td>
<td>All cardiac anatomy, AI, LV function, PEF</td>
<td>Limited visualization</td>
</tr>
<tr>
<td>TEE</td>
<td>Aortic Valve to diaphragm</td>
<td>Yes</td>
<td>Accurate as viewed</td>
<td>All cardiac anatomy, AI, LV function, PEF</td>
<td>Limited to above diaphragm</td>
</tr>
<tr>
<td>CT</td>
<td>Aortic valve to femorals</td>
<td>Yes</td>
<td>Accurate</td>
<td>Some anatomy, PEF, LV function</td>
<td>Dye load, radiation, motion artifact</td>
</tr>
<tr>
<td>MRI</td>
<td>Aortic valve to femorals</td>
<td>Yes</td>
<td>Accurate</td>
<td>Most cardiac anatomy, AI, LV function, PEF</td>
<td>Patient tolerance and safety</td>
</tr>
<tr>
<td>Angiography</td>
<td>Aortic valve to femorals</td>
<td>Yes</td>
<td>Accurate</td>
<td>Nada</td>
<td>Invasive, restricted availability</td>
</tr>
</tbody>
</table>

- **TTE** (Transesophageal Echocardiogram):
  - Extent: AV, Proximal aorta & arch
  - Atheroma: No
  - Dissection: Limited
  - Associated Disease: All cardiac anatomy, AI, LV function, PEF
  - Limitations: Limited visualization

- **TEE** (Transcranial Echocardiogram):  
  - Extent: Aortic Valve to diaphragm
  - Atheroma: Yes
  - Dissection: Accurate as viewed
  - Associated Disease: All cardiac anatomy, AI, LV function, PEF
  - Limitations: Limited to above diaphragm

- **CT** (Computed Tomography):  
  - Extent: Aortic valve to femorals
  - Atheroma: Yes
  - Dissection: Accurate
  - Associated Disease: Some anatomy, PEF, LV function
  - Limitations: Dye load, radiation, motion artifact

- **MRI** (Magnetic Resonance Imaging):  
  - Extent: Aortic valve to femorals
  - Atheroma: Yes
  - Dissection: Accurate
  - Associated Disease: Most cardiac anatomy, AI, LV function, PEF
  - Limitations: Patient tolerance and safety

- **Angiography:**  
  - Extent: Aortic valve to femorals
  - Atheroma: Yes
  - Dissection: Accurate
  - Associated Disease: Nada
  - Limitations: Invasive, restricted availability
Measuring the Aorta

- Measure and record at multiple, predefined sites
- “Aortic root” = biggest proximal dimension
- Most patients will require at least one evaluation of the entire aorta
- Tailor subsequent assessment to area of disease
- Measure internal dimensions on TEE, external with CT
Evaluating the Aorta: Which Technique Sees What
“Acute Aortic Syndrome”

- Acute aortic dissection
  - Type A, B
- Acute intramural hematoma
- Rapidly expanding aneurysm
- Ruptured Aneurysm
- Penetrating ulcer
WG: 24 YO male

- Told of dilated aorta at age 18
  - No meds and no follow-up
- Sudden chest pain at work
- Cardiac arrest in ambulance
- CPR not successful in ED
- Autopsy: type I dissection
SJ: 54 YO male

- PMHx = HTN, type 2 diabetes
- Dull retrosternal pain for 40 minutes
  - Normal ECG and cardiac enzymes
- Discharged after MI excluded
- Subsequent arrest at home
- Autopsy: type I dissection

Litigation Pending
Classification of Aortic Dissection

If the ascending aorta is involved, call a surgeon!
Classic Dissection vs. Intramural Hematoma (IMH)

Presenting signs and symptoms, management strategies and outcomes are virtually identical.
Aortic Dissection: High Risk Conditions

- Marfan Syndrome
- Connective tissue disease*
- Family history of aortic disease
- Known aortic valve disease
- Recent aortic manipulation (surgical or catheter-based)
- Known thoracic aortic aneurysm
- Genetic conditions that predispose to TAD†

* Loeys-Dietz syndrome, vascular Ehlers-Danlos syndrome, Turner syndrome, or other connective tissue disease.

† Patients with mutations in genes known to predispose to thoracic aortic aneurysms and dissection, such as FBN1, TGFBR1, TGFBR2, ACTA2, and MYH11.
Aortic Dissection: Incidence

- Incidence estimated at 5-20/million
- Anticipate ~ 5000/year in U.S.
  - 500,000 acute MI/year
- Mortality for type A dissection
  - 1% / hour in first 24 hours
  - 75 – 90% at 30 days
- Current data suggest incidence may be higher and mortality a bit lower
Legends

• Only “tall people” dissect
• Dissection is always preceded by significant dilation of the aorta
• The pain of dissection is classic and allows a precise diagnosis
• The physical exam and CXR will accurately screen for acute dissection
• Dissection most often results in fatal cardiac complications
• Surgery is much “better” now than in prior years
• Surgery always must be undertaken immediately
“Classic” vs. Common

Flo Hyman 1954 - 1986

John Ritter
Marfan Syndrome
TEE of Bicuspid AV with Dilated Aorta
Aortic Dilation in Bicuspid Aortic Valve
### Younger vs. Older Patients with Acute Aortic Dissection - IRAD

<table>
<thead>
<tr>
<th>Variables</th>
<th>Age &lt;40 n = 68</th>
<th>Age ≥ 40 n = 883</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs (mean ± SD)</td>
<td>30.7 ±6.6</td>
<td>63.9 ±11.5</td>
<td>NA</td>
</tr>
<tr>
<td>Type A</td>
<td>46 (68)</td>
<td>574 (65)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>23 (34)</td>
<td>635 (72)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Marfan Syndrome</td>
<td>34 (50)</td>
<td>19 (2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Bicuspid aortic valve</td>
<td>6 (9)</td>
<td>12 (1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hypertension (SBP &gt; 150 mm Hg)</td>
<td>17 (25)</td>
<td>394 (45)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Januzzi et al JACC 2004
Aortic Diameter vs. Likelihood of Acute Dissection

- Aortic size on presentation with acute Type A dissection
- 591 patients
- Size from CT / TEE / MR or angiography
- HTN and age were associated with dissection at smaller size
- Marfan associated with larger size

Pape et al. IRAD, Circulation, 2007
Aortic Diameter vs. Likelihood of Acute Dissection

Pape et al. IRAD, Circulation, 2007
### Clinical Presentation: Pain Character

<table>
<thead>
<tr>
<th>Pain</th>
<th>A + B</th>
<th>Type A</th>
<th>Type B</th>
<th>p=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any pain</td>
<td>95.5%</td>
<td>93.8%</td>
<td>98.3%</td>
<td>.02</td>
</tr>
<tr>
<td>Abrupt</td>
<td>84.8%</td>
<td>85.4%</td>
<td>83.8%</td>
<td>.65</td>
</tr>
<tr>
<td>Chest</td>
<td>72.7%</td>
<td>78.9%</td>
<td>62.9%</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Anterior</td>
<td>60.9%</td>
<td>71%</td>
<td>44%</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Back</td>
<td>53.2%</td>
<td>46.6%</td>
<td>63.8%</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Abdominal</td>
<td>29.6%</td>
<td>21.6%</td>
<td>42.7%</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Hagan et al. JAMA 2000
Clinical Presentation: Pain Character

<table>
<thead>
<tr>
<th>Pain</th>
<th>A + B</th>
<th>Type A</th>
<th>Type B</th>
<th>p=</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 of 10</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Sharp</td>
<td>64%</td>
<td>62%</td>
<td>68%</td>
<td></td>
</tr>
<tr>
<td>Tearing</td>
<td>51%</td>
<td>49%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>Migrating</td>
<td>17%</td>
<td>13%</td>
<td>19%</td>
<td>.22</td>
</tr>
<tr>
<td>Radiating</td>
<td>28%</td>
<td>27%</td>
<td>30%</td>
<td>.51</td>
</tr>
<tr>
<td>Syncope</td>
<td>9%</td>
<td>13%</td>
<td>4%</td>
<td>.002</td>
</tr>
</tbody>
</table>

Hagan et al.   JAMA 2000
The Pain of Dissection: Practical Clues

- Classic, abrupt, tearing chest & back pain does occur – but it represents a minority of cases
- Other clues:
  - Pain with multiple migratory areas
  - Recurrent pain - stable EKG
  - Pain not responsive to NTG
  - Minimal troponin leak
  - **Abrupt onset, no prodrome**
Clinical Presentation: Physical Exam

<table>
<thead>
<tr>
<th></th>
<th>A + B</th>
<th>Type A</th>
<th>Type B</th>
<th>p=</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI on exam</td>
<td>32%</td>
<td>44%</td>
<td>12%</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pulse deficit</td>
<td>15%</td>
<td>19%</td>
<td>9.2%</td>
<td>.006</td>
</tr>
<tr>
<td>CVA</td>
<td>4.7%</td>
<td>6.1%</td>
<td>2.3%</td>
<td>.07</td>
</tr>
<tr>
<td>CHF</td>
<td>6.6%</td>
<td>8.8%</td>
<td>3.0%</td>
<td>.02</td>
</tr>
</tbody>
</table>

On echocardiography, > 70% of patients will have aortic insufficiency

Hagan et al. JAMA 2000
Clinical Presentation: CXR

<table>
<thead>
<tr>
<th></th>
<th>N= 427</th>
<th>A + B</th>
<th>A</th>
<th>B</th>
<th>p=</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Abnormality</td>
<td>12%</td>
<td>11%</td>
<td>16%</td>
<td></td>
<td>.08</td>
</tr>
<tr>
<td>Mediastinum Nl</td>
<td>21%</td>
<td>17%</td>
<td>27%</td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>Wide Mediastinum</td>
<td>62%</td>
<td>63%</td>
<td>56%</td>
<td></td>
<td>.17</td>
</tr>
<tr>
<td>Aorta Abnormal</td>
<td>50%</td>
<td>47%</td>
<td>53%</td>
<td></td>
<td>.20</td>
</tr>
<tr>
<td>Heart Abnormal</td>
<td>26%</td>
<td>27%</td>
<td>24%</td>
<td></td>
<td>.49</td>
</tr>
<tr>
<td>Pleural Effusion</td>
<td>19%</td>
<td>17%</td>
<td>22%</td>
<td></td>
<td>.24</td>
</tr>
</tbody>
</table>

Hagan et al. JAMA 2000
When to Order Which Test?

- Order the test which works best in your hands and establishes / excludes the diagnosis the fastest and most reliably
- Generally this will be CTA or TEE
- Liberally order a second test if #1 is inconclusive or specific data are missing
- Over 75% of patients in IRAD centers undergo two or more imaging studies
56 YO Male with Chest Pain
56 YO Male with Chest Pain
Acute Type A Dissection
Type A with AI
Mechanism of AI in Type A Dissection
### Accuracy of Transesophageal Echocardiography for Detection of Aortic Dissection

<table>
<thead>
<tr>
<th>Ref.</th>
<th>N</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erbel et al., 1987</td>
<td>21</td>
<td>21/21 (100%)</td>
<td>N/C</td>
<td>SP</td>
</tr>
<tr>
<td>Erbel et al., 1989</td>
<td>164</td>
<td>81/82 (98.7)</td>
<td>78/80 (97.5%)</td>
<td>SP</td>
</tr>
<tr>
<td>Hashimoto et al., 1989</td>
<td>22</td>
<td>22/22 (100%)</td>
<td>N/C</td>
<td>BP</td>
</tr>
<tr>
<td>Adachi et al., 1991</td>
<td>45</td>
<td>44/45 (97.7%)</td>
<td>N/C</td>
<td>SP, BP</td>
</tr>
<tr>
<td>Ballal et al., 1991</td>
<td>61</td>
<td>33/34 (97%)</td>
<td>27/27 (100%)</td>
<td>SP, BP</td>
</tr>
<tr>
<td>Simon et al., 1992</td>
<td>32</td>
<td>28/28 (100%)</td>
<td>4/4 (100%)</td>
<td>SP, BP</td>
</tr>
<tr>
<td>Nienaber et al., 1993</td>
<td>70</td>
<td>43/44 (97.7%)</td>
<td>20/26 (76.9%)</td>
<td>BP</td>
</tr>
<tr>
<td>Karen et al., 1996</td>
<td>112</td>
<td>48/49 (98%)</td>
<td>60/63 (95%)</td>
<td>BP, MP</td>
</tr>
<tr>
<td>Total</td>
<td>527</td>
<td>320/325 (98.5%)</td>
<td>189/200 (94.5%)</td>
<td></td>
</tr>
</tbody>
</table>
Limitations of Transesophageal Echocardiography

- No visualization below the diaphragm
- Inexperienced operator
- Inexperienced operator
- Inexperienced operator
- Limited IMH
- Isolated arch pathology
Discrete Arch Aneurysm
Discrete Arch Aneurysm
Causes of Mortality in Acute Aortic Dissection

- Cardiovascular
  - Tamponade
  - Aortic rupture
  - Coronary compromise
- Major organ compromise
  - Mesenteric
  - Renal
  - CNS
- Surgical and post surgical

Generally Early

All equally fatal.

Generally Delayed
Type A Dissection: Hospital Mortality

• Acute Type A dissection
  – $n=547$
  – age $62 \pm 14$ years
  – 32.5% Hospital mortality

• Demographics and clinical presentation for markers of adverse outcome

• Predictive model developed

R Mehta for the IRAD Investigators, Circulation 2002
63 YO Male with Syncope
63 YO Male with Syncope: Two Minutes Later
63 YO Male with Syncope: Three Minutes Later
### Type A Dissection Predictive Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Score</th>
<th>O.R.</th>
<th>P=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 70 years</td>
<td>0.5</td>
<td>1.7</td>
<td>0.03</td>
</tr>
<tr>
<td>Female</td>
<td>0.3</td>
<td>1.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Abrupt pain</td>
<td>1.0</td>
<td>2.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Abnormal ECG</td>
<td>0.6</td>
<td>1.8</td>
<td>0.03</td>
</tr>
<tr>
<td>Pulse deficit</td>
<td>0.7</td>
<td>2.0</td>
<td>0.004</td>
</tr>
<tr>
<td>Renal failure</td>
<td>1.6</td>
<td>4.8</td>
<td>0.002</td>
</tr>
<tr>
<td>Hypotension / shock</td>
<td>1.1</td>
<td>3.0</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

R Mehta for the IRAD Investigators, Circulation 2002
Mortality With Acute Type A Aortic Dissection: vs. Predictive Score

Mehta et al. circulation 2002
Intramural Hematoma
Intramural Hematoma
Evolution in Diagnosis of IMH

Evangelista A, et al., Circulation 2005;111:1063-1070
In-hospital Mortality for IMH

- 1010 patients with AAD in IRAD
- IMH in 58 (5.7%)
- Less likely to have AI or pulse deficits
- More difficult to diagnose
- Less often surgically treated

Evangelista A, et al., Circulation 2005;111:1063-1070
Adventitial Hematoma

- Represents leak of blood outside the aortic lumen
- Implies partial rupture at some location along the dissection
- Potentially unstable hemodynamics
- Independent predictor of mortality in surgical patients
TEE: Patent False Lumen

- Acutely allows further propagation of dissection (type A)
- Subsequent additional organ compromise
- Chronically in type B appears protective
False Lumen Thrombosis

- Implies a completed event
- No hydrodynamic drive for further propagation
- Presumed stable wall structure
“Healed Type B Dissection

At presentation

Three months later
Ulcerated Plaque

- Symptoms of an acute aortic syndrome
- Virtually always have severe atheromatous disease, usually in descending thoracic aorta
- Penetrates to variable degree and may extend through aortic wall
- Treatment based on “anatomic insult”
  - Medical vs. Surgical vs. Percutaneous
Ulcerated Plaque
Ulcerated Plaque
Ulcerated Plaque or Natural History Museum Diaorama?
2009: Where are We with Surgery for Acute Aortic Dissection?

There’s good news, and there’s bad news.

First the good news!!
Type A: Pre OP TEE
Type A: Pre Op
Type A: Post Op
Type A: Post Op
2009: Where are We with Surgery for Acute Aortic Dissection?

Now the bad news.
Surgical Management

- 30 year experience
- 360 patients, 256 male, age 57 ± 14
- 174 acute type A (48%)
- Operative mortality 24%

Fann et al, Stanford; Circulation 1995
Aortic Dissection: Surgical Mortality

Fann et al. Circulation 1995
Surgical Results for Acute Type A Dissection: IRAD

• 526 patients with acute type A dissection

• Unstable (Group I) if:
  • Cardiac tamponade
  • Shock
  • Coma
  • Stroke
  • Myocardial ischemia / infarction
  • Renal or mesenteric ischemia

• Stable (Group II) in the absence of above

• Valve replaced in 111 (23%)

Trimarchi et al, JTCVS, January 2005
Mortality in Unstable and Stable Patients vs. Time to Surgery

Trimarchi et al. JTCVS, January 2005.
Acute Aortic Dissection: Conclusions

• Presentation more variable than traditionally taught
  – It’s not just tall people
  – Need to consider early and more often

• Remains highly lethal
  – Mortality often has nothing to do with the heart

• Emergent surgery for type A dissection
  – Definite role for delayed surgery / percutaneous intervention
  – Maybe, just maybe, there is a lower risk Type A population that can be defined by imaging
Go Blue!