Diseases of the Aorta: Dissection, Hematoma and Trauma

SAX

Normal Ao Valve

Long Axis

LVOT Sinus of Valsalva

RCC LCC NCC

Aortic Valve

LVOT Sinus of Valsalva

RCC LCC NCC

LVOT Sinus of Valsalva
Identify the Reason for this Emergency TEE

Type of Aneurysm: Causes

- False saccular aneurysm: Trauma
- True diffuse and saccular aneurysms: Connective tissue generic disorders, Non-inflammatory medial disease, Aortitis, Atherosclerosis
- Dissecting aneurysms: Connective tissue disorders: Hypertension, Marfan’s
PATHOPHYSIOLOGY

• Deterioration of medial collagen and elastin

• A tear in the intimal layer allows blood to enter the intima-media space

• Blood then propagates down this new space creating a “true” and a “false” lumen

Cystic Medial Change

- Hypertension
- Marfan’s and Ehler-Danlos
- Coarctation and bicuspid aortic valve
- Pregnancy
- Trauma
- Perforation through an intimal atheromatous plaque
### Types of Aortic Dissection

<table>
<thead>
<tr>
<th>De Bakey</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stanford</td>
<td>Type A</td>
<td>Type A</td>
<td>Type B</td>
</tr>
</tbody>
</table>

**Hallmark:** visualization of mobile dissection flap motion that is independent of the Aorta. Visualization on more than one view. Clear distinction from reverberations.
Predicting Death in Patients with Acute Type A Aortic Dissection

- 547 pts; IRAD; Jan 96-Dec 99
- In hospital mortality 32.5%
  - Age $\geq$ 70 years
  - Abrupt onset of Cx pain
  - Hypotension, shock, tamponade
  - Kidney failure
  - Pulse deficit
  - ECG abnormalities

Circulation 2002;105:200-206
Distal or descending – Type III Aortic Dissection

Iatrogenic (intra-arterial catheterization) – Type IV

Management of Aortic Dissection

Depends not only on the type but also on time elapsed between onset and presentation

- Acute < 2 weeks
  - 24 Hour hyper-acute period (Risk of rupture approaching 1% per hour)
  - 75% of AD related deaths occur in first two weeks
- Subacute > 2 weeks - 2 months
- Chronic > 2 months
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>

Aortic Dissection: Pulse Loss

Due to direct compression
Blockade due to flap of intima
Survival Curves for Type A Dissection
By Number of Pulse Deficits on Presentation

Circulation 2003;108:628-635

GOALS OF DIAGNOSTIC IMAGING

- Confirm the diagnosis
- Classify the dissection and determine extent
- Detect extravasation
- Detect and Grade AI

- Aortography
- Spiral CT
- MRI
- TTE / TEE
Aortic Dissection: Choice of Imaging Technique

• Fine tradeoff in sensitivity and specificity
• Availability of technique
• Experience and expertise at a given institution
• Degree of urgency
• Stability of the patient

Aortic Dissection: Why Multiple Studies?

• Initial study often done at referral site
  Confirmation needed or desired
• If CT first
  Still need cardiac anatomy, valve status etc
• If echocardiography first
  Still need assessment of abdominal aorta in many instances
Procedure Used for the Diagnosis of Aortic Dissection


Diagnostic value of different imaging modalities in acute aortic syndromes

<table>
<thead>
<tr>
<th>Lesion</th>
<th>TTE</th>
<th>TEE</th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending aortic dissection</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Aortic arch dissection</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Descending aortic dissection</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Size</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Mural thrombus</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Intramural hematoma</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Penetrating aortic ulcer</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Involvement of aortic branches</td>
<td>+²</td>
<td>(+)</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

²Can be improved when combined by vascular ultrasound (carotid, subclavian, vertebral, celiac, mesenteric, and renal arteries). +++=excellent; ++=moderate; +=poor and inconstant; CT=computed tomography; MRI=magnetic resonance imaging; TOE=transesophageal echocardiography; TTE=transthoracic echocardiography.
**TEE in Aortic Dissection**

- Hallmark is visualization of mobile dissection flap
- Motion that is independent of the Aorta
- Visualization on more than one view
- Clear distinction from reverberations

Systolic expansion of the true lumen
Diastolic expansion of the false lumen

**Aortic Dissection: Intimal Flap and Entry Site**
Advantages of TEE in Aortic Dissection

• Origin and proximal extent of the dissection flap
• Dimension of the aorta
• Severity of Aortic Insufficiency
• Pericardial effusion
• Coronary involvement

TEE in AD: Disadvantages

• Interposition of the trachea between the ascending aorta and the esophagus impeding visualization of distal ascending aorta and proximal arch
• Brachiocephalic and LCC artery difficult to visualize
• Celiac trunk and superior mesenteric artery cannot be consistently imaged
• Reverberation artifacts
TTE Echo in Aortic Dissection
Suprasternal Approach

3D Epicardial Echo in Aortic Dissection
Advantages of CT in Aortic Dissection

- **CT first time imaging modality**
- In 62% of Type A Ad, CT is the first imaging modality
- Diagnostic accuracy near 100% to exclude Ad
- Evaluation of the entire aorta and branches
- Shortest time to diagnosis
- Disadvantage: Need for iodinated contrast and radiation

Information required from imaging in acute aortic dissection

- Visualization of intimal flap
- Extent of the disease (aortic segmentation)
- Identification of the false and true lumens (if present)
- Localization of entry and re-entry tears (if present)
- Identification of severity and mechanism of aortic valve regurgitation
- Involvement of side branches
- Detection of pericardial effusion
- Detection and extent of pleural effusion
- Detection of peri-aortic and mediastinal bleeding
Aortic Dissection: Complications

- Aortic regurgitation
- Pericardial effusion (rupture of the false lumen into the pericardium) Echo best for pericardial effusion; CT for pleural effusion and peri-aortic hematoma
- Coronary artery involvement (invagination of intimal flap into the coronary
- Other branch vessel involvement

Aortic Dissection: Mechanism of AR

AR occurs in 50% of patients with typeA aortic dissection

Dilatation of aortic root. Pressure from dissecting hematoma may depress one leaflet below line of closure. Prolapse or flail Torn annular support of the leaflets.
Aortic Dissection: Mechanism of AR
Aortic Dissection: Mechanism of AR

Intimal Flap Prolapse

Aortic Dissection: Complications
Aortic Dissection: Endovascular Repair

• 1,3,6 and 12 months then yearly
• Ao diameter and status of the false lumen
  • (thrombosed or patent)
• Dilatation of the Ao is predictor of rupture
  • (Diameter > 60 or annual growth > 5 mm)
• Completely thrombosed false lumen (improved outcomes)
• Patent false lumen (risk for expansion and death)
  • Entry tear size
• Flap confined to ascending Ao (improved outcomes)
Classification of Acute Aortic Syndrome in Aortic Dissection

Class 1: Classic AD with True and False Lumen

Class 2: Intramural Hematoma

Class 3: Discrete AD with bulging of the Ao wall

Class 4: Ulceration of Aortic plaque following plaque rupture

Class 5: Iatrogenic or traumatic AD

Atypical Aortic Dissection

Intramural Hematoma

Penetrating Atherosclerotic Ulcer
**Intramural Hematoma**

- Rupture of the VASA vasorum
  - Discrete hematoma
    - Extends for a variable distance by dissecting along the outer media beneath the adventitia

**Intramural Hematoma: Diagnosis**

- Contained hemorrhage within the medial layer of the aortic wall
- Crescentic area along the aortic wall

- MRI
- TEE
- CT
**Imaging features of IMH**

- IMH represents hemorrhage into medial layer of aorta with absence of dissection flap and false lumen
- Focal aortic wall thickening (crescentic > concentric)
- Preserved luminal shape with smooth luminal border
- Echoluscent regions may be present in the aortic wall
- Central displacement of intimal calcium

**Significance of Echo-Free Space Detected by TEE in Type B AIH**

- Prevalence 60%
- Not a poor prognostic factor
- Not associated with the development of AD
Differential Diagnosis

Acute and Chronic Complications of IMH

Day 1

Day 7
Intramural Hematoma: Natural History

1, 3, 6, 9, and 12 months, then yearly

- Regress
- Dissection with longitudinal propagation
- Localized Dissection
- Fusiform aneurysm
- Persistence of IMH
- Saccular aneurysm
- Pseudo-aneurysm

IMH: Predictors

- Can progress to localized or frank dissection or rupture
- IMH thickness (>10 mm) and maximal aortic diameter (4cm) predict risk for progression
- Peri-aortic hemorrhage or pleural effusion (microperforations or inflammatory exudate)
- Penetrating ulcer or ulcer-like projection secondary to localized dissections in the involved segment
Penetrating Aortic Ulcer

- Ulceration of an atherosclerotic lesion penetrates the aortic internal elastic lamina into the aortic media
- Disease of the intima
- Mid and distal descending thoracic aorta

Penetrating Atherosclerotic Ulcer

- Almost exclusively in the descending Ao
- Usually remains localized
- Chest and back pain without associated AR or neurological deficits
Details required from imaging in Penetrating Aortic Ulcer

- Localization of the lesion (length and depth)
- Co-existence of intramural hematoma
- Peri-aortic tissue and bleeding
- Thickness of the residual wall
- CT, MRI and TEE

PAU’s: imaging parameters to report

- Lesion location
- Lesion depth of penetration
- Width at entry site
- Axial length of associated intramural hematoma
Natural history is unclear
No defined strategy
Surgical repair for
Pseudoaneurysm
Transmural rupture
Hemodynamic instability
Continued pain
Distal embolization
Aneurysmal dilatation

Differential Diagnosis

- Ao Dissection
- Thrombosed False Lumen
- Ao atherosclerotic aneurysm
- Pseudoaneurysm
- IAH
Aortic Root and Ascending Aortic Aneurysm

Stretching of the entire thickness of the aorta
The majority involve root and proximal tubular ascending aorta

- Confirm diagnosis
- Maximal diameter
- Define longitudinal extent
- Involvement of the aortic valve
- Involvement of arch vessels
- Mural thrombus, dissection, periaortic hematoma

*Aortic diameter principal predictor of rupture increases significantly >6 cm*

CT first line
MRI second line
TTE second line
TEE third line
## Grading system for severity of aortic atherosclerosis

<table>
<thead>
<tr>
<th>Grade</th>
<th>Severity (atheroma thickness)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td>Intimal thickness &lt;2mm</td>
</tr>
<tr>
<td>2</td>
<td>Mild</td>
<td>Mild(focal or diffuse) intimal thickening of 2-3 mm</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Atheroma &gt;3-5mm (no mobile/ulcerated components)</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>Atheroma &gt;5mm (no mobile/ulcerated components)</td>
</tr>
<tr>
<td>5</td>
<td>Complex</td>
<td>Grade 2,3, or 4 atheroma plus mobile or ulcerated components</td>
</tr>
</tbody>
</table>

### Examples

- **Intimal thickness <2mm**
  - Grade 1: Normal
  - Grade 2: Mild
  - Grade 3: Moderate
  - Grade 4: Severe
  - Grade 5: Complex

- **Intimal thickness 2-3mm**
  - Grade 1: Normal
  - Grade 2: Mild
  - Grade 3: Moderate
  - Grade 4: Severe
  - Grade 5: Complex

### Complex

Complex: Grade 2,3, or 4 atheroma plus mobile or ulcerated components
High-Speed Deceleration Accident

- Cardiac contusion
- Aortic injury
- Myocardial valve injury

Blunt Chest Trauma

Generates shearing forces that act maximally on the aortic isthmus
Blunt Aortic-Brachiocephalic Trauma

Fisher et al, 1981 (n=510)

- 88%
- 8%
- 4%

Vignon et al, 1998 (n=25)

- 84%
- 8%

Aortic Disruption: Anatomical Types

- Complete
- Subtotal
- Partial Tear
- Intimal Tear
Complete Transection

- Circular flap, separation of media from adventitia along entire circumference of the aorta
- Elongation of the aorta consistent with pseudoaneurysm formation
- Increased distance from the sector consistent with hemomediastinum
- Turbulent color flow at the site of the tear

Subtotal Transection

- Media flap involves at least 2/3 of aortic circumference
- Spiral effect, small section of intact media and adventitia
- Flap is vertically oriented
- Tubulent color flow Doppler on both sides of the flap
- Oblong shape of the aorta
**Partial Tear**

- Localized media flap involving a relatively small section of the aorta
- Extravasation of blood between the media and adventitia
- Usually can define an entry site into a pseudoaneurysm

**Intimal Tear**

- Intima is lifted off of the media
- Free, highly mobile
- No color flow disturbance on Doppler
- Unclear prognostic importance
Dissection vs. Disruption

TEE Longitudinal View

Dissection

Disruption
Figure 51. Abdominal aortic pulsed-wave Doppler examination in a patient with severe aortic coarctation demonstrates reduced and delayed systolic forward flow and persistent forward flow during diastole (yellow arrow). This "diastolic tail" is a pathognomonic sign of a hemodynamically significant coarctation.
Figure 9 | Endovascular repair of Stanford type B aortic dissection. A catheter is used to insert an expandable stent graft into the aorta to cover the site of the intimal tear. In cases in which the stent graft occludes a branching artery, pre-emptive surgery is required (hybrid intervention) to vascularize the occluded artery. The covered stent graft excludes the false lumen, which collapses. Bleeding from the false lumen rupture is prevented by thrombosis within the false lumen and the covered stent graft. The endovascular approach may induce re-approximation and remodelling of the dissected segment. In the figure on the left, the arrow indicates blood flow out of the true lumen and into the false lumen.

Table 5  Laboratory tests required for patients with acute aortic dissection

<table>
<thead>
<tr>
<th>Laboratory tests</th>
<th>To detect signs of</th>
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<tbody>
<tr>
<td>Red blood cell count</td>
<td>Blood loss, bleeding, anaemia</td>
</tr>
<tr>
<td>White blood cell count</td>
<td>Infection, inflammation (SIRS)</td>
</tr>
<tr>
<td>C-reactive protein</td>
<td>Inflammatory response</td>
</tr>
<tr>
<td>ProC5kinin</td>
<td>Differential diagnosis between SIRS and sepsis</td>
</tr>
<tr>
<td>Creatine kinase</td>
<td>Reperfusion injury, rhabdomyolysis</td>
</tr>
<tr>
<td>Troponin I or T</td>
<td>Myocardial ischaemia, myocardial infarction</td>
</tr>
<tr>
<td>D-dimer</td>
<td>Aortic dissection, pulmonary embolism, thrombosis</td>
</tr>
<tr>
<td>Creatinine</td>
<td>Renal failure (existing or developing)</td>
</tr>
<tr>
<td>Aspartate transaminase/</td>
<td>Liver ischaemia, liver disease</td>
</tr>
<tr>
<td>Alanine aminotransferase</td>
<td></td>
</tr>
<tr>
<td>Lactate</td>
<td>Bowel ischaemia, metabolic disorder</td>
</tr>
<tr>
<td>Glucose</td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Blood gases</td>
<td>Metabolic disorder, oxygenation</td>
</tr>
</tbody>
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SIRS = systemic inflammatory response syndrome.
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