Contents Under Pressure: Radiologic Findings of Abdominal Aortic Aneurysmal Rupture

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Our Patient: Initial Presentation

• History of Present Illness:
  63 year-old woman with a known history of abdominal aortic aneurysm (AAA) presents with acute onset chest and lower back pain s/p MVC
Our Patient: Initial Presentation

- **Past Medical History:** Hypercholesterolemia, PUD, s/p gastric bypass
- **Family History:** AAA in father and uncle
- **Vitals:** Hypotensive in the 80’s
- **Labs:** WNL
# Differential Diagnosis

**GI**
- Appendicitis
- Small bowel obstruction
- Large bowel obstruction
- Gastritis / PUD
- Diverticular disease
- Pancreatitis
- Ischemic bowel
- Reflux

**GU**
- Pyelonephritis
- Nephrolithiasis

**Cardiovascular**
- AAA
- Aortic Dissection
- MI

**Miscellaneous**
- Musculoskeletal pain
In particular, ruptured AAA is often misdiagnosed as:

- Renal colic
- Diverticulitis
- MI
- MSK back pain
Our Patient: Diagnosis

Given patient’s history, a complication of AAA is very high on the differential

⇒ What is an AAA?
Abdominal Aortic Aneurysm (AAA)

Dilatation of the abdominal aorta to > 1.5 times its normal diameter

Normal diameter is approx. 2 cm

An AAA is therefore defined as an aortic diameter greater than 3 cm

Anatomy of the Aorta

95% of AAA’s are infrarenal

About 2/3 extend into one or both of the iliac arteries as well
## AAA: Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
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</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>5.57</td>
</tr>
<tr>
<td>Male sex</td>
<td>4.56</td>
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<tr>
<td>Positive family history</td>
<td>1.95</td>
</tr>
<tr>
<td>White versus black race</td>
<td>2</td>
</tr>
<tr>
<td>Atherosclerosis</td>
<td>1.5</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.2</td>
</tr>
<tr>
<td>(Diabetes)</td>
<td>(0.54)</td>
</tr>
</tbody>
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Aneurysm Detection and Management (ADAM) Veterans Affairs Cooperative Study Group, Ann Inter Med 3/97
AAA Rupture: Risk Factors

• Aneurysm diameter
• Rate of expansion
• Female gender
• Other less proven factors
  - Smoking
  - Decreased FEV1
  - Amino terminal procollagen propeptide
## Risk of Rupture: Diameter

<table>
<thead>
<tr>
<th>Diameter (cm)</th>
<th>Annual Risk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4.0</td>
<td>0</td>
</tr>
<tr>
<td>4.0-4.9</td>
<td>0.5-5</td>
</tr>
<tr>
<td>5.0-5.9</td>
<td>3-15</td>
</tr>
<tr>
<td>6.0-6.9</td>
<td>10-20</td>
</tr>
<tr>
<td>7.0-7.9</td>
<td>20-40</td>
</tr>
<tr>
<td>&gt;8.0</td>
<td>30-50</td>
</tr>
</tbody>
</table>

J Vasc Surg 2003 May;37(5):1106-17
Risk of Rupture: Rate of Increase

- 0.19 cm per year for aneurysms 2.8 to 3.9 cm in baseline diameter
- 0.27 cm per year for those 4.0 to 4.5 cm in baseline diameter
- 0.35 cm per year for those 4.6 to 8.5 cm in baseline diameter

- Rate of increase is more rapid in smokers (Estimates of 20-25% increase in rate)
Risk of Rupture: Gender

Risk of rupture in women is significantly higher than in men

May reflect smaller initial lumenal diameter
Risk of Rupture: Other Factors

- Diameter is not the whole story…

- 10 - 24% of ruptured AAAs were less than 5 cm in diameter (Nicholls, et al)

- Some have advocated looking at geometry of aneurysm (contribution to wall stress) as opposed to mere diameter (Vorp, et al)

- Other factors include ongoing smoking, decreased FEV1, diabetes mellitus, and serum marker amino-terminal procollagen propeptide
AAA: Importance of Early Detection

• When repaired electively, mortality is 0.9-5%
• When repaired after rupture, mortality is up to 75%

Clinical Presentation of AAA

Pre-Rupture
- Usually asymptomatic
- Vague epigastric discomfort
- Mild back/abdominal pain

Post-Rupture
- Severe, constant pain in abdomen or back.
- Tachycardia / Hypotension
- Pulsatile abdominal mass
- Nausea and vomiting
Menu of Tests

Pre-Rupture
- Plain film
- Ultrasound (US)
- Computed Tomography (CT)
- Magnetic Resonance Angiography (MRA)
- Digital Subtraction Angiography (DSA)

Post-Rupture*
- CT
- US

*If not diagnosed clinically
Our Patient

The E.D. opted for C.T.
Diagnosis of Rupture: CT

**PRO’S**

- Detailed imaging of aneurysmal size, location, and neighboring anatomy

- Delineates presence of thrombus

- Detect active extravasation

- Reveals systemic effects of rupture
CON’S

-TIME

Avg. time to diagnosis on CT = 83 minutes (compared to 5.4 minutes of ultrasound)


-Contrast (allergy/ renal function)
-Expensive
Our patient’s CT findings…
Out Patient: Aortic Arch

Jagged, irregular aortic arch
Our Patient: Aorta

Free fluid

Calcified aorta

PACS, BIDMC
Axial (C+) CT
Our Patient: High Attenuating Crescent Sign

Possible intramural hematoma
Companion Patient: High Attenuating Crescent Sign

Represent an acute hematoma within either the mural thrombus or the aneurysmal wall, strongly associated with AAA rupture (75% PPV)

http://www.radiologyassistant.nl/en/452fe3aa7ef9c

Our Patient: Hematoma

Extravasated contrast

Retroperitoneal hematoma

PACS, BIDMC
Axial (C+) CT

26
Our Patient: Site of Rupture

Site of rupture
Widest diameter (post-rupture)
= 4.7 cm
Most Common Site of Rupture

- Right lateral wall - 28%
- Pelvic arteries - 22%
- Posterior wall - 19%
- Left lateral wall - 17%
- Anterior wall - 10%
- Suprarenal - 4%

Our Patient: Site of Aneurysm

Renal artery
Infrarenal AAA’s

95% of AAA’s are infrarenal

About 2/3 extend into one or both of the iliac arteries as well
Our Patient: Aneurysm Shape

Possible fusiform morphology (post-rupture)
Saccular AAA’s are thought to be more prone to rupture than fusiform AAA’s. 

-CT “tortuosity index” may provide a more accurate prediction of rupture

Systemic Effects of Aneurysmal Rupture in our Patient
Our Patient: Flattening of IVC

“Slit-like” IVC

PACS, BIDMC
Axial (C+) CT
Anteriorly displaced R kidney
Site of Hemorrhage

- Retroperitoneal - 85.3%
- Peritoneal - 7.1%
- Inferior vena cava (IVC) or iliac vein - 5.8%
- Enteric - 1.8%
Retroperitoneum: Anatomy

http://radiographics.rsna.org/content/28/6/1571/F2.large.jpg
Our Patient: Kidneys

Wedge shaped segment of hypoenhancement
AAA: Renal Involvement

As many as 30% of patients with AAA have concomitant renal artery stenosis

Our Patient: Liver

Wedge shaped area of hypoperfusion
Other Possible CT Findings That Were Not Evident in Our Patient
AAA Rupture: Periaortic Stranding

http://www.ajronline.org/content/vol188/issue1/images/large/01_05_1554_03C.jpeg
Focal Calcium Discontinuity

47% PPV

http://www.radiologyassistant.nl/en/452fe3aa7ef9e
Tangential Calcium

74% PPV

http://www.radiologyassistant.nl/en/452fe3aa7ef9c
Draped Aorta

61% PPV

http://www.radiologyassistant.nl/en/452fe3aa7ef9c
Are there any other options for evaluation of a ruptured AAA?
Screening: Ultrasound

- Excellent screening tool \textit{prior} to rupture
  - Simple and safe
  - Cost-effective
  - No exposure to ionizing radiation
  - Sensitivity and specificity nearly 100%
  - However, highly operator dependent

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http://www.med-ed.virginia.edu/courses/rad/edus/index8.html
Diagnosis of Rupture: Ultrasound

- Not as reliable as CT, but may be the only viable diagnostic option for the hemodynamically unstable patient

- Use of contrast enhanced US aids detection

- One report cited a 4% sensitivity in US detection of rupture
  - When combined with other clinical factors, however, sensitivity was 95%

AJR 2005; 184:423-427
Diagnosis of Rupture: Baseline Ultrasound
Diagnosis of Rupture: Contrast Enhanced Ultrasound

http://www.ajronline.org/content/vol184/issue2/images/large/00_03_0181_01b.jpeg
Diagnosis of Rupture:
Contrast Enhanced Ultrasound

http://www.ajronline.org/content/vol184/issue2/images/large/00_03_0181_02anew.jpeg
Diagnosis of Rupture: Color-Flow Doppler Ultrasound

- Color-flow Doppler can aid in detecting the site of extravasation

- Adjustment to low velocity scales may be necessary to register leaks with low flow rates

http://www.vmth.ucdavis.edu/cardio/cases/case38/color_flow.htm
CT vs US

Average time to diagnosis by bedside US = 5.4 minutes

Average time to diagnosis by CT = 83 minutes

Our Patient: Treatment

Patient underwent emergent open repair of AAA with placement of a 12 mm Dacron graft

https://clevelandclinic.org/heartcenter/pub/guide/disease/aorta_marfan/marfansurgery_actual.htm
Treatment of Ruptured AAA

May be repaired open or endovascularly

British Journal of Radiology (2005) 78, 62-64

http://www.gvg.org.uk/aaagraft.jpg
Our Patient: 4 Month Follow Up

Normal sized Lumen

Kidney

PACS, BIDMC
Axial (C+) CT
Our Patient: 4 Month Follow Up

Thickened bowel wall
Potential Postoperative Complications

- Colonic ischemia (1st week)
- Aortoenteric fistula
- Atheroembolism
- Declamping hypotension
- Acute renal failure
- Impotence (sympathetic plexus injury)
- Anterior spinal syndrome
- Graft infection
Summary

- Ruptured AAA can be diagnosed clinically, with CT, or with US

- While CT can provide exquisite detail regarding the rupture and systemic effects, the necessary time sacrifice is a considerable drawback

- Ultrasound is a rapid diagnostic modality, but is highly operator dependent and not as informative
Acknowledgements

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References