Interventional Radiology and Endovascular Repair of Abdominal Aortic Aneurysms

Ralph Vetters, Harvard Medical School - Year III
Gillian Lieberman, MD
Our Patient: J.M.

- 68 year old male
- Divorced, lives alone in a Boston rooming house
- Mason and member of the Bricklayers Union
- Tobacco: occasional pipe, no cigarettes last 20 years
- History of alcoholism - sober for 28 years
Significant Medical History

- Family history of coronary heart disease and myocardial infarction in two brothers
- 1997 MI treated by Percutaneous Transluminal Coronary Angioplasty (PTCA) and stent
  - LAD 30-40% occluded, RCA 30-40% occluded
- 1998 second angioplasty for stenotic RCA
- Hypertension and hypercholesterolemia
- Chronic inactive Hepatitis C
Incidental Finding

In June, 1999, an ultrasound obtained at an outside hospital to evaluate hepatobiliary status serendipitously demonstrated an abdominal aortic aneurysm (AAA).
Menu of Tests for Imaging AAA

1. Ultrasound
2. CT/CTA
3. MRI/MRA
4. Conventional angiography (invasive)
5. Abdominal plain film (Insensitive, high false negative, need densely calcified walls).
Ultrasound as a Screening Modality

• non-invasive, may be performed at bedside
  – Can detect free peritoneal blood
  – Unable to detect leakage, rupture, branch artery involvement
• Air-filled bowel may block imaging
  – Pressure of transducer or positional change improves imaging
• 98% diagnostic accuracy in asymptomatic patients
• 100% accuracy in symptomatic cases (palpable abdominal mass, tachycardia, severe abdominal pain)
• Monitor change in aneurysmal diameter: best in axial plane
  – Normal: 2 -3 cm tapering to 1.5 cm at bifurcation
  – >3 cm is abnormal
  – 5 - 6 cm an indication for medical intervention
Example of AAA on Ultrasound

Identifying the Aorta

- Thicker than inferior vena cava
- White echodense walls
- Pulsatile, not undulating
- Not compressible with transducer
- Located to left and smaller than IVC
- Normal lumen is anechoic
- Thrombi moderately echogenic, echogenicity changing with thrombus age
- Calcified plaques in wall produce shadowing

Sagital View: 4.93 cm AAA
Axial view: 4.78 cm AAA

Both images:
MRI and CT

• **MRI**
  – Images comparable to CT without contrast or radiation
  – Better than CT at imaging branch vessels
  – Not suitable for unstable patients
  – High cost

• **CT:**
  – High sensitivity (100%)
  – Better than US at defining aorta size, length, involvement of visceral vessels, leakage
  – 3 dimensional imaging
  – Needs technician
  – Higher cost
  – longer study time
  – exposure to contrast and ionizing radiation
J.M.’s Clinical Course

• J.M. asymptomatic at first detection of AAA in June, 1999.
• January 4, 2000 follow up ultrasound:
  \textit{AAA diameter of 4.5 cm}
• March 3, 2000 ultrasound (complains of backache):
  \textit{AAA diameter of 5.1 cm}
• Rate of growth: \textit{0.6 cm in two months.}

Let’s look at some case information on AAA to help decide what treatment J.M. needs.
AAA

• **Etiology**
  - Atherosclerosis
  - Trauma
  - Syphilis
  - Congenital abnormalities
  - Mycotic aneurysms

• **Majority found infrarenally**

• **Epidemiology**
  - Tend to occur in 5th decade of life
  - Present in 2% of elderly population
  - 5:1 male to female ratio

• **Prognosis**
  - Average rate of expansion of aneurysm diameter: 0.2 - 0.4 cm/year
  - 40% of AAA > 6 cm will rupture (untreated survival average 17 months)
  - 20% of AAA < 6 cm will rupture (untreated survival 34 months)
  - Dissection risk 2 - 3 times greater than rupture risk (35% mortality within 15 minutes)

J.M. clearly needs an intervention.
Operative Option #1: Infrarenal Abdominal Aneurysmectomy

- 4% operative mortality
- 5 – 10% risk of complications
  - Bleeding
  - Renal failure
  - MI
  - Stroke
  - Graft infection
  - Limb loss
  - Bowel ischemia
  - Impotence
  - Paraplegia

Operative Option #2: Endovascular Graft-Stent Placement

- No laparotomy
- No dissection of aorta from viscera
- Minimal blood loss
- Decreased incidence of cardiac/pulmonary complications
- Less hospital time
- Decreased cost
- Accessible to patients with previously contraindicated co-morbidities

Graft-Stent Devices

Aorto-iliac component

Primary access site

Iliac limb

Contralateral access site
Pre-Operative Evaluation: Assessment of Aorta

- Plaque, thrombus, calcification-free margin at aortic neck
  - to ensure stent grip on aorta wall
  - to prevent “endoleaks” at distal and proximal sites
  - to prevent graft migration
- Accurate measurement of lumen length
  - to tailor device to patient-specific pathology - no second chance to stent
  - to prevent “endoleaks”
- External iliacs at least 7 mm in diameter
  - to allow passage of placement device
- Assess mesenteric vascular disease
  - celiac/SMA stenosis increases risk of bowel ischemia
Radiological Assessment of J.M.’s Aorta
CT Angiography with 180 cc of Optiray
April 19, 2000

Axial Projection

- Neck of moderately tortuous aorta seen 3 cm distal to left renal artery
- Neck diameter 1.5 x 2.3 cm
- Aneurysm length to bifurcation 9.1 cm.
- Aneurysm from cephalad edge to caudal edge of common iliacs: R 13.5 cm, L 13.3 cm
- Greatest cross sectional diameter is 5.5 x 5 cm
- Right and left common iliacs 1.3 and 1.2 cm in diameter respectively
- Length of common iliacs from bifurcation to internal iliac R 4.4 cm, L 4.2 cm
- No free fluid or masses
Multiplanar CTA Reconstruction to Determine Mid-Lumen Path and Length

Sagital Plane Reconstructions

Radiology Report

- Lumen has tortuous hourglass shape
- Aortic bifurcation points left in 7 o’clock direction
- Moderate tortuosity of left external iliac and mild tortuosity of right external iliac

Determines mid-luminal path, diameter of lumen, tortuosity, relative anatomical

Both images
CT 3D Reconstruction

- Visualizes tortuosity of aorta – the graft path.
- Illustrates stenoses – barriers to graft deployment
- Displays relationship to vascular anatomy in case of emergency aneurysmectomy.
Limitations of CT Angiography

- Axial slices of CT scan may transect aorta obliquely, misrepresenting true aneurysmal diameter
- Must be complemented by conventional angiography with beaded marker catheter

Conventional DS Angiography: J.M.

150 cc Conray 30%, May 16, 2000

Radiology Report

- Mild stenosis of left renal artery
- Right renal is small in size
- Superior mesenteric artery is patent
- Inferior mesenteric is small
- Ectatic dilatation of both common iliacs without evidence of stenosis
- Internal iliacs are patent
- Included AP, left lateral, and oblique exposures

Beaded catheter to measure lumen length
Intraoperative Digital Subtraction Fluoroscopic Angiography

- Real time acquisition and display of information
- “Road mapping”
- Less contrast used than in conventional angiography
- Detects presence of dissections and other adverse events
Aortograms Visualize Site of Proximal Stent During Procedure: May 26, 2000

Step 1: Straight flush catheter advanced via left femoral to renal artery: Aortogram demonstrates patent renal arteries and location of proximal stent site – “road map.”

Step 2: Catheter advanced via right femoral to aorta. Medtronic stent graft device threaded over guide wire.

Step 3: Repeat aortogram via left catheter to assure stent is placed below renal arteries.
Deployment of the Stent Graft

Stent graft deployed after aortogram.

Self-expanding nitinol AneuRx Medtronic stent graft responds to body heat to grip proximal stent site and distal site in right femoral artery.
Deployment of Second Limb of Stent Graft

Radiology Report:

“A second limb was brought through the stent graft from the left. A pelvic arteriogram on the left side followed through the left-sided sheath which demonstrated an irregular plaque of the common iliac artery just proximal to the takeoff of the mildly stenotic internal iliac artery. After delivery of the stent graft, there was good adaptation.”
Intraoperative Intravascular Ultrasonography: An Alternative to Angiography

Angiography can miss residual stenoses and underdeployed stents. IVUS immediately post-deployment is more sensitive in detecting these problems.

Examples from two different patients.

Poor approximation after deployment. Good approximation after 2nd ballooning.

J.M.’s Post-Operative Progress

- June 20, 2000 – one month post-op – returns to BIDMC ER with complaints about left groin incision pain:
  - Indurated
  - Warm
  - Erythema down left thigh
  - No discharge or fluctuance
- DX: seroma
- TX: keflex
Post-Op Graft Leak Check: July 6, 2000
(6 weeks post-procedure)

Plain Film

- Graft is within aortic aneurysm.
- Graft extends into iliac arteries.
- No sign of graft migration.
- Unable to distinguish leaks or changes in aorta diameter.
Post-Op Evaluation, Multiplanar and 3D Reconstruction: July 6, 2000

- No kinks
- No distortions of anatomy
- No significant change in aneurysmal diameter
- Visualize “fit” of graft.
- Confirm placement: no migration.
Axial CT Post-Op Evaluation of Stent-graft
July 6, 2000

No evidence of leakage.

No change in size of aneurysm:
Pre-insertion 5.2 x 5.5 cm. Now 5.1 x 5.5 cm.

Graft in aneurysmal lumen
Patient’s Progress

- July 6 imaging shows excellent result - no leak.
- July 11, 2000: doing well
  - BP: 120/70, HR 70; no JVD; normal S1 and S2.
- Meds: Metoprolol, Zestril, Zocor, aspirin
CT as Standard Post-Op Study

- More sensitive than doppler ultrasound in detecting leaks.
- More accurate and reproducible diameter measurements.
- Spiral CT better than conventional:
  - Data over entire volume of scan
  - Narrow axial reconstructions
  - Multiplanar reformats
  - “Cine” mode to follow leaks to source
- Follow up at 1, 6 and 12 months then annually.
Example of Endoleak on CT

Thrombus in aneurysm

Graft

Leak from proximal end

Doppler ultrasound is a good adjunct to CTA for patients with suspected post-op endoleak.

- Can detect endoleaks, limb stenoses, occlusions.
- Can follow changes in maximum aortic diameter (CT has better accuracy).
- No radiation.
- Cheaper than CT.
- 85% accuracy in detecting leak (spiral CT 98% accurate).
- Technician dependent
- Problems with the obese patient and gas-filled bowel

References


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The End