ABDOMINAL AORTIC ANEURYSM IMAGING

SURGICAL AND PERCUTANEOUS SELECTION

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No disclosures.
OUTLINE

• NATURAL HISTORY
• ANATOMICAL FEATURES
• IMAGING MODALITIES
• ROLE OF IMAGING
  • OPEN VS ENDO REPAIR
  • POST REPAIR SURVEILLANCE
• CHALLENGING CASES
AAA DISEASE

“The natural history of an abdominal aortic aneurysm is to enlarge and rupture”.
MOST AAAS ARE ASYMPTOMATIC

Many patients are not diagnosed prior to symptoms and fatal rupture.
The USPSTF recommends a one-time screening for abdominal aortic aneurysm by ultrasonography in men aged 65 to 75 who have ever smoked (Grade B).

The USPSTF recommends against routine screening for AAA in women (Grade D).

The SVS recommends screening for men & women with a family history of AAA at age 55 & 65 years, respectively.
Epidemiology

- Increasing incidence with age
- Increasing prevalence over past 30 years
- Likelihood of having an aneurysm is 1 in 10 among 75 year old men
AAA Classification

Fusiform

Saccular
ONLY Roy Rogers survived a ruptured AAA…
Albert Einstein

- 1948 underwent cellophane wrap of his AAA
- 1955 aneurysm ruptured and Einstein refused further treatment (he wanted to die with "dignity")
- Dubost did first open surgical repair in 1951
  - Open surgery becomes standard of care for AAA
## Diameter and Risk of Rupture

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Annual Risk of Rupture</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4 cm</td>
<td>0 %</td>
</tr>
<tr>
<td>4 - 5 cm</td>
<td>0.5 - 5 %</td>
</tr>
<tr>
<td>5 - 6 cm</td>
<td>3 - 15 %</td>
</tr>
<tr>
<td>6 - 7 cm</td>
<td>10 - 20 %</td>
</tr>
<tr>
<td>7 - 8 cm</td>
<td>20 - 40 %</td>
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<tr>
<td>&gt; 8 cm</td>
<td>30 - 50 %</td>
</tr>
</tbody>
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HIGH RISK FEATURES

- AAA > 4 cm
- AAA 4 to 5 cm with increase in size of > 5mm past 6 months
- AAA size twice the size of infrarenal neck
- Saccular

J Vasc Surg 2001;33:S135-45
Sizing the Endograft

Numerous Pre-Procedural Assessments Necessary
Infra-renal neck (10 – 15 mm), <60 degree angulation
Access/iliac vessels (>7 mm)

Diagram:
- Celiac axis
- SMA
- Kinking
- Cephalad neck
- IMA
- Lumbar
diameter
- Iliac artery
- Int. iliac artery
- Caudal neck
- Femoral artery/runoff

Image:
- Angiographic view of the aorta and iliac arteries.
ROLE OF IMAGING IN OPEN VERSUS ENDO REPAIR PLANNING

- ANATOMICAL CONSIDERATIONS
  - AAA and Iliac Size
  - Angulation and Tortuosity
  - Infra-Renal Neck
  - Thrombus

- PROCEDURAL PLANNING
  - Side Branches

- POST REPAIR SURVEILLANCE
  - Endoleaks and Re-intervention Planning
  - Device Migration
ANATOMIC CONSIDERATIONS

- **Proximal aortic neck**
  - Diameter of device oversized 10-20%
  - Length $\geq 1.5$ cm for all FDA approved devices

- **Angulation/tortuosity**
  - *Short angulated necks, short wide necks, & severe AAA tortuosity can lead to suboptimal outcomes*

- **Iliac access**
  - Large enough to accommodate 16F-24F delivery systems
    (7-8mm for bifurcated devices)
ANGULATION

- Defined as the angle formed between the vertical plane and a line that transects the long axis of either the neck or the aneurysm.
- An angle of 60° or more leads to difficulties in implantation, kinking, leakage, and the possibility of downward migration of the device.
- Relative contra-indication to EVAR.
ANGULATED NECKS
FAILURE OF FIXATION AND SEAL
“REJECTION” CRITERIA FOR EVAR

- Aortic neck diameter >29mm
- Aortic neck length <15mm
- Aortic neck angulation >60 degrees
- Severe iliac tortuosity
- Extensive aortic neck thrombus
- Access artery diameter (iliacs) <7mm
- Aortic bifurcation diameter <18mm
- Bilateral common iliac artery aneurysm requiring coverage of both hypogastric arteries
- Essential accessory renal artery

Vasc Endovasc Surg 40:196f, 2006
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Radiograph shows calcification of the abdominal aorta.

The left wall is clearly depicted and appears aneurysmal.

The right wall overlies the spine.

Lateral view may help.

Uncertain diagnosis.
CTA

- **The “gold-standard”**.
- Timed-bolus, intravenous contrast-enhanced, thin-cut, spiral technique.
- Usually operator-independent.
- Accurately demonstrates dilatation of the aorta and involvement of major branch vessels proximally and distally.
  - location and number of renal arteries
  - caliber of the aneurysm
  - degree of calcification
  - length of the neck and iliac arteries
  - presence of mural thrombus
- Three-dimensional reconstruction programs of state-of-the-art, multidetector-row, helical CT scans can help in preoperative planning.
- False-positive diagnosis
  - rupture if fluid resulting from another cause is seen in the abdomen.
  - aneurysm or rupture can be missed in a patient with a recent barium study.
- Radiation and CIN.
PREOPERATIVE IMAGING

CTA (3mm cuts)
PREOPERATIVE IMAGING

3D Reconstruction
PRE-PROCEDURAL CTA PLANNING
CASE SELECTION

Aortic Angulation

Iliac Angulation
**MRI**

- Absence of iodinated contrast material and radiation are advantages.
- More sensitive to motion than CT
  - Longer “motionless” period than current multidetector-row helical CT
  - Remaining organs in the abdomen are not well seen
- May not be possible or limited
  - Prior abdominal surgery has been performed
  - Metal clips or devices were used
ULTRASOUND

- Screening examination of choice
  - Availability
  - Speed
  - Low cost

- Limitations
  - Operator-dependent
  - Body habitus (obesity, distended bowel, gas)
INTRAVASCULAR ULTRASOUND (IVUS)

VISIONS PV 8.2F
INTRAVASCULAR ULTRASOUND IMAGING CATHETER

64 IMAGING ELEMENTS
GUIDEWIRE
IVUS

- Confirms measurements from CT scan.
- Identifies side branches.
- Pullback measures centerline lengths.
- Visualizes guide wire position in “the gate” after main body is deployed and before limb is deployed.
- Confirms true diameter of proximal neck and common iliac arteries to choose appropriate size PTA balloon(s).
- Identifies apposition and endoleaks.
- May be used to save contrast in CKD patients.
AAA PROXIMAL AND DISTAL NECK
AAA MAXIMAL DIAMETER AND ILIAC DIAMETER
TYPE 1 ENDOLEAK IN ILIAC FIXATION ZONE BY IVUS
ANGIOGRAPHY

- If a large amount of luminal thrombus is present, the true diameter of the aneurysm may be obscured.
- An angiogram is a “lumenogram”
  - leads to significant underestimation of the diameter of the aneurysm.
- Invasive, increased complications.
- Limited screening role.
ANGIOGRAPHY LIMITATIONS...

An angiogram is a “lumenogram”
PERFORM ANGIOGRAPHY IN SEVERAL PROJECTIONS
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Endovascular Options for Repair

Open Surgical
**ENDOVASCULAR REPAIR COMPARED TO OPEN REPAIR**

Level 1 evidence through these randomized trials confirmed *early benefit* of EVAR vs OPEN.

<table>
<thead>
<tr>
<th>Trial</th>
<th>EVAR</th>
<th>OPEN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EVAR I</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 - Day Mortality</td>
<td>1.7 %</td>
<td>4.7 %</td>
</tr>
<tr>
<td>Secondary Interventions</td>
<td>9.8 %</td>
<td>5.8 %</td>
</tr>
<tr>
<td><strong>DREAM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 - Day Mortality</td>
<td>1.2 %</td>
<td>4.6 %</td>
</tr>
<tr>
<td>Combined Op Mortality &amp; Complications</td>
<td>4.7 %</td>
<td>9.8 %</td>
</tr>
</tbody>
</table>
ENDOVASCULAR REPAIR

- Minimally invasive
- Reduced morbidity
- Reduced hospital stay
- Early return to function
  - Typically 2 to 4 weeks for full recovery
- Surveillance imaging
- Migration
- Endoleaks
- Need for re-intervention
ELECTIVE OPEN REPAIR AAA

- Major surgical procedure
  - Mortality 2% to 5%

- Complications
  - Pseudoaneurysms
  - Erectile dysfunction
  - Aortoenteric fistula
  - Graft thrombosis
  - Graft infection

- Recovery period 6 weeks to 4 months
ROLE OF IMAGING IN OPEN VERSUS ENDO REPAIR PLANNING

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CURRENTLY AVAILABLE DEVICES (USA)

Medtronic AneuRx
US Trial Implants 1193

Gore Excluder
US Trial Implants 235

Cook Zenith
US Trial Implants 352

Endologix Powerlink
US Trial Implants 192
## AAA Device Specifications

### Main Body / Limb

<table>
<thead>
<tr>
<th>Company / Device</th>
<th>Mainbody Length (cm)</th>
<th>Mainbody Diameter (mm)</th>
<th>Iliac Limb(s) Length (cm)</th>
<th>Iliac Limb(s) Diameter (mm)</th>
<th>Mainbody Delivery System Profile (OD) (ID)</th>
<th>Iliac Limb Delivery System Profile (OD) (ID)</th>
<th>Fixation Location</th>
<th>Stent Material</th>
<th>Graft Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Zenith</td>
<td>7.4 8.8,10.3, 11.7, 13.2 9.5,11.3,13.1, 14.9(36mm)</td>
<td>22,24,26,28,30, 32,36</td>
<td>3.7,5.4,7.1,8.8, 10.5,12.2</td>
<td>8,10,12,14,16, 18,20,22,24</td>
<td>18,20,22 Fr (ID)</td>
<td>14,16,18 Fr (ID)</td>
<td>Supra-renal</td>
<td>Stainless Steel</td>
<td>Woven Polyester</td>
</tr>
<tr>
<td>Endologix Powerlink</td>
<td>8,10</td>
<td>25,28</td>
<td>4.5,5</td>
<td>16,20 (Bell Bottom with Cuff)</td>
<td>21 Fr (OD)</td>
<td>9.17, 19 Fr (OD)</td>
<td>Infra-renal</td>
<td>Cobalt Chromium</td>
<td>ePTFE / FEP</td>
</tr>
<tr>
<td>Gore Excluder</td>
<td>14,16,18</td>
<td>23,26,28.5</td>
<td>10,12,14 9.5,11.5,13.5 (Flared Limb)</td>
<td>12,14.5, 16,18,20</td>
<td>18 Fr (ID)</td>
<td>12,18 Fr (ID)</td>
<td>Infra-renal</td>
<td>Nitinol</td>
<td>ePTFE</td>
</tr>
<tr>
<td>Medtronic AneuRx</td>
<td>13.5,16.5</td>
<td>20,22,24,26,28</td>
<td>8.5,11.5,13.5</td>
<td>12,13,14,15, 16,18,20,22, 24</td>
<td>21 Fr (OD)</td>
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Perigraft Flow/Endoleak: Definitions*

Type I
Attachment leak

Type II
Branch flow

Type III
Defect in graft or modular disconnection

Type IV
Fabric porosity

* White et al., Endoleak Classification, Journal of Endovascular Surgery, 1998;5:305-309
• 63-year-old Caucasian male.

• Past medical history significant for tobacco abuse/COPD, hypertension, and dyslipidemia.

• Ultrasound of the abdomen in 12/2009 to evaluate his kidneys discovered a large abdominal aortic aneurysm.

• A CT angiogram was performed to assess the size of AAA:
  - AP: 6.8 cm
  - Transverse: 8.4 cm
  - Cranio-caudal: 10.5 cm
ENDOLEAK CASE - EVAR

- Abdominal aortogram was performed.
- PTA of bilateral iliacs was performed with a 10 x 40 balloon.
- Medtronic AAA Talent Stent Graft was deployed with a left iliac limb.
- Right and left extension cuffs were placed in right and left iliac arteries.
- Palmaz-Schatz stent (40 x 10 mm) was placed at the proximal end of the stent graft.
ENDOLEAK CASE – POST EVAR FOLLOW UP

- At the end of the procedure, there was no extravasation into the aneurysmal sac.
- Patient was discharged home.
- CT scan performed 30 days post EVAR showed a large Type 1 endoleak into the sac.
Abdominal aortogram confirmed the presence of a Type 1 endoleak.

2 cuffs (28 x 28 x 40 mm) were deployed at the proximal end of the stent graft.
  - Ostium of the left inferior renal artery compromised
  - Left superior renal artery remained patent

Patient did well, stable renal function.

Discharged home on day 3
• No symptoms or rise in creatinine noted.
• Repeat per-protocol CTA was performed to follow up the EVAR and endovascular Type 1 endoleak repair.
• CT scan now showed a Type 2 endoleak.
ENDOLEAK CASE – TYPE 2 ENDOLEAK REPAIR

- Trans right femoral abdominal aortogram with selective superior mesenteric angiogram performed.
- Sub-selective middle colic angiogram, injection of thrombin into the endoleak, and embolization (using micro coils) of the inferior mesenteric artery.
- Patient did well and was discharged home on day 3 following procedure.
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EVAR CASE – CLINICAL INFO

- 58 year old Caucasian M
- Smoker, severe COPD
- HTN, DM-2, stable CAD, normal LVEF
- Chronic back pain
- Hx of open saccular TAA repair 2 years prior
  - Aortic arch and proximal descending thoracic aorta
  - Re-implantation of left subclavian artery
  - Complex 50-day inpatient post-op course
- Enlarging fusiform infra-renal AAA
  - Transverse 4.8 x 5.2 cm
  - Progression >6 mm/last 6 months
  - Cranio-caudal 6 cm
  - Short infra-renal neck (~10 mm)
  - Low left renal artery
- Scheduled for EVAR
EVAR CASE – PROCEDURAL INFO

- Spinal anesthesia, moderate sedation.
- 9 F LFA sheath → 17 F LFA delivery sheath.
- 6 F RFA.
- Bilateral Iliac PTA (10 x 40 mm balloons).
- Bifurcated Endologix 28-70-16-30 mm device.
- Supra-renal aortic cuff, with graft material just below the left renal artery.
- PTA of main body endograft device and iliac limbs.
- Bilateral percutaneous closure using “Preclose” Perclose technique.
- Stable renal function post EVAR.
- Discharged home 3 days post EVAR.
CONCLUSIONS

- AAA Screening and Detection
- Anatomical Features ➔ Management Strategy
- Proceed with EVAR if:
  - Suitable infra-renal neck length (>15 mm) and width (<29 mm)
  - Suitable access vessel diameter (>6-8 mm)
  - Aortic tortuosity <60 degrees
  - Favorable iliac tortuosity and aortic thrombus burden
  - No significant renal/mesenteric side branch compromise
- Post EVAR surveillance for migration and endoleaks.
- Not all aneurysms are created equal.
EXTRA SLIDES
Reverse Taper, Thrombus Laden Neck with Tortuous Iliacs

LONG TERM MIGRATION CONCERNS?
POTENTIAL ENDOLEAKS ASSOCIATED WITH THROMBUS?
EMBOLIZATION CONCERNS?
LIMB SEPARATION CONCERNS?
GATE CANNULATION?

Proximal Neck - Slice 111
Length: 2.675 cm (36.040 pix)

Distal Neck - Slice 141
Length: 3.135 cm (44.586 pix)
Anatomical Fixation to prevent migration

Struts on the inside force wall apposition

ActiveSeal extends seal zone for reverse taper and maintains seal without hooks or barbs

Not reliant on barbs which may not contact aortic wall due to thrombus

No gate cannulation due to Unibody Design

Unibody stent graft in iliacs cannot separate
Reverse Taper, Thrombus Laden Neck
Angulated Neck and NDA

LONG TERM MIGRATION CONCERNS?
REduced SEAL LENGTH?
WILL THE GRAFT CONFORM TO THE ANGULATION?

LIMB COMPETITION CONCERNS?
GATE CANNULATION?
Anatomical Fixation to prevent migration

Struts on the inside force wall apposition

Not reliant on barbs which may be forced off wall

ACTIVESEAL extends seal zone

No gate cannulation due to Unibody Design

No Limb competition
Angulated Neck

PRE

POST
Diseased Infrarenal Neck

Infrarenal neck contains heavy circumferential calcification and thrombus

Open: Clamp placement in this region should be avoided
Endovascular: Poor proximal seal -- Risk for Type I endoleak
Severe Angulation/Tortuosity of the Infrarenal Neck

Severe angulation (> 60°): High risk for endograft migration → Type I endoleak
Endovascular AAA Repair

Proximal Diameters:
- 22mm–36mm
- 2mm increments

Universal docking gate
- 14mm diameter
- Interlocks with all contralateral limbs

Covered Lengths:
- 140mm
- 155mm
- 170mm

Distal Diameters:
- 12mm–20mm
- 2mm increments
Endovascular AAA Repair

Flex Iliac Leg Dimensions

- Leg Diameters 8-24 mm
- Leg Lengths 37-124 mm

[Image of Flex Iliac Leg Dimensions]
Powerlink® System for AAA

- Unibody Bifurcated Design
- Long Main Body
- Low-Porosity Proprietary ePTFE Formulation
- Cobalt Chromium Alloy Stent
- Single-wire Main Body Construction
Perigraft Flow/Endoleak: Definitions

Type I
Attachment Leak

Type II
Branch Flow

Type III
Defect in Graft or Modular Disconnection

Type IV
Fabric Porosity

Type V - Endotension
AAA enlargement without Defined leak

A total of 112 consecutive patients, who underwent EVAR to treat abdominal aortic aneurysms, were examined retrospectively.

33 patients were assigned to the IVUS group because of renal failure, a suspected allergy to contrast agents or anatomical difficulties.

Remaining 79 patients were assigned to the non-IVUS group.

Patients in the IVUS group required fewer intra-arterial contrast agents than those in the non-IVUS group (67 vs. 123 ml; p < 0.01).

Renal deterioration evaluated by chronic kidney disease stage was found to a greater extent in the non-IVUS group.