Abdominal Aortic Aneurysms: Minimally Invasive Strategies

Andrew T. Kwa, MD
UC Davis Medical Center
Outline

• Aorta

• AAA
  ▪ Epidemiology
  ▪ Etiology
  ▪ Diagnosis & Screening
  ▪ Management
    • Open surgical vs Endovascular
  ▪ Trials
Types of Aortic Aneurysms

- Normal aorta
- Aorta with large abdominal aneurysm
AAA Definition

- Varies by age, gender, body surface area
- Typically diagnosed if aortic diameter is $\geq 3.0$ cm*

AAA Facts

• AAA affects 1-5% of population (up to 9% of adults older than 65 years of age)
• Increasing prevalence
  - 12.2/100,000 to 36.2/100,000
• Most commonly diagnosed in the seventh decade
• 4:1 male to female
• 33,000 repairs every year

Ernst C. *NEJM* 1993;328:1167
Abdominal Aortic Aneurysms: Risk Factors

- Older age
- Male sex
- Cigarette smoking
- Family history (15-20%)
- Peripheral arterial disease
- Hypertension
- COPD
- Dyslipidemia
Abdominal Aortic Aneurysms: Risk Factors

Impact of cigarette smoking
Abdominal Aortic Aneurysms: Etiology

- Classically described as atherosclerotic or degenerative aneurysms
- Frequently occur in patients with atherosclerosis and share many of several common risk factors
- Site of disease process different
Etiology Abdominal Aortic Aneurysms: Etiology

- Atherosclerosis – predominantly intimal in location
- Aneurysm – media and adventitia
**Figure 1.** A Model of Cyclophilin A and Abdominal Aortic Aneurysms.

A recent study by Satoh et al.\(^2\) showed that angiotensin II, through induction of reactive oxygen species, induces cyclophilin A in smooth-muscle cells; this, in turn, triggers recruitment of inflammatory cells, activation of matrix metalloproteinase-2, and production of reactive oxygen species. Together, these factors lead to matrix degradation, apoptosis of smooth-muscle cells, and consequently, aneurysm formation. Cyclophilin A, itself induced by reactive oxygen species, acts through autocrine and paracrine mechanisms to up-regulate production of reactive oxygen species; this is indicative of a positive feedback loop.
Progression of a AAA

- Pathological changes cause the aorta wall to:
  - Become thinner
  - Bulge
  - Tear
  - Rupture
Abdominal Aortic Aneurysms: Presentation

- Asymptomatic in 75% at time of diagnosis
- Local mass effects on the GI tract, lumbar spine, ureters
- Thrombosis
- Embolization: *Blue toe syndrome*
- Abdominal or back pain
- Rupture
Abdominal Aortic Aneurysms: Rupture

• 12th leading cause of death in elderly men (15,000/yr)
• 70% of those with AAA are unaware of diagnosis until rupture
  • 90% mortality for out of hospital rupture
  • 50% mortality for in-hospital rupture
• Risk of related to aneurysm size
AAA: risk of rupture

Risk of rupture for untreated aneurysm within 5 years (%)

- 5-5.9 cm: 25%
- 6-6.9 cm: 35%
- ≥7 cm: 75%

Most expand at a rate of 2-4 mm/year

Simplified estimates based on various studies
Symptoms of AAA rupture

- Abdominal/back pain
- Pulsatile abdominal mass
- Hypotension

- Clinical triad occurs in only about one-third of cases
ACC/AHA screening high-risk

- Men ≥ 60 yrs who are siblings or offspring of AAA patients
- Men 65-75 yrs who have ever smoked
  - Physical exam and ultrasound

Class I
Class IIa
Class IIb
Class III

Abdominal Aortic Aneurysms: Diagnosis

Sensitivity of physical exam is 50% in patients with waist size of 38” or more.
Abdominal Aortic Aneurysms: Diagnosis
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Abdominal Aortic Aneurysms: Diagnosis
Medical Therapy for AAA

- Beta Blocker
- Statin
- MMP inhibitors?
- Angiotensin II blocker?
- JNK inhibitor?

Good control of HTN
Aggressive management of risk factors
Abdominal Aortic Aneurysm

When to refer for repair?
Abdominal Aortic Aneurysms: Natural History

  - Population-based study from clinical epidemiology section
  - Expansion rate of 2.1mm annually
  - Only 24% had expansion rate of 4mm or more per year
  - Challenged dogma that AAAs expanded 4–5 mm/ year
  - 0% risk of rupture in the 130 patients with aneurysms less than 5cm
Abdominal Aortic Aneurysms: Natural History

- The UK Small Aneurysm Trial Participants: Mortality results for randomized controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms (Lancet 1998;352:1649)
  - Prospective randomized trial examining the repair of aneurysms between 4-5.4 cm
  - 1090 patients randomized to either observation or open repair
  - Mean aneurysm diameter 4.6cm
Abdominal Aortic Aneurysms: UK Small Aneurysm Trial

No survival benefit to early *open* operative
When to Refer for Repair?

- Men with AAA > 5.5 cm
- Women with AAA > 5.0 cm
- 4.0 – 5.5 cm if rapid rate of aneurysm growth (> 0.5 cm in 6 months)
- Symptomatic aneurysm
- Saccular aneurysm
ACC/AHA Guidelines AAA repair

- Infrarenal/juxtarenal AAA ≥5.5 cm should undergo repair; 4.0-5.4 cm, ultrasound/CT scans every 6-12 mo
- Repair can be beneficial for infrarenal/juxtarenal AAAs 5.0-6.0 cm
- Repair probably indicated for suprarenal/type IV thoracoabdominal AA >5.5-6.0 cm
- AAA <4.0 cm, ultrasound every 2-3 years is reasonable
- Intervention not recommended asymptomatic infrarenal/juxtarenal AAAs <5.0 cm (men) or <4.5 cm (women)

Class I
Class IIa
Class IIb
Class III

Treatment options

Open surgery

Endovascular stent grafting
Infrarenal AAA
Infrarenal AAA Repaired With Dacron Graft
Open repair: advantages

- Established procedure more than 40 years of clinical experience
- Excludes aneurysm and prevents sac growth
- Proven, long-term results
## AAA Operative Mortality Past 10 Years

<table>
<thead>
<tr>
<th>Study Type</th>
<th>n</th>
<th># of Pts</th>
<th>Op Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Center Reports</td>
<td>7</td>
<td>2,162</td>
<td>2.1%</td>
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<tr>
<td>Multicenter Reports</td>
<td>5</td>
<td>10,366</td>
<td>4.2%</td>
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<tr>
<td>Population Based Reports</td>
<td>3</td>
<td>9,681</td>
<td>7.3%</td>
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</table>
Open surgical repair (OSR): drawbacks

- Significant incision in the abdomen
- 30–90 minute cross-clamp
- Up to 4-hour procedure
- 1–2 days intensive care
- 7–14 days hospitalization
- 4–6 weeks recovery time
Contraindications to OSR

High anesthesia risk
Severely obese
Significant cardiac co-morbidities
Previous abdominal surgery/hostile abdomen

Difficult recovery for patient:
- risks functional impairment [1]
- risk of erectile dysfunction [2]

Endovascular Aneurysm Repair (EVAR)

- Minimally invasive
- Reduced morbidity and mortality
- Less blood loss/need for transfusion
- Shorter hospital stay
- Quicker recovery time
- Reduced cost?
Background

- Concept of intraluminally placed stent-graft first proposed by Dotter in 1969
- First experimental work with polyurethane covered Z stent published in 1986
- Feasibility studies in sheep, dogs, and minipigs (experimentally constructed aneurysms)
- First human AAA stent-graft procedure performed in September 1990 (Parodi, Palmaz)
Aorto-aortic and Aortoiliac Endoluminal Grafts
FDA-approved Devices

- AnCure: ’99 – ’03
  - Removed from the market
  - Perioperative complications
- AneuRx: ’99
- Excluder: ’02
- Zenith: ’03
- Powerlink: ’04
- Talent: ’08
- Endurant: ‘10
AAA Device

Sealing cuff

Barbs
Aneurysm Morphology

Type A

Type B

Type C
Aneurysm Morphology

Illo-iliac Axis $\vartheta < 90^\circ$

Angulation Proximal
Neck $\beta > 60^\circ$
Endovascular Stent-Grafting Techniques

**Critical Dimensions:**

- Diameter and length of proximal neck
- Diameter of the common iliac arteries (attachment site)
- Diameter of external iliac and common femoral arteries (for device passage)
- Length from renal arteries to aortic bifurcation and iliac bifurcation (device selection)
Endoluminal Stent-Grafts

- 88 year old male
- History of COPD and pacemaker
- High surgical risk
- 6.5 cm AAA
AAA Repair with Stent-Graft

Preoperative angiogram

Postoperative angiogram
Endoluminal Stent-Grafts

Baseline CT Scan

Following Stent-Graft
AAA Shrinkage
Open surgery vs EVAR: Patient preference

“Once you go Endo, you cannot come back”

T Ohki, MD

Open surgery

4 days after

Endovascular

4 hrs after
Potential Endoluminal Graft Complications

Early
- Iliac Dissection/Rupture
- Limb ischemia
- Thromboembolic Event
- Renal failure (crossing the renal arteries)
- Ischemic bowel
- Wound complications
- Endoleak

Late
- Endoleak
- Limb Occlusion
- Graft Migration
- Graft material failure - prosthetic Leak
- Aneurysm rupture
ACCESS ISSUES
AORTIC ENDOGRAFTS

Large sheath
Inflexible devices

DANGER !!
Calcification
Tortuosity
Small iliacs (women)
Lifelong Monitoring Required

- CT
- MRI
- Duplex
- Pressure sensor
AAA Pressure Sensor

Goal

• Non-invasive sac pressure measurement
• Endovascular introduction at time of stent-graft implantation
• Compatible with all stent-grafts
Pressure Sensor
Post operative surveillance: Sac pressure

72/51 mmHg
Randomized Trials of EVAR vs. Open Surgical Repair

EVAR Trial

DREAM Trial
### EVAR vs OSR 30-day outcomes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Endpoint</th>
<th>EVAR</th>
<th>OPEN</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>EVAR [1]</td>
<td>Mortality</td>
<td>1.7 %</td>
<td>4.7 %</td>
<td>0.009</td>
</tr>
<tr>
<td>N=1082</td>
<td>Secondary interventions</td>
<td>9.8 %</td>
<td>5.8 %</td>
<td>0.02</td>
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<tr>
<td>≥ 5.5 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DREAM [2]</td>
<td>Mortality</td>
<td>1.2 %</td>
<td>4.6 %</td>
<td>0.1</td>
</tr>
<tr>
<td>N=345</td>
<td>Mortality &amp; severe complications</td>
<td>4.7 %</td>
<td>9.8 %</td>
<td>0.1</td>
</tr>
<tr>
<td>≥ 5.0 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## EVAR vs OSR 2-year outcomes

### DREAM

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>EVAR</th>
<th>OPEN</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>89.7%</td>
<td>89.6%</td>
<td>0.86</td>
</tr>
<tr>
<td>Survival free of moderate-severe complications</td>
<td>65.6%</td>
<td>65.9%</td>
<td>0.88</td>
</tr>
<tr>
<td>Aneurysm-related death</td>
<td>2.1%</td>
<td>5.7%</td>
<td>0.05</td>
</tr>
</tbody>
</table>

DREAM Trial – Cumulative survival rates

- Randomized trial of 351 patients with AAA >5 cm

69.9% open repair
68.9% EVAR
P=0.97

De Bruin, NEJM 2010 May 20;362(20):1881-9
DREAM Trial – Cumulative rates of freedom from secondary interventions

81.9% open repair
70.4% EVAR
P=0.03

De Bruin, NEJM 2010 May 20;362(20):1881-9
Endovascular vs. Open Repair of Abdominal Aortic Aneurysms in the Medicare Population

Marc L. Schermerhorn, M.D., A. James O’Malley, Ph.D., Ami Jhaveri, M.D., Philip Cotterill, Ph.D., Frank Pomposelli, M.D., and Bruce E. Landon, M.D., M.B.A.
EVAR vs Open Repair

- 45,660 medicare patients who underwent EVAR or open repair (22,830 in each group) from 2001-2004
- Mean age 76 years
- 20% women
- 10% had MI in previous 2 years
Probability of Survival: All Ages
Probability of Survival: ≥85 yo
Ongoing studies EVAR vs OSR

- **France**
  - **Anévrisme de l’aorte abdominale: chirurgie versus endoprothèse (ACE)**
  - ClinicalTrials.gov identifier: NCT00224718

- **US**
  - **Open versus endovascular repair (OVER) trial for AAA**
  - ClinicalTrials.gov identifier: NCT00094575
Conclusions

- For older, high risk patients, EVAR is the clearly procedure of choice if anatomically applicable

- EVAR results are improving, and for younger, healthier patients with suitable anatomy, EVAR is becoming the preferred method of repair

- Lifelong surveillance remains important