Aortic Aneurysms

Michael R. Go, MD, FACS
Assistant Professor
Division of Vascular Diseases and Surgery
Department of Surgery
The Ohio State University Wexner Medical Center

Objectives

- **Abdominal aortic aneurysms**
- **Demographics**
- **Pathophysiology**
- **Symptoms**
- **Diagnosis**
- **Treatment**

Aneurysma

- **"A widening"**
- **Ectasia - < 50% diameter increase**
- **Arteriomegaly - diffuse ectasia**
- **Aneurysmosis**
- **Aneurysm - > 50% diameter increase**

AORTA	DIAMETER	GENDER
Root	3.50–3.72	Female
	3.63–3.91	Male
Ascending	2.86	Female/male
Descending	2.45–2.64	Female
	2.39–2.98	Male
At diaphragm	2.40–2.44	Female
	2.43–2.69	Male
Infrarenal	1.5-1.7	Female
	1.7-1.9	Male

Aneurysm

- **Pathological dilatation of the aorta involving one or several segments**
- **A permanent localized dilatation having a diameter at least twice the normal diameter of that segment**

Demographics

- 200,000 patients diagnosed with non-ruptured AAA each year
- 1.5 to 2 million are estimated to have an undiagnosed AAA
- 50% of patients with untreated aneurysms > 5.5 cm will die of rupture within five years
- 15,000 deaths each year

Inexorable Progression to Rupture

- Average rate of growth
  - 0.4 cm / year
  - ~ 10% per year

Growth Rate of AAA

Initial size (cm)	Mean growth rate (cm/yr)	95% CI
3.0- 3.9	0.39	0.20-0.57
4.0-4.9	0.36	0.21-0.50
5.0-5.9	0.43	0.27-0.60
6.0-6.9	0.64	0.16-1.10

Ann Surg 1984; 200: 255-63

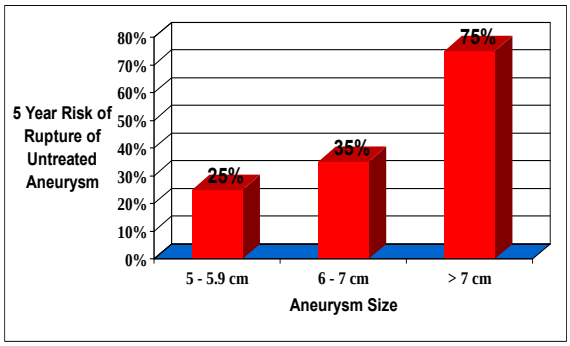
Risk of Rupture

- Mortality = 35 - 75%
  - unchanged over past 4 decades
  - higher with COPD, multiple co-morbidities

Diameter	Annual Risk of Rupture
< 4 cm	0 %
4 - 5 cm	0.5 - 5 %
5 - 6 cm	3 - 15 %
6 - 7 cm	10 - 20 %
7 - 8 cm	20 - 40 %
> 8 cm	30 - 50 %

J Vasc Surg 2003; 37: 1106-17

Risk of Rupture



Rutherford: Vascular Surgery, 6th ed., 2005.

Rupture

- Approximately 40% of patients with ruptured AAAs die prior to presentation to the emergency department
- Only 10% to 25% of individuals with ruptured AAA survive until hospital discharge
- Prevent rupture!

Classification

- True Aneurysms
  - saccular
  - fusiform
- False Aneurysms
  - not all layers of the arterial wall (intima, media, adventitia) are present
  - one or more layers of the arterial wall have been disrupted

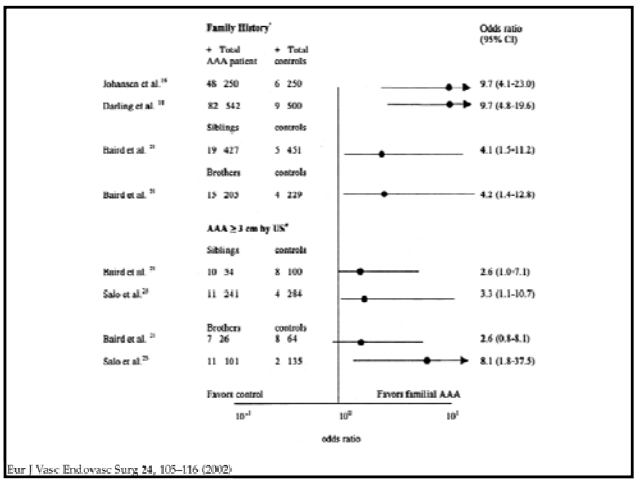
Etiology: Medial Degeneration

- Aging
- Atherosclerosis
- Infection
- Inflammation
- Trauma
- Congenital anomalies
- Smoking
- Genetic predisposition

Genetics and Pathophysiology

- Most of what we know about AAA is descriptive
- 20% of AAA patients will have a first degree relative with AAA
- OR of AAA in first degree relative of index patient 9.7
- Thought to be autosomal dominant based on family studies

Cardiovascular Surgery, Vol. 5, No. 3, pp. 256–265, 1997



Eur J Vasc Endovasc Surg 24, 105–116 (2002)

Risk Factors

- Males
  - account for 80% of AAA
  - 5% of men over 60 have AAA
- Age > 55
- COPD / smoking
  - > 100 packs smoked confers 7x greater risk of AAA
- Caucasians
- High blood pressure
- Diabetes
- Hypercholesterolemia

Risk Factors

- Atherosclerosis
  - not a risk factor?
  - localizes to infrarenal aorta
  - plaque is present in AAA wall
  - shares RF with AAA (smoking, HTN, hypercholesterolemia)
- Squirrel monkeys fed an atherogenic diet
  - all developed ASD
  - only 1.6% developed AAA
- Theories
  - related to atherosclerotic injury response
  - related to ASD plaque regression

Inflammation

- Both AAA and ASD are characterized by:
  - inflammatory cells that elaborate
    - proteolytic enzymes
    - cytokines that upregulate proteolysis
  - infiltration of macrophages and lymphocytes into plaque, intima, and adventitia

Cardiovascular Surgery, Vol. 5, No. 3, pp. 256–265, 1997

Inflammation

- ASD
  - primarily a T lymphocyte infiltrate
  - late adventitial inflammation
- AAA
  - T and B lymphocyte infiltrate
  - consistent adventitial involvement
  - immunoglobulins
  - complement
  - "inflammtory" aneurysm – an extreme on the continuum of AAA inflammation

Autoimmunity

- Aneurysm wall IgG is an autoantigen that has homology with elastin microfibrils, stimulating an anti-elastin immune response
- AAA is associated with an MHC III locus related to RA

Paik DC, Ramey WG, Dillon J, Tilson MD. The nitrite/elastin reaction: implications for in vivo degenerative effects. *Connect Tissue Res*. 1997; 36: 241-51.

- Nitrite ion
  - nitric oxide
  - nitrogen dioxide
  - cigarette smoke by-products
- Elastin degradation

Lindholt JS, Heickendorff L, Antonsen S, Fasting H, Henneberg EW. Natural history of abdominal aortic aneurysm with and without coexisting chronic obstructive pulmonary disease. *J Vasc Surg*. 1998; 28: 226-33.

- **141 of 4404 (4.2%) had AAA**
- **7.7% of pts w/COPD had AAA (OR 1.59)**
- **Association of aneurysms with COPD may be related to medication and coexisting disease**

	Yearly Expansion Rate
COPD	2.74 mm
No COPD	2.72 mm
Steroids	4.7 mm
No Steroids	2.6 mm

Systemic Levels of Cotinine and Elastase, but not Pulmonary Function, are Associated with the Progression of Small Abdominal Aortic Aneurysms

J. S. Lindholt,[1*] B. Jørgensen,[2] N. A. Klitgaard[2] and E. W. Henneberg[3]

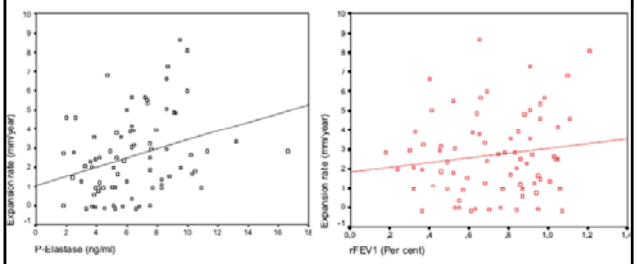


Fig. 2. Scatter plot of plasma level of P-Elastase and the expansion rate of small abdominal aortic aneurysms. Spearman's correlation coefficient $r = 0.30$ ($p = 0.0004$).

Fig. 3. Scatter plot of the relative pulmonary function and the expansion rate of small abdominal aortic aneurysms. Spearman's correlation coefficient $r = 0.13$ ($p = 0.26$).

Symptoms

- **Most nonruptured AAA patients are asymptomatic at diagnosis**
- **Vague abdominal pain with back pain is the most common complaint**
  - **constant or throbbing**
  - **rapid expansion may cause intense pain**
- **GI symptoms (uncommon)**
  - **Early satiety, nausea, weight loss may indicate intestinal compression**

Diagnosis

- **History**
- **Physical exam**
  - **pulsatile, tender abdominal mass**
  - **bruit**
- **Ultrasound**
  - **Good Screening Test**
  - **> 80% accurate**
- **CT**
- **Angiography – not good for diagnosis**

Physical Exam

- n = 198
- 48% of AAA were diagnosed clinically
- Physical exam missed 38% of cases detected radiographically

Eur J Vasc Endovasc Surg 2000; 19: 299-303

Physical Exam

Aneurysm diameter	Sensitivity
3.0-3.9 cm	29%
4.0-4.9 cm	50%
≥ 5.0 cm	76%

JAMA 1999; 281: 77-82

Ultrasound

- Sensitivity 82% to 99%
- Approaches 100% in cases with a pulsatile mass
- In a small proportion of patients, visualization of the aorta is inadequate because of obesity, bowel gas, or periaortic disease

Surg Clin North Am 1989; 69: 713-20

Screening

- 1 / 1000 in adults less than 60
- 7 / 1000 in adults in 60's
- 3 / 1000 in adults older than 70
- 5 – 10% of men over 60 have AAA, most are small
- Prevalence of AAA is 6x lower in women than men

Screening

Table V. Prevalence of small and medium AAAs among 73,451 US military veterans between 50 to 79 years†

Race	*Gender*	*Smoking status*	*AAA ≥3cm (%)*	*AAA ≥4cm (%)*
White	Male	Smoker	5.9	1.9
		Nonsmoker	1.9	0.4
White	Female	Smoker	1.9	0.3
		Nonsmoker	0.6	0
Black	Male	Smoker	3.2	0.8
		Nonsmoker	1.4	0.1

A Sustained Mortality Benefit from Screening for Abdominal Aortic Aneurysm

Lois G. Kim, MSc; R. Alan P. Scott, MCh; Hilary A. Ashton, MSc; and Simon G. Thompson, DSc, for the Multicentre Aneurysm Screening Study Group

Ann Intern Med. 2007;146:699-706.

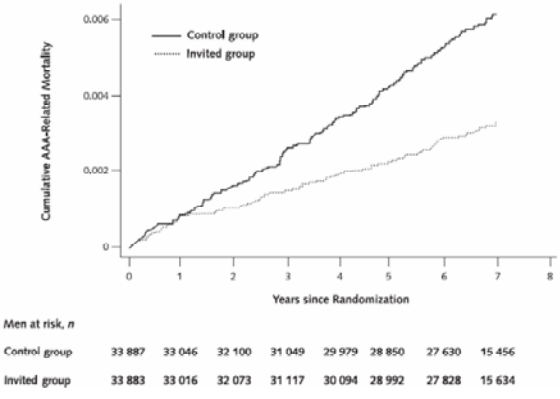
- **70,495 men 65 – 74 years old**
- **Randomized to ultrasound screening or no screening**
- **In the screened group**
  - **> 3 cm were rescreened**
  - **< 3 cm were not rescreened**
- **Endpoints of AAA-related mortality and overall mortality**

MASS

Table 1. **Deaths Related to Abdominal Aortic Aneurysm, Ruptured Abdominal Aortic Aneurysm, and Other Causes***

Variable	Control Group (n = 33 887)	Invited Group (n = 33 883)
Follow-up, person-years	216.0	216.6
Deaths within 30 days of elective surgery, n†	12	18
Deaths from ruptured AAA, n†	153	67
Deaths from ruptured aortic aneurysm at unspecified site, n‖	31	20
Total AAA-related deaths, n (n per 1000 person years)	196 (0.91)	105 (0.48)
Hazard ratio (95% CI)	1.00]	0.53 (0.42–0.68)
Nonfatal ruptured AAA, n	61	30
Total ruptured AAA, n (n per 1000 person-years)¶	257 (1.18)	135 (0.62)
Hazard ratio (95% CI)	1.00]	0.52 (0.42–0.64)
Non-AAA cardiovascular deaths, n		
Ischemic heart disease	1805	1690
Stroke	403	416
Other	508	622
All cardiovascular deaths, n**	2912	2723
Deaths from cancer, n	2409	2386
Deaths from other causes, n††	1797	1774
All deaths, n (n per 1000 person-years)	7119 (32.8)	6882 (31.6)
Hazard ratio (95% CI)	1.00]	0.96 (0.93–1.00)

MASS



MASS

- **50% reduction in AAA related death at 7 years**
- **Cost effective**
- **Women?**

One-time ultrasound screening for AAA is recommended for all men at or older than 65 years. Screening men as early as 55 years is appropriate for those with a family history of AAA.

Level of recommendation:	Strong
Quality of evidence:	High

One-time ultrasound screening for AAA is recommended for all women at or older than 65 years with a family history of AAA or who have smoked.

Level of recommendation:	Strong
Quality of evidence:	Moderate

Re-screening patients for AAA is not recommended if an initial ultrasound scan performed on patients 65 years of age or older demonstrates an aortic diameter of <2.6 cm.

Level of recommendation:	Strong
Quality of evidence:	Moderate

Surveillance imaging at 12-month intervals is recommended for patients with an AAA of 3.5 to 4.4 cm in maximum diameter.

Level of recommendation:	Strong
Quality of evidence:	Low

Surveillance imaging at six-month intervals is recommended for those patients with an AAA between 4.5 and 5.4 cm in maximum diameter.

Level of recommendation:	Strong
Quality of evidence:	Low

Follow-up imaging at three years is recommended for those patients with an AAA between 3.0 and 3.4 cm in maximum diameter.

Level of recommendation:	Strong
Quality of evidence:	Low

Follow-up imaging at five-year intervals is recommended for patients whose maximum aortic diameter is between 2.6 and 2.9 cm.

Level of recommendation:	Weak
Quality of evidence:	Low

Treatment Options

- **Watch and wait**
  - **AAA < 5cm, asymptomatic**
  - **surgical risks > risk of rupture**
  - **lifestyle changes cannot reduce the size of the AAA**
- **Open surgical repair**
- **Endovascular repair**
- **SVS guidelines…**

Repair is recommended for patients that present with an AAA and abdominal or back pain.

Level of recommendation: Strong
Quality of evidence: High

Elective repair is recommended for patients that present with a fusiform AAA ≥5.5 cm in maximum diameter, in the absence of significant co-morbidities.

Level of recommendation: Strong
Quality of evidence: High

Elective repair is suggested for patients that present with a saccular aneurysm.

Level of recommendation: Weak
Quality of evidence: Low

Surveillance is recommended for most patients with a fusiform AAA in the range of 4.0 cm to 5.4 cm in maximum diameter.

Level of recommendation: Strong
Quality of evidence: Moderate

Young, healthy patients, and especially women, with AAA between 5.0 cm and 5.4 cm in maximum diameter may benefit from repair.

Level of recommendation: Weak
Quality of evidence: Low

The benefit of repairing a small aneurysm is uncertain in patients who will require chemotherapy, radiation therapy, or solid organ transplantation.

Level of recommendation: Weak
Quality of evidence: Low

Prognosis of Patients Turned Down for Conventional AAA Repair

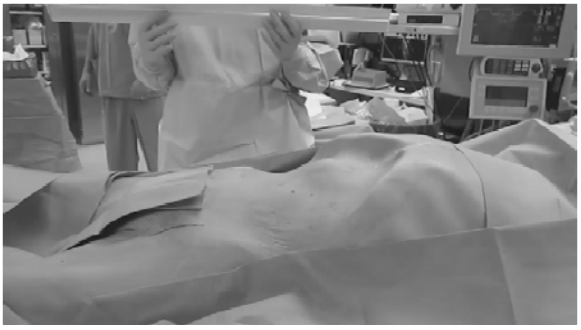
- **106 patients turned down for elective repair**
  - **aneurysms > 5.5 cm**
  - **patient refusal, unfit for surgery, advanced age, cardiac disease, cancer, respiratory disease, dementia, paraplegia**
- **By the end of the study, 76 patients had died (median survival: 9 months)**
  - **37 died from AAA rupture**
  - **17% 3 year survival**

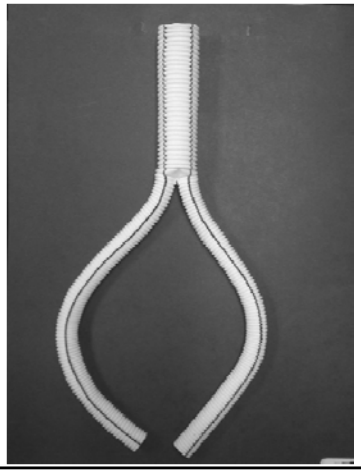
J Vasc Surg 2001; 33: 752-7

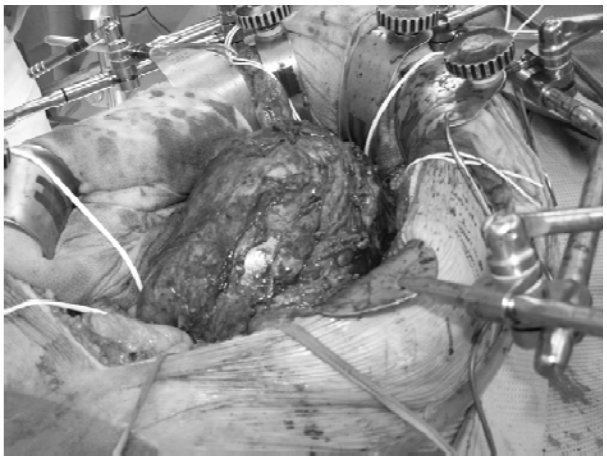
AAA Treatment Options

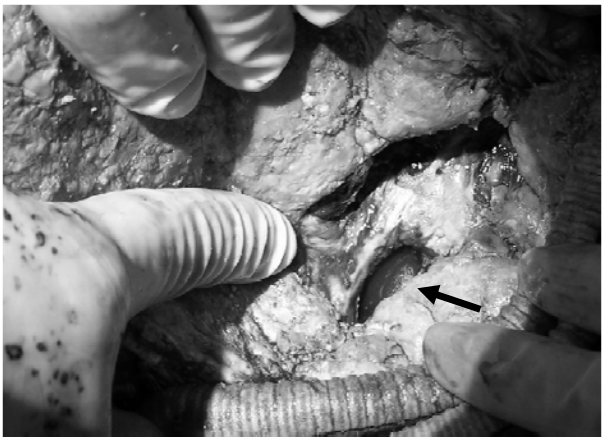
Mounir Haurani, MD
Assistant Professor – Clinical
Division of Vascular Diseases and Surgery
Department of Surgery
The Ohio State University Wexner Medical Center

AAA Treatment Options









Open Abdominal Aortic Aneurysm Repair

- Major surgical procedure
  - Mortality 3% to 8%
  - Other complications
    - Pseudoaneurysms (3%)
    - Erectile Dysfunction (20-30%)
    - Graft thrombosis (2%)
    - Graft infection (1-2%)
- Recovery time 2-4 months

Mayo Study on Open Repair, Early and Late Graft-Related Complications

- 307 patients underwent AAA repair
- Anastomotic aneurysm 9 (3.0%)
- Graft thrombosis 6 (2.0%)
- Graft-enteric erosion/fistula 5 (1.6%)
- Graft infection 4 (1.3%)
- Anastomotic hemorrhage 4 (1.3%)
- Colon ischemia 2 (0.7%)
- Tissue loss 1 (0.3%)
- Atheroembolism 1 (0.3%)

9.4% of patients had a major graft-related complication

J Vasc Surg 1997; 25: 277-86

Complications

- 15% non-aneurysm-related
  - cardiac
  - pulmonary
  - renal

Long-Term Recovery

	n	%
Assisted living facility	4	3
Skilled nursing facility	9	6
Home	106	69
Hospital	1	1

33% felt they never fully recovered

Williamson, W. Kent, et al. "Functional outcome after open repair of abdominal aortic aneurysm." *Journal of vascular surgery* 33.5 (2001): 913-920.

Early OSR vs. Watchful Waiting

- **Combined ADAM and UKSAT trials**
- **Early/immediate repair vs. surveillance/delayed OSR**
- **AAA < 5.5 cm**
- **N = 2226**

Endpoint	Relative Risk	95% CI
All cause mortality	1.01	0.77-1.32
Aneurysm-related mortality	0.78	0.56-1.10

Lederle. *Ann Intern Med* 2007; 146: 735-741

Transition to Endovascular Aneurysm Repair

		Midwest	*Northeast*	*South*	*West*	*National*
Number of patients	OPEN	10,195	6175	13,571	4722	34,663
	EVAR	18,433	13,012	28,102	8,823	68,370
	%EVAR	64.4%	67.8%	67.4%	65.1%	66.4%
		$P > .001$				
30-mortality	OPEN	4.9%	4.8%	5.0%	4.6%	4.9%
	EVAR	2.6%	1.9%	2.4%	2.5%	1.6%
		$P > .001$ (OPEN vs EVAR)				
5-year survival	OPEN	74.4%	73.8%	72.7%	74.1%	73.6%
	EVAR	75.5%	73.6%	74.1%	75.3%	74.6%
		($P = .4$ for OPEN vs EVAR, $P = .9$ for regions)				

- **Total number of AAA repairs was not different (25,246 vs 25,850)**
- ***Percentage of EVARS performed was significantly* higher in 2007 (14,001 [55%] vs 19,471 [75%], *P=0.001)***

Paradigm shifts in the treatment of abdominal aortic aneurysm: Trends in 721 patients between 1996 and 2008

Francisco C. Albuquerque Jr, MD, Britt H. Tonnessen, MD, Robert E. Noll Jr, MD, Giancarlo Cires, MD, Jason K. Kim, MD, and W. Charles Sternbergh III, MD, *New Orleans, Louisiana*

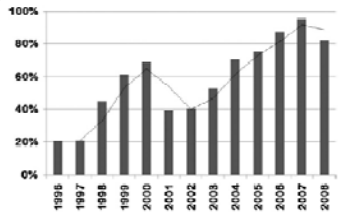


Fig 3. The percentage of endovascular aneurysm repair use in the study period significantly increased in the second period, averaging 77% between 2003 and 2008 ($P < .05$).

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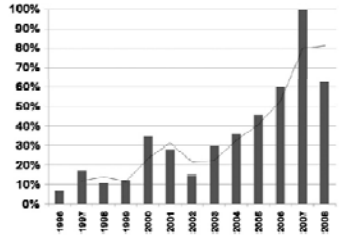
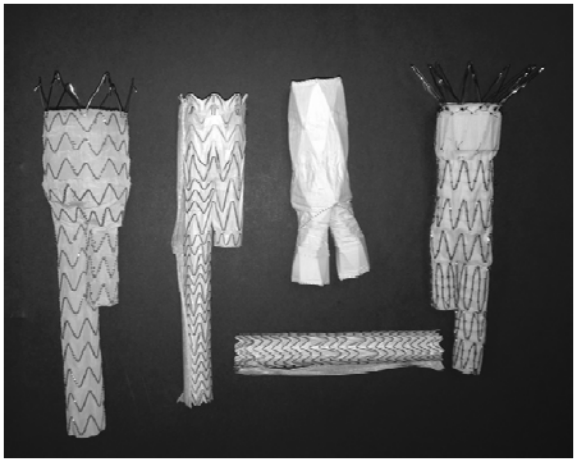
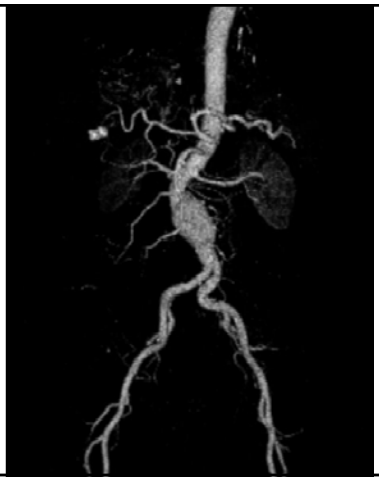


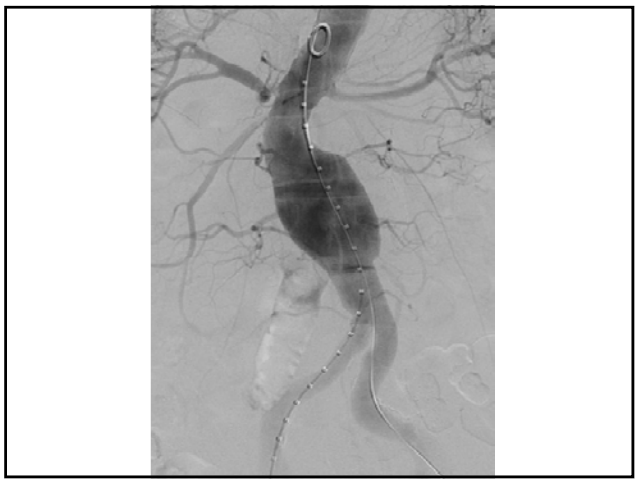
Fig 4. The percentage of juxtarenal abdominal aortic aneurysm (AAA) in the open repair group in the study period significantly increased in the second period ($P < .05$).

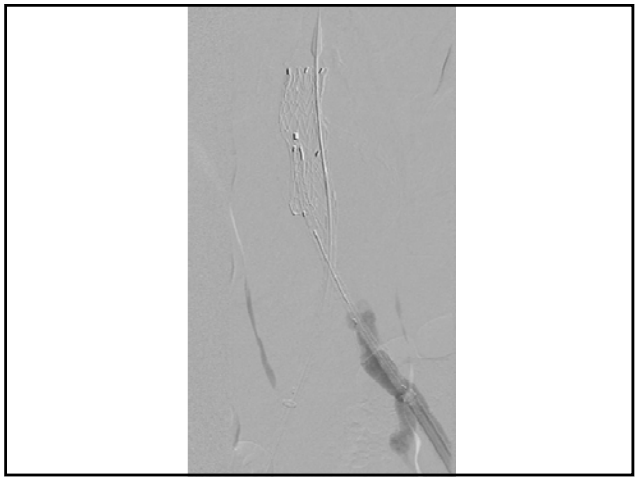
Conclusions

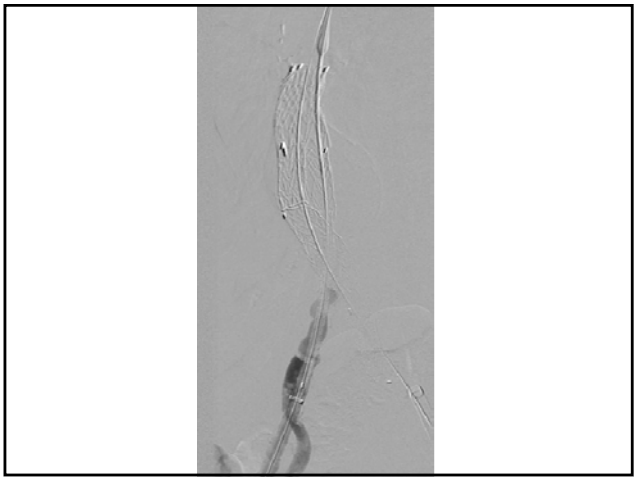
- **Now over 80% of AAA are repaired with EVAR**
- **Overall mortality dropped from 4.9% to 1.8% over the 13 year study period**
- **Rupture mortality has significantly improved**
- **Open AAA repair has become more complex**

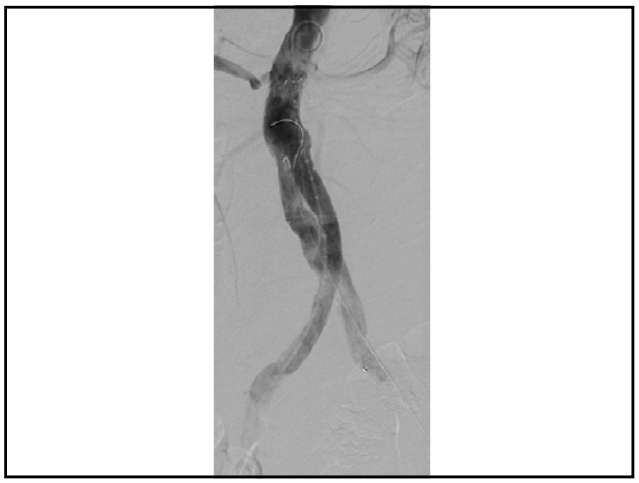


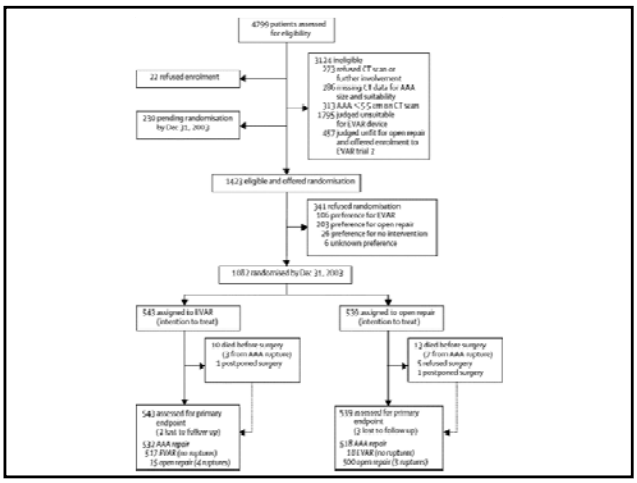




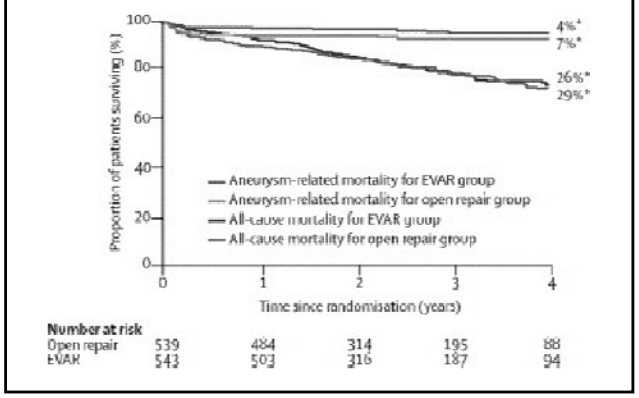




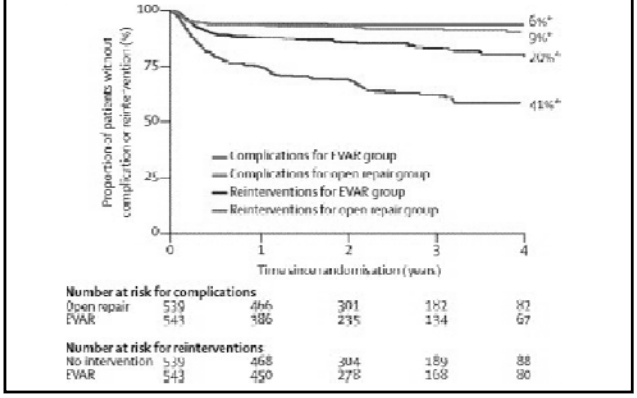




EVAR 1 Trial



EVAR 1 Trial

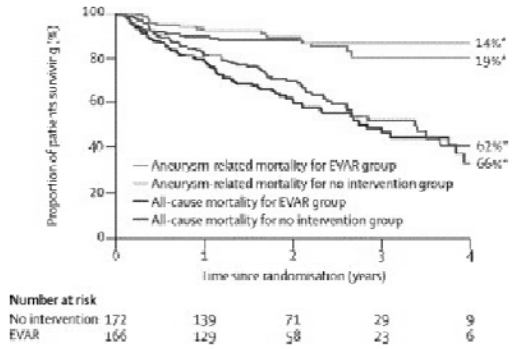


EVAR 1 Conclusions

- Compared with open repair
  - EVAR offers no advantage with respect to all-cause mortality
  - Is more expensive
  - Leads to a greater number of complications and reinterventions.
  - 3% better aneurysm-related survival.

The Lancet Volume 365, Issue 9478, 25 June–1 July 2005, Pages 2179–2186

EVAR 2 (Patients deemed unfit for Open Repair)



EVAR 2 Trial

- EVAR had a considerable 30-day operative mortality in patients already unfit for open repair.
- EVAR did not improve survival over no intervention
- EVAR associated with a need for continued surveillance and reinterventions

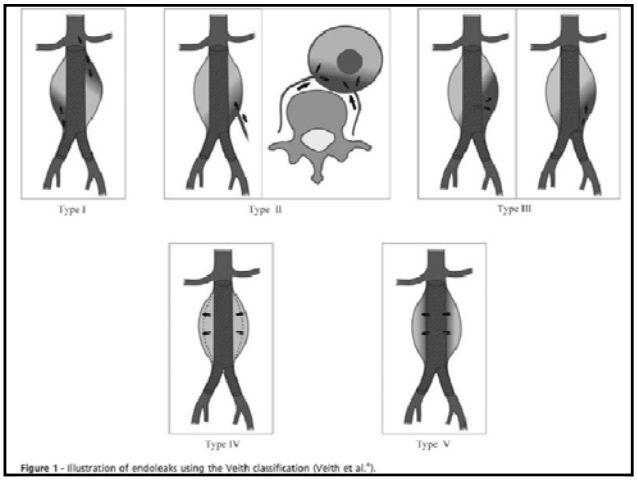
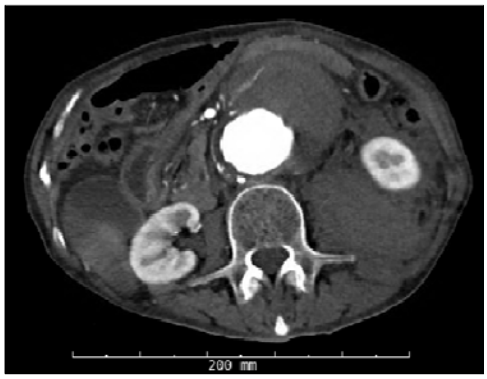


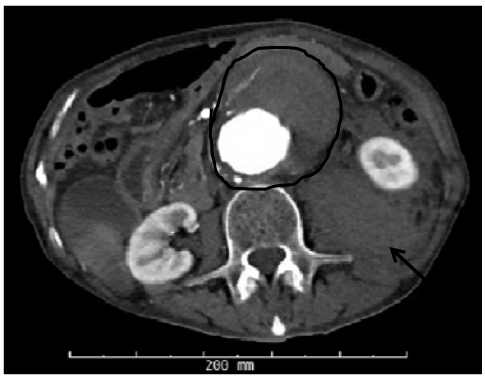
Figure 1 - Illustration of endoleaks using the Veith classification (Veith et al.[6]).

Ruptured AAA



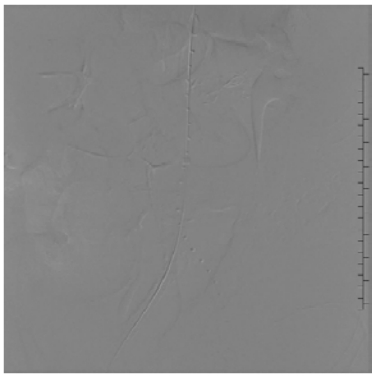
Ruptured AAA

12:38pm



Ruptured Pre

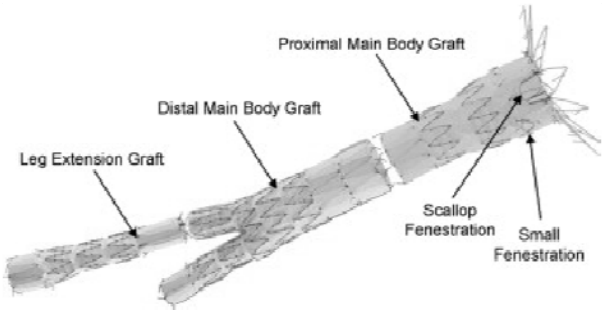
1:47 pm



Ruptured Post

2:58 pm

Future Directions



Journal of Vascular Surgery Volume 50, Issue 4, October 2009, Pages 730–737.e1