Aneurysm Definition

- The abnormal enlargement or bulging of an artery caused by an injury or weakness in the blood vessel wall.

- A localized dilatation of the aorta with an increase in diameter of >1.5 times its normal diameter.
AAA Facts

• Over the last three decades, incidence has tripled\(^1\)
• 1.5 million people in the US have AAAs\(^2\)
• Men present 4:1 over women\(^3\)
• Risk increases for men by 40% every 5 years after age 65\(^4\)
• 15,000 deaths annually due to ruptured AAAs in the US – 13\(^{th}\) leading cause of death\(^2\)
AAA Facts

• Most AAAs are infrarenal – patients often have other aneurysms, including iliac (41%) and femoropopliteal (15%) lesions\(^1\)
• Hypertension (30 – 40\%)\(^4\)
• Smoking (6:1)\(^4,5\)
• > 50,000 procedures per year for AAA repair\(^6\)
AAA Incidence and Location

- Incidence of aortic aneurysms
  Each year, physicians diagnose approximately 200,000 people in the United States with AAA.
  (www.vascularweb.org/contribution pages/patient information)
Clinical Challenge

• The majority of patients are asymptomatic.

• Approximately 40% of patients with ruptured AAAs die prior to presentation to the emergency department\textsuperscript{6}.

• Only 10% to 25% of individuals with ruptured AAAs survive until hospital discharge.
Major Risk Factors

- Current or former smoker
  - A history of smoking has been associated with a 3- to 5- fold increase in AAA prevalence across all age groups\(^3\)
- Family history of AAA
- Age – over 60
- Gender
  - Abdominal aneurysms are four times more common in men than women\(^4\)
    - 5% of US males over 60 are estimated to have a AAA
Risk Factors

Lesser Risk Factors

- Hypertension
- Atherosclerosis
- CAD
<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>&lt;5 cm</td>
<td>5-6 cm</td>
<td>&gt;6 cm</td>
</tr>
<tr>
<td>Gender</td>
<td>—</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Wall stress</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>(&lt;30 N/cm²)</td>
<td>(30-40 N/cm²)</td>
<td>(&gt;40 N/cm²)</td>
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<tr>
<td>Smoking</td>
<td>—</td>
<td>Never, former</td>
<td>Current</td>
</tr>
<tr>
<td>Pulmonary/COPD</td>
<td>None, mild</td>
<td>Moderate</td>
<td>Severe, steroids</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Expansion rate</td>
<td>&lt;0.3 cm/yr</td>
<td>0.3-0.6 cm/yr</td>
<td>&gt;0.6 cm/yr</td>
</tr>
<tr>
<td>Family history</td>
<td>None</td>
<td>One</td>
<td>Multiple</td>
</tr>
<tr>
<td>Hypertension</td>
<td>None</td>
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<tr>
<td>Statin use</td>
<td>On statin</td>
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<td></td>
</tr>
</tbody>
</table>

Risks are portrayed as “average,” “lower than average,” or “higher than average” for an example patient, depending on the presence or absence of a particular risk factor. They can also be displayed as calculated fields based on quantitative data from the literature or risk models when available. COPD, chronic obstructive pulmonary disease.
Prevalence of AAAs

• AAAs encountered more frequently in contemporary practice due to:
  – Better diagnosis
  – True increase in prevalence

• Prevalence as well as rupture risk increase sharply with age$^7$

• Population over the age of 65 will grow from 34 million to 50 million by 2020$^8$
Symptoms

• AAA is often called a “silent killer” because there are no obvious symptoms of the disease (www.SIRweb.org)
  – Three out of four aneurysms show no symptoms at the time they are diagnosed (www.SIRweb.org)

• Possible symptoms may include:
  – Abdominal pain
  – Pain in the lower back that may extend to the buttocks, groin or legs
  – Pulsating sensation in the abdomen

• Symptoms indicating a rupture may include:
  – Sudden onset of severe back or abdominal pain
  – Nausea
  – Dizziness, fainting and/or sudden weakness
Diagnostic Methods

• Physical exam, palpation and auscultation

• Abdominal Ultrasound
  – Commonly used as a primary screening tool
  – Provides details of the vessel wall and plaque

• Computed Tomography Arteriography (CTA)
  – Most accurate test to determine size and location
  – Readily available
  – Eliminates the need for invasive angiography but requires IV contrast
Diagnostic Methods

- Arteriogram
  - Less useful modality
  - Unable to accurately delineate AAA due to thrombus lining the flow lumen
  - Provides images of associated arterial occlusive disease
When to Treat

Elective repair of AAA is recommended when the maximal aneurysm diameter is 5.5 cm or more.

Aneurysms that have a saccular morphology may be considered for repair even if < 5 cm in diameter.

Aneurysms that have a fusiform morphology may be considered for repair if they are painful, have caused distal embolization, or are rapidly enlarging (>0.5 cm/year).
AAA Treatment Options

• Medical Management / Monitor
  - Wait, watch and control hypertension
  - Typically reserved for aneurysms < 5 cm that are not rapidly expanding or causing symptoms
  - Most commonly monitored with regular CT scans or ultrasound examinations
AAA Treatment Options

• Surgical Treatment
  - Elective repair has a perioperative mortality rate of about 3 - 5%\(^3\)
  - 22 - 30% morbidity
  - High risk surgical group includes: cardiac, renal, pulmonary disease, and morbid obesity\(^9\)
  - Patients > 75 years of age have a higher perioperative mortality rate\(^9\)
  - Average 7 to 10 days hospitalization\(^10\)
  - Emergency repair: mortality 40 - 50%\(^11\)
  - Coronary events are the leading cause of death following repair of AAAs\(^12\)
AAA Treatment Options

<table>
<thead>
<tr>
<th>Risk Diameter (cm)</th>
<th>Rupture (% per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>0%</td>
</tr>
<tr>
<td>4 - 5</td>
<td>0.5 - 5%</td>
</tr>
<tr>
<td>5 - 6</td>
<td>3 - 15%</td>
</tr>
<tr>
<td>6 - 7</td>
<td>10 - 20%</td>
</tr>
<tr>
<td>7 - 8</td>
<td>20 - 40%</td>
</tr>
<tr>
<td>&gt; 8</td>
<td>30 - 50%</td>
</tr>
</tbody>
</table>

- **AAA Expansion Rate**\(^{14}\)
  - Although a number of studies have found that small AAAs expand at approximately 0.5 cm in diameter per year, individual patients show considerable variation in aneurysm expansion rates.
Open Surgical Repair

Surgical Treatment - Two Methods:

• Transabdominal
  – Most common approach

• Retroperitoneal
  – Reduced gastrointestinal impairment following operation
Open Surgical Repair

- Results of Standard Open Repair
  - Effective and durable…but
    - 4 - 5% mortality in population-based studies\textsuperscript{15,16,17}
    - Recovery 2 - 4 months\textsuperscript{18}
    - High risk patients often denied repair\textsuperscript{19}
    - 5-year survival rate of 46%\textsuperscript{9}
Open Surgical Repair

• Complications
  – Infection
  – Limb thrombosis
  – Aortoenteric fistula (AEF)
  – Paraplegia
  – Pseudoaneurysm formation at anastomoses
Open Surgical Repair

- Infection: Catastrophic event\(^1\)
  - Mortality (25 - 88%)
  - Incidence (1 - 2%)
  - Mean time to onset (6 months - 4 years)
  - 8 - 10% of all aneurysms yield positive bacterial cultures
Endovascular Repair

- Principles of Endovascular Aortic Repair (EVAR)
  - Anchoring and secure fixation of endoluminal device above and below AAA in normal arterial segments
  - Hemostatic seals exclude AAA from circulation
  - Exclusion and depressurization prevent AAA rupture
Endovascular Repair

• Goal of EVAR

− Accurate placement and secure attachment of a sutureless prosthesis across an aneurysm, to effect repair quite similar to standard open surgical grafting but using only:
  • Small groin incision
  • Minimal anesthesia
AAA Endovascular Repair

- Potential Benefits of EVAR
  - Shorter hospital stay; 1 - 3 days vs. 5 - 13 days\(^2,16\)
  - Safer option for high risk patients: most have significant concomitant disease (e.g., CAD, COPD)\(^2\)
  - Anesthesia:\(^{15,16}\)
    - General = shorter time and less blood loss
    - Regional = epidural
    - Local = percutaneous (closure devices)
  - Overall lower morbidity
  - Lower mortality rate
  - Patient comfort\(^{14}\)
Challenges of Endovascular AAA repair

Prevent rupture — Continued pressurization

Endoleaks — Unique to endovascular repair

Device durability — Long Term data unknown

Aneurysm enlargement (not curing the disease or removing the diseased aorta)

Patient must be able to comply with follow-up requirements
Figure 129-1  A type I endoleak (periprosthetic) occurs at the proximal or distal attachment zones (or at both). A type II endoleak is caused by retrograde flow from patent lumbar or inferior mesenteric arteries. A type III endoleak arises from a defect in the graft fabric, an inadequate seal, or disconnection of modular graft components. A type IV endoleak is due to graft fabric porosity, which often results in a generalized mild blush of contrast material within the aneurysm sac. (From White GH, May J, Waugh RC, et al. Type III and type IV endoleak: toward a complete definition of blood flow in the sac after endoluminal AAA repair. J Endovasc Surg. 1998;5:305-309.)
Risk factors associated with endo-leak formation and repeat intervention in EVAR patients:

- Short infra renal-neck (<1.5cm)
- Acute angulation of the infra-renal aorta
- Thrombus in the proximal infra-renal landing zone
- Limb ischemia from compression or contortion of the EVAR limbs
- Shape changes in the aneurysm sac as it shirks (due to being depressurized) changing the stent graph purchase or orientation in the infra-renal aorta.
Table 127-8 Method of Portraying Risk Factors in a Unified Fashion for Patient-Specific Education

<table>
<thead>
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Figure 127-6  Basic decision-making algorithm. AAA, abdominal aortic aneurysm; EVAR, endovascular aneurysm repair.
Results of Ruptured Abdominal Aortic Aneurysms from Recent Administrative Data, Systematic Reviews and Mega-Analyses

<table>
<thead>
<tr>
<th>SERIES</th>
<th>DATE AND SOURCE</th>
<th>OPEN</th>
<th>EVAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dillavou</td>
<td>2006 /CMS, 2003</td>
<td>5,042</td>
<td>598</td>
</tr>
<tr>
<td>Greco</td>
<td>2006/4 states, 2000-2003</td>
<td>5,508</td>
<td>290</td>
</tr>
<tr>
<td>McPhee</td>
<td>2007/NIS, 2001-2004</td>
<td>18,839</td>
<td>2,093</td>
</tr>
<tr>
<td>Harkin</td>
<td>2007/Systematic review</td>
<td>5,983</td>
<td>891</td>
</tr>
<tr>
<td>Hoornweg</td>
<td>2008/Meta-analysis 1991-2006</td>
<td>60,822</td>
<td>48.5%</td>
</tr>
<tr>
<td>Mastracci</td>
<td>2008/Systematic/meta-analysis</td>
<td>3,213</td>
<td>436</td>
</tr>
<tr>
<td>Lesperance</td>
<td>2008/NIS, 2003-2004</td>
<td>8,982</td>
<td>949</td>
</tr>
<tr>
<td>Giles</td>
<td>2009/NIS, 2001-2005</td>
<td>20,836</td>
<td>2,499</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>129,225</strong></td>
<td><strong>44.6%</strong></td>
<td><strong>7,756</strong></td>
</tr>
</tbody>
</table>

This chart compares the 30-day mortality of Open and EVAR repair of ruptured AAA.
Endovascular versus Open Repair of Abdominal Aortic Aneurysm

The United Kingdom EVAR Trial Investigators*

ABSTRACT

BACKGROUND
Few data are available on the long-term outcome of endovascular repair of abdominal aortic aneurysm as compared with open repair.

METHODS
From 1999 through 2004 at 37 hospitals in the United Kingdom, we randomly assigned 1252 patients with large abdominal aortic aneurysms (≥5.5 cm in diameter) to undergo either endovascular or open repair; 626 patients were assigned to each group. Patients were followed for rates of death, graft-related complications, reinterventions, and resource use until the end of 2009. Logistic regression and Cox regression were used to compare outcomes in the two groups.

RESULTS
The 30-day operative mortality was 1.8% in the endovascular-repair group and 4.3% in the open-repair group (adjusted odds ratio for endovascular repair as compared with open repair, 0.39; 95% confidence interval [CI], 0.18 to 0.87; P=0.02). The endovascular-repair group had an early benefit with respect to aneurysm-related mortality, but the benefit was lost by the end of the study, at least partially because of fatal endograft ruptures (adjusted hazard ratio, 0.92; 95% CI, 0.57 to 1.44; P=0.73). By the end of follow-up, there was no significant difference between the two groups in the rate of death from any cause (adjusted hazard ratio, 1.05; 95% CI, 0.86 to 1.23; P=0.72). The rates of graft-related complications and reinterventions were higher with endovascular repair, and new complications occurred up to 8 years after randomization, contributing to higher overall costs.

CONCLUSIONS
In this large, randomized trial, endovascular repair of abdominal aortic aneurysm was associated with a significantly lower operative mortality than open surgical repair. However, no differences were seen in total mortality or aneurysm-related mortality in the long term. Endovascular repair was associated with increased rates of graft-related complications and reinterventions and was more costly. (Current Controlled Trials number, ISRCTN57095451.)
Figure 2. Kaplan–Meier Estimates for the Time to the First Graft-Related Complication or Reintervention during 8 Years of Follow-up.

The rates of graft-related complications (Panel A) and reinterventions (Panel B) were higher among patients in the endovascular-repair group than among those in the open-repair group. New complications occurred throughout the 8-year follow-up period, contributing to the higher overall costs of the endovascular procedure.
Figure 1. Kaplan–Meier Estimates for Total Survival and Aneurysm-Related Survival during 8 Years of Follow-up.

Among patients randomly assigned to either endovascular repair or open repair of an abdominal aortic aneurysm, an early benefit with respect to aneurysm-related mortality in the endovascular-repair group was lost by the end of the study, at least partially because of fatal endograft ruptures (adjusted hazard ratio with endovascular repair, 0.92; 95% CI, 0.57 to 1.49; P=0.73). By the end of 8 years of follow-up, there was no significant difference between the two groups in the risk of death from any cause (adjusted hazard ratio, 1.03; 95% CI, 0.86 to 1.23; P=0.72).
Long-Term Outcome of Open or Endovascular Repair of Abdominal Aortic Aneurysm

Jorg L. De Bruin, M.D.; Annette F. Baas, M.D.; Jaap Buth, M.D.; Monique Prinsen, M.D.; Eric L.G. Verhoeven, M.D.; Philippe W.M. Cuypers, M.D.; Marc R.H.M. van Sambeek, M.D.; Ron Balm, M.D.; Diederick E. Grobbbee, M.D.; and Jan D. Blankenstein, M.D., for the DREAM Study Group

ABSTRACT

BACKGROUND
For patients with large abdominal aortic aneurysms, randomized trials have shown an initial overall survival benefit for elective endovascular repair over conventional open repair. This survival difference, however, was no longer significant in the second year after the procedure. Information regarding the comparative outcome more than 2 years after surgery is important for clinical decision making.

METHODS
We conducted a long-term, multicenter, randomized, controlled trial comparing open repair with endovascular repair in 351 patients with an abdominal aortic aneurysm of at least 5 cm in diameter who were considered suitable candidates for both techniques. The primary outcomes were rates of death from any cause and reintervention. Survival was calculated with the use of Kaplan–Meier methods on an intention-to-treat basis.

RESULTS
We randomly assigned 178 patients to undergo open repair and 173 to undergo endovascular repair. Six years after randomization, the cumulative survival rates were 69.9% for open repair and 68.9% for endovascular repair (difference, 1.0 percentage point; 95% confidence interval [CI], −8.8 to 10.8; P=0.97). The cumulative rates of freedom from secondary interventions were 81.9% for open repair and 70.4% for endovascular repair (difference, 11.5 percentage points; 95% CI, 2.0 to 21.0; P=0.03).

CONCLUSIONS
Six years after randomization, endovascular and open repair of abdominal aortic aneurysm resulted in similar rates of survival. The rate of secondary interventions was significantly higher for endovascular repair. (ClinicalTrials.gov number, NCT00421330.)
Long-Term Comparison of Endovascular and Open Repair of Abdominal Aortic Aneurysm

Frank A. Lederle, M.D., Julie A. Freischlag, M.D., Tassos C. Kyriakides, Ph.D., Jon S. Matsumura, M.D., Frank T. Padberg, Jr., M.D., Ted R. Kohler, M.D., Panagiotis Kougiou, M.D., Jessie M. Jean-Claude, M.D., Dolores F. Cikrit, M.D., and Kathleen M. Swanson, M.S., R.Ph., for the OVER Veterans Affairs Cooperative Study Group

ABSTRACT

BACKGROUND

Whether elective endovascular repair of abdominal aortic aneurysm reduces long-term morbidity and mortality, as compared with traditional open repair, remains uncertain.

METHODS

We randomly assigned 881 patients with asymptomatic abdominal aortic aneurysms who were candidates for both procedures to either endovascular repair (444) or open repair (437) and followed them for up to 9 years (mean, 5.2). Patients were selected from 42 Veterans Affairs medical centers and were 49 years of age or older at the time of registration.

RESULTS

More than 95% of the patients underwent the assigned repair. For the primary outcome of all-cause mortality. 146 deaths occurred in each group (hazard ratio with endovascular repair versus open repair, 0.97; 95% confidence interval [CI], 0.77 to 1.22; P=0.81). The previously reported reduction in perioperative mortality with endovascular repair was sustained at 2 years (hazard ratio, 0.63; 95% CI, 0.40 to 0.98; P=0.04) and at 3 years (hazard ratio, 0.72; 95% CI, 0.51 to 1.00; P=0.05) but not thereafter. There were 10 aneurysm-related deaths in the endovascular-repair group (2.3%) versus 16 in the open-repair group (3.7%) (P=0.22). Six aneurysm ruptures were confirmed in the endovascular-repair group versus none in the open-repair group (P=0.03). A significant interaction was observed between age and type of treatment (P=0.006); survival was increased among patients under 70 years of age in the endovascular-repair group but tended to be better among those 70 years of age or older in the open-repair group.

CONCLUSIONS

Endovascular repair and open repair resulted in similar long-term survival. The perioperative survival advantage with endovascular repair was sustained for several years, but rupture after repair remained a concern. Endovascular repair led to increased long-term survival among younger patients but not among older patients, for whom a greater benefit from the endovascular approach had been expected. (Funded by the Department of Veterans Affairs Office of Research and Development; OVER ClinicalTrials.gov number, NCT00094575.)
Cumulative Probability of Death

Hazard ratio, 0.97 (95% CI, 0.77–1.22)
P=0.81

No. at Risk
Open       437  410  386  354  329  266  169  102  35
Endovascular 444  423  410  381  347  265  159  94  34
B

Cumulative Probability of Death or Secondary Procedure

Years

Hazard ratio, 1.06 (95% CI, 0.87–1.28)
P=0.57

No. at Risk
Open 437 385 347 314 284 222 133 79 28
Endovascular 444 389 366 334 292 217 123 69 23
Endovascular Repair of Aortic Aneurysm in Patients Physically Ineligible for Open Repair

The United Kingdom EVAR Trial Investigators

ABSTRACT

BACKGROUND
Endovascular repair of abdominal aortic aneurysm was originally developed for patients who were considered to be physically ineligible for open surgical repair. Data are lacking on the question of whether endovascular repair reduces the rate of death among these patients.

METHODS
From 1999 through 2004 at 33 hospitals in the United Kingdom, we randomly assigned 404 patients with large abdominal aortic aneurysms (25.5 cm in diameter) who were considered to be physically ineligible for open repair to undergo either endovascular repair or no repair; 197 patients were assigned to undergo endovascular repair, and 207 were assigned to have no intervention. Patients were followed for rates of death, graft-related complications and reinterventions, and costs until the end of 2009. Cox regression was used to compare outcomes in the two groups.

RESULTS
The 30-day operative mortality was 7.3% in the endovascular-repair group. The overall rate of aneurysm rupture in the no-intervention group was 12.4 (95% confidence interval [CI], 9.6 to 16.2) per 100 person-years. Aneurysm-related mortality was lower in the endovascular-repair group (adjusted hazard ratio, 0.53; 95% CI, 0.32 to 0.90; P=0.02). This advantage did not result in any benefit in terms of total mortality (adjusted hazard ratio, 0.99; 95% CI, 0.78 to 1.27; P=0.97). A total of 48% of patients who survived endovascular repair had graft-related complications, and 27% required reintervention within the first 6 years. During 8 years of follow-up, endovascular repair was considerably more expensive than no repair (cost difference, £9,826 [U.S. $14,867]; 95% CI, 7,638 to 12,013 [11,556 to 18,170]).

CONCLUSIONS
In this randomized trial involving patients who were physically ineligible for open repair, endovascular repair of abdominal aortic aneurysm was associated with a significantly lower rate of aneurysm-related mortality than no repair. However, endovascular repair was not associated with a reduction in the rate of death from any cause. The rates of graft-related complications and reinterventions were higher with endovascular repair, and it was more costly. (Current Controlled Trials number, ISRCTN55703451.)
Endovascular repair; aneurysm-related survival, 86% (95% CI, 79–90)

No intervention; aneurysm-related survival, 64% (95% CI, 55–72)

Endovascular repair; total survival, 30% (95% CI, 26–37)

No intervention; total survival, 26% (95% CI, 20–32)

<table>
<thead>
<tr>
<th>Years since Randomization</th>
<th>Patients Who Survived (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>91</td>
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<td>81</td>
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<td>6</td>
<td>40</td>
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<td>7</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
</tr>
</tbody>
</table>

No. at Risk

Endovascular repair: 197, 127, 81, 39, 6

No intervention: 207, 137, 80, 39, 7
• These studies are all large prospective randomized studies which reveal remarkably similar, yet surprising results.
• The risk of aneurysm-related death was low in both patient groups, but overall mortality was high in all patients.
• In the DREAM trial, 118 of the 351 patients (34%) died during a median follow up of 6 years, yet only 2 (<1%) died of aneurysm rupture.
• In EVAR 1, a total of 524 of the 1252 patients (42%) patients died during a median follow up of 6 years, but only 76 (5%) died of aneurysm rupture.
• In the OVER study Of 881 patients followed a mean of 5.2 years, 33% died, but only 3% from aneurysm-related disease.
• The strong relationship between cigarette smoking and aneurysm formation makes the AAA patient group susceptible to numerous, more common diseases associated with smoking, including CAD, CVD, cancer and COPD. mortality catch-up”
• The initial reduction in morbidity and mortality in the EVAR patients was offset by a “mortality catch-up” among the patients in the endovascular repair group.
• Aneurysm rupture represents a small portion, but does account for all of the “mortality catch-up”.
• Proper care of patients with AAA yields excellent outcomes with low AAA-related mortality as long as 6 years.
• A diagnosis of AAA should immediately indicate modification of cardiovascular risk factors consistent with the secondary prevention of cardiovascular events.
• Similar long-term outcomes allow patient preference-related decision making to be part of the process. In the absence of a significant long-term mortality between the two types of repair, patients can weigh the value of open repair, a major operation with greater upfront morbidity and mortality, against that of endovascular repair, with its lower early-event rate but the need for indefinite radiological surveillance.
EVAR has reduced the pain and suffering associated with AAA repair, but offers no long term survival advantage over Open AAA repair.

EVAR is associated with a lower operative mortality rate for ruptured AAA.

Attention to other smoking related illnesses is warranted as they represent the majority of causes of morbidity and mortality after AAA surgery (open or closed).

Long term surveillance of EVAR patients is mandatory due to the high need for repeat interventions and possible late rupture.
Thank You