The Current Status of AAA Stent Grafting

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ABSTRACT

It is now 16 years since the endovascular treatment of abdominal aortic aneurysm (AAA) was first described. It is probably true to say that, with current device technology, > 50% of all patients with an infrarenal aneurysm can be treated with an endograft. Endografting has become an important tool in the treatment of AAA. There are many reasons for this success. Rapid technical development followed the initial “homemade” devices, allowing easy accurate insertion. In early cohort series it was always the case that the operative mortality of endografting in AAA was lower than surgical treatment. In addition, postoperative management was easier and hospital stay was shorter after an endograft. No evidence indicated that quality of life improved after the perioperative period, however, and it was unclear whether the reduction in intensive hospital care requirement justified the considerable extra costs for an endovascular device. Despite these shortcomings, early widespread public awareness pushed endograft treatment forward. Patients started to ask for this new treatment option. But long-term outcome data then, and to some extent today, are still lacking.

KEYWORDS: EVAR 1 and 2 Trials, DREAM Trial, Eurostar Registry, eEVAR

Objectives: Upon completion of this article, the reader should (1) have knowledge of the current state of the art concerning the treatment of AAA, and (2) be able to make evidence-based decisions.

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It is generally accepted that surgical treatment of symptomatic infrarenal abdominal aortic aneurysms (AAAs) prevents untimely death from rupture and exsanguination, based on data from several case series published over the past 50 years. The situation with asymptomatic aneurysms is different. European and American trials that have randomized small aneurysms to watchful waiting or early open surgery have shown that surgery does not improve the 5-year survival rate if the aneurysm diameter does not exceed 5.5 cm,^{1–3} and the morbidity and mortality of surgery is greater than the rupture rate below this size.⁴ The uncertainty of

treatment requires further studies for larger aneurysms. However, no such studies have ever been applied to endovascular treatments for aneurysms. The optimal aneurysm diameter to gain any benefit from endografting has not yet been investigated.⁴

Since the first publication on stent grafts for the treatment of AAA by Parodi et al in 1991,⁵ there have been many publications on this topic. The majority of these papers are technical case reports, case series, and uncontrolled retrospective and prospective studies including several registries. None of these publications has any high scientific value.

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There are, however, several studies that help us to determine the current status of endovascular AAA treatment based on scientific evidence.^{6–11} Two of these are prospective randomized multicenter studies that provide level 1 data.^{6,10,11} The other is a large European registry that also provides some important information.^{12,13}

It was clear from the EUROSTAR Registry data that long-term follow-up with computed tomography (CT) was mandatory and that secondary interventions were not uncommon, including embolization and even late conversions. However, the implications of this could only be answered by a randomized controlled trial. We now have the data from such trials; the Dutch Randomized Endovascular Aneurysm Management (DREAM) study⁶ and the British Endovascular Aneurysm Repair Trials (EVAR 1 and EVAR 2).^{9,10} The data from these trials have provided us with evidence about perioperative morbidity and mortality, follow-up, reinterventions, quality of life, and costs. This state-of-the-art overview is based on these three important sources.

ASYMPTOMATIC ABDOMINAL AORTIC ANEURYSMS

Perioperative Mortality

In the DREAM trial, the in-hospital mortality was 1.2% for endovascular treatment versus 4.6% for open surgery. To understand this better we need to look at the number needed to treat (NNT), a measure of how many patients need to be treated with an endograft to prevent one death if open surgery was the only option. In the DREAM trial the NNT is 29. In the EVAR 1 study, the results are similar. In the endovascular group, mortality was 2.1% versus 6.2% for open surgery. Here the NNT is 24. There is an absolute risk reduction of 4.1%.

Perioperative Morbidity

Aneurysm surgery has a high morbidity. The most common problems are renal insufficiency, myocardial infarction, ischemic bowel, and stroke. In the DREAM trial, there were 3.6% serious complications in the endovascular group versus 5.4% in the open surgery group. Combining mortality and morbidity, this is 4.7% for endovascular and 9.8% for open surgery. The EVAR 1 study is not very clear on perioperative major complications but very clear about all causes of 4-year morbidity.

Mortality During Follow-up

Death from all causes was calculated in both trials. In EVAR 1 after 4 years, there was a 74% survival in the endovascular group versus 71% in the open surgery group. This difference was almost entirely due to the

lower perioperative mortality but was not shown to be significant at the end of the trial. In other words, the initial advantage of the endovascular approach is not maintained after the perioperative period. The small perioperative gain for mortality in DREAM could not be maintained after 2 years. Survival was 90% in both groups at 2 years. Again, although there is a small reduction in perioperative mortality, this difference is maintained at 4 years but does not increase.

Reinterventions

Fifteen percent of patients in EVAR 1 required surgical or radiological interventions in the endovascular group during follow-up. The figure in the surgical group was 7%. Most reinterventions were done for endoleak or thrombosis. The EUROSTAR registry concludes that the high incidence of late secondary interventions is a cause for concern with regard to broad application of endovascular AAA repair, and it emphasizes the need for lifelong surveillance.¹²

Quality of Life

Quality of life (QOL) is an important parameter for success of AAA treatment because we are dealing with an elective treatment to prevent a statistical chance of rupture. From the early days of endograft treatment, it was said that its main advantage would be the minimally invasive nature of the treatment and the presumed consequent better QOL versus open surgery.

In the DREAM trial, after 3 months, no difference could be detected in QOL between endovascular and open treatment.¹¹ Although EVAR 1 did not focus on this item, we can find confirmation for the DREAM results here too. This is not surprising when we consider that by all validated QOL questionnaires, arteriopathies have a lower baseline QOL than nonarteriopathies.

Costs

Endografts currently are very expensive. The question has been raised whether these higher costs are balanced by shorter hospital stays. EVAR 1 looked at this problem. All costs, in hospital, reinterventions, complications, and follow-up scans, were calculated. The total costs for endovascular treatment were ~30% higher than open surgery.

Does Endovascular Treatment Confer a Survival Advantage on Patients Unfit for Open Surgery?

The EVAR 2 trial¹⁰ randomized 338 patients older than 60 years considered unfit for open surgery by their American Society of Anesthesiologists (ASA) grading to either endovascular treatment or best medical therapy

and follow-up. The 30-day mortality following endovascular repair at 30 days was 9%. At 4 years, 142 of the original 338 patients had died (42%), and 42 of these (40%) had died from an aneurysm-related complication. It must also be noted that 27% of patients in EVAR 2 crossed over from nonoperative to endovascular repair, and these patients had lower procedure mortality from EVAR than those originally assigned to it (2% versus 9%). Some have interpreted these 47 cases, plus the exclusion of 14 patients dying while waiting for EVAR, as showing that EVAR confers a survival over those receiving no treatment in a post hoc analysis. But per protocol analysis of the EVAR 2 trial data performed by the EVAR investigators did not show a significant difference in either all-cause or aneurysm-related mortality even when the crossovers were included. In other words, at 4 years no survival difference between the EVAR group and the group treated nonoperatively could be determined. In the EVAR group the number of reinterventions was high at 26% while only 4% of the nonoperative group required an intervention. QOL showed no difference at any point in time. The cost of nonoperative management was €12,000 lower than the costs per patient in the EVAR group.

We can draw two important conclusions from this high-level evidence. In asymptomatic high-risk patients with an aneurysm > 5.5 cm, endovascular treatment has no advantage over conservative treatment considering mortality from all causes. Also QOL is not better after endovascular treatment and costs are far higher. There may be a subgroup where endovascular treatment has an advantage, for instance a patient with an aneurysm > 7 cm, but this is unknown. The lower mortality in the crossover group after EVAR compared with the nonoperative group suggests that the emphasis should be placed on making unfit patients fit for surgery by concentrating on their cardiac and respiratory status. EVAR may provide survival advantage on unfit patients after contained AAA rupture, but there is no statistical analysis to confirm this. Nevertheless, current recommendations are that unfit patients who have a ruptured AAA should be considered for EVAR if possible.

The second conclusion is that young patients with low surgical risk might be better treated with surgery. This is because long-term follow-up data from endovascular treatment are lacking, and these patients have a very low morbidity and mortality risk after surgery. The main disadvantage of endovascular treatment is lifelong follow-up and the apparent high risk of reintervention. But EUROSTAR data¹³ have suggested that the high rate of reintervention apparent in the early days of both the EVAR and DREAM trials might not be such an issue in the future because device technology has improved and the previous headlong rush to treat type 2 endoleaks is no longer necessary, the majority being self-limiting. Similarly, the rupture risk, also calculated from

the EUROSTAR data, of 1% in the first year after endovascular treatment¹³ is an important issue to discuss with the patient but might not be as relevant with today's devices and surveillance.

Some have interpreted the EVAR and DREAM studies as not showing any survival advantage for endovascular repair over open repair. They conveniently ignore the 3% lower perioperative mortality risk for EVAR. Systemic review¹⁴ confirms this advantage, which many patients might feel is important. The EVAR and DREAM trials have provided us with important data, but there are still wide gray areas where we have to interpret the evidence. The doctor and the patient have to use the data to decide the best option for a specific individual.

ACUTE AAA RUPTURE

The data just discussed for EVAR in elective AAA treatment is compelling, and it would be useful if these results could be extrapolated to the endovascular treatment of ruptured AAA by emergency EVAR (eEVAR). Given the high morbidity and mortality associated with open repair, improved outcomes would certainly be welcome. Unfortunately thus far, eEVAR studies have consisted of small series with significant selection bias. One of the major problems is that not all patients have aneurysms that are anatomically suitable for endografting, which contributes massively to selection bias. No clear advantage has been demonstrated for endovascular treatment, and firm recommendations cannot be made. While awaiting further studies, eEVAR for ruptured AAA should be considered on a case-by-case basis, understanding that open repair may be more appropriate in selected patients.

Coppi et al studied patients with acute stable and acute unstable ruptured AAA treated with open surgery or by eEVAR. The overall 30-day mortality for eEVAR was 30% (unstable, 53%; stable, 11%), and the mortality rate was 46% for open repair (unstable, 61%; stable, 21%). Overall endograft eligibility rate was 52%, and the overall endovascular treatment rate was 27%.¹⁵ Although these results seem encouraging, this is a small single center study with serious selection bias. Visser et al also published a single center experience in a consecutive group of 55 patients. Thirty-day mortality was 8 (31%) of 26 patients who underwent endovascular repair and 9 (31%) of 29 patients who underwent open surgery ($p = 0.98$).¹⁶ This study was influenced by small numbers and again selection bias.

It is interesting to consider how many patients, presenting with a ruptured aneurysm, actually can be treated with an endograft. The Amsterdam Acute Aneurysm Trial investigated a cohort of patients who had presented with a diagnosis of ruptured aneurysm in the Amsterdam region, to see how many would have

been candidates for endovascular treatment.¹⁷ In this prospective cohort, the suitability for endovascular repair in patients with a ruptured AAA (RAAA) confirmed on computed tomographic angiography (CTA) was 45.8%. The details are interesting in that rupture was initially diagnosed in 128 of 256 patients, presenting with clinical suspicion of a ruptured aneurysm, but only 105 patients were brought to the trial center where CTA confirmed RAAA in 83. In 38 of these 83 patients (45.8%) with positive CTA, the anatomy of the aorta and iliac arteries was considered suitable for endovascular repair. Exclusion from endovascular repair was due to unsuitable infrarenal neck (37) or iliac anatomy (8). Overall, endovascular treatment was applicable in 38 of 128 patients (29.7%) with a RAAA in the Amsterdam region and in 38 of 105 patients (35.5%) admitted to the trial centers.

At the time of writing it seems clear that in patients who are hemodynamically unstable, an aortoiliac graft is the preferred endovascular approach. Reports of aortoiliac stent grafts and femorofemoral bypass have demonstrated good results.^{18,19} Nevertheless, problems such as graft failure or infection can arise that can cause long-term morbidity. Future studies should include specific patient care protocols prior to endovascular treatment such as controlled hypotension and the efficacy of local anesthesia rather than general anesthesia. Only a randomized controlled trial will provide data that will inform us whether endovascular treatment of ruptured AAA is the way forward. The Amsterdam Acute Aneurysm Trial is such a randomized trial, but we have to wait for it to be finished in 2008.²⁰

THE FUTURE

What new developments can we expect in endovascular treatment of AAA? It is most likely that the French size of introduction systems will decrease. What this will do with column and radial strength of endografts needs to be determined. Anatomical realities of the pararenal aortic aneurysm have limited the widespread use of endovascular aneurysm repair. Some publications have dealt with this problem. A recent evaluation of the intermediate-term results of fenestrated and branched endografts supports their limited use in patients with contraindications for standard endograft treatment.²¹ First-year failures have been reported, but complications seem to level off at longer follow-up. We have to wait for more new trial data to really know the future of fenestrated and branched grafts. Whatever the future of these branched and fenestrated devices, this group will always be a small subset of all aortic aneurysms.

Finally, we have to find a follow-up protocol that does not rely on CT. Radiation doses are cumulative and with the multidetector CT scanner this will only increase. The first publications on a wireless pressure-monitoring system show very promising data.²² A first

study showed that at the completion of the procedure, there was agreement between the sensor measurement and angiography regarding the presence or absence of a type I or III endoleak in 92.1% of the measurements. Implantation of the wireless pressure sensor seems to be safe, and remote aneurysm sac pressure sensing is feasible. But long-term studies will be needed to prove its efficacy for postoperative surveillance.

REFERENCES

1. The UK Small Aneurysm Trial Participants. Mortality results for randomised controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms. *Lancet* 1998;352:1649-1655
2. Lederle FA, Wilson SE, Johnson GR, et al. Immediate repair compared with surveillance of small abdominal aortic aneurysms. *N Engl J Med* 2002;346:1437-1444
3. The UK Small Aneurysm Trial Participants. Long-term outcomes of immediate repair compared with surveillance of small abdominal aortic aneurysms. *N Engl J Med* 2002;346:1445-1452
4. Legemate DA, Bossuyt PM. From innumeracy to insight: the uncertainty of help versus harm in treatment of asymptomatic aortic aneurysms. *Eur J Vasc Endovasc Surg* 2006;32:620-623
5. Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. *Ann Vasc Surg* 1991;5:491-499
6. Blankensteijn JD, de Jong SE, Prinsen M, et al. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. *N Engl J Med* 2005;352:2398-2405
7. Prinssen M, Verhoeven EL, Buth J, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. *N Engl J Med* 2004;351:1607-1618
8. Greenhalgh RM, Brown LC, Kwong GP, et al. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR-1), 30-day operative mortality results: randomised controlled trial. *Lancet* 2004;364:843-848
9. EVAR Trial Participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. *Lancet* 2005;365:2179-2186
10. EVAR Trial Participants. Endovascular aneurysm repair and outcome in patients unfit for open repair of abdominal aortic aneurysm (EVAR trial 2): randomised controlled trial. *Lancet* 2005;365:2187-2192
11. Prinssen M, Buskens E, Blankensteijn JD. Quality of life after endovascular and open AAA repair: results of a randomised trial. *Eur J Vasc Endovasc Surg* 2004;27:121-127
12. Laheij RJ, Buth J, Harris PL, et al. Need for secondary interventions after endovascular repair of abdominal aortic aneurysms: intermediate-term follow-up results of a European collaborative registry (EUROSTAR). *Br J Surg* 2000;87:1666-1673
13. Fransen GA, Vallabhaneni SR Sr, van Marrewijk GJ, et al. Rupture of infra-renal aortic aneurysm after endovascular repair: a series from EUROSTAR registry. *Eur J Vasc Endovasc Surg* 2003;26:487-493

14. Drury D, Michaels JA, Jones L, Ayiku L. Systemic review of recent evidence for safety and efficacy of elective endovascular repair in the management of infrarenal abdominal aortic aneurysm. *Br J Surg* 2005;92:937-946
15. Coppi G, Sillingardi R, Gennai S, Saitta G, Ciardullo AV. A single-center experience in open and endovascular treatment of hemodynamically unstable and stable patients with ruptured abdominal aortic aneurysms. *J Vasc Surg* 2006;44:1140-1147
16. Visser JJ, Bosch JL, Hunink MG, et al. Endovascular repair versus open surgery in patients with ruptured abdominal aortic aneurysms: clinical outcomes with 1-year follow-up. *J Vasc Surg* 2006;44:1148-1155
17. Hoorneweg LL, Wisselink W, Vahl A, et al. The Amsterdam Acute Aneurysm Trial: suitability and application rate for endovascular repair of ruptured abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg* 2007; February 1 (Epub ahead of print)
18. Yilmaz LP, Abraham CZ, Reilly LM, et al. Is cross-femoral bypass grafting a disadvantage of aortomonoiliac endovascular aortic aneurysm repair? *J Vasc Surg* 2003;38:753-757
19. Hinchliffe RJ, Alric P, Wenham PW, et al. Durability of femorofemoral bypass grafting after aortouniiliac endovascular aneurysm repair. *J Vasc Surg* 2003;38:498-503
20. Amsterdam Acute Aneurysm Trial Collaborators. Amsterdam Acute Aneurysm Trial: background, design and methods. *Vascular* 2006;14:1-6
21. Muhs BE, Verhoeven EL, Clark J, et al. Mid-term results of endovascular aneurysm repair with branched and fenestrated endografts. *J Vasc Surg* 2006;44:9-15
22. Ohki T, Ouriel K, Silveira PG, Katzen B, White R. Initial results of wireless pressure sensing for endovascular aneurysm repair: the APEX Trial—Acute Pressure Measurement to confirm Aneurysm Sac Exclusion. *J Vasc Surg* 2007;45:236-242