Endovascular Treatment versus Open Repair for Abdominal Aortic Aneurysms: The Influence of Fitness in Decision Making

Konstnatinos G. Moulakakis, MD, PhD, MSc, FEBVS¹ Ilias Dalainas, MD, PhD¹
John Kakisis, MD, PhD, FEBVS¹ Spyridon Mylonas, MD¹ Christos D. Liapis, MD, PhD, FACS, FEBVS¹

¹ Department of Vascular Surgery, "Attikon" University Hospital, Athens, Greece

Int J Angiol 2013;22:9–12.

Address for correspondence Konstantinos G. Moulakakis, MD, PhD, MSc, FEBVS, Department of Vascular Surgery, "Attikon" University Hospital, Rimini 1 Str., Athens, Greece
(e-mail: konmoulakakis@yahoo.gr).

Abstract

Two methods of repair are currently available for an abdominal aortic aneurysm (AAA), open aneurysm repair and endovascular aneurysm repair (EVAR). The decision making depends on the balance of risks and benefits. The treating physician must take into account the patient's life expectancy, the patient's fitness, the anatomic suitability that makes endovascular repair possible, and finally the patient's preference. The patient's fitness is an important variable predicting the outcome of AAA surgical reconstruction. The hypothesis is that the impact of risk factors upon perioperative mortality might differ between patients undergoing open repair and endovascular repair. The purpose of this review article is to investigate whether fitter patients with a large AAA benefit more from having endovascular rather than open repair. According to the available data, there is emerging evidence that patients at high medical risk for open repair may benefit from EVAR while in low risk patients with suitable anatomy for EVAR, both techniques have similar effects. There is rising evidence that a patient with ruptured AAA would benefit more from an endovascular procedure if eligible, and thus fitness in such emergencies is not the first priority but anatomical suitability for EVAR.

Keywords

- abdominal aortic aneurysm
- endovascular treatment
- fitness

The treatment options for asymptomatic AAAs are continuing surveillance or surgical repair according to size. Two methods of repair are currently available for an AAA, open aneurysm repair (OR) and endovascular aneurysm repair (EVAR). The conventional thinking is that open repair is appropriate for young, healthy patients and EVAR for older, sicker patients if they are anatomically suitable. The hypothesis is that the impact of risk factors upon perioperative mortality might differ between patients undergoing open repair and endovascular repair. Patient fitness influences operative mortality, and there has been much speculation on the interaction between fitness and the decision on type of treatment for AAA.

The purpose of this brief review article is to investigate whether fitter patients with a large abdominal aortic aneu-

rysm (AAA) benefit more from having endovascular rather than open repair.

EVAR or Open Repair Works Best?

The evolution in the endovascular area has influenced the management of AAA. The efficacy of endovascular repair compared with open surgical repair has been tested in four randomized trials; the EVAR I and the DREAM trial, which were published in 2005, and the OVER and ACE trial, which were published in 2009 and 2011, respectively.^{1–4} These trials with the exception of the ACE had relatively similar results and showed an initial survival advantage with the endovascular technique. The 8 and 6 years follow-up results of the EVAR I and DREAM trial demonstrated similar survival rates

Table 1 Risk indices based on clinical cardiac risk factors were developed to stratify vascular surgical patients

Glasgow Aneurysm Score ⁶ (1994)	Leiden Risk Model ⁵ (1995)	L'Italien Index ⁸ (1996)	Customized Probability Index ⁷ (2005)
Endpoint: All-cause perioperative mortality	Endpoint: All-cause perioperative mortality	Endpoint: Cardiac death and nonfatal MI	Endpoint: All-cause perioperative mortality
<ul style="list-style-type: none">• Myocardial disease• Cerebrovascular disease• Renal dysfunction• Age	<ul style="list-style-type: none">• Myocardial infarction• Congestive heart failure• ECG evidence of ischemia• Chronic pulmonary disease• Renal dysfunction• Age (< 60, 60–70, > 70)• Female gender	<ul style="list-style-type: none">• Myocardial infarction• Congestive heart failure• Angina pectoris• Prior coronary revascularization• Diabetes mellitus• Age > 70	<ul style="list-style-type: none">• Ischemic heart disease• Congestive heart failure• Cerebrovascular events• Hypertension• Chronic pulmonary disease• Renal dysfunction• Type of vascular surgery

between patients treated with OR and EVAR, but patients with EVAR in long-term follow-up were associated with increased rates of graft-related complications and reinterventions.^{5,6}

Stratification Scales Developed for Vascular Surgical Procedures

In the era of decision making, the patient’s fitness is an important variable predicting the outcome of AAA surgical reconstruction. The necessity to accurately define and differentiate the “high risk” patient from the “low risk,” led to stratification scales. Various scoring systems, such as the Leiden Score and the Glasgow Aneurysm Score, have been considered and applied to determine the fitness status. Described in 1994, the Glasgow Aneurysm Score was a cardiac risk score intended solely for vascular surgical procedures, while 1 year later the Leiden Risk Model was developed to assess perioperative mortality in patients with AAA.^{7,8} Two more risk indices giving emphasis in cardiac risk assessment have been developed for vascular surgical procedures, the Customized Probability Index and the L’Italien Index^{9,10} (→Table 1).

EVAR or Open Repair Works Best for Fit and Unfit Patients

Analysis of data from EVAR 1 trial based on Customized Probability Index showed that the fittest group of patients experienced the greatest benefit of EVAR over open repair in terms of 30-day operative mortality.¹¹ The authors concluded that EVAR offers a clear operative mortality benefit over open repair in patients fit for both (open and EVAR) procedures, but this early benefit is not translated into a long-term survival advantage.¹²

The Glasgow Aneurysm Score was used to predict 30-day and 2-year mortality in the patients from the (DREAM) trial. The study showed that the optimal cutoff Glasgow Aneurysm Score value that predicts perioperative outcomes was lower for open repair than for EVAR (75.5 vs. 86.5) indicating that fitter patients may benefit more from having endovascular rather than open repair.¹³ By 2 years postoperatively, this benefit for EVAR was lost. The authors concluded that Glasgow Aneurysm Score was most valuable in identifying low-

risk patients and not very useful for the identification of high-risk patients.¹³

Additional data of the recent literature have given space in relatively contradicting conclusions. Egorova et al in a recent report applied a new scoring system in 44,630 patients, assessing baseline risk factors such as renal failure with dialysis, renal failure without dialysis, clinically significant lower extremity ischemia, patient age, heart failure, chronic liver disease, female gender, neurological disorders, chronic pulmonary disease, surgeon’s experience in EVAR, and hospital annual volume in EVAR.¹⁴ The authors identified a group of high-risk patients that should not be treated with EVAR because of prohibitively high mortality.¹¹ Similar results are described in a study resulting from a different database of 862 patients. The Glasgow Aneurysm Score, the Modified Leiden Score, and the Modified Comorbidity Severity Score were correlated for perioperative mortality in both open repair and endovascular reconstruction.¹⁵ This study revealed that patients at low medical risk for open repair did not derive statistically significant mortality benefit with EVAR, whereas patients at high medical risk for open repair derived significant benefit from EVAR.¹⁵ On the contrary, Giles et al, based on 22,830 patients and using a multiple logistic regression model to evaluate the risk prediction score for perioperative mortality, concluded that mortality after AAA repair is predicted by comorbidities, gender, and age, and these predictors have similar effects for both methods of AAA repair.¹⁶

Moreover, Wahlgren and Malmstedt¹⁷ using a large population-based registry in Sweden to determine the operative mortality and long-term survival of elective EVAR compared with open repair in high-risk patients. Surprisingly, they found that elective open repair had better outcome compared with EVAR. They concluded that patients deemed for open repair have a better long-term outcome compared with patients deemed fit and suitable for EVAR in a high-risk cohort, and thus, in clinical practice, open repair may be at least as good as EVAR in high-risk patients fit for surgery.¹⁷

Fitness-Specific Parameters and AAA: Renal Function, Cardiac and Pulmonary Complications

Renal dysfunction negatively influences patients’ fitness for surgical aortic reconstruction, and it is also a crucial point for

the decision of an endovascular procedure because of the contrast-enhanced renal damage.¹⁸ Poor outcome after AAA repair and renal dysfunction has been observed in many studies for both open and endovascular repair.^{19–21} Furthermore, renal dysfunction has been shown to be an important prognostic indicator in the risk scores that have been developed and validated in patients undergoing aneurysm repair.^{22,23}

EVAR 1 and EVAR 2 trials offered the first opportunity to investigate changes in renal function of patients with AAA considered anatomically suitable for EVAR. Based on these results, Brown et al investigated the impact of different management policies on renal function in patients with AAA.²² They concluded that “in the long-term, beyond 1 year after aneurysm repair, renal function in patients with large AAA appears to be remarkably stable over time and that there is little evidence to suggest any difference attributable to aneurysm management policies.”²² Thus, there is no evidence to suggest a greater deterioration in renal function after EVAR or open repair beyond a year after treatment.

The rate of cardiac and pulmonary complications has been shown to be more frequent after open repair rather than EVAR. Elkouri et al²⁴ showed 11% cardiac morbidity after EVAR which was 50% reduced compared with 22% cardiac morbidity after open repair ($p < 0.01$). Their rate was very similar to the one of Makaroun et al²⁵ who showed 21% cardiac morbidity after open repair. Some authors have published less cardiac morbidity in open repair²⁶; however, differences in definition and exclusion of minor cardiac morbidity may explain these differences.²⁴ In the same study, Elkouri et al²⁴ showed 3% pulmonary morbidity after EVAR, compared with 16% after open repair, which is a relative reduction of 80%. Both cardiac and pulmonary morbidity were significantly reduced after EVAR compared with open repair.

EVAR versus No-Intervention for Unfit Patients

Only one study, the EVAR 2 trial, randomized patients unfit for OR between EVAR and conservative nonoperative management. This trial demonstrated a high operative mortality rate associated with EVAR in the highest risk patients.²⁷ The EVAR 2 trial concluded that EVAR does not even improve survival over no-intervention for patients unfit for open repair. The message, which was emphasized by the investigators, was that “If the patient is high risk, the importance should be to get the patient fit enough first rather than perform early EVAR.” In the 8 years follow-up results of the EVAR 2 trial, the investigators found that EVAR was associated with a significantly lower rate of aneurysm-related mortality than no repair.²⁸ However, EVAR was not associated with a reduction in the rate of death from any cause.¹²

Ruptured Aneurysms and Patient’s Fitness

Concerning the management of ruptured aneurysms, no sufficient available data exist, describing the influence of

fitness on perioperative mortality after EVAR and open repair. Population review studies provide evidence that mortality from EVAR appears to be lower than open surgery.^{29–31} In a recent study comparing rEVAR and open repair, the authors demonstrated significantly decreased in perioperative mortality and complication rates with rEVAR.³² Multivariate analysis of in-hospital mortality and complications showed an association between prognosis and treatment modality: EVAR was associated with a 79% reduction in mortality and 51% fewer complications than open repair.

However, these results should be balanced through the understanding that in these studies there were publication bias and significant patient selectivity according to hemodynamic instability, suitability for EVAR, and surgeon’s preference. In addition, a randomized study, the Nottingham trial, failed to demonstrate any benefit of EVAR over OR.³³ Three randomized studies are currently running and in near future will attempt to elucidate whether EVAR has the potential to improve outcome after ruptured AAA and to clarify the impact of risk factors upon perioperative mortality.^{34–36}

According to the available data, there is rising evidence that a patient with ruptured AAA would benefit more from an endovascular procedure if eligible, and thus fitness in such emergencies is not the first priority but anatomical suitability for EVAR.

Conclusion

According to the available data, there is emerging evidence that patients at high medical risk for open repair may benefit from EVAR while in low-risk patients with suitable anatomy for EVAR, both techniques have similar effects. Therefore, the decision making depends on the balance of risks and benefits and medical advice for the treatment of an AAA should be individualized. The treating physician must take into account the patient’s life expectancy, the patient’s fitness, the anatomic suitability that make endovascular repair possible, and finally the patient’s preference. There is increasing evidence that patients with ruptured AAA have more benefit from EVAR than open repair; thus in ruptured AAAs, anatomical suitability and intention to treat with an endovascular procedure could be justified independently from patient’s fitness.

Conflict of Interest

The authors declare no actual or potential conflict of interest in relation to this article.

References

- 1 Blankensteijn JD, de Jong SE, Prinssen M, et al; Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. *N Engl J Med* 2005;352(23):2398–2405
- 2 EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR

- trial 1): randomised controlled trial. *Lancet* 2005;365(9478):2179–2186
- 3 Lederle FA, Freischlag JA, Kyriakides TC, et al; Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group. Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. *JAMA* 2009;302(14):1535–1542
 - 4 Becquemin JP, Pillet JC, Lescalie F, et al; ACE trialists. A randomized controlled trial of endovascular aneurysm repair versus open surgery for abdominal aortic aneurysms in low- to moderate-risk patients. *J Vasc Surg* 2011;53(5):1167–1173, e1
 - 5 Steinbauer MG, Stehr A, Pfister K, et al. Endovascular repair of proximal endograft collapse after treatment for thoracic aortic disease. *J Vasc Surg* 2006;43(3):609–612
 - 6 Idu MM, Reekers JA, Balm R, Ponsen KJ, de Mol BA, Legemate DA. Collapse of a stent-graft following treatment of a traumatic thoracic aortic rupture. *J Endovasc Ther* 2005;12(4):503–507
 - 7 Steyerberg EW, Kievit J, de Mol Van Otterloo JC, van Bockel JH, Eijkemans MJ, Habbema JD. Perioperative mortality of elective abdominal aortic aneurysm surgery. A clinical prediction rule based on literature and individual patient data. *Arch Intern Med* 1995;155(18):1998–2004
 - 8 Biancari F, Leo E, Ylönen K, Vaarala MH, Rainio P, Juvonen T. Value of the Glasgow Aneurysm Score in predicting the immediate and long-term outcome after elective open repair of infrarenal abdominal aortic aneurysm. *Br J Surg* 2003;90(7):838–844
 - 9 Kertai MD, Boersma E, Klein J, et al. Optimizing the prediction of perioperative mortality in vascular surgery by using a customized probability model. *Arch Intern Med* 2005;165(8):898–904
 - 10 L'Italien GJ, Paul SD, Hendel RC, et al. Development and validation of a Bayesian model for perioperative cardiac risk assessment in a cohort of 1,081 vascular surgical candidates. *J Am Coll Cardiol* 1996;27(4):779–786
 - 11 Brown LC, Greenhalgh RM, Howell S, Powell JT, Thompson SG. Patient fitness and survival after abdominal aortic aneurysm repair in patients from the UK EVAR trials. *Br J Surg* 2007;94(6):709–716
 - 12 Brown LC, Powell JT, Thompson SG, Epstein DM, Sculpher MJ, Greenhalgh RM. The UK EndoVascular Aneurysm Repair (EVAR) trials: randomised trials of EVAR versus standard therapy. *Health Technol Assess* 2012;16(9):1–218
 - 13 Baas AF, Janssen KJ, Prinssen M, Buskens E, Blankensteijn JD. The Glasgow Aneurysm Score as a tool to predict 30-day and 2-year mortality in the patients from the Dutch Randomized Endovascular Aneurysm Management trial. *J Vasc Surg* 2008;47(2):277–281
 - 14 Egorova N, Giacomelli JK, Gelijns A, et al. Defining high-risk patients for endovascular aneurysm repair. *J Vasc Surg* 2009;50(6):1271–1279, e1
 - 15 Faizer R, DeRose G, Lawlor DK, Harris KA, Forbes TL. Objective scoring systems of medical risk: a clinical tool for selecting patients for open or endovascular abdominal aortic aneurysm repair. *J Vasc Surg* 2007;45(6):1102–1108
 - 16 Giles KA, Schermerhorn ML, O'Malley AJ, et al. Risk prediction for perioperative mortality of endovascular vs open repair of abdominal aortic aneurysms using the Medicare population. *J Vasc Surg* 2009;50(2):256–262
 - 17 Wahlgren CM, Malmstedt J; Swedish Vascular Registry. Outcomes of endovascular abdominal aortic aneurysm repair compared with open surgical repair in high-risk patients: results from the Swedish Vascular Registry. *J Vasc Surg* 2008;48(6):1382–1388, discussion 1388–1389
 - 18 Wahlberg E, Dimuzio PJ, Stoney RJ. Aortic clamping during elective operations for infrarenal disease: the influence of clamping time on renal function. *J Vasc Surg* 2002;36(1):13–18
 - 19 Bicknell CD, Cowan AR, Kerle MI, Mansfield AO, Cheshire NJ, Wolfe JH. Renal dysfunction and prolonged visceral ischaemia increase mortality rate after suprarenal aneurysm repair. *Br J Surg* 2003;90(9):1142–1146
 - 20 Dardik A, Lin JW, Gordon TA, Williams GM, Perler BA. Results of elective abdominal aortic aneurysm repair in the 1990s: a population-based analysis of 2335 cases. *J Vasc Surg* 1999;30(6):985–995
 - 21 Powell RJ, Roddy SP, Meier GH, Gusberg RJ, Conte MS, Sumpio BE. Effect of renal insufficiency on outcome following infrarenal aortic surgery. *Am J Surg* 1997;174(2):126–130
 - 22 Brown LC, Brown EA, Greenhalgh RM, Powell JT, Thompson SG; UK EVAR Trial Participants. Renal function and abdominal aortic aneurysm (AAA): the impact of different management strategies on long-term renal function in the UK EndoVascular Aneurysm Repair (EVAR) Trials. *Ann Surg* 2010;251(5):966–975
 - 23 Prytherch DR, Sutton GL, Boyle JR. Portsmouth POSSUM models for abdominal aortic aneurysm surgery. *Br J Surg* 2001;88(7):958–963
 - 24 Elkouri S, Gloviczki P, McKusick MA, et al. Perioperative complications and early outcome after endovascular and open surgical repair of abdominal aortic aneurysms. *J Vasc Surg* 2004;39(3):497–505
 - 25 Makaroun MS. The Ancure endografting system: an update. *J Vasc Surg* 2001;33(2, Suppl):S129–S134
 - 26 Scott RA, Wilson NM, Ashton HA, Kay DN. Influence of screening on the incidence of ruptured abdominal aortic aneurysm: 5-year results of a randomized controlled study. *Br J Surg* 1995;82(8):1066–1070
 - 27 EVAR trial participants. Endovascular aneurysm repair and outcome in patients unfit for open repair of abdominal aortic aneurysm (EVAR trial 2): randomized controlled trial. *Lancet* 2005;365(9478):2187–2192
 - 28 Greenhalgh RM, Brown LC, Powell JT, Thompson SG, Epstein D; United Kingdom EVAR Trial Investigators. Endovascular repair of aortic aneurysm in patients physically ineligible for open repair. *N Engl J Med* 2010;362(20):1872–1880
 - 29 McPhee J, Eslami MH, Arous EJ, Messina LM, Schanzer A. Endovascular treatment of ruptured abdominal aortic aneurysms in the United States (2001–2006): a significant survival benefit over open repair is independently associated with increased institutional volume. *J Vasc Surg* 2009;49(4):817–826
 - 30 Giles KA, Hamdan AD, Pomposelli FB, Wyers MC, Dahlberg SE, Schermerhorn ML. Population-based outcomes following endovascular and open repair of ruptured abdominal aortic aneurysms. *J Endovasc Ther* 2009;16(5):554–564
 - 31 Veith FJ, Lachat M, Mayer D, et al; RAAA Investigators. Collected world and single center experience with endovascular treatment of ruptured abdominal aortic aneurysms. *Ann Surg* 2009;250(5):818–824
 - 32 Mandawat A, Mandawat A, Sosa JA, Muhs BE, Indes JE. Endovascular repair is associated with superior clinical outcomes in patients transferred for treatment of ruptured abdominal aortic aneurysms. *J Endovasc Ther* 2012;19(1):88–95
 - 33 Hinchliffe RJ, Bruijstens L, MacSweeney ST, Braithwaite BD. A randomised trial of endovascular and open surgery for ruptured abdominal aortic aneurysm—results of a pilot study and lessons learned for future studies. *Eur J Vasc Endovasc Surg* 2006;32(5):506–513, discussion 514–515
 - 34 Powell JT, Thompson SG, Thompson MM, et al; IMPROVE Trial. The immediate management of the patient with rupture: Open versus endovascular repair (IMPROVE) aneurysm trial—ISRCTN 48334791 IMPROVE trialists. *Acta Chir Belg* 2009;109(6):678–680
 - 35 Desgranges P, Kobeiter H, Castier Y, Sénéchal M, Majewski M, Krimi A. The Endovasculaire vs Chirurgie dans les Anévrismes Rompus PROTOCOL trial update. *J Vasc Surg* 2010;51(1):267–270
 - 36 Amsterdam Acute Aneurysm Trial Collaborators. Amsterdam Acute Aneurysm trial: background, design, and methods. *Vascular* 2006;14:130–135