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Original Article

Long-Term Outcomes of Endovascular Repair versus Open Repair of Abdominal Aortic Aneurysm

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Objectives: To compare the long-term outcomes of endovascular repair (EVAR) versus open repair for abdominal aortic aneurysm (AAA).
Design: We retrospectively reviewed consecutive AAA patients treated with EVAR (n = 89) or open repair (n = 136) from January 1998 to December 2008.
Results: More patients in the open repair group had a longer duration of hospital stay. The operation time was significantly longer in open surgery than in EVAR (p <0.001), and the percentage of patients requiring a transfusion was higher in the open repair group than in EVAR. Patients in the open repair group had a higher incidence of cardiac insufficiency after surgery than did those in the EVAR group. Kaplan-Meier analysis indicated that the proportion of patients without complications in the EVAR group was significantly less than that in the open repair group (68.1% vs. 91.1%; p <0.0001), and the long-term survival rate in EVAR group was similar to open surgery group (87.5% vs. 91.1%; p = 0.555). Thrombosis was found inside of the aneurysm; postoperative complications in the EVAR group included ischemic legs, graft stenosis, and endoleaks that required further endoluminal treatment.
Conclusions: Endovascular repair of abdominal aortic aneurysm causes less trauma in patients with AAAs in the short term, and patients treated with EVAR have similar survival rate with open repair in the long term, but have postoperative complications requiring further interventional treatment.

Keywords: abdominal aortic aneurysm, endovascular repair, open repair, endoleaks

Introduction

Aortic aneurysm is generally defined as an aortic diameter of 30mm or greater. Most abdominal aortic aneurysms (AAA) are asymptomatic and found incidentally. Some large AAAs possess the risk of rupture if they are left untreated. The mortality rate after rupture is as high as 85%–95%.[1] Conventionally, AAAs are treated by replacing the aorta with a prosthetic graft in open surgery,which is associated with a 2% to 6% mortality.[1] An alternative to open repair was initially reported by Parodi in 1991.[2] A covered stent was inserted within the aneurysm by an endoluminal route via the femoral artery. About 90 per cent of AAAs can be excluded from the circulation with low risk of subsequent aneurysm rupture, thereby reducing significantly postoperative pain, critical care requirement and hospital stay.[3,4]

There are numerous reports on the long-term effects of patients after EVAR, including the DREAM, EVAR1 and EVAR2 studies.[5–8] These trials showed that EVAR is more likely to be more cost-effective than open repair in terms of operative mortality with no differences in mortality or aneurysm-related mortality existing between both groups in long-term.[5–8] However, patients undergoing the EVAR procedure have a higher rate of graft-related complications and more costly reinterventions.[8,9]

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Table 1 Demographics and comorbidity of patients with AAAs who underwent EVAR or open repair

Variable	EVAR(n = 89)	open repair(n = 136)	*p* value
Age (year)	66.79 ± 8.78	68.77 ± 9.51	0.118
Men	72 (80.9	103 (75.7	0.236
CAD	27 (30.3)	33 (24.3)	0.314
Angina with 30 days	2 (2.2)	3 (2.2)	1
Recent CABG	12 (13.5)	19 (14.0)	0.917
History of PTCA	6 (6.7)	11 (8.1)	0.709
MI within 6 months	4 (4.5)	3 (2.2)	0.566
CHF with 30 days	1 (1.1)	2 (1.5)	1.000
Hypertension	40 (44.9)	71 (52.2)	0.287
Cerebrovascular disease	12 (13.5)	11 (8.1)	0.191
History of PVD	8 (9.0)	3 (2.2)	0.046
DM	6 (6.7)	12 (8.8)	0.574
Smoker	24 (27.0)	34 (25.0)	0.742
Co-morbidity			
with unilateral IAA	19 (21.35)	23 (16.21)	0.404
with bilateral IAA	8 (8.99)	9 (6.62)	0.689
Descending aortic dissection	1 (1.12)	2 (1.47)	0.655
Takayasu's arteritis			
with DA A and AAA	1 (1.12)	3 (2.21)	0.482
Diameter of aneurysm			0.097
5.5–8 cm	75 (84.27)	102 (75.0)	
>8 cm	14 (15.73)	34 (25.0)	
Mid-abdominal pulsatile mass	34 (38.2)	66 (48.53)	0.127
Severe abdominal pain with back pain	27 (30.34)	42 (30.88)	0.931

CAD: coronary artery disease; CABG: coronary artery bypass grafting; PTCA: percutaneous coronary angiography; CHF: chronic heart failure; PVD: peripheral vascular disease; DM: diabetes mellitus; IAA: iliac artery aneurysm; DAA: descending aorta aneurysm; AAA: abdominal aortic aneurysm

In order to investigate the long-term effect of EVAR, we retrospectively reviewed the outcomes of AAA patients who underwent EVAR versus open repair.

Patients and Methods

After approval by our hospital review board, all patients with AAAs treated surgically from January 1998 to December 2008 at our hospital were identified from a medical file database and were included in the retrospective observational study. Some 89 patients underwent EVAR (EVAR group), whereas 141 patients underwent open repair surgery (open repair group), of which, 5 patients with ruptured AAAs were excluded from the study to avoid selection bias; thus, 136 patients were included in the open repair group (**Table 1**). Inclusion criteria included infrarenal AAA requiring surgery, adequate infrarenal neck, aortic-iliac anatomical configuration suitable for EVAR and signed informed consent. Exclusion criteria included maximum aneurysm diameter <50 mm, suprarenal AAA, infrarenal neck unsuitable for endovascular fixation, presence of active infection and patient's condition unsuitable for laparotomy and urgent ruptured AAAs.

Myocardial diseases referred to previously documented myocardial infarction (MI), or ongoing angina. Cerebrovascular disease implied all grades of stroke including transient ischemic attacks. Shock was considered when patients had tachycardia, hypotension, pallor and sweating. Renal disease included a history of chronic or acute renal failure, oliguria or anuria, abnormal serum level of urea and or creatinine (>200 μmol/L). Comorbidity included those associated with aortic dissection or multiple aneurysm and iliac artery aneurysm. Stent migration was defined as caudal displacement over 10 mm. Most patients presented initially with central abdominal pulsatile mass. The diagnosis was subsequently confirmed with computed tomography angiography (CTA) or MRI. Patients were followed up for 12–130 months through outpatient visit, telephone or emails.

Statistical analysis

Data were analyzed using SPSS statistical software package for window (version 13.0, Chicago, IL, USA).

Table 2 Complications within 30 days following EVAR or open repair for AAAs

Variable	EVAR (n = 89)	Open repair (n = 136)	*p* value
Surgical time (h)	1.79 ± 0.79	3.43 ± 0.99	0.000
ICU >24h	23 (25.8)	46 (33.8)	0.038
Overnight hospital stay (days)	6.76 ± 0.89	12.0 ± 0.98	0.000
Blood infusion	200 ± 0	616 ± 242	0.000
Pneumonia	18 (20.2)	40 (29.4)	0.025
Cardiac insufficiency	6 (6.7)	12 (8.8)	0.574
Acute renal failure	5 (5.6)	18 (13.2)	0.065
Hemorrhage (requiring	3 (3.4)	23 (16.9)	0.004
transfusion)	2 (2.2)	19 (13.9)	0.006
Wound infection shock	10 (11.2)	18 (13.2)	0.657
Reoperation	0	9 (6.6)	0.012
Mortality	1 (1.12)	4 (2.94)	0.344

Patient demographics, co-morbidities, perioperative events and outcomes were compared between open repair and EVAR group. Categorical variables were computerized by the use of chi-square or Fisher exact tests; continuous variables were analyzed using Student's t tests for parametric data. Kaplan-Meier analysis was used to study long-term survival rates of patients in both groups. $p < 0.05$ was considered as statistical significance.

Results

There were no statistical differences between EVAR and open repair groups in terms of age, gender, presence of coronary artery disease, angina or chronic heart failure prior to surgery, history of a prior revascularization, hypertension, and peripheral vascular disease (PVD), cerebrovascular disease and diabetes mellitus (DM) (**Table 1**). The median follow-up time was 45 months (range: 12–130 months). The follow-up rate in EVAR and open surgery was 80.89%, 82.35%, respectively.

Table 2 demonstrates that more patients in open repair group required longer duration in ICU and hospital stay. The surgical time was significantly longer in open surgery than in EVAR($p = 0.001$). The percentage of patients requiring transfusion and the volume of intraoperative blood transfusion were 8 and 3 times in the open group over EVAR group, respectively. Patients in open repair group had a trend toward cardiac insufficiency after surgery than in EVAR group. One AAA patient with descending aortic dissection was treated with EVAR initially, and an open repair was converted on the same day due to the uncontrolled aortic dissection.

Overall operative mortality was comparable without significant difference (**Table 2**). Regarding the cause of demise, one patient underwent failed EVAR attempts and was converted to immediate, open surgery, died from multiple organ failure; in open repair surgery, the causes of death were acute extensive inferior myocardial infarction (n = 1), postoperative multiple organs failure (n = 2) and lung cancer (n = 1).

Morbidity was defined all the complications after the procedure. Overall morbidity was higher after open repair including long time duration in ICU, pneumonia, followed by hemorrhage, wound infection, renal failure and shock (**Table 2**). One 80-year old man experienced weakness of left leg with claudication after open repair, and color Doppler ultrasound revealed left external iliac artery stenosis; his symptoms were improved after medical treatment. Two patients with AAAs had bilateral iliac artery aneurysm, and after exclusion one side of internal iliac artery aneurysm, obvious endoleak was found in the other side, and this warranted further EVAR intervention, later the patient had severe gluteal pain and difficulty walking with no abdominal pain or melena, and his conditions were improved with symptomatic treatment.

Some mistakes occurred during EVAR procedure. A stent was misplaced into the aneurysm in a 57-year old man with AAA at 5.5 cm in diameter, and caused an aortic dissection at the level of left renal artery during EVAR procedure, he experienced loss of sensation, severe swollen of left leg and absence of left femoral pulse. CTA showed obstruction of blood flow within bilateral common iliac arteries, on day 1 post-EVAR procedure, an axillobifemoral bypass was required and fasciotomy on the left lower extremity was preformed to relieve acute osteofascial compartment syndrome. He experienced transient acute renal failure with anurea for two days, abnormally high level of creatine and urea and being unable

Table 3 Long-term complications following EVAR

Complication	Case	Total Cases	%
Lower limb ischemia within 12 months	1	79	1.3
Graft stenosis within 36 months	1	75	1.3
Endoleaks			
Type Ia at 24 months	3	72	4.17
Type Ib at 24 months	5	72	6.94
Type II at 48 months	6	70	8.57
Type III at 56 months	1	68	1.47
Type IV at 56 months	1	68	1.47
Stent migration within 24 months	2	79	2.5
Stent migration within 36 months	3	75	4

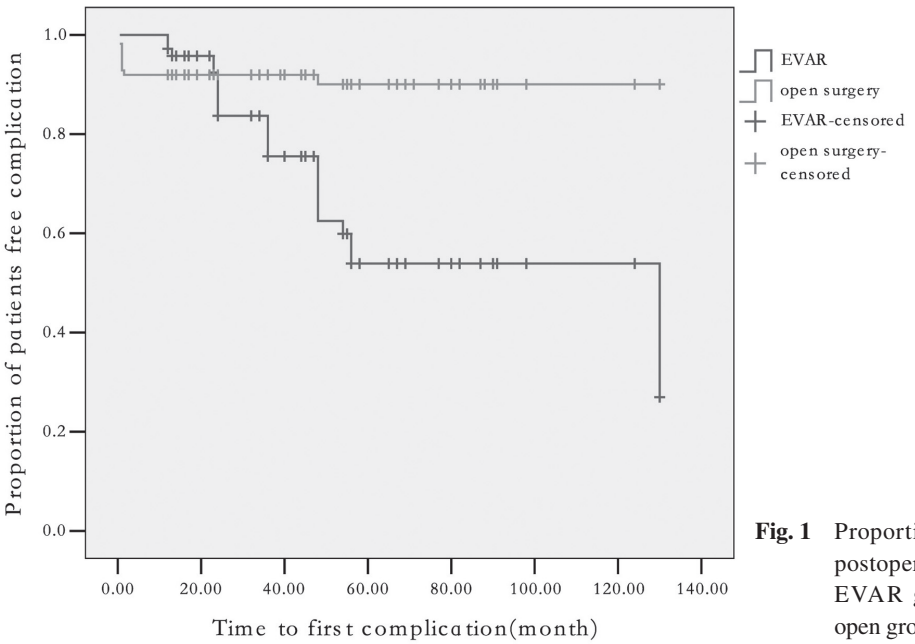

Fig. 1 Proportion of patients without postoperative complications in EVAR group is less than in open group(p <0.0001)

to raise his left leg for six days. One patient in EVAR group underwent open repair due to endoleak at 12 month after EVAR. Stent migration rate was 2.5 % (2/79) and 4 % (3/75) within 12 months and within 36 months, respectively. On follow-up with CTA, thrombosis was formed inside of aneurysm. Endoleaks were observed in 16 patients (22.22%, 16/72), including type Ia in 3 patients, type Ib in 5 patients, type II in 6 patients, and each patient in type III and type IV (**Table 3**). All of them were treated successfully with balloon dilatation and or stent replacement. In comparison, in open repair group, nine patients (6.6%) in open repair group required a subsequent reoperation due to hemorrhage, and one patient had a stroke due to uncontrolled hypertension. Kaplan-Meier estimators for two groups in **Table 3** with log-rank analysis show proportion of patients without postoperative complications in the open group was significantly higher than that in EVAR group(68.1% vs. 91.1%; p <0.0001; **Fig. 1**).

Incidences of wound infections, pneumonia and renal failure were higher in the open group than in the EVAR group. Surgical time, postoperative intubations periods and length of hospital stay were longer significantly in open repair group than EVAR group (**Table 2**).

Regarding the long-term mortality, there was a negligible difference in both groups(9/72, 12.5% in EVAR vs. 10/112, 10.3% in open repair; $X^2 = 0.604$, $p = 0.437$). Nine patients died in EVAR group from myocardial infarction (n = 3), pneumonia (n = 2), diabetic renal failure (n = 3) and unknown reason (n = 1); whereas ten patients died in open surgery from heart failure (n = 4), cerebral stroke (n = 3), traffic accident (n = 1), diabetic renal failure (n = 1) and lung cancer (n = 1). The survival time in both groups was not significantly different (EVAR: 115 ± 5.38 month,95% CI:104.81–125.91 vs. open surgery:

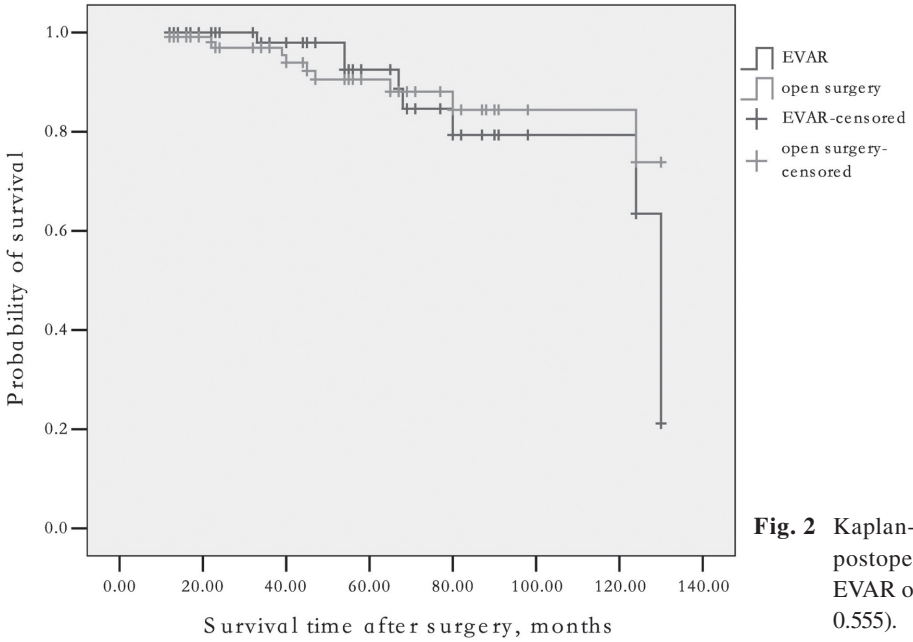

Fig. 2 Kaplan-Meier analysis for the postoperative survival time in EVAR or open repair group (p = 0.555).

116.25 ± 3.22 month, 95% CI:109.28-124.66; p = 0.56). There was no difference of survival rate in both group (87.5% in EVAR vs. 91.9% in open surgery, p = 0.555; **Fig. 2**).

Discussion

This retrospective study assessed the outcomes of EVAR and open repair for AAAs, and the results indicated that EVAR procedure provided better outcomes than open repair in terms of morbidity and mortality of the patients in spite of a greater proportion of comorbidity and similar preoperative conditions. The perioperative complications, hospital stay and blood transfusion in EVAR patients were less than those in open repair. The most common complications were prolonged intubation and pneumonia, followed by hemorrhage, wound infection, renal failure and shock.

EVAR is a prophylactic procedure for asymptomatic AAAs patients to reduce the risk of complications.[5–7,9] The size of aneurysm impacts the risk of rupture of AAAs, age and co-morbidity affect the risks associated with open repair surgery. Selection of appropriate criteria for EVAR is associated with satisfactory outcomes. The accepted criteria for EVAR included length of proximal neck of aneurysm >15 mm, internal diameter of aneurysm <28 mm, angle between the longitudinal axis and neck of aneurysm >120 degree, the angle between abdominal aorta and iliac artery or between iliac artery and femoral artery <90 degree, internal diameter of common iliac artery <12 mm,

Trans Atlantic Inter-Society Consensus (TASC) classifications of lesions TASC type A; whereas open repair surgery was performed when the aneurysm is at least 5.5 cm in diameter or over 4.5 cm with an increase of 0.5 cm in the 6 months prior to intervention of TASC types B, C or D.[3,9,10] In our EVAR group, two patients with type Ia endoleak after EVAR had internal diameter of proximal aneurysm greater than 28 mm, and internal diameter outside of anchoring area at iliac artery greater than 12 mm, one patient had extensive calcification and stenosis with an internal diameter at 5 mm accompanied with aneurysm at bilateral iliac and femoral artery, on follow up at 12 months restenosis occurred and was treated with open surgery.

In open surgery, for patients with AAAs accompanied with bilateral iliac artery aneurysm, one should be very cautious to ensure the patency of the iliac artery in order to avoid extensive glutei ischemia. In case there are lesions on the aortic artery in the vicinity of the origin of inferior mesenteric artery (IMA), if ligation of the internal iliac artery is unavoidable due to the bilateral iliac arterial aneurysms, reconstruction of IMA is particularly critical to prevent the ischemia or necrosis of a sigmoid colon or rectum, one of our patients was treated in this way successfully.

The randomized studies[5,6] including Dutch Randomised Endovascular Aneurysm Management

(DREAM) and Comparison of Endovascular Aneurysm Repair with Open Repair in Patients with Abdominal Aortic Aneurysm (EVAR-1), demonstrated favorable early results with EVAR; yet the rates of all-cause mortalities at 2 and 4 years were not different. Patients in the EVAR group required more re interventions. EVAR trial 2 showed that EVAR had a considerable 30-day operative mortality rate and failed to improve the survival over no treatment.[7] Similarly, our results showed the early advantage of EVAR versus open repair in terms of morbidity, and operative mortality was similar in both groups, and there was no significant difference of the survival rate between EVAR group and open repair group. EVAR is a minimally invasive procedure with less trauma to patients, and open repair simply precipitates risk of the fatal complications, and even death. This could explain our results; this is in agreement with the principal randomized trials.[5–8] Even though there was a negligible difference in the survival rates of patients between the two groups, we have to be aware that endoleaks post EVAR procedure required surgical intervention; this would cause trouble to patients economically and medically. On the other side, a large aneurysm, co-morbidity or previous abdominal surgery would significantly increase the risks of open repair; this situation warrants the use of EVAR. Furthermore, surgeons' learning curve and advances in device technology are considerations in interpreting these results,[12–14] even though we did not compare these factors.

Limitation in this study was a retrospective review of medical files rather than the randomized controlled study. This could cause the bias to compare the outcomes of procedures for the treated patients.

In conclusion, endovascular repair of abdominal aortic aneurysm caused less trauma in patients with AAAs than open repair in the short term, and long-term survival rates in both groups were similar. Yet, complications such as endoleaks following an EVAR procedure that warrant further endoluminal underscores the benefits of EVAR in short terms.

Disclosure Statement

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References

1) Akkersdijk GJ, Puylaert JB, de Vries AC. Abdominal aortic aneurysm as an incidental finding in abdominal ultrasonography. Br J Surg 1991; **78**: 1261-3.
2) Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991; **5**: 491-9.
3) Nevala T, Biancari F, Manninen H, et al. Type II endoleak after endovascular repair of abdominal aortic aneurysm: effectiveness of embolization. Cardiovasc Intervent Radiol 2010; **33**: 278-84.
4) Michaels JA. Use of mortality rate after aortic surgery as a performance indicator. Br J Surg 2003; **90**: 827-31.
5) EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. Lancet 2005; **365**: 2179-86.
6) De Bruin JL, Baas AF, Buth J, et al. Long-term outcome of open or endovascular repair of abdominal aortic aneurysm. N Engl J Med 2010; **362**: 1881-9.
7) 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**: 2187-92.
8) United Kingdom EVAR Trial Investigators, Greenhalgh RM, Brown LC, et al. Endovascular versus open repair of abdominal aortic aneurysm. N Engl J Med 2010; **362**: 1863-71.
9) Kim SJ, Kim W, Kim JB, et al. Determinants of procedural success and patency following subintimal angioplasty in patients with TASC C and D femoropopliteal arterial disease. Circ J 2010; **74**: 1959-64.
10) Han DK, Shah TR, Ellozy SH, et al. The success of endovascular therapy for all TransAtlantic Society Consensus graded femoropopliteal lesions. Ann Vasc Surg 2011; **25**: 15-24.
11) Blankensteijn JD, de Jong SE, Prinssen M, et al. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. N Engl J Med 2005; **352**: 2398-405.
12) Oberhuber A, Schwarz A, Hoffmann MH, et al. Influence of different self-expanding stent-graft types on remodeling of the aortic neck after endovascular aneurysm repair. J Endovasc Ther 2010; **17**: 677-84.
13) Ghouri MA, Dougherty KG, Krajcer Z. Technical tips for endovascular treatment of abdominal aortic aneurysms with challenging infrarenal neck anatomy using the Excluder endoprosthesis. J Endovasc Ther 2010; **17**: 705-11.
14) Moulakakis KG, Dalainas I, Mylonas S, et al. Conversion to open repair after endografting for abdominal aortic aneurysm: a review of causes, incidence, results, and surgical techniques of reconstruction. J Endovasc Ther 2010; **17**: 694-702.