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Open Versus Endovascular Repair of Inflammatory Abdominal Aortic Aneurysms: A Comparative Study and Meta-Analysis of the Literature

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Abstract

Objectives: Open surgical repair (OSR) of inflammatory abdominal aortic aneurysms (IAAAs) can have significant morbidity. The aim of the present investigation was to compare IAAA outcome after OSR and endovascular aneurysm repair (EVAR) and perform a meta-analysis of the literature. **Methods:** Twenty-seven patients with an intact IAAA operated on during a 21-year period were included. **Results:** Nine patients were managed with EVAR and 18 with OSR. In the EVAR group, the number of transfused red blood cell units ($P = .001$), procedure duration ($P < .001$), and postoperative hospitalization ($P = .004$) were significantly reduced compared to OSR. A trend for decreased morbidity with EVAR (11% vs 33% for OSR, $P = .36$) was observed. On literature review and meta-analysis, morbidity after EVAR was 8.3%, significantly lower compared to OSR (27.4%, $P = .047$). Mortality for nonruptured IAAAs was 0% after EVAR and 3.6% after OSR ($P = 1.00$). **Conclusions:** Endovascular aneurysm repair of IAAAs is associated with decreased procedure duration, transfusion needs, hospitalization, and morbidity compared to OSR.

Keywords

inflammatory abdominal aortic aneurysms, open repair, endovascular repair, complications

Introduction

Open surgical repair (OSR) of inflammatory abdominal aortic aneurysms (IAAAs) is often challenging and can be associated with significant morbidity, due to adhesions of the aneurysm and injury of the surrounding structures, including the duodenum and the inferior vena cava,[1] and the occasional need for suprarenal clamping. The above facts are reflected by an excessive mortality, 6% in a recent review,[2] which is higher than the typical mortality figures for the ordinary atherosclerotic aneurysms.

In recent years, endovascular aneurysm repair (EVAR) has emerged as a promising less invasive approach to manage IAAAs,[3,4] and a meta-analysis has demonstrated that EVAR for IAAAs is feasible, excludes the aneurysm effectively, and has a very low periprocedural and midterm mortality.[5] Additionally, EVAR reduced periaortic fibrosis (PAF) and renal impairment in most patients and had an acceptable reintervention rate. However, there is a paucity of studies directly comparing these 2 methods of repair because of the relative rarity of IAAAs. Based on the results of the randomized trials, EVAR is nowadays the preferred method for the management of typical atherosclerotic aneurysms; however, the survival benefit with EVAR compared to OSR is lost after a few years, which is mostly true for the elderly patients.[6]

The aim of our investigation was to compare OSR with EVAR in the management of IAAAs. Superior outcome of EVAR in IAAAs would justify this already widespread paradigm shift that is supported by inadequate evidence. Our investigation was performed to fill this particular gap in knowledge.

Methods

Consecutive patients with a nonruptured IAAA operated on during a 21-year period (1991-2011) in 3 institutions were identified by searching prospectively maintained departmental databases. Diagnosis of IAAAs was made on the grounds of

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computed tomography (CT) scanning[7] and/or intraoperative findings (shiny/glistening/whitish, thickened aneurysm wall with adhesions to the surrounding structures). For the purpose of this comparative study, patient symptoms on presentation, baseline demographics (age and gender), risk factors and comorbidities, imaging findings including aneurysm size and iliac artery involvement, mode of management (urgent or emergent vs elective), white blood cell count, steroid use, anesthesia type, procedure type and details (blood transfusion, duration of surgery, postoperative intensive care unit [ICU], and hospital stay), and complications (intraoperative and postoperative) including in-hospital death and long-term patient outcome (including changes in PAF on follow-up CT scans in patients who underwent EVAR) were identified from the databases, patient electronic medical records, and supplemented by case notes and telephone follow-up. Patients were divided into 2 groups, according to the method of management of the IAAA, EVAR or OSR, which was based on the local expertise endograft availability (first use for IAAA in 1996) and anatomical suitability for EVAR.

Literature Review

A PubMed search (restricted to full-length articles published in the English language) was performed in April 2012, updated in December 2012, and also in May 2013 (key word: inflammatory aneurysm), followed by a manual search of the references. Series of IAAAs were sought to determine its frequency and mortality after open repair and also to identify studies comparing EVAR with OSR, with extracted information being publication year, mean patient age, morbidity, mortality, long-term complications, and the effect of these two treatment modalities on the status of PAF and hydronephrosis.

Statistics

All data were analyzed with IBM SPSS statistics (version 20; IBM Co, Armonk, New York), except meta-analyses which were performed with Review Manager (RevMan, version 5.2. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012) and Comprehensive Meta-Analysis (Biostat, Eaglewood, New Jersey). Categorical data were analyzed with χ^2 or Fisher exact test, where appropriate. Based on the sample size and/or normality of distribution, parametric (*t* test) or nonparametric (Mann–Whitney) tests were used to compare numerical data, as appropriate. The overall survival during long-term follow-up was evaluated with Kaplan–Meier curves, whereas log-rank test was used to compare the two study groups. Postoperative mortality was included in the calculation of long-term mortality in order to increase the power of the study. Odds ratios and risk difference were calculated, and forest plots were drawn for the purposes of the meta-analysis, and heterogeneity was assessed with the I^2 statistic. Patients were stratified according to age (<60 years and $\geq$60 years) to investigate a possible effect of age on morbidity and mortality.

Results

Twenty-seven patients (26 males, median age 67 years) were identified and included in the present report. Nine patients were managed with EVAR and 18 with OSR. The two study groups were comparable in terms of preoperative characteristics (Table 1). All patients underwent preoperative CT scanning, with aneurysm size being only marginally bigger in patients undergoing OSR compared to EVAR. Median (interquartile range) IAAA size was 6.0 (5.1-7) cm. This predominantly male patient population had several risk factors and comorbidities, with the IAAA being symptomatic in most patients. Abdominal and/or back pain was reported in 15 (56%) cases and dominated the clinical picture, prompting urgent or emergent repair in 11 (41%) of them to treat a presumably ruptured, symptomatic or acutely expanding, potentially fatal, aneurysm (P = .001). Other presentation modes included report of constitutional symptoms (weight loss/malaise/fever) in 15% and leg ischemia, due to chronic left iliac artery occlusion and peripheral embolism, in 2 patients, respectively. Hydronephrosis was present preoperatively in 44% (4 of 9) and 11% (2 of 18) of patients undergoing EVAR and OSR, respectively (P = .14). Two patients, one in each group, had impaired renal function due to hydronephrosis preoperatively. Methylprednisolone was given preoperatively and continued postoperatively in 5 patients undergoing EVAR but in no patients undergoing OSR.

Operative details are shown in Table 2. Open surgical repair of IAAA was performed under general anesthesia through a transperitoneal approach (n = 18) and EVAR under local (n = 8) or spinal anesthesia (n = 1) through open exposure of the femoral arteries. A variety of endografts was used for EVAR, commercially available in all but two cases managed during the 1990s, where custom-made devices were deployed. Ancillary procedures included use of an aortic cuff extender to successfully manage an intraoperative type Ia endoleak in one patient and use of a reversed aortouniiliac Endofit 28 to 16 mm endograft as a bell-bottom limb to avoid bilateral coverage of the hypogastric arteries. All EVARs were technically successful. Bifurcated grafts were used in most OSRs. In 4 patients, one or both graft limbs were anastomosed to the femoral artery(ies), and in an additional patient, a jump graft from an iliac limb to the femoral artery was performed intraoperatively due to leg ischemia. In 3 patients (17%) undergoing OSR, left renal vein ligation was necessary to facilitate proximal clamping, whereas in an additional patient with leg embolism, an embolectomy was performed. Packing was finally performed in one patient with intraoperative bleeding. Intraoperative injury of the surrounding organs (ie, duodenum, inferior vena cava, etc) was not reported. In the EVAR group, the median (interquartile) number of transfused red blood cell (RBC) units was significantly reduced (1 [0-1] vs 3.0 [2.0-5.0] for OSR, P = .001) and similarly procedure duration (70 [68-105] minutes vs 240 [180-360] minutes for OSR, P < .001).

A trend for decreased morbidity with EVAR (11% vs 33% for OSR, P = .36, odds ratio: 4.0, 95% confidence interval [CI]: 0.40-39.8) was observed. Complications with EVAR

Table 1. Baseline Characteristics of Patients With Inflammatory Abdominal Aortic Aneurysms Undergoing Endovascular or Open Repair.

	Endovascular Repair (n = 9)	Open Repair (n = 18)	*P*	All Patients (n = 27)
Age, median (interquartile range), years	55 (53.5-70)	68.5 (61.3-71.5)	.30	67 (54-71)
Gender (male/female)	9/0	17/1	1.00	26/1
Risk factors/comorbidities				
Smoking	7 (78%)	12 (67%)	.68	19 (70%)
Hypertension	6 (67%)	9 (50%)	.68	15 (56%)
Diabetes mellitus	1 (11%)	1 (6%)	1.00	2 (7%)
Coronary artery disease	3 (33%)	3 (17%)	.37	6 (22%)
Preoperative symptoms				
Pain	4 (44%)	11 (61%)	.45	15 (56%)
Other[a]	3 (33%)	3 (17%)	.37	6 (22%)
White blood cell count per mm^3, median (IQR)[b]	7700 (6550-10 105)	6950 (6412-10 327)	.51	7300 (6575-10 185)
Aneurysm size, cm	5.5 (4.6-6.4)	6 (6-7)	.07	6 (5.1-7)
Iliac artery aneurysm, coexisting	2 (22%)	7 (39%)	.67	9 (33%)
Urgent or emergent management	5 (56%)	7 (39%)	.45	12 (44%)

[a]Leg ischemia (n = 2) and constitutional symptoms (n = 4).
[b]Missing values in 9 patients.

Table 2. Operative Details and Outcome of Endovascular and Open Repair of Inflammatory Abdominal Aortic Aneurysms.

	Endovascular repair (n = 9)	Open Repair (n = 18)	*P*	All Patients
Anesthesia			<.001	
General	0 (0%)	18 (100%)		18 (67%)
Spinal	1 (11%)	0 (0%)		1 (3.5%)
Local	8 (89%)	0 (0%)		8 (29.5%)
Repair type			N/A	
Anaconda endograft	3 (33%)	6 (33%)		3 (11%)
Excluder endograft	2 (22%)	12 (67%)		2 (7%)
Other endografts[a]	4 (89%)			4 (15%)
Straight (tube) graft				6 (22%)
Bifurcated graft[b]				12 (44%)
Number of transfused red blood cell units, median (interquartile range)	1 (0 -1)	3 (2-5)	.001	2 (1-4.5)
Procedure duration, median (interquartile range), minutes	70 (68-105)	240 (180-360)	.001	175 (83-298)
Postoperative hospitalization, median (interquartile range), days	4 (2.5-7)	8 (6.5-11.5)	.004	7 (6-11)
Morbidity	1 (11%)	6 (33%)	.36[c]	7 (26%)
In-hospital mortality	0 (0%)	2 (11%)	.54	2 (7.4%)
Overall 5-year survival	100%	75%	.75	82%

[a]Custom made (n = 2), Endofit (n = 1, tube), and Endologic (n = 1, with ancillary cuff placement).
[b]Aortobiiliac, aortoiliofemoral, and aortobifemoral grafting in 8 patients, 3 patients, and one patient, respectively, not including one case of graft limb extension to the common femoral to manage intraoperative leg ischemia.
[c]Odds ratio: 4.0, 95% confidence interval: 0.40 to 39.8.
Abbreviation: N/A, not applicable.

included one type Ia endoleak (11%), mentioned above, whereas 6 patients after OSR (33%) developed intraoperative bleeding (n = 1, complicated with small bowel fistula, multiple organ failure, and death), atelectasis (n = 2), acute renal failure (n = 1, deterioration of preoperative renal dysfunction, resolved by postoperative day 12), delayed intestinal obstruction (n = 1, fatal), and postoperative sepsis (n = 1). A significant association between age-group and morbidity was observed (0% [0 of the 10] for patients younger than 60 years and 41.2% [7 of the 17] for those older than 60 years, P = .026). None of the patients undergoing EVAR required admission to the ICU, however 6 (33%) patients undergoing OSR did so, mostly for one day, but in two patients, ICU stay was extended to 2 and 45 days in total, respectively. Although comparison of ICU length of stay (LOS) for the two groups was not significant (P = .18), ICU LOS per se was marginally significant (0 of the 9 for EVAR vs 6 of the 18 for OSR, P = .07). Postoperative hospitalization was significantly shorter with EVAR (4 [2.5-7] days for EVAR vs 8.0 [6.5-11.5] days for OSR, P = .004). The presence of complications was associated with a longer postoperative hospital stay (12.5 [10-23.25] days vs 7 [6.5-8.5] days for no complications, P = .005). No such association was found for the number of RBC units transfused (3 [0.75-11] vs 3 [2-5] for no complications, P = .79), duration of procedure (300 [170-433] minutes vs 210 [175-325] minutes for no complications, $P = .29$), and ICU LOS (0.5 [0-12] days vs 0 [0-0.5] days for no complications, $P = .39$). Finally, in-hospital mortality after EVAR was lower (0%) compared to OSR (2 of 18, 11%, $P = .54$). No association between age-group and mortality was observed (0% [0 of 10] for patients younger than 60 years and 11.8% [2 of the 17] for those older than 60 years, $P = .52$).

Mean (maximum) follow-up for OSR and EVAR was 7 (16) years and 3.1 (7) years, respectively. During long-term follow-up after EVAR, routinely relying on CT scanning, two patients developed type II endoleaks, one at 3 years managed with hypogastric coil embolization and the second one at 1.5 months being observed. Aneurysm size decreased in 5 patients, whereas in the remainder, the size of the aneurysm remained the same. Periaortic fibrosis, seen preoperatively in 67% (6 of 9) of EVAR cases, improved in 67% (4 of 6) of cases and remained stable in 33% of them. Hydronephrosis, present preoperatively in 44% (4 of 9) of cases undergoing EVAR, resolved (n = 2) or improved (n = 1), but in one patient, it did not, led to unilateral renal atrophy, and necessitated a contralateral nephrostomy. Periaortic fibrosis and/or hydronephrosis improved or resolved in 80% (4 of 5) of patients receiving steroids. No graft-related complication was seen after OSR, whereas in the single patient with renal failure due to hydronephrosis, both resolved postoperatively. The overall survival (postoperative mortality included) of the two groups (100% for EVAR vs 75% for OSR at 5 years) was in favor of EVAR, but the difference was not statistically significant ($P = .75$; Figure 1).

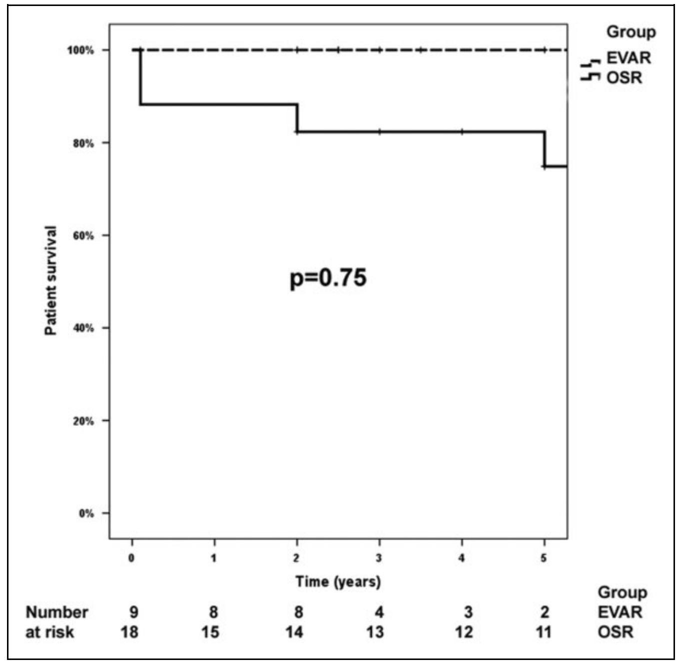

Figure 1. The overall long-term survival (postoperative mortality included) of the endovascular aneurysm repair (EVAR) and open surgical repair (OSR) groups.

Review of the Literature

Twenty-two series on OSR for IAAA were identified.[1,8-28] A statistically significant decline in IAAA incidence was observed in studies published after 1999 (3.1% from 5% in earlier studies, $P < .001$; Table 3), a finding confirmed on meta-regression analysis (Figure 2). Additionally, operative mortality of OSR was significantly reduced by 59% (from 9.8% to 4%, $P = .003$, odds ratio: 0.38, 95% CI: 0.20-0.74; Table 3) in studies published after 1999. Similar results were obtained with meta-regression analysis (Figure 3).

Our literature search retrieved only two nonrandomized case-controlled studies shown in Table 4, comparing EVAR with the "gold-standard" OSR,[22,27] and their results were combined with our results. A pooled mortality rate of 6% (7 of 117) after OSR and 0% (0 of 24) after EVAR ($P = .60$) was found, however after excluding 6 patients with rupture undergoing OSR and mortality of 50% (3 of 6), mortality for nonruptured IAAAs fell to 3.6% (4 of 111, $P = 1.00$). Morbidity after EVAR was 8.3% (2 of 24, excluding intraoperative maneuvers to manage endoleak and failed cannulation but including one patient with rupture) significantly reduced compared to 27.4% (32 of 117) after OSR ($P = .047$), however the latter group included 6 patients with ruptured IAAA, and since their complications were not separately reported, it was not possible to take them apart from the total cohort. A forest plot showing similar results appears in Figure 4.

Discussion

In our study, a shorter operative time as well as reduced transfusion needs and hospitalization in favor of EVAR of IAAAs was demonstrated. These end points are reflective of a smoother postoperative course compared to OSR, and indeed, our meta-analysis found a decreased morbidity rate and a trend for reduced mortality as well.

Unfortunately, mainly case reports, series, and meta-analyses of EVAR for IAAA have been reported, [2-5,29-35] with direct comparison of EVAR with the "gold-standard" OSR being scarce.[22,27] Indeed, our search of the literature retrieved only two nonrandomized comparative studies comparing these two treatment modalities.[22,27]

Presentation of IAAAs was mostly acute in the present study, with abdominal pain being present in most patients, similar to other studies.[1] Inflammatory abdominal aortic aneurysms constitute a significant proportion of symptomatic abdominal aortic aneurysms (AAAs),[36] necessitating urgent repair to exclude perceived rupture. Repair type (tube graft vs bifurcated grafts) and duration of surgery in our study were similar with other series on OSRs.[13,19,26] Transfusion requirements were also relatively low, with median number of transfused RBCs during OSR being 3 compared to 1 for EVAR. Median RBC units transfused during OSR have been reported to be as high as 5 to 6,[1,37] a much higher figure than we report. In the EUROSTAR registry, which compared EVAR of IAAA and ordinary AAAs, endograft limb stenoses and hypogastric

Table 3. Incidence of IAAAs and Operative Mortality During the Last 40 Years.[a]

		Patient No				
Author	Year	All AAAs	All IAAAs	Operated IAAAs	Mortality	Cases With Rupture
Walker et al[8]	1972	119	16	15	4	
Hall et al[9]	1985			14	0	
Pennel et al[1]	1985	2816	127	127	10	
Hill and Charlesworth[10]	1988	780	37	36	11	3
Moosa et al[11]	1989	265	19	18	1	
Luna et al[12]	1990	439	25			
Lindblad et al[13]	1991	2026	98	94	8	
Gans et al[14]	1993	258	8			
Nitecki et al[15]	1996			29	2	
Lacquet et al[16]	1997			110	9	
Sasaki et al[17]	1997	265	16	16	0	
Subtotal	1972-1999	6968	346 (5%)	459	45 (9.8%)	
Di Marzo et al[18]	1999	102	15			
Sultan et al[19]	1999	598	32	31	1	2
Bonati et al[20]	2003			18	0	
Railo et al[21]	2005			15	1	
Ockert et al[22]	2006			37[b]	0	
Dalainas et al[23]	2007	2275	52	52	1	
Yusuf et al[24]	2007	238	17	17	2	
Paravastu et al[25]	2009	421	38	36	5	
Yin et al[26]	2010	412	11	11	1	
Stone et al[27]	2012	3500	69	59	1	3
Maeda et al[28]	2013			24	0	
Subtotal	1999-2013	7546	234 (3.1%)	300	12 (4%)	
All studies	1972-2013	14 514	580 (4%)	759	57 (7.5%)	

Abbreviations: AAA, abdominal aortic aneurysm; EVAR, endovascular aneurysm repair; IAAA, inflammatory abdominal aortic aneurysm.
[a]A decreased incidence was observed over time ($P < .001$), although mortality was significantly reduced ($P = .003$, odds ratio: 0.38, 95% confidence interval: 0.20-0.74) after 1999, year EVAR became commercially available in the United States.
[b]Includes 3 thoracoabdominal inflammatory aortic aneurysms and 4 juxtarenal IAAAs.

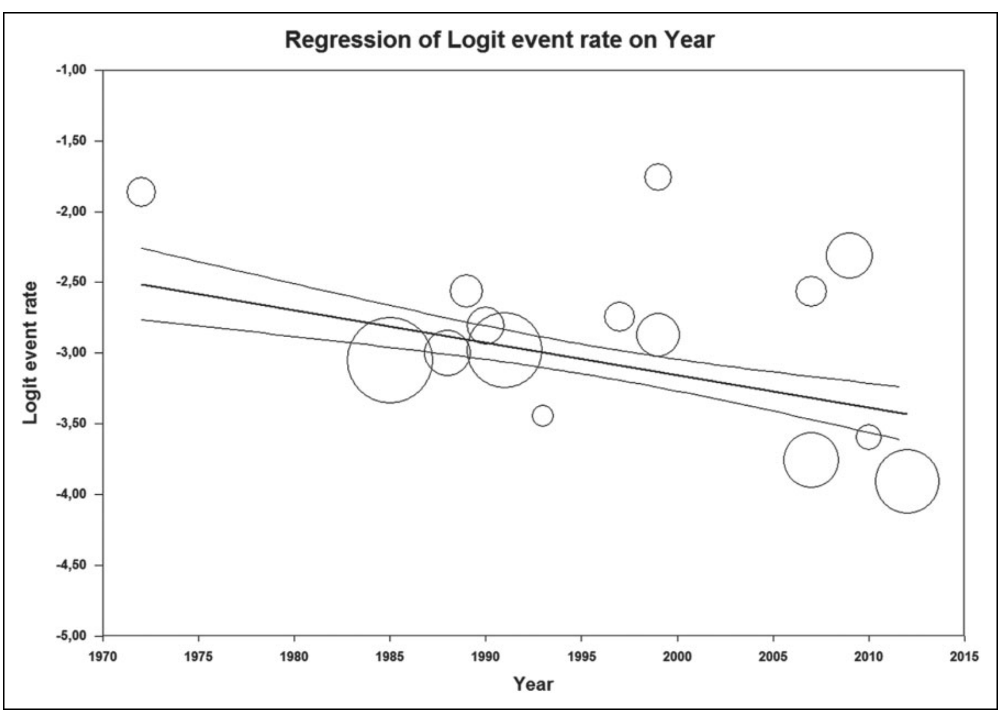

Figure 2. Bubble plot with fitted meta-regression line and 95% confidence intervals showing the relationship between logit frequency rate and publication year. Bubble sizes vary with inverse of within-study variance (weight in a fixed-effect meta-analysis, $P < .001$).

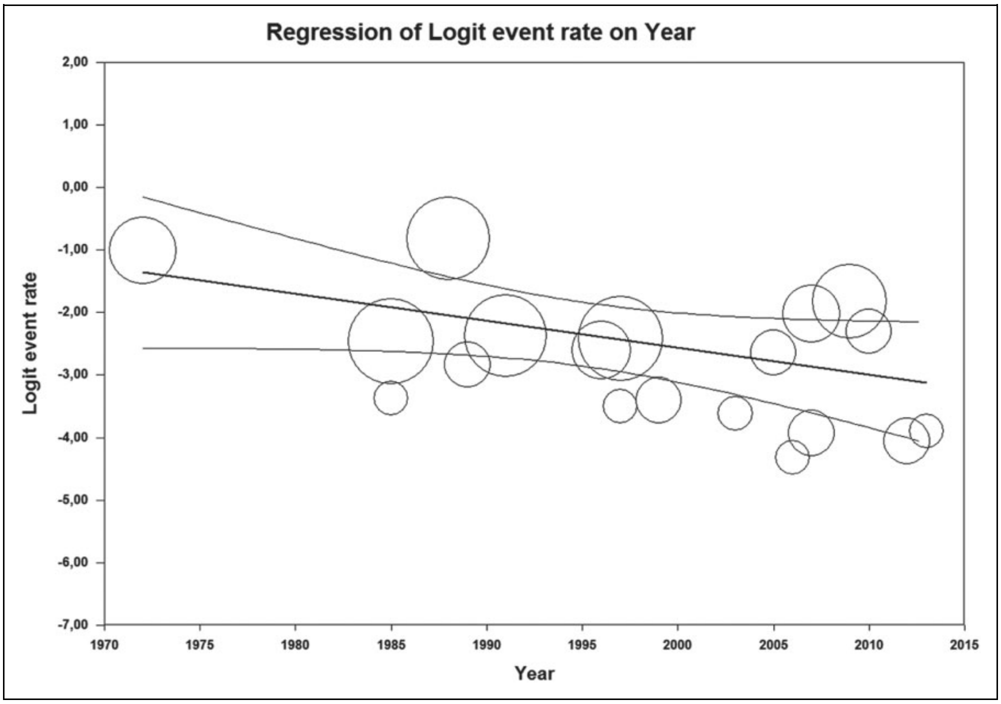

Figure 3. Bubble plot with fitted meta-regression line and 95% confidence intervals showing the relationship between logit mortality rate and publication year. Bubble sizes vary with inverse of within-study variance (weight in a fixed-effect meta-analysis, $P = .008$).

Table 4. Studies Comparing OR With EVAR for IAAA Repair and Reported Outcomes.

Study	Year	Mean Age, years	Morbidity	Mortality	Long-Term Complications	Course of PAF and Hydronephrosis
Ockert et al[22]	2006	67.3	EVAR: 10% (4 of 40); OR: 0% (0/5)	EVAR: 0%; OR: 4% (4 of 40)	EVAR: type Ic (n = 1) and IIb (n = 1) endoleaks; OR: none	EVAR: PAF regression in 100% (2 of 2); OR: PAF regression in 89% (17 of 19); hydronephrosis resolved in 50% (2 of 4)
Stone et al[27]	2012	67.1	EVAR: 20% (2 of 10); OR: 37% (22 of 59)	EVAR: 0%; OR: 1.6% (1 of 59)	EVAR: none; OR: anastomotic pseudoaneurysm (n = 1)	EVAR: hydronephrosis progressed or developed de novo 20% (2 of 10); OR: hydronephrosis resolved in 58% (7 of 12)

Abbreviations: EVAR, endovascular aneurysm repair; OR, open repair; PAF, periaortic fibrosis.

occlusions were more common for IAAAs, indicative of a more complex anatomy, alternatively the result of stiffer iliac wall due to the presence of the fibrosis.[29] We have not encountered such problems in our series; however, a single type Ic endoleak from an iliac occluder has been reported by 1 of the 2 studies we included in the present meta-analysis.[22] Frequency of ICU admission (at the discretion of the anesthetist, not obligatory) after EVAR was also decreased compared to OSR in the present study.

We have demonstrated a trend for reduced morbidity after EVAR compared to OSR for IAAAs, which was significant in our meta-analysis. Morbidity of EVAR for IAAAs and ordinary atherosclerotic AAAs has been reported to be the same in EUROSTAR[29] and similarly very small in a meta-analysis of mainly case series.[5] On the other hand, morbidity after OSR of IAAAs is typically high,[1,19,21,25] 45% in one study,[15] and is probably associated with unselected patient population presenting acutely with a difficult-to-repair AAA. These observations obviously favor EVAR as the preferred method of repair of IAAAs, especially in high-risk patients.

An increased operative mortality after OSR of IAAA has been demonstrated by the present study. As a result of acute presentation and the need to perform urgent repair, preoperative risk stratification and risk factor modification cannot be optimal, and suboptimal preoperative workup might explain the increased mortality rates associated with a usually urgent repair, especially during the first part of our meta-analysis. Additionally, this excessive mortality has been attributed to technical problems encountered and intraoperative complications, as a result of the inflammatory changes leading to adhesion of the IAAA with the surrounding structures, including but not limited to the duodenum, the ureters, the left renal, and the

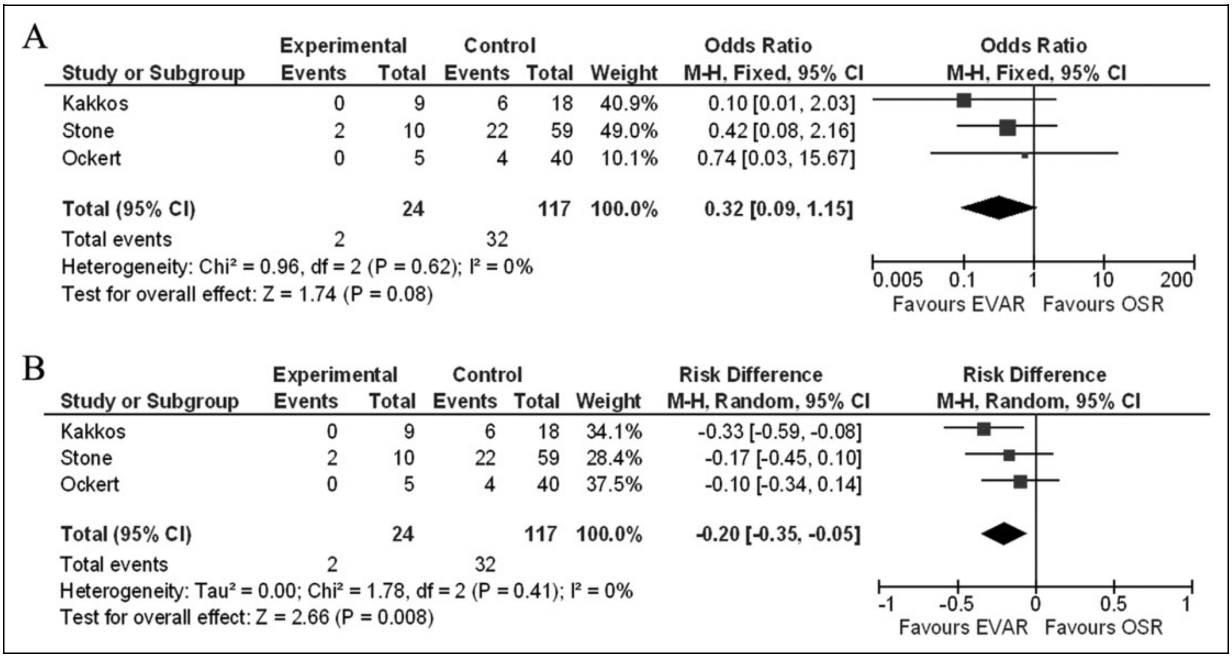

Figure 4. Forest plot analysis of the morbidity in the endovascular aneurysm repair (EVAR) and open surgical repair (OSR) groups of the 3 studies included in the meta-analysis, expressed as odds ratio (A) and risk difference (B).

iliac veins.[1,11,15] As a result, increased mortality,[13] 7.9% in one series compared to 2.4% for ordinary atherosclerotic AAAs,[1] has been reported. Nevertheless, even in contemporary series shown in Table 3, mortality figures amount to 4%, higher than what is achieved nowadays for ordinary atherosclerotic AAAs. On the other hand, mortality after EVAR for IAAA (1.9%) has been reported to be low and the same with EVAR performed for atherosclerotic AAAs (2.1%).[29] It is obvious that the difference in outcomes between the two study groups is the result of the worse performance of OSR, not the better results of EVAR performed under local anesthesia, which are expected and also comparable with those reported in the literature. On direct comparison of OSR with EVAR of IAAA, we demonstrated a nonsignificant trend for reduced mortality with EVAR (0% vs 3.6% for OSR), perhaps due to a type II error. On formal power calculations, 282 patients, more than double in our meta-analysis, would be required to demonstrate statistical significance. Another meta-analysis on 1120 patients, comparing mostly case series, showed that 30-day mortality was less with EVAR (2.4%) compared to OSR (6.2%), but the difference was also not significant ($P = .1$).[2] Therefore, a very large number of patients would be required to demonstrate statistical significance in favor of EVAR in an era of reducing mortality rates. Because a firm conclusion on mortality cannot be made, decisions should be based on anatomical suitability for EVAR and balance early mortality after OSR with delayed mortality after IAAA rupture after EVAR.

Absence of PAF regression after EVAR was reported in 33% of our series. Persistent PAF after IAAA repair in relation to hydronephrosis and renal failure has been a subject of concern in a systematic review of the literature, with EVAR being worse than OSR in achieving PAF regression, with no regression being observed in 40% and 14%, respectively.[38] The authors suggested that additional medical and/or urological treatment should be considered in selected cases of PAF. A meta-analysis showed a lack of regression in 26% and 31% and progression in 1% and 4% after OSR and EVAR, respectively.[2] Of the two studies included in our meta-analysis, the first one demonstrated excellent results for open repair (89% PAF regression), but outcome after EVAR (100% regression) was based only on two patients.[22] The second study on EVAR reported that IAAA wall thickness decreased by 51%, aneurysm size decreased by 18%, and deterioration or de novo development of hydronephrosis occurred in 20%, with the potential for renal atrophy.[27] In a meta-analysis of case series of IAAAs investigating the course of hydronephrosis after OSR compared to EVAR, this characteristic regressed postoperatively in 69% and 38%, respectively ($P = .01$).[2] However, hydronephrosis progressed in 9% of patients after OSR and in 21% after EVAR ($P = .1$), whereas new-onset hydronephrosis developed in 6% undergoing OSR compared to 2% with EVAR ($P = .2$). This is a point of concern, indicating the need for close follow-up and use of adjuvant treatment. Indeed, a systematic review showed that steroids can decrease the incidence of deterioration of preoperative hydronephrosis after EVAR from 25% without steroids to 11% with steroid use.[2] Follow-up after EVAR in our series was performed with annual CT scanning, although several years after the procedure in selected patients with stable sac size or regression, no endoleak, and PAF remission, ultrasound surveillance combined with abdominal x-rays may substitute routine CT scanning. Computed tomography scanning was the mostly used modality in the literature, but alternatively magnetic resonance imaging and ultrasonography have been used.[2-5,22,27,29-35]

Long-term patient survival in our study was similar with what has been previously reported for IAAAs and ordinary atherosclerotic AAAs.[1,15,17,26] Similar to our study, a meta-analysis has shown that patient survival curves diverge further at 1-year follow-up,[2] indicative of long-term effects of OSR. Anastomotic pseudoaneurysms were not seen after OSR in our study, an additional reason that is thought to favor EVAR and not OSR.[20]

Our study has certain limitations. Its retrospective nature and the lack of imaging in patients after OSR reduce the value of our conclusions; additionally during the early years, only OSR (n = 4) was feasible, and there has been a steady increase in favor of EVAR throughout the study period. We were able to find only comparative studies on EVAR versus OSR in our literature search, and the conclusions of our meta-analysis might be biased. Therefore, randomized controlled studies in patients eligible for both EVAR and OSR might be necessary to reveal the relative short outcome benefit with EVAR and compare it with long-term ineffectiveness in hydronephrosis management and prevention of IAAA rupture. The rarity, however, of IAAAs might render this task impossible. Future work should also confirm the role of steroids in preventing hydronephrosis after EVAR, in view of recent developments in IAAA pathophysiology.[37,39,40]

Conclusion

Endovascular aneurysm repair of IAAAs is associated with a shorter operative time, reduced transfusion needs, and hospitalization, reflective of a smoother postoperative course compared to OSR, findings that explain the reduced morbidity and mortality with EVAR. Further trials should focus on the role of EVAR for IAAAs by confirming the results of comparative studies and provide long-term results, including the course of PAF and hydronephrosis, aneurysm-related mortality, and all-cause mortality.

Authors' Note

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