Outcomes After Elective Aortic Aneurysm Repair: A Nationwide Danish Cohort Study 2007—2010

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WHAT THIS PAPER ADDS

This study of AAA repair reports nationwide results from 2007 to 2010. It supplies more recent results than the existing register studies and may reflect the improvements over time in stent-graft design and operator proficiency. Furthermore, we report detailed information on late outcomes after open aneurysm repair that are seldom reported and which show a higher total frequency of procedure-related complications after OR than EVAR. Our findings support recent reports that demographics rather than type of procedure cause the difference in long-term mortality and corroborate the notion that endovascular treatment of AAA is not as inferior in the long run as the early randomized controlled trials reported.

Objective: To assess outcomes after treatment for asymptomatic abdominal aortic aneurysm (AAA) in Denmark in a period when both open surgery (OR) and endoluminal repair (EVAR) have been routine procedures.
Methods: We performed a retrospective nationwide cohort study of patients treated for asymptomatic AAA between 2007 and 2010. Data on demographics, procedural data, perioperative complications, length of stay (LOS), 30-day reinterventions and readmissions, late aneurysm and procedure-related complications and mortality were obtained from the Danish Vascular Registry and the Danish National Patient Register.
Results: 525 EVAR and 1176 OR for asymptomatic AAA were identified. LOS was shorter after EVAR than OR (4 vs. 7 days, $p < .001$). During primary hospitalization procedure-related complications (12% vs. 6%) and general complications (21% vs. 8%) were more common after OR than EVAR ($p < 0.001$). The 30-day reintervention rate was higher for OR than EVAR (18% vs. 6%, $p < 0.001$), but there was no difference in readmissions within 30 days. During follow-up (mean 29 $\pm$ 15 months) aneurysm-related complications after EVAR were outweighed by procedure-related complications after OR.
Conclusion: Elective AAA repair in Denmark is overall comparable with international results and both perioperative and late outcomes after EVAR of elective AAA are better than the results after OR.

Article history: Received 14 January 2013, Accepted 16 April 2013, Available online 15 May 2013
Keywords: Abdominal aortic aneurysm, Endoluminal repair, Open surgery, Reintervention, Mortality, Aneurysm-related complications

INTRODUCTION

Endovascular aortic repair (EVAR) is a well-established minimally invasive procedure for abdominal aortic aneurysm (AAA) repair[1] and offers a reduction in postoperative complications[2] compared with open surgery (OR, open repair). Also, a reduced hospital length of stay (LOS)[2—4] and 30-day mortality (0—2% vs. 2—5%) have been reported.[2—6] However, late aneurysm-related complications (13% vs. 3%)[7] and rupture rates (2% vs. 0.5%)[2] have been reported to be higher for EVAR than for OR. In the long-term, reinterventions for aneurysm-related complications were more common after EVAR than after OR,[2,7] whereas the rate of surgery for laparotomy-related complications was lower after EVAR than after OR.[2] Hospitalization without surgery for laparotomy-related complications was also lower after EVAR than after OR.[2] In the early reports the benefit from EVAR on survival rates was offset after 2—4 years.[2,3,7] However, recently published reports show similar long-term survival after EVAR and OR.[8,9]

Previously published data are based on studies performed between 1999 and 2008 involving use of older generation devices. Current stent grafts are more refined with lower profile and more suitable for adverse anatomy and offer less traumatic and more precise deployment. These technical improvements coupled with increasing endovascular proficiency should be associated with better outcomes, potentially making the reported results from

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1078-5884/$ — see front matter
http://dx.doi.org/10.1016/j.ejvs.2013.04.020

early register studies and randomized controlled trials (RCTs) outdated.[10]

The endovascular treatment of AAAs is centralized to three departments and has been a treatment option in Denmark since 1996. In total, 763 endovascular procedures for both symptomatic and asymptomatic aneurysms were performed from 1996 to 2010. In comparison 8482 aneurysms were treated by open repair (performed at 8 departments) in the same period.[11]

The aim of this study was to assess recent outcomes after endovascular repair of asymptomatic AAA in Denmark and to compare these results with open aneurysm repair in Denmark.

MATERIALS AND METHODS

We obtained nationwide data on patients treated electively for an asymptomatic AAA between January 1, 2007, and December 31, 2010. Data were primarily retrieved from the Danish Vascular Registry a validated database of prospectively collected data on all procedures performed at vascular surgical departments in Denmark.[12] A manual search on each individual patient using their unique social security number was done to match the prospective data from the Danish Vascular Registry with data from the Danish National Patient Register (LPR).

By combining output from the two registries we recorded data on demographic characteristics, procedural data, complications, length of stay (LOS), 30-day reinterventions and readmissions, late aneurysm, and procedure-related complications and mortality. Results are reported by intention-to-treat. Data were censored at the end of October 2011. The flowchart of cohort identification is shown in Fig. 1.

The perioperative period was defined as the first 30 days from the date of primary surgery.

LOS was defined as the period from surgery to hospital discharge — reported in days.

The American Society of Anesthesiologists (ASA) score consists of four categories, but based on a previous study we have compressed it to a binary score to achieve a higher reliability.[13]

General ("medical") complications were defined as moderate to severe affection of lungs, heart or kidneys (acute tubular necrosis and/or dialysis), MODS (multiorgan dysfunction syndrome), compartment syndrome, stroke, pulmonary embolism, deep venous thrombosis or >3 days stay in an ICU (intensive care unit).

Surgical complications were defined as bleeding, bowel ischemia, bowel obstruction, embolization, nerve lesion, or rupture of the abdominal fascia.

Wound complications were defined as hematoma, wound infection, lymphorrhea, lymphocele, or sloughing wound edges (wound necrosis).

Thirty-day reinterventions and readmissions are for all causes not just procedure related. Reinterventions, readmissions, and rates of complications were based on number

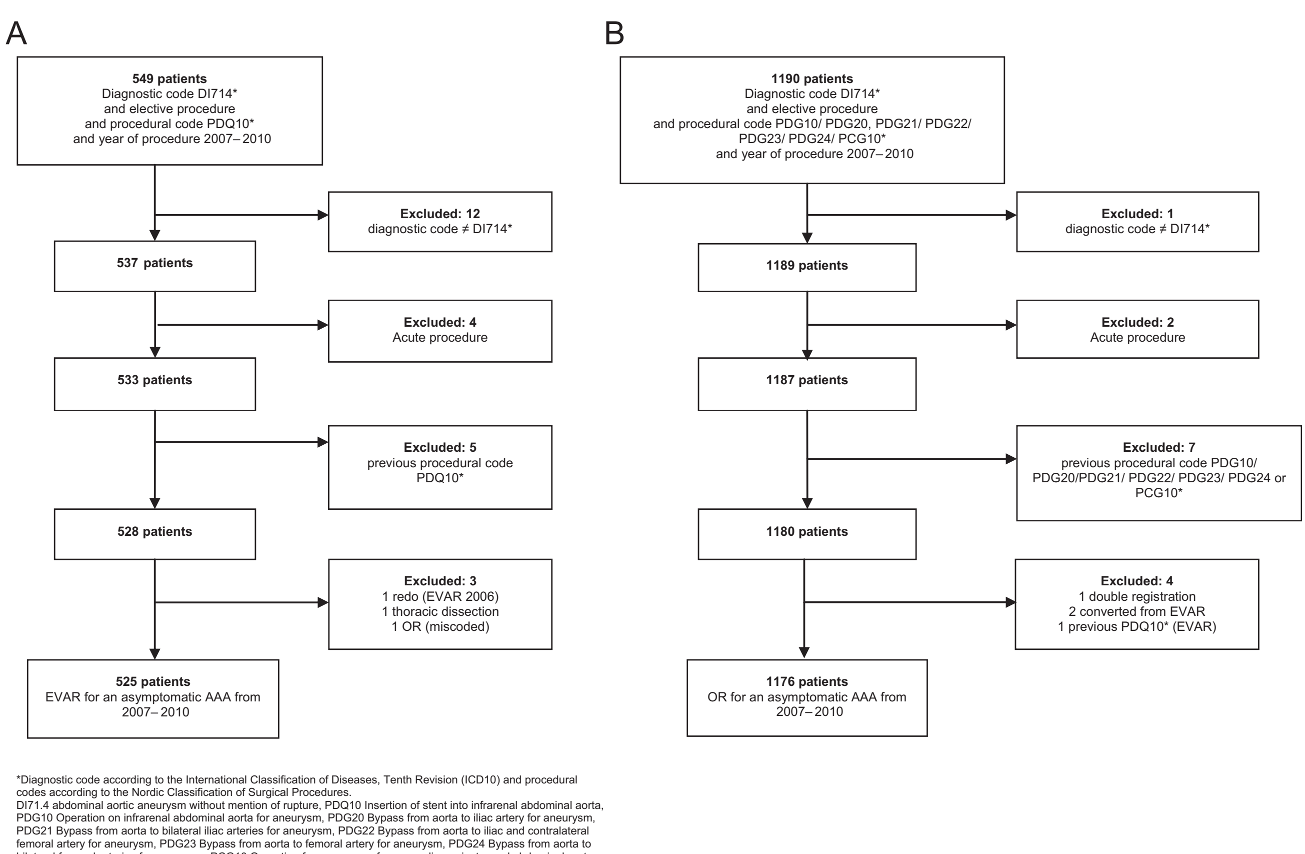

Figure 1. Flowchart of cohort identification. Endovascular repair (A), open repair (B). AAA = abdominal aortic aneurysm; EVAR = endovascular aortic repair.

of patients — so each patient only counted once for each type of event.

Acute kidney injury (AKI) following intervention was defined as impaired renal function and/or dialysis in patients without a preoperative diagnosis of renal impairment. However, perioperative need for dialysis in patients with preoperative renal impairment was recorded. The Danish Vascular registry does not provide a strict plasma creatinine limit defining AKI but use the definition "an increase in creatinine, rendering nephrological expertise necessary or affecting the postoperative course." Late dialysis was defined as continuous need for dialysis more than 12 months after the procedure.

Peripheral arterial disease (PAD) was defined as the postoperative onset of acute lower limb ischemia or claudication.

According to the reporting standards for EVAR endoleak was defined by the persistence of blood flow outside the endoluminal graft but within the aneurysm sac. The type of endoleak is not recorded and only endoleaks that require treatment are registered in the Danish Vascular Registry. In Denmark follow-up with imaging (computed tomography and duplex ultrasound) after EVAR is performed at 3 months, 12 months, and yearly thereafter.

Bowel ischemia, incisional hernia, and bowel obstruction were recorded if no diagnosis or abdominal surgery had been registered prior to the aneurysm procedure. Other abdominal complications compress explorative laparotomies, iatrogenic bowel lesions, and intra-abdominal abscesses.

Major aneurysm-related reinterventions included open or endovascular procedures for rupture/anastomotic rupture, open procedure for endoleak, revision of open repair, or an axillobifemoral or unifemoral bypass with or without resection of the old prosthesis.

Cause of death is registered for in-hospital deaths in the Danish National Patient Register but is seldom verified by autopsy. Therefore, we report all-cause mortality.

The study was registered with the Danish Data Protection Agency ref. no. 2007-58-0015 and approved by the board of the Danish Vascular Registry.

Statistics

We compared the characteristics of the two groups by using the Mann—Whitney *U* test for continuous data and cross-table methods with the Fisher exact test for dichotomous categorical variables.

Survival rates were calculated using the Kaplan—Meier method for survival curves and the log-rank test for comparison of Kaplan—Meier curves. Curves have been trimmed at 50 months to obtain more reliable tests. Cox regression was performed to test the independent effects of baseline patient characteristics. Applying a significance level of 0.1 we included gender, age, hypertension, cardiac morbidity, pulmonary morbidity, cerebral morbidity, cancer, diabetes, baseline creatinine, and ASA score, apart from EVAR and OR, in the multivariate analysis by forward stepwise selection.

A p value <0.05 (two-tailed) was considered to indicate statistical significance. We used the Bonferroni correction to compensate for multiple testing.[14]

RESULTS

There were 525 patients who underwent elective EVAR and 1176 patients who underwent elective open repair for asymptomatic AAA from 2007 to 2010 (Fig. 1). Two EVAR patients (0.4%) were intraoperatively converted to open repair. The mean follow-up was 29.1 $\pm$ 15.0 months.

Patients treated with the endovascular technique were older and more often males than the patients treated by open repair (Table 1). The EVAR patients also had a higher ASA score, reflecting the higher rates of cardiac and pulmonary morbidity than the OR patients (Table 1). Preoperative renal status did not differ in the two cohorts (Table 1). The duration of the endovascular procedure was on average shorter and the EVAR patients were discharged significantly earlier than the patients treated by OR (Table 1). In addition the OR patients were more often discharged to another hospital department (11% vs. 5%) ($p < 0.001$).

There was a higher rate of both general and surgical complications after OR than after EVAR (Table 2), but wound complications were significantly more frequent after EVAR than after OR (Table 2). However, 28 (15%) out of 190 patients treated with an open aortobifemoral procedure in the OR cohort had wound complications similar to the rate of wound complications after EVAR 14% ($p = 0.9$).

Perioperative AKI was seen in 13 EVAR patients; of these, three patients were in need of dialysis. Both figures were significantly lower than for OR, where 39 out of 81 patients with perioperative AKI required dialysis (Table 2). There were high mortality rates related to perioperative dialysis, EVAR 33%, and OR 38% ($p = 1.0$). After 3 months one EVAR and seven OR patients still required dialysis. However, three out of seven OR patients gained remission within 12 months, and late dialysis was recorded in one EVAR and four OR patients (Table 3).

Postoperative onset of lower limb ischemic symptoms (onset PAD) was seen in 11 patients after EVAR and 37 patients after OR (Table 2). In nine (1.7%) of the EVAR patients and 27 (2.3%) of the OR patients it was critical limb ischemia that required acute intervention ($p = 0.6$). In addition, one EVAR patient and 15 OR patients with known PAD underwent acute intervention for critical limb ischemia after the procedures.

Thirty-day reinterventions were more common after OR, whereas readmissions within 30 days were equally frequent (Table 2). Most reinterventions after EVAR were groin related (66%), comprising 38% hematomas/bleeding from the groin, 16% wound infections/necrosis, and 12% lymphocele.

Thirty-day mortality was lower after EVAR than after OR (Table 2), but at 1 year the advantage was offset by an increase in mortality in the EVAR cohort (EVAR 6.1% vs. OR 7.7%, $p = 0.26$). By 2 years, mortality was higher after EVAR

Table 1. Patient characteristics and operative data.

	EVAR (n = 525)	OR (n = 1176)	p Value[a]
Gender (male)	474 (90)	941 (80)	<0.001
Age (years)	74 (69–78)	70.5 (66–75)	<0.001
Smoking[b]	446 (85)	984 (84)	0.5
Hypertension	329 (63)	790 (67)	0.08
Cardiac morbidity[c]	157 (30)	215 (18)	<0.001
Pulmonary morbidity[c]	123 (23)	153 (13)	<0.001
Cerebral morbidity[d]	72 (14)	127 (11)	0.09
Cancer	28 (5)	34 (3)	0.02
Diabetes	71 (14)	105 (9)	0.006
Baseline creatinine (μmol/L)	87 (74–107)	85 (70–103)	0.1
Diagnosed renal impairment	3 (0.6)	12 (1)	0.6
Preoperative dialysis	0	4 (0.3)	0.3
ASA score			<0.001
1 (class 1 + 2)	298 (57)	928 (79)	
2 (class 3 + 4)	226 (43)	246 (21)	
Duration of surgery (hours)	01:50 (01:27–02:22)	02:40 (02:06–03:20)	<0.001
Blood loss (mL)	200 (100–500)	1700 (1050–2600)	< 0.001

Note. Data are given as the count (percentage) and median (25th to 75th percentiles). ASA = Surgical risk according to the American Society of Anesthesiologists physical status score; EVAR = endovascular aortic repair.

[a] As the comparison involved 15 tests, the significant p value was lowered to 0.05/15 = 0.003 according to Bonferroni.

[b] Smoking is defined as "ever smoked".

[c] Cardiac and pulmonary morbidity defines any condition requiring treatment.

[d] Cerebral morbidity defines cerebrovascular disease or any cerebral condition requiring treatment.

than after OR (11.3% vs. 10.4%, $p < 0.001$). Survival rates are illustrated in Fig. 2A. To evaluate the effect of baseline characteristics on survival we performed a Cox regression analysis. Age (hazard ratio 2.05, CI 2.03–2.07), cardiac morbidity (hazard ratio 1.67, CI 1.52–1.88), and ASA score (hazard ratio 1.49, CI 1.38–1.62) had a negative effect on survival. When adjusting for age, cardiac morbidity, and ASA score there was no difference in all cause mortality after EVAR vs. OR ($p = 0.7$) (Fig. 2B).

During follow-up endoleaks requiring treatment were seen in 23 (4.4%) of the EVAR patients; 18 were diagnosed within the first 12 months (Fig. 3). Aneurysm rupture occurred in one EVAR patient (0.2%) 18 months after the primary procedure due to an undetected type 1 endoleak. Three anastomotic ruptures (0.26%) were recorded in the OR cohort at three different centers, all within 3 months of the primary procedure and one with fatal outcome. In total, four EVAR patients and eight OR patients underwent major aneurysm-related reinterventions ($p = 0.8$) (Table 3). After OR 10.3% developed incisional hernia, bowel obstruction occurred in 3.4%, and 3.1% were diagnosed with bowel ischemia. One incidence of bowel ischemia in relation to a prosthesis infection was recorded in the EVAR cohort, but no incisional hernias or cases with bowel obstruction were recorded (Table 3). Of the 121 patients diagnosed with an incisional hernia 71 (6%) were treated surgically; regarding bowel obstruction 27 out of 40 patients diagnosed were operated (2.3%). In the OR cohort 89% of the cases of bowel ischemia were seen in the perioperative period and treated without exception.

Table 2. Perioperative outcomes.

	EVAR (n = 525)	OR (n = 1176)	p Value[a]	Relative risk associated with open repair (95% CI)
Stay at ICU >3 days	3 (0.6)	70 (6)	<0.001	10.42 (3.29–32.93)
General complications	41 (8)	244 (21)	<0.001	2.66 (1.94–3.64)
Surgical complications	29 (6)	139 (12)	<0.001	2.14 (1.45–3.15)
Wound complications	75 (14)	82 (7)	<0.001	0.49 (0.36–0.66)
Acute kidney injury	13 (3)	81 (7)	<0.001	2.78 (1.56–4.95)
Dialysis	3 (0.6)	39 (3)	<0.001	5.80 (1.80–18.69)
Reinterventions	32 (6)	204 (18)	<0.001	2.85 (1.99–4.07)
Readmissions	68 (13)	143 (13)	0.6	0.94 (0.72–1.23)
LOS (days)	4 (2–5)	7 (6–9)	<0.001	
30-day mortality	5 (1)	39 (3.3)	0.004	3.48 (1.38–8.78)
Onset PAD	11 (2)	37 (3)	0.3	1.50 (0.77–2.92)

Note. Data are given as the count (percentage) and median (25th to 75th percentiles). EVAR = endovascular aortic repair; ICU = intensive care unit; LOS = length of stay; PAD = peripheral arterial disease.

[a] As the comparison involved 11 tests, the significant p value was lowered to 0.05/11 = 0.005 according to Bonferroni.

Table 3. Follow-up (0–57 months).

	EVAR ($n = 525$)	OR ($n = 1176$)	p Value	Relative risk associated with open repair (95% CI)
Dialysis >12 months	1 (0.2)	4 (0.3)	1.0	1.79 (0.20–15.94)
Endoleak	23 (4)	–	–	
Bowel ischemia	1 (0.2)	37 (3)	<0.001	16.52 (2.27–120.07)
Bowel obstruction	0	40 (3)	<0.001	a
Incisional hernia	–	121 (10)	–	
Other abdominal complication	0	6 (0.5)	0.1	a
AAA sac rupture	1 (0.2)	–	–	
Anastomotic rupture	–	3 (0.3)	–	
Graft-enteric fistula	0	1 (0.1)	0.5	a
Prosthesis infection	3 (0.6)	11 (0.9)	0.5	1.64 (0.46–5.84)
Major aneurysm-related intervention	4 (0.8)	8 (0.7)	0.9	0.89 (0.27–2.95)

Note. Data are given as the count (percentage). AAA = *abdominal aortic aneurysm*; EVAR = *endovascular aortic repair.*
[a] Value not attainable.

The three centers performing EVAR are university clinics, and regarding OR 61% of the procedures were performed outside the university clinics (UNI). However, there was no difference in 30-day mortality (UNI OR 3.1% vs. other OR 3.5%, $p = 0.7$), general or wound complications. Surgical complications were more frequent in the non-university centers (UNI OR 10% vs. other OR 15%, $p = 0.008$).

If we only compare data from the university clinics on EVAR and OR, results are the same as nationwide: general complications, UNI EVAR 8% vs. UNI OR 24% ($p < 0.001$); surgical complications, UNI EVAR 6% vs. UNI OR 10% ($p = 0.01$); wound complications, UNI EVAR 14% vs. UNI OR 7% ($p < 0.001$); reinterventions, UNI EVAR 6% vs. UNI OR 16% ($p < 0.001$); and 30-day mortality, UNI EVAR 1% vs. UNI OR 3.1% ($p = 0.02$) (see Table 2 for comparisons).

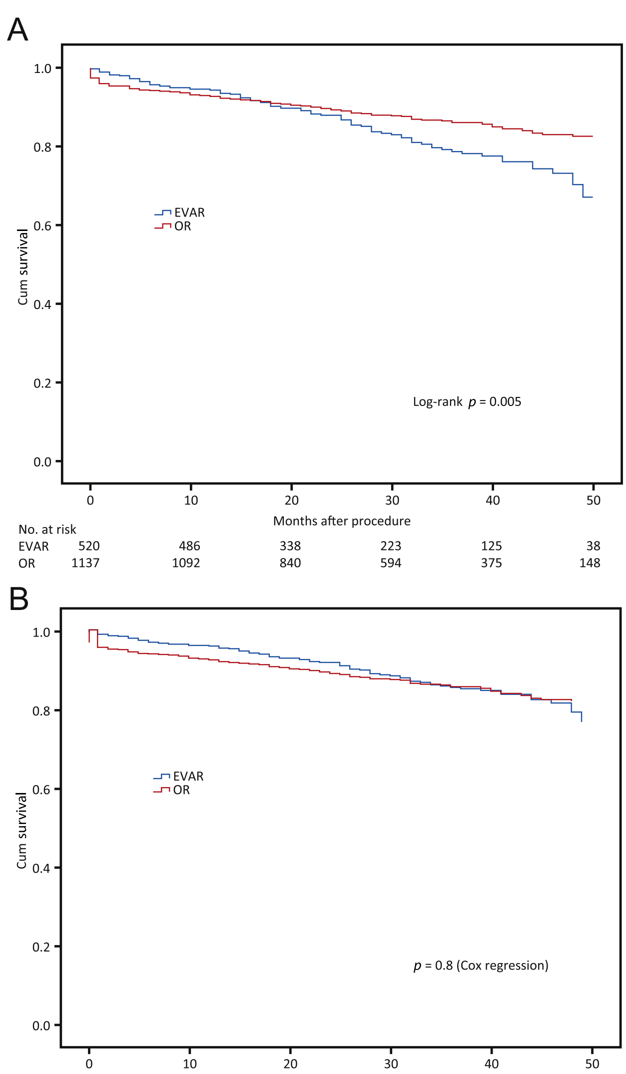

Figure 2. Kaplan–Meier plots of survival (A) and survival function after correction for age, cardiac morbidity, and American Society of Anesthesiologists score (B) according to type of aneurysm repair.

DISCUSSION

This study shows a significant perioperative benefit of EVAR over OR for elective repair. Like previous studies,[2,4,15] we found that EVAR was associated with fewer major complications, a shorter length of stay, and lower perioperative mortality than OR.

Because of the non-random assignment to EVAR vs. OR in this cohort study, the results cannot be compared with the results from RCTs. Where the limitations to randomized

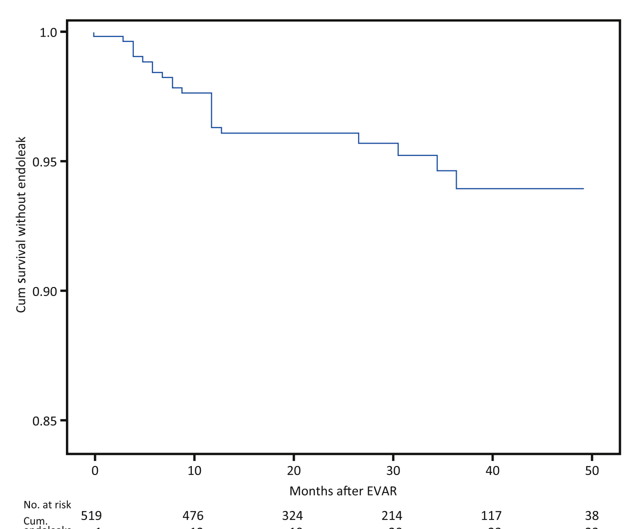

Figure 3. Kaplan–Meier plot of freedom from endoleak requiring treatment in the endovascular aortic repair cohort.

trials are highly selected cohorts due to eligibility to both treatments the historical cohorts like ours are limited due to selection bias regarding aneurysm anatomy, patient co-morbidity, and age. Another limitation related to historical register data is the possible underestimation of numbers. Although the Danish Vascular Registry is a validated database, the recordings for some parameters could be inconsistent and potentially resemble minimum figures. Specific limitations related to our data are the missing information on AAA diameter and location, procedure-specific information on clamping, additional stenting of visceral arteries and occlusion of the hypogastric artery, and follow-up information on endoleaks regardless of the need for intervention. Many of these parameters have been added to the Danish Vascular Registry after 2009 but are not reported in our study since the data were not registered for all the patients treated during 2007—2009.

The vascular surgery service in Denmark is organized to secure sufficient volume and proficiency. All departments perform a minimum of procedures, and based on mortality and complication rates in the university clinics versus non-university clinics we are confident that there is no major center effect. This is supported by the finding that results on EVAR versus OR based on data from university clinics alone are similar to nationwide results.

Regarding late results we have a follow-up period similar to the large registry study performed by Schermerhorn et al.[2] on Medicare beneficiaries in the USA. By comparing data from the Danish Vascular Registry and the Danish National Patient Register we have obtained 100% validation of the figures on readmissions, reinterventions, and mortality.

Compared with Medicare beneficiaries, Danish patients were on average younger (EVAR 74 and OR 70 years vs. Medicare 76 years), Danish EVAR patients were more often males (90% vs. 80%) and discharged later (LOS 4.3 days vs. 3.4 days).[2] However, the Danish OR patients were discharged earlier than the OR patients in the Medicare study (7 days vs. 9 days) and more often discharged home than the OR patients in the Medicare study (89% vs. 82%).[2] The rate of primary conversion from EVAR to OR was significantly lower in our study than in the study by Schermerhorn et al. (0.4% vs. 1.6%), which might reflect the increased endovascular experience and technical improvements obtained in the time between the two studies.

Thirty-day mortality in the Danish cohort (EVAR 1% vs. OR 3.3%) was similar to the Medicare results (EVAR 1.2% vs. OR 4.8%), and in the long term the overall survival curves after EVAR and OR crosses within 2—4 years as both RCTs and previous registry studies have shown. We could not confirm the advantage in long-term survival after EVAR vs. OR reported by Jackson et al.,[8] but when adjusting for age, cardiac morbidity, and ASA score we found no difference in survival after the two procedures, which is similar to previous findings.[16—18]

Similar to other register studies,[2,19] we found higher rates of AKI and dialysis after OR than after EVAR in the perioperative period, notably with no difference in preoperative renal status. However, aneurysm location is a possible confounder since juxtarenal AAA may be associated with a higher rate of AKI and is more likely to be treated by OR. The assessment of acute renal injury in the Danish Vascular Registry relies on a vague definition which represents an obstacle in the reporting of AKI. This possibly leads to underestimation of acute renal impairment, whereas the rate of acute renal failure requiring dialysis is reliable. However, the assumed underestimation affects both OR and EVAR and presumably reflects the right proportion between the rates of AKI and dialysis in the two groups. Further analysis indicated that perioperative dialysis was associated with high mortality rates, comparable to previous studies,[20,21] and a notable risk of continuous dialysis after 3 months. However, remission from dialysis is possible within the first year (3 out of the 7 OR patients gained remission).

Groin incisions are more prone to infectious complications than abdominal incisions, and by comparing the open aortobifemoral procedures to the EVAR procedures we found similar rates of wound complications. Nevertheless, the high rate of wound-related complications requires improvement.

The first randomized trials on OR vs. EVAR reported significantly higher rates of aneurysm-related complications and reinterventions after EVAR than after OR[7,22] but lacked data on laparotomy-related complications and reinterventions. Although the OVER trial supplied insight on this aspect by showing equal frequencies of aneurysm-related complications after EVAR and laparotomy-related complications after OR[3] controversy persists regarding the benefits of EVAR compared with OR due to late aneurysm-related complications.

Fig. 3 illustrates the time-dependency of endoleaks. The vast majority of endoleaks in our study occurred within the first 12 months, no new endoleaks were diagnosed after 3 years, and our data show a concentration of diagnoses concurrent with the routine imaging. Comparison of results on endoleaks is difficult. We report endoleaks requiring treatment (4.4%), whereas Schermerhorn et al.[2] reported 6.7% in need of minor endovascular reintervention and 1.1% in need of open aneurysm repair but not the indication for intervention. Considering the difference in how data are reported, a significantly lower rate of endoleaks might reflect the improvements in stent graft design and deployment proficiency. However, you also have to take into account the change in indication for treatment of endoleak which has occurred over time. In the early days type 2 endoleaks were often treated, whereas nowadays the approach is predominantly watchful waiting. However, since type of endoleak is not consistently recorded in the Danish Vascular Registry we cannot verify this assumption.

The rupture rate for the Danish EVAR cohort was 0.2% compared with 1.8% in the Medicare cohort[2] and 0.7% in the Lifeline Registry.[17] This is possibly an underestimation since we have far from a 100% autopsy rate in Denmark. However, this is true for most countries and therefore a general condition in the assessment of aneurysm-related mortality and rupture rates after both EVAR and OR.

Therefore, the low rupture rate in our cohort should be proportionally reliable and might again reflect the improvements in the endovascular treatments. Rupture as such does not exist after OR since the aneurysm sac is not preserved. However, anastomotic ruptures do occur after OR and are comparable in severity to aneurysm sac rupture. We recorded equal frequencies of the two types of rupture in the respective Danish cohorts and the rate of rupture after OR in Denmark is also comparable to the Medicare result (0.3% vs. 0.5%).

Our study supports the findings in the OVER trial[3] and the Medicare study[2] regarding procedure-related complications. During the entire follow-up period the Danish OR cohort had a higher total rate of procedure-related complications than the EVAR cohort. This was mainly due to laparotomy-related complications, but contrary to the Medicare study[2] we found similar rates of rupture, graft-enteric fistula, prosthesis infection, and major aneurysm-related reintervention between the two groups. Also, bowel ischemia was significantly more frequent after OR than EVAR.

It could be argued that aneurysm-related outcomes are the only relevant parameters after aneurysm repair. However, if a treatment option results in a relatively low rate of aneurysm-related complications but a high total frequency of procedure-related complications it might be worth considering the alternative less invasive treatment option with the higher but still not alarming rate of aneurysm-related complications, especially considering that the vast majority of these complications can be treated by minor endovascular reintervention.

CONCLUSION

Outcomes after endovascular repair of asymptomatic AAA in Denmark between 2007 and 2010 are comparable with international observations and generally better than the results after open surgery for AAA in Denmark. Similar to previous register studies, the EVAR population were older and more comorbid but despite this showed similar long-term survival to the younger and healthier OR population. Contrary to previous findings we found similar rates of rupture and major aneurysm-related reinterventions after the two procedures, and seen in the light of the higher rate of procedure-related reinterventions after open surgery EVAR seems more tempting for all patients who are anatomically fit. However, it should be borne in mind that more complex aneurysms most likely underwent open surgery, which might explain the higher rate of, for example, AKI after OR. Finally, we believe there is room for optimization of the minimally invasive endovascular procedure to reduce wound complications, reinterventions, and length of stay.

FUNDING

The study was funded by grants from The Danish Heart Foundation, The Tove & John Girotti Foundation and by research funds from Copenhagen University Hospital, Rigshospitalet.

CONFLICT OF INTEREST

None.

ACKNOWLEDGMENT

We thank the Danish Vascular Registry for supplying data for this study.

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