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Outcome of Fenestrated Endovascular Aneurysm Repair in Octogenarians: A Retrospective Multicentre Analysis

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WHAT THIS PAPER ADDS
The fenestrated endograft for complex abdominal aortic aneurysm appears as a valuable treatment option in the experience of two tertiary referral centres.

Objective: An ageing population leads to more age related diseases, such as complex abdominal aortic aneurysms (AAA). Patients with complex AAAs and multiple comorbidities benefit from fenestrated endovascular aneurysm repair (FEVAR), but for the elderly this benefit is not completely clear.
Methods: Between 2001 and 2016 all patients treated for complex AAA by FEVAR at two tertiary referral centres were screened for inclusion. Group 1 consisted of patients aged 80 years and older and group 2 of patients younger than 80 years of age. The groups were compared for peri-operative outcome, as well as patient and re-intervention free survival, and target vessel patency during follow up.
Results: Group 1 consisted of 42 patients (median age 82 years; interquartile range [IQR] 81—83 years) and group 2 of 230 patients (median age 72 years; IQR 67—77 years). No differences were seen in pre-operative comorbidities, except for age and renal function. Renal function was 61.4 mL/min/1.73 m^2 *vs.*74.5 mL/min/1.73 m^2 ($p < .01$). No differences were seen between procedures, except for a slightly longer operation time in group two. Median follow up was 26 and 32 months, respectively. No difference was seen between the groups for estimated cumulative overall survival ($p = .08$) at one, three, and five years, being 95%, 58%, and 42% for group 1, and 88%, 75%, and 61% for group 2, respectively. There was no difference seen between groups for the estimated cumulative re-intervention free survival ($p = .95$) at one, three, and five years, being 84%, 84%, and 84% in group 1, respectively, and 88%, 84%, and 82% in group 2, respectively. Ultimately, no difference was seen between groups for the estimated cumulative target vessel patency ($p = .56$) at one, three, and five years, being 100%, 100%, and 90% for group 1, and 96%, 93% and 92% for group 2, respectively.
Conclusion: Age itself is not a reason to withhold FEVAR in the elderly, and choice of treatment should be based on the patient's comorbidities and preferences.

Keywords: Complex abdominal aortic aneurysm, Fenestrated endovascular aneurysm repair, Octogenarian
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INTRODUCTION

Abdominal aortic aneurysm (AAA) is an age related and potentially life threatening disease, due to the risk of rupture.[1,2] The life expectancy of the Western population has increased and, consequently, more octogenarians will need treatment for an AAA.[2—5] The elderly are often considered to be unfit for open surgical AAA repair.[6]

Endovascular aortic repair (EVAR) has increasingly replaced open repair for the treatment of an AAA.[5,7] EVAR in octogenarians is associated with less morbidity and mortality than open repair.[8] However, the 30 day mortality after EVAR is higher than in patients younger than 80 years and varies from 2.6% to 7.0%.[8—10]

Fenestrated EVAR (FEVAR) is used to treat complex aneurysms, including short neck infrarenal or juxtarenal AAAs.[11] FEVAR is a feasible alternative to open repair, with a 30 day mortality varying from 2.0% to 5.8%.[12,13] With the introduction of FEVAR elderly patients, who are too frail for open surgery but who have a complex AAA unsuitable for EVAR and in whom watchful waiting is not an option, got a

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new opportunity to get treatment.[14] A recent study by Locham *et al*. showed the 30 day mortality rate in octogenarians with complex AAA who were treated by either open repair or FEVAR.[15] The octogenarians undergoing open repair had a higher 30 day mortality rate than patients treated by FEVAR (8.5% *vs.* 4.1%).[15] A few other studies with small sample sizes on the outcomes of FEVAR in octogenarians have been published recently.[7,16] Their findings suggest that octogenarians might not benefit from treatment by FEVAR, but the results are ambiguous. Knowledge of the results of FEVAR in octogenarians remains sparse. Most studies focus on peri-operative mortality and short term survival.[15,16] Information about other outcomes, such as re-interventions and survival in the longer term, is limited. To the authors' knowledge only the studies by Hertault *et al*. and Roy *et al*. presented data on mid term results; consequently, more results will enable assessment of FEVAR in the elderly.[7,17]

This study aimed to evaluate the results of FEVAR in octogenarians related to patient survival, complications, and number of re-interventions, and target vessel patency in the mid term.

Table 1. Baseline characteristics of 272 patients undergoing fenestrated endovascular aneurysm repair (FEVAR), stratified by age

	Octogenarians (n = 42)	Non-octogenarians (n = 230)	p value
Mean age ± SD (range) – y	82.3 ± 2.5 (80–91)	71.4 ± 6.1 (50–79)	<.01
Men	37 (88)	199 (87)	.78
ASA ≥ 3	29 (69)	165 (72)	.73
Diabetes mellitus	3 (7)	37 (16)	.14
Hyperlipidaemia	21 (50)	159 (69)	.01
Arterial hypertension	28 (67)	183 (80)	.98
Coronary artery disease	29 (69)	137 (60)	.24
Pulmonary disease	10 (24)	82 (36)	.15
Mean renal function ± SD (range) – mL/min/ 1.73 m^2 (eGFR)	61.4 ± 17.4 (29–96)	74.5 ± 22.1 (25–132)	<.01

Data are n (%) unless otherwise stated.
SD = standard deviation; ASA = American Society of Anaesthesiologists' score; eGFR = estimated glomerular filtration rate.

MATERIALS AND METHODS

Study design

This retrospective cohort study included patients with a short neck infrarenal or pararenal AAA. The patients were treated primarily or after previous aneurysm repair with type I endoleak or para-anastomotic aneurysm. One urgent treatment of a contained ruptured aneurysm after EVAR was also included as the fenestrated stent graft was already in the authors' possession. Patients with thoraco-abdominal aortic aneurysm were excluded. The custom made fenestrated endografts used were the Zenith Fenestrated endografts (Cook Medical, Bloomington, IN, USA) or the Fenestrated Anaconda endograft (Terumo Aortic, Inchinnan, UK). Data were collected from two tertiary referral centres for patients treated between 2001 and 2016. The study was approved by the institutional review board (METc-2017-540). Retrospective patient file research does not fall under the scope of the Dutch Act on Medical Scientific Research involving Human Beings. Therefore, informed patient consent was not required and not obtained. Patient related data were analysed anonymously.

Data collection and definitions

Data collection included demographics and comorbidities, including cardiovascular and pulmonary disease, renal failure, dialysis, and diabetes mellitus. Procedural information included type of fenestrated endograft, number of fenestrations, operating time, adjunctive procedures, and (assisted) primary technical success. Patients treated with a fenestrated endograft including only scallops were excluded.

Cases were assigned to two groups: patients aged 80 years and older were assigned to group 1 (octogenarian group), and patients younger than 80 years were assigned to group 2 (non-octogenarian group). Both groups were divided into quartiles (≤2006, 2007–2009, 2010–2012, and ≥2013) to check for change in median age at the time of surgery.

The primary technical success was defined as the successful introduction and deployment of the device and the absence of surgical conversion or mortality, type I or III endoleaks, or graft limb obstruction, extending into the first 24 h post-operatively. When successful unplanned endovascular procedures were done within 24 h, they were defined as assisted primary technical success.[1] Endoleaks were defined as described by Jain *et al*.[18] Post-operative information about re-intervention and 30 day mortality was also registered. Follow up information included patient survival rate, re-intervention free survival rate, and target vessel patency.

Statistical analysis

Chi square tests were used for differences between groups with categorical variables. Distribution normality was tested with the Shapiro–Wilk test. Results are presented as mean ± standard deviation (SD) for normally distributed data, and as median (interquartile range [IQR]) for skewed data. Differences between groups with continuous variables were analysed with the Student's t test (normal distribution), or with the Mann–Whitney U test (skewed distribution). Differences in continuous data between multiple groups were tested with the Kruskal–Wallis test. For paired

Table 2. Aneurysm specific baseline characteristics of 272 patients undergoing fenestrated endovascular aneurysm repair (FEVAR), stratified by age

	Octogenarians (n = 42)	Non-octogenarians (n = 230)	p value
Mean aneurysm diameter ± SD (range) – mm	65.3 ± 8.4 (54–89)	63.3 ± 8.6 (42–92)	.17
Proximal aneurysm location			
Short neck aneurysm	20 (48)	91 (40)	.95
Juxtarenal aneurysm	22 (52)	126 (55)	.77
Suprarenal aneurysm	0 (0)	13 (6)	.12
Type Ia endoleak	3 (7)	12 (5)	.62
Para-anastomotic aneurysm	0	1 (0.4)	.67

Data are n (%) unless otherwise stated. SD = standard deviation.

data, the Wilcoxon signed rank test was used. Kaplan–Meier analysis and log rank test were used for patient survival, re-intervention free survival, and target vessel patency. P values < .05 were considered statistically significant. SPSS version 24.0 (IBM, Armonk, NY, USA) was used for analysis.

RESULTS

Characteristics

A total of 272 patients (236 men) were included. Baseline characteristics are shown in Tables 1 and 2. Group 1 consisted of 42 (15.4%) cases (median age 82 years, range 80–91 years) and group 2 of 230 (84.6%) cases (median age 72 years, range 50–79 years). The median age in the four time periods did not change (p = .79 in group 1; p = .98 in group 2), nor was there a difference seen in the relative number of cases in group 1 *vs.* group 2 (p = .09). Two hundred and fifty five patients were treated with the Zenith fenestrated graft (41 in group 1 and 214 in group 2), while 17 patients were treated with a Fenestrated Anaconda (one in group 1 and 16 in group 2; p = .26). A total of 89 fenestrations (mean 2.1.74) were incorporated in group 1 and 527 fenestrations (mean 2.3.80) in group 2 (p = .20).

Intra-operative results

On completion angiogram, in group 1, two type Ia (4.8%), one type Ia/IIIc (2.4%), one type Ic (2.4%), and eight type II (19.0%) endoleaks were observed. During follow up, the two type Ia endoleaks resolved spontaneously, the type Ia/IIIc endoleak needed Amplatzer vascular plug embolisation of the left renal artery (LRA) and coiling with thrombin injection of the aneurysm sac, and the type Ic endoleak was treated by relining of the LRA. In group 2, eight type Ia (3.5%), one type Ib (.4%), one type Ic (.4%), 43 type II (18.7%), one type IIIa (0.4%), and one type IIIc (0.4%) endoleaks were recorded (Table 3). All the type I endoleaks resolved spontaneously during follow up, expect for one type Ia endoleak. The follow up computed tomography angiography (CTA) revealed a type IIIc instead of a type Ia endoleak, which was treated by relining of the target vessels. No significant difference was noted between the two groups regarding primary technical success or primary assisted technical success (p = .84 and p = .56, respectively).

Early outcome

Thirty day morbidity and mortality for the two groups are presented in Table 4. The 30 day mortality was 2.4% in

Table 3. Procedural outcomes of fenestrated endovascular aneurysm repair (FEVAR) in 272 patients, stratified by age

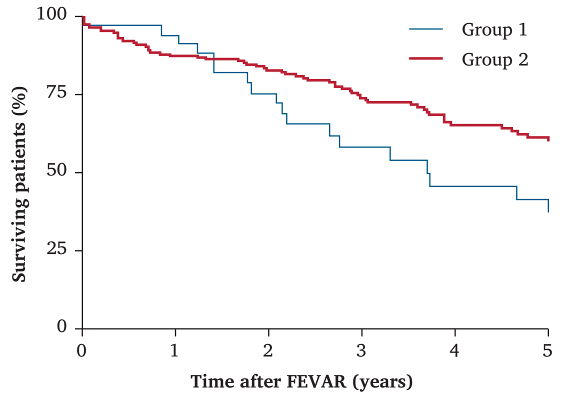
	Octogenarians (n = 42)	Non-octogenarians (n = 230)	p value
Intra-operative mortality	0 (0)	0 (0)	1.00
Primary technical success	33 (79)	179 (78)	.84
Assisted primary technical success	38 (90)	214 (93)	.56
Endoleak on completion angiography	12 (29)	55 (24)	.35
Iliac branched device	1 (2)	1 (0.4)	.18
Adjunctive procedure	9 (21)	59 (26)	.56
Median contrast volume (IQR) – mL	150 (100–183)	170 (130–210)	.07
Median procedure time (IQR) – min	171 (145–235)	200 (160–267)	.048

Data are n (%) unless otherwise stated.
IQR = interquartile range.

Table 4. Early outcomes after fenestrated endovascular aneurysms repair (FEVAR) in 272 patients, stratified by age

	Octogenarians (n = 42)	Non-octogenarians (n = 230)	p value
Mean ICU length of stay ± SD (range) – d	0.2 ± 0.6 (0–3)	0.9 ± 4.6 (0–62)	.39
Mean lenght of hospital stay ± SD – d	5.8 ± 3.4 (1–18)	6.9 ± 10.8 (1–120)	.54
Mean postoperative renal function ± SD (range) – mL/min/1.73 m^2 (eGFR)	61.0 ± 22.7 (8–117)	72.5 ± 26.5 (13–154)	.01
Spinal cord ischaemia	0 (0)	5 (2)	.34
Visceral ischaemia	1 (2)	9 (4)	.63
Lower limb ischaemia	2 (5)	15 (7)	.67
30 day mortality	1 (2)	7 (3)	.82

Data are n (%) unless otherwise stated.
SD = standard deviation; eGFR = estimated glomerular filtration rate; ICU = intensive care unit.



No. at risk (SE in %)

	0	1	2	3	4	5
Group 1:	42 (0)	32 (4)	23 (8)	15 (9)	11 (10)	10 (10)
Group 2:	230 (0)	166 (2)	136 (3)	103 (3)	76 (4)	54 (4)

Figure 1. Cumulative Kaplan Meier estimates of patient survival after fenestrated endovascular aneurysm repair (FEVAR), stratified by age. Group 1 consists of octogenarians; group 2 consists of non-octogenarians. SE = standard error.

group 1. In one patient, a renal artery was presumably punctured by a guidewire, leading to bleeding and development of a haematoma in the left kidney. This patient, with an already poor cardiac condition, evolved rapidly into cardiogenic shock and death, without the opportunity for re-intervention. The 30 day mortality was 3.0% (seven patients) in group 2. Five patients died of gastrointestinal ischaemia. Four had a superior mesenteric artery (SMA) and/or coeliac artery (CA) occlusion. Although laparotomy was performed, these occlusions led to multi-organ failure and death at 2, 2, 4, and 11 days, respectively. In the last patient there was a SMA dissection which, despite open surgical patch plasty, eventually led to death 23 days post-operatively. Two patients died of myocardial infarction, both on post-operative day four.

In group 1, three patients underwent a re-intervention within 30 days (7.1%). In the first, a post-operative groin bleed was sutured on the evening of initial surgery. In the second, there was dissection of the external iliac and common femoral arteries, and an endarterectomy was performed, including placement of an iliac stent four days post-operatively. In the last patient the LRA stent disconnected during operation, and could not be bridged. On day seven coil embolisation of the LRA was performed because of persistent endoleak.

In group 2, 13 patients needed a re-intervention within 30 days (5.6%). The five patients undergoing laparotomy were mentioned above. Three patients had an iliac artery occlusion followed by a bypass (day 0) in one and stent placement in two (both day 15). In two patients additional stenting was performed: one on day six to the right renal artery (RRA) due to stent fracture and another on day 15 to a LRA, resolving a type III endoleak. In one patient the SMA stent showed a stenosis and additional percutaneous transluminal angioplasty was performed on day five. In two patients a compartment syndrome, with ischaemia of the lower leg, was noted on the day of operation and a fasciotomy of the lower leg was performed.

In patients with signs of spinal cord ischaemia, a spinal drain was used to lower spinal pressure. This was only done in group 2 patients (five cases [2.2%]). One patient was paraplegic post-operatively due to thalamic ischaemia possibly combined with spinal ischaemia. After spinal drainage and rehabilitation a paresis of the left leg persisted. In the other four cases the patient had paresis of both lower limbs, which disappeared fully after spinal drainage.

Mid term outcome

Patient survival. Median follow up in group 1 was 26 months (IQR 12—58 months) and in group 2 it was 32 (IQR 9—58 months) ($p = .72$). In 16 cases follow up after 30 days was available, of whom eight died (one in group 1 and seven in group 2), and in eight cases (one in group 1 and seven in group 2) no follow up was available. In those last cases the follow up took place at the primary referral centre.

No difference was seen between groups for estimated cumulative patient survival ($p = .08$) at 1, 3, and 5 years, being 95% $\pm$ 4%, 58% $\pm$ 9%, and 42% $\pm$ 10%, respectively for group 1, and 88% $\pm$ 2%, 75% $\pm$ 3%, and 61% $\pm$ 4%, respectively for group 2 (Fig. 1).

In group 1, the causes of death were cardiac failure in three, respiratory failure in one, a cerebrovascular event in one, and malignancy in three. In three cases the deaths were considered aneurysm related. One patient had a type Ib endoleak and aneurysm growth, but refused further treatment, subsequently leading to rupture 45 months post-operatively. A second patient was admitted 17 months after surgery with a mycotic aneurysm, subsequently developing abdominal pain and instability during admission. On suspicion of aneurysm rupture conservative care was chosen with subsequent death. The cause of death was unknown in 12 cases.

In group 2, causes of death were cardiac failure in 16, respiratory failure in three, cerebrovascular events in six, and malignancy in 12. Another five cases were considered aneurysm related. In one patient, a laparotomy was performed four months after surgery because of an endograft infection. At 44 months the SMA occluded in this patient, resulting in death. In another case occlusion of both renal arteries led to death 100 months post-operatively. In three cases there was an infected endograft, of which one combined with a type Ia endoleak led to rupture and death five months post-operatively. The two other cases were managed conservatively, and both died 33 months post-operatively. The cause of death was unknown in 38 cases.

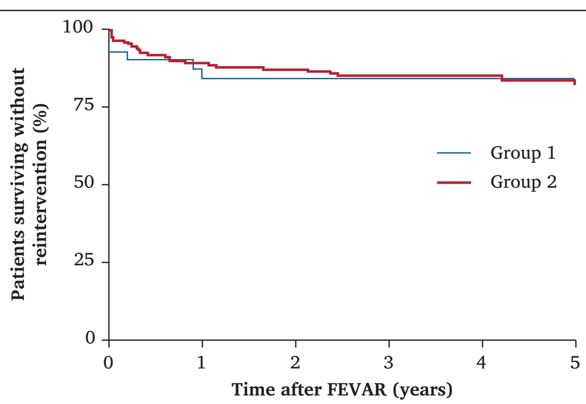
Complications and re-intervention free survival. After the 30 day post-operative period, 23 patients needed a re-intervention. Three patients had a re-intervention in group 1. In the first patient a persistent type Ic endoleak was treated by an additional LRA stent at 2.4 months. In the second patient a stent was placed because of a sharp iliac angle at 11 months, and in the third patient an uncovered stent was placed for a type IIIa endoleak to push two aortic endograft components together at 12.1 months.

Twenty patients underwent a re-intervention in group 2. One patient had an uneventful index procedure and a normal post-operative CTA. However, 2.9 months later the patient presented at the emergency room with chest pain and lower limb ischaemia. CTA detected a type B retrograde thoraco-abdominal aortic dissection from the left subclavian artery to just above the fenestrated endograft, with occlusion of the SMA and thrombosis of a popliteal aneurysm. Initially, a stent was placed in the SMA to preserve patency and a femoropopliteal bypass was performed. Three weeks later a second intervention was performed with a carotid—subclavian bypass, stenting of the CA, and thoracic stent graft. In one, a laparotomy was performed after four months for endograft infection as mentioned above, and in another groin re exploration for a groin abscess at eight months. In one patient a severely stenotic LRA prevented cannulation and stenting, and was therefore left unstented. A second cannulation attempt was performed at 3.8 months to treat the type IIIc endoleak and the deterioration in renal function. However, the digital subtraction angiography (DSA) images showed total occlusion of the artery, after which the attempt was abandoned. With repeated DSA imaging, the LRA appeared to be occluded. Only a small niche filled with contrast and there was insufficient space to occlude the fenestration with an Amplatzer plug. In the fifth case the CA occluded and thrombolysis with urokinase was tried at 11 months, without effect, and no further clinical consequences. In the sixth case, at 14 months thrombin injection of a false aneurysm of the femoral artery was performed. A lumbar artery was coiled for a type II endoleak at 65 months in the seventh case. Re-intervention of the iliac or femoral artery was performed for occlusion in four cases by stent (2.4 months), thrombectomy (3.5 months), ilio-femoral (4.0 months), and ilio-iliac crossover bypass (5.0 months). Relining of visceral arteries was performed for a fractured stent (20 and 29 months), a stenosis or occlusion (7.3, 13.0, 15.0 and 62.0 months), a displaced stent (6.0 months), a type Ib endoleak (31.6 months), or a type III endoleak (30.0 months).

No difference was seen between the groups for estimated cumulative re-intervention free survival ($p = .95$) at 1, 3, and 5 years, being 84% $\pm$ 6%, 84% $\pm$ 6%, and 84% $\pm$ 6%, respectively for group 1, and 88% $\pm$ 2%, 84% $\pm$ 3%, and 82% $\pm$ 3%, respectively for group 2 (Fig. 2).

Target vessel patency and renal function. At last follow-up there had been three one target vessel occlusions (3.4%) in group one (one in the LRA and two in the RRA), and 29 occlusions (5.4%) in group 2 (two in the CA, 9 in the SMA, 9 in the LRA, and 9 in the RRA [$p = .44$]). All necessary interventions are mentioned above. The estimated target vessel patency at 1, 3, and 5 years were 100% $\pm$ 0%, 100% $\pm$ 0%, and 90% $\pm$ 7% in group 1, respectively, and 96% $\pm$ 1%, 93% $\pm$ 1%, and 92% $\pm$ 2% in group 2, respectively ($p = .56$; Fig. 3).

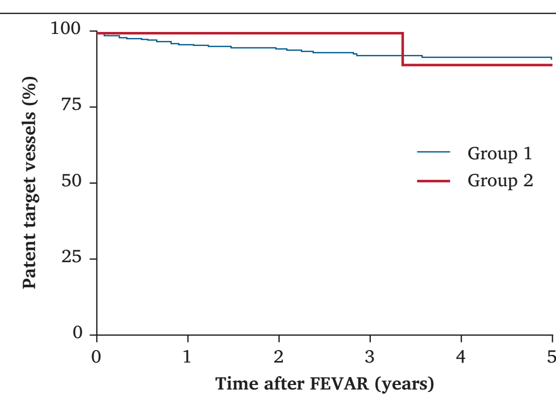
In group 1 the pre-operative mean estimated glomerular filtration rate (eGFR; 61.417 mL/min/1.73 m^2) remained stable *vs.* a post-operative eGFR of 61.023 mL/min/1.73 m^2 ($p = .47$) and the last follow up eGFR (61.124 mL/min/1.73 m^2) ($p = .06$). In group 2, the mean pre-operative eGFR changed from 74.5 $\pm$ 22 mL/min/1.73 m^2 to 72.5 $\pm$ 26 mL/min/1.73 m^2 post-operatively ($p = .77$), and declined further to 60 $\pm$ 20 mL/min/1.73 m^2 at the last follow up ($p < .001$). There was no statistically significant difference between the two groups regarding eGFR decline at the last



No. at risk (SE in %)

	0	1	2	3	4	5
Group 1:	42 (0)	28 (6)	19 (6)	12 (6)	8 (6)	7 (6)
Group 2:	230 (0)	150 (2)	123 (3)	93 (3)	69 (3)	51 (3)

Figure 2. Cumulative Kaplan Meier estimates of reintervention free survival after fenestrated endovascular aneurysm repair (FEVAR), stratified by age. Group 1 consists of octogenarians; group 2 consists of non-octogenarians. SE = standard error.



No. at risk (SE in %)

	0	1	2	3	4	5
Group 1:	87 (0)	53 (0)	37 (0)	21 (0)	17 (1)	13 (1)
Group 2:	533 (0)	356 (1)	271 (1)	191 (1)	140 (2)	82 (2)

Figure 3. Cumulative Kaplan Meier estimates of target vessel patency after fenestrated endovascular aneurysm repair (FEVAR), stratified by age. Group 1 consists of octogenarians; group 2 consists of non-octogenarians. SE = standard error.

follow up ($p = .91$). No post-operative dialysis dependence was observed in group 1 but occurred in five patients in group 2 ($p = .34$).

Endoleaks. After implantation, 15 endoleaks were noted in 15 patients (35.7%) in group 1 and 52 endoleaks in 50 patients in group 2 (22.0%) ($p = .06$).

In group 1, one type Ia/IIIc endoleak, one type Ib, one type Ic, 10 type II, one type IIIa, and one type IIIb endoleaks were found. A re-intervention was performed in two cases, as mentioned above.

In group 2, two type Ia endoleaks, one type Ib, one type Ic, 43 type II, and four type IIIc were found, and one patient had a type Ib, type II, and type IIIc endoleak. Re-intervention was performed in six patients. The patient with the three endoleaks had relining of an iliac artery for the type Ib endoleak, coiling of a lumbar artery for the type II endoleak, and the type IIIc endoleak was treated by watchful waiting. Relining of one or more visceral arteries was performed for a type III endoleak in four patients. One patient needed coiling of a lumbar artery for a type II endoleak due to growing aneurysm sac. All other endoleaks disappeared spontaneously or were followed by watchful waiting.

DISCUSSION

This multicentre retrospective cohort study shows no statistically significant difference in survival and re-intervention free survival benefit of FEVAR in the treatment of complex AAA in octogenarians and in younger patients.

Pre-operative patient characteristics were comparable in both groups. Obviously, pre-operative age was different, probably also resulting in lower pre-operative renal function in the octogenarian group. The other similarities might be the result of a selection of healthier elderly people, which might result in a selection bias for the octogenarian group. It could be argued that despite the absence of statistical significance, a slight difference in aneurysm diameter between groups was observed (65 mm in group 1 *vs.* 63 mm in group 2), and maybe this is the consequence of withholding treatment in cases with multiple comorbidities and a borderline AAA diameter.

The assisted primary technical success in the present study is similar to earlier work by Hertault *et al*. and Timaran *et al*.[7,16] The 30 day mortality in the octogenarian group, however, is different than found by Hertault *et al*. and Timaran *et al*. In the study by Timaran *et al*.,[16] octogenarians with a mean age of 84 years ($n = 18$) treated by FEVAR for complex AAA were compared with patients with a mean age of 71 years ($n = 67$), and there was a 30 day survival of 100% in both groups.[16] Additionally, there was no difference between groups for estimated survival at 20 months. The larger study by Hertault *et al*. included a group with a mean age of 82 years ($n = 33$) and a group with a mean age of 70 years ($n = 255$).[7] They observed a slightly higher 30 day mortality rate in the elderly group of 9% *vs.*1.9% in the younger group after FEVAR.[7] These findings suggest that octogenarians might not benefit from treatment by FEVAR.

The explanation of the discrepancy between those two studies and the present one is not completely clear, but the 30 day mortality in the current study is comparable to other studies not differentiating in age, suggesting age is not a limiting factor for the technical success of FEVAR.[12,19,20]

In the general population, overall survival is expected to be lower in octogenarians simply due to age. The estimated overall survival rate at five years in this study did not differ statistically from the non-octogenarian group (42% *vs.* 62%), but it seems the octogenarian group has lower long term cumulative survival than the non-octogenarian group and a reported five year survival of 59.4%.[17] Although a difference can be seen, the lack of statistical significance in this fairly large cohort suggests the difference is not as clear as that described by Hertault *et al*.[7]

No difference was seen between groups for re-intervention free survival. Timaran *et al*. found a re-intervention free survival of 90% in octogenarians at 20 months, but a 43% rate in the non-octogenarian group.[16] This difference is remarkable although, due to a small sample size, not statistically significant. Comparing this with the estimated re-intervention free survival and available literature, it seems more plausible that age does not influence AAA or endograft related re-intervention rate during follow up.[21]

Target vessel patency related to age is not well described. Besides a higher chance of cardiovascular disease with older age, the elderly tend to have larger AAAs and more angulation. It could be said that this makes them more difficult to treat and therefore more at risk of stent occlusion than younger patients.[22] However, the present study showed good estimated target vessel patency rates at five years (Fig. 3).

One interesting issue in this study is the lower post-operative renal function in the octogenarian group (Table 3). The pre-operative renal function was lower in the octogenarian group (Table 1), probably related to older age. During follow up renal function remained stable in the octogenarian group, while there was a decline in renal function in the younger group. It is possible that the small sample size led to a type II statistical error or a lower pre-operative renal function made clinicians initiate a more active treatment of renal function or use more protective measures. Altered renal function did not lead to dialysis dependency in this study. A decline in renal function often happens after FEVAR and age is an independent risk factor of long term decline in renal function after FEVAR. Special care should be taken in those with already borderline renal function.[12,23,24]

A relatively higher (non-significant) number of endoleaks was seen in the octogenarian group. As higher age involves greater peri-operative risk, it is possible that the treatment of octogenarian patients was done preferably with an endovascular approach over open surgical repair, despite more challenging anatomy, consequently leading to a slightly higher number of type I endoleaks. It seems that there is no other clear reason why there were more endoleaks in the octogenarian group.

CONCLUSIONS AND RELEVANCE

The treatment of patients with a complex abdominal aortic aneurysm will include more elderly people owing to the increasing longevity of the population. In the elderly particularly, survival rates after treatment with fenestrated endografts will remain part of the discussion, but age itself is not a reason to refuse treatment. The choice of treatment should be weighed by all comorbidities and the preference of the patient.

CONFLICTS OF INTEREST

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