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RESEARCH

MIDTERM OUTCOMES OF ELECTIVE ENDOVASCULAR AORTIC REPAIR IN OCTOGENARIANS: WHEN IS IT TOO OLD?

Abstract

Introduction: Endovascular aortic repair outcomes in octogenarians remain unclear. We aim to investigate whether the results for octogenarians differ from those of the younger population in elective endovascular aortic repair.

Materials and Methods: From January 2013 to January 2022, 313 patients were treated with elective endovascular aortic repairs. Patient demographics and perioperative and postoperative features were obtained from the hospital database. The primary goals were to explore the early mortality rates of patients aged 80 years and older and compare them with those under 80. The secondary goal was to analyze the comorbid factors.

Results: A total of 245 patients were under 80 years old, and 68 patients were 80 years and older. The early mortality rate was 2.94% in the octogenarians and 0.81% in the rest, and there was no significant difference between the two (p = 0.24). However, being 80 years and older led to a significantly lower survival probability at the five-year follow-ups. The American Society of Anesthesiologists' score was found to help predict late mortality risk and patient selection for elective endovascular aortic repair.

Conclusion: As octogenarians are fragile and sensitive to complications, patient selection, careful consideration of life expectancy, and clinical assessment are key to repair. Furthermore, age should not be an independent exclusion criterion in the endovascular aortic repair treatment decision.

Keywords: Aortic Aneurysm, Abdominal; Endovascular Procedure; Octogenarians.

INTRODUCTION

Improvements in the medical management of the progressive nature of atherosclerosis, population screening with ultrasonography, computed tomography (CT), and the aging of the world population have led to a considerable number of octogenarians emerging as candidates for elective abdominal aortic aneurysm (AAA) repair. As age-related diseases are expected to increase, the incidence and prevalence of cardiovascular diseases in the elderly are becoming more common day by day for healthcare professionals (1).

Being 80 years and older has been indicated as the cut-off point for age-based risk estimation in elective endovascular aortic aneurysm repair (EVAR) procedures (2). Alberga et al. studied 12,054 EVAR and 3,815 open surgical repair patients divided into octogenarian and non-octogenarian groups and found a 1.9% operative mortality rate for EVAR and an 11.8% mortality rate for open surgical repair in octogenarians (3). Although EVAR has provided a better solution for AAA, EVAR treatment in octogenarians for elective AAA is still subject to controversy due to the lower life expectancy (4). Even though the technical process may be similar, it is undeniable that elderly patients are fragile and more sensitive to complications. The current European Society for Vascular Surgeon (ESVS) guidelines point out that it is reasonable to consider elective AAA repair for octogenarians with reasonable life expectancy and quality of life after informing them of the pros and cons of different treatment strategies, including conservative options (5). However, there is no consensus on the comprehensive midterm and long-term results for EVAR in patients 80 years and older.

Our paper aimed to compare the early and midterm outcomes of elderly patients undergoing EVAR with those of younger patients. Furthermore, the groups were compared according to complications, endoleaks, and reinterventions. We also aimed to emphasize the factors affecting postoperative mortality and assess the hazard ratio.

METHODS

Data Source and Patient Selection:

From January 2013 to January 2022, 313 patients underwent elective EVAR by the same cardiovascular surgeon team in our clinic. A total of 245 patients were under 80 years old, and 68 patients were 80 years or older. In this study, elderly patients were defined as those who had turned 80 years old or older in the procedural year. The endovascular team assessed all patients in terms of their suitability for EVAR treatment. According to our clinical preferences, EVAR has been the first-choice treatment modality for abdominal aortic aneurysms if suitable to the instruction for use. The patients' preferences have correlated with surgeons', and the selections have been made under consensus. Conventional surgery has been performed in inadequate neck anatomies, unhealthy landing zones, or contraindications to EVAR as a necessity, not selection. Contrastly, EVAR has been performed in patients with unacceptable high risk to conventional surgery as a last chance to prevent aneurysm-related death even if unsuitable for use. Data were retrospectively obtained from the hospital database and records. The study protocols followed the Declaration of Helsinki, and the design was reviewed and approved by the Institutional Review Board (E1-19-161).

Early mortality, or in-hospital mortality, occurs in the first month after procedures, and mortality after the first month is called late mortality. Evaluating early and late mortality in elderly patients was the primary goal. The secondary goal was to assess the hazard ratio of being 80 years or older and other comorbidities and secondary reinterventions.

The same endovascular team performed all procedures in a hybrid operating room. Five types of brands (Ankura AAA (Lifetech), AFX (Endologix), Endurant-II (Medtronic), the Gore Excluder (Gore), and the E-vita Abdominal XT (Jotec)) were used in these procedures. The unibody Endologix endograft was used in 70 patients (23.3%); the rest received bifurcated modular endografts. General anesthesia was performed on 254 patients (81.1%); the remainder was subject to loco-regional anesthesia. Endoleaks were assessed with completion angiography and then treated. Angiography was obtained with contrast or carbon dioxide (CO_2). For 16 patients (5.1%) who had severe chronic kidney disease (CKD) or a high risk of kidney failure, we performed contrast-free angiography with a procedure using CO_2.

Postoperative Follow-Up:

Clinical and radiological assessments were performed in the first month, the 6th month, the 12th month, and annually after the procedures. All patients had colored Doppler ultrasonography (CDUS), and case-by-case CDUS or contrast-enhanced CT angiography was performed according to the patients' individual characteristics, as previously described (6). Secondary interventions, as if needed, were performed by the same team, and complete angiography was then carried out. Mortalities, morbidities, and reinterventions were investigated and documented.

Statistical Analysis:

The variables were explored using visual (e.g., histograms and probability plots) and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk tests) to determine the normality of their distribution. Normally distributed continuous variables were expressed as means ± standard deviations (SD) or median values with ranges, if not normally distributed. Categorical variables were expressed as numbers and percentages. Demographic parameters, operating variables, and follow-up data were compared using the Mann–Whitney U test, Student's t-test, and chi-square test. A Student's t-test was conducted to analyze the preoperative and follow-up diameters of the aneurysm sacs. A Kaplan–Meier analysis was conducted to demonstrate the probability of survival and event freedom. A log-rank analysis was performed to compare the groups in the Kaplan–Meier curves. In the Kaplan–Meier survival curves with confidence limits, the upper and lower confidence limits were computed in SPSS following the generated Kaplan–Maier estimate. The hazard ratio (HR) and 95% confidence intervals (CI) were estimated with different Cox proportional hazard models to estimate the independent predictors of survival, with adjustment for the predefined possible risk factors. A p-value of < 0.05 was statistically significant, and all statistical analyses were performed using the SPSS for Windows version 20.0 statistical software program (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 313 patients underwent the EVAR procedure in 9 years. Patients treated with EVAR were divided into two groups according to whether they were 80 years of age, which was the cut-off point. Group 1 included 245 younger patients under 80 years old, while Group 2 included 68 patients who were 80 years old and older. Group 2 also included 10 patients aged 90 years and older. The baseline characteristics of all patients are presented in Table 1. The groups were compared according to these characteristics, and the homogeneity of the groups was assessed. The number of elderly patients with CKD (baseline creatinine levels of 1.8 mg/dl and above) was significantly higher than that of the other group ($p = 0.011$). The octogenarians had higher American Society of Anesthesiologists (ASA) scores at the preoperative assessments by an ordinal increase ($p = 0.045$). Smoking was significantly higher in Group 2 (p=0,025). There were no statistically significant differences between the two groups when comparing other baseline characteristics (Table 1). Furthermore, there was no

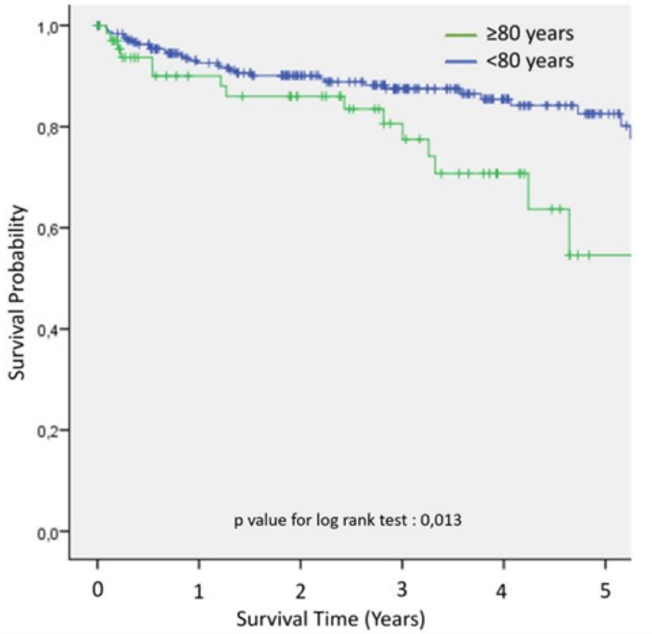
Table 1. Demographics and comorbid factors within the groups.

Baseline characteristics of the patients			
Parameter	**N (%) or mean (range) (N=222)**		**p**
	Group 1 n = 245 Aged under 80 years	**Group 2 n = 68 Aged 80 years and over**	
Age[years]	67.27 ± 6.21 (42–79)	83,91 ± 3.93 (80–97)	
Male gender	230 (93.8%)	55 (80.8%)	*0.002
ASA grade:			
2	30 (12.2%)	7 (10.2%)	*0.045
3	95 (38.7%)	17 (25%)	
4	87 (35.5%)	30 (44.1%)	
5	33 (13.4%)	14 (20.5%)	
Hypertension (HT)	181 (73.8%)	51 (75%)	0.87
Diabetes mellitus (DM)	63 (25.7%)	17 (25%)	0.905
Hyperlipidemia (HL)	75 (30.6%)	24 (35.2%)	0.465
Coronary artery disease (CAD)	104 (42.4%)	33 (48.5%)	0.371
Peripheral artery disease (PAD)	20 (8.2%)	6 (8.8%)	0.86
Chronic obstructive pulmonary disease (COPD)	69 (28.1%)	25 (36.7%)	0.171
Chronic kidney disease (CKD)	28 (11.4%)	16 (23.5%)	*0.011
EF < 30	6 (2.4%)	2 (2.9%)	0.686
Smoking	135 (55.1%)	27 (39.7%)	*0.025
Malignancy	14 (5.7%)	5 (7.3%)	0.907
TIA/CVE	9 (3.6%)	6 (8.8%)	0.104
AAA diameter [mm]	62.15 ± 13.47 (52–116)	65.33 ± 16.2 (55–118)	0.101
≥ 6.0 cm	130 (53%)	39 (57.3%)	0.96

EF: Ejection fraction, TIA/CVE: Transient ischemic attack/cerebrovascular event, AAA: Abdominal aortic aneurysm.

significant difference in perioperative procedural features. The most used type of endograft was the modular type, and the average lengths of the intensive care unit stay and hospital stay were the same.

Cumulative Kaplan–Meier survival analyses were generated for the probability of survival, event freedom, and secondary intervention. In the first postoperative month, two patients died in both groups, and the mortality rates were 2.94% in elderly patients and 0.81% in younger patients. There was no statistical difference between the groups according to the early mortality rate ($p = 0.24$; Table 2). In 5 years of follow-up, overall late mortality after elective EVAR was 54 patients (17.2%), with 39 in Group 1 (15.9%) and 15 in Group 2 (22%). Being 80 years and older led to a significantly worse survival probability ($p = 0.013$) and event freedom rate ($p = 0.035$) in the Kaplan–Meier analysis (Figure 1). Secondary reinterventions were performed on 20 patients (6.3%), including 15 patients in Group 1 and 5 in Group 2. The log-rank analysis indicated that both groups had similar curves for secondary intervention rates ($p = 0.81$). Octogenarians had



≥80 years		%90 CI: %82-98	%86 CI: %77-95	%77 CI: %65-90	%70 CI: %56-88	%54 CI: %32-72
Patient at risk	68	45	38	26	13	2
<80 years		%92 CI:%89-96	%90 CI: %86-94	%87 CI: %83-92	%85 CI: %80-91	%82 CI:%76-89
Patient at risk	245	191	153	111	71	39

Figure 1. Kaplan–Meier analysis of survival for groups. Survival curves are demonstrated by the green line for individuals ≥ 80 years old and the blue line for those < 80 years old. The probability of the groups is shown, respectively, with 95% confidence intervals (CI) for group 1 at 82% (76–89%) and group 2 at 54% (32–72%; p = 0.013).

Table 2. Perioperative features and procedural details in the groups. Causes of in-hospital mortality by groups were documented

Perioperative procedural features			
Feature	**N (%) or median (range) (N = 313)**		**p**
	Group 1 n = 245 Aged under 80 years	**Group 2 n = 68 Aged 80 years and over**	
General anesthesia	202 (82.4%)	52 (76.4 %)	0.58
Local/regional anesthesia	43 (17.5%)	16 (23.5 %)	
Duration of the procedure [minutes]	120 (80–370)	125 (95–365)	0.89
Fluoroscopy time [minutes]	14 (4–78)	14 (5–80)	0.91
Amount of contrast agent [ml]	60 (0–160)	50 (7–120)	0.96
Length of intensive care unit stay [hours]	4 (1–240)	4 (2–120)	0.76
Length of hospital stay [days]	2 (1–30)	2.5 (0–21)	0.56
Early-stage mortality	2 (0.8%)	2 (2.9%)	0.24
Causes of death by groups	One patient died in postoperative 1st day due to cardiac reasons One patient died in postoperative 2nd day due to Acut Miyocard Infaction	One patient died in postoperative 1st day due to Acut Kidney Failure One patient died in postoperative 8th day due to Acut Kidney Failure	

Table 3. Outcomes after EVAR in groups and reinterventions for endoleaks.Causes of late mortality were documented by groups

Follow-up data			
Data	**Group 1 (n)**	**Group 2 (n)**	**Reinterventions**
Endoleaks:			
Type Ia	4	2	4 proximal extensions 2 ballooning procedure
Type Ib	4	1	5 distal extensions
Type II	18	8	26 untreated (follow-up)
Type III	4	2	2 open conversions 4 endovascular relining 2 untreated (patient preference)
Type V	0	1	1 follow-up
Limb occlusion	1	2	1 femoral-femoral artery bypass 1 endovascular intervention 1 untreated (asymptomatic)
Late conversion to open surgery	2	0	
Secondary intervention	15	5	
Late mortality	39	15	
**Causes of Late Mortality*	6 aneursym-realted 17 cardiac reasons 7 cancer 3 pnomonia 3 chronic renal insufiency 3 unknown	3 aneursym-realted 7 cardiac reasons 2 cancer 1 pnomonia 2 unknown	

lower late survival rates, with a similar secondary reintervention rate after elective EVAR. Moreover, there were 10 patients aged 90 years and older, and no early mortality was observed.

Clinical data were obtained from routine follow-ups, the data of which are shown in Table 3. In our patient cohort, there were 44 (14%) endoleaks, of which 26 were type 2 (59%). The rates of type 1 and type 3 endoleaks necessitating secondary interventions were 3.5% and 2.2%, respectively. There were 20 secondary interventions in total. Open conversions after EVAR were performed on two patients after failed endovascular attempts. Limb occlusion after EVAR occurred in three patients. One was treated with a cross-over femoral-femoral artery bypass, another with endovascular intervention, and the last was untreated because of being asymptomatic. Additionally, type 5 endoleaks were present in one patient (Table 3).

Univariant and multivariant Cox regression models revealed independent risk predictors for late mortality. After we determined the primary risk factors for late mortality with an unadjusted analysis, we performed a multivariate analysis. Having CKD (basal creatinine levels ≥ 1 .8mg/dl; unadjusted HR: 2.37; 95% CI: 1.212–4.664; $p = 0.012$), an ASA-

Table 4. Multivariate and univariate Cox regression analysis for factors.

Parameter	Unadjusted analysis			Adjusted analysis		
	P-value	**HR**	**95% CI**	***P-value***	**HR**	**95% CI**
Age ≥ 80	*0.015	2.149	1.158–3.988	*0.014	2.302	1.18–4.48
Gender (male)	0.145	23.381	0.33–1624.7			
CAD	0.89	1.609	0.931-2.782			
PAD	0.356	1.492	0.638-3.493			
ASA grade 5	*0.002	2.6	1.23–4.93	*0.022	2.186	1.12–4.26
Diabetes mellitus	0.18	0.609	0.296–1.256	0.36	0.705	0.33–1.49
COPD	*0.022	1.94	1.101–3.42	*0.015	2.073	1.15–3.72
Malignancy	*0.001	5.094	2.62–9.904	*0.001	4.47	2.12–9.42
Renal diseases	*0.012	2.37	1.212–4.664	0.9	1.04	0.485–2.26
EF<30%	*0.015	4.324	1.332–14.05	*0.044	3.99	1.03–15.37
Symptomatic aneurysm	*0.019	1.976	1.12–3.48			
AAA diameter ≥ 6.0 cm	0.22	1.44	0.803–2.582	*0.031	1.88	1.036–3.42

CAD: Coronary Artery Disease, PAD: Pepheral Arterial Diseases, ASA: American Society of Anesthesiologist classifications, COPD: Chronic obstructive pulmonary disease, EF: Ejection fraction, AAA: Abdominal aortic aneurysm.

5 score (unadjusted HR: 2.6; 95% CI: 1.23–4.93; p = 0.002), chronic obstructive pulmonary disease (COPD; unadjusted HR: 1.94; 95% CI: 1.101–3.42; p = 0.022), or being symptomatic significantly increased the late mortality rate. Patients with diabetes mellitus (DM) were likely to have lower late mortality rates, but this difference was not significant. Being 80 years and older (unadjusted HR: 2.149, 95% CI: 1.58–3.98; p = 0.015) and having a malignancy (unadjusted HR: 5.04, 95% CI: 2.62–9.904; p = 0.001) were independent hazard factors for late mortality. These two factors also increased the late mortality rates in the multivariant analysis (respectively, adjusted HR: 2.302, 95% CI: 1.18–4.48; p = 0.014; adjusted HR: 4.47, 95% CI: 2.12–9.42; p = 0.001). Among these covariates, having low EF was found to decrease survival in both the univariate and multivariate analyses (respectively, unadjusted HR: 4.324, 95% CI: 1.332–14.05; p = 0.015; adjusted HR: 3.99, 95% CI: 1.03–15.37; p = 0.044; Table 4).

DISCUSSION

Age is a well-known independent risk factor for procedural-related death (2), and EVAR treatment is a preferred solution in elderly patients for elective AAA (3, 4). Scallen et al. compared the long-term results of open surgical repair (OSR) and EVAR in octogenarians and demonstrated significantly lower early mortality for EVAR over OSR, with a survival benefit of one year. However, there was no survival advantage during the 5-year follow-up period. Long-term outcomes have also been found to be similar, except for an 18% late reintervention rate in the EVAR group (7). In our nine years of experience, we treated 68 octogenarians and nonagenarians with EVAR. We found that the early and midterm outcomes of endovascular procedures for patients 80 years and older had acceptable results, despite the patients being 80 years and older having twice the HR in late survival. According to early mortality, the groups had similar mortality rates. The early mortality rate was 2.94% in the elderly patients and 0.81% in the younger participants. Although the re-interventional rates in both groups were similar, elderly patients may be less able to recover from the complications than younger participants. Interestingly, there was no mortality in the nonagenarians. Therefore, discussing the patient's life expectancy and clinical assessment should be key for deciding on the operation, not how old they were.

Even though this study was constructed retrospectively, the comorbid factors were similar within both groups, except for gender, smoking, and having CKD. In fact, gender may not alter the outcomes after EVAR treatment, as previously described (8). In the present study, the male population was higher for both groups, and younger participants had a significantly higher male population. CKD was associated with increased morbidity and death in EVAR treatment (9). The fact that there was a higher incidence of CKD in the elderly patients could have a negative effect on outcomes. Other comorbidities were similar for both groups in the present study.

Endoleaks remain the most common complication after EVAR. Type 1 and 3 high-flow endoleaks especially require reintervention (10). Due to the same rate of early complications and reinterventions, there may be the same early mortality rates for octogenarians and others.

The multivariate analysis indicated that being 80 years and older led to a two-fold increase in the HR for survival. As previously described, octogenarians treated with EVAR had higher mortality rates than their younger counterparts (11). However, Budtz-Lilly et al. reported outcomes such as a 1.8% mortality rate for octogenarians after EVAR as for younger participants (12). In a previous study, concomitant malignancy was associated with higher mortality after TEVAR (13). In our research, having a malignancy led to a four-fold increase in mortality. Assessing life expectancy might therefore be wise for a cancer patient before EVAR. Furthermore, in our study, we found that patients with COPD who underwent EVAR had higher mortality rates, and CKD had no effect on late mortality. This could be attributed to the performance of contrast-free angiography and the use of CO_2 in CKD cases. Another result indicated that the ASA score was correlated with the mortality rate. Not every elderly patient has a higher ASA score, and not every elderly patient has a similar risk. ASA scores may therefore be helpful in identifying the appropriate candidates for elective EVAR. Specifically, EVAR may be considered a good and safe treatment for octogenarians, as long as they have a score under ASA-5 (14). Although not reported in the results, two patients did not accept the EVAR treatment due to high ASA scores and operational risks and were treated medically. In this respect, discussions with patients having high ASA scores are also practical to improve outcomes.

We found similar cumulative reintervention rates for both groups. Because elderly patients are fragile and sensitive to complications, the results may be even worse in the octogenarian. Rueda-Ochoa reported that EVAR in octogenarians has a long-term beneficial impact on their life expectancy. However, perioperative complications and reinterventions nearly doubled the long-term mortality rate in octogenarians (15).

According to the EVAR-2 trial, EVAR versus only medical treatment could not improve the outcomes in 60 years and older patients who were physically ineligible for open repair (16). Based on this study, no-intervention for abdominal aortic aneurysm might be a suitable option in octogenarian unless the physical status had been considered. Our study indicated that performing an EVAR on a patient over 80 years of age and performing an intervention on a patient under 80 years of age with COPD has almost the same risk. Although age is a comorbid factor, it cannot be a definitive contraindication. AAA repair aims to prevent rupture and, to prolong the life. Since medical treatment alone will not eliminate the risk of rupture, we consider it appropriate to perform EVAR to increase survival in suitable patients. Another important inference is that the survival curves of the groups differ after 2 years following the procedure. Therefore , a balance between the risk of intervention and the benefits of prolonging and maintaining the quality of life is thus needed. In this context, the inclusion of all patient groups, regardless of suitability for open surgery, strengthens our study. Finally, it should be added that there are some limitations to this research due to it being a single-center, retrospective-designed study. Long term follow-ups and more data are needed for further evalution.

CONCLUSION

Being an octogenarian implies a two-fold increase in the HR for overall mortality. Not every octogenarian has the same operational risk, and not all EVAR indications are vital and beneficial to perform. Therefore, clinical assessment and understanding of the risk-benefit ratio are the keys to effective EVAR treatment in elderly patients. Despite shorter life expectancy and comorbidities, EVAR's early and midterm outcomes are acceptable in octogenarians, and age should not be an exclusion criterion. Our single-center experience shows that EVAR can be performed safely in the geriatric patient group.

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