ORIGINAL ARTICLES

Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm

Oscar L. Rueda-Ochoa [a,b,‡], Pieter van Bakel [c,‡], Sanne E. Hoeks [c], Hence Verhagen [c], Jaap Deckers [a], Dimitris Rizopoulos [a], Mohammad A. Ikram [a], Ellen Rouwet [c], Klaas Ultee [c], Sander ten Raa [c], Oscar H. Franco [a,d], Maryam Kavousi [a,¶,*], Marie Josee van Rijn [c,¶,]**

[a] Department of Epidemiology, Erasmus Medical Center, Rotterdam, the Netherlands
[b] School of Medicine, Faculty of Health, Universidad Industrial de Santander UIS, Bucaramanga, Colombia
[c] Department of Vascular Surgery, Erasmus Medical Center, Rotterdam, the Netherlands
[d] Institute of Social and Preventive Medicine (ISPM), University of Bern, Bern, Switzerland

WHAT THIS PAPER ADDS

Long-term survival after endovascular aortic aneurysm repair (EVAR) in octogenarians remains unclear. We report, for the first time, that after EVAR, the life expectancy of octogenarians equals that of the matched octogenarians from the Rotterdam Study, provided that they do not develop early postoperative complications. Furthermore, if a complication occurred, octogenarians, had a nearly two-fold increase in long-term mortality compared to the general population octogenarians. Our results suggest that performing EVAR in octogenarians has a long-term beneficial impact on their life-expectancy, given that patients with low susceptibility to peri- and post-operative complications are selected.

Objective: Long term survival after endovascular aortic aneurysm repair (EVAR) in octogenarians remains unclear. This was evaluated by comparing octogenarians after EVAR with a matched group of octogenarians without an abdominal aortic aneurysm (AAA) from the Rotterdam Study (RS). The influence of complications after EVAR on survival was also studied with the aim of identifying risk factors for the development of complications in octogenarians.

Methods: Using propensity score matching (PSM), 83 EVAR octogenarians were matched for comorbidities with 83 octogenarians from the RS, and survival was compared between these two groups using Cox proportional hazard analysis. Then, complications were studied, defined as cardiac or pulmonary, renal deterioration, access site bleeding, acute limb ischaemia or bowel ischaemia, within 30 days of surgery between 83 EVAR octogenarians and 475 EVAR non-octogenarians. Also, the difference in baseline characteristics between the octogenarians with and without complications after EVAR were studied, and survival was compared between the RS controls and the complicated and uncomplicated EVAR octogenarians separately.

Results: The total EVAR octogenarian population did not show an increased mortality risk compared with RS octogenarian controls (hazard ratio [HR] 1.28, 95% confidence interval [CI] 0.84—1.97). Post-operative complications occurred in 22 octogenarians (27%) and 59 non-octogenarians (12.4%, $p < .001$), mainly cardiac, pulmonary, and bleeding complications. All baseline characteristics were similar in the complicated EVAR octogenarians compared with the uncomplicated EVAR octogenarians. After uncomplicated EVAR, octogenarians had a similar survival compared with the RS controls (HR 1.09, 95% CI 0.68—1.77), but after complicated EVAR their mortality risk increased significantly (HR 1.93, 95% CI 1.06—3.54).

[‡] Oscar L. Rueda-Ochoa and Pieter van Bakel contributed equally to this work.[¶] Maryam Kavousi and Marie Josee van Rijn contributed equally to this work.
* Corresponding author
** Corresponding author
E-mail addresses: oscarleonel8a@gmail.com; o.ruedaochoa@erasmusmc.nl (Oscar L. Rueda-Ochoa); m.kavousi@erasmusmc.nl (Maryam Kavousi); m.vanrijn@erasmusmc.nl (Marie Josee van Rijn).

https://doi.org/10.1016/j.ejvs.2020.01.026

Please cite this article as: Rueda-Ochoa OL et al., Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm, European Journal of Vascular and Endovascular Surgery, https://doi.org/10.1016/j.ejvs.2020.01.026

Conclusions: After standard EVAR, the life expectancy of octogenarians is the same as that of a matched group from the general population without an AAA, provided they do not develop early post-operative complications. Patient selection and meticulous peri-operative care are key.

Keywords: Complications, EVAR, Long term survival, Non-octogenarians, Octogenarians
Article history: Received 11 June 2019, Accepted 23 January 2020, Available online XXX

INTRODUCTION

With ageing of the population, there has been an increase in octogenarians considered for endovascular aortic aneurysm repair (EVAR).[1] The EVAR technical success rate in octogenarians is high, although the complication rate was found to be higher compared with younger patients.[1,2] Short term benefits of AAA repair are clear (i.e. avoiding aneurysm rupture), but the question remains whether this preventive surgery will actually increase survival in octogenarians.

So far, studies have merely compared survival after EVAR between octogenarians and younger patients,[2] the latter obviously having a longer life expectancy and usually fewer comorbidities.[1,3,4] A meaningful comparison of EVAR efficacy among octogenarians should include control groups of the same age and risk profile. In the absence of any randomised controlled trials (RCTs), available data from large population based cohort studies could be useful to compare long term survival of octogenarians undergoing EVAR with matched controls.

The main aim of this study was to compare long term survival in octogenarians after EVAR with matched octogenarian controls from the prospective population based Rotterdam Study (RS), without an AAA, using propensity score matching (PSM). Furthermore, complications after EVAR were studied. First, post-EVAR complications were compared between octogenarians and younger patients. The next aim was to study the impact of complications on long term survival after EVAR among octogenarians and to identify octogenarians at high risk of the development of these complications.

METHODS

Study population

EVAR patient population. Data were obtained on patients with AAA treated by EVAR between January 2000 and December 2015 from a prospectively maintained database at the Vascular Surgery Department of the Erasmus University Medical Centre, Rotterdam, the Netherlands. Patients with ruptured aortic aneurysms and re-interventions after previous EVAR were excluded, as well as patients with a diagnosis other than degenerative AAA and isolated iliac aneurysms. All AAAs were infrarenal and treated by standard EVAR. The patients were divided into two groups; patients $\geq$80 years (octogenarians) and $<$80 years of age (non-octogenarians). A team of vascular anaesthetists pre-operatively examined patients using the risk calculator of the ACS NSQIP®. If the peri-operative risk was too high, patients were declined EVAR. These patients were not registered in the database. Informed consent was waived according to institutional policy on retrospective research. This study was approved by the Medical Ethics Committee (MEC-2019—0143).

Control group from the population based Rotterdam Study. Controls were selected from the RS,[5] a prospective population based cohort study that included participants aged 45 years or older from the district of Ommoord, in Rotterdam. The RS cohort began in 1990 with 7 983 participants. The cohort has been extended twice; in 2000 with 3 014 and in 2006 with 3 932 new participants. The follow up examinations take place every three to four years consisting of a home interview and two visits to the research centre. An abdominal ultrasound measuring the diameter of the abdominal aorta is part of the visits. Participants are continuously monitored for major outcomes through access to general practitioners and municipality records. For the current study, controls were chosen from RS visits that took place between April 2002 and March 2016 to provide a similar recruitment period to that of the EVAR patient population. Individuals with an aortic diameter greater than 30 mm on ultrasound were excluded as controls for this study. The RS was approved by the Medical Ethics Committee according to the Wet Bevolkingsonderzoek ERGO (Population Study Act Rotterdam Study). All participants provided written informed consent.

Clinical variables

Demographic characteristics of participants (age and sex) and comorbidities (ever smoking, hypertension, peripheral artery disease [PAD], ischaemic heart disease [IHD], stroke, diabetes mellitus [DM], and cancer) were included in this analysis. Medical history and information on medication use were obtained. Hypertension was defined as systolic blood pressure $>$140 mm Hg, diastolic blood pressure $>$90 mm Hg, use of blood pressure lowering medication, or a previous diagnosis of hypertension. Information about PAD and cancer was obtained through medical interview and confirmed by checking general practitioners' records for the RS and obtained from the medical history for the EVAR database. PAD was always symptomatic, and not solely based on an ankle brachial index. IHD was defined as myocardial infarction (MI), coronary artery bypass graft, or

Table 1. Baseline characteristics of octogenarians treated by endovascular aneurysm repair (EVAR) of abdominal aortic aneurysm (AAA) or matched octogenarian controls without AAA from the Rotterdam Study (RS) before and after propensity score matching

Characteristic	Before propensity score matching			After propensity score matching		
	EVAR $n = 83$	RS $n = 2212$	p*	EVAR $n = 83$	RS $n = 83$	p*
Age − years	83.02 ± 3.0	83.45 ± 2.9	.18	83.02 ± 3.0	82.56 ± 2.5	.28
Female gender	14 (16.9)	1350 (61.0)	<.001	14 (16.9)	16 (19.3)	.69
Smoking (ever)	58 (69.9)	773 (35.4)	<.001	58 (69.9)	60 (72.3)	.73
Hypertension	65 (78.3)	1811 (84.9)	.10	65 (78.3)	66 (79.5)	.85
PAD	11 (13.3)	176 (9.2)	.21	11 (13.3)	10 (12.1)	.82
IHD	32 (38.6)	314 (14.4)	<.001	32 (38.6)	32 (38.6)	1.0
Stroke	15 (18.1)	177 (8.1)	<.01	15 (18.1)	14 (16.9)	.84
DM	15 (18.1)	393 (19.3)	.79	15 (18.1)	19 (22.9)	.44
Cancer	19 (22.9)	280 (13.9)	.02	19 (22.9)	24 (28.9)	.38

Data are given as mean ± standard deviation or n (%). DM = diabetes mellitus; EVAR = endovascular aortic aneurysm repair; IHD = ischaemic heart disease; PAD = peripheral artery disease; RS = Rotterdam Study.
* Difference between the EVAR octogenarians and the Rotterdam Study octogenarian controls.

percutaneous transluminal angioplasty, and was confirmed by electrocardiogram or medical records. Strokes identified in medical records were reviewed by research physicians and verified by an experienced stroke neurologist for the RS and obtained from the medical history for the EVAR database. DM was defined as fasting glucose >6.9 mmol/L, non-fasting glucose >11.0 mmol/L, use of blood glucose lowering medication, or a previous diagnosis of DM. Complications of interest after EVAR included cardiac complications, renal deterioration (defined as an increase in creatinine of >0.5 mg/dL or new haemodialysis), pulmonary complications, access site bleeding (any bleeding requiring blood transfusion or re-operation), acute limb ischaemia and bowel ischaemia intra-operatively and/or within 30 days post-operatively. Cardiac complications included atrial fibrillation, heart failure, myocardial infarction, and/or elevated troponin levels. As a standard of care, after every vascular procedure, serum troponin was measured three times a week. A post-operative high-sensitivity troponin T (hsTnT) of 20–65 ng/L with an absolute change of 5 ng/L, a hsTnT >65 ng/L or a TnT level >0.03 were scored as elevated.[6,7]

EVAR clinical success was defined as successful deployment of the endovascular device at the intended location without death as a result of aneurysm related treatment, type I or III endoleak, graft infection or thrombosis, aneurysm expansion (diameter 5 mm, or volume 5%), aneurysm rupture, or conversion to open repair. The presence of graft dilatation of 20% or more by diameter, graft migration, or a failure of device integrity classified a case as a clinical failure.[8]

Outcomes and follow up

EVAR patients were routinely followed with a 30 day and yearly computed tomography angiogram (CTA). In selected patients with an anticipated lower risk of complications or renal function impairment, CTA was replaced by colour duplex ultrasound or by non-contrast CT. If an endoleak or sac growth were detected, patients underwent a CTA. The database of the Dutch Central Bureau of Statistics was used to check mortality for the whole database on 26 April 2016. Medical data on the study participants were anonymised by authorised data managers employed by the Central Bureau of Statistics. This data set was subsequently imported and

Table 2. Baseline characteristics and peri-operative complications of octogenarians and non-octogenarians treated by endovascular aneurysm repair (EVAR) of abdominal aortic aneurysm

Characteristic	Octogenarians $n = 83$	Non-octogenarians $n = 475$	p*
Age at surgery − years	83.0 ± 2.9	70.2 ± 6.3	<.001
Aneurysm diameter − mm	63.5 ± 10.4	60.5 ± 12.6	.05
Female gender	14 (16.9)	46 (9.7)	.05
Smoking (ever)	55 (68.8)	353 (76.7)	.12
Hypertension	65 (78.3)	330 (70.8)	.16
PAD	11 (13.4)	78 (16.9)	.44
IHD	32 (38.6)	167 (35.8)	.62
Stroke	15 (18.1)	63 (13.6)	.29
Pulmonary disease	13 (16.9)	70 (15.4)	.73
DM	15 (18.1)	77 (16.5)	.72
History of cancer	13 (17.6)	91 (20.9)	.51
Clinical success	62 (74.7)	353 (74.3)	.86
Complications < 30 days†	22 (27)	59 (12.5)	<.001
Cardiac	13 (15.7)	23 (4.9)	<.001
Asymptomatic troponin increase	3 (3.6)	12 (2.5)	.37
Renal deterioration	0	5 (1.1)	
Pulmonary	4 (4.8)	6 (1.3)	.03
Access site bleeding	5 (6.0)	9 (1.9)	.03
Limb ischaemia	1 (1.2)	12 (2.5)	.46
Bowel ischaemia	1 (1.2)	0	

Data are given as mean ± standard deviation or n (%). DM = diabetes mellitus; IHD = ischaemic heart disease; MI = myocardial infarction; PAD = peripheral artery disease.
* Difference between the octogenarians and non-octogenarians.
† Complications of interest occurred intra-operatively and/or within 30 days post-operatively.

Please cite this article as: Rueda-Ochoa OL et al., Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm, European Journal of Vascular and Endovascular Surgery, https://doi.org/10.1016/j.ejvs.2020.01.026

Table 3. Baseline characteristics of uncomplicated and complicated endovascular aneurysm repair (EVAR) octogenarians

Characteristic	Uncomplicated EVAR octogenarian $n = 61$	Complicated EVAR octogenarian $n = 22$	p
Age at surgery – years	83.1 ± 2.9	82.7 ± 3.3	.58
Aneurysm diameter – mm	64.3 ± 11.2	61.4 ± 7.8	.28
Female gender	10 (16.4)	4 (18.2)	.85
Smoking (ever)	41 (67.2)	17 (77.3)	.38
Hypertension	45 (73.8)	20 (90.9)	.10
PAD	6 (9.84)	5 (22.7)	.13
IHD	23 (37.7)	9 (40.9)	.79
Stroke	8 (13.1)	7 (31.8)	.05
Pulmonary disease	8 (13.1)	5 (22.7)	.29
DM	10 (16.4)	5 (22.7)	.51
History of cancer	16 (26.2)	3 (13,6)	.23

Data are given as mean ± standard deviation or n (%). DM = diabetes mellitus; IHD, ischaemic heart disease; PAD = peripheral artery disease.

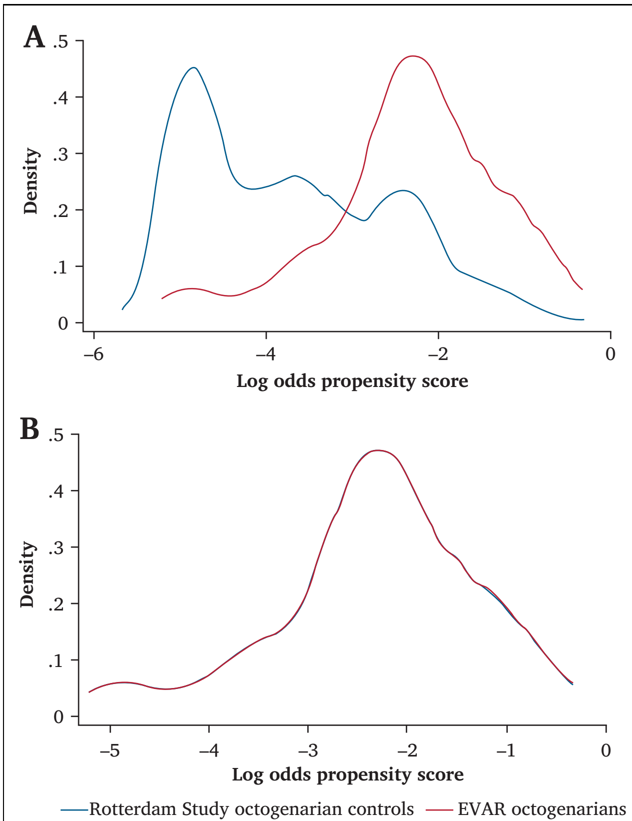

Figure 1. Distribution of propensity scores for the octogenarians treated by endovascular aneurysm repair (EVAR) of abdominal aortic aneurysm (AAA) or matched octogenarian controls without AAA from the Rotterdam Study before (A) and after (B) propensity matching procedure.

linked to the Dutch death registry. According to Dutch privacy legislation, data analysis was only allowed to an authorised researcher (K.U.) inside a secure environment after approval from the institutional ethical committee. All cause mortality was evaluated. Information on the status of RS participants was obtained until 13 June 2016 from the central registry of the municipality in Rotterdam and through digital linkage with records from general practitioners. The completeness of follow up on mortality within this cohort per common end date 26 April 2016 was 100% as all participants (both from the RS and the EVAR database) were checked for mortality.[9]

Statistical analysis

Continuous variables are presented as mean ± standard deviation and categorical variables as count (percentages, %). For the analyses shown in Tables 2 and 3, continuous variables were compared with the Student *t* test for variables with normal distribution and with the Mann–Whitney *U* test for non-normally distributed variables. Categorical variables were compared using the Pearson's χ^2 test. Analyses were performed on available cases per analysis. Missing were 0.6% for stroke, 1.3% for smoking, 1.4% for IHD, 3.7% for hypertension, 5.5% for clinical success, 8.4% for DM, 9.4% for cancer, 15% for PAD, and 18% for serum troponin levels. The STROBE guidelines were followed (http://www.strobe-statement.org).

To properly select octogenarian controls from the RS cohort, PSM was used with Greedy approach.[10] Several variables including age (at the moment of surgery for the EVAR patients, at the clinical visit for the RS controls), sex, ever smoking, and presence of comorbidities (hypertension, PAD, IHD, stroke, DM, and cancer) were used to calculate the propensity scores. PSM was based on a logistic regression model that included EVAR intervention *vs.* no intervention as a dichotomous outcome. PSM allows comparison of every treated subject to every untreated subject and finds the closest possible match (Greedy approach). The closest pair will be paired off. This procedure will continue until there are no more possible pairings. The calliper suggested for the Greedy approach was <0.1. Plots were made to evaluate the distribution of propensity scores between the intervention and control groups. Through evaluating standardised differences, the balance between the intervention and control groups was made after matching.

Further, survival among EVAR octogenarians was compared with survival of RS controls. Survival analysis was performed using Cox proportional hazards analysis. Time to all cause mortality was the outcome of interest. All participants were followed up until their date of death or censoring. Moreover, EVAR octogenarians were divided into patients with and without 30 day post-operative complications. Kaplan–Meier curves were built to compare total mortality among complicated, uncomplicated EVAR patients and matched controls.

Cox proportional hazards model and parametric survival models. In the Cox proportional hazards model for time to primary outcome, a dummy variable of complications (0 = RS controls, 1 = EVAR uncomplicated, 2 = EVAR complicated) was included. Cox proportional hazards assumptions were evaluated through Schoenfeld residuals, goodness of fit through linktest and Cox Snell residuals, linearity of covariates through martingales and devianza residuals and influential observations through dfbetas and cook distance. Akaike information criteria were used to select the best model. Statistical analyses were performed in STATA version 14.2 (Station College, TX, USA). All tests were two sided and significance level was set to $p < .05$.

RESULTS

EVAR octogenarians vs. RS octogenarians

Eighty-three octogenarians underwent EVAR (mean age 83.0 ± 2.9 years). For PSM, 2 212 octogenarian controls from the RS were initially included (mean age 83.5 ± 2.9 years). Table 1 details the characteristics of octogenarians before and after PSM. The 83 RS controls matched the 83 EVAR cases after PSM. Fig. 1 shows the plot distribution of propensity scores before and after matching. The distribution of log odds propensity scores between the two groups was identical after PSM. First, the survival of the 83 EVAR octogenarians was examined with the 83 RS controls based on PSM and no difference in survival were found (HR 1.28, 95% confidence interval [CI] 0.84—1.97) (Fig. 2A).

EVAR octogenarians vs. EVAR non-octogenarians

Table 2 shows the baseline characteristics of EVAR octogenarians and non-octogenarians, as well as the complications after EVAR. The mean age for the octogenarians was 83.0 ± 2.9 years and for the non-octogenarians was 70.2 ± 6.3 years. Although non-significant, there were more women in the octogenarian group (16.9% *vs.* 9.7%,

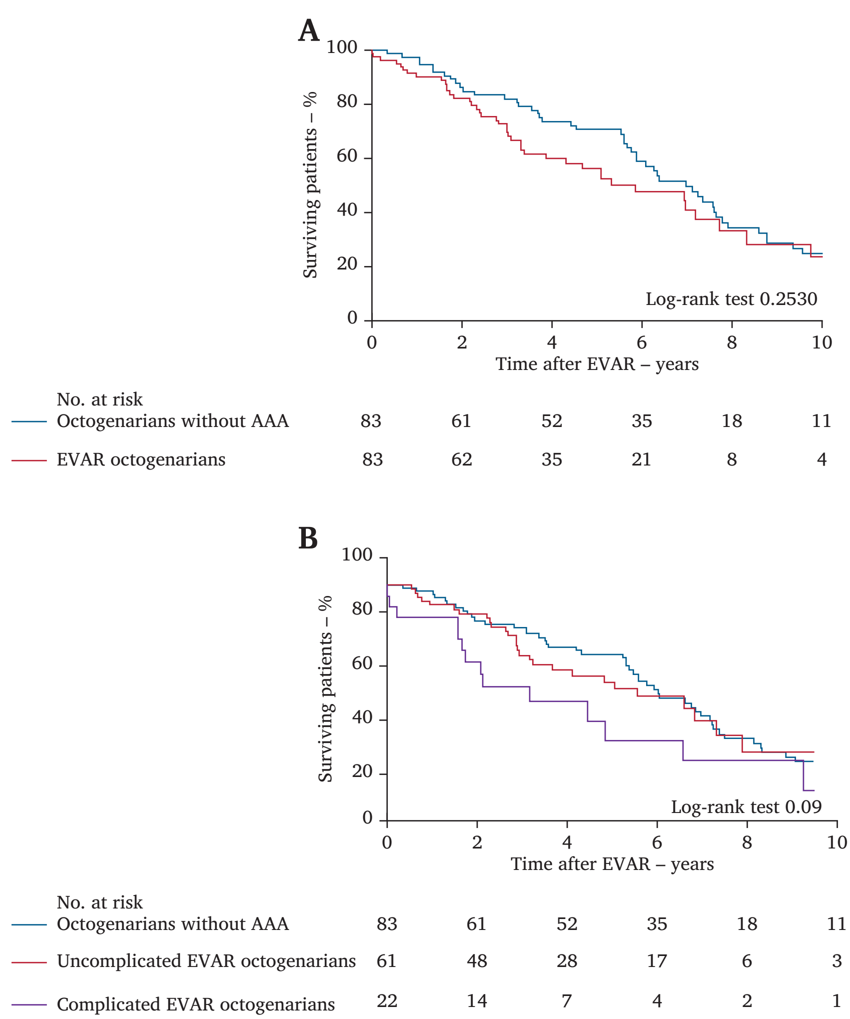

Figure 2. Cumulative Kaplan—Meier estimates for total mortality among (A) octogenarian patients treated by endovascular aneurysm repair (EVAR) of abdominal aortic aneurysm (AAA) and matched octogenarian controls without AAA or (B) EVAR octogenarian uncomplicated patients, EVAR octogenarian complicated patients, and matched octogenarian controls from the Rotterdam Study.

Please cite this article as: Rueda-Ochoa OL et al., Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm, European Journal of Vascular and Endovascular Surgery, https://doi.org/10.1016/j.ejvs.2020.01.026

$p = .052$) with a slightly larger median aneurysm diameter (63.5 mm *vs.* 60.5 mm, $p = .053$) compared with the non-octogenarians. Complications occurred in 22 octogenarians (27%) and in 59 non-octogenarians (12.5%) ($p < .001$), mainly the result of cardiac complications (15.7% *vs.* 4.9%, $p < .001$, of which 3.6% asymptomatic troponin increase in octogenarians and 2.5% in non-octogenarians, ns). Respiratory (4.8% *vs.* 1.3%, $p = .03$) and bleeding complications (6.0% *vs.* 1.9%, $p = .03$) also occurred more often in octogenarians (Table 2). None of the patients who had a bleeding complication also had a cardiac complication. There was no difference between the groups with respect to type of anaesthesia.

Uncomplicated vs. complicated EVAR octogenarians

The EVAR octogenarians were further stratified to uncomplicated ($n = 61$) and complicated EVAR ($n = 22$). When comparing baseline characteristics between the two groups (Table 3), there were no statistically significant differences.

Compared with the matched octogenarians from the RS, octogenarians who underwent EVAR without any complications did not have an increased mortality risk (HR 1.09, 95% CI 0.68–1.77). After six years of follow up, 50% of uncomplicated EVAR octogenarians were still alive. However, octogenarians with complications after EVAR had an increased mortality risk compared with controls from the RS (HR 1.93, 95% CI 1.06–3.54) (Fig. 2B).

DISCUSSION

The main finding of this study was that octogenarians who underwent EVAR had the same long term survival as matched octogenarians from the general population without an AAA. This suggests that in this group the presence of aneurysm disease by itself did not negatively influence overall survival. Six years after EVAR, 50% of the uncomplicated EVAR octogenarian patients were still alive. The powerful approach of PSM enabled creation of a matched control group of octogenarians, without an AAA, from the general population. To the present authors' knowledge, this is the first study in which survival of octogenarians after EVAR *vs.* a matched cohort of octogenarians is described. For the first time it is reported that octogenarians after complicated EVAR had an almost two fold increase in mortality compared with the general population of octogenarians. Thus, pre-operative patient selection is key. As long as these high risk patients cannot be identified, the present findings raise the question of whether the threshold for AAA repair should be adapted with increasing age.

The baseline characteristics in this study, including smoking, hypertension, PAD, stroke, and IHD, did not differ between octogenarians and younger patients, which differs from the findings of other EVAR studies.[1,11,12] In the study institution, a team of vascular anaesthetists pre-operatively examine all patients using the surgical risk calculator of the ACS NSQIP®. Treatable comorbidities are corrected where possible to perform surgery on patients in good physical condition. If the peri-operative risk is too high, patients are declined EVAR. This might, at least partly, explain the similarity in the prevalence of risk factors between the octogenarians and non-octogenarians at baseline. This might also explain why the long term survival after uncomplicated EVAR was similar to that of the matched octogenarians from the RS; the fittest patients were selected for surgery. Unfortunately, the turndown rate was unknown, so it was not possible to compare the patients unfit for surgery with the controls from the RS. A previous study on outcome after ruptured AAA repair in octo- and nonagenarians also found that if patients survived the first 90 days, their long term survival was only marginally decreased compared with age and sex matched controls. In these very old cohorts, aneurysmal disease by itself seems to play a less important role in their survival.[13]

It was shown that cardiac complications occurred more frequently among octogenarians compared with non-octogenarians after EVAR and to a lesser extent pulmonary and bleeding complications. Considering that comorbidities of the two groups were similar at baseline, it is hypothesised that the EVAR procedure triggered the occurrence of such complications. Cardiac complications in the present study occurred more often than has been reported in the literature,[2,14,15] and several studies did not find a higher occurrence of MI after EVAR in octogenarians.[1,12,16] The larger cardiac complication rate in the present study is explained by use of a combined endpoint of atrial fibrillation, heart failure, myocardial infarction, and elevated troponin levels. Post-operative troponin levels were routinely measured in all patients in the present study. Therefore, it was possible to identify elevated troponin levels in patients without symptoms and count these as cardiac complications.

A post-operative increase in troponin levels has been reported as a risk factor for early mortality (also in the present EVAR patients).[7,17] Checking this routinely might lead to identification at an early stage, of patients who need a cardiac intervention. At the study institution, this is now also checked pre-operatively for all patients. This can be helpful in predicting which octogenarians will develop post-operative cardiac complications, as was recently reported.[18] In the current ESVS guidelines on AAA management there is no recommendation on checking troponin levels routinely prior to or after EVAR.[19] In patients with poor functional capacity or with significant clinical risk factors, referral for cardiac work up and optimisation is recommended prior to elective abdominal aortic aneurysm repair. More research is needed to confirm that in this elderly population a different cardiac work up might be needed compared with younger patients planned for EVAR.

To reduce pulmonary complications, performing the procedure under local anaesthesia might be considered, as significantly fewer pulmonary complications have been reported.[20] Lastly, careful selection has to be made with respect to access strategy (open or percutaneous) to decrease the chances of bleeding complications. The guidelines recommend that an ultrasound guided percutaneous approach should be considered in EVAR. No

Please cite this article as: Rueda-Ochoa OL et al., Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm, European Journal of Vascular and Endovascular Surgery, https://doi.org/10.1016/j.ejvs.2020.01.026

recommendation is made for type of anaesthesia.[19] Further research is necessary to identify more risk factors that predict peri-operative complications. For the whole group of EVAR patients, patients without PAD less often had elevated troponin levels (3.5% *vs.* 9.3%, $p = .03$) and cardiac complications (5.5% *vs.* 12.4%, $p = .02$), compared with patients with PAD.

Current guidelines lack recommendations on treatment in relation to age of the patient or risk of complications. As EVAR is a preventive treatment, risks and benefits should be weighed. If the risk of complications is high, a higher AAA diameter threshold should be selected for treatment. Current guidelines state only that elective AAA repair is not recommended in patients with a limited life expectancy (two to three years).[19]

Before EVAR, the octogenarians were at an increased risk of aneurysm rupture and death as they had large diameter AAAs. A surveillance study in patients unfit for AAA surgery showed that during a follow up period of over six years, 11% died of rupture when the AAA was 5.1—6.0 cm, 20% when it was 6.1—7.0 cm and 43% with an AAA >7.0 cm.[21] The mean aneurysm diameter at the time of treatment was 63.5 mm for the octogenarians, equalling a significant annual rupture risk. Although the present study is not a RCT randomising between EVAR and no treatment, survival curves of the octogenarians with an AAA would probably have been lower compared with the survival curves in Fig. 2, if the AAA had been left untreated.

The strengths of this study include detailed characterisation of a well defined AAA patient group, use of PSM to define a matched control group from the general population, availability of detailed information on a variety of risk factors as well as long term follow up data for both AAA patients and the control group. The limitations of this study also merit attention. This was not a RCT and the control group is not the best to answer the question of whether or not octogenarians have increased survival after EVAR. For that, comparisons should have been made with octogenarians with an AAA who were not treated by EVAR. Unfortunately, these controls are not available from the RS as all octogenarians with an AAA had been referred to a vascular surgeon, and it was not registered which patients were turned down for EVAR. Also, it is unknown if patients who developed complications could have had better survival if their AAA was not treated. Although all patient data were carefully collected prospectively, there remains a chance that relevant characteristics might not have been recorded. Furthermore, this study was performed in a single tertiary referral institution and may therefore not be applicable to patients treated in other hospitals. Also, matches were only made on comorbidities known for patients, so the matching would not have excluded all confounding variables (residual confounding). The complicated and uncomplicated EVAR octogenarians were not matched with two separate groups of RS controls. Lastly, the patient group was relatively small, especially when performing subgroup analyses. Therefore, this might have been underpowered to detect significant smaller differences between the groups.

Conclusions

This is the first study to compare octogenarians after EVAR with matched octogenarian controls without an AAA from the general population. The life expectancy is equal in both groups, provided that the octogenarians do not develop early post-operative complications. If complications do occur, their mortality risk nearly doubles. Future research should focus on developing algorithms to identify which octogenarians are likely to develop complications and to optimise peri-operative care to lower the chance of complications around EVAR treatment.

CONFLICT OF INTEREST

None.

FUNDING

Oscar L. Rueda-Ochoa receives a scholarship from COLCIENCIAS-Colombia and support from Universidad Industrial de Santander, UIS-Colombia.

REFERENCES

1 Lange C, Leurs LJ, Buth J, Myhre HO. Endovascular repair of abdominal aortic aneurysm in octogenarians: an analysis based on EUROSTAR data. *J Vasc Surg* 2005;**42**:624—30.
2 Han Y, Zhang S, Zhang J, Ji C, Eckstein HH. Outcomes of endovascular abdominal aortic aneurysm repair in octogenarians: meta-analysis and systematic review. *Eur J Vasc Endovasc Surg* 2017;**54**:454—63.
3 Hicks CW, Obeid T, Arhuidese I, Qazi U, Malas MB. Abdominal aortic aneurysm repair in octogenarians is associated with higher mortality compared with nonoctogenarians. *J Vasc Surg* 2016;**64**:956—965 e1.
4 Pol RA, Zeebregts CJ, van Sterkenburg SM, Ferreira LM, Goktay Y, Reijnen MM. Outcome and quality of life after endovascular abdominal aortic aneurysm repair in octogenarians. *J Vasc Surg* 2014;**60**:308—17.
5 Ikram MA, Brusselle GGO, Murad SD, van Duijn CM, Franco OH, Goedegebure A, et al. The Rotterdam Study: 2018 update on objectives, design and main results. *Eur J Epidemiol* 2017;**32**:807—50.
6 Botto F, Alonso-Coello P, Chan MT, Villar JC, Xavier D, Srinathan S, et al. Myocardial injury after noncardiac surgery: a large, international, prospective cohort study establishing diagnostic criteria, characteristics, predictors, and 30-day outcomes. *Anesthesiology* 2014;**120**:564—78.
7 Writing Committee for the VSI, Devereaux PJ, Biccard BM, Sigamani A, Xavier D, Chan MTV, et al. Association of postoperative high-sensitivity troponin levels with myocardial injury and 30-day mortality among patients undergoing noncardiac surgery. *JAMA* 2017;**317**:1642—51.
8 Chaikof EL, Blankensteijn JD, Harris PL, White GH, Zarins CK, Bernhard VM, et al. Reporting standards for endovascular aortic aneurysm repair. *J Vasc Surg* 2002;**35**:1048—60.
9 von Allmen RWS, Tevaearai H, Kuemmerli C, Tinner C, Carrel T, Schmidli J, et al. Completeness of follow-up determines validity of study findings: results of a prospective repeated measures cohort study. *PLoS One* 2015;**10**:e0140817.
10 Baser O. Too much ado about propensity score models? Comparing methods of propensity score matching. *Value Health* 2006;**9**:377—85.

11 Biebl M, Lau LL, Hakaim AG, Oldenburg WA, Klocker J, Neuhauser B, et al. Midterm outcome of endovascular abdominal aortic aneurysm repair in octogenarians: a single institution's experience. *J Vasc Surg* 2004;**40**:435–42.
12 Pol RA, Zeebregts CJ, van Sterkenburg SM, Ferreira LM, Goktay Y, Reijnen MM, et al. Outcome and quality of life after endovascular abdominal aortic aneurysm repair in octogenarians. *J Vasc Surg* 2014;**60**:308–17.
13 Sonesson B, Bjorses K, Dias N, Rylance R, Mani K, Wanhainen A, et al. Outcome after ruptured AAA repair in octo- and nonagenarians in Sweden 1994–2014. *Eur J Vasc Endovasc Surg* 2017;**53**:656–62.
14 Fonseca R, Rockman C, Pitti A, Cayne N, Maldonado TS, Lamparello PJ, et al. Intermediate-term EVAR outcomes in octogenarians. *J Vasc Surg* 2010;**52**:556–60.
15 Lagergren E, Chihade D, Zhan H, Perez S, Brewster L, Arya S, et al. Outcomes and durability of EVAR in octogenarians. *Ann Vasc Surg* 2019;**54**:33–9.
16 Raval MV, Eskandari MK. Outcomes of elective abdominal aortic aneurysm repair among the elderly: endovascular versus open repair. *Surgery* 2012;**151**:245–60.
17 Winkel TA, Schouten O, van Kuijk JP, Verhagen HJ, Bax JJ, Poldermans D. Perioperative asymptomatic cardiac damage after endovascular abdominal aneurysm repair is associated with poor long-term outcome. *J Vasc Surg* 2009;**50**:749–54.
18 Humble CAS, Huang S, Jammer I, Bjork J, Chew MS. Prognostic performance of preoperative cardiac troponin and perioperative changes in cardiac troponin for the prediction of major adverse cardiac events and mortality in noncardiac surgery: a systematic review and meta-analysis. *PLoS One* 2019;**14**:e0215094.
19 Wanhainen A, Verzini F, Van Herzeele I, Allaire E, Bown M, Cohnert T, et al. Editor's choice - European society for vascular surgery (ESVS) 2019 clinical practice guidelines on the management of abdominal aorto-iliac artery aneurysms. *Eur J Vasc Endovasc Surg* 2019;**57**:8–93.
20 Van Orden K, Farber A, Schermerhorn ML, Goodney PP, Kalish JA, Jones DW, et al. Local anesthesia for percutaneous endovascular abdominal aortic aneurysm repair is associated with fewer pulmonary complications. *J Vasc Surg* 2018;**68**:1023–1029 e2.
21 Western CE, Carlisle J, McCarthy RJ, Currie IC. Palliation of abdominal aortic aneurysms in the endovascular era. *Eur J Vasc Endovasc Surg* 2013;**45**:37–43.

Please cite this article as: Rueda-Ochoa OL et al., Survival After Uncomplicated EVAR in Octogenarians is Similar to the General Population of Octogenarians Without an Abdominal Aortic Aneurysm, European Journal of Vascular and Endovascular Surgery, https://doi.org/10.1016/j.ejvs.2020.01.026