Effectiveness of treatment for octogenarians with acute abdominal aortic aneurysm

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Objective: **To investigate whether advanced age may be a reason to refrain from treatment in patients with an acute abdominal aortic aneurysm (AAAA).**

Methods: **This was a retrospective cohort study that took place in a tertiary care university hospital with a 45-bed intensive care unit. Two hundred seventy-one patients with manifest AAAA, admitted and treated between January 2000 and February 2008, were included. Six patients died during operation and were included in the final analysis to ensure an intention-to-treat protocol, resulting in 234 men and 37 women with a mean age of 72 ± 7.8 years (range, 54-88 years). Forty-six patients (17%) were 80 years or older. Interventions involved open or endovascular AAAA repair.**

Results: **Mean follow-up was 33 ± 30.4 months (including early deaths). Mean hospital length of stay was 16.9 ± 20 days for patients younger than 80 and 13 ± 16.7 days for patients older than 80 years of age. Kaplan-Meier survival analysis revealed a significantly better survival for the younger patients ($P < .05$). Stratification based on urgency or type of treatment did not change the difference. Two-year actuarial survival was 70% for patients younger than 80 and 52% for those older than 80. At 5-year follow-up, these figures were 62% and 29%, respectively. Mean survival in patients older than 80 was 39.8 ± 6.8 months versus 64.5 ± 3.0 months in those younger than 80.**

Conclusions: **For octogenarians, our liberal strategy of treating patients with AAAA was associated with satisfactory short- and long-term outcome, with no difference with regard to disease- or procedure-related morbidity between the younger and older group. Assuming an integrated system for managing AAAA is in place, advanced age is not a reason to deny patients surgery. (J Vasc Surg 2011;53:918-25.)**

The incidence of abdominal aortic aneurysms (AAA), treated both in elective and acute setting, has significantly increased over the past decade. [1] Also, population screening programs for AAA, such as single duplex ultrasound scanning in men older than 65 years of age, are being instituted in many centers as a way to reduce the total mortality in acute AAA (AAAA).[2,3] At the same time, the population in most Western countries is aging rapidly, and, therefore, an increasing number of octogenarians are being referred for AAA intervention and subsequent intensive care unit (ICU) admission. Interventions may be planned on an elective basis, but a substantial part will still be carried out as an emergency intervention, once the aneurysm has progressed to an AAAA. Acute aneurysms may be categorized into acute non-ruptured or so-called symptomatic aneurysms (sAAA) and acute ruptured aneurysms (rAAA). Obviously, results from rAAA repair are poorer than those from sAAA repair, but they tend to vary widely in literature, and are also dependent on the treatment modality used (open or endovascular repair). Even though there has been an increased awareness with earlier diagnosis and treatment, a meta-analysis of open repair of rAAA demonstrated an overall mortality of 49% over the last 15 years, with no significant change over time.[4] In our own report designed to define cost-effectiveness of the introduction of a preferential endovascular strategy in patients with AAAA, we found that in-hospital mortality dropped from 31% (historical open repair control group) to 18% (for endovascular repair of selected patients).[5] These results compare well with the literature and resulted in a local treatment strategy in which patients were virtually never denied treatment, regardless of their age.

On the other hand, as in many European countries, in The Netherlands too there is a rapidly increasing demand for health care resources. With current budget restraints, one may bring up treatment of rAAA and subsequent ICU admission in the elderly patient for discussion. Certainly, a balanced view between annual risk of rupture and natural life expectancy on the one hand, and surgical risk and late-term survival on the other hand, seems important. Also to this context, advanced age may be considered a factor to refrain from further treatment and ICU admission. The purpose of this study was to investigate whether this holds true for octogenarians suffering AAAA.

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Table I. Patient characteristics

Parameter	*Number or mean ± SD[a] (Percentage or range)*
Number of patients	271
Mean age (years)	72 ± 7.8 (54-88)
Age <80 years	225 (83)
Age >80 years	46 (17)
Gender	
Men	234 (86)
Women	37 (14)
Open treatment	196 (72)
Endovascular treatment	75 (28)
Apache II[b]	17 ± 6 (4-36)
Follow-up (months)	33 ± 30 (0-98)

[a]Standard deviation.
[b]APACHE II: Acute Physiology and Chronic Health Evaluation. Mean APACHE II score calculated from a total of 176 patients. Fifty-four patients, all treated with an endovascular stent graft, were never admitted to the intensive care unit. From 35 patients, no reliable APACHE II could be calculated due to incomplete data.

METHODS

Design of the study. Between January 2000 and February 2008, a total of 290 consecutive patients with manifest AAAA were presented at our hospital. Four patients died at our emergency room before surgery could be initiated. Fifteen patients were excluded from surgical intervention due to the criteria mentioned in the preoperative management section. Of these 15 patients (nine men, six women), nine patients were not treated due to severe comorbidities, two patients refused treatment, and four patients were too hemodynamically unstable. All died shortly after arrival at the hospital. The remaining 271 patients were admitted to and treated in our tertiary referral hospital and form the basis of this report. Six of the 271 patients died during the operation and were included in the final analysis to ensure an intention-to-treat protocol. Data were prospectively entered into a vascular registry and analyzed retrospectively.

Preoperative management. At the regional level, we have an integrated system for the rapid transport and immediate treatment of AAAA. Our strategy was to treat all patients unless they had a very poor performance score (Karnofsky performance score ≤40). As such, 95% received treatment. Further details regarding transport and early management have been described previously.[6] In short, for those transferred from another hospital, median transport time (from initial telephone call for ambulance transport to the first hospital to patient arrival at our hospital) was 40 minutes. Patients were only volume-resuscitated in case of hemorrhagic shock with an altered mental state, regardless of actual blood pressure values. Furthermore, patients were almost never intubated before or during transport, as induction of anesthesia interacts with the sympathetic stimulus to maintain the blood pressure, often leading to a rapid decrease in blood pressure. Exclusion criteria for surgery were prolonged cardiac arrest despite resuscitation, advanced Alzheimer's disease and a poor Karnofsky performance score (≤40 [ie, the patient is disabled and requires special care and help]), or severe cardiovascular disease associated with a New York Health Association-IV performance score. If information was incomplete, the patient was still offered surgery, regardless of his/her age. Also, if the patient denied surgery after being extensively informed, no surgical intervention was performed.

Upon admission at the emergency department, evaluation of each patient was done simultaneously by a certified vascular surgeon, an anesthesiologist, and an interventional radiologist, who were all called in even before the patient arrived at the hospital. At the same time, the operating room was alerted. On arrival, the presumed diagnosis was verified by physical examination and duplex ultrasound. When duplex ultrasound excluded AAAA (aortic diameter within normal range, no free intra-abdominal fluid), the patient received further examination and testing. If feasible, a computerized tomography (CT) scan was immediately performed to further confirm the diagnosis and to evaluate suitability for endovascular repair (endovascular aneurysm repair [EVAR]). Until aortic clamping or balloon occlusion in the operating room, low systolic blood pressure was accepted as long as the patient remained conscious with coherent verbal responses. Patients who arrested during transport or in the emergency room, but were successfully resuscitated, were offered open repair and included in the study. The consideration and arguments leading to either one of the treatment modalities have been described before.[5,7] In short, the multidisciplinary team on-call decided, based on hemodynamic status as well as the CT images, whether the patient was suitable for EVAR (proximal neck length >15 mm with <60° angulation and access vessels ≥7 mm) or open treatment.

Any intervention was performed by at least one certified vascular surgeon. For those who underwent open repair, a rapid sequence induction of anesthesia and intubation was performed. A midline laparotomy was performed. After proximal and distal clamping, the aneurysm was opened and lumbar arteries were ligated. Reconstruction was conducted by placing either a Dacron aortic tube or aorto-iliac bifurcated graft. After surgery, all patients remained intubated and mechanically ventilated and were transferred to our tertiary ICU.

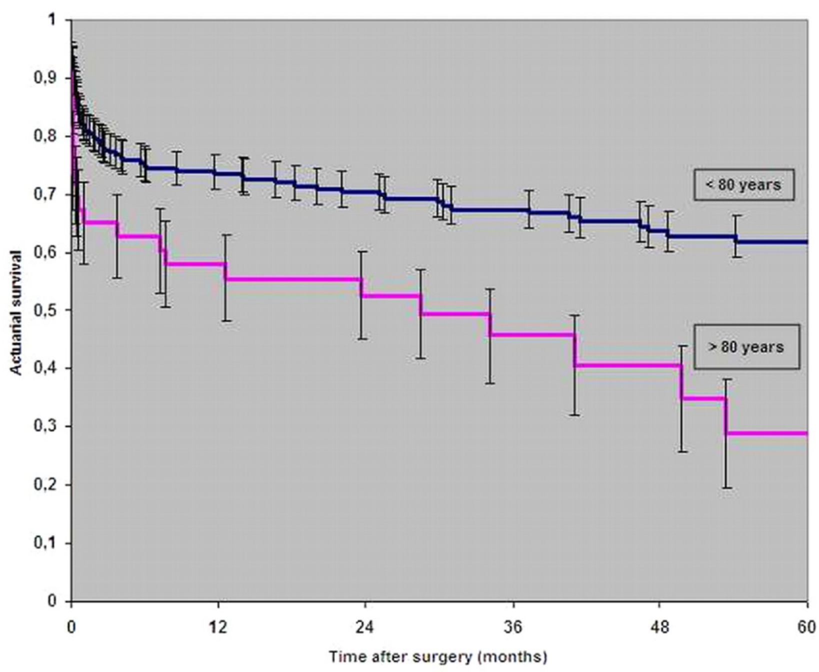
Patients suitable for endovascular repair were preferably treated under local anesthesia, which included approximately 85% of all patients who underwent endovascular repair for AAAA.

Study cohort. A total of 271 patients were analyzed. There were 234 men and 37 women with a mean age of 72 ± 7.8 years (range, 54-88 years). Seventeen percent of the patients were 80 years or older (n = 46). Sixty patients who underwent endovascular repair were not admitted to the ICU, and therefore no Acute Physiology and Chronic Health Evaluation (APACHE) score could be calculated. From 35 patients, no reliable APACHE II could be calculated due to missing data. For the remaining 176 patients, the mean APACHE II score was 17 ± 7 (range, 4-36). Open treatment was performed in 196 patients (72%) and

Table II. Early and late procedure- and disease-related outcomes; stratification by age

Outcome[a]	*Mean (Percentage or range)*	*Age <80 years (Percentage or range) (n = 225)*	*Age >80 years (Percentage or range) (n = 46)*	P[b]
Intensive care unit length of stay (days)	6.7 ± 11 (0-98)	6.9 ± 11.5 (0-98)	5.7 ± 7.8 (0-30)	.33
Hospital length of stay (days)	16.4 ± 19.8 (0-134)	16.9 ± 20.4 (0-134)	13.7 ± 16.7 (0-75)	.11
In-hospital mortality[c]	58 (21)	42 (19)	16 (35)	.02
Overall mortality[d]	105 (39)	79 (35)	26 (56)	.007

[a]Results presented as number or mean ± SD (standard deviation).
[b]*P* values <.05 were considered a significant difference (tested with Pearson χ^2 test [2 variables]).
[c]Defined as mortality during postoperative intensive care unit and hospital stay.
[d]After mean follow-up (33 ± 30.4).



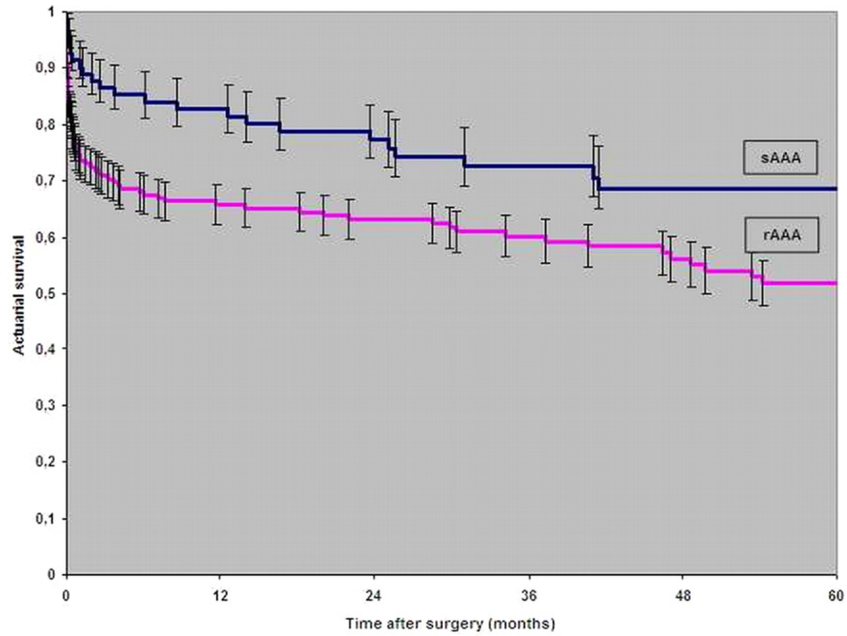
No. at risk						
< 80 years	225	152	130	100	74	59
> 80 years	46	24	19	12	7	3

Fig 1. Probability of patient survival according to the Kaplan-Meier method following repair of acute abdominal aortic aneurysm; comparison of patients younger than 80 years of age and those 80 years or older. There was a significantly better survival for the younger patients (log-rank test *P* < .05).

endovascular treatment in 75 (28%). When divided into a younger (<80 years) and an older (≥80 years) group, no differences were observed, except for more women in the older group (Table I).

Definitions and outcome measures. Acute AAA was defined as either acute non-ruptured (n = 82) or ruptured (CT- or laparotomy-proven; n = 189). The rAAA classification was only awarded in the presence of a retroperitoneal hematoma on CT or when clearly visible as a retroperitoneal hematoma during laparotomy. All other AAAAs were classified as sAAA as determined by acute onset of abdominal or back pain combined with pain at aneurysm palpation. Primary outcome measures were hospital and long-term mortality. Secondary outcome measures included ICU and hospital length of stay and morbidity. Morbidity was specifically added to our analysis in order to assess quality of life in octogenarians.

Statistical analysis. Survival rates were calculated by means of Kaplan-Meier analysis. Differences in survival were determined using log-rank testing. Primary end point



No. at risk						
sAAA	82	64	53	40	28	21
rAAA	189	112	96	72	53	41

Fig 2. Probability of patient survival according to the Kaplan-Meier method following repair of acute abdominal aortic aneurysm; comparison of patients with a symptomatic aneurysm (*sAAA*) or ruptured aneurysm (*rAAA*). There was a significantly better survival after sAAA (log-rank test $P < .05$).

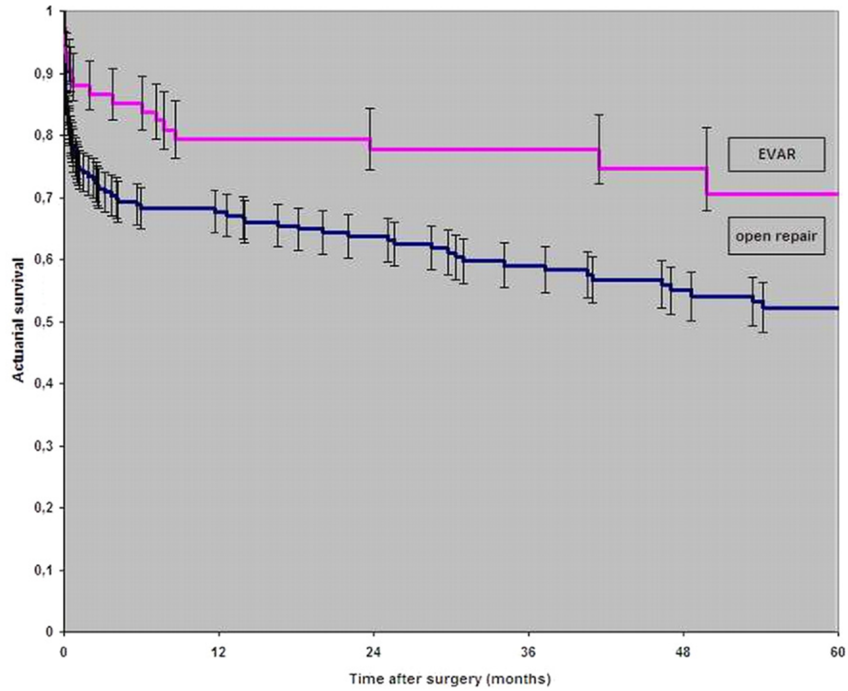
was any cause mortality. Differences between categorical variables were tested with Pearson χ^2 test (2 variables) or Kruskal-Wallis test (>2 variables). Differences between means were tested with Student's two-tailed test (normal distribution) or Mann-Whitney *U* test (skewed distribution). Significance was set at $P < .05$. Data are presented as means (SD), unless stated otherwise. All statistical analyses were done with the Statistical Package for the Social Sciences (SPSS 16.0.1; SPSS, Chicago, Ill).

RESULTS

Early outcome. Mean ICU length of stay of all patients was 6.7 ± 11.0 days. The elderly patients did not tend to stay longer at the ICU, as mean ICU length of stay was 6.9 ± 11.5 days for patients younger than 80 and 5.7 ± 7.8 days for patients older than 80 years of age ($P = .33$). The same accounts for duration of hospital stay. Mean hospital length of stay of all patients was 16.4 ± 19.8 days. Again with a cut-off at the age of 80 years, mean hospital length of stay was 16.9 ± 20.4 days for patients younger than 80 and 13.7 ± 16.7 days for patients older than 80 years of age ($P = .11$; Table II).

Fifty-eight patients (21%) died during postoperative ICU and hospital stay. Mean age of these 58 patients was 75.8 ± 6.8 years. Twelve of 42 (28%) were 80 years of age or older, and 40 of 223 (18%) were younger than 80 years. Mean age of patients who survived during ICU and hospital stay was 70.9 ± 7.8 years.

Late outcome – mortality. The mean follow-up was 33 ± 30.4 months (including early deaths). During follow-up, 79 out of 225 patients younger than 80 years of age died, whereas 26 out of 46 patients older than 80 years died, including those already mentioned in the early outcome section ($P < .05$). As expected, a higher APACHE II score was significantly associated with a diminished survival (log-rank test, $P < .001$). However, APACHE II scores did not differ between younger and older patients ($P = .36$). One-year actuarial survival for all patients was 71%. After 2 and 5 years, these numbers were 67% and 57%, respectively. Kaplan-Meier survival analysis revealed a significantly better survival for the younger patients ($P < .05$) (Fig 1). Stratification based on urgency (rAAA vs sAAA) or treatment (EVAR vs open repair) did not change the difference (Figs 2 and 3). Furthermore, 18 out of 75 patients (24%) who underwent endovascular repair died during follow-up, compared with 87 out of 196 patients (44%) in the open repair group ($P < .05$). Two-year actuarial survival was 70% for patients younger than 80 and 52% for those older than 80. At 5-year follow-up, these figures were 62% and 29%, respectively. Mean survival in patients younger than 80 was 64.5 ± 3.0 months versus 39.8 ± 6.8



No. at risk						
EVAR	75	52	45	31	18	12
Open repair	196	124	104	81	63	50

Fig 3. Probability of patient survival according to the Kaplan-Meier method following repair of acute abdominal aortic aneurysm; comparison of patients after endovascular aneurysm repair (*EVAR*) or open repair. There was a significantly better survival for the EVAR patients (log-rank test $P < .05$).

months in those older than 80. The overall mortality for sAAA was 29% (21 of 73) for patients younger than 80 and 44% (4 of 9) for patients older than 80 years ($P = .34$). Overall mortality for rAAA was 37% (58 of 152) for patients younger than 80 and 55% (22 of 37) for patients older than 80 years ($P = .02$).

Late outcome – morbidity. Twenty-five patients (9%) developed lower leg peripheral thromboembolism, which was treated by surgical thrombectomy in 22 patients. Three patients were considered unsuitable for redo surgery due to severe concurrent multi-organ failure and death. These figures were included in the above-mentioned actuarial survival rates. One patient (0.4%) underwent an above-the-knee amputation. Renal insufficiency, defined as needing renal replacement therapy, was divided into temporary and chronic renal failure. Eight patients (3%) developed temporary renal failure, whereas four patients (1.5%) required chronic or permanent dialysis. Twelve patients died with renal failure, mostly due to multiple organ failure. Another severe, disease-related complication after surgery was colonic ischemia, which arose in 28 patients (10%). Twenty-four patients underwent surgery, with resection of the affected colonic segment and colostomy, and four

Table III. Disease-related complications: stratification based on age

Complication	*Total (%)*	*<80 years of age (%)*	*>80 years of age (%)*	P[a]
Peripheral emboli	25 (9)	20 (75)	5 (25)	.91
Intervention[b]	22 (8)	18 (82)	4 (18)	.25
No intervention	3 (1)	2 (67)	1 (33)	.54
Amputation	1 (0.4)	1 (100)	0 (0)	.66
Renal failure[c]	24 (9)	22 (92)	2 (8)	.27
Temporary	8 (3)	8 (100)	0 (0)	.42
Chronic	4 (2)	3 (75)	1 (25)	.54
Died with renal failure	12 (5)	9 (75)	3 (25)	.43
Colonic ischemia[d]	28 (11)	22 (78)	6 (22)	.29
Requiring surgery	24 (9)	19 (79)	5 (21)	.48
Permanent stoma	22 (8)	17 (77)	5 (33)	.48
Graft infection	2 (1)	2 (100)	0 (0)	.54

[a]*P* values <.05 were considered a significant difference (tested with Pearson χ^2 test [2 variables]).
[b]Surgical thrombectomy.
[c]Requiring dialysis.
[d]Requiring surgical resection with colostomy (Hartmann's procedure).

Table IV. Disease-related complications: stratification based on urgency

Complication	*sAAA*[a]	*rAAA*[b]	P[c]
Peripheral emboli	3 (4%)	21 (11%)	.05
Renal failure[d]	4 (5%)	20 (11%)	.13
Colonic ischemia[e]	1 (1%)	23 (12%)	.004
Graft infection	0 (0%)	2 (1%)	.35
Death	25 (30%)	80 (39%)	.06

[a]Symptomatic (non-ruptured) abdominal aortic aneurysm (n = 82).
[b]Ruptured or symptomatic abdominal aortic aneurysm (n = 189).
[c]*P* values <.05 were considered a significant difference (tested with Pearson χ^2 test [2 variables]).
[d]Requiring dialysis.
[e]Requiring surgical resection with colostomy (Hartmann's procedure).

patients died. In 92% of the patients, the colostomy was permanent (Table III). Mortality due to multiple organ failure, renal insufficiency, or colonic ischemia was also included in the actuarial survival rates mentioned in the late outcome-mortality section. No statistical differences were observed in the above-mentioned complications between the younger (<80 years of age) and older (>80 years of age) group (Table III). As expected, there was a significant difference in most procedure- and disease-related complications, as well as ICU and hospital length of stay, in favor of sAAAs (Tables IV and V).

DISCUSSION

This study shows that our strategy of treating octogenarians with AAAA was associated with satisfactory short- and long-term outcome. Furthermore, the disease-related morbidity seems very acceptable, with no statistical difference between the younger and older patients. Remarkably, octogenarians had a similar duration of hospital, as well as ICU, length of stay compared with younger (>80 years) patients. Our 2- and 5-year actuarial survival results are consistent with the literature.[6-11] Whereas most studies concentrate on survival rate, we also focused on morbidity, with similar good results in this already highly vulnerable group. From different studies, focusing on outcome after abdominal surgery in the elderly, we know that the hospital mortality can be as high as 15% to 26%.[12,13] Although age and most age-related comorbidities, such as renal dysfunction and cardiopulmonary disease, are repeatedly mentioned as negative predictive factors for survival, the outcome seems far less dismal than reported and suggested in the literature.[14,15] Even though the survival rates for octogenarians are less favorable compared with a younger group, a mean of 3.3 more life-years (median, 2.4 years) can be gained with a relatively low morbidity. With a mean survival for octogenarians in the Dutch population (matched for both age and gender) of 6.05 years (median, 3.92 years), there is clearly much to gain.[16] Recent studies assessing the outcome of critically ill elderly patients in the ICU found not only that high age alone is no longer a reason to refuse intensive care admission, but also, over the past decade, an improvement in survival is noticed.[17,18] This does suggest that our previous understanding of determining who is fit enough for elective AAA repair, and who could potentially benefit from it, should also be reconsidered.

There are, however, several drawbacks in this study that need to be addressed. Patients who arrived alive at the hospital but who were denied surgery or were excluded due to the criteria mentioned in the preoperative management section (n = 15) were excluded from further analysis. Although we did use an intention-to-treat analysis for patients who arrived at the operating room, there may still be some sort of selection bias. However, in view of the main objective of our study, there was an equal distribution in age (seven patients <80 years and eight patients >80 years). Also, this was a retrospective cohort study, and no randomization was performed. However, with a natural course resulting in death, in case of rAAA, a study design with randomization is unethical. Also, a quality of life assessment was not part of this study. However, when assuming that quality of life is (partially) determined by complications interfering with the activities of daily living, our procedure- and disease-related complications are low and comparable both with the literature as well as with a younger population.[19] In our population, one patient (0.4%) underwent an amputation of a lower extremity. This patient died 2 months after surgery due to an infected graft. Four patients (1.5%) needed permanent hemodialysis, of which three patients died during follow-up, all of a non-aneurysm related cause. Nevertheless, these factors must be taken into account when assessing these patients for surgery. Unlike primary outcome measures such as survival and procedure-related morbidity, functional outcome should be considered as well. Even the effect of a procedure-related event such as a lower leg amputation can be disastrous. In a heterogenic population, only 40% of patients who underwent amputation of a lower extremity regain full mobility, and 30% are dead after 2 years.[20] If survival after rAAA is followed by permanent disability and long-term care institutionalization, the benefit would clearly become less apparent. However, these arguments do not apply on our population of ruptured or symptomatic aneurysms needing emergency surgery. But in an elective setting, these numbers seem far more relevant. Furthermore, constant improvements in both surgical techniques and postoperative ICU care probably have contributed to our results and will do so in the near future with further development of endovascular techniques. And with the increasing use of endovascular procedures in octogenarians reported in the literature, this will probably further contribute to lowering the procedure-related morbidity and mortality. Although not a primary focus of this study, we did find a significantly lower mortality rate and reduced ICU and hospital length of stay in the EVAR group (Table VI). Even though endovascular repair is associated with a higher incidence of reinterventions and without the benefit of reducing all-cause mortality, it is still associated with a significant reduction in postoperative complications.[21] This, of course, is an advantage which fits well with an

Table V. Early and late procedure- and disease-related outcomes; stratification by urgency (symptomatic vs ruptured aneurysm)

Outcome[a]	*Mean (Percentage or range)*	*sAAA (Percentage or range; n = 82)*	*rAAA (Percentage or range; n = 189)*	P[b]
Intensive care unit length of stay (days)	6.7 ± 11 (0-98)	2.6 ± 3.2 (0-13)	8.5 ± 12.5 (0-98)	.0001
Hospital length of stay (days)	16.4 ± 19.8 (0-134)	11.2 ± 9.9 (0-54)	18.7 ± 22.5 (0-134)	.02
In-hospital mortality[c]	58 (21)	7 (8)	49 (26)	.001
Overall mortality[d]	105 (39)	25 (30)	80 (42)	.06

[a]Results presented as number or mean ± SD (standard deviation).
[b]*P* values <.05 were considered a significant difference (tested with Pearson χ^2 test [2 variables] or Mann-Whitney *U* test [skewed distribution]).
[c]Defined as mortality during postoperative intensive care unit and hospital stay.
[d]After mean follow-up (33 ± 30.4).

Table VI. Early and late procedure- and disease-related outcomes; stratification by type of treatment (endovascular vs open repair)

Outcome[a]	*Mean (Percentage or range)*	*EVAR (Percentage or range; n = 79)*	*Open repair (Percentage or range; n = 196)*	P[b]
Intensive care unit length of stay (days)	6.7 ± 11 (0-98)	2.2 ± 4.7 (0-22)	8.5 ± 12.1 (0-98)	.0001
Hospital length of stay (days)	16.4 ± 19.8 (0-134)	10.6 ± 17.4 (0-134)	18.6 ± 20.3 (0-105)	.0001
In-hospital mortality[c]	56 (21)	9 (12)	47 (25)	.03
Overall mortality[d]	105 (39)	18 (24)	87 (44)	.002

[a]Results presented as number or mean ± SD (standard deviation).
[b]*P* values <.05 were considered a significant difference (tested with Pearson χ^2 test [2 variables] or Mann-Whitney *U* test [skewed distribution]).
[c]Defined as mortality during postoperative intensive care unit and hospital stay.
[d]After mean follow-up (33 ± 30.4).

already high-risk population such as octogenarians. Several studies do confirm this idea and found good results after endovascular repair with a lower early mortality in octogenarians.[22-26] With an already limited life expectancy, the benefit of reducing postoperative morbidity and mid-term mortality seems specifically applicable to this group.

CONCLUSIONS

In conclusion, even with a devastating event such as rAAA and sAAA, a median survival of more than 2.8 years can be achieved in octogenarians, while ICU and hospital length of stay is not prolonged compared with younger patients, with certain death without treatment. Also, there is no statistical difference in disease-related complications between a younger (<80 years of age) and older (>80 years of age) group. Assuming an integrated system for managing AAA is in place, advanced age is not a reason to deny patients surgery.

AUTHOR CONTRIBUTIONS

Conception and design: MS, RP, CZ
Analysis and interpretation: MS, RP, MN, CZ
Data collection: RP, JH
Writing the article: MS, RP, CZ
Critical revision of the article: IT, EV, JD, MN, CZ
Final approval of the article: MS, RP, JH, IT, EV, JD, MN, CZ
Statistical analysis: RP, JH, CZ, MN
Obtained funding: N/A
Overall responsibility: CZ
MS and RP contributed equally to this work.

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