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Original Article

Is Conventional Open Repair for Abdominal Aortic Aneurysm Feasible in Nonagenarians?

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Background: Although endovascular repair for abdominal aortic aneurysm has been found to be beneficial in very elderly patients, some patients have contraindications to this procedure. For nonagenarians, the results of open repair remain unclear. The purpose of this study was to compare the outcomes of open vs. endovascular repair for abdominal aortic aneurysm in nonagenarian patients.
Methods and Results: Fourteen patients undergoing open surgical repair and 24 undergoing endovascular repair for abdominal aortic aneurysm were evaluated. There was no significant difference in early mortality between the open and endovascular groups (0% vs. 4.1%, p=0.16). The open repair group required much longer hospital stays (26.4 vs. 10.6 days, respectively, p=0.003). Finally, 12 patients (86%) undergoing open repair vs. 21 (88%) undergoing endovascular repair returned home (p=0.49). During a mean follow-up period of 23.4±23.5 months, cumulative estimated 1- and 3-year survival rates were 90.0% and 48.0%, respectively in the open repair group and 90.6% and 54.9%, respectively in the endovascular repair group (p=0.51).
Conclusion: Although endovascular repair for abdominal aortic aneurysm was superior in terms of recovery, the results of conventional open repair were acceptable even in nonagenarian patients. Open repair remains an alternative for patients with contraindications to endovascular repair.

Keywords: abdominal aortic aneurysm, nonagenarians, open repair, endovascular repair, surgery

Introduction

In recent years, the elderly (over 65 years of age) have become the fastest growing segment of the world's population.[1,2] In the 10 countries with the highest life expectancy, life expectancy is over 80 years.[3] Therefore, the number of elderly patients with cardiovascular disease is expected to increase.

Abdominal aortic aneurysm (AAA) is a well-known cardiovascular disease seen in the elderly. Recent reports have described the utility of endovascular AAA repair (EVAR) in the elderly.[4–9] Because EVAR has several contraindications in such patients, including a short neck or a narrow access route,[10] whether conventional open repair should be performed remains controversial due to the increased mortality and morbidity associated with patient age.[11,12] Moreover, a small number of reports have concluded that EVAR is also suitable for nonagenarians,[4,5,8,9] although the outcomes of open repair in nonagenarians remain unclear. In the present study, the outcomes of conventional open repair for AAA were compared with those of EVAR in nonagenarian patients.

Methods

A total of 38 patients over 90 years of age were diagnosed with AAA between January 2003 and December 2015. Of these, 14 patients (8 males; mean age, 92.0±1.6 years) underwent open repair and 24 (10 males, 92.3±2.0 years) underwent EVAR. Patient demographics, comorbidities, operations, and postoperative complications were analyzed and compared between the two groups. Although EVAR is normally the first course of treatment for patients over 75 years of age in our institution, the decision to perform open repair vs. EVAR depended on patients' characteristics. Our basic strategy for AAA repair in nonagenarians included four primary considerations: 1) patients' families should be duly consulted and patients' consent should be obtained; 2) EVAR remains the first choice; 3) when EVAR is inappropriate due to anatomy, open repair should be selected after careful preoperative evaluation; and 4) for patients with ruptured or symptomatic AAA, their condition (with presence or absence of shock) at arrival remains an important factor in choosing whether to perform open repair or EVAR, because stent grafts of all sizes are not available in our hospital. When patients had

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contraindications to EVAR and showed severe comorbidities such as serious cognitive impairment or terminal cancer, medical therapy was an alternative. However, in this study, after receiving detailed explanations, including information on expected mortality and morbidity, the families of all patients chose open repair.

The characteristics of the patients in each group are summarized in **Table 1**. Computed tomography showed that the maximum AAA size was 58.2±6.5 mm in open repair patients and 59.4±5.0 mm in EVAR patients ($p=0.56$). All patients had multiple comorbidities including hypertension, coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, diabetes mellitus with insulin therapy, cerebrovascular disease, peripheral arterial disease, and previous open AAA surgery. There was no significant difference in comorbidities between the two groups of patients.

Two patients (14%) in the open repair group and six of the EVAR patients (25%) had dementia ($p=0.20$). Cancer was present in three of the open repair patients (21%) and five of the EVAR patients (21%; $p=0.41$). All patients who were treated by open repair had multiple anatomical contraindications to EVAR, such as a short neck or narrow access route due to arteriosclerosis obliterans, or the unavailability of an appropriate stent graft during emergency treatment.

Open repairs were performed via midline laparotomy under general anesthesia in all 14 cases. One patient had a pararenal AAA, which required a suprarenal aortic clamp for 36 min. After tube or bifurcated grafts were implanted, the inferior mesenteric artery was reconstructed in 10 cases. Five patients (36%) underwent emergency surgeries, including four ruptured AAA cases and one symptomatic AAA case. To prevent acute compartment syndrome following open repair for ruptured AAA, the wound was left open with the application of a vacuum-assisted closure system on a sponge that covered the bowel. The wound was closed on the second or third examination, several days after the initial repair, at a point when there were no signs of bowel ischemia or compartment syndrome.

Endovascular grafts were delivered from bilateral femoral arteries under general anesthesia, and four of the 24 EVAR patients (17%) required emergency repair for one ruptured and three symptomatic AAA cases. Additional procedures were performed in five patients, with coil embolization of the internal iliac artery (IIA) in two patients, an external iliac artery (EIA) to IIA bypass in one patient, and an EIA to femoral arterial bypass in one patient. One

Table 1 Patient characteristics (n=38)

	Open repair (n=14)	Endovascular repair (n=24)	p-value
Male	8 (57%)	10 (42%)	0.19
Female	6 (43%)	14 (58%)	0.19
Age (y)	92.0±1.6	92.3±2.0	0.34
Height (cm)	157.4±7.0	151.8±10.9	0.06
Weight (kg)	48.9±10.4	47.0±6.5	0.27
Body mass index (kg/m^2)	21.2±3.6	20.5±3.1	0.3
AAA size (mm)	58.2±6.5	59.4±5.0	0.56
Emergency	5 (36%)	4 (17%)	0.23
Ruptured AAA	4	1	0.05
Symptomatic AAA	1	3	0.26
Contraindications for endovascular repair			
Anatomy (short neck, access route)	6 (43%)		
Unavailability of stent graft	8 (57%)		
Comorbidities (N)			
Hypertension	12 (86%)	20 (83%)	0.41
Coronary artery disease	6 (42%)	8 (33%)	0.22
COPD	2 (14%)	1 (4%)	0.18
Chronic kidney disease	4 (29%)	9 (38%)	0.29
Diabetes (insulin therapy)	2 (14%)	2 (8%)	0.3
Cerebrovascular disease	2 (14%)	8 (33%)	0.09
Peripheral arterial disease	2 (14%)	2 (8%)	0.3
Previous AAA surgery	2 (14%)	1 (4%)	0.18
Dementia	2 (14%)	6 (25%)	0.2
Cancer	3 (21%)	5 (21%)	0.41

AAA: abdominal aortic aneurysm; COPD: chronic obstructive pulmonary disease patient with a ruptured AAA showed lactic acidosis during the EVAR procedure, which required surgical laparotomy to evaluate bowel ischemia.

The Ethics Review Board of the National Cerebral and Cardiovascular Center approved this study. Although individual consent was waived, written, informed consent for the procedure was obtained from all patients' families. Statistical analysis was performed with JMP version 11.2.0 (SAS Institute, Cary, NC, USA). Values are given as means ± standard deviation, as appropriate. In addition to descriptive statistics, Kaplan–Meier survival analysis was performed with either re-operation or death as an event, followed by the log-rank test to compare the event risk for patients in both groups. Significance was defined as $p<0.05$.

Results

Mean operation times for open repair and EVAR patients were 214.5 ± 42.1 and 184.9 ± 89.4 min, respectively ($p=0.09$). The need for blood transfusion was significantly higher in the open repair group (2344.5 ± 1471.2 mL), compared to the EVAR group (384.5 ± 643.1 mL, $p=0.0005$, **Table 2**). There was one (4.0%) early death following EVAR; this patient died from non-obstructive mesenteric ischemia on postoperative day 3. There were no hospital deaths recorded in the open repair group, which included five patients with a ruptured AAA. Two (14.0%) patients required enterectomy for intestinal ischemia after open repair for a ruptured AAA. Minor cerebral infarction was found in one (7.0%) patient in the open repair group, and one (4.0%) patient in the EVAR group required medical treatment for subacute myocardial infarction. Respiratory complications, including pneumonia or prolonged mechanical ventilation support over 48 h, were significantly higher in patients after open repair ($p=0.008$). One patient (4.0%) in the EVAR group required re-intervention for a type 1 endoleak two weeks after the initial repair. Hospital stay was significantly longer in the open repair than in the EVAR group (26.4 vs. 10.6 days, respectively, $p=0.003$).

During the same period, 244 open repair cases and 237 EVAR cases were performed on patients aged 80–89 years. Of these, in-hospital death occurred in four (1.7%) patients in the open repair group and one (0.4%) in the EVAR group. There was no significant difference in early mortality between nonagenarian patients and octogenarian patients after either open repair or EVAR.

In the present study, 10 (71%) patients in the open repair group and 19 (79%) in the EVAR group were discharged directly home after the procedure. The remaining four (29%) patients in the open repair group and four (17%) in the EVAR group were transferred to rehabilitation facilities for further improvement of activities of daily living. Two of these patients were able to return home after intensive rehabilitation. Finally, 12 (86%) patients who had undergone open repair and 21 (88%) who had undergone EVAR returned home ($p=0.49$, **Fig. 1**).

Over a mean follow-up time of 23.4 ± 23.5 months, there was no aneurysm-related death in either group. The 1, 2, and 3-year survival rates were 90.0%, 80.0%, and 48.0%, respectively in the open repair group. In the EVAR group, the 1, 2, and 3-year survival rates were 90.6%, 82.4%, and 54.9%, respectively. There was no significant difference between the two groups in these survival rates ($p=0.51$, **Fig. 2**). Freedom from vascular-related re-operation rates were 90% each at 1, 2, and 3 years in the open repair group and 95.7% each at 1, 2, and 3 years in the EVAR group ($p=0.75$, **Fig. 3**).

Table 2 Operative findings and postoperative complications in patients treated with open repair vs. EVAR (n=38)

	Open repair (n=14)	EVAR (n=24)	p-value
Operation time (minutes)	214.5±42.1	184.9±89.4	0.09
Blood transfusion (mL)	2344.5±1471.2	384.5±643.1	0.0005
Hospital death (N)	0 (0%)	1 (4%)	0.16
Bleeding (N)	1 (7%)	0 (0%)	0.16
Neurologic (N)	1 (7%)	0 (0%)	0.16
Cardiac (N)	0 (0%)	1 (4%)	0.16
Respiratory (on ventilator>48 h, pneumonia; N)	6 (42%)	1 (4%)	0.008
Renal (N)	0 (0%)	0 (0%)	—
Mesenteric (N)	2 (14%)	0 (0%)	0.08
Re-intervention<30 days (N)	0 (0%)	1 (4%)	0.16
Hospital stay (days)	26.4±18.2	10.6±5.4	0.003

EVAR: endovascular aortic aneurysm repair

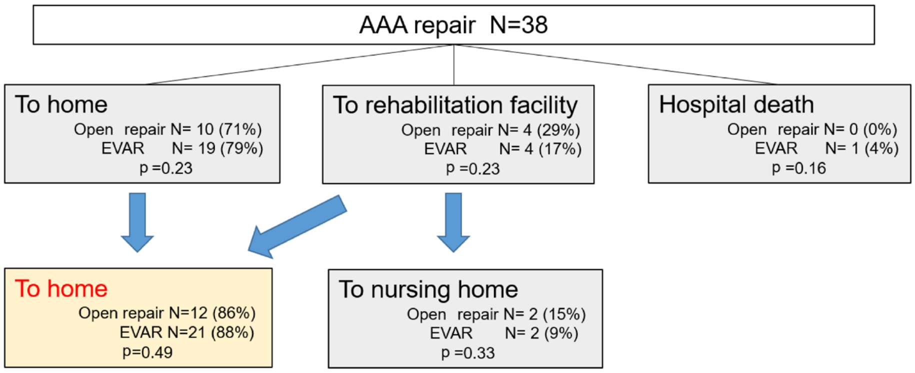

Fig. 1 Flow charts of the patients after hospital discharge.

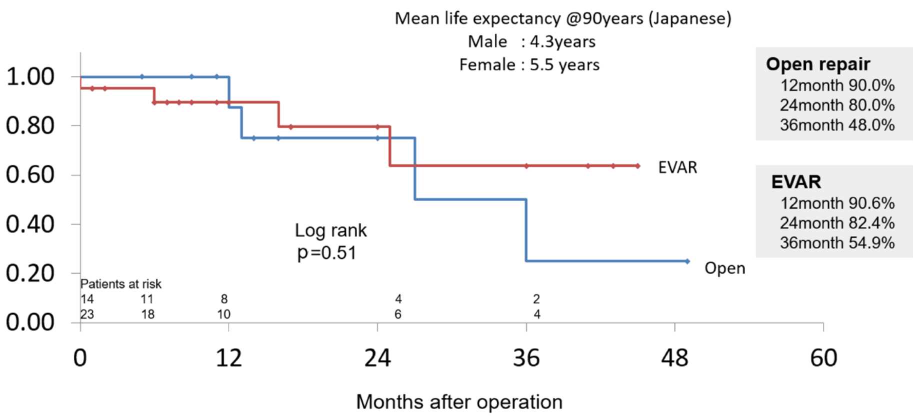

Fig. 2 Long-term survival of open repair and EVAR patients.

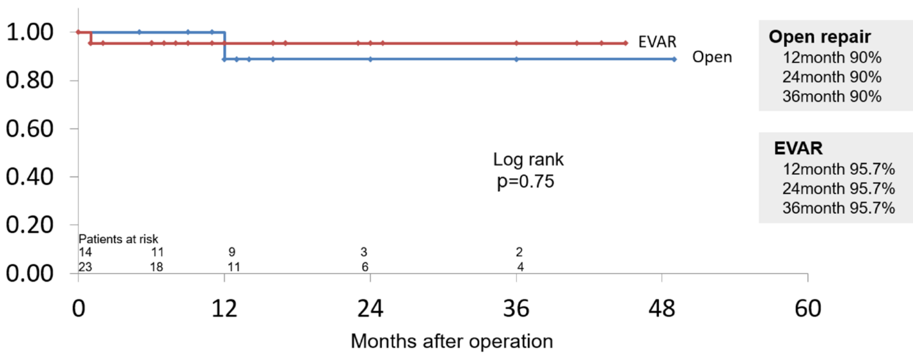

Fig. 3 Freedom from reoperation in patients with open repair or EVAR.

Discussion

Several reports have investigated AAA repair for nonagenarian patients.[5–8] The mortality rate of EVAR for nonagenarians in these reports was similar to that observed in the present study, at 3%–5.6%.[5–8] Although we agree with these previous authors who concluded that EVAR is feasible for nonagenarian patients with acceptable perioperative mortality, compared to octogenarians in our institution, there was no significant difference in mortality between nonagenarian and octogenarian patients after open repair and EVAR. The operative mortality in open repair patients was reported to be higher in other reports, at 18.3% and 25%,[5,6] but there were no deaths recorded in the present study over the first 30 days after surgery in the patients who had undergone open repair. ACS is widely known to be associated with high mortality rates[13–16] of 30%–70% following both open repair and EVAR.[14,15] Patients who develop ACS following repair of a ruptured AAA have a higher incidence of colon ischemia, sepsis, and multi-organ failure. Since the recent focus on prevention and early recognition has led to improved outcomes, we have routinely prevented ACS by leaving the abdomen open in all ruptured cases following graft replacement.

Even in EVAR cases for ruptured AAA, we use laparotomy and leave the abdomen open if abdominal distension is recognized, and thus the bowel is decompressed. This strategy might contribute to a reduction in operative mortality even in nonagenarians following open repair for a ruptured AAA.

After the operation, more patients in the open repair group had respiratory complications because of age-related frailty. Another possible cause was that more patients with a ruptured AAA required delayed wound closure, which prolonged mechanical ventilation support. In addition, a higher incidence of blood transfusion for open repair would lead to acute lung injury. Therefore, respiratory complications such as pneumonia and tracheotomy occurred more frequently in open repair patients. This would lead to longer hospital stays in patients following open repair.

As surgical risk assessments are heavily reliant on age,[6,11,12] they remain inadequate for the evaluation of surgical risk among nonagenarians. Goldstein et al. reported that very elderly patients with more than five comorbidities showed significantly lower survival than those with five or less comorbidities.[5] However, it is common for patients over 90 years of age to have multiple comorbidities, and we must also consider that the condition of each disease might differ between patients. The majority of patients in the present study had multiple comorbidities, although some patients were in good condition as a result of proper medical therapy, and others were ill due to only one severe disease. It is difficult to evaluate the surgical risks of individual patients by considering the number of comorbidities alone. The procedure, then, should be based upon individualized patient selection following careful preoperative evaluation of frailty. For patients over 75 years of age, we recommend EVAR as the first course of treatment. When patients have contraindications to EVAR and severe cognitive impairment or terminal cancer, medical therapy is an alternative. In such cases, whether to perform open repair or provide medical therapy depends on the family's decision after giving detailed explanations on information including expected mortality and morbidity. All families in the present series chose open repair.

Some patients were temporarily transferred to the rehabilitation facility after discharge from the hospital, but even after open repair, 12 patients (85.7%) returned home. During the follow-up period, the mean survival rates were approximately 90%, 80%, and 50% at 1, 2, and 3 years, respectively, in both groups. The estimated life expectancy at 90 years of age is 4.3 years for Japanese men and 5.5 years for Japanese women.[17] Therefore, the survival rates after AAA repair using both open repair and EVAR were reasonable in the present study.

There were several limitations to the present study. First, this was a retrospective study in its approach to the analysis of long-term data and involved only a single center. Second, this study could not evaluate the natural history of untreated AAA patients over 90 years of age. Additional studies with larger populations of nonagenarian patients with AAA may be required.

Conclusion

In conclusion, there were no significant intergroup differences in short and long-term mortalities between patients with AAA treated with open repair vs. EVAR. Our strategy of selecting EVAR as the first line of treatment was acceptable when compared to other age groups, and open repair remains an acceptable choice for those nonagenarians who cannot undergo EVAR.

Disclosure Statement

We have no conflict of interest to disclose.

Author Contributions

Study conception: KU, HM, JK
Data collection: KU, HM
Analysis: KU, HM
Investigation: KU, YI, AO, YS, HS
Writing: KU
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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