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ORIGINAL ARTICLE

Predictors of early operative mortality and long-term survival in octogenarians undergoing open and endovascular repair of abdominal aortic aneurysm

Y. Law, Y.C. Chan*, S.W. Cheng

Division of Vascular and Endovascular Surgery, Department of Surgery, University of Hong Kong Medical Center, Pokfulam, Hong Kong

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Operative mortality;
Survival;
Re-intervention

Summary *Background:* The study aims to report outcomes of open repair (OR) and endovascular aneurysm repair (EVAR) in octogenarians.
Methods: Consecutive patients aged between 80 and 89 who underwent OR or EVAR were identified from a prospectively collected departmental database. Short-term outcomes included 30 days mortalities and perioperative complications; long-term outcomes included overall survival and re-intervention using the Kaplan—Meier method. Logistic regression was used to identify predictors for operative mortality and Cox regression analysis was used to identify predictors for long-term survival.
Results: From January 1999 to December 2013, 53 underwent open repairs (23 emergency and 30 elective) and 115 underwent endovascular repairs (11 emergency and 104 elective). For ***elective procedures***, 30 days operative mortalities were 6.7% and 0% in OR and EVAR respectively (Chi square test, $p = 0.049$). For ***emergency procedures***, 30 days mortalities were 39.1% and 27.2% respectively (Chi square test, $p = 0.705$). Overall 5 years survival rates were 40.4% and 36.7% after OR and EVAR respectively. Rupture of aneurysm (Odd ratio 18.8, 95% CI 3.4—104.5, $p = 0.001$) was the only predictor for 30 days mortality. Rupture of aneurysm (Hazard ratio 2.0, 95% CI 1.3—3.3, $p = 0.003$), history of lung disease (Hazard ratio 1.7, 95% CI 1.0—2.9, $p = 0.039$) and history of renal disease (Hazard ratio 2.1, 95% CI 1.4—3.1, $p < 0.001$) were independent predictors for long-term overall survival.

* Corresponding author. Division of Vascular & Endovascular Surgery, Department of Surgery, University of Hong Kong Medical Centre, South Wing, 14th Floor K Block, Queen Mary Hospital, Pokfulam Road, Hong Kong. Fax: +852 2255 4967.
E-mail address: ycchan88@hkucc.hku.hk (Y.C. Chan).

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Conclusion: Decision of AAA repair in octogenarians should not be based on age alone. Both elective OR and EVAR had acceptable perioperative risk, but emergency repair, lung disease and renal impairment predicted poor long-term survival.

1. Introduction

With an ever aging population, the number of patients with abdominal aortic aneurysm (AAA) will inevitably increase.[1] The decision to treat octogenarians with infrarenal aortic aneurysm purely based on chronological age is not appropriate, as it is often the biological age and co-morbidity of the patients that predict post-operative performances. It was perceived that the repair of infrarenal aortic aneurysms in patients more than 80 years of age may be associated with higher perioperative risks, but this is not the case as shown in multiple published series.[2–10]

The aim of this study was to report the short and long term outcomes of open repair (OR) and endovascular aneurysm repair (EVAR) in octogenarians at our tertiary referral vascular centre.

2. Material and methods

2.1. Study population

For the period from 1 January 1999 till 31 December 2013, consecutive patients aged between 80 and 89 underwent OR or EVAR for abdominal aortic aneurysms in our single-centre institution were retrospectively reviewed from our prospectively collected computerized departmental database. Patient selection for OR or EVAR were non-randomized.

2.2. Departmental policy on treatment

In the case of emergency, our strategy was to consider all patients unless patient categorically refused intervention or had advanced directory. For those who were haemodynamically unstable, they would be directly transferred to operating theater from the Accident & Emergency resuscitation room without computer tomography (CT) scan. For those with stable haemodynamics, they would undergo a contrast CT scan to evaluate anatomical suitability for emergency EVAR. Pre-operative planning was performed using the Digital Imaging and Communications in Medicine (DICOM) data sets imported into the TeraRecon Aquarius workstation (San Mateo, California). This allowed rapid appreciation of the 3D aortic anatomy which would be difficult to be evaluated on a 2D planar CT imaging. The mode of treatment will be determined accordingly.

Patients with asymptomatic AAA were treated when size of aneurysm was more than or equal to 5 cm. Other indications included rapid increase in size or painful aneurysm. Preoperative multi-disciplinary assessment and optimization were important, for pre-operative assessment and for consideration of EVAR unless anatomically unsuitable. All EVARs were done by dedicated vascular surgeons in our hybrid endovascular operating suite (Siemens Artis Zee, Multi-axis Imaging System, Erlangen, Germany) situated in the Minimally Invasive Surgical Centre. All the patients would be nursed in high dependent unit/intensive care unit after operation.

2.3. Post-operative surveillance

Clinical and image follow up were performed routinely in all patients post aneurysm repair. We recommended duplex ultrasound at 1 week, and computer tomography (CT) scans or duplex ultrasounds six-monthly post procedure for 2 years, and then annually afterwards, unless if symptomatology demanded more frequent follow-up or admission to hospital.

2.4. Statistical analysis

Patients' and AAAs' baseline characteristics and follow up period were reported. Short-term outcomes measured 30 days mortalities and perioperative complications. Long-term outcomes measured overall survival and re-intervention using Kaplan–Meier analysis. Categorical data were presented as count and/or percentage and compared using Chi Square test, while continuous data were presented as mean and/or standard deviation and compared using student t test. Binary logistic regression was used to identify predictors for operative mortality. Cox regression analysis was used to identify predictors for long-term survival of variables included means of treatment, sex, American Society of Anesthesiologists (ASA) grade, comorbidities, size of aneurysm, proximal aneurysm extent, distal aneurysm extent and rupture or not. Statistical analysis was calculated by SPSS version 22. A p-value was two tailed and less than 0.05 was defined as statistically significant.

Definition of heart disease was any history of ischemic heart disease or arrhythmia, lung disease was any history of chronic obstructive airway disease, and renal disease was serum creatinine level equal or greater than 120 μmol/L. Emergency repair was for treatment of ruptured cases only, while painful or rapidly expanding aneurysm was counted as elective repair.

3. Results

3.1. Baseline characteristics

Out of 913 AAA repairs during the study period, one hundred and sixty-eight octogenarians underwent repairs. Fifty-three underwent OR (30 elective and 23 emergency). Median follow up period for OR group was 36 months (range

0–144). One hundred and fifteen underwent EVAR (104 elective and 11 emergency). Median follow up period for EVAR group was 38 months (range 0–164) (Fig. 1a). Over the years, more octogenarians were operated and higher proportions were selected for EVAR (Fig. 1b).

Patients' and aneurysms' baseline characteristics were summarized in Tables 1 and 2 respectively. OR group had lower ASA grade, more emergency cases, and larger aneurysm size as compared to EVAR group. While there were no differences in age, sex, co-morbidities, aneurysm proximal and distal extent between the two groups.

3.2. Short term results

For ***elective procedures***, 30 days operative mortalities were 6.7% and 0% in OR and EVAR respectively (Chi square test, $p = 0.049$). For ***emergency procedures***, 30 days mortalities were 39.1% and 27.2% respectively (Chi square test, $p = 0.705$) (Table 3).

For ***elective procedures***, 57% of OR had one or more complications compared to 33% in EVAR (Chi Square test, $p < 0.020$). For ***emergency procedures***, OR and EVAR had similar high rates of at least one complication, 91% and 82% respectively (Chi Square test, $p < 0.020$). Table 4 showed the break down of the specific complications.

3.3. Long term results

The OR group presented overall survival of 60.4%, 56.6%, 52.7%, 42.7% and 40.4% at 1, 2, 3, 4 and 5 years respectively; while that for EVAR group were 85.0%, 72.5%, 64.7%, 59.7% and 36.7% (Log rank $p = 0.309$) (Fig. 2a). For ***elective procedures***, OR group presented overall survival of 80.0%, 73.3%, 62.9%, 55.5% and 51.5% at 1, 2, 3, 4 and 5 years respectively; while that for EVAR group were 89.2%, 76.4%, 67.8%, 62.5% and 38.4% (Log rank $p = 0.810$) (Fig. 2b). For ***emergency procedures***, OR group presented overall survival of 34.8%, 34.8%, 30.4% and 26.1% at 1, 2, 3 and 4 years respectively; while that for EVAR group were 45.5%, 45.5%, 36.4% and 36.4% (Log rank $p = 0.089$) (Fig. 2c). The causes of death were tabulated in Table 5. Ruptured aneurysm was the main cause for those died within 30 days; while cardiovascular disease, chest infection and malignancy predominated after 30 days of operation.

Table 1 Baseline patients' characteristics.

	OR (n = 53)	EVAR (n = 115)	P value
Age (mean, ±standard deviation/SD, range)	83.2, ±2.2, 80-89	83.6, ± 2.6, 80-89	0.387[a]
Male (count, percentage)	37, 70%	90, 78%	0.251[b]
ASA grade (count, percentage)			
- I–II	15, 28%	15, 13%	0.029[b]
- III–V	38, 72%	100, 87%	
Comorbidities (count, percentage)			
- Hypertension	32, 60%	73, 63%	0.733[b]
- Diabetes mellitus	4, 8%	20, 17%	0.102[b]
- Heart disease	20, 38%	53, 46%	0.321[b]
- CVA	7, 13%	26, 23%	0.210[b]
- Lung disease	8, 15%	16, 14%	0.817[b]
- Renal disease	18, 34%	44, 38%	0.611[b]
Nature of operation (count, percentage)			
- Emergency	23, 43%	11, 10%	<0.001[b]
- Elective	30, 57%	104, 90%	

[a] Student t test.
[b] Chi Square test.

Cumulative ***re-intervention rates*** in OR were 5.7%, 5.7%, 8.8%, 8.8% and 8.8% at 1, 2, 3, 4 and 5 years respectively; while that for EVAR were 8.4%, 9.4%, 15.8%, 19.6% and 21.7% (Log rank $p = 0.042$) (Fig. 3). Indications for first re-intervention were tabulated in Table 6. Majority of re-intervention after EVAR was due to graft related complications. One patient whom underwent emergency open repair for ruptured aneurysm two years after EVAR died within 30 days of re-intervention; otherwise there were no mortality or major morbidities associated with other re-interventions.

3.4. Predictors for 30 days mortality

Univariate logistic regression showed open repair, smokers, and ruptured cases were predictors of 30 days mortality. With subsequent multivariate logistic regression, only

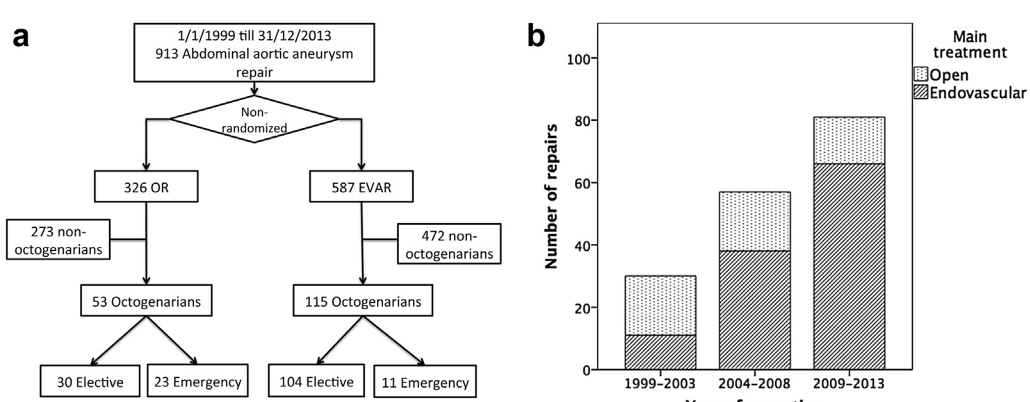

Figure 1 (a) Flow chart of octogenarians underwent OR or EVAR, (b) Numbers of OR and EVAR over the years.

Table 2 Baseline aneurysms' characteristics.

	OR (n = 53)	EVAR (n = 115)	P value
Mean aneurysm diameter (cm) (mean, ±SD, range)	7.1, ±1.3, 5.0–10.0	6.1, ±1.2, 3.3–9.2	<0.001[a]
Proximal extension (count, percentage)			
Thoracoabdominal/ Suprarenal/Juxtarenal/ Pararenal	8, 15%	7, 6%	0.079[b]
Infrarenal	45, 85%	108, 94%	
Iliac involvement (count, percentage)	20, 38%	41, 36%	0.732[b]
Mean operation time (minutes) (mean, ±SD, range)	204, ±81, 35–540	183, ±83, 50–520	0.125[b]
Mean operation blood loss (ml) (mean, ±SD, range)	1850, ±1821, 200–8000	233, ±223, 0–1200	<0.001[b]

[a] Student t test.
[b] Chi Square test.

Table 3 30 days mortality.

	OR (n = 53)	EVAR (n = 115)	P value
Emergency	9/23 (39.1%)	3/11 (27.2%)	0.705[a]
Elective	2/30 (6.7%)	0/104 (0%)	0.049[a]
Overall	11/53 (20.8%)	3/115 (2.6%)	<0.001[a]

[a] Chi Square test.

ruptured aneurysm was found to be independent significant risk factor for 30 days mortality (Odd ratio = 18.8, 95% CI 3.4–104.5, p = 0.001) (Table 7).

3.5. Predictors for long-term survival

Cox regression analysis showed that pre-existing lung disease, renal disease, AAA diameter, proximal extent of aneurysm and ruptured cases were predictors for worse long term survival. With subsequent multivariate analysis, rupture of aneurysm (Hazard ratio 2.0, 95% CI 1.3–3.3, p = 0.003), history of lung disease (Hazard ratio 1.7, 95% CI 1.0–2.9, p = 0.039) and history of renal disease (Hazard ratio 2.1, 95% CI 1.4–3.1, p < 0.001) were independent predictors for long-term overall survival (Table 8).

Table 4 Post operative complications.

Emergency	OR (n = 23)	EVAR (n = 11)	P value
Cardiac			
Minor	4	0	0.240[a]
Symptomatic	0	1	
Cardiac arrest/fatal	5	2	
Respiratory			
Minor	7	2	0.522[a]
Bronchial toilet	3	0	
Tracheostomy	3	1	
Ventilator/fatal	3	2	
Renal			
Transient, no dialysis	6	0	0.062[a]
Transient, dialysis	1	1	
Permanent/fatal	0	2	
Cerebral vascular accident			
Transient ischemic attack	1	0	0.602[a]
Permanent deficit	1	0	
Fatal	0	0	
Gastrointestinal tract	2	0	1.000[a]
Local complications	3	2	1.000[a]
Overall complications	**21 (91%)**	**9 (82%)**	**0.580**[a]
Elective	**OR (n=30)**	**EVAR (n=104)**	**P value**
Cardiac			
Minor	9	6	<0.001[a]
Symptomatic	0	5	
Cardiac arrest/fatal	1	0	
Respiratory			
Minor	9	6	<0.001[a]
Bronchial toilet	1	0	
Tracheostomy	0	0	
Ventilator/fatal	0	1	
Renal			
Transient, no dialysis	3	3	0.194[a]
Transient, dialysis	0	0	
Permanent/fatal	0	2	
Cerebral vascular accident			
Transient ischemic attack	0	2	0.652[a]
Permanent deficit	0	1	
Fatal	0	0	
Gastrointestinal tract	1	0	0.224[a]
Local complications	2	12	0.735[a]
Overall complications	**17 (57%)**	**34 (33%)**	**0.020**[a]

[a] Chi Square test.

4. Discussion

This is a study to demonstrate that age was not a determining factor in who to operate with AAA. Thirty days operative mortalities for elective repairs were acceptable at 6.7% and 0% in OR and EVAR respectively. 5 years survival rate for elective repairs were 51.5% and 38.4% in OR and EVAR respectively. The results were comparable to the world series. In a systemic review by *Henebiens et al*,[11] thirty-nine articles concerning elective AAA repair in octogenarians were summarized. The median aneurysm size was 6.7 cm in the OR group of 1534 patients. The perioperative mortality was 0%–33%, with a pooled mortality of 7.5% (95% CI 6.2%–9.0%). The median 5-year survival rate for this group was 60% (range 14%–86%). In the 1045 patients treated with EVAR, the median aneurysm size was 5.9 cm. Their pooled perioperative mortality varied from 0%

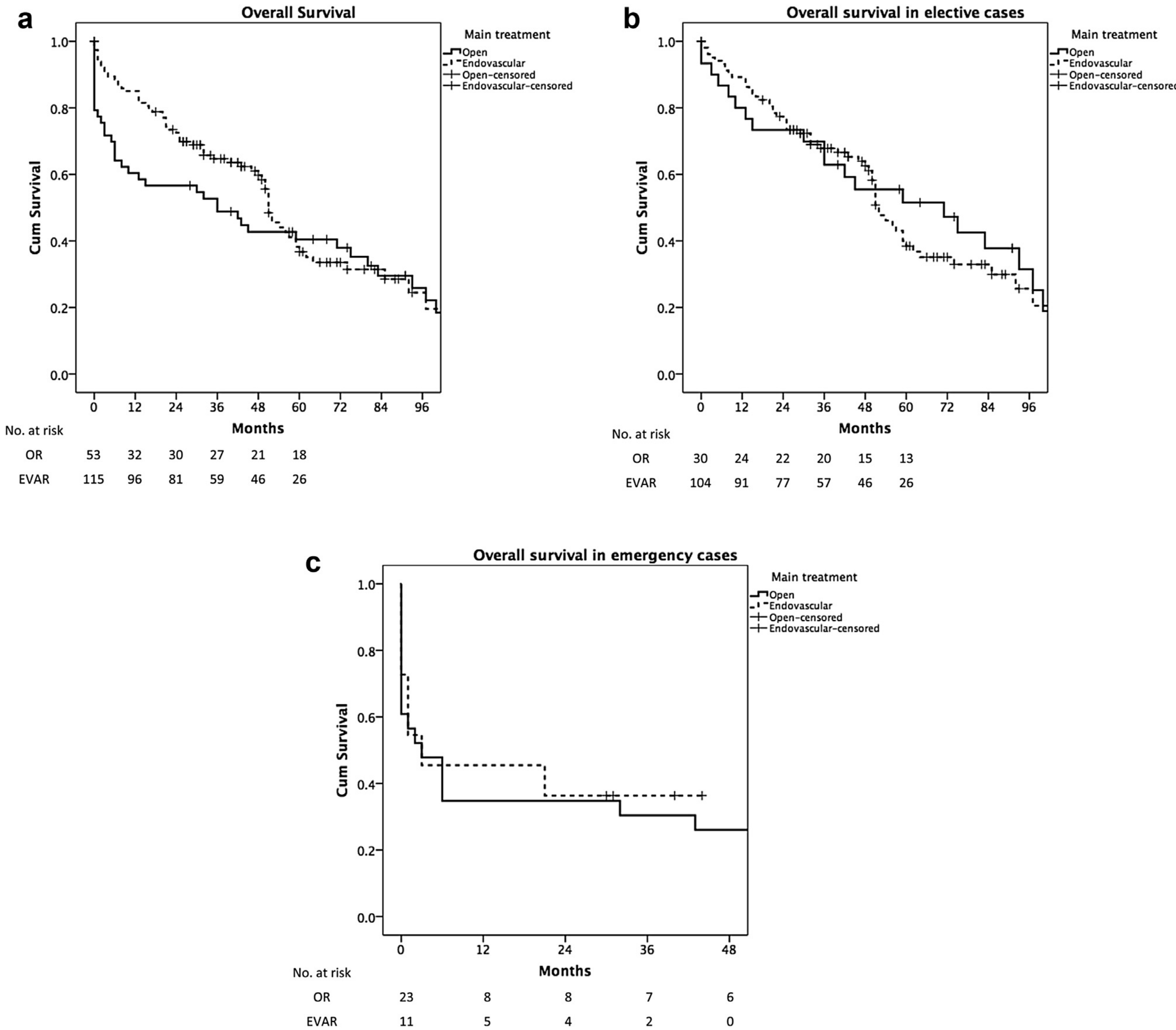

Figure 2 (a) Overall survival, (b) Overall survival in elective repair, (c) Overall survival in emergency repair.

Table 5 Cause of death.

	Within 30 days		Beyond 30 days		Overall	
	OR (n = 53)	EVAR (n = 115)	OR (n = 42)	EVAR (n = 112)	OR (n = 53)	EVAR (n = 115)
Any cause	**11**	**3**	**30**	**63**	**41**	**66**
Ruptured aneurysm	10	2	3	3	13	5
Cardiovascular						
Myocardial infarction	1	1	1	7	2	8
Congestive heart failure			2	3	2	3
Type A dissection				1		1
Cerebral vascular accident			3	5	3	5
Chest infection			12	20	12	20
Malignancy			4	11	4	11
Renal failure			1	1	1	1
Miscellaneous			1	5	1	5
Unknown			3	7	3	7

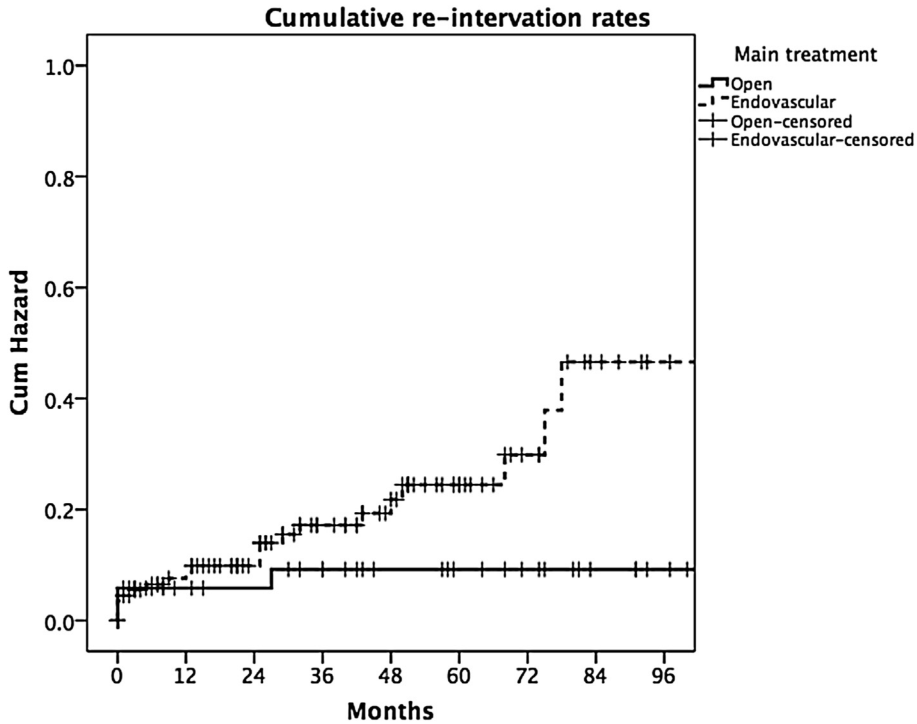

Figure 3 Cumulative hazard for re-intervention.

to 6%, with a pooled mortality of 4.6% (95% CI 3.4–6.0%). Another meta-analysis by Biancari et al[12] reported six observational studies on 13,419 patients with AAA aged 80 years or older. The pooled immediate mortality rate after OR was 8.6%, whereas it was 2.3% after EVAR. The risk of immediate postoperative mortality was higher after OR compared with EVAR (risk ratio 3.87, 95% CI 3.19–4.68). Pooled analysis of three studies showed similar overall survival at 3 years after EVAR and OR were at the range of 60–80% (risk ratio 1.10, 95% CI 0.77–1.57). We cannot, therefore, deny octogenarians for aneurysm repair based solely on age.

Emergency repair, on the other hand, was worse for aged greater than 80, especially for open. This was based on biological and ASA grades. Thirty days operative mortalities for emergency repairs were high at 39.1% and 27.2% in our OR and EVAR respectively. Over two-third of patients died after 3 years of emergency repairs with survival of 30.4% and 36.4% in OR and EVAR respectively. There was a paucity of literature reporting short-term and long-term mortality after emergency AAA repair specifically for octogenarians. In a meta-analysis by Luebke et al,[13] patients of ALL AGES underwent emergency AAA repair were summarized. Among 64 studies, the 30 days mortality occurred in 28,480 of 67,975 (41.90%) of the patients who underwent OR and in 3644 of 13,706 (26.59%) patients treated with EVAR.

Our recommendation was therefore to avoid emergency repair. This may be achieved by population based screening program. Meta-analysis demonstrated that screening was associated with a lower AAA rupture rate at 3–5 years (risk ratio 0.52, 95% CI 0.35–0.79), 7 years (risk ratio 0.53, 95% CI 0.43–0.65), and 10–11 years (risk ratio 0.27, 95% CI 0.11–0.65) of follow up.[14] Furthermore, octogenarians with asymptomatic AAA should never be denied of operation based on age alone. EVAR was the preferred choice provided good aneurysm anatomy. It was because of its short-term advantage on survival and perioperative complication. Speedy recovery was of utmost important among these patients with limited life expectancy. The inferior

Table 6 Indication for first re-intervention.

Indication	OR (n = 53)	EVAR (n = 115)	Overall (n = 168)
Any	4	22	26
Graft related indication			
Thrombo-occlusive disease	2	3	5
Type I endoleak		3	3
Migration		4	4
Endotension		2	2
Material failure		1	1
Para-anastomotic aneurysm			
Aneurysm rupture		1	1
Wound-related indication			
Incisional hernia			
Wound infection			
Miscellaneous		2	2
Local or systematic indication			
Bleeding			
Type 2 endoleak		6	6
Bowel resection or ileus	2		2
Miscellaneous			

Table 7 Predictors for 30 days mortality.

	Uni-variate			Multi-variate		
	OR	95% CI	P value	OR	95% CI	P Value
OR vs. EVAR	9.78	2.60–36.78	0.001	2.93	0.40–21.66	0.292
Female	1.27	0.38–4.27	0.705			
ASA III-V	1.33	0.28–6.29	0.716			
Smoking	0.21	0.05–0.98	0.048	0.38	0.05–2.65	0.328
Hypertension	0.78	0.26–2.37	0.666			
Diabetes mellitus	1.73	0.45–6.71	0.430			
Heart disease	1.83	0.60–5.52	0.286			
CVA	1.13	0.30–4.29	0.861			
Lung disease	1.73	0.45–6.71	0.430			
Renal disease	2.47	0.82–7.49	0.110			
AAA diameter	1.34	0.90–2.01	0.153			
Infrarenal	0.31	0.08–1.26	0.102			
Iliac involvement	1.54	0.49–4.83	0.456			
Emergency	36.00	7.54–171.92	<0.001	18.78	3.37–104.53	0.001

By binary regression analysis.
AAA diameter was continuous variable, while others were categorical.
OR = odd ratio, CI = confident interval.
Variable in bold was independent risk factor.

Table 8 Predictors for long-term survival.

	Uni-variate			Multi-variate		
	HR	95% CI	P value	HR	95% CI	P Value
OR vs. EVAR	1.23	0.83–1.83	0.315			
Female	1.44	0.89–2.35	0.140			
ASA III-V	1.57	0.92–2.69	0.096			
Smoking	1.11	0.74–1.66	0.607			
Hypertension	1.00	0.67–1.48	0.985			
Diabetes mellitus	1.01	0.57–1.78	0.975			
Heart disease	1.33	0.91–1.94	0.143			
CVA	1.04	0.65–1.68	0.863			
Lung disease	1.98	1.20–3.27	0.007	1.73	1.03–2.90	0.039
Renal disease	2.08	1.42–3.06	<0.001	2.05	1.38–3.05	<0.001
AAA diameter	1.19	1.04–1.37	0.012	1.13	0.97–1.31	0.125
Infrarenal	0.37	0.21–0.64	<0.001	0.56	0.31–1.02	0.057
Iliac involvement	0.93	0.63–1.38	0.716			
Emergency	2.24	1.43–3.50	<0.001	2.03	1.27–3.26	0.003

By Cox regression analysis.
AAA diameter was continuous variable, while others were categorical.
HR = Hazard ratio, CI = confident interval.
Variables in bold were independent risk factors.

durability of EVAR is less of a concern here. Those refused elective repair should make aware of the extreme high mortality of emergency repair in case of rupture. They should advise against emergency surgery if conservative treatment was chosen.

Our predictor model showed that survival were not affected by treatment modality i.e. OR or EVAR; whilst emergency surgery was the only independent predictor for both short-term and long-term survival. This fact further supports our recommendation. Re-intervention was more common after EVAR compared to OR. This was well reported by randomized control trials.[15,16] In our series, all re-interventions after OR required open surgeries (1 femoral exploration, 2 bowel resection and 1 cross femoral bypass). The majority of re-interventions after EVAR were endovascular. Among 22 re-interventions after EVAR, 15, 5 and 2 were done by endovascular, open and laparoscopic means respectively.

There were several limitations. There was inevitable selection bias, as the treatment choice was non-randomized. In additional, those too ill would not be considered for OR or EVAR, so this paper did not reflect the true picture of all octogenarians with AAA. Those patients who were too ill would be treated conservatively. The quality of life, physical function, and cognition after surgery were not reported in our study. These were important consideration for elderly and their caretakers.[17]

5. Conclusion

Chronological age should not be the sole reason to deny AAA repair. Both elective OR and EVAR in octogenarians had acceptable perioperative risk and mortality, but EVAR was associated with less post-operative morbidity and faster recovery.

Conflict of interest

No conflict of interests declared. This study received no financial support.

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References

1. Choke E, Vijaynagar B, Thompson J, et al. Changing epidemiology of abdominal aortic aneurysms in England and Wales: older and more benign? *Circulation*. 2012;125(13):1617—1625.
2. Mailapur R, Yousuf AM, Girishkumar HT, et al. A decade of experience with abdominal aortic aneurysm repair in octogenarians. *J Cardiovasc Surg (Torino)*. 2001;42(4):525—528.
3. de Donato G, Setacci C, Chisci E, et al. Abdominal aortic aneurysm repair in octogenarians: myth or reality? *J Cardiovasc Surg (Torino)*. 2007;48(6):697—703.
4. Hynes N, Kok N, Manning B, et al. Abdominal aortic aneurysm repair in octogenarians versus younger patients in a tertiary referral center. *Vascular*. 2005;13(5):275—285.
5. Morisaki K, Matsumoto T, Matsubara Y, et al. Elective endovascular vs. open repair for abdominal aortic aneurysm in octogenarians. *Vascular*. 2016;24(4):348—354.
6. Paolini D, Chahwan S, Wojnarowski D, et al. Elective endovascular and open repair of abdominal aortic aneurysms in octogenarians. *J Vasc Surg*. 2008;47(5):924—927.
7. Lange C, Leurs LJ, Buth J, et al. Endovascular repair of abdominal aortic aneurysm in octogenarians: an analysis based on EUROSTAR data. *J Vasc Surg*. 2005;42(4):624—630. discussion 630.
8. Raval MV, Eskandari MK. Outcomes of elective abdominal aortic aneurysm repair among the elderly: endovascular versus open repair. *Surgery*. 2012;151(2):245—260.
9. Prenner SB, Turnbull IC, Malik R, et al. Outcome of elective endovascular abdominal aortic aneurysm repair in octogenarians and nonagenarians. *J Vasc Surg*. 2010;51(6):1354—1359.
10. Sicard GA, Rubin BG, Sanchez LA, et al. Endoluminal graft repair for abdominal aortic aneurysms in high-risk patients and octogenarians: is it better than open repair? *Ann Surg*. 2001; 234(4):427—435. discussion 435-7.
11. Henebiens M, Vahl A, Koelemay MJ. Elective surgery of abdominal aortic aneurysms in octogenarians: a systematic review. *J Vasc Surg*. 2008;47(3):676—681.
12. Biancari F, Catania A, D'Andrea V. Elective endovascular vs. open repair for abdominal aortic aneurysm in patients aged 80 years and older: systematic review and meta-analysis. *Eur J Vasc Endovasc Surg*. 2011;42(5):571—576.
13. Luebke T, Brunkwall J. Risk-adjusted meta-analysis of 30-day mortality of endovascular versus open repair for ruptured abdominal aortic aneurysms. *Ann Vasc Surg*. 2015;29(4): 845—863.
14. Guirguis-Blake JM, Beil TL, Sun X, et al. In: *Primary Care Screening for Abdominal Aortic Aneurysm: A Systematic Evidence Review for the U.S. Preventive Services Task Force*. 2014. Rockville (MD).
15. United Kingdom ETI, Greenhalgh RM, Brown LC, et al. Endovascular versus open repair of abdominal aortic aneurysm. *N Engl J Med*. 2010;362(20):1863—1871.
16. De Bruin JL, Baas AF, Buth J, et al. Long-term outcome of open or endovascular repair of abdominal aortic aneurysm. *N Engl J Med*. 2010;362(20):1881—1889.
17. Aitken SJ, Naganathan V, Blyth FM. Aortic aneurysm trials in octogenarians: are we really measuring the outcomes that matter? *Vascular*. 2016 Aug;24(4):435—445.