J Korean Med Sci. 2023 Oct 9;38(39):e321
https://doi.org/10.3346/jkms.2023.38.e321
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article
Surgery

Check for updates

Treatment Outcomes of Patients With Ruptured Abdominal Aortic Aneurysms

Hyangkyoung Kim [1], **Tae-Won Kwon** [2*], **Yong-Pil Cho** [2], **Jun Gyo Gwon** [2], **Youngjin Han** [2], **Sang Ah Lee** [2], **Ye-Jee Kim** [3] and **Seonok Kim** [3]

[1]Department of Surgery, College of Medicine, Ewha Womans University, Seoul, Korea
[2]Division of Vascular Surgery, Department of Surgery, College of Medicine, University of Ulsan, Asan Medical Center, Seoul, Korea
[3]Department of Clinical Epidemiology and Biostatistics, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

OPEN ACCESS

Received: Mar 7, 2023
Accepted: Jun 26, 2023
Published online: Sep 18, 2023

Address for Correspondence:
Tae-Won Kwon, MD, PhD
Division of Vascular Surgery, Department of Surgery, College of Medicine, University of Ulsan, Asan Medical Center and Department of Emergency Critical Care Trauma Surgery, Korea University Guro Hospital, 148 Gurodong-ro, Guro-gu, Seoul 08308, Korea.
Email: twkwon257@gmail.com

*Current affiliation: Department of Emergency Critical Care Trauma Surgery, Korea University Guro Hospital, Seoul, Korea and Armed Forces Trauma Center, Armed Forces Capital Hospital, Seongnam, Korea

ORCID iDs
Hyangkyoung Kim
https://orcid.org/0000-0002-2021-815X
Tae-Won Kwon
https://orcid.org/0000-0003-3803-0013
Yong-Pil Cho
https://orcid.org/0000-0002-0639-451X

ABSTRACT

Background: Ruptured abdominal aortic aneurysm (rAAA) is a serious complication of abdominal aortic aneurysm associated with high operative mortality and morbidity rates. The present study evaluated the perioperative and long-term outcomes of Korean patients with rAAA based on national health insurance claims data.
Methods: The National Health Insurance Service (NHIS) database was searched retrospectively to identify patients with rAAA who underwent endovascular aneurysm repair (EVAR) and open surgical repair (OSR) from 2009 to 2018. Perioperative (≤ 30 days), early postoperative (≤ 3 month), and long-term (> 3 month) survival, reinterventions, and complications were assessed.
Results: The search identified 1,034 patients with rAAA, including 594 who underwent EVAR and 440 who underwent OSR. When the study period was divided into two, the total numbers of patients with rAAA, patients who underwent EVAR, and octogenarians were higher during the second half. The perioperative mortality rate was 29.8% in the EVAR and 35.0% in the OSR group ($P = 0.028$). Hartmann's procedure for bowel infarction was performed more frequently in the OSR than in the EVAR group (adjusted odds ratio, 6.28; 95% confidence interval [CI], 2.33–21.84; $P = 0.001$), but other complication rates did not differ significantly. All-cause mortality during the entire observation period did not differ significantly in the EVAR and OSR groups (adjusted hazard ratio, 1.17; 95% CI, 0.98–1.41; $P = 0.087$). Abdominal aortic aneurysm-related reintervention rate was significantly lower in the OSR group (adjusted hazard ratio, 0.31; 95% CI, 0.14–0.70; $P = 0.005$).
Conclusion: Although EVAR showed somewhat superior perioperative outcomes for rAAA, the long-term outcomes of EVAR after excluding initial 3 months were significantly worse than OSR. When anatomically feasible for both treatments, the perioperative mortality risk and reasonable prospects of long-term survival should be considered in rAAA.

Keywords: Aortic Aneurysm, Abdominal; Aneurysm, Ruptured; Mortality; Complication, Peroperative; Endovascular Abdominal Aortic Repair; Open Abdomen Techniques

Jun Gyo Gwon
https://orcid.org/0000-0002-1681-1014
Youngjin Han
https://orcid.org/0000-0002-5315-0155
Sang Ah Lee
https://orcid.org/0000-0002-3510-9175
Ye-Jee Kim
https://orcid.org/0000-0002-3307-2970
Seonok Kim
https://orcid.org/0000-0001-9010-5460

Funding

This study was supported by a grant from the Asan Institute for Life Sciences and Corporate Relations of Asan Medical Center, Seoul, Korea (2020).

Disclosure

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Kim H. Data curation: Kim H, Kwon TW, Kim YJ, Kim S. Formal analysis: Kim YJ, Kim S. Funding acquisition: Kwon TW. Investigation: Kim H, Gwon JG, Han Y. Methodology: Kim H, Kim YJ. Software: Kim YJ, Kim S. Validation: Cho YP, Gwon JG, Han Y, Lee SA. Visualization: Kim H, Kim YJ. Writing - original draft: Kim H. Writing - review & editing: Kwon TW, Cho YP, Gwon JG, Han Y, Lee SA.

INTRODUCTION

Ruptured abdominal aortic aneurysm (rAAA) is associated with high mortality and morbidity rates despite recent technical advances in surgical procedures and critical care. Over the last decade, endovascular aneurysm repair (EVAR) has emerged as a less invasive but clinically comparable alternative to open surgical repair (OSR) for the treatment of rAAA, markedly altering rAAA management.[1] Furthermore, guidelines from both the Society for Vascular Surgery (SVS) and the European Society for Vascular Surgery (ESVS) recommend EVAR as a first-line option for anatomically suitable rAAA management.[2,3] The relative effectiveness of these procedures for rAAA repair remains unclear.[4-6] Randomised trials have reported no significant differences between EVAR and OSR,[7-10] whereas other studies have suggested that EVAR significantly reduced mortality risk.[11,12] In non-rAAA, early postoperative mortality was significantly lower with EVAR than OSR, although their long-term benefits were unclear.[13,14] Observational studies on rAAA and findings extrapolated from studies on non-rAAA have suggested that EVAR may provide advantages for long-term survival.[5,11,12] Because the use of EVAR is limited by aortic anatomy and the initial presentation of rAAA varies among patients, the therapeutic outcome of rAAA in real world situations outside randomised trials is greatly affected by factors other than the outcome of the procedure itself.

Variations in the short-term outcomes of previous studies and the relative lack of long-term comparisons of EVAR with OSR indicate the need for additional studies evaluating the effectiveness of EVAR. The present study therefore assessed the nationwide annual trend of treatment of rAAA for 10 years in Korea and the outcomes of EVAR and OSR using National Health Insurance Service (NHIS) data.

METHODS

Data on patients with rAAA from 2009 to 2018 were collected retrospectively from the NHIS administrative database. The study flow diagram is depicted in **Fig. 1**. To exclude patients possibly misdiagnosed with abdominal aortic aneurysm (AAA), the NHIS database was screened for patients aged ≥ 50 years and diagnosed with an International Classification of Diseases,Tenth Revision (ICD-10) code for AAA. Patients who visited the outpatient clinic only once with a relevant ICD-10 code for AAA were excluded. To limit the study to patients with the degenerative type of AAA, patients with AAA related to Behcet's disease (ICD-10 code M35.2) or syphilis (ICD-10 code A50-53) were excluded, as were patients with a history of typhoid fever or salmonellosis (ICD-10 code A02, and procedure codes NHIS O2034, O2036, and O2039) within the 6 months prior to the diagnosis of AAA. Patients with rAAA were identified using the ICD-10 codes I71.3 and I71.8. Patients enrolled during the first 6 months and the last 6 months of the study period were also excluded. The index date of AAA was defined as the initial date of diagnosis of AAA.

The primary outcomes were perioperative mortality and in-hospital mortality. Perioperative mortality was defined as mortality within 30 days of AAA repair, and in-hospital mortality was defined as mortality during index admission. The secondary outcome was long-term mortality. Diagnostic codes for complications and outcomes are summarised in **Supplementary Table 1**.

https://doi.org/10.3346/jkms.2023.38.e321

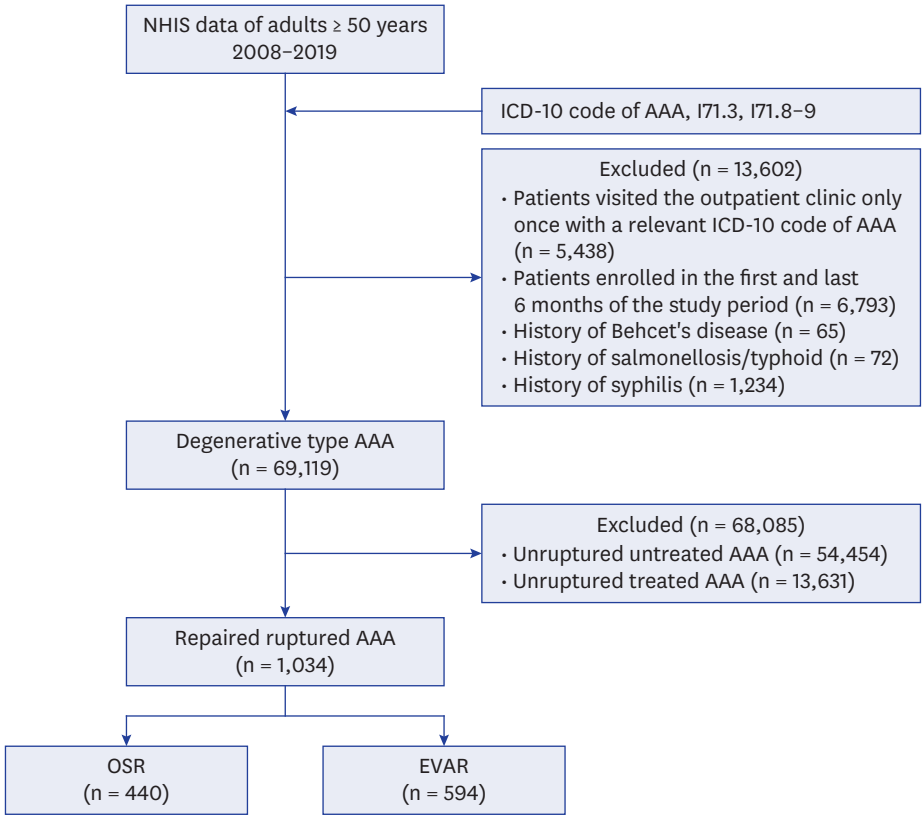

Fig. 1. Flow diagram.
NHIS = National Health Insurance Service, ICD-10 = International Classification of Diseases-Tenth Revision, AAA = abdominal aortic aneurysm, OSR = open surgical repair, EVAR = endovascular aneurysm repair.

Statistical analysis

Categorical variables were presented as number (frequency) and compared by Pearson χ^2 tests, whereas continuous variables were presented as mean and standard deviation (SD), and compared by Student's *t*-tests. Perioperative and long-term outcomes were compared, and odds ratio (OR) and corresponding 95% confidence intervals (CIs) were calculated for comparisons of EVAR and OSR, with the EVAR group as a reference. Patient survival and reinterventions related to rAAA were assessed by the Kaplan–Meier method and compared with the Cox proportional hazard model, with hazard ratios (HRs) and corresponding 95% Cis calculated with the EVAR group as a reference. The incidence rate of rAAA was presented per 100,000 population after standardisation to the Korean population in 2005. The reintervention rate was analysed using a Fine and Gray subdistribution hazard model that considered death as a competing risk. Statistical analyses were performed using SAS Enterprise guide version 7.1 (SAS Institute Inc., Cary, NC, USA) and R software version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria), with $P < 0.05$ considered statistically significant.

Ethics statement

The protocol of the present study was approved by the Institutional Review Board (IRB approval number: 2020-1242) of Asan Medical Centre, which waived the requirement for written informed consent due to the retrospective nature of this study.

https://doi.org/10.3346/jkms.2023.38.e321

RESULTS

Demographic characteristics of patients with rAAA and incidence rate of rAAA indicated for treatment

The review of the NHIS database identified 1,034 patients diagnosed with rAAA, including 594 who underwent EVAR and 440 who underwent OSR (**Fig. 1**). Patients' baseline demographic and clinical characteristics are summarised in **Table 1**. The percentages of patients with high surgical risk factors, including diabetes, hypertension and chronic kidney disease, were higher in the EVAR than in the OSR group. The majority of procedures were conducted in urban areas, including the capital area and six metropolitan cities, rather than rural areas, and in tertiary hospitals rather than other types of hospitals. There was a significant difference in the proportion of procedures between EVAR and OSR.

The annual standardised incidence rate of rAAA showed an overall increasing trend between 2008 and 2019 (**Fig. 2A**). When the study period was divided into halves, the number of EVAR procedures was higher and the number of OSR procedures was lower during the second than during the first half (**Table 2**). The incidence rate of rAAA was especially high in octogenarian patients, especially in women. The number of patients diagnosed with rAAA was highest in the group aged 75–79 years (**Fig. 2B**), and 178 patients (22.8%) were aged < 65 years.

Perioperative outcomes

Perioperative complications and mortality are summarised in **Fig. 3**. The complication rates did not differ significantly in the EVAR and OSR groups, except that the rate of irreversible ischaemic colitis requiring Hartman's procedure was significantly higher in the OSR group (adjusted OR, 6.28; 95% CI, 2.33–21.84; $P = 0.001$). Overall perioperative mortality rates in patients who underwent EVAR and OSR were 29.8% and 35.0%, respectively, and in-hospital mortality rates were 31.6% and 38.9%, respectively. Perioperative mortality (adjusted OR, 1.36; 95% CI, 1.03–1.79; $P = 0.028$) and in-hospital mortality (adjusted OR, 1.48; 95% CI, 1.13–1.94; $P = 0.004$) risks were significantly higher in the OSR group.

Table 1. Baseline demographic and clinical characteristics of the study patients who underwent repair of rAAA from 2009 to 2018

Characteristics	Total (N = 1,034)	EVAR (n = 594)	OSR (n = 440)	*P*
Age, yr	72.9 ± 9.2	73.3 ± 9.6	72.5 ± 8.5	< 0.001
Men	801 (77.5)	442 (74.4)	359 (81.6)	0.006
Co-morbidities				
Diabetes mellitus	229 (22.2)	148 (24.9)	81 (18.4)	0.013
Hypertension	704 (68.1)	423 (71.2)	281 (63.9)	0.012
Dyslipidemia	486 (47.0)	310 (52.2)	176 (40.0)	0.000
Ischaemic heart disease	10 (0.97)	4 (0.67)	6 (1.36)	0.339
Heart failure	87 (8.4)	43 (7.2)	44 (10.0)	0.114
Chronic kidney disease	77 (7.5)	56 (9.4)	21 (4.8)	0.005
ESKD	21 (2.0)	16 (2.7)	5 (1.1)	0.079
CVA	2 (0.2)	1 (0.2)	1 (0.2)	> 0.999
Geographical region				0.826
Urban	857 (82.9)	491 (57.3)	366 (42.7)	
Rural	177 (17.1)	103 (58.2)	74 (41.8)	
Hospital type				0.061
Tertiary	744 (72.0)	414 (55.6)	330 (44.4)	
Others	290 (28.1)	180 (62.1)	110 (37.9)	

Values are presented as mean ± standard deviation or number (%).
rAAA = ruptured abdominal aortic aneurysm, EVAR = endovascular aneurysm repair, OSR = open surgical repair, ESKD = end-stage kidney disease, CVA = cerebrovascular accidents.

https://doi.org/10.3346/jkms.2023.38.e321

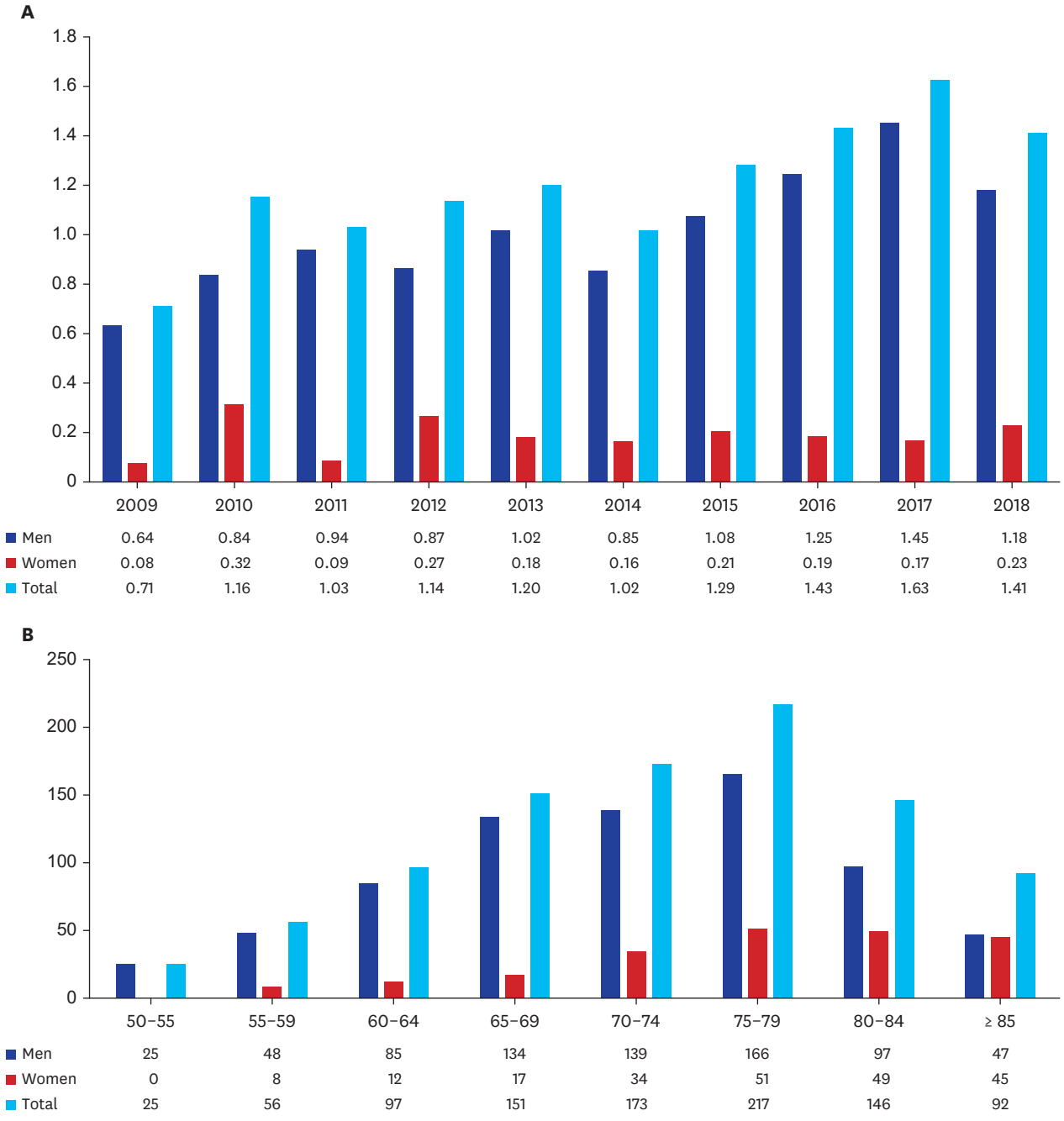

Fig. 2. Annual standardised incidence rates of patients treated for ruptured abdominal aortic aneurysm per 100,000 population from 2009 to 2018 (**A**) and number of patients with ruptured abdominal aortic aneurysm by age group (**B**). Groups were standardised relative to the numbers of persons aged ≥ 50 years in Korea in 2005 (11,302,213 persons).

https://doi.org/10.3346/jkms.2023.38.e321

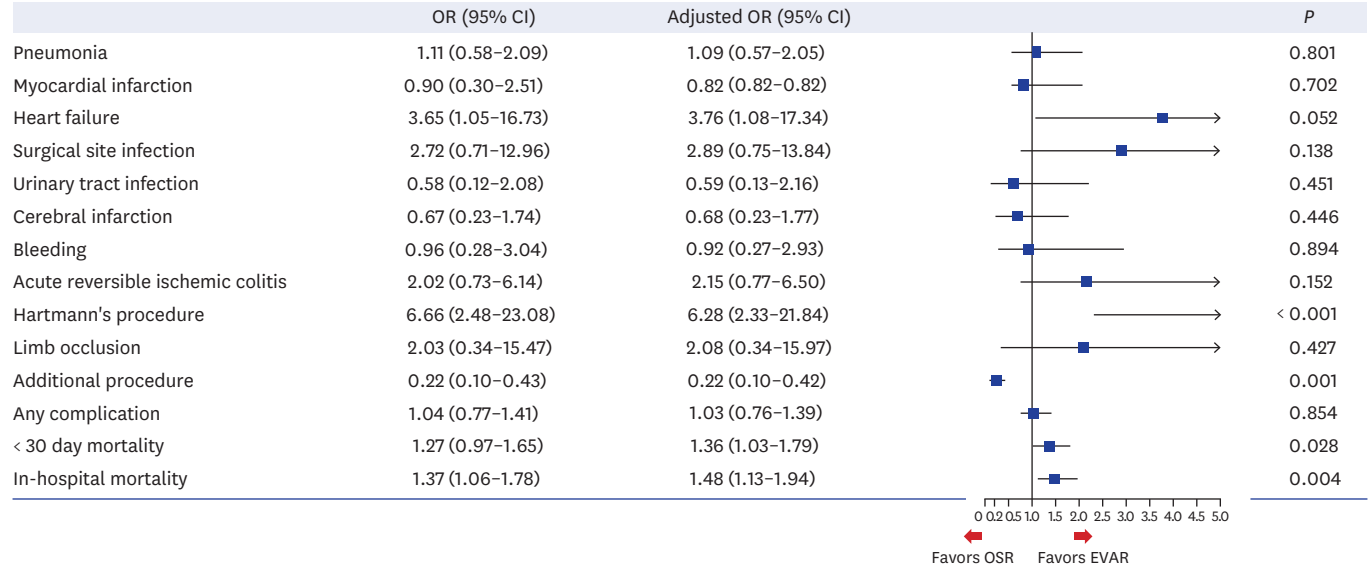

Fig. 3. Forest plot comparing perioperative outcomes, including perioperative complications and mortality, in patients who underwent EVAR or OSR for ruptured abdominal aortic aneurysms. The OR was calculated with EVAR as the reference. The adjusted OR was calculated by adjusting for age and sex.
EVAR = endovascular aneurysm repair, OSR = open surgical repair, OR = odds ratio, CI = confidence interval.

Table 2. Numbers of patients who underwent repair of ruptured abdominal aneurysm by time period

Variables	2008.07–2013.12	2014.01–2019.06	Total	*P*
Total	377	657	1,034	
EVAR	189 (50.1)	405 (61.6)	594 (57.5)	< 0.001
OSR	188 (49.9)	252 (38.4)	440 (42.6)	
Age[a], yr	71.4 ± 9.3	73.8 ± 9.0	72.9 ± 9.2	0.980
Octogenarians	75 (19.9)	183 (27.9)	258 (25.0)	0.005
Men	286 (75.9)	515 (78.4)	801 (77.5)	
EVAR	133 (46.5)	309 (60.0)	442 (55.2)	< 0.001
OSR	153 (53.5)	206 (40.0)	359 (44.8)	
Age[a], yr	70.3 ± 9.0	72.5 ± 8.7	71.7 ± 8.9	< 0.001
Octogenarians	46 (16.1)	109 (21.2)	155 (19.4)	0.571
Women	91 (24.1)	142 (21.6)	233 (22.5)	
EVAR	56 (61.5)	96 (67.6)	152 (65.2)	0.398
OSR	35 (38.5)	46 (32.4)	81 (34.8)	
Age[a], yr	75.0 ± 9.1	78.5 ± 8.4	77.1 ± 8.9	< 0.001
Octogenarians	29 (31.9)	74 (52.1)	103 (44.2)	0.003

Values are presented as mean ± standard deviation or number (%).
EVAR = endovascular aneurysm repair, OSR = open surgical repair.
[a]Age at time of repair of ruptured abdominal aortic aneurysm.

Long-term outcomes

Survival curves after 30 days were roughly parallel (**Fig. 4A**). All-cause mortality rates per 100 person-years of patients in the EVAR and OSR groups were 17.3 and 17.3, respectively (**Fig. 5**). Mortality rate within 3 months was significantly higher in the OSR group (adjusted HR, 1.29; 95% CI, 1.07–1.55; $P = 0.009$; **Fig. 5**), whereas the mortality rate excluding initial 3 months outcome was significantly lower in the OSR group (adjusted HR, 0.12; 95% CI, 0.03–0.49; $P = 0.003$). The reintervention rate, considering death as a competing risk, was significantly lower in the OSR group (adjusted HR, 0.31; 95% CI, 0.14–0.70; $P = 0.005$; **Figs. 4B** and **5**).

https://doi.org/10.3346/jkms.2023.38.e321

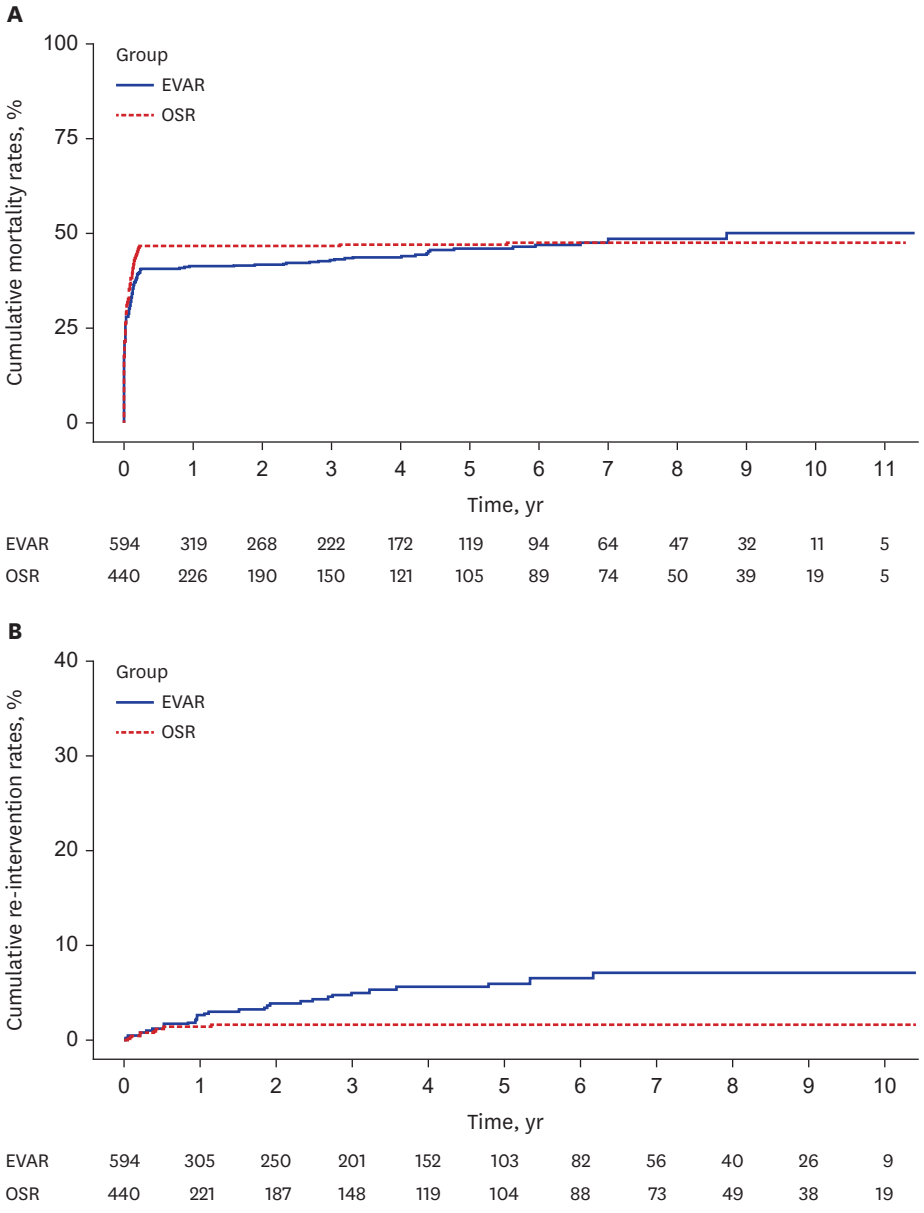

Fig. 4. Mortality rates of patients who underwent EVAR and OSR for ruptured abdominal aortic aneurysms over time (**A**) and cumulative incidence of reintervention, with death considered a competing risk (**B**).
EVAR = endovascular aneurysm repair, OSR= open surgical repair.

DISCUSSION

The present study evaluated the annual trends of rAAA management and outcomes using the Korean NHIS database. Compared with the first half of the study period, the total number of patients diagnosed with rAAA and the mean age of the patients were higher during the second half. In addition, the number of EVAR procedures increased, while the number of OSR procedures decreased. The perioperative complication rates in the two groups did not differ significantly. The bowel infarction rate requiring Hartmann's procedure and the perioperative mortality rate were significantly higher in the OSR group, whereas long-term

https://doi.org/10.3346/jkms.2023.38.e321

	Mortality rate (/100 person-years)				
	EVAR	OSR	HR (95% CI)	Adjusted HR (95% CI)	*P*
All-cause mortality	17.3	17.3	1.07 (0.89–1.29)	1.17 (0.98–1.41)	0.087
≤ 3 mo mortality	239.2	296.3	1.18 (0.98–1.42)	1.29 (1.07–1.55)	0.009
Long-term mortality[a]	1.8	0.2	0.10 (0.02–0.42)	0.12 (0.03–0.49)	0.003
Re-intervention[b]	2.2	0.6	0.29 (0.13–0.67)	0.31 (0.14–0.70)	0.005

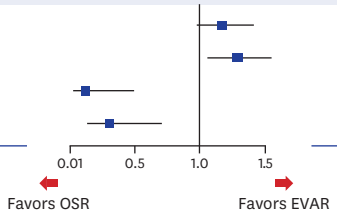

Fig. 5. Forest plot comparing all-cause mortality, mortality at ≤ 3 months, mortality at > 3 months, and reintervention in patients who underwent EVAR or OSR for ruptured abdominal aortic aneurysms. The HR was calculated with EVAR as the reference. The adjusted HR was calculated by adjusting for age and sex.
EVAR = endovascular aneurysm repair, OSR = open surgical repair, HR = hazard ratio, CI = confidence interval.
[a]Long-term mortality was calculated after excluding initial 3 months' outcome.
[b]The reintervention rate considered death as a competing risk.

mortality rate was lower in the OSR group, with no significant between group difference in all-cause mortality rate.

Similar to previous studies, EVAR was preferred for patients with rAAA in the present study.[15,16] Although the EVAR group generally included more patients with co-morbidities than the OSR group, the rates of major co-morbidities, including cerebrovascular accidents and ischaemic heart disease, were similar in the two groups. The decision whether to perform EVAR or OSR for rAAA mainly depended on surgeon preference, with the main determinant of procedure type being anatomic suitability rather than co-morbidities. The finding, that the reintervention rate was significantly higher in the EVAR than in the OSR group, suggests that the application of EVAR to patients with rAAA may be limited. The all-cause mortality rates were 17.30/100 person-years in both groups, similar to previous findings based on administrative data.[15] Because analysis of the Vascular Quality Initiative database showed that EVAR was associated with similar long-term survival but lower hospital morbidity rates than OSR, recent ESVS and SVS guidelines have recommended EVAR as the first-line treatment for rAAA.[2,3,17,18] In our study, when excluding initial 3 months' outcome, long-term mortality was significantly higher in the EVAR. This finding was in line with previous literature.[19] Therefore, considering the higher perioperative mortality in the OSR group and the worse long-term survival outcome with a higher reintervention rate in the EVAR group, the perioperative mortality risk and life expectancy should be considered when deciding the treatment method for rAAA, when anatomically suitable for both treatments.

In the present study, although the rates of postoperative complications were similar in the EVAR and OSR groups, the rate of Hartmann's procedure due to bowel infarction was significantly higher in the OSR group. rAAA is regarded as the most important determinant of postoperative bowel ischaemia.[20] Because bowel ischaemia is significantly associated with perioperative mortality, close monitoring, including frequent colonoscopy and early exploratory laparotomy, is warranted.[3,20]

The present study found that the number of patients who underwent repair for rAAA was higher during the second half than during the first half of the study period. Although this finding may indicate an actual increase in the prevalence of rAAA, the number of procedures can be affected by several other factors, including the rate of patients with rupture who arrive at the hospital alive and the proportion of patients turned down for surgical repair. Of the patients diagnosed with rAAA during the study period, only 22.5% were women,

https://doi.org/10.3346/jkms.2023.38.e321

with the percentage decreasing over time. The proportion of women was higher than in previous studies,[15,21,22] as was the proportion of octogenarians. The latter may be due to the marked increase in life expectancy in Korea, but it may also indicate that the number of ageing patients with a general condition allowing repair has increased. Thus, in an ageing society such as Korea, efforts will be needed to reduce rupture rates and improve mortality in the elderly population. An analysis of AAA mortality before and after the introduction of screening indicated that screening in itself may further reduce AAA-related mortality.[23-25] Increases in rAAA rates may lead to the introduction of a screening program and the identification of appropriate target populations to be screened.

This study had several limitations, including its retrospective design and the inability to determine the actual prevalence of rAAA because of limited information on patients dying outside a hospital setting. The main strength of this study was its determination of rAAA on nationwide data over a relatively long study period. A more reliable comparison of reintervention rates could be obtained by considering the high perioperative mortality of patients who underwent OSR as a competing risk. Moreover, to account for differences in follow-up periods among individual patients, this study calculated mortality rates as person-years. Detailed determinations of the trends in prevalence and mortality of rAAA may enable improvements in health care as well as comparisons with populations of other countries.

In conclusion, the total numbers of Korean patients with rAAA who underwent EVAR and the total numbers of octogenarians were higher from 2014 to 2018 than from 2009 to 2013. Although EVAR showed somewhat superior perioperative outcomes for rAAA, the long-term outcomes of EVAR after excluding initial 3 months were significantly worse than OSR. When anatomically feasible for both treatments, the perioperative mortality risk and reasonable prospects of long-term survival should be considered in rAAA.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Diagnostic and treatment codes used to define complications and outcomes in abdominal aortic aneurysm treatment

Click here to view

REFERENCES

1. Hurks R, Ultee KHJ, Buck DB, DaSilva GS, Soden PA, van Herwaarden JA, et al. The impact of endovascular repair on specialties performing abdominal aortic aneurysm repair. *J Vasc Surg* 2015;62(3):562-568.e3.
PUBMED | CROSSREF
2. Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA, et al. The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. *J Vasc Surg* 2018;67(1):2-77.e2.
PUBMED | CROSSREF
3. 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(1):8-93.
PUBMED | CROSSREF

4. IMPROVE Trial Investigators. Comparative clinical effectiveness and cost effectiveness of endovascular strategy *v* open repair for ruptured abdominal aortic aneurysm: three year results of the IMPROVE randomised trial. *BMJ* 2017;359:j4859.
PUBMED | CROSSREF
5. Edwards ST, Schermerhorn ML, O'Malley AJ, Bensley RP, Hurks R, Cotterill P, et al. Comparative effectiveness of endovascular versus open repair of ruptured abdominal aortic aneurysm in the Medicare population. *J Vasc Surg* 2014;59(3):575-82.
PUBMED | CROSSREF
6. Gunnarsson K, Wanhainen A, Djavani Gidlund K, Björck M, Mani K. Endovascular versus open repair as primary strategy for ruptured abdominal aortic aneurysm: a national population-based study. *Eur J Vasc Endovasc Surg* 2016;51(1):22-8.
PUBMED | CROSSREF
7. Sweeting MJ, Balm R, Desgranges P, Ulug P, Powell JT; Ruptured Aneurysm Trialists. Individual-patient meta-analysis of three randomized trials comparing endovascular versus open repair for ruptured abdominal aortic aneurysm. *Br J Surg* 2015;102(10):1229-39.
PUBMED | CROSSREF
8. Reimerink JJ, Hoornweg LL, Vahl AC, Wisselink W, van den Broek TA, Legemate DA, et al. Endovascular repair versus open repair of ruptured abdominal aortic aneurysms: a multicenter randomized controlled trial. *Ann Surg* 2013;258(2):248-56.
PUBMED | CROSSREF
9. Desgranges P, Kobeiter H, Katsahian S, Bouffi M, Gouny P, Favre JP, et al. Editor's choice - ECAR (Endovasculaire ou Chirurgie dans les Anévrysmes aorto-iliaques Rompus): a French randomized controlled trial of endovascular versus open surgical repair of ruptured aorto-iliac aneurysms. *Eur J Vasc Endovasc Surg* 2015;50(3):303-10.
PUBMED | CROSSREF
10. IMPROVE Trial Investigators, Powell JT, Sweeting MJ, Thompson MM, Ashleigh R, Bell R, et al. Endovascular or open repair strategy for ruptured abdominal aortic aneurysm: 30 day outcomes from IMPROVE randomised trial. *BMJ* 2014;348:f7661.
PUBMED | CROSSREF
11. Mohan PP, Hamblin MH. Comparison of endovascular and open repair of ruptured abdominal aortic aneurysm in the United States in the past decade. *Cardiovasc Intervent Radiol* 2014;37(2):337-42.
PUBMED | CROSSREF
12. Mayer D, Aeschbacher S, Pfammatter T, Veith FJ, Norgren L, Magnuson A, et al. Complete replacement of open repair for ruptured abdominal aortic aneurysms by endovascular aneurysm repair: a two-center 14-year experience. *Ann Surg* 2012;256(5):688-95.
PUBMED | CROSSREF
13. Lederle FA, Freischlag JA, Kyriakides TC, Padberg FT Jr, Matsumura JS, Kohler TR, et al. Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. *JAMA* 2009;302(14):1535-42.
PUBMED | CROSSREF
14. United Kingdom EVAR Trial Investigators, Greenhalgh RM, Brown LC, Powell JT, Thompson SG, Epstein D. Endovascular repair of aortic aneurysm in patients physically ineligible for open repair. *N Engl J Med* 2010;362(20):1872-80.
PUBMED | CROSSREF
15. Salata K, Hussain MA, de Mestral C, Greco E, Awartani H, Aljabri BA, et al. Population-based long-term outcomes of open versus endovascular aortic repair of ruptured abdominal aortic aneurysms. *J Vasc Surg* 2020;71(6):1867-1878.e8.
PUBMED | CROSSREF
16. Acher C, Acher CW, Castello Ramirez MC, Wynn M. Operative mortality and morbidity in ruptured abdominal aortic aneurysms in the endovascular age. *Ann Vasc Surg* 2020;66:70-6.
PUBMED | CROSSREF
17. Ali MM, Flahive J, Schanzer A, Simons JP, Aiello FA, Doucet DR, et al. In patients stratified by preoperative risk, endovascular repair of ruptured abdominal aortic aneurysms has a lower in-hospital mortality and morbidity than open repair. *J Vasc Surg* 2015;61(6):1399-407.
PUBMED | CROSSREF
18. D'Oria M, Hanson KT, Shermerhorn M, Bower TC, Mendes BC, Shuja F, et al. Editor's choice - Short term and long term outcomes after endovascular or open repair for ruptured infrarenal abdominal aortic aneurysms in the vascular quality initiative. *Eur J Vasc Endovasc Surg* 2020;59(5):703-16.
PUBMED | CROSSREF

19. Antoniou GA, Antoniou SA, Torella F. Editor's choice - Endovascular vs. open repair for abdominal aortic aneurysm: systematic review and meta-analysis of updated peri-operative and long term data of randomised controlled trials. *Eur J Vasc Endovasc Surg* 2020;59(3):385-97.
PUBMED | CROSSREF

20. Ultee KH, Zettervall SL, Soden PA, Darling J, Bertges DJ, Verhagen HJ, et al. Incidence of and risk factors for bowel ischemia after abdominal aortic aneurysm repair. *J Vasc Surg* 2016;64(5):1384-91.
PUBMED | CROSSREF

21. Martinelli O, Fenelli C, Ben-Hamida JB, Fresilli M, Irace FG, Picone V, et al. One-year outcomes after ruptured abdominal aortic aneurysms repair: is endovascular aortic repair the best choice? a single-center experience. *Ann Vasc Surg* 2018;53:63-9.
PUBMED | CROSSREF

22. Dias-Neto M, Castro-Ferreira R, Mani K, Freitas A, Leite-Moreira A, Sampaio SM. Nationwide analysis of ruptured abdominal aortic aneurysm in Portugal (2000-2015). *Eur J Vasc Endovasc Surg* 2020;60(1):27-35.
PUBMED | CROSSREF

23. Wanhainen A, Hultgren R, Linné A, Holst J, Gottsäter A, Langenskiöld M, et al. Outcome of the Swedish Nationwide Abdominal Aortic Aneurysm Screening Program. *Circulation* 2016;134(16):1141-8.
PUBMED | CROSSREF

24. Glover MJ, Kim LG, Sweeting MJ, Thompson SG, Buxton MJ. Cost-effectiveness of the National Health Service Abdominal Aortic Aneurysm Screening Programme in England. *Br J Surg* 2014;101(8):976-82.
PUBMED | CROSSREF

25. Guirguis-Blake JM, Beil TL, Senger CA, Coppola EL. Primary care screening for abdominal aortic aneurysm: updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA* 2019;322(22):2219-38.
PUBMED | CROSSREF