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Original Article

Nationwide Epidemiologic Study of Abdominal Aortic Aneurysms in Korea: A Cross-Sectional Study Using National Health Insurance Review and Assessment Service Data

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Purpose: The prevalence and treatment patterns of abdominal aortic aneurysm (AAA) vary according to ethnicity and region. This study analyzed nationwide data on the epidemiology, practice patterns, and mortality rates of AAA in Korea.

Materials and Methods: Data from patients treated for AAA from 2012 to 2016 were extracted from the Korean Health Insurance Review and Assessment (HIRA) database.

Results: A total of 30,766 patients in Korea had treatment codes for AAA and 2,618 patients were treated for ruptured AAA. Of the 6,356 patients treated surgically, 1,849 and 4,507 underwent open surgical aneurysmal repairs (OSAR) or endovascular aneurysmal repairs (EVAR), respectively. The number of surgical treatments performed annually for AAA increased from 1,129 cases in 2012 to 1,501 cases in 2016. The number of EVAR cases increased from 753 to 1,109 during these five years, while the number of OSAR cases remained similar, at 376 and 392, respectively. The 30-day mortality rates after EVAR and OSAR were 4.2% and 10.6%, respectively. The mortality rates were significantly higher in patients with hypertension, dyslipidemia, chronic renal disease, diabetes mellitus, and congestive heart failure. There were significant differences in the prevalence, proportion of EVAR, and mortality rates according to the regional area.

Conclusion: The prevalence of AAA and the proportion of EVAR in Korea increased in the past 5 years, while the rupture rate and the proportion of OSAR remained similar. To minimize mortality and regional discrepancies, nationwide registry and treatment standardization are needed.

Key Words: Abdominal aortic aneurysm, Korea, Big data, Health insurance, Mortality

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INTRODUCTION

The prevalence and treatment patterns of abdominal aortic aneurysm (AAA) vary globally [1,2]. In western countries, the prevalence of AAA has increased during recent decades [3-6]. However, a significant reduction in AAA prevalence has been reported in recent years [7-10]. As AAA-related death is an important cause of preventable death, several governments and health organizations including the American Heart Association in the United States and National Health Service in the United Kingdom report annual statistics on the nationwide epidemiology of AAA [11,12]. However, the nationwide data of AAA in Korea is limited due to the lack of a nationwide registry. Therefore, data from single centers or collection of questionnaires from experts have been used to gauge the national practice patterns of AAA in Korea [13-17].

Since April 2014, the Health Insurance Review and Assessment (HIRA) service has provided big data based on health insurance claims, which can be used to construct a nationwide Korean database by the healthcare big data center. This study analyzed the epidemiology of AAA in South Korea, including the prevalence, practice patterns, mortality rates, and regional differences.

MATERIALS AND METHODS

1) HIRA database

The public medical insurance system in South Korea covers almost all patients through the National Health Insurance (NHI) and National Medical Aid (NMA) programs. The HIRA service is a government-operated organization that builds accurate review and quality assessment systems for NHI and NMA claims. Healthcare service providers submit claims data to the HIRA for reimbursement for services provided to patients. Access to HIRA data is regulated by the Rules for Data Exploration and Utilization of the HIRA. The present study used data after receiving approval from the HIRA data access committee. All data were delivered anonymously and none of the researchers had access to any potentially identifying personal information, including the patient names, addresses, and dates of birth. This study was approved by the Institutional Review Board of Seoul National University Hospital (IRB No. E-1707-059-868).

Data on patients treated for AAA between 2012 and 2016 were extracted from the HIRA database by complete enumeration. The patients were classified according to year, regions of medical centers at which they received treatment, age, sex, and risk factors or comorbidities. All patients had one or more disease codes of AAA (I71.3, I71.4, I71.5, I71.6, I71.8, and I71.9) according to the Korean standard classification of diseases (KCD, 7th). Age was classified as underage (less than 20 years), young (20 to 39 years), middle-age (40 to 59 years), or old (60 years or more). The risk factors or comorbidities included hypertension (I10–13, I15), dyslipidemia (E78), diabetes mellitus (E10–14), coronary artery disease (I20–25, Z95.1, Z95.5), cerebral vascular accident (I60–69), chronic renal disease (N17–19, I12, I13), vasculitis (M05.2, M31.4, M32, M35.2, I77.6, I79.1), congestive heart failure (I50), and chronic obstructive pulmonary disease (J44). Smoking (F17) and obesity (E66), also well-known risk factors, were excluded due to the lack of data. The AAA type was categorized as ruptured (I71.3, I71.5, I71.8) or unruptured (I71.4, I71.6, I71.9). Additionally, surgical treatment for AAA was divided into endovascular aneurysmal repair (EVAR) or open surgical aneurysmal repair (OSAR).

2) Definitions

Rehospitalization and patient death occurring within 30 days after AAA treatment were considered AAA-related rehospitalization and death.

① Classification of medical institutions

The medical institutions were classified according to the regions and referral grade as primary, secondary, or tertiary hospitals. A primary hospital was defined as a hospital with fewer than 100 beds. A secondary hospital was defined as a hospital with more than 100 to 300 beds and with 7 to 9 or more medical departments. A tertiary hospital was defined as a specialized center for severe diseases with 20 or more medical departments assigned at least one specialist, which was designated by the Ministry of Health and Welfare every three years. Korea contains 42 tertiary hospitals; 13 in Seoul, five in Gyeonggi, four each in Busan and Daegu, three in Incheon, two each in Chungnam, Jeonbuk, Gwangju, and Gyeongnam, and one each in Daejeon, Gangwon, Chungbuk, Jeonnam, and Gyeongbuk.

② Regional classification

South Korea was divided into seven metropolitan cities and nine provinces and the data were provided by the HIRA according to regions. Metropolitan cities, defined as a city with populations exceeding one million, included Seoul, Busan, Incheon, Daegu, Daejeon, Gwangju, and Ulsan. The regional populations as of 2016, published by the National Statistical Office, were as follows: Gyeonggi (12,671,956), Seoul (9,805,506), Busan (3,440,484), Gyeongnam (3,339,633), Incheon (2,913,024), Gyeongbuk (2,682,169), Daegu (2,461,002), Chungnam (2,132,566), Jeonbuk (1,833,168), Jeonnam (1,796,017), Chungbuk (1,603,404), Daejeon (1,535,445), Gangwon (1,521,751), Gwangju (1,501,557), Ulsan (1,166,033), and Jeju (623,332) (Statistics Korea, http://kostat.go.kr).

3) Statistics

The statistical analyses were conducted using SAS Enterprise Guide 6.1 and SAS Enterprise Miner 13.2 (SAS Institute Inc., Cary, NC, USA). The data were analyzed in the remote analysis system provided by the HIRA. The data used in the statistical analyses were expressed as means±standard deviation and P-values <0.05 were considered statistically significant. Chi-square tests were used to evaluate the correlations between each risk factor and mortality. Statistical maps were provided by Bing Maps (Microsoft, Redmond, WA, USA).

RESULTS

1) Prevalence

The national prevalence of AAA and ruptured AAA increased during the five-year study period (Fig. 1). The prevalence of AAA patients tended to be high in metro-

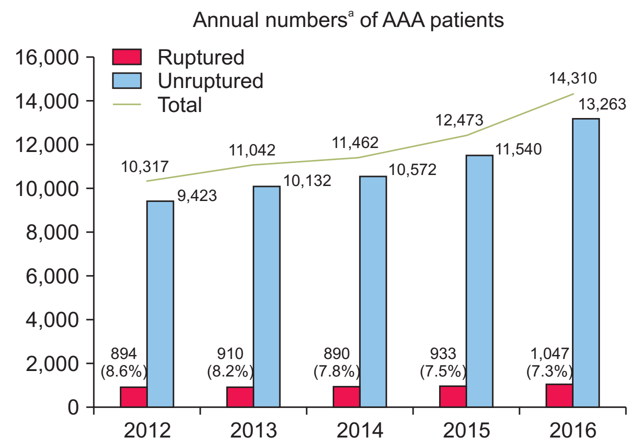
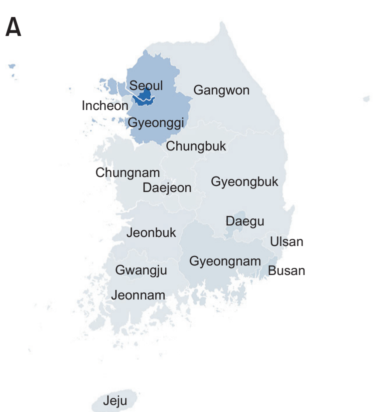


Fig. 2. Annual changes in ruptured or unruptured abdominal aortic aneurysm (AAA). [a]Duplicate patient between each year was not removed.

A



Total AAA	2012	2013	2014	2015	2016
National	10,317	11,042	11,462	12,473	14,310
Seoul	4,474	4,645	4,688	5,103	5,761
Gyeonggi	1,522	1,705	1,753	1,973	2,343
Busan	815	934	895	962	1,109
Daegu	750	828	892	976	1,093
Gyeongnam	510	526	571	610	719
Gwangju	444	504	494	568	654
Incheon	360	372	412	446	521
Daejeon	316	307	375	369	426
Jeonbuk	243	250	284	316	356
Ulsan	163	183	221	230	293
Gangwon	228	236	257	295	286
Gyeongbuk	225	238	245	246	281
Jeju	189	190	186	205	279
Jeonnam	204	210	223	240	242
Chungnam	142	150	173	181	218
Chungbuk	129	155	167	185	217

Ruptured AAA	2012	2013	2014	2015	2016
National	894	910	890	933	1,047
Seoul	286	271	262	264	296
Gyeonggi	153	146	125	143	176
Busan	85	91	88	95	112
Daegu	78	95	109	99	102
Gyeongnam	51	60	48	66	71
Gwangju	45	50	37	53	62
Incheon	34	33	46	35	38
Ulsan	10	17	25	20	38
Jeonbuk	26	19	21	36	31
Chungbuk	11	6	15	15	27
Jeju	11	21	19	18	27
Daejeon	31	20	26	28	25
Gangwon	36	35	34	23	25
Gyeongbuk	20	31	24	21	22
Chungnam	19	24	18	22	20
Jeonnam	13	13	10	27	11

B

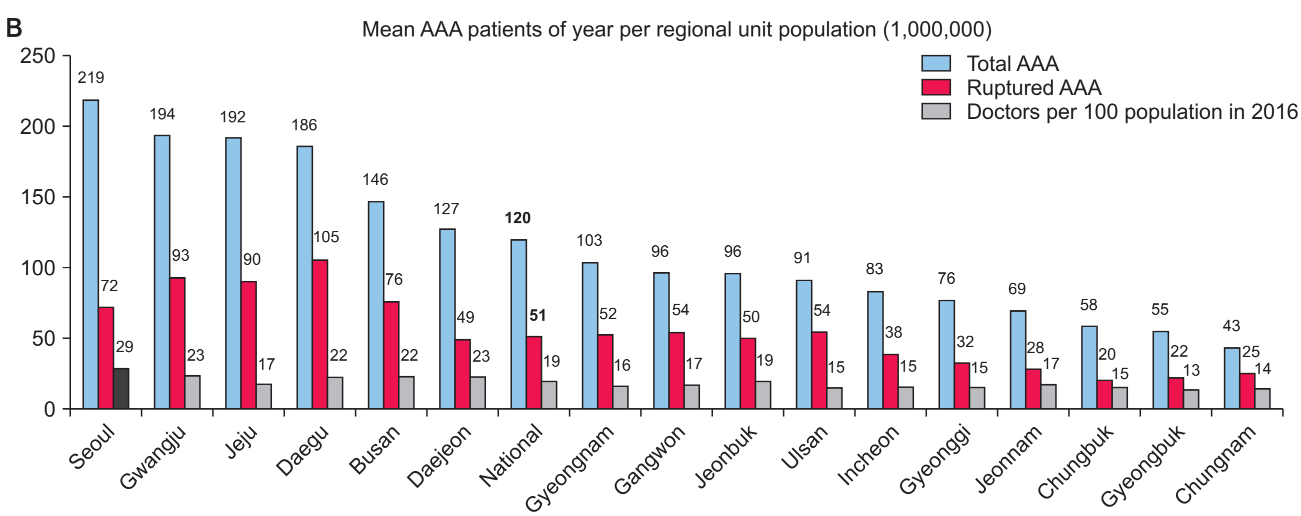


Fig. 1. National prevalence of abdominal aortic aneurysm (AAA) in Korea. (A) Prevalence of total and ruptured AAA. (B) Prevalence of AAA according to region. Duplicate patient between each year was not removed.

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politan cities including Seoul than that in other regions in 2012 and 2016, although the difference was not statistically significant (P=0.229, 0.236); moreover, the number of ruptured AAA patients also tended to increase (P=0.240 in 2012, 0.191 in 2016) (Fig. 1A). However, the mean prevalence of total AAA and ruptured AAA patients during the five-year period without duplicate were significantly higher in metropolitan cities than other regions (P=0.023 for total AAA, P=0.031 for ruptured AAA) (Fig. 1B). The prevalence of patients may be affected by the number of regional doctors. The numbers of doctors per regional population were higher in metropolitan cities than those in other regions (2.13±0.49 vs. 1.93±0.18, P=0.008). The number of total AAA patients was significantly correlated with both the number of regional doctors (P<0.001) and the number of patients with ruptured AAA (P=0.005). From 2012 to 2016, cases of both total and ruptured AAA increased consistently (Fig. 2). However, the ratio of ruptured/total AAA decreased significantly, from 8.6% in 2012 to 7.3% in 2016 (P<0.001).

2) Age, sex, and comorbidities

The mean age was 63.5±1.56 years (Fig. 3) and was lowest in Seoul (68.7±1.87) and highest in Jeonnam (71.4±2.09).

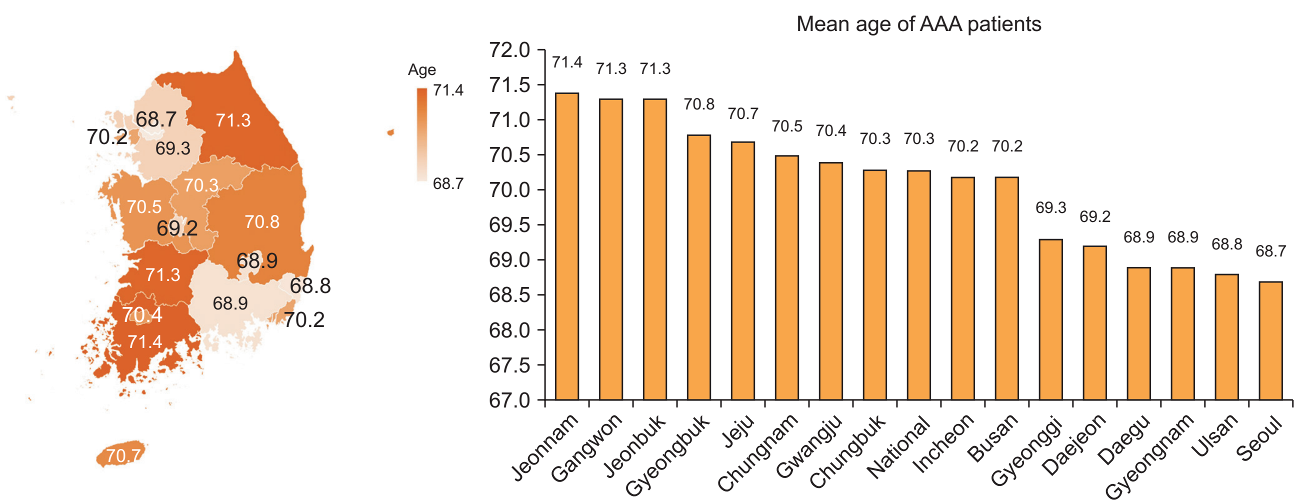
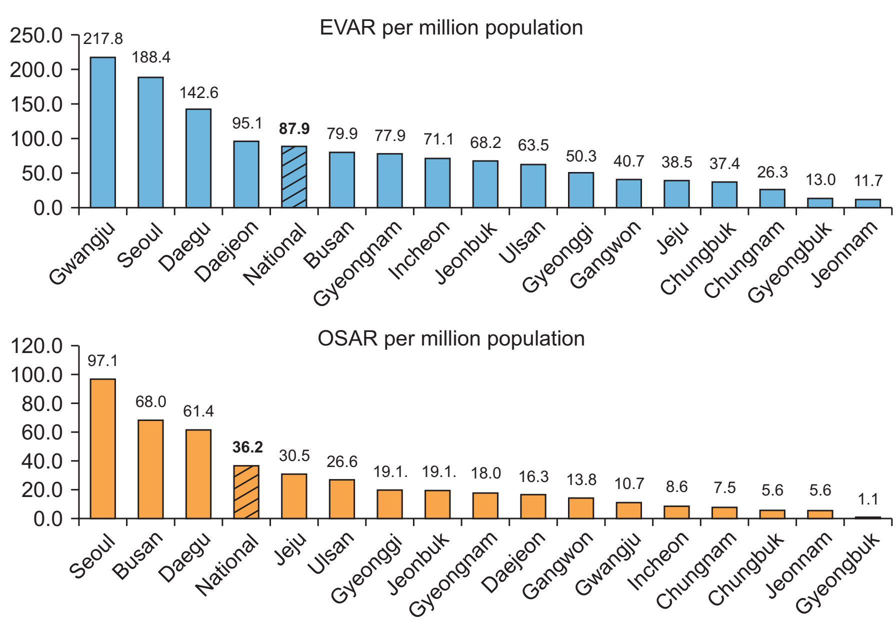


Fig. 3. Mean age of patients with abdominal aortic aneurysm (AAA).



	EVAR (n)	OSAR (n)	EVAR/Total (%)
Gwangju	327	16	95.3
Gyeongbuk	35	3	92.1
Incheon	207	25	89.2
Chungbuk	60	9	87
Daejeon	146	25	85.4
Gyeongnam	260	60	81.3
Jeonbuk	125	35	78.1
Chungnam	56	16	77.8
Gangwon	65	21	74.7
Gyeonggi	637	242	72.5
National	4,507	1,849	70.9
Ulsan	74	31	70.5
Daegu	351	151	69.9
Jeonnam	21	10	67.7
Seoul	1,847	952	66
Jeju	24	19	55.8
Busan	275	234	54

Fig. 4. National practice patterns of abdominal aortic aneurysm (AAA) surgery by endovascular aneurysmal repair (EVAR) or open surgical aneurysmal repair (OSAR).

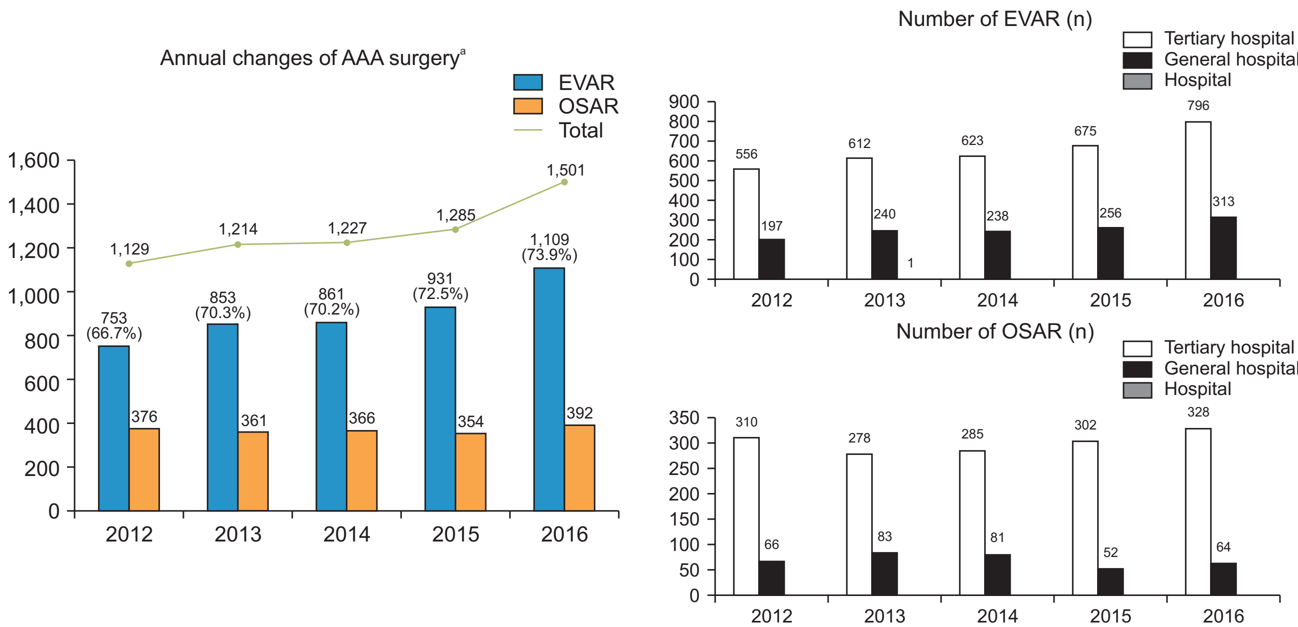


Fig. 5. Annual changes in abdominal aortic aneurysm (AAA) surgery by endovascular aneurysmal repair (EVAR) or open surgical aneurysmal repair (OSAR). [a]Duplication is excluded between each year.

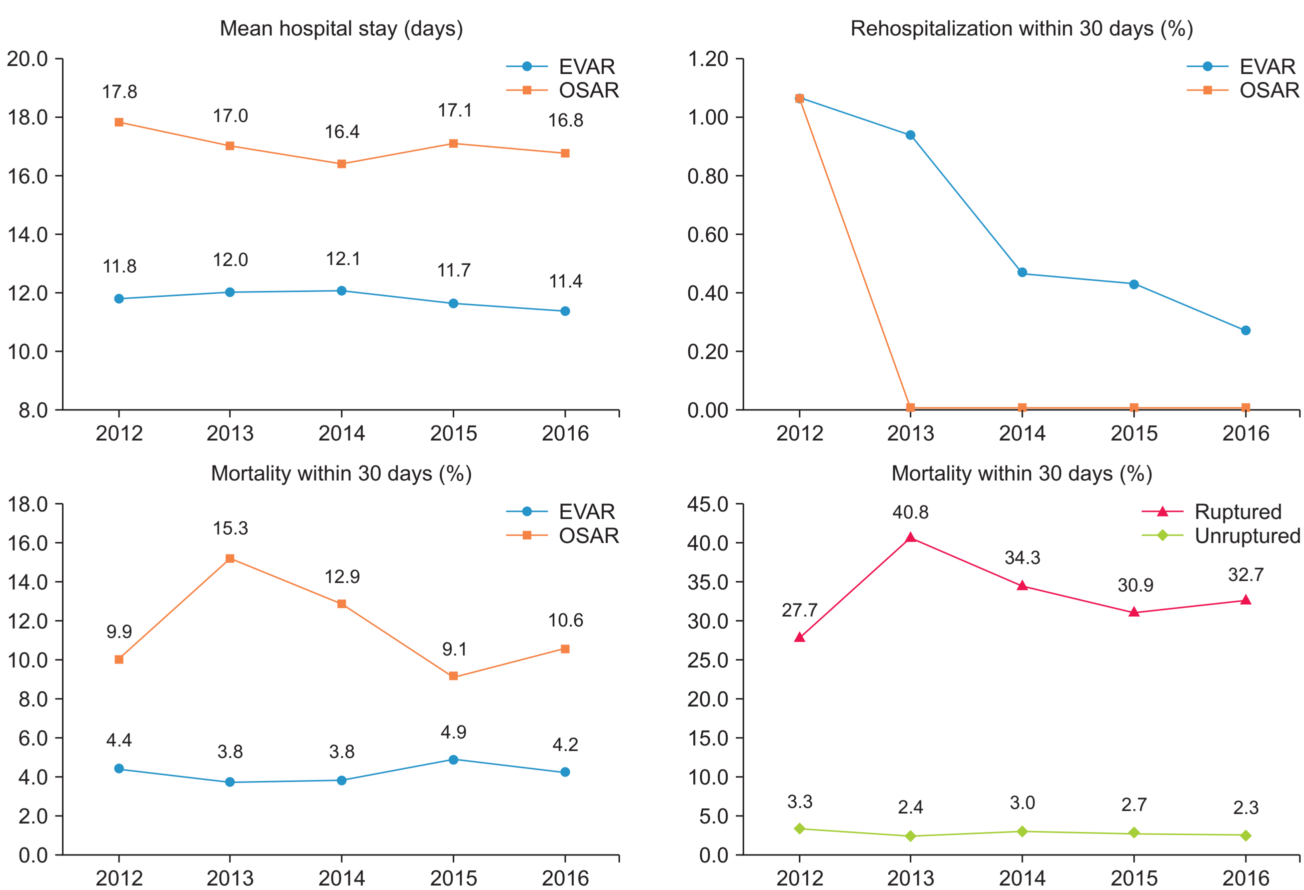


Fig. 6. Hospital stay, rehospitalization, and mortality for endovascular aneurysmal repair (EVAR) or open surgical aneurysmal repair (OSAR).

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There was no difference in age between metropolitan cities and other regions (P=0.232). Males comprised 68.5% of patients. The comorbidities included hypertension (6.40%), dyslipidemia (4.21%), coronary artery disease (2.59%), chronic kidney disease (2.46%), diabetes (1.99%), cerebral vascular accident (0.89%), congestive heart failure (0.78%), chronic obstructive pulmonary disease (0.49%), and vasculitis (0.10%).

3) Treatment

During the 5-year study period, 6,356 (20.7%) patients with AAA received surgical treatment including EVAR or OSAR. EVAR was performed in 70.9% of cases (Fig. 4), and the EVAR ratio in total AAA surgery did not differ between metropolitan cities and other regions (72.7%±13.6% vs. 76.3%±10.6%, P=0.718).

While the total number of surgical treatments increased during the 5-year study period, the ratio of surgical treatments per total AAA patients did not differ between 2012 (21.2%) and 2016 (20.3%) (P=0.255). However, the ratio of EVAR increased significantly from 2012 (66.7%) to 2016 (73.9%) (P<0.001) (Fig. 5).

By volumes of procedures according to medical institution types, EVARs performed at tertiary hospitals decreased from 73.8% in 2012 to 71.8% in 2016. OSARs conducted at tertiary hospitals increased from 82.4% in 2012 to 83.5% in 2016. OSAR was rarely performed at primary hospitals (0% to 0.1%).

4) Hospital stay, rehospitalization, and mortality

The mean hospital stays for EVAR and OSAR were 11.8 and 17.0 days, respectively (Fig. 6). The mean hospital stays for EVAR and OSAR also did not differ significantly from 2012 to 2016 (P=0.956 and P=0.974, respectively). Rehos-

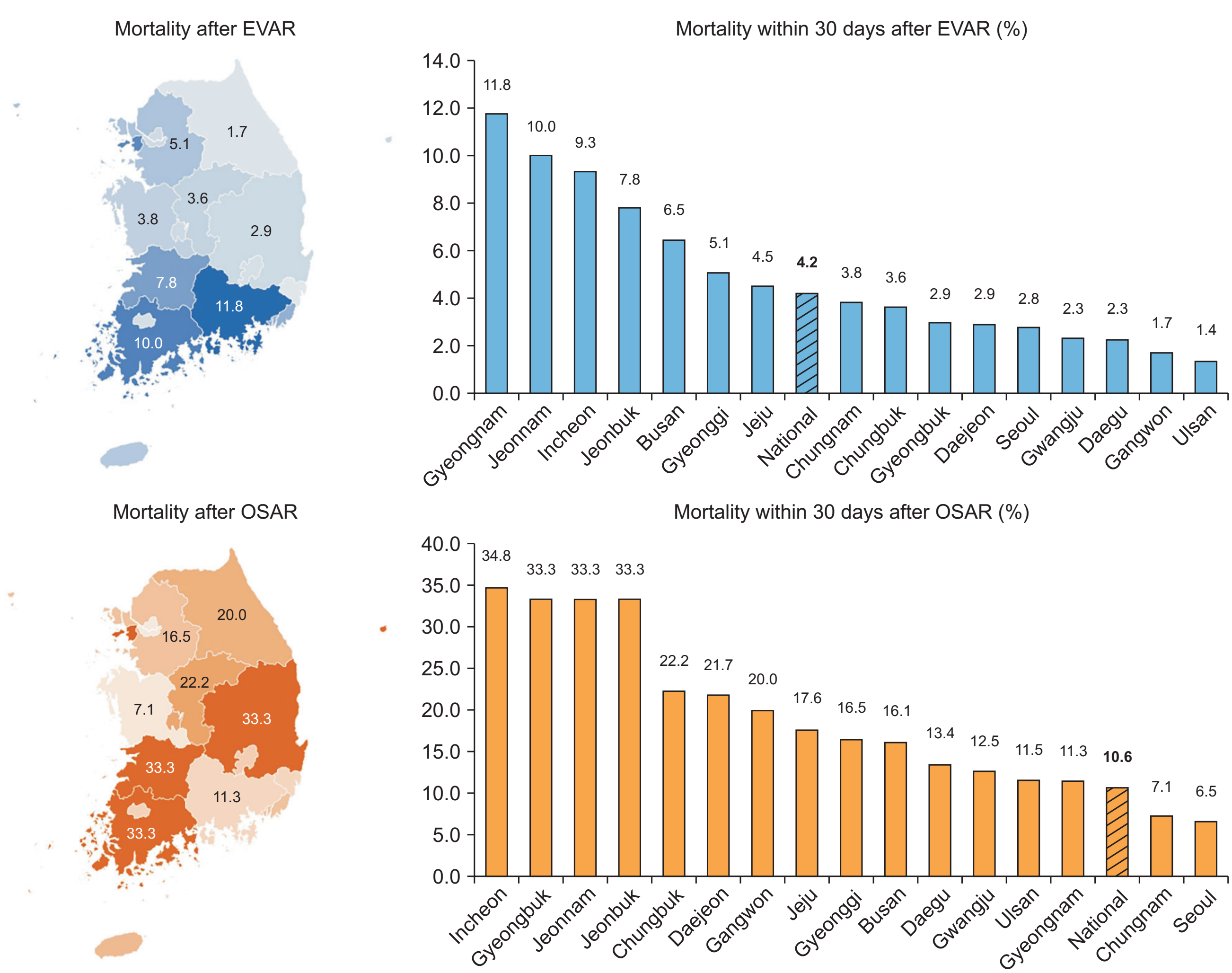
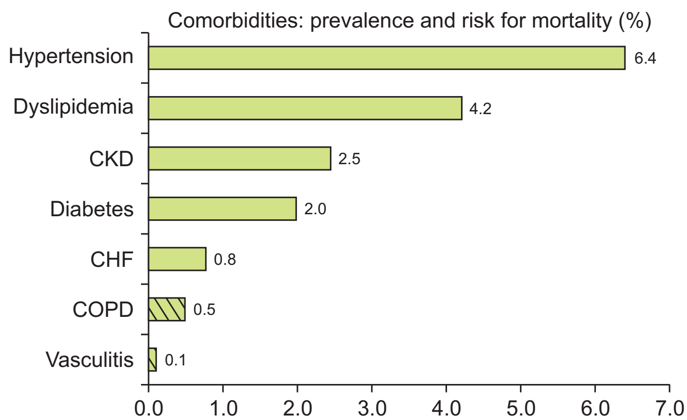


Fig. 7. Nationwide 30-day mortality following endovascular aneurysmal repair (EVAR) or open surgical aneurysmal repair (OSAR).



OR	P
1.510	**<0.0001**
1.307	**<0.0001**
7.841	**<0.0001**
1.463	**0.0006**
1.795	**0.0016**
1.667	0.4139
1.367	0.3231

Fig. 8. Risk factors for mortality within 30 days after abdominal aortic aneurysm surgery. CKD, chronic kidney disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; OR, odds ratio.

pitalization within 30 days decreased in the EVAR group from 2012 (1.06%) to 2016 (0.27%) without statistical significance (P=0.316). OSAR patients had no readmission codes within 30 days.

Mortality within 30 days did not change significantly for either EVAR (P=0.986) or OSAR (P=0.818) between 2012 and 2016. However, the mortality rates were much lower in the EVAR group (4.2±0.5) than those in the OSAR group (11.6±2.5) (P<0.001). The mortality rate was higher in the ruptured AAA group (33.3±4.9) compared to that in the unruptured AAA group (2.7±0.4) (P<0.001). The changes in 30-day mortality during the study period did not differ between the rupture (P=0.544) and unruptured AAA groups (P=0.659). Despite regional differences, the nationwide mortality of total AAA was 4.2% after EVAR and 10.6% after OSAR (Fig. 7). No significant differences in 30-day mortality after EVAR and OSAR were observed between metropolitan cities and other regions. However, the difference between the highest and lowest mortality rates according to region was significant in both EVAR (P=0.002) and OSAR (P<0.001).

The risk factors related to mortality after AAA treatment according to comorbidities included chronic kidney disease (odds ratio [OR], 7.841; P<0.0001), congestive heart failure (OR, 1.795; p=0.0016), hypertension (OR, 1.510; P<0.0001), diabetes (OR, 1.463; P=0.0006), and dyslipidemia (OR, 1.307; P<0.0001) (Fig. 8).

DISCUSSION

The healthcare database based on health insurance claims provided by the HIRA makes it easy to access healthcare big data and analyze data from a nationwide survey. However, detailed disease information such as AAA diameter is not provided and it is difficult to confirm the medical history. All information is provided in KCD codes; thus, researchers must draw conclusions based on these disease codes. In addition, only the disease codes claimed for insurance reimbursement were included; thus, diseases or conditions not covered by the insurance may have been omitted from the database. For example, while we tried to analyze the prevalence of obesity and smoking with AAA, the number was too small to reflect these in the real world because these codes were not claimed on health insurance. Another limitation is that the HIRA data does not provide personally identifiable information to match patients and remove duplications during the study period. We tried to extract data without duplication and sometimes manually eliminated the duplicates. Despite these limitations, the HIRA data includes almost all medical information associated with health insurance claims for the entire population by complete enumeration. Therefore, the present nationwide big data study using the HIRA data is very reliable and highly reproducible compared to surveys using sample data or questionnaires [16,18,19].

The prevalence of AAA in Korea increased during the study period, from 201 to 278 per million population, respectively, in 2012 and 2016. In contrast, the prevalence of AAA in Swedish individuals aged 65 to 75 years is decreasing (men 16.9%, women 3.5% in 1999; men 5.7%, women 1.1 % in 2010) [7]. Moreover, the proportion of ruptured AAA decreased in Korea (8.6% in 2012, and 7.3% in 2016), Sweden (6.1% in 2006–2010 and 4.0% in 2010–2014), and England (3.62% decrease from 2000 to 2009) [8,9]. This could be due to early detection by screening studies and best medical therapies including statins. The increased use EVAR for the treatment of AAA seems to be a global trend, including in Korea, where the number and ratio of EVAR procedures in Korea have been increasing annually since the early 2000s [19,20]. The popularity of EVAR is mainly due to its minimally invasive nature, short hospital stay, and low mortality despite concerns regarding its long-term safety and cost-effectiveness [21,22].

By region, the mean numbers of total or ruptured AAA were higher in large metropolitan cities, including Seoul, than those in other regions, which reflected improved ac-

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cessibility in large cities. About one-third of tertiary hospitals are concentrated in Seoul and two-thirds in large metropolitan cities. Regional differences in the ratios of EVAR to OSAR may reflect these difference in medical resources and medical staff preferences [21,22]. Considering the increasing rate of EVAR for AAA compared to that for OSAR in general hospital grades, this phenomenon could be due to inevitable selection for limited medical resources. Differences in rewards given to medical institutions by treatment type, EVAR or OSAR, may also impede medical investments in these regions. However, the differences between the highest and lowest mortalities rates were significant in both EVAR (11.8% vs. 1.4%) and OSAR (34.8% vs. 6.5%), although no regional difference in mortality after EVAR or OSAR were observed between metropolitan cities and other regions. This may reflect the need for treatment standardization and quality control in addition to the different regional distributions of critically ill patients.

Because this study was based on claim disease codes, it was difficult to accurately identify the actual causes of rehospitalization and death. We considered rehospitalization and mortality within 30 days after treatment to be AAA-related and found the rates to be much higher than those reported in the literature. This finding underscored the need to establish a nationwide prospective registry to define real AAA-related complications.

Since the detailed medical information of each patient was not provided, AAA characteristics such as diameter, anatomy, accompanying vasculitis or infection, and combining risk factors were difficult to analyze. Particularly, previous literature reported that hypertension accompanied 23.8% to 92.3% of AAA patients [23]. However, only 6.8% of the patients in the present study had accompanying hypertension. The rate could have been underestimated if the code for hypertensive disease was not included during AAA treatment. Similarly, we observed no cases of rehospitalization within 30 days after OSAR. This may have occurred because the patients were admitted with another code without AAA code or the data was not filtered to the same patient when admitted to another hospital. The new data platform linking individual healthcare data between the HIRA and the Korea Health Insurance Corporation was opened on September 17, 2019, and is expected to overcome these problems (http://hcdl.mohw.go.kr). We hope that these renewal datasets can be used to conduct future researches such as correlation studies.

CONCLUSION

The prevalence of AAA patients in Korea was increasing probably due to increasing aging population and changes to western lifestyle. However, the prevalence of ruptured AAA remained consistent. The total number of AAA surgeries increased, with increasing proportions of EVAR and consistent proportions of OSAR. As expected, EVAR showed better outcomes of mean hospital stay and 30-day mortality compared to those for OSAR. Significant regional differences were observed in the type of AAA repair and 30-day mortality. A nationwide registry is required to define the accurate 30-day mortality rates and their causes. Moreover, a national audit of patient care is needed to standardize treatment protocols for optimal patient outcomes.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

Concept and design: CC, SKM. Analysis and interpretation: CC, RS. Data collection: CC, RS. Writing the article: CC, SKM. Critical revision of the article: SA, SM, MA, JH, SKM. Final approval of the article: HJY, SKM. Statistical analysis: CC, HJY, RS, SHC. Obtained funding: none. Overall responsibility: CC, HJY, SKM.

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