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Clinical Research

Risk Factors for Abdominal Aortic Aneurysm in the Korean Population

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Background: Ultrasound screening shows a clinical benefit in reducing abdominal aortic aneurysm (AAA)–related mortality. However, its cost-effectiveness remains unclear. Understanding the relationship between risk factors and AAA is important to maximize the benefit of AAA screening. However, risk factors for AAA have not been reported in Korea. The purpose of this study is to determine the prevalence of, and risk factors for, AAA among the Korean population.

Methods: The study population consisted of patients >50 years of age who consented for AAA screening. Screening was performed as follows for all participants: collection of demographic information, including risk factors, physical examination, and ultrasound screening. We measured the maximal diameter of the aorta from the outer to outer layer at 5 levels: suprarenal, renal, and infrarenal aorta, and bilateral common iliac arteries. AAA was defined as maximal aortic diameter >3 cm. The risk factors and risk ratio for AAA were determined. Chi-square test and a logistic regression model were used for statistical analysis. All P-values <0.05 were considered significant.

Results: A total of 2,035 participants were enrolled. Among them, 908 (44.6%) were men and 1,127 (55.4%) were women. Mean age was 66.9 ± 10.3 years (range 23–95). AAA was detected in 18 of 908 (2.0%) men and 4 of 1,127 (0.4%) women. The presence of an AAA was significantly correlated with male sex ($P < 0.001$), advanced age ($P = 0.01$), smoking ($P < 0.001$), alcohol consumption ($P < 0.01$), and the presence of pulmonary disease ($P = 0.01$). Multivariate analysis revealed that smoking was the only significant risk factor for AAA.

Conclusions: The prevalence of AAA was 2.0% in men and 0.4% in women. Male sex, old age, smoking, alcohol use, and pulmonary disease are possible risk factors for AAA in the general Korean population. Smoking is the strongest risk factor for the development of AAA.

INTRODUCTION

An abdominal aortic aneurysm (AAA) can remain asymptomatic or produce minimal symptoms for many years, despite a large diameter. However, AAA rupture is associated with abdominal distension, a pulsating abdominal mass, hypovolemic shock, and eventual death, if not repaired immediately. Growing evidence suggests that ultrasound screening can be effective in avoiding the need for emergent operations and reducing AAA-related mortality.[1–3]

Despite this evidence of a clinical benefit, the cost-effectiveness of ultrasound screening remains unclear.[4,5] Estimates of cost-effectiveness for ultrasound screening of AAA are country-specific because of variable prevalence of AAA and ultrasound costs. An international consensus suggests that one-off ultrasound screening in men aged about 65 years is cost-effective.[4]

The relationship between risk factors and AAA is important to maximize the benefit of AAA

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screening. Classic risk factors for atherosclerosis are the same as those for AAA, such as cigarette smoking, male sex, age, hypertension, and hyperlipidemia.[3,6] However, the risk factors for AAA have not been reported in Korea. The purpose of this study is to determine the prevalence and risk factors for AAA in the Korean population.

MATERIALS AND METHODS

The study population was recruited from Hanam city, Seoul city, Ulsan city, and Uiwang city, South Korea, and was extended from our previous study.[7] Recruitment was achieved with an official document of authority without any advertisement or reward. Subjects >50 years of age who consented to AAA screening were included in the study. Subjects of any age who had a family history of AAA were likewise included. We excluded subjects diagnosed with an AAA, those with a history of open or endovascular AAA repair, those with a history of abdominal aortic surgery such as aortobifemoral bypass, those with life expectancy <2 years based on the Statistics Korea life table, and those who refused AAA screening. This study was approved by the Institutional Review Board of Kyung Hee University Hospital at Gangdong.

Screening was performed using the same strategy as described in our previous study. Briefly, history was taken from each participant and all participants underwent physical and ultrasound examinations. We obtained the demographic information with a detailed questionnaire. We investigated the patients for history of diabetes, hypertension, hyperlipidemia, heart disease, pulmonary disease, cerebrovascular disease, and renal function impairment, and inquired about their surgical history. Questions about the family history of AAA, stroke, and peripheral arterial occlusive disease were also asked. Social history included smoking history, alcohol history, and amount of exercise. All participants were asked whether they had any aneurysm-related symptoms, such as abdominal pain or back pain. After obtaining the pertinent history, the subject's abdomen was palpated to evaluate the presence of a pulsating mass. Finally, duplex scanning was performed after fasting for 8 hr. Duplex scanning was performed by experienced sonographers who were certified Registered Vascular Technologists by the American Registry for Diagnostic Medical Sonography. We used 2 types of ultrasound machines, namely Zonare (Zonare Medical Systems, Mountain View, CA) and HD7 (Philips, Amsterdam, The Netherlands). A 2.5—5 MHz convex ultrasound probe was used for the examination. Duplex scanning was done from the infradiaphragmatic level to bilateral iliac arteries. We measured the maximal diameter of the aorta from the outer to outer layer. Anteroposterior and lateral diameters were measured. We recorded the 2 diameters at the levels of the suprarenal, renal, and infrarenal aorta, and the right and left iliac arteries. The ''suprarenal'' diameter was measured at the level between the superior mesenteric artery and the renal artery. The ''renal'' diameter was the aortic diameter at the level of the renal artery. If both renal arteries were projected at the same level, the maximal diameter at the level of the renal artery was measured in the anteroposterior plane. The ''infrarenal'' diameter was measured at the level between the lower renal artery and the aortic bifurcation. The iliac artery diameters were measured at the common iliac artery between the aortic bifurcation and the origin of the internal iliac artery on both sides. If the iliac artery was tortuous, the diameter of the iliac artery was measured only in the anteroposterior plane. If bowel gas interfered with adequate measurement of the diameter, subjects were asked to return for reexamination the next day.

AAA was defined as maximal aortic diameter >3 cm. Maximal aortic diameter was calculated as the sum of the diameter on the anteroposterior plane and the lateral plane, divided by 2. Hypertension and hyperlipidemia were defined as intake of antihypertensive and lipid-lowering medications, respectively. Cardiovascular risk factors included arrhythmia, coronary artery disease, myocardial infarction, angina, and a history of coronary angioplasty or stenting. Cerebrovascular risk factors included transient ischemic attack, reversible ischemic neurologic deficit, and stroke. Respiratory risk factors included chronic obstructive pulmonary disease, asthma, pneumonia, and pulmonary tuberculosis. Renal impairment was defined as undergoing dialysis.

We used SPSS version 19.0 software (SPSS, Inc., Chicago, IL) for the statistical analysis. The risk factors and risk ratio for AAA were determined. Chi-squared test was used for the univariate analysis, and a logistic regression model was used for the multivariate analysis. All *P*-values <0.05 were considered significant.

RESULTS

A total of 2,035 participants were enrolled. All participants completed the questionnaires and underwent the examinations. Among them, 908

(44.6%) were men and 1,127 (55.4%) were women. Mean age was 66.9 ± 10.3 years (range 23–95). An AAA was detected in 22 (1.1%) individuals (Table I). The prevalence of AAA was 18 of 908 (2.0%) men, and 4 of 1,127 (0.4%) women, and prevalence was found to increase with age. The average diameter of the aneurysm was 49.7 ± 18.2 mm (range 30.3–80.7). No participant <50 years of age had an AAA. Three (0.8%) of 382, 4 (0.6%) of 633, and 11 (1.5%) of 744 had an AAA at 50–59, 60–69, and 70–79 years, respectively. Participants ≥80 years old had the highest prevalence, with 4 of 182 (2.2%) having the disease. A high-risk group, based on the Centers for Medicare and Medicaid Services guidelines, was analyzed, which included those with a family history of AAA and men 65–75 years who have smoked at least 100 cigarettes throughout their life. In this group, 15 (3.2%) of 476 patients had an AAA.

Risk factors are shown in Table II. Hypertension was the most common risk factor, with 998 (49.0%) subjects having hypertension and taking antihypertensive medications. This was followed by smoking ($n = 759$, 37.3%), alcohol consumption ($n = 749$, 36.8%), hyperlipidemia ($n = 577$, 28.4%), and diabetes ($n = 387$, 19.0%). A total of 196 (9.6%) subjects had coronary artery disease, mainly ischemic heart disease. In total, 130 (6.4%) had a cerebrovascular problem, including transient ischemic attack, reversible ischemic neurologic deficit, and stroke, and 52 (2.6%) had pulmonary disease, mainly chronic obstructive pulmonary disease. Twenty-two (1.1%) patients had end-stage renal disease and were undergoing hemodialysis.

The univariate analysis of risk factors for AAA is shown in Table III. The presence of AAA was strongly correlated with male sex ($P < 0.001$), increased age ($P = 0.01$), smoking ($P < 0.001$), alcohol consumption ($P < 0.01$), and the presence of pulmonary disease ($P = 0.01$). Multivariate analysis revealed that smoking was the only significant factor for AAA (Table IV). The odds ratio (OR) was 7.4 (95% confidence interval [CI] 2.55–21.47, $P < 0.001$). Male sex, age, alcohol, and pulmonary disease were not significant in the multivariate analysis.

Table I. Prevalence of abdominal aortic aneurysm

Characteristics	Screening (%)	AAA (%)
Total	2,035 (100)	22 (1.1)
Sex		
Male	908 (44.6)	18 (2.0)
Female	1,127 (55.4)	4 (0.4)
Age (years)		
<50	94 (4.6)	0 (0)
50–59	382 (18.8)	3 (0.8)
60–69	633 (31.1)	4 (0.6)
70–79	744 (36.6)	11 (1.5)
≥80	182 (8.9)	4 (2.2)

DISCUSSION

This study showed that the prevalence of AAA in a general Korean population aged >50 years is 1.1%. Men were 5 times more likely to have an AAA compared with women. In addition, the frequency of AAA increased with age. AAA was detected in 2.2% of subjects >80 years. Smoking is a well-known risk factor for AAA. In our study, smoking was the only significant risk factor for the development of AAA in the multivariate analysis. Smokers are 7.4 times more likely to have an AAA than nonsmokers.

According to research from the United States and from European countries, AAAs occur in 5–10% of men and 0.5–1.5% of women aged 65–79 years.[8,9] Known risk factors include age, smoking, male sex, and family history.[8] AAAs are 3–5 times more likely to develop in patients with a smoking history. Approximately 9,000 deaths annually are linked to AAAs in the United States, mostly in men >65 years old. However, only a few studies have been performed on the incidence of AAA in the Asian population, apart from reported differences in the occurrence of AAAs in black and Caucasian populations. The prevalence of AAA in our study was 2.0% of men and 0.4% of women in a Korean population. AAA was detected in 2.1% of men aged 65–79 years. There was no AAA detected in women aged 65–79 years. The prevalence of AAAs in high-risk Koreans was 3.2%. Our results showed that AAA is not uncommon in the Korean population and that the incidence is comparable with that in Western countries. Data from Malaysia support our results, with incidence rates for the at-risk male population >50 years are 2.56%, and 7.83% for men >70 years.[10]

Mortality after rupture of an AAA approaches 80% for patients who reach the hospital and 50% for those who undergo emergency surgery.[8] Fatal outcomes after a ruptured AAA have been highlighted by AAA screening programs for decades, because mortality from an AAA decreases significantly among patients in whom the AAA is discovered at screening (men 65–79 years: OR 0.60, 95% CI 0.47–0.78).[9] Therefore, establishing a

Table II. Risk factors in the screened population

Risk factors	Frequency (%)
Hypertension	998 (49.0)
Smoking	759 (37.3)
Alcohol	749 (36.8)
Hyperlipidemia	577 (28.4)
Diabetes	387 (19.0)
Coronary artery disease[a]	196 (9.6)
Cerebrovascular disease[b]	130 (6.4)
Pulmonary disease[c]	52 (2.6)
End-stage renal disease	22 (1.1)

[a]Mainly ischemic heart disease.
[b]Including transient ischemic attack, reversible ischemic neurologic deficit, and stroke.
[c]Mainly chronic obstructive pulmonary disease.

Table III. Univariate analysis of risk factors for abdominal aortic aneurysm

Risk factors	Variable (%)	*P* value[a]
Sex	Male (2.0) Female (0.4)	<0.001
Age	<50 (0), 50s (0.7), 60s (0.7), 70s (1.5), >80 (2.8)	0.01
Smoking	Non-smoker (0.4) Ex-smoker (1.6) Current smoker (8.0)	<0.001
Alcohol	No (0.5), yes (2.0)	<0.01
Body mass index ($\geq$25 kg/m^2)	No (1.0), yes (1.1)	0.81
Diabetes	No (1.0), yes (1.3)	0.59
Hypertension	No (1.0), yes (1.2)	0.60
Hyperlipidemia	No (0.8), yes (1.7)	0.07
Coronary artery disease	No (1.0), yes (1.5)	0.46
Pulmonary disease	No (1.0), yes (5.9)	0.01
Cerebrovascular disease	No (1.1), yes (0.8)	1.00
End-stage renal disease	No (1.1), yes (0)	1.00

[a]Chi-square test.

modernized screening program is necessary. A meta-analysis that analyzed 4 contemporary randomized controlled trials strongly supported the benefits of screening for AAAs.[3]

Identifying the risk factors for AAA is important to increase the efficacy of screening programs. Independent risk factors for AAA have not been clearly defined in multivariate analyses of large patient

Table IV. Multivariate analysis of risk factors for abdominal aortic aneurysm

Risk factors	Odd ratio	95% CI	*P* value[a]
Male sex	1.7	0.35−8.57	0.49
Age per 10 years	0.6	0.18−1.99	0.40
Smoking	7.4	2.55−21.47	<0.001
Alcohol	0.6	0.21−1.88	0.40
Pulmonary disease	3.0	0.63−14.55	0.16

[a]Multiple logistic regression analysis.

populations. The classic risk factors for atherosclerosis, such as tobacco smoking, male sex, age, hypertension, and hyperlipidemia, are all risk factors for AAA.[3,6,11] Our data revealed that male sex, age, alcohol, and pulmonary disease were significant risk factors for univariate analysis; however, smoking was the only significant factor for multivariate analysis.

Although one study reported that current smoking is not a significant risk factor for AAA,[12] smoking was the strongest risk factor in our study, which is similar to several other studies.[13−18] A dose-response effect of smoking duration and quantity was reported in a prospective analysis of the Tromsø study.[19] Smoking increases the expansion rate and rupture risk of an AAA.[20,21] Inflammation, proteolysis, smooth muscle cell apoptosis, and angiogenesis have been implicated in the pathogenesis of AAAs.[22,23] Nicotine stimulates matrix metalloproteinase expression by vascular smooth muscle, endothelial, and inflammatory cells in the vascular wall and induces angiogenesis in aneurysmal tissues.[24−26]

An interesting finding of our study was the correlation between alcohol consumption and the risk of AAA on univariate analysis. Studies investigating the role of alcohol in the development of AAAs are few. Moderate alcohol consumption is considered to decrease the risk of cardiovascular events and reduce acute myocardial infarction.[27] A Swedish cohort study also showed a lower risk for AAA with moderate alcohol consumption, specifically wine and beer.[28] Taylor et al.[29] demonstrated a linear dose-response relationship, with a relative risk of 1.57 in subjects consuming 50 g of pure alcohol per day and 2.47 in hypertensive subjects consuming 100 g/day. Similarly, 2 studies focused on the negative effect of alcohol consumption on the pathogenesis of AAA. Alcohol is independently correlated with aortic diameter.[30] Wong et al.[31] reported that baseline alcohol consumption is independently associated with a diagnosis of AAA after adjusting for other risk factors, including smoking, hypertension, and body mass index (p for trend = 0.03), with a maximum hazard ratio of 1.21 (95% CI 0.78–1.87) for ≥30.0 g daily alcohol consumption. According to an alcohol consumption and dietary habit survey among Koreans, 2,962 of 3,597 men (82.3%) were alcohol drinkers. A total of 1,002 subjects (27.9%) drank ≥30 g of alcohol per day and 248 subjects (6.8%) drank ≥80 g of alcohol per day. The amount of alcohol consumed per day increased with increasing age. Alcohol drinkers also tend to be smokers.[32] This issue is controversial but the unique Korean drinking practice could affect the prevalence of AAA.

Our study has several limitations. First, the study population was relatively small. Therefore, some of the statistical correlations were weak. Second, our study population comprised citizens from specific areas and was nationwide. Therefore, the prevalence of AAA may have a small selection bias. Despite these limitations, it is recommended to perform ultrasound screening of AAA for male smokers ≥65 years in Korea.

CONCLUSIONS

In this Korean population, the prevalence of AAA was 2.0% in men and 0.4% in women. Risk factors for development of AAA included male sex, old age, smoking, alcohol use, and pulmonary disease. Those patients at high risk for AAA had a higher prevalence of AAA (3.2%). Smoking is the strongest risk factor for the development of AAA. A nationwide screening study is required to evaluate the prevalence of AAA and its risk factors.

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