Abdominal Aortic Aneurysm Prevalence in China

Determining specific screening parameters to assess abdominal aortic aneurysms in the Chinese population.

BY WEI GUO, MD, AND TAO ZHANG, MD

Abdominal aortic aneurysm (AAA) is ranked as the 13th leading cause of death in the United States.[1] The overall mortality rate of ruptured AAAs is as high as 80% to 90%.[2-4] AAA has such nonspecific clinical symptoms that it has been neglected by the public, and most patients do not get diagnosed and treated until rupture occurs. The proportion of elective surgery versus emergency surgery for AAA was approximately 8.4% versus 68%, respectively, during a 10-year period in the United States (1984–1994).[5]

There is growing evidence that AAA-related mortality during emergency operation after rupture, compared with elective surgical repair of stable disease, is significantly reduced from 40% to 50% down to 2% to 6%.[6-10] Evidence from four randomized trials showed the benefits of screening, demonstrating a highly significant reduction in aneurysm-related mortality by four per 1,000 and long-term all-cause mortality by five per 1,000 in men in the screened population.[11,12] Meta-analysis data also demonstrated that early diagnosis of AAA is crucial to reducing mortality, and a cost-effective AAA screening program for a selective at-risk population (eg, men older than 65 years or those with a history of smoking) was recommended.[13-16] Screening programs have been implemented in several countries, including nationwide coverage in Sweden, Spain, the United Kingdom, and the United States as part of the Medicare program.

The essential precondition for a AAA screening program is an epidemiological profile of AAAs, such as the distribution of aortic diameter, abnormal aorta reference values, and prevalence of AAA. Such epidemiological studies have taken place in Western countries since the 1980s, which reported the prevalence of AAAs as 1.3% to 8.9% in men and 0.6% to 2.5% in women.[17-32] The literature on Asian populations (ie, Japan, Saudi Arabia, Iran, South Korea, and Hong Kong) report corresponding AAA prevalence and associated risk factors in the region,[33-35] yet these data are not as well established for those in China's mainland population.

The universal screening method is performed via ultrasound imaging, which is noninvasive and has a sensitivity and specificity of nearly 100% for AAAs. In our study, we established the distribution of sex- and age-specific measurements for abnormal aortic diameters, as assessed by ultrasound, in a community-based cohort of adult men and women and identified the prevalence of AAA in the Yangtze-Huai Plain of China based on the AAA definition for Caucasians.

METHODS

Subjects

The participants of the study were placed into two cohorts. The first cohort consisted of 22,110 subjects who were 45 to 80 years of age with a history of hypertension and were drawn from a substudy of the community-based China Stroke Primary Prevention Trial (NCT00794885) study cohort, which began in 2008. The second cohort consisted of 2,665 new subjects, who closely resembled the first cohort in most respects, but without a history of hypertension; their enrollment began in 2013. Of all of the 24,775 participants, 965 (3.9%) had incomplete data or dropped out. Thus, the final analysis was performed for 23,810 participants of the overall study cohort. Inclusion and exclusion criteria were based on those in the China Stroke Primary Prevention Trial. The study was approved by the institutional review boards of the Peking University Health Science Center and the PLA General Hospital. All participants provided written informed consent.

The populations enrolled in the study underwent standard clinical examination. This included a physician questionnaire interview, a physical examination, laboratory tests (including liver and kidney function, homocysteine, and corresponding methylenetetrahydrofolate reductase [MTHFRC677T] genotype), and imaging examination (including electrocardiography, fundoscopy, ankle-brachial index, pulse wave velocity, and carotid and abdominal aorta ultrasonography).

TABLE 1. COHORT CHARACTERISTICS

Characteristic	Value (n = 23,810)
Male sex	8,976 (37.7%)
Age, mean (SD), years	64.6 ± 7.5
Height, mean (SD), cm	157 ± 8.2
Weight, mean (SD), kg	61 ± 11.3
BSA, mean (SD), m^2	1.6 ± 0.2
BMI, mean (SD), kg/m^2	24.7 ± 5.3
Systolic blood pressure, mean (SD), mm Hg	139.4 ± 18.3
Diastolic blood pressure, mean (SD), mm Hg	82.5 ± 10.8
Fasting plasma glucose, mean (SD), mmol/L	5.63 ± 1.65
Total cholesterol, mean (SD), mmol/L	5.21 ± 1.19
Triglycerides, mean (SD), mmol/L	1.53 ± 1.2
High-density lipoprotein cholesterol, mean (SD), mmol/L	1.81 ± 0.6
Homocysteine, mean (SD), mmol/L	11.36 ± 6.24
Smoking	
Current	7,000 (29.4%)
Former	1,334 (5.6%)
Never	1,5476 (65%)
Alcohol consumption	
Current	4,833 (20.3%)
Former	3,405 (14.3%)
Never	1,5572 (65.4%)
Labor intensity	
Light	9,024 (37.9%)
Middle	11,405 (47.9%)
Heavy	3,381 (14.2%)
Living standard	
Worse	4,262 (17.9%)
Average	18,858 (79.2%)
Better	690 (2.9%)
Sleep quality	
Good	10,167 (42.7%)
Middle	12,072 (50.7%)
Bad	1,571 (6.6%)

Abbreviations: BSA, body surface area; SD, standard deviation.

After the patient had rested for 5 minutes in the seated position, trained technicians used a standardized protocol to obtain systolic and diastolic blood pressures in the left upper extremity by automated oscillometry. Body mass index (BMI) was calculated with the patient lightly clothed (without shoes). Body surface area (BSA) was calculated as 0.20247 x Height (m) 0.725 x Weight (kg) 0.425. Smoking and alcohol consumption status was defined as current, former, or never. The normal aorta tapers distally, and thus, the main criterion for normality was this anatomic characteristic. Any local aberration from this was measured, and the diameter of any bulging was measured. AAA was defined as the infrarenal aortic diameter having 50% dilatation compared to the adjacent normal artery or ≥ 30 mm.

Imaging Acquisition and Analysis

Ultrasound examinations were performed by specially trained surgeons from the Vascular and Endovascular Surgery Department of PLA General Hospital in Beijing, China. One of these surgeons was responsible for the training, supervision, and surveillance of the technicians. The examination was scheduled to last approximately 15 minutes. We used the SonoScape S6 ultrasound system (with a 3.5-MHz transducer [SonoScape Technologies, Shenzhen, China]) to perform these examinations. Information was recorded regarding food or fluid intake before the ultrasound examination.

While the ultrasound exam was being conducted, a longitudinal scan of the aorta was performed. The aorta was scanned with the probe in the transverse (horizontal) position and then in the sagittal (vertical) position. The greatest diameter in any area of the aorta was measured according to the "leading-edge-to-leading-edge" principle[1] and recorded. There were five predefined aortoiliac segments: (1) just inferior to the level of the renal arteries of the abdominal aorta, (2) the maximal infrarenal abdominal aorta, (3) the aortic bifurcation, (4) the left common iliac artery, and (5) the right common iliac artery. At each of the five locations, the mean anteroposterior and transverse measurements were calculated. Mean values were used to help control for obliquity of the vasculature on a small number of scans inherent in the use of axial images.

The ultrasonographers met twice during the study to review techniques and to compare measurement distributions. To assess interobserver and intraobserver measurement reliability, reliability measurements were acquired in a random subset of 100 participants (age range, 45–80 years) who were drawn from the overall cohort. The random sample included approximately equal numbers of men and women and approximately equal numbers of participants in each of the age groups (younger than 60, 60–69, and 70 years or older). To evaluate interobserver reliability, two of

the trained observers performed independent measurements of the 100-participant subset in random order. To evaluate intraobserver reliability, one of the observers independently repeated these measurements 1 week later in random order. The intraobserver intraclass correlation coefficient was > 0.97 (range, 0.97–0.99), suggesting an excellent correlation between readings, with an average difference of 0.5 mm between readings. There was also an excellent interobserver intraclass correlation between readings (all values > 0.96; range, 0.96–0.99), with an average difference of 0.8 mm between reviewers across the measurements.

Statistical Analysis

Descriptive statistics of the study cohort were summarized by means and standard deviations for normally distributed continuous variables and medians and ranges for non-normally distributed continuous variables. Categoric variables were summarized using frequencies and percentages. The level of significance for this study was $P = .05$. Analyses were conducted using R software (R Inc., Chicago, IL).

RESULTS

Characteristics of the General Population

Characteristics of the 23,810 participants are presented in Table 1. In the study, the ratio between men and women is 1:1.6. The mean age and BSA were 64.6 ± 7.5 years and 1.6 ± 0.2 m^2, respectively. The mean BMI was 24.7 ± 5.3 kg/m^2. Approximately 35% and 34.6% of the population had a history of smoking or alcohol consumption, respectively. Furthermore, 49.1% of the population had controlled/normal blood pressure at the time of the study examination.

Distribution of Abdominal Aortic Diameter

The average diameters were 14.4 ± 2.2 mm (range, 6.9–43.9 mm) for the location just inferior to the level of the renal arteries of the abdominal aorta, 14.6 ± 2.2 mm (range, 7.3–51.3 mm) for the maximal infrarenal abdominal aorta, 12.9 ± 2 mm (range, 4.7–51.3 mm) for the aortic bifurcation, 8.4 ± 1.6 mm (range, 3.2–24.3 mm) for the left common iliac artery, and 8.5 ± 1.7 mm (range, 3.5–24.8) for the right common iliac artery.

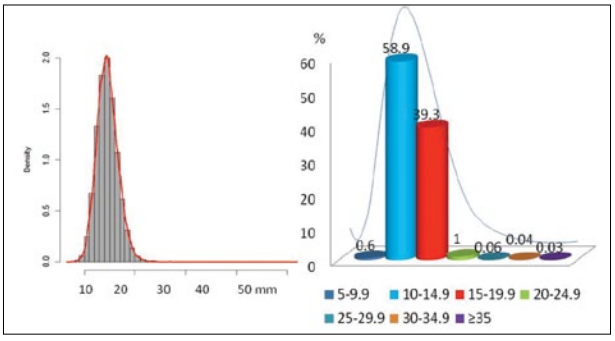

Figure 1. Distribution of maximal infrarenal abdominal aorta diameters among the overall study population. The ordinate indicates the percentage of population; the horizontal indicates the diameter range.

When compared, the abdominal aorta diameters were significantly larger in men than in women at any anatomic site. The average diameters at the each location for men and women were 15.4 ± 2.2 mm versus 13.8 ± 2 mm for the area just inferior to the level of the renal arteries, 15.6 ± 2.2 mm versus 14 ± 1.9 mm for the maximal infrarenal abdominal aorta, 13.8 ± 2.1 mm versus 12.4 ± 1.8 mm for the aortic bifurcation, 9 ± 1.7 mm versus 8 ± 1.5 mm for the left common iliac artery, and 9.1 ± 1.7 mm versus 8.1 ± 1.5 mm for the right common iliac artery, respectively.

Aortic dilation was more common in patients older than 60 years versus those younger than 60 years (39.9% vs. 33.8%; $P < .05$). The mean diameters at the location just inferior to the level of the renal arteries, maximal infrarenal abdominal aorta, aortic bifurcation, left common iliac artery, and right common iliac artery were 14.2 ± 2 mm, 14.4 ± 2 mm, 12.8 ± 1.9 mm, 8.3 ± 1.6 mm, and 8.4 ± 1.6 mm, respectively, in patients younger than 60 years. The corresponding positions were 14.6 ± 2.5 mm, 14.8 ± 2.5 mm, 12.9 ± 2.1 mm, 8.4 ± 1.7 mm, and 8.5 ± 1.7 mm, respectively, in patients older than 70 years.

The differences in the overall, sex-specific, and age-adjusted groups were also compared. Figure 1 shows that the distribution of maximal infrarenal abdominal aortic diameters among the study population was mainly between 10 to 15 mm. The distribution of abdominal aortic diameters between men and women showed a few differences; for example, the range for men is primarily from 15 to 20 mm, whereas the range for women is primarily from 10 to 15 mm (Figure 2). The difference was also shown in terms of age classification: aortic diameters ranging from 15 to 20 mm were significantly more prevalent in patients older than 60 years than those younger than 60 years (Figure 3).

Prevalence of AAA

Based on the general classification of AAA, with the transverse artery diameter being 50% more dilated than the adjacent normal artery, the presence of AAA was found in 26 patients (0.11%), with a mean age of 72.5 ± 6.2 years. The prevalence was higher among men (n = 16) than women (n = 10), and the mean AAA size was 28.8 ± 7.2 mm.

According to the second AAA classification rule, with the aortic diameter ≥ 30 mm, the presence of AAA was found in 16 patients (0.07%), aged 73.1 ± 6.4 years. This prevalence was also higher among men (n = 13) than women (n=3), and the mean AAA size was 35.8 ± 6.8 mm. In summary, the

diameter of the AAA increased with age, and was larger in the male group than in the female group.

DISCUSSION

There are several published, large-population–based ultrasound screening studies of the abdominal aorta; however, published work regarding patients in mainland China is scarce. In our ultrasound study in men and women in a community-based cohort, we sought to describe the distribution of abdominal aortic diameters stratified by sex and age. We further researched the prevalence of AAA according to Western diagnostic criteria in all participants in the study. This is the first study that we are aware of to present such community-based data for those living in China's mainland.

Previous studies on the epidemiology of abdominal aortic diameter are limited. Singh and his colleagues[36] investigated 221 patients (without aneurysms) by ultrasound in 2004 and found that the mean diameter of the abdominal aorta

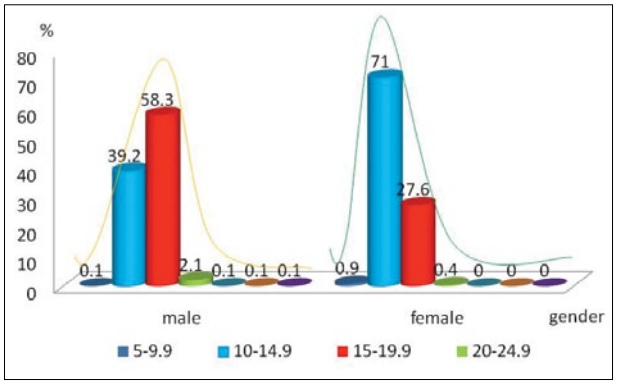

Figure 2. Distribution of maximal infrarenal abdominal aorta diameters according to classification of sex. The ordinate indicates the percentage of population; the horizontal indicates the diameter range.

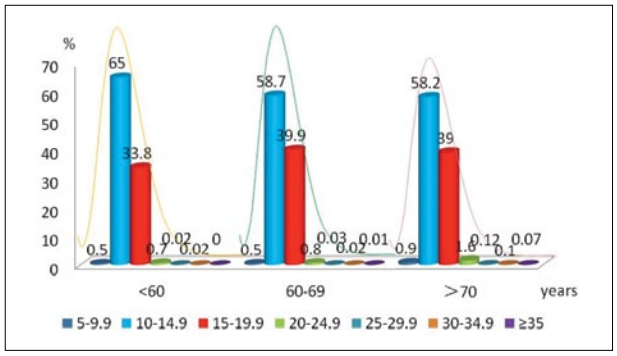

Figure 3. Distribution of maximal infrarenal abdominal aorta diameters according to age. The ordinate indicates the percentage of the population; the horizontal indicates the diameter range.

was 20.9 ± 2.9 mm at 1 cm infrarenal level, 19.1 ± 2.9 mm at the bifurcation level, 13 ± 2.1 mm at the left common iliac artery, and 13.6 ± 3 mm at the right common iliac artery. Allison et al[37] also found that the mean diameter of the abdominal aorta just inferior to the superior mesenteric artery was 21.3 ± 2.9 mm, 19.3 ± 2.5 mm at the midpoint, and 18.6 ± 2.2 mm at the bifurcation in an electron-beam CT study of 504 adults who were a mean age of 57.8 years.

In the recent Framingham Heart study,[38] findings from 3,431 patients undergoing CT of the aorta were analyzed, and the mean diameter of the infrarenal abdominal aorta was 19.3 mm. The lower abdominal aorta was 18.7 mm for men, and for women, the average diameters were 16.7 mm for the infrarenal abdominal aorta and 16 mm for the lower abdominal aorta.

Our results confirmed that the diameter of the aorta decreases from the upper abdominal aorta to the abdominal aortic bifurcation. The diameter of the abdominal aorta increases with age and is larger in men. The diameter of the right common iliac artery is slightly larger than the left in the same patient. In addition, our study showed a significant difference from the Western report in that the abdominal aortic diameters in Chinese patients are much smaller than in Caucasian patients (Figure 4). We have seen similar results in previous work that shows that Americans of Chinese, African, and Hispanic descent had smaller aortic diameters than Caucasian-Americans (5 cm above the bifurcation), even after adjusting for differences in body size and other covariates.[39]

The literature has shown that the results of AAA screening performed in Europe and the United States have revealed a prevalence ranging from 1.25% to 5.1% in overall population.[1,6,10,11-13,15] The prevalence of AAA in Japan and Korea is reported to be 0.3% and 0.55% respectively.[17-19] The results of our screening, revealing incidences of 0.11% in total (0.18% in men and 0.07% in women, all 65 years or older) seem significantly lower than those of previous reports (Table 2), indicating that AAA might be less common in Chinese people, possibly because of genetic or lifestyle differences.

LIMITATIONS

Our study has several limitations. First, our study population was mainly composed of selected patients with a history of hypertension. Therefore, these patients had more cardiovascular risk factors than a healthy general population. Second, the screening protocol via ultrasound failed to clearly visualize the abdominal aorta in approximately 20% of the subjects, most of whom were obese. Therefore, the prevalence of AAA may have a small selection bias. Finally, the number of AAA cases was small. Therefore, we cannot provide a clinical risk

TABLE 2. RESULTS OF SCREENING FOR AAA: THE LITERATURE AND OUR DATA

No.	Author	Country	Publication Year	Population Sex, Age (y)	Number Screened	Criteria for Positive Findings (Infrarenal Max Diameter, mm)	Screening Method	Prevalence or Incidence
Europe								
1	Scott RA et al[17]	UK	1991	Overall, 65–80	Total, 4,237; men, 1,947; women, 2,290	≥ 30	US	4.3% 7.6% 1.4%
2	Smith FC et al[18]	UK	1993	Men, 65–75	2,669	> 29	US	8.4%
3	Scott RA et al[19]	UK	2001	Men, 64–81	2,212	≥ 30	US	7.7%
4	Scott RA et al[20]	UK	2002	Overall, 65–80	Total, 15,775; men, 6,433; women, 9,342	≥ 30	US	3.9% 7.6% 1.3%
5	Thompson SG et al[21]	UK (MASS study)	2002 (2012)	Men, 65–74	67,770	≥ 30	US	4.9%
6	Duncan JL et al[22]	UK	2005	Overall, 65–74	8,355	> 29	US	5.1%
7	Hafez H et al[23]	UK	2008	Men, 64–84	22,961	≥ 30	US	4.4%
8	Lindholt JS et al[24]	Denmark	1998	Men, 65–73	4,404	≥ 30	US	4.2%
9	Grøndal N et al[25]	Denmark (VIVA study)	2010	Men, 65–74	50,000	≥ 30	US	4%
10	Sconfienza LM et al[26]	Italy	2013	Overall, 64–86	1,200	≥ 30	US	1.3%
North and South America								
11	Lederle FA et al[27]	United States (ADAM study)	2001	Overall, 50–79	Total, 125,722; men, 122,272; women, 3.450	≥ 30	US	4.2% 4.3% 1%
12	DeRubertis BG et al[28]	United States	2007	Overall, > 60	Total, 17,540; men, 7,528; women, 10,012	≥ 30	US	2.1% 3.9% 0.7%

TABLE 2. RESULTS OF SCREENING FOR AAA: THE LITERATURE AND OUR DATA (CONTINUED)

No.	Author	Country	Publication Year	Population Sex/Age (y)	Number Screened	Criteria for Positive Findings (Infrarenal Max Diameter, mm)	Screening Method	Prevalence or Incidence
North and South America (continued)								
13	Kent KC et al[29]	United States (LLS study)	2010	Overall, 50-85	3,056,455	≥ 30	US	1.4%
14	Puech-Leão P et al[30]	Brazil	2004	Overall, > 50	Total, 2,756; men, 1,228; women, 1,528	> 29	US	2.3% 4.6% 0.6%
Australia								
15	Scott RA et al[31]	Australia	1995	Overall, 65–80	Total, 13,281; men, 5,547; women, 7,734	> 30	US	4%; 7.6%, 1.4%
16	Norman PE et al[32]	Australia	2004	Men, 65–83	12,203	≥ 30	US	7.2%
Asia								
17	Adachi K et al[33]	Japan	2000	Overall, 35–82	1,591	≥ 30	US	0.25%
18	Ishikawa S et al[34]	Japan	2001	Overall, 60–93	Total, 4,428; men, 1,721; women, 2,707	50% greater than proximal aorta	US	0.36% 0.87% 0.11%
19	Oh SH et al[35]	Korea	2010	Overall, 12–98	Total, 4,939; men, 2,365; women, 2,574	≥ 30	TEE	0.55% 0.97% 0.16%
20	Present study	China	2013	Overall, 45–80	Total, 23,810; men, 8,976; women, 14,834	50% dilatation of the adjacent normal artery or ≥ 30 mm	US	0.11% 0.18% 0.07%

Abbreviations: TEE, transesophageal echocardiography; US, ultrasound.

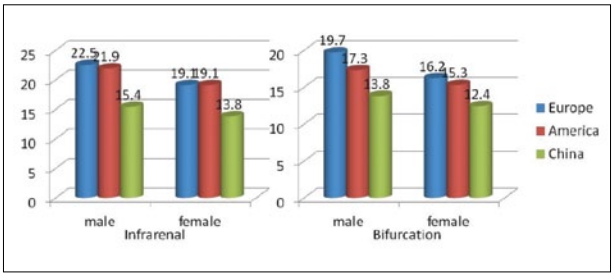

Figure 4. Comparison of abdominal aortic diameter around the world. The ordinate indicates the diameter of the abdominal aorta; the horizontal indicates the sexes.

assessment model for AAA. However, our data suggest that the criteria for AAA screening in Western countries (male sex and older than 65 years) could be appropriately applied to the Asian population as well.

CONCLUSION

The prevalence of AAA in the population of China who are older than 65 years is approximately 0.11%. In men, it is estimated to be 0.18%, and in women it is estimated to be 0.07%. We can easily draw the conclusion that the abdominal aortic diameters in Chinese people are much smaller than in Caucasians. Thus, we speculate that the current diagnostic criteria for AAA as a "one-size-fits-all" value (ie, 30 mm) may be inadequate for patients in China. It is time to provide sex-specific reference cutoff points for abdominal aortic diameters in the asymptomatic AAA population in the Chinese community. In addition, with the inherent anatomical morphological difference, Asian patients may be more challenging to treat with endografting procedures (due to tight access, small aortas, short common iliac arteries, etc.), and the success rate of endovascular AAA repair may be compromised when using the "standard" stent graft. ■

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