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Normal diameters of abdominal aorta and common iliac artery in middle-aged and elderly Chinese Han people based on CTA

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Abstract

To investigate the normal diameter of the abdominal aorta and common iliac arteries of the middle-aged and elderly people in China and the relationship of the diameters with age, sex, height, weight, body mass index (BMI), and body surface area (BSA). This retrospective study enrolled 625 patients including 380 males and 245 females aged 60.00 years (interquartile range 13.00 years). All clinical data and the diameters of the abdominal aorta and common iliac arteries were analyzed. The diameter of the abdominal aorta was 21.49 ± 2.49 mm at the proximal, 16.94 (interquartile range 2.39) mm at the middle, and 15.65 (interquartile range 2.90) mm at the distal segment. The diameter of the common iliac artery was 10.76 (interquartile range 1.99) mm at the right proximal, 10.41 (interquartile range 2.05) mm at the left proximal, 10.74 (interquartile range 2.25) mm at the right distal, and 10.67 (interquartile range 2.22) mm at the left distal segment. The height, weight, BSA, BMI, diameters of the proximal, middle and distal abdominal aorta as well as the proximal and distal left and right common iliac arteries were significantly higher in males than those in females ($P < .001$). Height, weight, BSA, and BMI were significantly ($P < .001$) positively correlated with the diameter of the abdominal aorta and common iliac artery at the proximal, middle, and distal segments. The middle and distal diameters of the abdominal aorta were significantly higher in males than those in females ($P < .05$). The diameter of the abdominal aorta at the proximal, middle, and distal segment as well as the diameter of the left and right common iliac artery at the distal segment were significantly ($P < .05$) increased with age. The normal values of the diameter of the abdominal aorta and common iliac arteries are suggested for the middle-aged and elderly Chinese people for clinical reference. The diameters are gender related and significantly positively correlated with BSA, height, weight, and BMI, which is beneficial for the diagnosis and treatment planning of relevant vascular diseases.

Abbreviations: BMI = body mass index, BSA = body surface area, CT = computed tomography, CTA = computed tomographic angiography.

Keywords: abdominal aorta, common iliac artery, computed tomographic angiography, normal reference value

1. Introduction

Abdominal aortic aneurysms tend to occur in the elderly, and its essence is expansion of aortic lumen or tear of aortic wall.[1] With the development of population aging, the incidence is increasing year by year, with the incidence of abdominal aortic aneurysms among people over 65 years old in the developed countries surpassing 9%.[2] In China, there are currently no formal normal reference values of the diameter of abdominal aorta and common iliac arteries. With the normal reference values of the diameter of aorta and common iliac artery, arterial dilation or stenosis can be assessed for the diagnosis of vascular diseases and guidance of interventional surgery. It is, therefore, of great clinical value to understand the normal diameter of abdominal aorta and left and right common iliac arteries in Chinese people. Because of the differences in race, diet, and region, there are great differences in height and body shape between Chinese and Western people, and there will be some differences in aortic diameter, which may affect the treatment plan of relevant vascular diseases. The purpose of this study was thus to investigate the normal reference values of the diameter of the abdominal aorta, left and right common iliac arteries in the middle-aged and elderly Chinese people and to explore the relationship of the arterial diameter with age, gender, body surface area (BSA), height, weight, and body mass index (BMI).

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate: This study was approved by the ethics committee of our hospital, and all patients had signed the informed consent to participate.

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2. Materials and Methods

2.1. Subjects

This retrospective one-center study was performed between May 2015 and November 2021 after approval by the ethics committee of our hospitals, and all patients had given their signed informed consent to participate. Middle-aged and elderly Chinese patients of the Han nationality who had undergone computed tomographic angiography (CTA) of the aorta and abdominal arteries were enrolled. Inclusion criteria were age ≥45 years and CTA of the aorta and abdominal arteries. Exclusion criteria were patients with Marfan syndrome, aneurysms, vasculitis, arterial dissection or ulcer, severe heart disease, congenital aortic abnormalities, abdominal aortic tortuosity, abdominal mass leading to abnormal aortic course, and poor image quality for accurate measurement. Patients with hypertension or atherosclerotic diseases were also excluded.

2.2. CT examinations

Aortic CTA or abdominal enhanced CT examination was performed with the GE64 (GE Healthcare Waukesha, WI) or Siemens dual-source CT scanner (Siemens Healthcare GmbH, Forchheim, Germany). The scanning was conducted with the patient being placed in the supine position and the scanning range being from the diaphragm to below the lower branch of pubis. The contrast agent was injected with a high-pressure syringe at a speed of about 4 mL/s and a dose of about 50 mL. The contrast agent is iohexol, a nonionic contrast agent. The breath was held at the end of a single breath, and the scanning lasted about 4 to 7 seconds. It adopted nonelectrocardiogram switching and automatic trigger scanning technology. The scanning parameters were tube current 200 to 300 mAs/revolution, tube voltage 120 KV, collimation 128 × 0.625, pitch 0.16 to 0.2, rotation time 270 to 330 ms, matrix 512 × 512, and display field 350 mm.

2.3. Postprocessing and measurement

After scanning, the data were transported to the working station for measurement of the diameter of abdominal and iliac arteries. The measurement was performed at the following locations: the proximal end of abdominal aorta (5 mm above the opening of the celiac trunk), the middle segment of the abdominal aorta (5 mm below the lower renal artery), distal abdominal aorta (5 mm above distal bifurcation), the proximal end of the left and right common iliac arteries (5 mm away from the bifurcation of the abdominal aorta), and the distal end of left and right common iliac artery (5 mm below the point of origin of the internal iliac artery). The maximal and minimal diameters of arteries were measured at each layer for calculation of the mean value (mm; Fig. 1).

The clinical data of the patients were collected, including age, sex, height, weight, BSA, and BMI. The BSA was calculated as BSA (m^2) = 0.0061 × height (cm) + 0.0128 × weight (kg) – 0.1529, and the BMI as BMI = weight (kg)/height^2 (m^2).

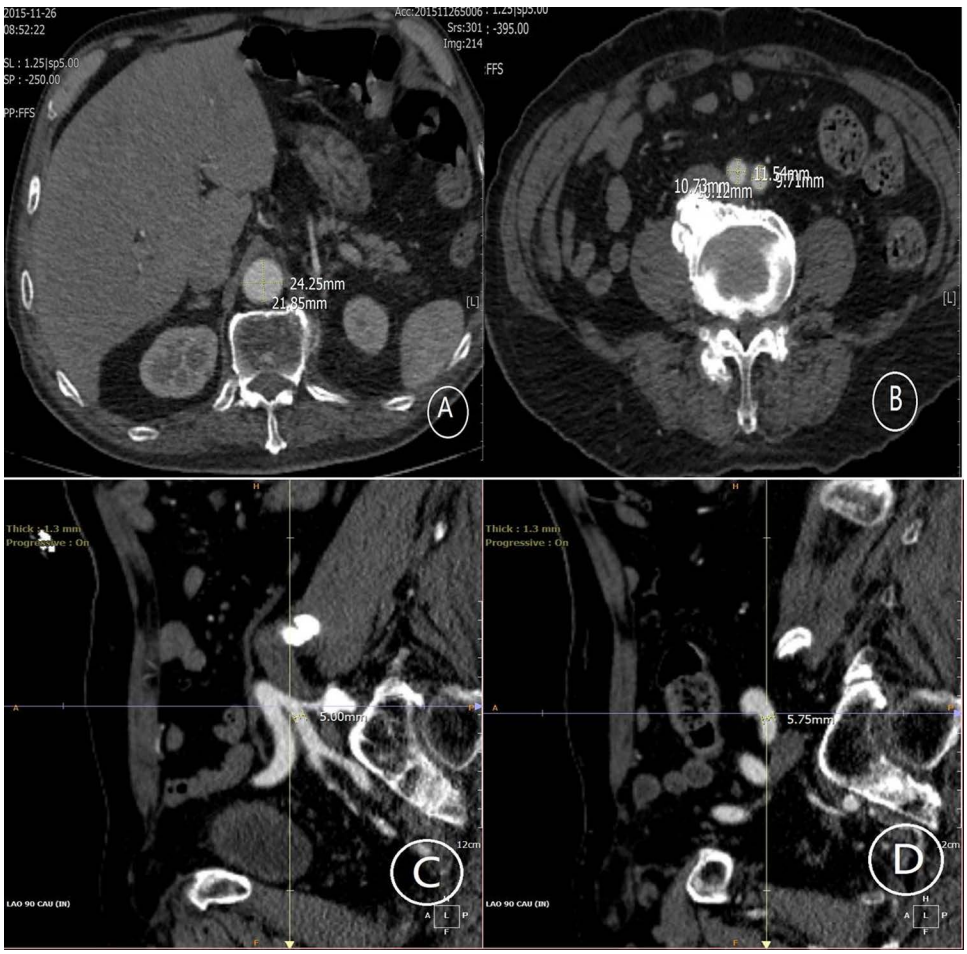

Figure 1. Measurement of the diameter of abdominal aorta and left and right common iliac arteries. A 79-yr-old man underwent abdominal enhancement computed tomography. (A) Measurement of the long and short diameters of the abdominal aorta is shown at 5 mm above the celiac trunk. (B) Measurement of the proximal diameter of the left and right common iliac arteries. (C, D). Measurement of the diameter of tortuous arteries is performed with the multiplanar reconstruction technique.

2.4. Statistical analysis

The statistical analysis was performed with the SPSS 25.0 (IBM, Chicago, IL). Continuous data were presented as mean ± standard deviation and tested with the independent *t* test if in normal distribution. If in skew distribution, the continuous data were presented as median and interquartile range and tested with the Mann–Whitney *U* test. Enumeration data were presented as frequency and percentages and tested with the chi-square test. The Spearman correlation coefficient was used to evaluate the correlation between aortic diameter and height, weight, BSA, or BMI. A *P* value of <.05 was considered statistically significant.

3. Results

A total of 625 patients with a median age of 60.0 years (interquartile range = 13.00 years, and range 45–84 years) were enrolled, including 380 males (60.8%) and 245 females (39.2%; Table 1). The median age was 60 years (interquartile range 12.00) for males and 61 years (interquartile range 18.00) for females, with no significant ($P > .05$) difference in age between 2 sexes.

The diameter of the abdominal aorta was 21.49 ± 2.49 mm at the proximal end, 16.88 (interquartile range 3.26) mm at the middle segment, and 15.45 (interquartile range 2.90) mm at the distal end (Table 1). The diameter of the common iliac artery was 10.50 (interquartile range 1.99) mm at the right proximal end, 10.25 (interquartile range 2.05) mm at the left proximal end, 10.70 (interquartile range 2.25) mm at the right distal end, and 10.60 (interquartile range 2.22) mm at the left distal end (Table 1). In comparison of the diameters of the abdominal aorta and iliac arteries between males and females, the height, weight, BSA, BMI, diameters of the proximal, middle, and distal abdominal aorta as well as the proximal and distal left and right common iliac arteries were significantly higher in males than those in females ($P < .001$).

Correlation analysis of the diameter of the abdominal aorta (proximal, middle, and distal end) and left and right common iliac arteries (proximal and distal) with age, height, weight, BSA, and BMI showed that height, weight, BSA, and BMI were significantly ($P < .001$) positively correlated with the diameter of the abdominal aorta and common iliac artery (Table 2).

In comparison of the diameter of the abdominal aorta and common iliac artery in the middle-aged and elderly patients after BSA standardization (Table 3), the middle and distal diameters of the abdominal aorta were significantly higher in males than those in females ($P < .05$), whereas no significant ($P > .05$) differences were detected in the diameter of the proximal end of the abdominal aorta or the proximal and distal ends of the left and right common iliac arteries between males and females.

After all subjects were divided into 4 groups according to age: 45 to 54 years (n = 207), 55 to 64 years (n = 219), 65 to 74 years (n = 159), and ≥75 years (n = 40), the diameter of the abdominal aorta at the proximal and distal ends and in the middle segment as well as the diameter of the left and right common iliac artery at the distal end were significantly ($P < .05$) increased with age (Table 4). The diameter of the right common iliac artery (at both proximal and distal ends) and of the left common iliac artery at the proximal end did not significantly ($P > .05$) increase with age.

4. Discussion

In this study investigating the normal diameters of abdominal aorta and iliac artery in middle-aged and elderly Chinese people,

Table 1

Baseline data and diameters of the abdominal aorta and common iliac arteries.

Variables	Total (n = 625)	M (n = 380)	F (n = 245)	*P* value
Age (yr)	60 (13)	60 (12.00)	61 (18.00)	.095
Height (cm)	160 (168.28)	168 (171.00)	155 (158.40)	<.001
Weight (kg)	70 (16.00)	74 (12.00)	61 (12.00)	<.001
BSA	1.75 (0.26)	1.83 (0.19)	1.60 (0.17)	<.001
BMI	25.06 (3.95)	25.34 (3.64)	24.69 (4.36)	.005
Proximal aortic diameter (mm)	21.49 ± 2.49	22.58 ± 2.07	19.80 ± 2.11	<.001
Middle aortic diameter (mm)	16.88 (3.26)	17.85 (2.39)	15 (2.47)	<.001
Distal aortic diameter (mm)	15.45 (2.90)	16.21 (2.30)	13.85 (2.38)	<.001
Right common iliac artery proximal diameter (mm)	10.50 (1.99)	11.15 (1.85)	9.75 (1.63)	<.001
Left common iliac proximal diameter (mm)	10.25 (2.05)	10.85 (1.90)	9.40 (1.64)	<.001
Right common iliac distal diameter (mm)	10.70 (2.25)	11.20 (1.95)	9.75 (1.90)	<.001
Left common iliac distal diameter (mm)	10.60 (2.22)	11.20 (1.94)	9.72 ± 1.45	<.001

The data are presented as mean and standard deviation if in normal distribution or as mean (interquartile range) if they are not in normal distribution.
BMI = body mass index, BSA = body surface area.

Table 2

Correlation of the diameter of abdominal aorta and common iliac arteries with age, height, weight, BSA, and BMI

		Abdominal aorta			Proximal common iliac artery		Distal common iliac artery	
Variables		Proximal	Middle	Distal	Right	Left	Right	Left
Age	*r*	0.114	0.082	0.089	0.025	0.077	0.124	0.120
	P	.004	.041	.026	.530	.053	.002	.003
Height	*r*	0.449	0.534	0.502	0.465	0.463	0.454	0.458
	P	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Weight	*r*	0.449	0.534	0.502	0.465	0.463	0.454	0.458
	P	<.001	<.001	<.001	<.001	<.001	<.001	<.001
BSA	*r*	0.498	0.585	0.544	0.504	0.500	0.479	0.490
	P	<.001	<.001	<.001	<.001	<.001	<.001	<.001
BMI	*r*	0.197	0.238	0.235	0.234	0.231	0.248	0.233
	P	<.001	<.001	<.001	<.001	<.001	<.001	<.001

BMI = body mass index, BSA = body surface area.

Table 3

Comparison of the diameter of abdominal aorta and common iliac arteries after BSA standardization (median and interquartile range).

	Variables	Total (n = 625)	M (n = 380)	F (n = 245)	*P* value
Aorta (mm)	Proximal	12.26 (1.86)	12.30 (1.83)	12.22 (1.95)	.780
	Middle	9.63 (1.47)	9.77 (1.45)	9.44 (1.49)	<.001
	Distal	8.82 (1.38)	8.89 (1.27)	8.71 (1.48)	.023
Proximal iliac artery (mm)	Right	6.08 (1.00)	6.11 (1.05)	6.02 (0.99)	.088
	Left	5.89 (1.01)	5.92 (1.07)	5.84 (1.01)	.194
Distal iliac artery (mm)	Right	6.11 (1.12)	6.11 (1.11)	6.10 (1.17)	.670
	Left	6.01 (1.18)	6.07 (1.15)	5.98 (1.21)	.149

The data are presented as median (interquartile range) because they are not in normal distribution.
BSA = body surface area.

Table 4

Diameters of abdominal aorta and common iliac arteries in different age groups.

Variables		45–54 yr (n = M/F = 120/87)	55–64 yr (n = 163/56)	65–74 yr (n = 80/79)	≥75 yr (n = 17/23)	*P* value
Proximal aorta (mm)	M	21.99 ± 1.93	23.05 ± 2.11	22.62 ± 1.93	22.06 ± 2.35	<.001
	F	19.19 ± 1.96	19.68 (2.99)	20.14 ± 2.20	20.28 ± 1.79	.022
Middle aorta (mm)	M	17.48 (2.14)	18.44 ± 2.06	17.87 ± 1.58	17.36 ± 1.91	.002
	F	14.56 ± 1.83	14.95 (2.54)	15.62 ± 1.70	15.91 ± 1.85	<.001
Distal aorta (mm)	M	15.93 (2.33)	16.65 (2.20)	16.37 ± 1.63	15.59 ± 1.29	<.001
	F	13.51 ± 1.69	14.15 (2.52)	14.25 (2.20)	14.36 ± 1.66	.020
Right proximal iliac artery (mm)	M	11.03 (1.69)	11.25 (2.15)	11.23 ± 1.46	10.69 ± 1.21	.090
	F	9.40 ± 1.37	9.95 (1.42)	9.90 (1.40)	9.61 ± 1.26	.254
Left proximal iliac artery (mm)	M	10.70 (1.89)	10.95 (1.85)	10.82 ± 1.43	10.87 ± 1.81	.259
	F	9.09 ± 1.29	9.03 (1.40)	9.78 ± 1.12	9.56 ± 1.30	.002
Right distal iliac artery (mm)	M	10.95 ± 1.54	11.59 ± 1.69	11.21 ± 1.26	11.33 ± 2.09	.024
	F	9.38 ± 1.52	9.70 (1.79)	10.05 (2.05)	10.71 ± 1.55	<.001
Left distal iliac artery (mm)	M	10.85 ± 1.33	11.45 (2.05)	11.34 ± 1.30	11.36 ± 1.83	.002
	F	9.42 ± 1.46	9.66 ± 1.22	9.84 ± 1.47	10.58 ± 1.53	.006

Data are presented as mean ± standard deviation if in normal distribution or median (interquartile range) if not in normal distribution.

the normal reference values of the abdominal aorta at 3 levels and the iliac arteries at 2 levels were given, and the diameters of the abdominal and iliac arteries were found to be gender related and significantly positively correlated with age, BSA, height, weight, and BMI. These findings were beneficial for the diagnosis and treatment planning of vascular diseases.

The abdominal aorta is the main artery of human body. It not only provides blood supply, but also plays an important role in cardiovascular system and peripheral circulation.[3,4] At present, the standard method for evaluating aortic dilatation is CT and magnetic resonance imaging.[5–8] The normal diameter of the aorta and iliac artery obtained through imaging measurement can be used to evaluate arterial dilation or stenosis, contributing to correct diagnosis of vascular disease and guidance of interventional therapy.

The normal reference values of aortic diameter have been reported in different countries and regions in the world. In Australia, the normal reference values of infrarenal aortic diameter in women and men had been reported to be 16 to 18 mm and 19 to 21 mm, respectively.[9] The mean diameter of infrarenal abdominal aorta was 19.3 and 16.7 mm, respectively, in asymptomatic patients of the Framingham Heart Study offspring and third-generation study cohorts in the United States.[5] An magnetic resonance imaging study of the elderly over 70 years of age in Sweden pointed out that the upper limit of the normal diameter of the aorta in men and women is 3.0 cm in men and 2.7 cm in women, respectively.[10] In a study of 596 Turkish patients measuring the diameter of the aorta, Sariosmanoglu et al[11] reported that the diameter of the subphrenic aorta (i.e., the proximal abdominal aorta) was 18 ± 3 mm in women and 19 ± 4 mm in men, whereas the mean diameter of aorta at the level of iliac artery bifurcation (i.e., the distal end of abdominal aorta) was 15 ± 3 mm in women and 16 ± 4 mm in men. In a study evaluating the diameters of the abdominal aorta, iliac, and femoral arteries in 1007 middle-aged (40–60 years) men (n = 505) and women (n = 502) in Finland using ultrasound,[12] it was found that men had significantly (*P* for all < 0.001) larger diameters of the abdominal aorta (mean 21.3 ± 2.8 vs 17.8 ± 1.3 mm), common iliac (13.4 ± 2.0 vs 12.2 ± 1.2), and common femoral arteries (11.0 ± 1.4 vs 9.7 ± 0.9) than women, with age, arterial plaques, and blood pressure increasing the arterial diameter significantly. In a study investigating the reference diameter of the abdominal aorta and iliac arteries in 1229 Korean patients with 478 men and 751 women (mean age of 63.9 ± 10.1 years, range 50 to 91),[13] the mean diameters (cm) of male/female were 2.20/2.11 (*P* < .001) at suprarenal, 2.04/1.90 (*P* < .001) at renal, 1.90/1.79 (*P* < .001) at infrarenal, 1.22/1.17 (*P* < .001) at right iliac, and 1.47/1.15 (*P* = .097) at the left iliac, with a significantly larger diameter in the male population and the diameter of each level increasing with age. In a study investigating the normal diameter and growth rate of infrarenal aorta and common iliac artery in 1340 Chinese patients aged 59.63 ± 13.13 years (range, 18–95 years),[14] the diameter was 16.49 ± 2.12 mm for the infrarenal aorta, 9.77 ± 1.75 mm for the right common iliac artery, and 9.65 ± 1.76 mm for the left common iliac artery in males. In females, the diameter was 14.50 ± 1.73 mm for the infrarenal aorta, 8.59 ± 1.31 mm for the right, and 8.45 ± 1.28 mm for the left common iliac artery. Moreover, the diameter of these arteries increases with age. In the current study focusing on patients aged 45 to 84 years with a narrower range of age compared with the above studies, the diameters of the aorta and iliac arteries were measured at more locations, including the proximal,

middle, and distal segments, with the patients being divided into 4 age groups for subtle analysis of relevant correlation of the arterial diameter with age. The mean diameter of the horizontal abdominal aorta above the celiac trunk was 22.58 ± 2.07 mm in men and 19.80 ± 2.11 mm in women, the mean diameter of horizontal aorta under the renal artery was 17.85 (interquartile range 2.39) mm in men and 15 (interquartile range 2.47) mm in women, and the mean diameter of the horizontal aorta on the bifurcation of the iliac artery was 16.21 (interquartile range 2.30) mm for men and 13.85 (interquartile range 2.38) mm for women. Therefore, the diameter of the abdominal aorta of asymptomatic Chinese people is smaller than that of the Western or Korean population, which may be in line with the differences in race, diet, body height, body shape, and physique between Chinese and Western people.

In the current study, the height, weight, BSA, BMI, diameters of abdominal aorta, and proximal and distal diameters of left and right common iliac arteries in males were significantly higher than those in females ($P < .001$; Table 1), and height, weight, BSA, and BMI were significantly positively correlated with the diameter of the abdominal aorta and common iliac artery ($P < .001$), with the strongest correlation being with BSA (Table 2). The positive correlation indicates that with increase of age, height, weight, BSA, and BMI, the diameters of the abdominal aorta and common iliac artery also increase. After the standardization of BSA, only the middle and distal diameters of abdominal aorta in the middle-aged and elderly male group were significantly higher than those in the female group ($P < .05$; Table 3). Therefore, age, height, weight, BSA, and BMI are all associated with aortic diameter, which is similar to the results of previous studies.[15–17] In the diagnosis of arterial stenosis, dilatation, and aneurysm formation of the abdominal aorta and common iliac arteries, the diagnostic accuracy can be improved via standardizing the measured values.

The aorta is an elastic artery, characterized by elastic membrane and elastic fibers in its vascular structures. Weakened vascular elasticity means a decrease in vasodilatation and contractility. With an increase in age, the elasticity of blood vessels is reduced, and the arterial lumen is dilated. It had been pointed out that with the increase of age, the mean diameter of suprarenal and infrarenal aorta gradually increased in men and women.[17] In the current study, the patients were divided into 4 groups with different ages, and the diameter of the abdominal aorta at the proximal, middle, and distal segments as well as the diameter of the left and right common iliac artery at the distal end were significantly ($P < .05$) increased with age (Table 4). This is in line with the outcomes of previous studies.[5,16,18]

Arterial lumen increase or enlargement is associated with age-related destruction of the vascular elastic laminas and loss of interlamina cross-links, with decreased matrix turnover, and throughout life, the elastogenesis is constantly decreased.[19] In uninjured blood vessels, proteases and their inhibitors are balanced so that the turnover of elastic fibers is low.[20] During aging and development of vascular pathologies, the balance between proteases and their inhibitors is destroyed via production of matrix metalloproteinase, activation of zymogens, or secretion of enzymes by inflammatory cells. Consequently, the elastic fibers of blood vessels are destroyed, leading to decreased elasticity of the aorta and common iliac artery and enlargement of arterial lumen or increase of arterial diameter. This is why the diameters of the abdominal aorta and common iliac arteries increase with age as revealed in the current study.

Some limitations existed in the current study, including the retrospective and one-center study design, a limited sample of patients, fewer patients over 75 years of age, and enrollment of Chinese Han nationality. The strength of the study may be the enrollment of Chinese Han nationality only, which excluded the effect of the influencing factor of race on vascular diameter, but the data were consequently more targeted. Future studies will have to resolve all the limitations for a better outcome.

In conclusion, the diameters of abdominal aorta and iliac artery have been obtained for normal reference in the middle-aged and elderly Chinese Han people of different genders and age based on aortic CTA or abdominal enhancement, and the diameters are gender related and significantly positively correlated with BSA, height, weight, and BMI, which is beneficial for the diagnosis and treatment planning of vascular diseases of abdominal aorta and iliac artery in China.

Author contributions

Xue-Tao Zhou and Ya-Zhen Liu acquired and analyzed the patient data. Zhi-Min Sun, Yu-Sha Zhen and Bu-Lang Gao analyzed and interpreted the patient data. Jie Hu and Zhi-Feng Zheng were major contributors in designing the study and writing the manuscript. All authors read and approved the final manuscript.

Consent for publication: All data have been approved for publication.

Availability of data and material: The data are available from the corresponding author on reasonable requirement.

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