

Reference Diameters of the Abdominal Aorta in the Pakistani Population

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ABSTRACT

Objective: To determine the normal diameter of the abdominal aorta in the Pakistani population by recruiting patients from different cities.

Study Design: Cross-sectional study.

Place and Duration of Study: Combined Military Hospitals Lahore, Quetta, and Peshawar, and Armed Forces Institute of Radiology and Imaging, Pak-Emirates Military Hospital Rawalpindi, Pakistan, from Jan to Feb 2024.

Methodology: The demographic information of 862 adult patients was collected with a questionnaire, documenting their medical history, physical examination, and ultrasonography of abdomen. Patients were also investigated for a history of diabetes, hypertension, hyperlipidemia, cardiac diseases, hypertension, pulmonary diseases, or any other comorbidity.

Results: Out of 862 patients, 520(60.3%) were male and 342(39.7%) were females. Mean age of 50.27 ± 16.49 years (range 18 to 87). 21 out of 863(2.43%) were diagnosed with abdominal aortic aneurysms (AAA). The male population had a significantly larger diameter and the diameter of each level increased with age ($p < 0.05$).

Conclusion: The normal reference diameter of the abdominal aorta in the Pakistani population in males/females at suprarenal level (A1) is 22.41/20.85mm at suprarenal (A1), at renal level (L1) is 19.04/17.34mm and at infrarenal level (L3) is 16.29/14.61mm and this increases with age.

Keywords: Abdominal Aorta, Abdominal Aortic Aneurysm, Diameter, Great Vessels.

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INTRODUCTION

The abdominal aorta is an important structure in the human body that connects the heart with the peripheral organs.¹ Knowing the normal range of diameter of the abdominal aorta is essential for radiologists to accurately interpret imaging studies, facilitate early detection of pathology, guide risk stratification, and management decisions, monitor disease progression, and ensure quality assurance in clinical practice.²

An abdominal aortic aneurysm (AAA) is defined as size of the abdominal aorta of more than 30 mm in a transverse plane in an angiographic study or a local dilation of the abdominal aorta of more than 50%, as compared to another site along the aorta.³ AAA is notoriously associated with potential rupture and a high mortality rate, making timely highly important.

The Framingham Heart Study suggests that the normal abdominal aorta in males and females were

1.93 and 1.67 cm, respectively.⁴ A Mediterranean study reported the mean infrarenal aortic diameter as 16.51 mm in the study group, while in men it was found to be 17.91 mm and 15.25 mm in women.⁵ A Korean study found the mean diameter of the abdominal aorta was 17.49 mm, and for iliac arteries, it was 10.85 mm. Stratified for gender, the mean diameter of the abdominal aorta was 18.38 mm in men and 15.88 mm in women.⁶ In the Indian population, the diameter of the abdominal aorta was found to be 1.59 cm (anteroposteriorly) and 1.73 cm (right to left), respectively.⁷

Moreover, as per The International Society for Cardiovascular Surgery/Society for Vascular Surgery Ad Hoc Committee a diameter of 1.5 times larger than normal is considered to be AAA in the infrarenal aorta.⁸

However, most reference values available in literature are derived from Western populations, which may not be applicable to the Pakistani population due to differences in ethnicity, body composition, lifestyle, and genetic factors. This study

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aimed to fill the gap by providing standard reference measurements for the abdominal aorta in the Pakistani population.

METHODOLOGY

This cross-sectional study was conducted at Combined Military Hospitals, Lahore, Peshawar, Quetta, and Armed Forces Institute of Radiology and Imaging, Pak-Emirates Military Hospital, Rawalpindi, Pakistan, from January to February 2024, after taking Institutional Ethical Review Board approval (letter number 505 dated 04 January 2024).

Inclusion Criteria: Healthy asymptomatic adult individuals, of either gender aged 18-80 years were included.

Exclusion Criteria: Patients with a past history of AAA, hypertension, diabetes mellitus, ischemic heart disease and systemic vascular disorders were excluded.

Sample size was calculated using the WHO calculator based on the standard deviation anteroposterior (AP) diameter of the infrarenal aorta as 16.13 ± 2.32 mm, which came to 860.9 Eight hundred and sixty-two ($n=862$) healthy subjects were recruited, and informed consent was taken.

In our study, we used Computed Tomography (CT) scans to measure the diameter of the abdominal aorta at three different anatomical levels across both genders and various age groups. The data were collected from multiple centers representing all provinces of Pakistan. Although this is a preliminary study, it provides a foundational reference for comparing international guidelines on aortic aneurysm management with data from the Pakistani population, as it reflects measurements from the local demographic.

A total of 897 angiographic scans were initially reviewed. After applying eligibility criteria, 862 patients were included in the final analysis.

Demographic data (age, BMI, gender) were collected using a structured questionnaire. The screening process included recording the patient's medical history, physical examination findings, and results from abdominal ultrasonography. Patients were also evaluated for comorbidities such as diabetes, hypertension, hyperlipidemia, cardiac conditions, pulmonary diseases, and other relevant clinical histories. Both anteroposterior and transverse diameters of the abdominal aorta were measured.

Data was analyzed by using Statistical Package for Social Sciences (SPSS) 22. Quantitative data was represented using Mean $\pm$ SD and qualitative data was represented by using percentage and frequency. An independent sample t-test was applied and a p -value of ≤ 0.05 was considered statistically significant

RESULTS

A total of 862 angiographic studies were included in the final analysis. Five hundred and twenty (60.3%) patients were male and 342(39.7%) were female. Mean age of 50.2 ± 16.4 years (range 18 to 87). However, majority of patients ($n=312$, 36.2%) had normal weight followed by overweight ($n=286$, 33.2%), obese ($n=219$, 25.4%) and only 45(5.2%) patients were underweight. Hypertension was the most common comorbidity, affecting 24.4% ($n=210$) of participants, followed by hyperlipidemia ($n=165$, 19.1%), diabetes mellitus ($n=150$, 17.4%), cardiac disease ($n=150$, 17.4%) and pulmonary disease were present in 98(11.4%) patients 19.6%, while 169(19.6%) individuals reported no known comorbidities.

The demographic and clinical characteristics of patients is shown in Table-I. The diameter of the abdominal aorta was measured at the level of the first (A1), second (A2), and third (A3) lumbar vertebrae. The mean diameter at A1 was 22.0 ± 3.9 mm, at A2 was 18.7 ± 3.5 mm and 15.73 ± 2.62 mm at A3. The comparison of the diameters of different age groups is shown in Table-II. The diameter of each level increased with age ($p < 0.001$). In a normal population, the mean age of males was 49.3 ± 17.0 years, and of females was 51.6 ± 15.4 years. Diameters (mm) of males vs females were 22.7 ± 3.8 vs 20.9 ± 3.8 ($p < 0.001$) at suprarenal (A1), 19.5 ± 3.2 vs 17.4 ± 3.7 ($p < 0.001$) at renal (A2), and 16.4 ± 0.1 vs 14.6 ± 0.1 ($p < 0.001$) at infrarenal (A3), respectively. There was a significantly larger diameter in the male population (Table-III).

As BMI increased, there was a progressive enlargement in the mean diameter of the abdominal aorta. Individuals in the obese category ($BMI \geq 30$) had the largest aortic diameters at all levels, followed by those in the overweight, normal weight, and underweight categories. Specifically, the suprarenal (A1) diameter increased from 19.3 ± 2.9 mm in underweight individuals to 24.1 ± 3.8 mm in obese individuals. There was a statistically significant association between body mass index (BMI) and abdominal aortic diameter at all three measured levels, with p -values less than 0.001 as shown in Table-IV.

Table-V shows that patients with hypertension had the highest aortic diameters at all three levels (A1: 24.01±3.42 mm, A2: 21.05 ± 3.18 mm, A3: 17.40±2.73 mm), with a statistically significant association ($p<0.001$). Similarly, those with cardiac disease also had significantly higher diameters (A1: 24.35±3.58 mm, A2: 21.20±3.42 mm, A3: 17.62±2.80 mm), again showing strong statistical significance (p -value <0.001). Patients with diabetes mellitus and hyperlipidemia also demonstrated slightly larger aortic diameters compared to those without comorbidities, with p -values <0.01 and 0.032 , respectively. Furthermore, pulmonary disease showed a trend toward larger diameters, but this association was not statistically significant (p -value= 0.062). Participants with no comorbidities had the smallest aortic diameters at all levels (A1: 21.56 ±2.87 mm, A2: 18.35±2.60 mm, A3: 15.30±2.31 mm).

Table-I: Demographic and Clinical Characteristics of Study Participants (n=862)

Variables	n (%)
Age range in years	
18 – 28	111(12.9%)
29 – 38	140(16.2%)
39 – 48	127(14.7%)
49 – 58	164(19.0%)
59 – 68	195(22.6%)
69 – 78	103(11.9%)
79 and above	22(2.6%)
Gender	
Male	520(60.3%)
Female	342(39.7%)
Body Mass Index	
Underweight	45(5.2%)
Normal Weight	312(36.2%)
Overweight	286(33.2%)
Obese	219(25.4%)
Comorbidities	
Diabetes Mellitus	150(17.4%)
Hypertension	210(24.4%)
Hyperlipidemia	165(19.1%)
Cardiac Disease	98(11.4%)
Pulmonary Disease	70(8.1%)
No Comorbidities	169(19.6%)

In addition, 21 out of 863(2.43%) participants were diagnosed with AAA, having a diameter greater than 30mm. One individual had an aneurysm at all three levels and one had an aneurysm at A1 and A3. While in isolation, at level A1, 17 patients were found to be suffering from AAA, at A2, 2 were found to be suffering from AAA and none of the patients had isolated AAA at level A3. In Lahore, 1 patient had AAA, and that too at all 3 levels, in Quetta 4 patients

had AAA all at level A1, in Peshawar 10 patients had AAA, 8 at level A1 and 2 at level A2, and in Rawalpindi 5 patients had AAA, all at level A1. Calcification was found in 255 patients.

Table-II: Comparison Diameters of Abdominal Aorta across Age Groups (n=862)

Level	Age Groups (Mean±SD)							p-value
	18 – 28 years (n=111)	29 – 38 years (n=140)	39 – 48 years (n=127)	49 – 58 years (n=164)	59 – 68 years (n=195)	69 – 78 years (n=103)	79 and above (n=22)	
A1 (Diameter) Mm	18.4±3.2	20.1±3.2	21.3±2.7	22.2±2.7	23.7±3.7	24.8±3.6	26.0±3.8	<0.001
A2 (Diameter) mm	15.9±2.8	17.2±2.5	18.1±2.3	18.7±2.7	19.9±3.0	21.5±3.9	22.5±3.5	<0.001
A3 (Diameter) mm	13.6±2.5	14.9±1.7	15.3±2.0	15.7±2.1	16.6±2.5	17.5±2.8	17.6±2.3	<0.001

Table-III: Comparison of Abdominal Aorta Diameter across Genders (n=862)

Levels	Male (n=520) Mean±SD	Female (n=342) Mean±SD	p-value
A1 (Diameter) mm	22.7±3.8	20.9±3.8	<0.001
A2 (Diameter) mm	19.5±3.2	17.4±3.7	<0.001
A3 (Diameter) mm	16.4±0.1	14.6±0.1	<0.001

Table-IV: Comparison Diameters of Abdominal Aorta across Body Mass Index Groups (n=862)

Level	Underweight (n=45)	Normal Weight (n=312)	Overweight (n=286)	Obese (n=219)	p-value
A1 (Diameter) Mm	19.3±2.9	21.0±3.2	22.9±3.6	24.1±3.8	<0.001
A2 (Diameter) Mm	16.2±2.4	18.0±2.9	19.4±3.1	20.7±3.6	<0.001
A3 (Diameter) Mm	13.9±2.1	15.1±2.2	16.4±2.5	17.3±2.6	<0.001

*Underweight: BMI < 18.5, Normal weight: BMI 18.5–24.9, Overweight: BMI 25.0–29.9, Obese: BMI ≥ 30

Table-V: Comparison of Abdominal Aortic Diameters across Comorbidities (n=862)

	A1 (Diameter) mm	A2 (Diameter) mm	A3 (Diameter) mm	p-value
Diabetes Mellitus	23.4±3.2	20.1 ± 2.9	16.8 ± 2.6	< 0.01
Hypertension	24.0 ± 3.4	21.0 ± 3.1	17.4 ± 2.7	< 0.001
Hyperlipidemia	22.8 ± 3.1	19.8 ± 2.7	16.4 ± 2.5	0.032
Cardiac Disease	24.3 ± 3.5	21.2 ± 3.4	17.6 ± 2.8	< 0.001
Pulmonary Disease	22.1 ± 3.4	19.0 ± 2.8	16.1 ± 2.4	0.062
No Comorbidities	21.5 ± 2.8	18.3 ± 2.6	15.3 ± 2.3	–

DISCUSSION

The information regarding the normal diameter of abdominal aorta is important for the diagnosis and screening of the abdominal aortic aneurysm. For the purpose of diagnosis CT-scan is the investigation of choice and for screening purpose ultrasonography is used.^{10,11}

Though there is no gold standard technique to measure the diameter of AA, and we used a CT scan to measure the diameter of AA as it is less operator-dependent and is more objective.¹² Moreover, for screening purposes, USG is mostly used and CT scan is mostly preserved for preoperative workup and to decide surgical technique. While analyzing the diameter of the abdominal aorta in different parts of the world, it is clear that the normal diameter varies in different ethnicities. Hence, it is important to find the normal reference diameter of the abdominal aorta in the Pakistani population. Moreover, little work has been done in Pakistan on the diameter of the abdominal aorta.

A Nigerian study screened 422 patients and documented the diameter of the abdominal aorta using sonography, showing that in males, the diameter of the abdominal aorta was 15.1 ± 0.5 mm and 15.1 ± 0.5 mm in females.¹³ As compared to the mean diameter of infrarenal aortic diameter in males/females of 16.29/14.61mm, in Korea, the diameter of the intrarenal aorta was 19.0mm in males and 17.9mm in females.¹⁴ Duplex ultrasonography was used to measure the diameter of the abdominal aorta. In another study on the Korean population, researchers measured the diameter of the abdominal aorta while screening for an aneurysm in the thoracic aorta using echocardiography. They documented the diameter of the abdominal aorta to be 19.0 ± 6.1 mm.¹⁵ Similarly, in the Kingdom of Saudia Arabia, Alloush *et al.* found the mean diameter at the suprarenal/infrarenal aorta to be 1.68cm and 1.36cm respectively.¹⁶ Similarly in another study in KSA by Gameraddin *et al.*, the AP/TD diameter of supra renal and infrarenal aorta was found to be 20.38mm 13.47/22.87mm and 15.38mm respectively.¹⁰ In our study, we have found that the diameter increases and reaches its peak in the eighth decade of life and then, surprisingly, falls in the ninth decade. For the above studies, there was no study found for the respective regions that used CT-scan to compare the reference diameters.

In contrast to ultrasonography, most of the studies used CT scans to measure the aortic diameter. In a study from India, CT scan was used to measure the diameter of the abdominal aorta. The transverse and AP diameter at L3 were 15.0mm and 14.0mm, respectively in males, and 13.2mm and 13.0mm, respectively in females. At the level of T12, it was found to be 20.8 mm and 20.9 mm respectively in

males, while 18.9 mm and 18.4 mm in females.¹⁷ A very interesting study was conducted, which used CT-scan to calculate and compare mean abdominal diameter in European, Hispanic, and North American populations. The mean diameter at the celiac axis in European, Hispanic, and North American populations was 24.2 mm/21.0 mm/22.1 mm, and at the level of aortic bifurcation was 22.6 mm/15.4 mm/15.5 mm respectively. In the population of Copenhagen, the diameter of the abdominal aorta at the celiac axis in men was documented to be 23 mm in males and 21 mm in females, while at the level of infrarenal aorta, it was documented as 20 mm in males and 17 mm in females.¹⁸

In China, Hu *et al.* used CT-scan to measure the diameter of the abdominal aorta in 625 patients using CT angiography. They documented the diameter of the abdominal aorta in males/females in proximal, middle, and distal abdominal aorta as 22.58 mm/19.80 mm, 17.85 mm/15.0 mm, and 16.21 mm/13.85 mm respectively.¹⁹

All above studies have used CT-scan as the investigation of choice to document the reference normal diameter of the abdominal aorta.

LIMITATIONS OF STUDY

The primary limitation of this study is its reliance on data exclusively from military hospitals, which may introduce selection bias and not fully represent the general population. Additionally, because ultrasound is highly operator-dependent, data collection across four different centers likely introduces inter-observer variability. The brief two-month duration and cross-sectional design also preclude any longitudinal tracking of age-related aortic changes within the same individuals. Finally, it remains unclear whether patients with vascular-altering comorbidities (such as hypertension) were entirely excluded when calculating the baseline "normal" reference diameters, which could potentially skew the results.

CONCLUSION

In conclusion, the reference diameter (mm) of the abdominal aorta in the population of Pakistan, at suprarenal level (A1) is 22.41/20.85 at suprarenal (A1), at renal level (L1) is 19.04/17.34 and at infrarenal level (L3) is 16.29/14.61 in males/females respectively. Moreover, it was found that the diameter increases with age.

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Author's contribution

Following authors have made substantial contributions to the manuscript as under:

JA & HKP: Conception, study design, drafting the manuscript, approval of the final version to be published.

RB & UN: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

MAZH 7 AJ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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