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Influence of Age, Gender and BMI on Normal Abdominal Aorta Diameter taken on Abdominal Sonography in Healthy Asymptomatic Pakistani Population

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ABSTRACT

Objective: To evaluate the abdominal aorta diameter in asymptomatic Pakistani population to determine the associations between age, gender and BMI and abdominal aortic diameter measured by ultrasonography.
Study Design: Case series.
Place and Duration of Study: Department of Radiology, Combined Military Hospital, Lahore, Pakistan, from Jun to Dec 2021.
Methodology: A total of ninety-four healthy asymptomatic subjects of both genders, between 18-80 years of age, were enrolled for the study. Aortic diameters were measured (inner to inner method) using electronic calipers on static images. The Anteroposterior and Transverse (TR) diameters were measured at three levels: the first at the aortic hiatus, which was directly below the abdominal aortic commencement, the second at the suprarenal (mid-point), and the third at the aortic bifurcation (lower level).
Results: Males had significantly larger (*p*-value<0.001) anteroposterior and transverse abdominal aorta diameters than females, with abdominal aorta diameter values found to be significantly higher (*p*-value 0.001) in age group of greater than 40 years except anteroposterior distal abdominal aorta diameter. Similarly, a significant difference (*p*-value <0.001) was noted in abdominal aorta diameter among patients with different BMI groups other than distal abdominal aorta diameter.
Conclusion: Abdominal aorta diameters vary greatly depending on age, gender and BMI. Clinicians must know the usual diameter of the abdominal aorta in order to recognize an aneurysm at an early stage.

Keywords: Abdominal aorta diameter, Abdominal aorta aneurysm, Anteroposterior diameter, Transverse diameter, Ultrasonography.

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INTRODUCTION

The abdominal aorta (AA) is the biggest vessel in the abdominal cavity with normal diameter of approximately 20mm, which supplies oxygenated blood to major abdominal organs such as the spleen, liver, diaphragm, gonads and pelvis.[1] Focal dilatation of at least 1.5 times the normal diameter of AA or an absolute value of 3.0 cm or greater causes abdominal aortic aneurysm (AAA) which is potentially a fatal condition.[2] Aneurysm development is characterised by the degradation of elastin and collagen in the media and adventitia, the release of cytokines and chemokines, and an oxidative burst resulting from a catalytic process that occurs after infiltration of inflammatory cells into the aorta wall. Previously published literature reported that diameter of AA is wider in male than female.[3] Men are four to six times as likely than women to develop AAAs. In addition, AAAs develop approximately 10 years later in women than in men.[4,5] However, males and females are equally affected by clinical risk factors for AAA, including as history of smoking, family history of AAA, advanced age, increased body mass, atherosclerosis, hypertension, and various comorbids.[2,3,6] According to recently published literature, there is a trend toward a strong relationship between BMI and the existence of AAA. However, the evidence for the association between obesity and AAA expansion are quite limited.[7,8] To avoid rupture, the diagnosis of a AAA should be made before to the onset of clinical symptoms. Ultrasound screening has been found to be an effective and cost-effective means of avoiding AAA rupture and lowering mortality, and it should be made available to males aged 65 and higher, especially those who have ever smoked or have a family history of AAA.[9] Findings of previous studies have reported a respectable diagnostic accuracy of ultrasound for AA and AAA.[10] Unfortunately, the majority of the data in the literature is based on demographic data from Western countries and there is

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paucity of local studies due to which, findings of western studies are used as reference on our local population. Assessing the relationship of physical attributes of our population with AA diameter will ultimately help Pakistani clinicians to understand the reference values of this vital parameter which is strongly associated with risk of AAA, cardiovascular disease risk factors and calcified atherosclerosis.

METHODOLOGY

The case series was conducted at Department of Diagnostic Radiology, Combined Military Hospital (CMH), Lahore, Pakistan, from June to December 2021. Sample size was calculated by using WHO sample size calculator on the basis of standard deviation of AAD as 1.78.[11] Using non-probability consecutive sampling technique, ninety-four (n=94) healthy subjects were recruited, after taking IERB approval via letter number 290/2021 and written informed consent from patients.

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

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

Detailed clinical history was taken and a thorough physical examination performed. Height and weight was measured using standard scale and BMI was calculated using the standard formula (i.e. Weight in kg/Height in m^2 ; kg/m^2). Patients were considered normal if BMI <24kg/m^2, Up to 29kg/m^2 considered overweight while > 29kg/m^2 were labelled as obese. The AA diameter was investigated sonographically using a Canon Xario 100G Doppler Ultrasound Machine with a 3.5 MHZ curvilinear probe. All participants were advised to fast for three to five hours prior to the ultrasound in order to be gas-free. The participants were scanned in supine position. Electronic calipers were used to measure both AP and Transverse aortic diameter using inner to inner method after acquiring static images. One consultant radiologist recorded all measurements to reduce operator dependent variability.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 25.0. Student t-test and one way ANOVA test was applied with *p*-values of ≤0.05 considered to be significant.

RESULTS

A total of 94 patients were enrolled for this study and most of the study participants were female (54, 57.4%) with mean age of 41.15±14.97 years, while male subjects were 40(42.6%) with mean age of 35.9±19.43 years. Mean height and weight of all the study population was noted as 164.82±7.43cm and 67.41±10.61 kg respectively. Patients were further classified on the basis of age and BMI (normal, overweight and obese). Demographic characteristics of study population are listed in Table-I. The cumulative mean anteroposterior AAD was 13.50±2.21mm for the proximal AA, 12.14±1.98mm for mid AA and 10.61±1.63mm for distal AA while cumulative mean transverse AAD was 15.23±2.88mm for the proximal AA, 13.76±2.53mm for mid AA and 11.77±2.28mm for distal AA, as shown in Table-II. On comparing the mean AAD between males and females, it was noticed that the values of AAD were significantly higher (*p*-value<0.05) in males than females, at all levels except transverse mid AA diameter. Values of transverse AAD found to be higher than anteroposterior values in both sexes at all three levels, as shown in Table-III. Similarly, mean AAD was also compared between different ages (Table-IV) and BMI groups (Table-V), and statistically significant difference was observed for all the AA levels.

Table-I: Demographic Characteristics of Study Participants (n=94)

Characteristics		n (%)
Gender	Male	40 (41.4)
	Female	54(58.6)
Cumulative Age (years) Mean±SD		38.91±17.11
Age Groups	18-30 years	33(35.1)
	31-40 years	26(27.7)
	41-60 years	20(21.3)
	> 60 years	15(16.0)
Height (cm) Mean±SD		164.26±8.71
Weight (kg) Mean±SD		66.06±12.08
Cumulative BMI (kg/m^2) Mean±SD		24.85±4.15
BMI Groups	Upto 24 kg/m^2 (Normal)	43(45.7)
	25-29 kg/m^2 (Overweight)	39(41.5)
	≥ 30 kg/m^2 (Obese)	12(12.8)

Table-II: Mean Abdominal Aorta Diameter at Different Levels Among Total Study Population, (n=94)

Abdominal Aorta Levels	Mean±SD (mm)
AP Proximal	13.50±2.21
Transverse Proximal	15.23±2.88
AP Mid	12.14±1.98
Transverse Mid	13.76±2.53
AP Distal	10.61±1.63
Transverse Distal	11.77±2.28

AAD; Abdominal aorta diameter, AA; Abdominal aorta, SD; Standard deviation, AP; Anteroposterior

Table-IV: Comparison of Mean Abdominal Aorta Diameter at Different Levels Among Male and Female Gender (n=94)

Abdominal Aorta Levels	Gender	AAD Mean±SD (mm)	*p*-value (Student t-test)
AP Proximal	Male	14.17±2.31	0.011
	Female	13.01±2.01	
Transverse Proximal	Male	15.90±2.32	0.050
	Female	14.73±3.16	
AP Mid	Male	12.76±2.17	0.009
	Female	11.68±1.71	
Transverse Mid	Male	14.30±2.31	0.074
	Female	13.36±2.64	
AP Distal	Male	11.02±1.78	0.033
	Female	10.30±1.45	
Transverse Distal	Male	12.38±2.58	0.026
	Female	11.32±1.95	

AAD; Abdominal aorta diameter, AA; Abdominal aorta, SD; Standard deviation, AP; Anteroposterior

Table-V: Comparison of mean Abdominal Aorta Diameter at Different Levels Among Study Subjects with Different Age Groups (n=94)

Abdominal Aorta Levels	Age Groups	AAD Mean±SD (mm)	*p*-value (ANOVA-test)
AP Proximal (n=94)	18-30 Years (n=33)	12.73±1.97	0.027
	31-40 Years (n=26)	13.38±2.51	
	41-60 Years (n=20)	14.38±1.82	
	> 60 Years (n=15)	14.25±2.15	
Transverse Proximal (n=94)	18-30 Years (n=33)	14.26±2.04	0.029
	31-40 Years (n=26)	15.02±2.93	
	41-60 Years (n=20)	16.36±2.88	
	> 60 Years (n=15)	16.23±3.69	
AP Mid (n=94)	18-30 Years (n=33)	11.44±1.98	0.009
	31-40 Years (n=26)	12.00±2.01	
	41-60 Years (n=20)	13.27±1.61	
	> 60 Years (n=15)	12.43±1.83	
Transverse Mid (n=94)	18-30 Years (n=33)	12.89±2.03	0.020
	31-40 Years (n=26)	13.57±2.53	
	41-60 Years (n=20)	14.99±2.50	
	> 60 Years (n=15)	14.36±3.00	
AP Distal (n=94)	18-30 Years (n=33)	10.32±1.53	0.336
	31-40 Years (n=26)	10.62±1.75	
	41-60 Years (n=20)	11.16±1.47	
	> 60 Years (n=15)	10.48±1.82	
Transverse Distal (n=94)	18-30 Years (n=33)	11.16±2.00	0.097
	31-40 Years (n=26)	11.59±2.37	
	41-60 Years (n=20)	12.29±2.12	
	> 60 Years (n=15)	12.74±2.66	

AAD; Abdominal aorta diameter, AA; Abdominal aorta, SD; Standard deviation, AP; Anteroposterior

Table-III: Comparison of Mean Abdominal Aorta Diameter at Different levels Among Study Subjects with Different BMI Groups (n=94)

Abdominal Aorta Levels	BMI Groups	AAD Mean±SD (mm)	*p*-value (ANOVA-test)
AP Proximal	Upto 24 kg/m² (n=43)	13.06±2.27	0.188
	24-29 kg/m² (n=39)	13.81±2.24	
	≥ 30 kg/m² (n=12)	14.09±1.63	
Transverse Proximal	Upto 24 kg/m² (n=43)	14.75±2.85	0.256
	24-29 kg/m² (n=39)	15.47±2.70	
	≥ 30 kg/m² (n=12)	16.17±3.43	
AP Mid	Upto 24 kg/m² (n=43)	11.69±2.09	0.127
	24-29 kg/m² (n=39)	12.52±2.01	
	≥ 30 kg/m² (n=12)	12.52±1.04	
Transverse Mid	Upto 24 kg/m² (n=43)	13.25±2.45	0.099
	24-29 kg/m² (n=39)	13.95±2.41	
	≥ 30 kg/m² (n=12)	14.95±2.95	
AP Distal	Upto 24 kg/m² (n=43)	10.34±1.57	0.361
	24-29 kg/m² (n=39)	10.83±1.77	
	≥ 30 kg/m² (n=12)	10.82±1.34	
Transverse Distal	Upto 24 kg/m² (n=43)	11.51±2.33	0.593
	24-29 kg/m² (n=39)	12.03±2.28	
	≥ 30 kg/m² (n=12)	11.84±2.20	

AAD; Abdominal aorta diameter, AA; Abdominal aorta, SD; Standard deviation, AP; Anteroposterior

DISCUSSION

Our study results demonstrated a decreasing trend of abdominal aorta diameter measured for both anteroposterior and transverse section among healthy subjects of central Punjab. Our findings are in line with the findings of Joh JH and colleagues.[11] They determined the normal reference diameters of the abdominal aorta in the Korean population and reported that AAD in this population was 2.14 cm at suprarenal level, 1.95 cm at renal level and 1.83cm at infrarenal level. These values are somewhat higher than our findings, however decreasing pattern is similar to our study. The main reason behind larger diameter in Korean population could be to the difference in BMI or body size of the study subjects. Another similarity to this study is the significantly larger diameter in older age and male population. However, they have taken the single measurement of

AAD, while in our study we have measured it in transverse as well as anteroposterior section. Usman *et al.* in a Nigerian study, reported nearly similar values of mean proximal and distal AAD as per described in our study.[12]

Similar to ours study, Gameraddin *et al.* established the normal criterion of AAD measured on abdominal ultrasonography in Sudanese population on the basis of age and gender.[13] Authors of this study, illustrated in their results that the anteroposterior AAD at hiatus, renal aorta and bifurcation level were 20.380±1.78 mm, 15.749±1.34 mm, and 13.473±1.23, respectively. On the other hand, transverse AAD at all of the above three levels were 22.868±2.60 mm, 17.098±1.31 mm and 15.38±2.13 respectively. If we compare these values to our results, we found it little bit higher than our study findings. As average height and weight of the Sudanese population is larger than Pakistani population (BMI of our study population is 24.5kg/m^2; which is 27.1 kg/m^2 for Sudanese population of same age group),[13] it could be one of the main causes of higher AAD in this study. On the other hand, both transverse and anteroposterior AAD decreased from proximal to distal end in this study which is inline with our findings. They concluded that AAD were significantly higher in male gender and vary significantly with age, gender and height.

Recently, Okpaleke and co-authors in their study developed the reference values for AAD in Nigerian population. Similar to our study, they also investigated the relationship of AAD with age, BMI and gender in the study subjects. Contrary to our study results, they ruled out that the values of AAD were not significantly different in healthy Nigerian male and female subjects (15.16±0.55 mm VS 15.15±0.55 mm). Mean AA diameter in total study population measured as 15.16±0.55 mm. Furthermore, they found weak significant correlation of the AAD with BMI while significant correlation with age.[14]

We found a significant relation between gender and AAD. Moreover, our gathered data reflected that range of mean anteroposterior diameter of proximal AAD in male was 9-19 mm and 9-17mm in women. While, the mean diameter at distal AA were noted as 8-16 mm in male, while 6-14 mm in female respectively. These values are lower than the findings of Norman PE *et al*. who reported the mean values of distal AAD in Australian population as 16-18mm in female and 19-21 in male. This vast difference in range of diameter could be due the racial variation or due to the age difference of study population.[15] A multicenter study conducted on Turkish population reported the AAD at hiatus level as 18±3 mm in women and 19±4 mm in men, while, 15±3 mm in females and 16±4 mm in males at bifurcation level.[16] Similarly, studies from some other western countries,[17,18] also reported a higher value of AAD in male and female population than our population. This reflected that not only gender but racial difference has a great impact on AAD.

Our results illustrated a significant association of age and BMI with AAD. In contrast to our findings, Takagi H *et al*. and Stackelberg O *et al*. found no significant association between different BMI levels and diameter of AA. Esposito R and colleagues described in their study that AAD was larger in subjects with age ≥50 years. Multivariate analysis in this study evaluated that their age, gender and BMI were independent predictor of AA size.[19] Valecchi D *et al*. also found a positive correlation of increasing AAD with age.[20]

In summary, results of our study and review of previously available studies reflected that there is a strong association of age, gender and BMI with diameter of AA. Furthermore, value of AAD greatly vary with racial variation. Therefore, a good knowledge of normal AAD of a specific population is essential for the early and prompt diagnosis of aortic abnormalities such as AAA and aortic stenosis. Major strength of the current study is that it is the first study reporting average age-, sex- and BMI-specific ultrasound-based reference values for AAD in healthy population of central Punjab. The potential limitation of our study is that it is a single center study, so results might not be generalizable to other ethnicities. Secondly, although ultrasonographic measurements were made by the single clinician under a standard protocol, ultrasound measurement remains to be highly operator dependent, and inter- and intra-observer variability exists. We recommend a similar larger scale study at national level to overcome these limitations.

LIMITATION OF STUDY

Although ultrasonographic measurements were made by the single clinician under a standard protocol, ultrasound measurement remains to be highly operator dependent, and inter- and intra-observer variability exists.

CONCLUSION

Determining the normal values of abdominal aorta in our local population, we identified that the aortic diameters

of our study subjects were lower than those reported in other ethnicities, which should be taken into account while developing intervention regimens for AAA. Moreover, age, gender and body mass index have a significant impact on AA diameter at various levels.

Conflict of Interest: None.

Authors' Contribution

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

QUA & AI: Data acquisition, critical review, approval of the final version to be published.

TM: Study design, data interpretation, drafting the manuscript, critical review, 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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