Normal abdominal aorta diameter on abdominal sonography in healthy asymptomatic adults: impact of age and gender

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ABSTRACT

The study aims to establish the normal criterion of abdominal aortic diameters measured on abdominal sonography based on gender and age, and to study the variation in aortic diameters with age, sex, and height. In this cross-sectional study, a total of 110 asymptomatic adults were examined by ultrasound using 3.5 MHz probes. The diameters of the abdominal aorta were measured at three levels. The results were analyzed using Student’s t-test and analysis of variance (ANOVA) on SPSS version 23. The anteroposterior and transverse diameters of the abdominal aorta were significantly higher in males than females and positively correlated with age (p-value <0.001). The diameters were significantly increased with height (p-value <0.001). The normal abdominal diameters were significantly higher in males more than females. The diameters vary significantly with age, gender, and height. Identifying the normal diameter of the abdominal aorta is essential for clinicians to detect an aneurysm at an early stage.

1. Introduction

The abdominal aorta (AA) is the largest vessel in abdominal cavity commencing at the hiatus of the diaphragm at the level of the twelfth thoracic vertebra and descends in the midline ending at the fourth lumbar vertebra, where it bifurcates into the common iliac arteries. Its length is approximately 13 cm (Richard, Vogl, & Adam, 2010). The diameter of the AA is important to be evaluated in abdominal sonography since it is frequently affected by vascular disorders in older adults. The evaluation of diameter of the abdominal aorta is essential for the diagnosis of an abdominal aortic aneurysm (AAA) which is diagnosed when it is >50% larger than the normal diameter (Debus & Grundmann, 2017).

Age is a risk factor that affects the diameter of the aorta. Advanced age is one of the clinical risk factors for AAA (Hannawa, Eliason, & Upchurch, 2009). Previous studies reported that the diameter of AA increases with age. AAA is diagnosed when the aortic diameter is 30 mm or above. The prevalence of AAA increased with age and is more common in the elderly. It is more frequent in men than in women, accounting for 1–3% of all deaths among men aged 65–85 years in developed countries (Sakalihasan, Limet, & Defawe, 2005). Therefore, evaluation of the aortic diameter is useful for the epidemiology of AAA and relevant systematic studies.

Gender is a significant risk factor that affects the diameter of AA. Previous studies reported the diameter of AA is wider in men than women (Zommorodi, Leander, Roy, Steuer, & Hultgren, 2018). Male sex is considered one of the most influential risk factors for AAA with advanced age. It was reported that the incidence was common in men over the age of 65 years (Carino, Sarac, Ziganshin, & Elefteriades, 2018; Lederle et al., 1997).

Screening ultrasonography is essential to assess AA. It is a useful diagnostic imaging modality since it is safe, simple, inexpensive, and accurate. Screening is beneficial in elderly who are suspected of higher risk of AAA. Besides, there are no risk factors associated with ultrasound investigation of the aorta compared to CT imaging which includes hazards from ionizing radiation.

In Khartoum State, there is a lack of previous studies on the normal diameter of AA. The purpose of this study is to evaluate the AA in Sudanese people to determine the associations between abdominal aortic diameter measured by ultrasonography with gender, age, and height. The results of this study are beneficial for clinicians and vascular surgeons in the diagnosis and management of abdominal aortic aneurysm.

2. Materials and methods

A cross-sectional study conducted at Khartoum state from the period of September 2014 to February 2015. A total of 110 healthy asymptomatic adults were recruited in the study. Patients with a previous history of AAA, hypertension, diabetes, cardiac disorders and systematic vascular diseases were excluded from the study. The study was approved by the institutional...
ethical committee of the Alzaiem Alazhari University. All participants obtained written informed consent.

2.1. The sonographic procedure and measurements

The participants were fasting three to five hours to be free of gases. Sonographic investigation of the AA is performed by three certified sonologists who specialized in medical ultrasound for more than seven years. The investigation was performed using a 3.5MHz curvilinear probe with ultrasound machine EUB-5500 ULTRASOUND SCANNER-HITACHI-JAPAN. The participants were scanned in a supine position, right and left lateral decubitus and right and left posterior oblique positions. Images are taken in coronal and transverse planes.

The AA was divided into three anatomic segments relative to the aortic morphology and branch vessel origins. The aortic diameters were evaluated at three levels, which nearly represents the whole course of the vessel. The anteroposterior (AP) and transverse diameters (TD) were measured at three levels. The first level was determined by aortic hiatus which lies immediately below the aortic commencement. The second level was the suprarenal (midpoint), and the third was bifurcation level (lower part) as illustrated in Figure 1. The suprarenal level was the aortic diameter superior to the level of renal artery which approximately lies at the midpoint. The bifurcation level lies immediately superior in the region where the aorta bifurcates into right and left common iliac arteries (Figure 1).

2.2. Statistical analysis

Descriptive statistics of the study sample were summarized by means and standard deviations for continuous variables. Categorical variables were summarized using frequencies and percentages. Pearson correlations were applied to calculate associations of aortic diameter with age and gender at each level of aortic measurement. Students t-test was used to compare the mean of aortic measures between males and females. P-values less than 0.05 were considered to be significant.

3. Results

The AA was measured at three levels in 110 healthy asymptomatic adults. The study composed of 56 males and 54 females and the mean age was 43 ± 8 years old (Table 1). The AP diameter of the AA at hiatus aorta, renal aorta, and bifurcation levels was 20.380 ± 1.78 mm, 15.749 ± 1.34 mm, and 13.473 ± 1.23, respectively. The TD at these levels was 22.868 ± 2.60 mm, 17.098 ± 1.31 mm and 15.38 ± 2.13 respectively. The levels of aortic measurements were demonstrated in Figure 1. Both TD and AP diameters were decreased inferiorly along the course of the aorta (Table 2). Figures 2 and 3 are sonograms showing the AP and transverse measurements of the abdominal aorta.

Figure 1. Aortic levels: 1: Hiatus level; 2: Suprarenal level; 3: Bifurcation level.
The diameters of AA have a significant association with gender. The AP and TD diameters were significantly higher in males than females at the three levels as shown in Table 3. The diameters of AA have a significant linear association with age (Figure 4). The diameters increased as age advanced. The highest significant correlations were found at bifurcation levels as shown in Table 4. The body height has a significant correlation with diameters of the AA in both sexes (Figure 5). The highest significant correlation was found at bifurcation levels as demonstrated in Table 5.

4. Discussion

Accurate anatomic descriptions of the aorta are necessary for the diagnosis of vascular diseases specifically the AAA. Several previous studies have investigated the morphometry of the AA using different imaging techniques such as computerized tomography and magnetic resonance imaging (MRI) (McBride et al., 2015; Rogers et al., 2013).

In our setting, the normal effective diameters of the aorta at three levels were determined for adults of different heights and both sexes. The measurement in three levels with two planes was effective for the aorta rather than one plane. Other studies were limited by measuring AA in only the anteroposterior dimension (AP) (Munk, Darge, Wiesel, & Troeger, 2002, p. 10). Additionally, several studies have evaluated only thoracic aortic root dimensions, using echocardiography (Vasan, Larson, Benjamin, & Levy, 1995, p. 11). It was observed that mean AP diameter was 20.380 ± 1.78 mm at the hiatus aorta; 15.749 ± 1.34 mm at renal level (midpoint) and 13.473 ± 1.23 mm at the level of bifurcation. These findings supported the fact that the diameter of AA decreases its course inferiorly (Shweta, Hamad, & Vikram, 2007).

The present study demonstrated that both gender and age have an impact on a diameter of the AA. It was found that the diameter has a positive correlation with age. The effect of age on AA has been demonstrated in several previous studies. Tarnoki et al. studied genetic and environmental effects that influence the development of AA. They reported that the morphology of AA is related to healthy aging and the size increase during life (Tarnoki et al., 2016).
Virmani et al. studied the effect of aging on aortic morphology and reported that the circumference of aorta increased with age (Virmani et al., 1991). In the current study, it was observed that the high correlation between age and AP aortic diameters was strongest at the level of aortic hiatus, followed by aortic bifurcation and suprarenal level. In transverse diameters, the strongest correlation was found at bifurcation level followed by hiatus aorta and suprarenal level respectively. However, all these findings supported our result that age is a significant factor influencing the diameter of AA.

The gender is one of the major factors that influence the diameters of the AA. In our setting, there was a significant difference between males and females in all levels of aortic diameters. In both sexes, the mean diameter was lesser than 30 mm which is consistent with that reported in previous studies (Erbel et al., 2001; Erbel & Eggebrecht, 2006). It was observed the AP and TD were significantly higher in males than females. Similar to this finding, Joh et al. evaluated the AA in the Korean

### Table 3. Anteroposterior and transverse measurements of the abdominal aorta compared of gender.

| Measurement | Mean ±SD (mm) | P-value |
|-------------|---------------|---------|
| AP1 Male    | 21.40 ± 1.59  | 0.00    |
| Female      | 19.32 ± 1.28  |         |
| AP2 Male    | 16.30 ± 1.14  | 0.00    |
| Female      | 15.18 ± 1.30  |         |
| AP 3 Male   | 14.09 ± 0.82  | 0.00    |
| Female      | 12.83 ± 1.26  |         |
| TD1 Male    | 25.22 ± 2.75  | 0.00    |
| Female      | 20.52 ± 2.46  |         |
| TD2 Male    | 17.55 ± 1.10  | 0.00    |
| Female      | 16.65 ± 1.53  |         |
| TD 3 Male   | 16.35 ± 1.70  | 0.00    |
| Female      | 14.41 ± 2.57  |         |

### Table 4. Correlation of age with levels of the aortic measurements.

| Level of aortic measurements | R    | R square | SE of the estimate | P-value |
|------------------------------|------|---------|--------------------|---------|
| AP at aortic hiatus level    | 0.401| 0.16    | 1.637              | < 0.001 |
| AP suprarenal level          | 0.214| 0.046   | 1.315              | 0.025   |
| AP aortic bifurcation level  | 0.372| 0.138   | 1.147              | < 0.001 |
| TD level of aortic hiatus    | 0.349| 0.122   | 3.305              | < 0.001 |
| TD suprarenal level          | 0.257| 0.066   | 1.353              | 0.007   |
| TD at aortic bifurcation level| 0.493| 0.243   | 2.069              | < 0.001 |

Figure 3. A sonogram of abdominal aorta demonstrates AP measurements along the aorta.

Figure 4. Correlation of age with the diameter of the abdominal aorta.
population and reported that the diameter of AA is significantly higher in males than females (Joh, Ahn, & Park, 2013). A study conducted by Jasper et al. evaluated the normal abdominal aortic diameter using CT reported that the aortic diameters correlated with gender. They found that the mean diameters of suprarenal and infrarenal aortic diameters were larger in men than women (Jasper et al., 2014). All these results supported the effect of gender on aortic diameters.

The body habitus is another factor that affects the diameter of the aorta. The literature reported an association between body habitus and diameters of AA. Some studies found a significant association with body height while other found association with weight (Lederle et al., 1997; Liddington & Heather, 1992). Matthew et al. reported that body mass index was significantly associated with increasing diameters of AA at levels of the superior mesenteric artery, midpoint, and bifurcation (Matthew, Kevin, Dominic, Michael, & Michael, 2008). Similar to this finding, we observed a significant correlation between height and aortic diameters.

4.1. Limitation of the study

The limitation of this study that it was a single center study in a single country and it involved a group of elderly patients in whom aortic diameters might be affected by atherosclerosis. However, lack of studies is another limitation since no studies conducted in the country using other modality such as CT scanning for assessing the abdominal aorta. Therefore, it is difficult to generalize the findings of this study to the whole population.

5. Conclusion

The sonographic morphometric analysis of the AA is essential to detect AAA as early as possible. The study concluded that age, gender, and height were significant factors affect the diameters of AA. Diameters of the AA are wider in men compared to women, vary significantly with age, gender and height.

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Disclosure statement

No potential conflict of interest was reported by the author.

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