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Biometric Data of Adults' Aortic Knob Diameter in Posteroanterior Chest Radiograph, Correlation to Age and Normative Heart Diameter: A Cross-Sectional Study

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Abstract

Background: The aortic knob (AK) is an essential feature on a chest x-ray. It could be the first sign of a cardiovascular problem if there is any deformation or enlargement of the knob. This study aimed to measure the normal AK diameter (AKD) on a posteroanterior chest radiograph in healthy adult Sudanese.

Methods and Results: The study was conducted in the Department of Radiology and Imaging in Ribat Hospital (Sudan) between Jun 2019 and Jan 2020. A total of 113 participants of both sexes (45.1% males and 54.9% females) with a normal chest x-ray and no history of diabetes, blood hypertension, cardiovascular disease, or skeletal abnormality were selected. Participants' age fluctuated from 18 to 75 years. The measurements (AK, heart diameter [HD], cardiothoracic ratio [CTR]) were carried out with the measuring tools available on the software of the computed radiography system. The mean AKD was 2.8±0.8 cm (2.94±0.8 cm in males and 2.51±0.77 cm in females, P=0.005)). The mean HD was 9.22±2.8 cm (9.8±3.3 cm in males and 8.7±0.2.1 cm in females, P=0.005). The mean CTR was estimated as 46.6±7.7% with a significant difference between males and females and significantly correlated with HD and BMI (P<0.05). The AKD increased by 0.0199 cm with an increase of one year of age (AKD = 0.0199(age)+1.9469), and there was a strong positive correlation between age and AKD (P<0.001).

Conclusion: The study found a significant positive correlation between age and AKD. Increased heart sizes increase AKD. The AKD value is greater in males than in females.(**International Journal of Biomedicine. 2022;12(4):570-574.**).

Keywords: chest radiograph • aortic knob • heart diameter • cardiothoracic ratio

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Abbreviations

AK, aortic knob; **AKD**, AK diameter; **BMI**, body mass index; **CTR**, cardiothoracic ratio; **HD**, heart diameter.

Introduction

Human physical variability has been a subject of great interest for scientists for a long time using a scientific technique for measuring the proportions of the human body that has evolved; this technique is known as *anthropometry*. The examination of anthropometric parameters is critical in resolving identification and pathology issues.[1] In medicine, measuring normal parts and organs is used as an index to assess pathology or for manufacturing medical devices to harmonize the bodies of patients.

Chest radiography with a posteroanterior view is one of the most significant studies; it is the primary line of investigation for many disorders. As a result, it is one of the most common inquiries in our daily work because it is the commonest imaging modality of the heart;[2] due to its

affordability and simplicity, it is most readily used. Physicians must understand how to evaluate basic chest radiographic results and summarize them. Before reading and diagnosing abnormalities,[3] the normal appearances, sizes/measurements, and variances in a chest radiograph must be familiar to physicians.

The aortic knob (AK), or aortic knuckle, is an essential feature on a chest x-ray. It could be the first sign of a cardiovascular problem[4,5] if there is any deformation or enlargement of the knob.[4] The left border of the cardiac silhouette on the posteroanterior (PA) chest radiograph is composed of a series of convex arcs. The AK, often known as the knuckle, is one of them; it is not a particular anatomical structure, although it does symbolize the aortic arch's distal end.[2] Plain radiography, computed tomography, echocardiography, magnetic resonance imaging, and radionuclide imaging can be used to determine the AK.[4] It can be expanded as a result of increased pressure flow in the aorta or changes in the elasticity of its wall, such as in systemic hypertension, medial cystic necrosis of the aorta, or aortic dissection, as well as atherosclerosis. The prominence of the AK is also seen in some instances of aortic stenosis (post stenotic dilation), coarctation of the aorta, and aortic aneurysm;[4] having a sensitivity of between 70% and 90% for cardiovascular diseases due to hypertension, it is an effective predictor of target organ damage.[6] Although many advanced investigations are required to diagnose cardiovascular disorders, these instruments are scarce in rural regions. Thus the chest x-ray remains the initial inquiry in suspected heart disease, particularly in rural areas.[4,7] As a result, the radiologic method's utility in determining and predicting direct measurement of AK size indicates the presence of any diseases in the cardiovascular system. Nonetheless, it differs depending on body type, gender, and ethnicity, according to previous studies on Africans,[6,8] Indians,[2,4] Asians,[9-11] and Caucasians. This study aimed to measure the normal AK diameter (AKD) on a posteroanterior chest radiograph presented as a baseline of dilated AK, to correlate it with different ages, genders, and body mass index (BMI), and to estimate the relationship between the AK index with various thoracic biometrics in healthy adult Sudanese.

Materials and Methods

The study was conducted in the Department of Radiology and Imaging in Ribat Hospital (Sudan) between Jun 2019 and Jan 2020. A total of 113 participants of both sexes (45.1% males and 54.9% females) with a normal chest x-ray and no history of diabetes, blood hypertension, cardiovascular disease, or skeletal abnormality were selected. Participants' age fluctuated from 18 to 75 years (mean age of 37.9±14.07 years; age range was classified with an interval of 10 years). All chest radiographs were taken with the patient erect, facing the stand bucky; the distance from the patient to the x-ray focus was 72 inches. The radiologist assessed a radiograph for the technique's normality confirmation and quality evaluation.

The measurements were carried out with the measuring tools available on the software of the computed radiography system. The AKD was measured by drawing a horizontal line from the trachea's lateral border to the aortic knob's left lateral wall.[4,6,11,12]

Transverse heart diameter (HD) was measured as the sum of the right atrium diameter from the midline plus the left ventricle diameter from the midline.[4,6] After obtaining the patient's height and weight, BMI was defined, and cardiothoracic ratio (CTR) was determined by dividing the HD by the maximum width of the chest diameter.[3] To minimize errors, all measurements were completed by a single reviewer.

Statistical analysis was performed using the statistical software package SPSS version 25.0 (Armonk, NY: IBM Corp.). Baseline characteristics were summarized as frequencies and percentages for categorical variables and as mean±SD for continuous variables. Levene's Test of Equality of Variances was used to assess meeting the statistical assumption of homogeneity of variance in between-subjects designs. A simple linear regression was performed. Pearson's Correlation Coefficient (r) was used to determine the strength of the relationship between the two continuous variables. Group comparisons with respect to categorical variables are performed using chi-square test. A probability value of $P<0.05$ was considered statistically significant.

Ethical approvals were obtained from the research center at Alzaiem Alzhari University Radiologic Sciences Faculty before collecting data. The data was only used for study purposes without individual details identifying the participant. Written informed consent was obtained from each research participant.

Results

The mean BMI was 23.6±5.03 kg/m^2 and distributed among males and females as 23.47 kg/m^2 and 25.06 kg/m^2, respectively. The mean AKD was 2.8±0.8 cm (2.94±0.8 cm in males and 2.51±0.77 cm in females, P=0.005). The mean HD was 9.22±2.8 cm (9.8±3.3 cm in males and 8.7±0.2.1 cm in females (P=0.005) (Table 1). All measurements significantly differed between both genders.

Table 1.
Mean BMI, AKD, HD, and CTR values according to gender.

	n	BMI, kg/m^2	AKD, cm	HD, cm	CTR, %
Male	51	23.47±4.28	2.94±0.8	9.8±3.3	45.3±0.7
Female	62	25.06±4.16	2.51±0.77	8.7±2.1	47.8±0.6
All	113	24.34±4.2	2.72±0.8	9.22±2.8	46.7±5.5
P-value		0.04	0.005	0.028	0.02

The study clarified a linear association between AKD and HD (Table 2). There was a strong positive correlation between the two variables (r=0.837, P=0.000). In addition, there was a significant association between AKD and age (r=0.342, P=0.000), and a significant difference was found in

AKD measurement between different age groups (P<0.001) (Table 2, Figure 1).

Table 2.
Pearson Correlations of AKD & CTR with age, BMI, and HD

Variable		r	Sig. (2-tailed)
AKD	Age	0.342	0.000
	BMI	0.104	0.275
	HD	0.837	0.000
CTR	Age	0.112	0.237
	BMI	0.302	0.001
	HD	0.358	0.000

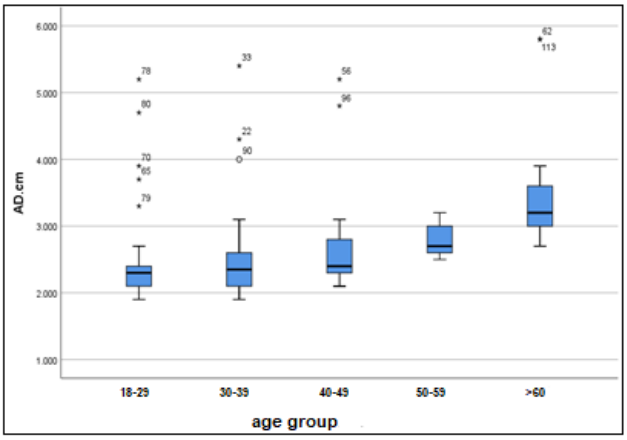

Figure 1. *Box plot. AKD in different age groups (r=0.359;P=0.000).*

A simple linear regression was developed to predict AKD based on age. A significant regression equation was found (F = 14.74, P<0.001, with R^2 = 0.1173. AKD = 0.0199(age) +1.9469 cm), the AKD increased by 0.0199 cm for each year of age (Figure 2).

The mean CTR was estimated as 46.6±7.7% with a significant difference between males and females and significantly correlated with HD and BMI (P<0.05); additionally there was an insignificant difference of CTR with AKD and age (P>0.05). CTR of females over 60 years was found to be larger than in other age groups, more than 50% (Table 1,2; Figure 3).

Discussion

As one of the highly regularly performed radiological examinations, a basic understanding and interpretation of chest radiographs is an unavoidable requirement for any physician involved in patient care.[3] Before evaluating anomalous data, it is necessary first to understand normal chest radiography characteristics and variations.

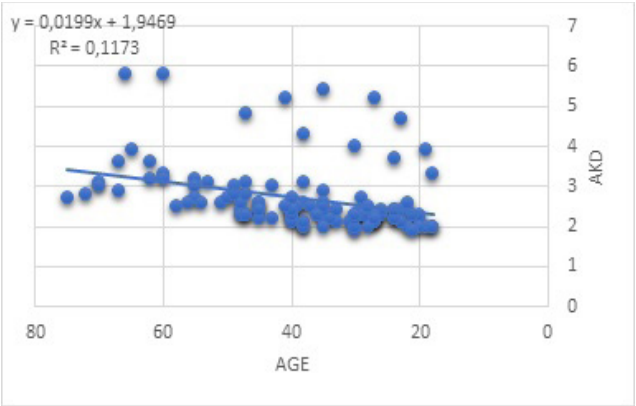

Figure 2. *Scatter plot. Linear regression of AKD predicted by age.*

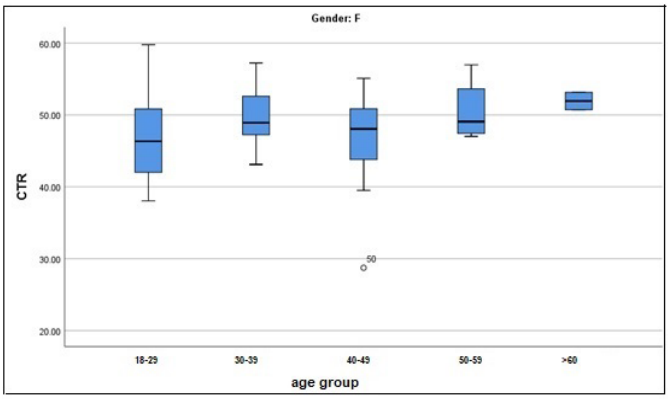

Figure 3. *Box plot. Comparison in CTR of females in different age groups.*

This study aimed to assess AKD in the Sudanese population using PA chest x-ray and to establish normative measurement to compare it with others and add a reference measurement.

In this study's sample population involving males and females, the mean AKD was 2.8±0.8cm; this is less than found in previous studies[2,4,5,7,10,11] and differs considerably from them.This value is smaller than Indian[2] AKD (3.04±0.59 cm) and Korean[10] AKD (32.29±5.30 mm) but nearly similar to the Nepal[9] population (2.786±0.19 cm). This could be due to variations in the method of measurement. In some previous studies,[2,13,14] measurements were taken from the lateral border of AKD to the midline of the body. Table 3 compares the measurements of this study with other studies in different countries.

In this study, measurements of AKD and HD were significantly different by gender; males had greater sizes than females. It could be related to differences in BMI. Many studies consistent with this study documented that males have higher values than females in the same age group.[2,5,7,15] The finding is also similar to Magera et al.[6] and Ray et al.[4] The HD in this study was smaller than in Nigerians, with a mean of 12.64±1.5cm, contrary to Magera's report.[6] Our results show a significant positive correlation between HD and AKD.

Table 3.
Comparison of the measurements made in this study with other studies in different countries.

Study	n	Age	BMI	AKD	HD	CTR
Shankar et al., 2010 (India) [2]	108			3.04±0.59 cm		
Kayastha et al., 2020 (Nepal) [9]	100	18-70 years		2.786±0.19 cm		
Lee et al., 2018 (Korea) [10]	3,970	45.45±11.56 years	23.88±3.35 kg/m^2	32.29±5.30 mm		
Anyanwu GE et al., 2007 (Nigeria) [8]	1018	32.2 years		4.7±0.46 cm	12.64±1.5 cm	46.68±4.3%
Sung et al., 2019 (Korea) [11]	696	46.85±12.89 years	24.02±3.51 kg/m^2	32.08±5.54 mm		
Current Study (Sudan)	113	37.9± 4.07 years	23.6±5.03 kg/m^2	2.8±0.8 cm	9.16±2.7 cm	46.7±5.5%

The CTR is a simple and helpful technique that can screen for cardiovascular disorders as an index of heart size.[16] In adults, the average range of CTR was determined to be 39%-50% (mean of 45%). However, it was proposed that a CTR of up to 52% be "acceptable."[17]

As exhibited in the results section, there was a notable normal mean of Sudanese CTR (46.7±5.5%). It was also observed that the mean CTR of females was higher than in males (47.8±0.6% and 45.3±0.7%, respectively). This result is similar to a study of the Indian population, which was published by Debnath et al.,[3] in their revising anatomical variations, which may be due to increasing body structure in males, or also may be due to the prevalence of increased BMI in females more than in males. This relationship was highlighted as a significant difference between the two genders.[2] Moreover, the CTR of females over 60 years was found to be more than 50%; this result was similar to the result found in the Ghanaian population by Mensah et al.[16] This was explained by the fact that older women experienced a more marked drop in trans-thoracic diameter with age.

There was a significant difference in AKD among different age groups. The AKD increased by 0.019cm with an increase of one year of age (AKD = 0.0199(age)+1.9469), and there was a strong positive correlation between age and AKD (P<0.001), which agreed with several studies.[2,4,5,7]The results of this study agree with previous studies,[2,5,8] which indicated an insignificant correlation between AKD and BMI; the result of this study is consistent with previous studies in that the AKD increases significantly with an increase in HD.[2,4,7]

Conclusion

The study found a significant positive correlation between age and aortic knob diameter; age can be used as a predictor for aortic knob diameter. The aortic knob diameter in adult Sudanese is smaller than in Nigerians, Indians, and Asians. Increased heart sizes increase aortic knob diameter. The aortic knob diameter value is greater in males than in females.

Competing Interests

The author declares that there is no conflict of interests.

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