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AORTIC ARCH DIAMETER AND ITS SIGNIFICANCE IN THE CLINICAL EVALUATION OF CARDIAC AND AORTIC ENLARGEMENTS

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ABSTRACT

Objective of the Study: To determine the relevance of the transverse aortic arch diameter in the evaluation of early aortic and cardiac enlargements.

Subject and Method: A total of 1818 chest radiographs of male and female normotensive and hypertensive Nigerians of age range 4 - 80 and 10 - 80 years respectively were used for this study. Ages of subjects were obtained and transverse aortic arch, chest and heart diameters were determined.

Results: Mean aortic arch diameter for the normotensive groups were noted to be 5.0± 0.5cm, 4.5±0.4cm and 4.7±0.5cm for males, females and both sexes respectively while 5.9 ± 0.9cm, 5.4 ±0.6cm and 5.6 ± 0.8cm for males, females and both sexes respectively were noted in the hypertensive group. Mean values were also generated for the chest and heart diameters. The study reports a mean difference in the aortic arch, heart and cardiothoracic ratio of 15% between the two groups.

Conclusion: Relationship between aortic arch and heart diameter was established and aortic arch diameter was noted to be significant ($p< 0.05$) in evaluating aortic and cardiac enlargements.

Key Words: Aortic arch diameter, aortic aneurysm, cardiac enlargement, normotensive.

INTRODUCTION

Available within the literature are several ways of clinically evaluating cardiac and aortic enlargements.[1-16] Within these methods of clinical diagnosis of aortic and cardiac enlargements are great differences such as in the approach, complexity, affordability and availability.[2,3,12,14,15,17]. Some of these methods are invasive while others are not. Predominant amongst these various approaches is the imaging technique such as radiography, echocardiography, ultrasonography, magnetic resonance imaging (MRI), and computed tomography (CT). [3,12,14,15,17]. The chest radiograph has proved to be of immense benefit and utmost importance in the initial diagnosis of cardiac and aortic enlargements particularly in a country like Nigeria where its easy affordability and availability is most highly appreciated coupled with the absence of more improved technologies with trained manpower in most rural areas of the country. This work uses values obtained from posteroanterior chest radiographs of healthy normotensive individuals and also clinically diagnosed hypertensive individuals to establish the role of transverse aortic arch diameter in the early diagnosis of aortic and cardiac enlargements.

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SUBJECT AND METHOD

This study was carried out in the University of Nigeria Teaching Hospital (UNTH) Enugu Nigeria. The study sample included male and female Nigerians from the ages 4 to 80 years. Out of 3200 samples physically examined for study, only 1818 radiographs of the subjects were used for interpretation and analysis of this study. The study sample was divided into two groups; A and B. Group A, was made up of healthy normotensive subjects without signs of any cardiovascular disease symptoms. The samples in this group were selected from candidates that came for chest X-ray examination as a result of requirements such as pre-employment, pre-admission, visa application and volunteer candidates without any cardiovascular disease. The subjects in group B included patients with clinically diagnosed cases of hypertension. Blood pressures of the candidates from the two groups were obtained. For group A, only candidates that had systolic blood pressure of between 110 and 145mmHg and diastolic pressure of 60 and 100mHg were included for this work. The PA chest radiographs of all the candidates were taken in the erect position with a film focus distance of 1.8m. The exposures were made at normal quiet inspiration. Subject's sex, age, and medical history were noted. All the radiographs admitted for this study were those that met the criteria of Kabala and Wide.[18]

Measurements of the thoracic, cardiac and aortic diameters were made. The transverse cardiac diameter was measured as the sum of the greatest cardiac distance to the right and to the left of the midline, while the transverse thoracic diameter was measured as the widest horizontal distance inside the rib cage at the level of the dome of the right diaphragm. The transverse aortic arch diameter was measured as the maximum extension of the aortic shadow to the right and to the left of the midline[19]. Radiographs, where the right border of the aorta could not be clearly differentiated from the spine were not included in the measurements. The cardiac, thoracic and aortic arch diameters were all measured in centimeters. Age was in years.

RESULT

In the entire distribution, males made up 862 number of the sampled population while the females made up the remaining 956. In group A, the sample gave a total of 1018 subjects, where the male population was 510 and the female; 508. Age ranged from 4 to 80 years. The sample size for group B was 800. Male population gave 352 while the females gave 448. Age ranged from 10 to 80 years. Cardiothoracic Ratio (CTR) is the ratio of the heart diameter (HD) with the thoracic diameter (TD) expressed in percentage. This ratio is calculated from the Formula presented by Danzer[20]:

$$CTR = \frac{\text{heart Diameter X100}}{\text{Diameter.}}$$

A summary of the mean values of the measured and calculated parameters for both groups has been given in table 1 below.

Table 1: **Summary of the Means of the Measured and Calculated Variables of the Distribution.**

Sex	TD	HD	AD	CTR	TD	HD	AD	CTR
Male	28.3±2.7	13.0±1.5	5.0±4.9	46.4±1.9	28.7±2.0	15.1± .1	5.9± 0.9	52.7±3.0
Female	26.0±2.3	12.3±1.3	4.5±4.5	47.2±4.4	26.2± 1.5	14.3± .3	5.4± 0.6	54.5± 5.0
Both	27.2±2.8	12.6±1.5	4.7±4.6	46.7±4.3	27.5± 2.1	14.7± .3	5.6± 0.8	53.5± 4.0

Table 2: **Relationship of Age with Means of the Various Groups of Measured and Calculated Variables of Group A.**

Age	N	TD	HD	AD	CTR
4 -10	45	20.7±3.5	10.0±1.5	3.50±0.4	48.4±3.5
11- 20	160	26.1±4.4	11.9±1.2	4.38±0.4	45.5±3.5
21- 30	332	27.5±4.6	12.6±1.3	4.62±0.5	45.7±3.7
31 - 40	200	28.1±4.8	13.1±1.4	4.83±0.5	46.7±4.6
41 - 50	139	27.7±5.0	13.3±1.2	4.99±0.5	48.5±5.3
51 - 60	95	27.7±5.0	13.2±1.0	5.13±0.5	47.6±3.4
61 - 70	34	27.1±5.4	13.3±1.5	5.19±0.5	49.0±4.1
71 - 80	12	27.6±5.1	13.0±1.1	5.30±0.5	47.1±4.0

Table 3: **Relationship of Age with Means of the various Groups of Measured and Calculated Variables of Group B.**

Age	N	TD	HD	AD	CTR
4 -10	89	23.0	13.2	4.2	57.0
11- 20	96	26.4±1.6	14.4±1.2	4.8±0.5	54.7±4.0
21- 30	107	28.7±2.3	15.0±1.5	5.4±0.8	52.6±5.0
31- 40	99	28.0±2.0	14.8±1.1	6.1±1.0	53.1±4.0
41- 50	109	27.1±1.5	14.5±0.9	5.6±0.7	53.5±4.0
51- 60	110	27.0±2.4	14.5±1.4	5.7±0.4	53.8±3.4
61- 70	95	27.8±2.0	14.7±1.6	6.1±1.0	52.8±4.0
71 - 80	92	28.2±1.2	15.5±0.5	6.5±0.5	55.1±2.0

Table 4: **Summary of the Correlation Coefficient of Aortic Arch Diameter (AD) with other Parameters in both Groups.**

Parameters	Age	TD	HD	CTR
Group A (r)	0.22*	0.22*	0.22*	0.05
Group B (r)	0.46*	0.02	0.06	0.08

* Correlation is significant at P< 0.05 level (2 tailed).

Table 5: **The values of the 80% Central Tendency in the CTR, Aortic and Heart Diameter Values of the sampled Population of Group A.**

Parameter	Lower Limit	Upper Limit
CTR	40	50
Heart diameter	10.6	14.5
Aortic diameter	3.7	5.5

From the result of table 1, it will be observed that the aortic diameter, heart diameter and cardiothoracic ratio of the subjects in group B, are notably higher than those in group A, with the chest diameter showing the least change. A mean percentage increase in both sexes of 16% was noted between the aortic diameters of the two groups, 14% for heart diameter and 15% for CTR.In the results of table 2 and 3, chest diameter showed the least degree of change between age groups of both samples of A and B. Aortic and heart diameters were noted to be larger within the same age groups of group B than in A. All the CTR values of candidates in group B for all the age group values were above 52% while no value in group A for any of the age groups was up to 50%. Table 5 showed the 80% central tendency of the values of CTR, Aortic and Heart diameters. This was derived from the calculations of the 10th and 90th percentiles of the various variables in group A. it was noted that at the upper limits of the values of CTR, heart and aortic diameters of the samples in group A, the values obtained are still lower than the mean values obtained in same parameters of group B.

DISCUSSION

The determination of normal diameters of the aorta at various levels has predominantly played a major role in determination of aortic aneurysm and cardiac enlargement [4,13,16]. Also, the direct relationship between aortic diameter with age, gender, body surface area and other indices of body size has made, possible the accurate estimation of expected normal aortic diameter of an individual[1,7,8,10,14,15]. So many research works have been done on this relationship[1-15] but majority of these works have been predominated by researches on the abdominal aorta and its branches[1,4-10]. This research has not only established the normal size of the aorta at the level of the aortic arch in various age groups using healthy normotensive subjects, but has also viewed the data obtained from these normotensive subjects with those obtained from hypertensive subjects. The work has noted positive significant correlations of aortic diameter with age for both the normotensive and hypertensive groups. While a significant correlation was noted between thoracic diameter and heart diameter for the normotensive group, but none was noted for the hypertensive.

This observation agrees with the findings of Ikeme et al[13]. A mean percentage difference of 14%, 15%, and 16% in the mean values of heart diameter, CTR, and aortic diameter respectively were noted between the two groups with the larger values recorded for the hypertensive group. It was also noted that all the hypertensive subjects of group B that showed aortic diameters above the mean aortic diameter established to be normal for this work also showed heart diameters values above values established to be normal for heart diameters. While CTR values were noted to be higher for females than males for both groups A and B, heart and aortic diameters were higher in the males than the females for both groups. This has also been noted by some other authors[1,10,13-15]. This work has shown relationship between aortic arch and heartdiameters. It has also shown the aortic arch diameter to be essential in the early evaluation of aortic aneurysm and cardiac enlargements. This work also shows the mean values obtained from the hypertensive group in the various parameters measured for all the age groups, to be larger than the upper limits of the values of the same parameters obtained from the normotensive group.

REFERENCES

1 **Pearce WH, Slaughter MS, LeMaires, Salyapongse AN, Fein glass J McCarthy WJ, Yao JS**. Aortic diameter as a function of age, gender and body surface area. Surgery. 1993; 114 (4) : 691-7.

2 **Lucarelli CL, Cirri GG.** Evaluation of normal thoracic and abdominal aortic diameter through Computerized tomography. Rev Hosp Clin Fac med Sao Paulo. 1996: 51 (6): 239-46.

3 **Pederson OM, Aslaksen A, Vik-Mo H**. Ultrasound measurement of the luminal diameter of the abdominal aorta and iliacarteries in patients without vascular disease. J Vasc Surg. 1993;17(3):596-601.

4 **Fleischmann D, Hastie TJ, Dannegger FC, Paik DS,Tilliach M, Zarins CK** et al. Quantitative determination of age-related geometric changes in the normal abdominal aorta. J Vasc Surg. 2001;33 (1) 97-105.

5 **Zarins CK, Xu C, Glagov S**. Atherosclerotic enlargement of the human abdominal aorta. Atherosclerosis.2001;155(1):157-64.

6 **lanne T, Sandgren T, Sonnesson B**. A dynamic view on the diameter of abdominal aortic aneursyms. Eur J Vasc Endovasc Surg. 1998;15(4):308-12.

7 **Munks A, Darage K, Wiesel M, Troeger J**. Diameter of the Infrarenal aortic and the iliac arteries in children: ultrasound measurements. Transplantation 2002, 27;73 (4) 631-5.

8 **Sonesson B, lanne T, Hansen F, Sandgren T**. infra renal aortic diameter in the health person. Euro J Vasc. Surge. 1994; 8 (1): 89-95.

9 **Sariosmaoglu N, Ugurlu B, Karacelik M, Tuzun E, Yorulmaz I, et al.** A multicentre study of abdominal aorta diameters in a Turkish population. J Int Med Res; 2002. 30(1):1-8.

10 **Ledercle FA, Johnson GR, Wilson SE, Gordon IK, Chute EP, Liturgy EP, Liturgy F. et al.** Relationship of age gender, race and body size to infra renal aortic diameter. The Aneurysm Detection and Management (ADAM) Veterans Affairs cooperative study investigation. J Vasc Surge. 1997; 26 (4): 595 - 601.

11 **Poutanem T, Tikanoja T, sairanem H, Jokinem E.** Normal aortic dimensions and flow in 168 children and young adults. Clin Physiology Funct Imaging.2003; 23 (4) : 224-9.

12 **Gardin JM, Davidson DM, Rohan MK, Bultmans, Garcia R, Dubria S, et al.** Relationship between age, body size, gender, and blood pressure and Doppler flow measurements in the aorta and pulmonary artery. Am Heart J 1987; 113 {1}: 101-9.

13 **Ikeme AC, Ogakwu AB, Nwakonobi FA**. The significance of the enlargement of the aortic shadow in adult Nigerians. Afr. J. Med. *Sc.* 1976; 5: 1995-99.

14 **Anyanwu GE, Agwuna KK.** Transverse arch diameter and body habitus amongst Nigerians within the South East zone. J.Biomed, 2006;4:(1) 45-47. **15 Obikili EN, Okoye IJ.** Aortic Arch diameter in frontal chest radiographs of a normal Nigerian population Nig J Med. 2004; 2 (13): 171-4.

16 **Umerah BC.** Unfolding of the aortic (Aortitis) associated with pulmonary tuberculosis Br J Radiol. 1982; 55:201-203.

17 **Hager A, Kaemmerer H, Rapp-Bernhardt U, Blucher S, Rapp K, Berhardt TM,** et al. Diameters of the thoracic aorta throughout life as measured with helical computed tomography. J of Thorac Cardiovasc Surg. 2002;123(6):1060-6.

18 **Kabala JE, Wide P**. The measurement of the heart size in anteroposterior chest radiograph. Br. J. Radiol. 1987; 60:981-986.

19 **Rose GR, Black Burn H.** Cardiovascular population study methods. Geneva WHO monographs. 1966.

20 **Danzer CS.** The cardiothoracic ratio: An Index of cardiac enlargement Am J. Med. Sc 1919; 157:513.