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Original Article

Cardiothoracic ratio and body mass index in normal young adult Nigerians

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Abstract

Background: Interest is growing in the value of the cardiothoracic ratio in clinical evaluation of patients, and the factors that influence its relevance. This study attempts to explore the normal values of the cardiothoracic ratio and asses its relation to the body mass index (BMI), height weight and age, of normal young Nigerians in a highland plateau area of Nigeria.

Methodology: In this prospective study, a total of 100, standard posterior–anterior chest radiographs taken from normal adult Nigerians (41 females and 59 males) in Jos environment were reviewed. From the Chest radiographs, the cardiac diameters (CDs) were measured at the widest point of the cardiac silhouette. The thoracic diameter (TD) was taken at the costophrenic insertion of the diaphragm. Using these data the cardiothoracic ratio (CTR) was computed. Body index was calculated based on the formula Weight (Kg)/Height^2 (m^2 (Kgm^{-2}) while CTR was determined by dividing the CD by the TD. Degree of correlation was assessed for all the parameters and analysis was made for regression and correlation coefficients using SPSS statistical package.

Results: The age range of all subjects was from 17 years to 44 years with a mean age of 24.93 ± 7.42 years. The mean age for the males was 25.59 ± 7.04 years and for the females 23.98 ± 7.92 years. The average cardiothoracic ratio in males was 0.46 ± 0.04 while in females it was 0.457 ± 0.042 showing a slightly higher but not significant CTR in males at the $P = 0.05$ significance level. The mean BMI for males and females were 26.94 ± 3.97 (Kgm^{-2}) and 28.94 ± 5.26 (Kgm^{-2}) respectively. The averageCD, TD, for males and females were 1.7 ± 0.039 m, 12.86 ± 1.22 cm, 27.88 ± 1.82 cm, and 1.5 ± 0.057 cm, 11.7 ± 1.19 cm, 25.65 ± 1.85, respectively.

Conclusion: The CTR did not correlate strongly with the BMI.

Key words: Body mass index, cardiac diameter cardiothoracic ratio, normal young adult Nigerians, thoracic diameter

Introduction

Several complex modalities have been used in the process of assessing the status of the heart in humans.[1] A multistage technique like cardiograph, angiocardiography, magnetic resonance (MRI) angiography is used in several centers and contrast enhanced CT angiography has also become popular in some advanced centers.[2] However cost, complexity and availability will not let patients with suspected cardiac problems have an assessment of their cardiac statuses with the aforementioned techniques in this environment.[3-5] There is therefore a need for some simple technique to assess the heart, if not absolutely at the first visit, at least on a serial film bases done at intervals to monitor progress. Theoretically, using two views of the heart at right angles to each other, posteroanterior -and lateral it is possible to compute the volume of the heart that could be an index of heart size.[3] This is cumbersome and expensive and most of the patients can hardly afford the money for the full study. An appropriate one film projection is ideal for this purpose considering the poverty level in our society.[6]

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With the current cost of production of films it is more economical to have some criteria for assessment of the cardiac status on one film projection only and to have a full knowledge of the other clinical indices that can modify the relevance of the results of measurements. The standard erect posteroanterior film that is the commonest view done routinely for those who come for medical consultations in any hospital can be used to advantage. Cardiac diseases

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are not uncommon,[1] and have high morbidity and mortality rates and as such we need some sensitive index in monitoring the heart as quickly as possible, as cheaply as possible and as reproducibly as possible for prompt and early intervention in the management of the cardiac patient[5] Several studies have been done at various centers to determine the normal value of some cardiac indices and various values have been arrived at for the cardiothoracic ratio (CTR)[1] and for other cardiac indices such as wall thickness in the atria and ventricles, volume of chambers in diastole and systole.[7]

Heart failure or other diseases of the heart may cause an increase in the dimensions of the heart. Establishing normal parameters in order to facilitate an early and firm diagnosis of heart diseases will be an asset. A question which easily comes to mind is 'Are these values of cardiac indices influenced by other body parameters like body mass index (BMI) in normal young adults?' This is what the work set out to address.

Methodology

This study was the prospective one, carried out between July 2005 and July 2006 in Jos North Central Nigeria. In this study, we looked at cardiac diameters (CDs) and CTRs, and have tried to establish any correlation between these parameters with age, weight, and height and BMI in young adult Nigerians. To be included in the study a physical examination was done by EJE, SDP, and MH to exclude structural abnormalities, in the subjects. Their clinical and laboratory records were reviewed to scrutinize the ECG tracings and assess the blood profile (full blood counts, differentials and ESR) and blood chemistry results (EandU, LFTs, and creatinine levels) when available.

Measurements of the cardiac parameters were taken on the radiographs using a transparent ruler. We used a digitized mini X-ray machine with programmed facilities for distance measurements, a Polymat 70 static machine and a GE silhouette machine to capture our images prior to measurements. The machines had a maximum KV in the range of 120–150 KV, maximum tube current of 400–500 ma, and a minimum exposure time of 0.1 s.

Two sets of readings were taken

- Cardiac diameter (CD): This was measured as the distance between The two tangents to the cardiac silhouette at its most lateral points on the right and the left, drawn parallel to the mid-sagittal plane [Figure 1]
- Thoracic diameter (TD) This measured the TD on the line passing through the costophrenic insertions of the diaphragm on both sides of the thorax. The distance is from one costophrenic insertion to the other costophrenic insertion [Figure 1].

During the same visit, the subject's heights and weights were measured using a bathroom weighing scale and a wall height chart. Weight was recorded in kilograms with subjects in light clothing only. Without shoes or head gear, patients stood feet apposed and touching the walls. Height was then read off on the wall chart in meters. From these two parameters the BMI was calculated using the formula

$$\text{BMI} = \frac{\text{Weight (Wt)}}{\text{Height } \left(\text{Ht}^2\right)}$$

This study was performed on subjects that had CXRs for the purpose of preadmission into university evaluation. Subjects whose CXRs were not well centered were also excluded. The CXRs of subjects satisfying aforementioned criteria were mounted on light viewing boxes with uniform but with adjustable intensity. Ethical Committee of Jos University Teaching Hospital clearance was gotten for this study and informed consent was given by the subjects to be included in the study.

Statistical Methods

Height, Weight, Age, BMI, and CTR, [Table 1] for each sex and for both sexes combined, that is, male and female groups combined. Correlation between the several parameters was assessed for both sexes individually and for both sexes together, with levels of significance determined as shown on the tables.

Pearson correlation coefficient was used to assess correlation, and the level for significance was set by the two-tailed significance tests, at levels stated in the results.

Results

Of all the candidates who came for medical examinations at the teaching hospital, the first 100 meeting our criteria were recruited. There were 59 males and 41 females. Subjects were newly enrolled undergraduate students of the University of Jos. In both males and females there was very poor correlation between CTR and BMI with a correlation coefficient r of 0.129 and 0.127, respectively, and a combined correlation coefficient r of 0.283 [Table 1].

The age range was from 17-44 years with the mean age of 25.59 ± 7.04 years, for males and 23.98 ± 7.92 years for females. The heights, ranged from 1.51-1.86 m with an average height of 1.71 ± 0.07 m for males and 1.61 ± 0.06 m for females. Their weights ranged from 46-91 kg. With an average weight of 67.25 ± 9.86 kg for males and 62.32 ± 11.31 kg for females. The TDs were measured at two points, the first was the visually perceived widest diameters of the chest, and the second

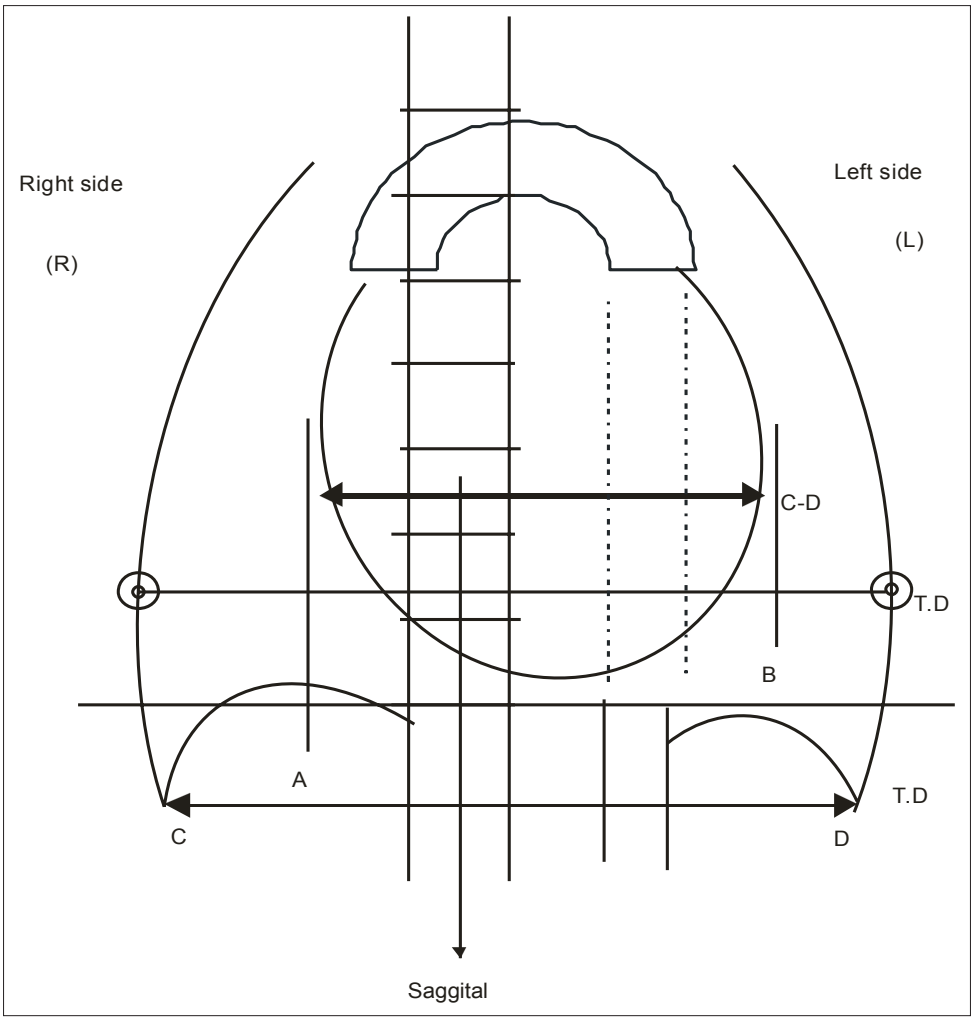

Figure 1: A schematic representation of the chest showing the different measurements done on the chest and the points from which measurements were done (a) Tangent to the cardiac silhouette at the most lateral part on the right side of the heart shadow. (b) Tangent to the cardiac silhouette at the most lateral part on the (L) side of the heart shadow. (c) Right costophrenic insertion of the diaphragm (d) Left costophrenic insertion of the diaphragm

Table 1: Means and standard deviations of the parameters measured from subjects

Sex	Height (m)	Weight (kg)	CD (cm)	STD (cm)	CTR	BMI	Height (m)²
Male							
Mean	1.7076	67.2542	12.8619	27.8847	0.462	26.94	2.5114
N	59	59	59	59	59	59	59
Std. Deviation	9.86 214	1.22 141	1.22 141	1.82 915	0.038	3.974	0.27 251
Range	45	5.5	5.5	10.3	0.18	20.31	1.2
Female							
Mean	1.6093	62.3171	11.7	25.6512	0.457	28.94	2.1599
N	41	41	41	41	41	41	41
Std. Deviation	0.05 716	11.30 584	1.1929	1.84 636	0.042	5.256	0.1784
Range	0.24	48	5.5	11	0.18	26.42	0.73
Total							
Mean	1.6673	65.23	12.3855	26.969	0.46	27.76	2.3673
N	100	100	100	100	100	100	100
Std. Deviation	0.08 079	10.70 434	1.33 372	2.1346	0.039	4.624	0.29 421
Range	0.4	49	7.1	11.5	0.91	28.73	1.43

CTR - Cardiothoracic ratio, BMI - Body mass index, CD - Cardiac diameters

was the diameter as measured from one costophrenic insertion of the diaphragm to the other. For the purpose of easy reproducibility we choose the later as there was no significant difference between the two measurements [Figure 1]. The average TD for males was 27.88 ± 1.83 cm and 25.65 ± 1.85 cm for females. The CDs ranged from 8.5 13.8 cm with an average CD of 11.7 ± 1.19 cm for females, and 10.1 15.6 cm and an average CD of 12.86 ± 1.22 cm for males. The average BMI for the males was 26.9 ± 3.97 and 28.9 ± 5.25 for the females.

The average CTR for the males was 0.46 ± 0.04 while for the females it was 0.45 ± 0.04. The males were slightly older than the females with an average age of 25.6 ± 7.04 years while the females' average age was 23.97y ± 7.92 years [Tables 2].

There was a significant correlation between the CTR and the age in the males and a slightly less correlation in

the females with a correlation factor r of 0.401 and 0.318, respectively [Table 3].

The correlation was better between CD with weight, CD with TD and CD with BMI.

The CTR correlation with age was better in the females than in the males. However, the CTR correlation with weight was negative in males but positive in females.

Regression analysis (line of best fit).

Table 2: Analysis of variance between parameters

		Sum of square	Df	Mean square	F	Sig.
Height (m)*Sex						
Between groups	(combined)	0.234	1	0.234	55.65	0
Within groups		0.412	98	0.004		
Total		0.646	99			
Weight (kg)* Sex						
Between group	(combined)	589.646	1	589.646	5.373	0.023
Within groups		10754.064	98	109.735		
Total		11343.71	99			
CD (cm)*Sex						
Between group	(combined)	32.655	1	32.655	22.31	0
Within groups		143.447	98	1.464		
Total		176.101	99			
STD (CM)*Sex						
Between group	(combined)	120.675	1			
Within group		330.419	98			
Total		451.094	99			
STD (cm)*Sex						
Between group	(combined)	120.675	1	120.675	35.79	0
Within groups		330.419	98	3.372		
Total		451.094	99			
CTR*Sex						
Between group	(combined)	0.001	1	0.001	0.379	0.539
Within groups		0.153	98	0.002		
Total		0.153	99			
BMI*Sex						
Between group	(combined)	96.009	1	98.009	4.655	0.033
Within groups		2021.119	98	20.624		
Total		2117.128	99			
Height (m)^2*Sex						
Between group	(combined)	2989	1	2.989	52.49	0
Within group		5.58	98	0.057		
Total		8.569	99			

CTR - Cardiothoracic ratio, BMI - Body mass index, CD - Cardiac diameters, TD - Thoracic diameter

A linear relationship between cardiac diameter (CD) and body weight (WT) was derived as CD = 0.06WT + 8.78 and another linear relationship between CD and TD (TD) was derived as CD = 0.34TD + 3.31.

Discussion

The CTR in a patient is a simple computation that is not time consuming and requires only one exposure to X-radiation to estimate. Its relevance and importance is apparent not only in assessing the patient at the first contact, but becomes increasingly important during subsequent assessment of the patient during follow up visits. The status of the patient with respect to the heart can be assessed and timely intervention made to save the patient.

As early as 1919, Denzer and Saul had written in the American Journal of Medical Sciences on the CTR as an index of cardiac enlargement. The value of a normal ratio has been shown in various studies to differ between children and adults, being higher in children than in adults.[1] A deliberate attempt in this study to determine the relationship between CTR and various body parameters has revealed a lot of interesting findings.

There was very weak relationship found between the CTR and BMI in males and females separately and in both sexes considered together. Ordinarily one would have expected the CTR to correlate significantly with BMI but this was not the case in this study.[7] Perhaps a gated estimate of CD placed at the 'R' point of the QRS complex of ECG[8,9] which should correspond to the widest or greatest diameter of the heart, that is, the 'presystolic' estimate would have given us different values for the CD. Whether this value of CD will vary significantly from the one measured in a conventional PA radiograph, done in full inspiration is yet to be estimated.

For a full one- time assessment of the heart a combination of Echocardiogphy, ECG, X-radiographs and Ultrasonography will be needed. However, in monitoring

Table 3: Summary of descriptive statistics: Correlation

	Correlation value	Remark
CTR vs. BMI	(a) Pearson's correlation coefficient-0.129 (M) (b) Pearson's correlation coefficient-0.127(F)	Not significant
CTR vs. HT^2	(a) Pearson's correlation coefficient-0.329 (M) (b) Pearson's correlation coefficient-0.143(F)	Significant At 0.05 level for females
CTR vs. Age	(a) Pearson's correlation coefficient-0.111 (M) (a) Pearson's correlation coefficient-0.318(F)	Sig. at 0.05 level for Females
CTR vs. TD	(a) Pearson's correlation coefficient-0.314 (M) (b) Pearson's correlation coefficient-0.111(F)	Sig at 0.05 level for males
CTR vs. CD	(a) Pearson's correlation coefficient-0.745 (M) (b) Pearson's correlation coefficient-0.732 (F)	Significant at 0.01 level for both

CTR - Cardiothoracic ratio, BMI - Body mass index, CD - Cardiac diameters, TD - Thoracic diameter

progress or deterioration in a patient, CTR comes in very handy as a good assessment index.[10,11]

We had hypothesized that finding a correlation between CTR and BMI would make the value of the CTR more discriminatory while taking decisions about what was normal for the different categories of patients. Male, female, heavily built individuals, tall or short people should have different CTR depending on the BMI. This we failed to establish. The results however called for caution in applying the general rule of CTR. This states that CTR greater than 50% is increased. While that less than 50% is regarded as normal. The negative relationship between CTR and the square of height in both males and females deserves mention especially in the tall asthenic individuals and short sthenic individuals. The CTR in Nigerians is found to be greater than that of Asians and Caucasians.[1]

Care should then always be applied in using the value of the CTR while taking decisions in any given patient a full assessment of the patient can only be had when the CTR is complemented with ultrasonography, echocardiography, ECG, and in possible CT angiography and MR imaging of the heart.

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