

Radiological Indices For Estimation Of Normal Heart Sizes

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ABSTRACT

The use of some ratios of cardiac, thoracic and aortic diameters as is noted in cardiothoracic ratio CTR, has proved to be of immense benefit in clinical assessment of normal size of heart, advanced clinical procedures, and in epidemiological studies. This research used the PA chest radiographs of 1,018 healthy male and female Nigerians within the southeast of ages 4 to 80 years to determine two ratios; Aorticthoracic Ratio (ATR) and Cardioaortic Ratio (CAR). These two ratios correlated significantly with CTR, heart, chest and aortic diameters. ATR gives a ratio of the aortic diameter with thoracic diameter while CAR is a ratio of the cardiac diameter with aortic diameter. From the research, any CTR less than 50%, ATR less than 20%, and CAR less than 41% is an indication of normal heart and aortic arch diameter.

Key words: Cardiothoracic ratio, Aortic arch diameter, Heart diameter, Cardiac mensuration.

INTRODUCTION

Methods for studying the size of the heart include physical examination, techniques employing the radiographic xrays and the Electrocardiograph. A patient's symptoms or family medical history, high blood pressure, characteristic heart murmur, forceful heart beat, swelling of the legs, or the sound of the fluid in the lungs can be clues to the diagnoses of cardiac enlargement. But despite the high rising technologically enhanced methods of assessing heart size, the cardiothoracic ratio CTR still remains the simplest formula to determine normal heart size. This formula was described by Danzer¹ since 1919. This formula which is just the ratio of

the heart diameter with the chest diameter, besides being one of the initial markers of cardiomegally²⁻⁴ has also been of use in epidemiological studies⁵, ultrafiltration therapies⁶, computer aided diagnosis of cardiothoracic disorders⁷ and so many others.

This research is designed to describe the ratios of other diameters still evident on a PA chest radiograph, determine their clinical and epidemiological importance and also correlate them with the already existing cardiothoracic ratio.

MATERIAL AND METHODS

A total of 1018 chest radiographs were accepted for this work from a total of 1885 radiographs of samples of Nigerian population within the Southeast that were selected for this research after physical examination. The studied population included males and females from the ages of four and above. This sample was 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 symptoms. The research was conducted in the University of Nigeria teaching hospital Enugu, Nigeria, and Hansa Special Diagnostic Centre, Enugu, Nigeria. All the radiographs admitted for this study were those that met the criteria of Kabala and Wide⁸

The blood pressures of the candidates were obtained, and only candidates that had normal blood pressures were included for

this work. The criteria for this normalcy were cases of systolic blood pressure of between 110 and 145mmHg and diastolic pressure of 60 and 100mmHg. 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. Radiographs where the right border of the aorta could not be clearly differentiated from the spine were not included in the measurements. T

RESULTS

The male population size was 510 while the female was 508. Age was broken into 10-year intervals.

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 Danzer¹:

$$\text{CTR} = \frac{\text{Heart Diameter} \times 100}{\text{Diameter.}}$$

Aorticothoracic Ratio (ATR) is a ratio of the transverse aortic diameter (AD) and thoracic diameter expressed as percentage. This ratio is being presented in this work as one of the indices of heart size. This ratio is calculated using the formula extrapolated from Danzer¹ as:

$$\text{ATR} = \frac{\text{Aortic Diameter} \times 100}{\text{Thoracic Diameter.}}$$

Cardioaortic Ratio (CAR) is the ratio of the aortic arch diameter with heart diameter. This ratio is also being presented in this research as one of the indices for heart size. It is also calculated using the formula extrapolated from Danzer¹:

$$\text{CAR} = \frac{\text{Aortic arch diameter} \times 100}{\text{Heart diameter.}}$$

Table 1: Summary of the means of the measured and calculated variables of the distribution

SEX	TD	HD	AD	CTR	CAR	ATR
Male	28.3±2.7	13.0±1.5	5.0±4.9	46.4±1.9	38.6±1.9	17.3±2.1
Female	26.0±2.3	12.3±1.3	4.5±4.5	47.2±4.4	37.1±2.0	17.4±2.1
Both	27.2±2.8	12.6±1.5	4.7±4.6	46.7±4.3	37.9±1.8	17.3±2.1

Table 2: Relationship of Age with means of the various groups of measured and calculated variables

SEX	AGE	HD	TD	AD	CTR	ATR	CAR
	In Yrs	CM	CM	CM	CM	CM	CM
M	4-10	9.8	21.0	3.6	46.8	17.1	36.4
	11-20	12.1	26.6	4.4	45.5	16.8	36.8
	21-30	13.2	29.1	4.8	45.4	16.6	36.4
	31-40	13.4	28.9	5.1	45.6	16.9	40.3
	41-50	13.6	29.4	5.2	47.4	17.8	37.6
	51-60	13.5	28.5	5.5	47.3	18.5	40.0
	61-70	13.6	27.8	5.3	49.0	19.9	40.4
	71-80	13.2	28.1			19.0	40.7
F				3.4	46.9		
	4-10	10.1	20.9	4.3	49.7	16.9	34.0
	11-20	11.6	25.6	4.9	45.5	16.8	36.9
	21-30	12.0	26.3	4.6	45.9	17.0	37.1
	31-40	12.8	26.9	4.9	47.9	17.5	36.6
	41-50	13.1	26.5	4.8	49.6	18.3	37.0
	51-60	12.7	26.4	4.8	48.2	18.7	36.9
	61-70	12.9	26.3	5.0	49.0	18.2	36.9
Both	71-80	12.1	25.0			20.0	41.3
				3.5	48.7		
	4-10	10.0	20.7	4.4	48.4	17.0	35.0
	11-20	11.9	26.1	4.6	45.5	16.8	36.9
	21-30	12.6	27.5	5.0	45.7	16.8	36.8
	31-40	13.1	28.1	5.0	46.7	17.2	38.5
	41-50	13.4	27.7	5.1	48.5	18.1	37.3
	51-60	13.2	27.7	5.2	47.6	18.5	39.0
	61-70	12.3	27.1	5.3	49.0	19.2	39.0
	71-80	13.0	27.6		47.1	19.2	40.7

DISCUSSION

It is a generally accepted fact that cardiac enlargement is an established evidence of a dysfunctional heart (except enlargements due to regular aerobic exercise). Some times, this enlargement may even be symptomless making early diagnosis of such conditions difficult. Acceptable, is the view that the best way to evaluate these enlargements is with echocardiogram⁹, this procedure remains uncommon till date in most developing Countries like the population in study. Most initial evaluations of heart size are done with the chest X-ray. The CTR over the years, despite some known limitations, has become accepted as one of the markers of cardiomegaly^{1, 5,10,11}. Two other ratios; the ATR and the CAR have been shown in this research also as markers for cardiac enlargement. ATR, in this research correlated significantly with heart diameter ($p \leq 0.05$) and CTR ($P \leq 0.01$). The relationship between aortic diameter and thoracic diameter, is such that within the limits of normality, the aortic diameter will always be less than a fifth (i.e. 1/5) of the thoracic diameter, or less than twenty

percent of the thoracic diameter. With an upper limit of 20% for this ratio, it follows that ATR values above 20% is already an indication of aortic unfolding or enlargement of the arch of the aortic. This ratio is recommended over the use of only mean values of aortic diameter to assess aortic enlargement, since ATR considers both the individual's thoracic diameter and also aortic diameter, thereby taking care of individual differences in variations of body size and by so doing makes the interpretation of aortic unfolding to be objective rather than subjective. It is also common knowledge that many cases of cardiac enlargement and dysfunction are characterized by increase in the size of arch of the aorta^{12,13}. This relationship has been substantiated by the parallel strong positive relationship between CTR and ATR. By this relationship it follows that candidates that present with CTR above 50% will most likely present with ATR above 20%.

The bases of comparison between aortic diameter and heart diameter were as a result of the very strong positive relationship between the two diameters ($P \leq 0.01$). This comparison was summed up in the Cardioaortic ratio (CAR).

This ratio puts into consideration the diameters of the heart and arch of the aorta of the same individual. Both diameters of which are very evident in the PA chest radiograph. Following the association of most cases of cardiomegally with aortic unfolding, this ratio offers the best objective interpretation of the relationship between the two diameters. This result shows the aortic arch diameter to be about 2/5th or about 40% of the heart diameter. It also sets an upper limit of normalcy of 41% for CAR.

In conclusion, two ratios; CAR and ATR have been shown in this study to have the same diagnostic potential as CTR. This result establishes any ATR value less than 20% and CAR less than 41% to be an indication of both normal aortic arch diameter and also normal heart sizes respectively. The use of CAR in prediction of heart size has provided an alternative to the use of thoracic diameter in the assessment of heart size as is done in CTR. This therefore offers an additional advantage over CTR in assessing heart sizes of patients with thoracic wall deformity.

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