

Radiographic Assessment of Cardiothoracic Ratio among Patients of University of Benin Teaching Hospital

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ABSTRACT

Introduction: CTR application and modification in medicine are used with varying clinical usefulness and it is cheap, quick, and a vital tool in assessing patients. Research on cardiothoracic ratio and its association with age and gender among adults of Edo State, Nigeria are scanty and this has left a huge knowledge gap in the research world today. This study therefore is aimed at assessing the CTR and determining its association with gender and age among patients who visited the University of Benin Teaching Hospital.

Materials and Methods: This study adopted a descriptive retrospective study design, which sampled 241 adult chest radiographs with ages ranging from 18 to 50 years of age in the Radiology Department of the University of Benin Teaching Hospital, Edo State after obtaining ethical clearance. The TTD and CTD were measured from each radiograph and their ratio was calculated in percentage. Data obtained were analysed using both descriptive statistics (Mean and Standard deviation) and inferential statistics (t-test) to describe the nature of the data. Pearson's correlation was used to check for the association between age and CTR ascertained at <0.05

Results: The outcome from analysed data displays prevalence among males than in females, although CTR was exceptional with its prevalence to be higher in females than in males. Also seen was a prevalence of TCD and TTD in males and a prevalence of CTR in the female counterpart. Age distribution assessment, displays an inconsistent outcome with an increase in age advancement, displaying prevalence in age 36 - 40. Also, age relation to TCD and CTR was observed to be prevalent in age 41- 45, while in relation to TTD, it was prevalent in age 26 - 30. Following findings from correlation, TCD with TTD and TCD with CTR display a significantly strong positive correlation.

Conclusion: The study outcome displayed CTR of females which was observed to be greater than the male's counterpart and this was compared with other African and Nigerian studies.

Keywords: Cardiothoracic Ratio, Patient and Benin, Radiographic.

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Introduction

Radiological medicine is one of the fundamental diagnostic measures to differentiate normal from pathology in medicine. Cardiologists and radiographers have employed the use of chest radiographs as a measure of observation, interpretation, and verdict of heart-related conditions.¹ The chest X-ray and electrocardiogram are vital, non-invasive screening tools for assessing heart conditions. These screening tools have been a common

imaging technique for cardiothoracic ratio and cardiac size evaluation.² The Cardiothoracic ratio (CTR) is one of the accepted methods of evaluating cardiac size, and it provides prognostic information to clinicians and anatomists in relation to cardiac dysfunctions: cardiomegaly.³ Cardiomegaly (heart enlargement) is a condition when the transverse diameter of the cardiac silhouette is greater than or equal to 50% of the transverse diameter of the chest on a posterior-

anterior view of a chest radiograph or a computed tomography. It is usually a manifestation of another pathologic process, which presents several forms of primary or acquired cardiomyopathies⁴. A chest radiograph is the most frequent method of detecting cardiomegaly worldwide as it aids in determining the size of the heart utilizing the cardiothoracic ratio.⁵

Cardiothoracic ratio (CTR) is the ratio of the maximal transverse cardiac diameter (TCD) to the maximal transverse thoracic diameter (TTD). This measurement is taken from the inner edge of the ribs, above the costophrenic angle on the posteroanterior (PA) chest radiographs.^{6,7} In determining cardio anomalies, the normal range of CTR needs to be brought to consciousness, which is between 0.42 and 0.50. Values that are more than 0.5 or less than 0.42 indicate pathologic situations like cardiomegaly, hypertension, and other heart diseases.⁵ CTR may be greater than 0.50 but still be termed as normal. This happens when there is an extra-cardiac cause of cardiac enlargement, due to the inability to take a deep breath because of pregnancy and ascites, pectus excavatum, and straight back syndrome compressing the heart. Sometimes CTR can be less than 0.50 but still assumes an abnormal heart. This happens when there is something obstructing the flow of blood from the ventricles since the ventricles respond at first by undergoing hypertrophy and have been proven to be reversed

by supplements like Ginkgo biloba,⁸ which is not always associated with cardiomegaly.⁹

CTR application and modification in medicine are used with varying clinical usefulness and it is cheap, quick, and a vital tool in assessing patients.¹⁰ Sequel to the controversial and conflicting diagnostic approach in using CTR as a diagnostic measure in detecting and early prevention of cardiomegaly, has made the use of CTR doubtful.^{11,12} More also research on the normal cardiothoracic ratio and its association with age and gender among adults of Edo State, Nigeria are scanty and this has left a huge knowledge gap in the research world today. This study therefore is aimed at assessing the CTR and determining its association with gender and age among patients who visited the University of Benin Teaching Hospital.

Materials and Methods

This study comprises 241 posterior-anterior(PA) chest radiographs of patients who attended the radiology department at the University of Benin Teaching Hospital, Edo State within the age range of 18 -50 years of which 146 were female and 95 were male, from January 1st 2018 to December 31st 2022. The study adopted a descriptive retrospective study design. Data was extracted from the Picture Archiving Communications System (PACS) of the hospital and these records were properly documented on a data collection sheet.

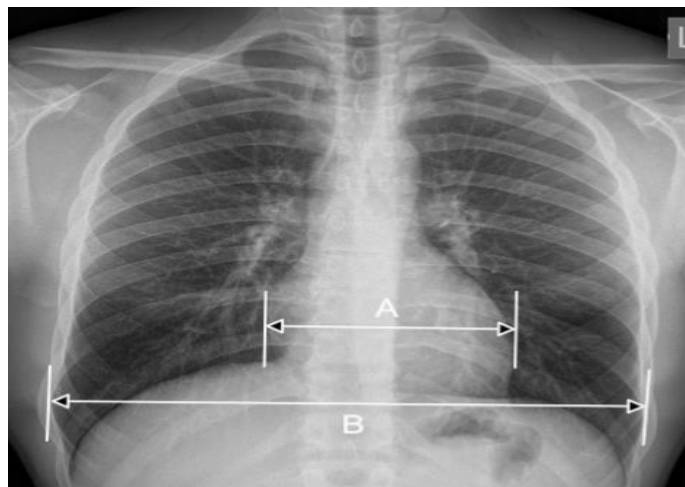


Figure 2.1: Diagram of the cardiothoracic ratio (Kiyonori et al. 2015).¹²

The following measurements were taken:

- Transverse thoracic diameter (TTD): It is the maximum horizontal distance inside the rib at the widest point above the costo-phrenic angle.¹⁴
- Transverse cardiac diameter (TCD): It is the largest horizontal diameter of the heart by obtaining the maximum transverse distance between the most lateral right and left borders of the heart.^[14]

$$CTR = \frac{TCD \times 100\%}{TTD}$$

Radiographs of normal individuals, properly documented postero-anterior chest radiographs, and individuals from patients who visited the University of Benin Teaching Hospital, Edo State were used for the study. Radiographs of patients whose request indicated cardiac or chest problems and radiographs of patients that are not postero-anterior view were excluded from the study. Ethical clearance was obtained from the Research and Ethics Committee of the Human Anatomy Department, Faculty of Basic Medical Sciences, Delta State University, Abraka with ethical number: DELSU/CHS/ANA/2023/60. Approval was also obtained from the University of Benin Teaching Hospital, Edo State with ethical number: ADM/E22/A/VOLVII148301210.

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 23). Descriptive statistics such as mean and standard deviations were used to summarize the data. Inferential statistics was also used: Independent sample t-test was used to check for gender differences, and Pearson’s correlation was used to check for the association between age and CTR. ANOVA was used to check for differences in the age groups. P value less than 0.05 was considered statistically significant.

Results

The study utilized 241 adult chest radiographs of both sex with age ranged from 18-50 years. Of these 241 radiographs, 95 (39.4%) were male while 146 (60.6%) were female as shown in Table 4.1.

| Gender | Frequency (%) |
|--------------|--------------------|
| Male | 95 (39.4) |
| Female | 146 (60.6) |
| Total | 241 (100.0) |

Table 4.1: Gender Distribution of the studied population.



Table 4.2 shows the age distribution of subjects in the studied population. The majority of the subjects were in the age group 36-40 (50, 20.7%)

while the minority were in the age group <20 (21, 8.7%).

| Age group (Years) | Frequency | Percent |
|-------------------|-----------|---------|
| <20 | 21 | 8.7 |
| 21-25 | 24 | 10.0 |
| 26-30 | 33 | 13.7 |
| 31-35 | 31 | 12.9 |
| 36-40 | 50 | 20.7 |
| 41-45 | 39 | 16.2 |
| 46-50 | 43 | 17.8 |

Table 4.2: Age Distribution of subjects in the studied population.

Table 4.3 shows the descriptive statistics of the parameters studied. The transverse cardiac diameter and transverse thoracic ratio ranged from 4.60cm-17.30cm and 10.80cm-29.50cm with mean and standard deviations 9.61 ± 1.99 cm and

19.87 ± 3.11 cm respectively. The cardiothoracic ratio ranged from 33.30-78.60% with mean and standard deviation of 48.27 ± 6.54 %.

| | N | Minimum | Maximum | Mean \pm SD |
|-----------------------------------|-----|---------|---------|------------------|
| Transverse cardiac diameter (cm) | 241 | 4.60 | 17.30 | 9.61 ± 1.99 |
| Transverse thoracic diameter (cm) | 241 | 10.80 | 29.50 | 19.87 ± 3.11 |
| Cardiothoracic ratio (%) | 241 | 33.30 | 78.60 | 48.27 ± 6.54 |

Table 4.3 Descriptive Statistics of the Parameters Studied.

Table 4.4 shows the sex comparison of parameters in the studied population. There was a statistically significant difference between males and females in the transverse thoracic diameter ($p < 0.05$)

while there was no significant sex difference in the transverse cardiac diameter and cardiothoracic ratio ($p > 0.05$).

| | Sex | N | Mean \pm SD | T-test | Df | P-value |
|----------------------------------|--------|-----|------------------|--------|-----|---------------|
| Transverse cardiac diameter (cm) | Male | 95 | 9.88 ± 1.92 | 1.72 | 239 | 0.086 |
| | Female | 146 | 9.43 ± 2.03 | | | |
| Transverse thoracic | Male | 95 | 20.84 ± 2.71 | | 239 | 0.000* |

| | | | | | | |
|--------------------------|--------|-----|------------|-------|-----|-------|
| diameter (cm) | Female | 146 | 19.23±3.21 | 4.03 | | |
| Cardiothoracic ratio (%) | Male | 95 | 47.35±6.47 | -1.78 | 239 | 0.076 |
| | Female | 146 | 48.88±6.53 | | | |

*= p value is statistically significant

Table 4.4: Sex comparison of parameters in the studied population.

Table 4.5 shows the age group differences in the transverse cardiac diameter. There were no statistically significant differences between the

age groups in the transverse cardiac diameter (p>0.05).

| Age group (Years) | Mean ± SD | p-value |
|-------------------|------------|---------|
| <20 | 9.18±1.42 | 0.405 |
| 21-25 | 9.96±2.06 | |
| 26-30 | 9.42±2.12 | |
| 31-35 | 9.48±2.09 | |
| 36-40 | 9.26±1.92 | |
| 41-45 | 10.02±2.22 | |
| 46-50 | 9.89±1.91 | |

Table 4.5: Age group differences in the Transverse Cardiac Diameter.

Table 4.6 shows the age group differences in the transverse thoracic diameter. There were no statistically significant differences between the

age groups in the transverse cardiac diameter (p>0.05).

| Age group (Years) | Mean ± SD | p-value |
|-------------------|------------|---------|
| <20 | 19.84±2.52 | 0.445 |
| 21-25 | 20.18±2.47 | |
| 26-30 | 20.51±3.98 | |
| 31-35 | 19.03±3.15 | |
| 36-40 | 19.41±3.17 | |
| 41-45 | 19.92±3.04 | |
| 46-50 | 20.30±2.91 | |

Table 4.6: Age group differences in the Transverse Thoracic Diameter.

Table 4.7 shows the age group differences in the cardiothoracic ratio. There were no statistically

significant differences between the age groups in the transverse cardiac diameter ($p > 0.05$).

| Age group (Years) | Mean \pm SD | p-value |
|-------------------|------------------|---------|
| <20 | 46.49 \pm 6.42 | 0.080 |
| 21-25 | 48.06 \pm 7.72 | |
| 26-30 | 45.97 \pm 5.49 | |
| 31-35 | 49.89 \pm 7.31 | |
| 36-40 | 47.89 \pm 6.20 | |
| 41-45 | 50.19 \pm 7.20 | |
| 46-50 | 48.57 \pm 5.28 | |

Table 4.7: Age group differences in the cardiothoracic ratio.

Table 4.8 shows the correlation of parameters studied with age. Transverse cardiac diameter, transverse thoracic diameter, and cardiothoracic

ratio showed a weak positive correlation with age. These associations showed no statistical significance ($p > 0.05$).

| | | Age | Transverse Cardiac Diameter (TCD) | Transverse Thoracic Diameter (TTD) | Cardiothoracic Ratio (CTR) |
|------------------------------|---------------------|-------|-----------------------------------|------------------------------------|----------------------------|
| Age | Pearson Correlation | 1 | 0.074 | 0.011 | 0.113 |
| Transverse Cardiac Diameter | Sig. (2-tailed) | | 0.252 | 0.866 | 0.081 |
| | Pearson Correlation | 0.074 | 1 | 0.734** | 0.635** |
| Transverse Thoracic Diameter | Sig. (2-tailed) | 0.252 | | 0.000* | 0.000* |
| | Pearson Correlation | 0.011 | 0.734** | 1 | -0.026** |
| Cardiothoracic Ratio | Sig. (2-tailed) | 0.866 | 0.000* | | 0.685 |
| | Pearson Correlation | 0.113 | 0.635** | -0.026 | 1 |
| | Sig. (2-tailed) | 0.081 | 0.000* | 0.685 | |

*. P-value is significant at the 0.05 level (2-tailed).
 **. Correlation is significant at the 0.01 level (2-tailed).

Table 4.8: Correlation of parameters studied with age.

Discussion

Assessed parameters from the index study display prevalence among males than in females, although CTR was exceptional with its prevalence to be higher in females than in males, with clear evidence of consistency in findings among previous studies carried out in both Nigeria and the World at large. Findings from the index study which display the prevalence of TCD and TTD in males and the prevalence of CTR in the female counterpart, are associated with the similar anthropometric features of the individual residing within a similar geopolitical region, influenced by genetic, environment, lifestyle (behaviour) and several other factors.^{5,12,16,17} More or also further review of the result displays statistical significant solemnly with TTD, which is contrary to some study^{3,14,16} where all assessed parameters display statistically significant in their study. Findings from the index study were also in keeping slightly with a study conducted by⁹ where the assessed parameter was seen to be prevalence in the male counterpart. This is explained by the fact that men are usually involved in more physically demanding activities than women, apart from the inherent influence of hormones in both sexes.^{18,19}

Findings following age distribution, display an inconsistent upshot with an increase in age advancement, despite the inconsistency in findings, there is a high prevalence among the age group 36-40 years of age, with respect to the assessed parameter there was a high prevalence which is observed to be similar in TCD and CTR among the age group 41-45 years of age and for TTD age distribution was higher among age group 26-30. More or also the assessed parameters with age group displayed non-statistical significance, with a weak positive correlation. This is relatively similar to a study conducted by¹⁶, where inconsistent finding was recorded with respect to age advancement and observed statistically significance in TTD and CTR. Similarly, a study conducted by¹⁷, reveal non-statistically significance CTR with age groups, but however, showed consistency in their findings with respect

to age advancement. This is also in keeping with a study conducted⁹ where advancement in age displays inconsistency, revealing statistical significant with assessed parameters with age. Similarly,¹² also had a similar report which reveals assessed parameters revealing slightly inconsistent findings with advance in age and observed to be statistically significant with age. The findings from the index study are also in keeping with¹⁴ studies in 2019. Which also displays inconsistent outcomes of assessed parameters with age, although was observed to be statistically insignificant. Consequently, findings from the index study contradict the study conducted by⁵, where the correlation between age and CTR displayed a significant correlation.

Following the finding from correlation, TCD with TTD and TCD with CTR display a significantly strong positive correlation. This is coherent with¹⁵ studies in 2023, which reveal a significantly weak positive correlation. This is also similar and clearly explained in the study of⁵, where he stated that the loss of elasticity of great vessels increases the vascular resistance hence, the need for higher cardiac muscle force to ensure effective cardiac output is needful. This subsequently causes enlargement of the ventricles and hypertrophy of the ventricular muscles contributing to the increase in the TCD, thereby increasing CTR due to its direct association with TCD. This is also in keeping with²⁰, where TCD was found to correlate significantly with age, height, weight, BMI, TTD, and CTR. Furthermore, the correlation of TTD with CTR displays a non-significant weak negative correlation. This is slightly similar to Ominde's study with the outcome displaying a significantly weak negative correlation. Similarly,¹² also had a similar report which revealed that among assessed parameters displayed statistical significant.

Conclusion

The study outcome display CTR of females which was observed to be greater than the male counterpart and this was compared with other

African and Nigerian studies. The research findings were observed to be associated with the anthropometric feature of individuals residing within the same geopolitical region, influenced by genetics, environment, lifestyle (behaviour), and several other factors which are believed to alter TCD, TTD, and CTR value. More also correlation of assessed parameters with age and among each assessed parameter was nonstatistically significant, except for the correlation between TCD and TTD and TCD and CTR which was statistically significant.

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