Measurement of Radiological Cardiothoracic Ratio: Acentric Study

Dheeraj Kumar, Abhishek Kumar Chaudhary

Abstract

Background: The Cardiothoracic Ratio (CTR) is a critical diagnostic parameter derived from chest X-rays, used to assess cardiac enlargement or cardiomegaly. While CTR is influenced by factors such as age and gender, population-specific studies are limited, particularly in the Indian context. This study explores the relationship between CTR, age, and gender using retrospective data from digital X-ray imaging.

Aim: The study aimed to evaluate the influence of age and gender on CTR and establish baseline CTR values for the studied population. It also sought to determine whether age and gender significantly predict CTR using statistical analyses.

Materials and Methods: Data were collected from 26 patients using the Kiran Medical Systems Ultisys-40 digital X-ray machine. CTR was calculated as the ratio of the maximum heart diameter to the maximum thoracic diameter. Descriptive statistics, paired t-tests, correlation analysis, and linear regression were employed to analyze the data. The sample was stratified by gender and age groups (18-25, 26-35, and 36-75 years) to assess variations in CTR.

Results: Descriptive analysis showed slight variations in CTR across age groups and genders. Females aged 26-35 had the highest median CTR (0.45), while males aged 36-75 exhibited the highest average CTR (0.46). The paired t-test revealed no significant difference in mean CTR between genders (p-value = 0.666). Regression analysis indicated a weak relationship between age and CTR, with non-significant coefficients for both males (p-value = 0.980) and females (p-value = 0.149). The models explained minimal variance (R^2 = 0.000025 for males and 0.0848 for females).

Conclusion: Age and gender do not significantly influence CTR in the studied population. The findings provide baseline CTR values for the Indian population, contributing to improved diagnostic accuracy. However, the weak predictive power of the models suggests the need for further research incorporating additional variables such as BMI and health conditions.

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Introduction

Advances in medical imaging technology have revolutionized the field of diagnostic medicine. X-ray imaging has evolved as one of the most important imaging modalities used for the evaluation of structural anatomy and assessment of pathological changes.[1] The most common measurement obtained from chest X-rays PA View is the cardiothoracic ratio, which is defined as the maximal horizontal diameter of the heart divided by the maximal horizontal diameter of the thorax.[2] In clinical practice, CTR values help in the diagnosis and follow-up of cardiac enlargement or cardiomegaly, conditions typically linked with cardiovascular diseases. The normal range of CTR in adults is 0.42 to 0.50.[3] If the CTR is above 0.50, it is termed cardiomegaly, while values below 0.42 are indicative of small heart syndrome.[4] Various studies have found that CTR differs across groups, and such differences appear to be due in part to age, gender, and general health condition. Therefore, knowledge about the distribution of CTR values within a particular group is paramount for establishing baseline values as well as finding variations, which may indicate some kind of disease or health condition. In the case of CTR and its relationship to age and gender, we are interested in investigating if there is any association as well as how these aspects may influence cardiac and thoracic dimensions.

In addition, we perform a variety of statistical tests, for example, mean and median calculation, p-value test, t-tests, correlation coefficients, and regression analyses for further quantification of relationships

Author Affiliations

Dheeraj Kumar , Assistant Professor;
Abhishek Kumar Chaudhary, BMRIT Student.
School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar-Pradesh, India 208024

Correspondence

Dheeraj Kumar
Assistant Professor
MRIT, Ph.D. (Radiology and Imaging) Pursing
School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar-Pradesh, India 208024
Email Id: dheeraj199494@gmail.com

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Keywords

Cardiothoracic Ratio (CTR), age, gender, digital X-ray, regression analysis.

between age, gender, and CTR[5] Such analyses are fundamental in medical research, because they provide a quantitative basis for determining normal ranges and potential risk factors. This study is important for several reasons. First, the establishment of baseline CTR values that are specific to the population studied can provide useful references for healthcare providers who are using similar equipment. Second, understanding the impact age and gender may have over a CTR value further increases the clinician's capacity to better interpret them, especially in regions where advanced healthcare facilities and testing apparatuses are scarce or difficult to access.

Materials and methods

Study Design: This was a retrospective, cross-sectional study conducted to observe CTR in a sample population, hence, based on digital radiographs. The study aims at measuring the relationship between CTR, age, and gender. Data collection was performed from a single digital X-ray machine: Ultisys-40 model from Kiran Medical Systems (under Trivitron Healthcare Pvt. Ltd.) equipment's ID: G-XR-208243.

Methodology: Data for the current paper were sourced from X ray reports over the time span of August 2024 to December 2024. All the radiographs were routine clinical reports. Ethical approval had taken place through the IRB, HEC Reference No. 2025 Jan 022, and patient data had been fully anonymized so as not to release any information that may be perceived to infringe on patients' rights for privacy concerns.

Eligibility criteria: The inclusion criteria for the study encompassed patients aged over 18 years, including both males and females, who had complete and reliable records of cardiothoracic ratio (CTR) measurements. In contrast, the exclusion criteria ruled out cases lacking CTR details and those with underlying cardiopulmonary diseases that could influence the accuracy of CTR measurement.

Cardiothoracic Ratio (CTR): The measurement of CTR was performed from the digital radiographs and recorded in mm[6].

Cardiothoracic Ratio (CTR) Measurement Formula:

$$CTR = \frac{\text{Maximum Heart Diameter}}{\text{Maximum Thoracic Diameter}}$$

The CTR was measured using the X-ray images from the Kiran Medical Systems Ultisys-40 digital X-ray machine software.

T-test: T-test is independent sample; it tested to see the difference in the mean CTR between the subjects of each gender. At a p-value of 0.05, with a two tailed test that was required to find whether there occurred any difference to be reckoned with that was apparent between the two genders concerned.

Correlation Analysis: To calculate the relationship of age with CTR among all participants as well as in each group of gender, Pearson's correlation coefficient was computed showing in table 2. It provides the linear association of age with CTR. The correlation analysis found a statistically significant positive correlation between the male's age and female's CTR ($r = 0.813$, $p < 0.01$) and between the male's age and female's age ($r = 0.571$, $p < 0.01$). A moderate, non-significant positive correlation was identified between female's age and female's CTR ($r = 0.291$, $p = 0.149$). There was

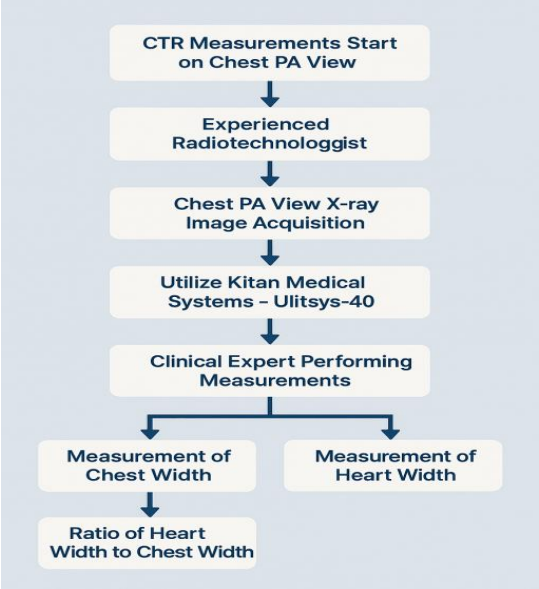


Figure 2 Showing CTR measurement flow chart

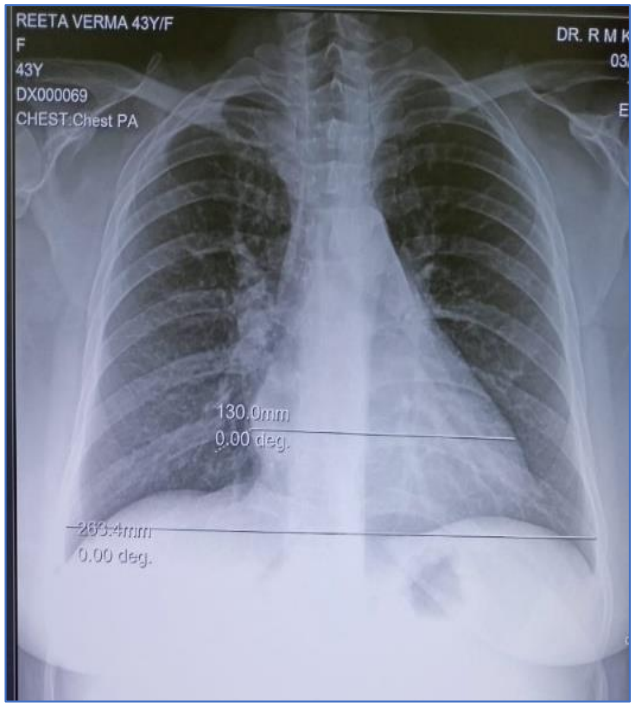


Figure 1 Chest PA View showing the CTR measurement Protocol by the digital radiography software.

Table1: Cardiothoracic Ratio (CTR) Distribution by Age Group and GenderMean, median, and standard deviation of CTR values across different age groups for male and female participants.

Group		
Gender	**Male**	**Female**
18-25 years:		
Mean	0.433	0.419
Standard Deviation	0.052	0.042
26-35 years:		
Mean	0.436	0.413
Standard Deviation	0.058	0.005
36-75 years:		
Mean	0.42	0.463
Standard Deviation	0.035	0.075

Table 1 Pearson Correlation Between Age and CTR in Male and Female Subjects

Correlations		AGE of Female	CTR of Female	AGE of Male	CTR of male
AGE of Female	Pearson Correlation	1	.291	.571**	-.067
	Sig. (2-tailed)		.149	.002	.743
CTR of Female	Pearson Correlation	.291	1	.813**	.113
	Sig. (2-tailed)	.149		.000	.583
	N	26	26	26	26
AGE of Male	Pearson Correlation	.571**	.813**	1	-.005
	Sig. (2-tailed)	.002	.000		.980
CTR of male	Pearson Correlation	-.067	.113	-.005	1
	Sig. (2-tailed)	.743	.583	.980	
	N	26	26	26	26

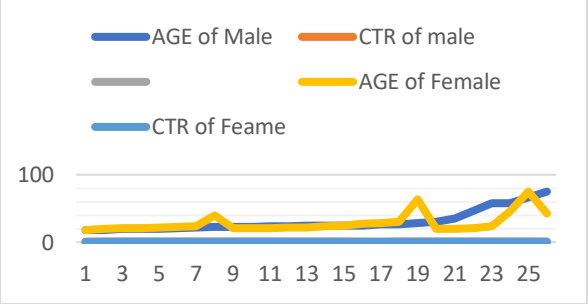
**. Correlation is significant at the 0.01 level (2-tailed).

no high correlation between CTR of male and any other variable, having very low correlation values with age and CTR of females or age of males ($p > 0.05$).

Stratified analysis

Data are stratified by gender and by three age groups (18-25, 26-35, 36-75) for the calculation of average, median, and total CTR within each age group, so that some insight might be gained as to CTR distribution by defined demographic segments.

Figure 3 Comparison of Female and Male CTR *With Age*.



Results

Descriptive Statistics

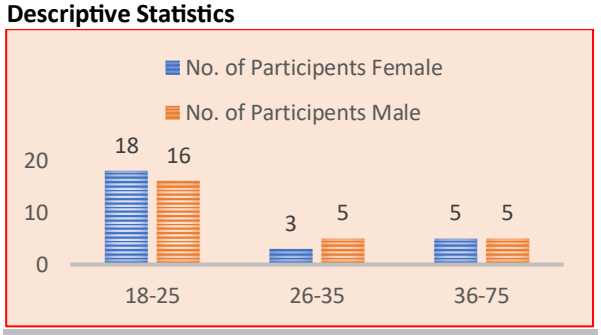


Figure 4 Bar graph showing gender wise participants with age range

The descriptive analysis of the Cardiothoracic Ratio (CTR) for both male and female participants across different age groups (18-25, 26-35, and 36-75) is summarized in bar graph below.

Overall, females aged 26-36 exhibited the highest median CTR (0.45), while males aged 36-75 exhibited the highest average CTR (0.46). The CTR values for both genders were similar in the 18-25 age range, with an average CTR of 0.43 for females and 0.41 for males. The bar graph above illustrates the number distribution for CTR for both genders, which were classified under Small Heart Syndrome, Normal, and Cardiomegaly. For females, there were 13 cases classified under Small Heart Syndrome, 12 under Normal, and 1 cardiomegaly. For the males, 11 were classified under Small Heart Syndrome, 14 normal, and 1 cardiomegaly. A similar pattern emerged between genders. Small Heart Syndrome and Normal predominated, and the rest included Cardiomegaly by only 1 case for both. This shows that most subjects had CTR values within or below the normal range, and cases of cardiac enlargement were rare.

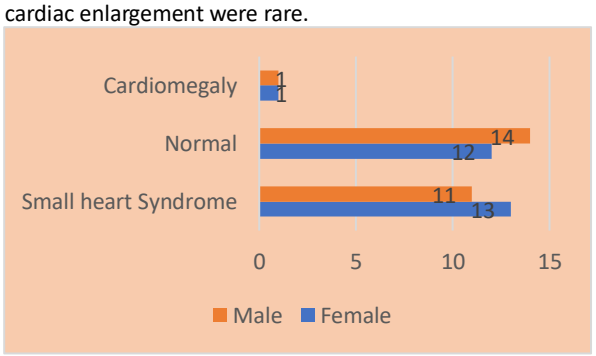


Figure 5 Cardiothoracic Ratio (CTR) for both male and female participants across different age groups

The paired two-sample t-test was conducted to compare the mean Cardiothoracic ratio (CTR) of females and males. The results show that the mean CTR for females is 0.4265, while the mean CTR for

males is 0.4319, indicating a slight difference between the two groups. The variances for females and males are 0.0021 and 0.0023, respectively, suggesting similar variability in CTR for both groups. The Pearson correlation coefficient is 0.113, indicating a weak positive relationship between the paired observations. The t-statistic is -0.437, and the p-value for the two-tailed test is 0.666, which is much greater than the common significance level of 0.05. Therefore, the mean CTR of females is not significantly different from that of males. Moreover, t-statistic is less than the critical t-value of 2.060 (two-tailed). As such, the conclusion should be that there is not any significant difference between means. Therefore, we fail to reject the null hypothesis that there is no difference in CTR between females and males. Variance is the measure that quantifies the spread or dispersion of the CTR values within a group. In this case, variances are pretty low; that is, the measurement of CTR within both groups is pretty tightly scattered around the respective means.

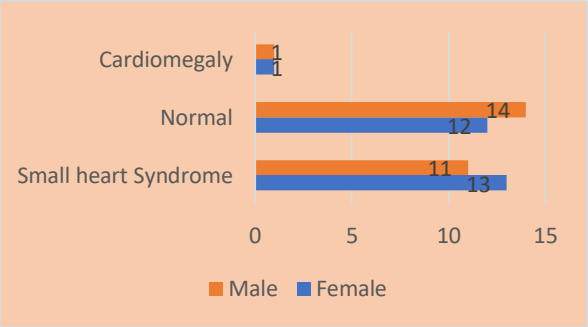


Figure 6 Bar graph showing the CTR of Participants, Cardiomegaly, normal, and small heart syndrome.

Discussion

The study explored the relationship between demographic factors (age and gender) and Cardiothoracic Ratio (CTR) using retrospective digital X-ray data. Establishing baseline CTR values for the Indian population is a key contribution, aiding in improved diagnostic accuracy[4]. The findings revealed that females aged 26–35 years had the highest median CTR (0.45), while males aged 36–75 years had the highest average CTR (0.46), aligning with global standards. However, statistical analysis (paired t-test, p = 0.666) showed no significant CTR difference between genders, and regression analysis confirmed that age was not a significant predictor for either gender (p = 0.980 for males, p = 0.149 for females). These results indicate that CTR remains consistent across age and gender groups, reinforcing its reliability as a diagnostic tool without the need for demographic adjustments.[7] This is particularly valuable in resource-limited settings where advanced diagnostic tools are scarce. The study also identified a low prevalence of cardiomegaly, suggesting a relatively healthy sample or exclusion of individuals with cardiopulmonary diseases. While CTR is useful for identifying individuals at cardiovascular risk, further research with a larger and more diverse sample is necessary for broader applicability.

Limitations include the small sample size (26 participants), single geographic region, and reliance on one imaging system (Kiran Medical Systems Ultisys-40). Future studies should incorporate larger samples, multiple imaging systems, and additional factors such as BMI, lifestyle, and comorbidities.

Conclusion

This study established the baseline Cardiothoracic Ratio values for the Indian population and demonstrated that age and gender have minimal influence on CTR. The findings reinforce CTR as a stable and reliable diagnostic parameter particularly in resource-limited settings where standardized reference values are essential. The study revealed slight variations in CTR across age and gender groups with Females aged 26–35 years showing the highest median CTR (0.45) and Males aged 36–75 years the highest average C However statistical analyses, including t-tests and regression models confirmed that neither gender nor age significantly affect CTR. These findings suggest that clinicians can use a standard CTR reference range without demographic adjustments and simplify cardiovascular assessments. While the study provides valuable insights its limitations, including a small sample size and single geographic focus, highlight the need for further research. Future studies should integrate more diverse populations and additional variables such as BMI, lifestyle and comorbidities to enhance the understanding of CTR's clinical utility.

By contributing to the growing body of literature on CTR in cardiovascular diagnosis, this study paves the way for more comprehensive research. Expanding the scope of analysis through advanced statistical modeling and multi-center studies could improve CTR diagnostic accuracy further improving patient outcomes in cardiovascular disease management.

Conflict of Interest: The authors declare no conflict of interest related to this study.

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