RESEARCH ARTICLE

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An Update on Cardiothoracic Ratio: A Study of X-Ray Measurements

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Abstract

Objectives: The aim of the study was to reveal the mean values of the cardiothoracic ratio (CTR) and the effect of gender and age on these measurements performed on chest radiographies.

Methods: After the exclusion of positive findings on radiographic images and the findings compatible with cardiovascular disease, the radiographies of 277 patients were re-evaluated regarding CTR measurements on chest X-rays. The maximum interval of the right and left heart borders, along with the horizontal thoracic diameter, were measured.

Results: The mean values of CTR were 0.45±0.02, 0.46±0.02 and 0.44±0.02 for the total study population, for the female group, and the male group respectively. Higher CTR was measured for females than for males ($p<0.001$). Age indicated a low but significant positive correlation with the CTR for the total study population ($p<0.001$).

Conclusion: Chest X-ray is a fast and inexpensive imaging method; performing CTR measurements is very easy to apply on chest X-rays. CTR still serves as a significant indicator of cardiovascular diseases along with other important parameters observed in chest radiographs.

Keywords: Cardiothoracic ratio, chest X-rays, heart, age, gender

Introduction

Chest X-ray examination constitutes an important part of the diagnostic process for many physicians. Pulmonary parenchyma, airways, and vessels, mediastinum, heart, chest wall, and pleura can be evaluated with chest X-rays.[1] This imaging modality quickly provides the first impression of cardiothoracic diseases, and chest radiographies obtained via posteroanterior X-ray projection are a part of routine examinations for general practitioners and for specialists across all branches of clinicians and surgeons.

Cardiothoracic ratio (CTR) expresses the relationship between the transverse size of the heart and the transverse diameter of the chest measured on chest X-rays. It is a commonly used parameter in the evaluation of cardiomegaly with a threshold value of 0.5, and a value greater than 0.5 should be interpreted as enlargement of the heart.[2]

In this study, the investigators aimed to contribute to the literature with an update of CTR values and the influence of gender and age on this parameter for adult patients who had no pathologies indicated on the chest X-ray images or any known pathological cardiothoracic condition.

Methods

This study was approved by the Erzincan Binali Yıldırım University, Ethics Committee of Clinical Research approval (decision no: 2025-12/02, date: 17.07.2025). The requirement for informed consent from each patient participating in the study has been waived by the ethics committee based on the research methodology. All patients who had undergone chest X-ray imaging between the 1st and the 30th of June 2025 in the ambulatory care rooms were scanned. There were 350 patients listed on the picture archiving and communication system (PACS) of our hospital. The study aimed to measure the CTR of the adult individuals; therefore, the patients under 18 years old (n=5) were excluded. Patients with consolidation (n=8), atelectasis (n=14), lung nodule or mass (n=3), mediastinal mass (n=9), pericarditis (n=1), pleural effusions (n=4), scoliosis (n=3), and any cardiac or thoracic operation (n=14), were excluded. Additionally, suboptimal radiographs and X-rays with technical errors (such as inadequate patient positioning, dosage, or patient inspiration) (n=12) were not included. Cysts, cavities, bronchiectasis, interstitial lung disease, and vertebral or costal fractures were also planned to be excluded from the study; however, there were no patients with these findings in the study group. After the exclusions,

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chest X-rays of 277 patients were included in the study (Figure 1). Chest X-ray examinations were performed using the Samsung XGEO GC80/GC80V series. On the posteroanterior projection chest X-rays, the CTR is measured as the ratio of the greatest transverse dimension of the heart [addition of the maximum distance of the right heart border to the midline (a) and the maximum interval of the left heart border to the midline (b)] to the greatest transverse diameter of the chest cavity measured between the inner surfaces of the ribs (c) (Figure 2). The a and b values were recorded in millimeters. All measurements were performed by a radiology specialist with 8 years of experience. A PACS (Akgün PACS Viewer v7.5, Akgün Software, Ankara, Türkiye) was used for re-evaluation of the chest X-rays and to perform CTR measurements in standard digital imaging communications in medicine formats.

Statistical Analysis

All statistical calculations of the research were performed using IBM Statistical Package for the Social Sciences Statistics for Windows version 22.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to analyze the distribution characteristics. The histogram graphics were used to present the data distribution of CTR measurement results for the total study population, females and males. After the data analysis, a normal data distribution could not be reached, therefore, a non-parametric test (Mann Whitney-U) was carried out to assess the significance of the difference between the female and the male group regarding CTR values. The correlation between age and all the other parameters of the study was calculated using Spearman's Rho test. Independent samples T-tests were carried out to reveal the difference between genders for the other parameters (a, b, c, and a+b). For all the statistical calculations, p values of <0.05 were considered to indicate statistical significance.

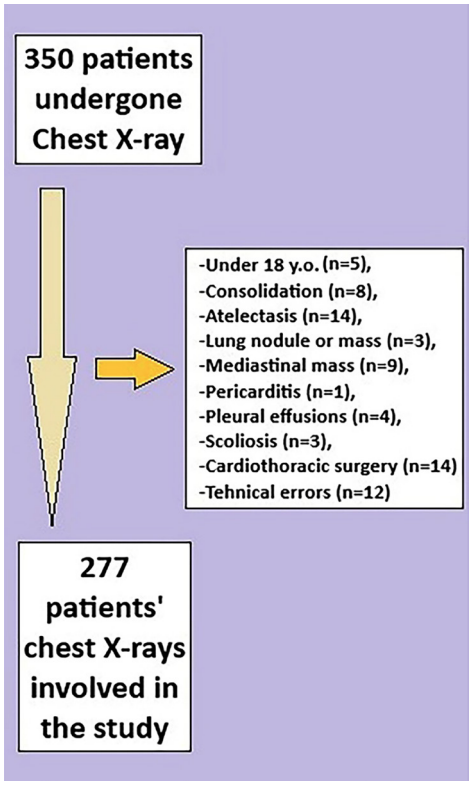

Figure 1. The workflow of the study

Results

Radiographies of 128 female and 149 male patients, totaling 277 patients, radiographies were re-evaluated regarding CTR measurements on chest X-rays. The mean age of the study population was 46.53±17.48. There was a significant difference between the female and male groups ($p<0.001$) regarding age (Table 1).

The data distribution was analyzed by the Kolmogorov-Smirnov test for the total study population, females, and the male group. The a, b, c, and a+b values indicated a normal data distribution, while a normal data distribution was not observed regarding age and the CTR values. The data distribution results were shown by boxplot analyses (Figure 3).

The male group showed higher a, b, a+b, and c values than females ($p=0.002$, $p<0.001$, $p<0.001$, and $p<0.001$, respectively) according to statistical calculations. Higher CTR values were reached for women compared to those of men in the study population ($p<0.001$) (Table 2).

Age indicated a significant positive and low correlation with b value, a+b value, and the CTR for the total study population ($p<0.001$ for each parameter). A significant, positive and moderate correlation was observed between age and the CTR for the female group ($p<0.001$), Age also showed a significant, positive, and moderate correlation with the a+b value in the male group ($p<0.001$) (Table 3).

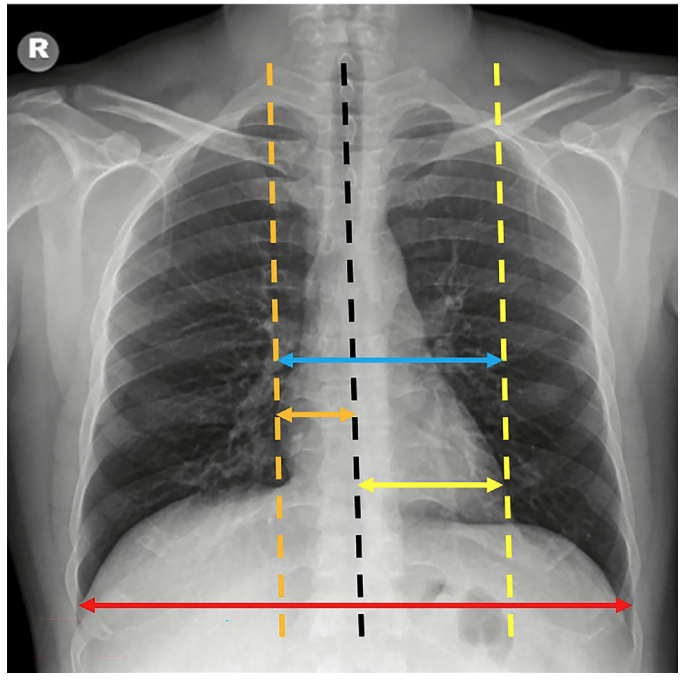

Figure 2. The dashed black line represents the midline in the radiograph. The orange line shows the maximum distance of the right heart border to the midline (a). The yellow line indicates the maximum distance from the left heart border to the midline (b). The red line shows the maximum transverse diameter of the chest cavity measured between the inner surfaces of the ribs (c). Cardiothoracic ratio is measured as (a+b)/(c)

Table 1. Demographic data of the study population

Gender (n)		Number		Percentage	
Females		128		46.2%	
Males		149		53.8%	
Total		277		-	
Age	**Mean**	**SD**	**Min.**	**Max.**	**p**
Females	50.57	16.56	18	88	<0.001
Males	43.07	17.55	18	81	
Total	46.53	17.48	18	88	-

SD: Standard deviation, Min.: Minimum, Max.: Maximum

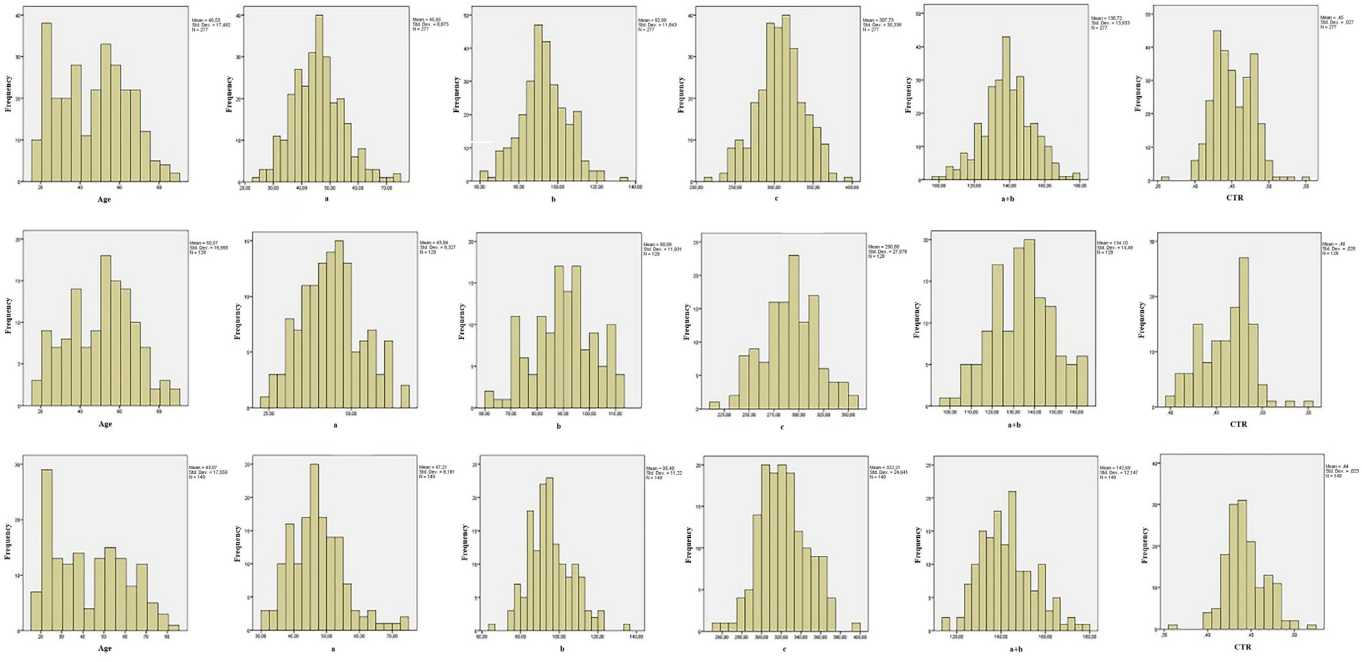

Figure 3. The histogram analysis for every measured parameter of the study. The upper, the middle and the lower row indicates the results for the total study population, the female group and the male group respectively. Normal data distribution could not be reached according to the Kolmogorov-Smirnov test regarding age and cardiothoracic ratio

Discussion

A well-obtained chest X-ray film should be observed with adequate penetration (vertebral bodies should be seen behind the heart to T7), no rotation (medial ends of clavicles should be equidistant from the vertebral spinous processes), and adequate inspiration (five to seven anterior ribs above the hemidiaphragm line). In a posteroanterior projection chest X-ray, the beam enters the chest posteriorly and the plate (detector) is located anterior to the patient. For ambulatory patients, radiographs were usually obtained in the standing position. As the heart is an anterior structure in the thorax, minimal magnification of the heart size is expected. The heart occupies less than half of the CTR, and cardiomegaly may be assumed when the ratio is greater than 50%. This assumption should not be made on any anteroposterior chest X-rays. In a normal chest X-ray, the right and left borders of the heart should be traced to make certain that there is no underlying pathological condition.[3] Heart diseases may be suspected with cardiomegaly (a CTR greater than 50%), with microcardia (a CTR less than 42%) or without an abnormality in shape or size of the heart.[4,5] On the other hand, anteroposterior radiographs have different geometries based on the X-ray projection. Based on the results of their work, Kabala and Wilde[6] proposed a 55% threshold to indicate the enlarged heart silhouette on anteroposterior radiographs. In their study, the width of the heart silhouette >165 mm for men and >150 mm for women is a significant indicator to exclude individuals with heart failure with a sensitivity of 92% and a specificity of 96%.

CTR is not only used to assess the cardiac size, but also for other significant purposes in medicine. A prospective study conducted with almost 3436 participants and a four-year follow-up revealed that an increased CTR is linked to an elevated risk (for both all-cause mortality and cardiovascular disease events) for individuals undergoing hemodialysis.[7] Hsu et al.[8] conducted a study on 186 patients undergoing hemodialysis and reported that CTR was higher in patients with vitamin D deficiency than in those without deficiency. In another study by Jiang et al.[9], the CTR is reported as a prognostic factor to predict poor outcomes in the patient group with rheumatic heart disease who have undergone valve replacement surgery. A CTR higher than 0.50 was found

to be associated with increased mortality and morbidity in outpatients with chronic heart failure.[10]

The mean value of the CTR was found to be 47.1%±3.7, and females had a significantly higher CTR than males (p=0.001) in a study by Brakohiapa et al.[11] In the current study, the measurement results for the CTR were 0.45±0.02, 0.46±0.02 and 0.44±0.02 for the total study population, for the female group and the male group, respectively. Moreover, a higher CTR was measured in females than in males, parallel to Brakohiapa et al.[12] study. In our research, a, b, a+b, and c values were also studied as distinct parameters and higher values were observed in males than in females. The study results might indicate higher cardiac dimensions in males. However, a higher horizontal chest diameter in men may explain the lower CTRs in the male group. Age was another parameter studied in the current research and showed a significant, positive, and low correlation with the b value, a+b value, and the CTR for the total study population. An increase in transverse cardiac diameter of 1 cm resulted in a CTR of greater than 0.50, in all patients except for males aged 21-40 years.

Table 2. The comparison between females and males regarding a, b, a+b, c and the CTR measurement results

	Mean	SD	p value
a value (mm)			
Females	43.83	9.32	0.002
Males	47.21	8.18	
Total	46.53	17.48	-
b value (mm)			
Females	90.09	11.93	<0.001
Males	95.47	11.21	
Total	92.98	11.84	-
c value (mm)			
Females	290.88	27.57	<0.001
Males	322.20	24.64	
Total	307.73	30.33	-
a+b value (mm)			
Females	134.09	14.49	<0.001
Males	142.68	12.14	
Total	138.72	13.93	-
CTR			
Females	0.46	0.02	<0.001
Males	0.44	0.02	
Total	0.45	0.02	-

a value: Maximum distance of the right heart border to the midline, b value: Maximum distance of the left heart border to the midline, c value: The maximum transverse diameter of the chest cavity measured between the inner surfaces of the ribs
SD: Standard deviation, CTR: Cardiothoracic ratio

Study Limitations

There are some aspects of this research that are limitations of the study. Even though the outpatients were chosen for the research, and the pathological cardiothoracic conditions were excluded from the statistical calculations, volunteers without symptoms of disease would be more suitable for reaching the normative mean values and ranges of the CTR. Moreover, some of the patients had not undergone a full cardiothoracic examination or relevant laboratory tests. There were patients referred to radiology from various departments of the hospital. The results showed a significant age difference between the female and the male groups. The females were older than the males in the study population. This situation might also influence the outcome of the study. Although the study was conducted on a relatively crowded population, a larger sample size would possibly reflect the normative values better.

Conclusion

To conclude, the chest X-ray is a fast and inexpensive imaging method that allows physicians to obtain rapid information about the presence of an underlying pathology. All doctors , including general practitioners, often use this modality to check the cardiothoracic conditions of patients quickly. Performing the measurements is very easy on chest X-rays, and the CTR still serves as a surrogate marker for the cardiovascular system along with other significant parameters from chest X-rays.

Table 3. The correlation analysis between age and five measured parameters (a, b, c, a+b and the CTR) for the total study population, the female group and the male group

		Total (n=277)	Female (n=128)	Male (n=149)
a value	Correlation coefficient	0.077	0.153	0.098
	p value	0.199	0.085	0.236
b value	Correlation coefficient	0.250	0.298	0.356
	p value	<0.001	0.001	<0.001
c value	Correlation coefficient	0.072	0.152	0.315
	p value	0.232	0.086	<0.001
a+b value	Correlation coefficient	0.283	0.351	0.427
	p value	<0.001	<0.001	<0.001
CTR	Correlation coefficient	0.392	0.461	0,260
	p value	<0.001	<0.001	0.001

a value: Maximum distance of the right heart border to the midline, b value: Maximum distance of the left heart border to the midline, c value: The maximum transverse diameter of the chest cavity measured between the inner surfaces of the ribs
CTR: Cardiothoracic ratio

Ethics

Ethics Committee Approval: This study was approved by the Erzincan Binali Yıldırım University, Ethics Committee of Clinical Research approval (decision no: 2025-12/02, date: 17.07.2025).

Informed Consent: The requirement for informed consent from each patient participating in the study has been waived by the ethics committee based on the research methodology.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.F.Ö., Concept: B.K., Design: B.K., Data Collection or Processing: B.K., M.F.Ö., Analysis or Interpretation: B.K., M.F.Ö., Literature Search: B.K., M.F.Ö., Writing: B.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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