Comparison of sensitivity and specificity of cardiac size estimation through plain chest x-ray and two echocardiography

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Abstract

BACKGROUND: Despite more accurate methods of cardiac imaging, plain chest X-ray (CXR) still is the first imaging method in people with suspected heart diseases. The most important application of CXR in cardiac patients is the estimation of cardiac size. There are two main methods for cardiac estimation in CXR; transverse diameter (TD) and calculation of cardiac width ratio to thoracic cage or cardiothoracic ratio (CTR). Echocardiography is a standard and more accurate method for cardiac size measurement; however, it requires more time and is costly, and is not as accessible as CXR.

METHODS: This study aimed to determine the sensitivity and specificity of CXR to diagnose enlarged heart (cardiomegaly) in comparison with echocardiography. In this study, 327 adults that referred for echocardiography to Hajar Hospital (Shahrekord, Iran) during summer 2001 were recruited. Their CXR findings were compared to echocardiography.

RESULTS: Mean age of the patients was 53.6 years and 46% were male. Considering the CTR ≤ 50% of thoracic cage width and TD ≤ 16 cm as normal, CTR resulted in 28.2% false-positive and 9.2% false-negative classification for cardiomegaly. The corresponding figures for TD were 8.8%and 58.5%, respectively.

CONCLUSION: In order to determine cardiomegaly, CTR had a higher sensitivity in comparison with TD; however, the specificity of TD was higher than CXR.

Keywords: Echocardiography, Plain Chest X-Ray, Cardiac Size.

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Introduction

Chest X-ray (CXR) is the most common and simplest method of radiography to assess cardiovascular system and also is an important guide for measuring cardiac size.[1-11]The advantages of this method are cost-effectiveness, being non-invasive and accessibility for patients.Therefore, it is suggested that this method be considered as a complementary toolin patients with suspected cardiac lesion.[11-15]In recent years, the importance of CXR in investigating cardiovascular diseases has been decreased due to development of more advanced non-invasive approaches such as echocardiography, CT scanning and MRI; however, these advanced methods are more expensive and less-accessible than CXR.[5,9]

Three method of cardiac size measurement are used based onCXR;transverse diameter (TD), cardiothoracic ratio (CTR) and cardiac volume (CV). The first two methods of CXR areusually used and the third one has very limited clinical applicationto estimate cardiac size.[3-5,8]

In a standard CXR, the upper limit of TD is defined as16 cm in males and 15 cm in females.[11,13]In addition, this diameter is 13.5 and 12.5 cm in 90% of males and females, respectively.[7,10]In terms of CTR, the values less than 50%are usually considered normal in adults.[11,14]

Several factors influence estimation of cardiac size in CXR method. Some of these factors are age, sex, height, weight, depth of breathing at the time of CXR, thoracic cage deformity and used technique in CXR.[7,13] These factors cause many mistakesin estimation of cardiac size in CXR.A considerable number of patients are diagnosed as cardiomegalyby CXR whilemore accurate examinations illustrate their

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heart size is normal or vice versa.[12,15]This study the sensitivity and specificity of CXR to diagnose cardiomegaly were assessed using echocardiography as gold standard.

Materials and Methods

In this study, adult patients who referred to Hajar Hospital (Shahrekord, Iran) for echocardiography during summer 2001 were recruited if they had a standard anterior posterior CXR. The patient's CXR analyzed by a radiologist and echocardiography was done by a cardiologist. The cardiac size measured in long axis parasternal view on M-Mode.[6]The number of studied patients was 327 comprised of 148 males and 179 females. The patients that their view was not suitable for measuring the left ventricular characteristics were excluded. The CXR findings were compared with echocardiography.

The age range of participants were from 12 years old (1 patient) to 100 years old (1 patient) and their mean age was 53.6 years. The patients were divided into four age groups, less than 30 years (43 patients), 31-50 years (95 patients), 51-70 years (129 patients) and over 70 years (61 patients). Moreover, the patients were divided into five groups based on body mass index (BMI), low weight (BMI less than 18.5), normal (BMI 18.5-24.9), overweight (BMI 25-29.9), obese (BMI 30-34.9) and very obese (BMI over 35).

According to CTR, the patients divided into two groups of CTR less than 50% and CTR equal or greater than 50%. In terms of TD, the patients were divided into two groups of TD less than 16 cm and TD equal or greater than 16 cm.The data were analyzed through SPSS softwareversion11using chi-square test. Numerical values were represented as mean ± standard deviation.

Results

Regardless of age, gender, height and weight, mean CTR was 46.9 ± 7 percent and mean TD was 13.7 ± 1.9 cmin participants without cardiomegaly (based on echocardiography).CTR in 90% of normal men and women was equal or less than 55.5% and 51.8%, respectively. In addition, TD in 90% of normal men and women was equal or less than 16.5 cm and 15.5 cm, respectively.

Considering 50%criterion asthe normal upper limit of CTR for diagnosis of cardiomegaly in CXR, there was 28.2%false-positive and 9.2% false-negative compared to echocardiography findings.Considering 16 cm criterion as the normal upper limit of TD for diagnosis of cardiomegaly, there was 8.8%false-positive and 58.8% false-negative compared to echocardiography.

Mean CTR and TD in patients who had echocardiographic cardiomegaly was 57.7 ± 5.7 percent and 16 ± 2.4 cm, respectively. In table 1, TD of normal people is illustrated in terms of age and sex. In normal subjects,TD in the age group younger than 30 years was lower than age group over 31 ($P < 0.05$).In terms of association between gender and TD, the difference was significant only in the age group over 70 ($P < 0.05$).

In table 2, cardiac width ratio to thoracic cage or CTR is illustrated in terms of age and sex. There was a significant difference between CTR of age group 12-30 years and age group 30-31 years ($P < 0.05$).In terms of gender and rate of CTR, there was a significant difference in the age group 51-70 between males and females ($P < 0.05$).

Furthermore, table 3 shows the impact of BMI on CTR and TD.CTR had a significant difference in those with BMI equal or less than 18.5 compared to those with BMI equal or greater than 30.TD had a significant difference in those with BMI less than 18.5 compared to those with BMI equal or greater than 25.

In case of considering 45% as the upper limit of CTR, the false-negative cases were reduced to 31%.In case of considering 13 cm as the normal upper limit of TD, false-negative values were reduced to 2.9%.

Table 1. Transverse diameter (cm) of normal people in terms of age and sex

Age group		12-30 years	31-50 years	51-70 years	Over 70
Females	Mean	11.5 ± 1.5	13.3 ± 1.6	14.1 ± 1.5	13.3 ± 1
	Upper limit	13	14.9	15.6	14.3
Males	Mean	11.3 ± 1.2	14.3 ± 1.6	14.7 ± 1.9	14.2 ± 2
	Upper limit	12.5	15.9	16.6	16.2

Table 2. Thoracic cage or cardiothoracic ratio (%) in normal people in terms of age and sex

Age group		12-30 years	31-50 years	51-70 years	Over 70
Females	Mean	41.3 ± 6.5	48 ± 5	50.9 ± 5.2	50.5 ± 2.9
	Upper limit	47.8	53	56.1	53.4
Males	Mean	39.1 ± 5	44.7 ± 4.5	47 ± 4.9	46.3 ± 5.1
	Upper limit	44.1	49.2	51.9	51.4

Table 3. The impact of MBI (Kg/m2) on cardiothoracic ratio (%) and Transverse diameter (cm) in normal subjects of the study

BMI	Less than 18.5	18.5-24.9	25-29.9	30-34.9	Over 35
Mean of CTR	43.9 ± 2.4	44 ± 6.3	48.4 ± 4.8	50.2 ± 5.1	52.4 ± 4.9
Mean of TD	11.1 ± 0.9	12.7 ± 1.7	14.3 ± 1.5	15 ± 1.7	17.1 ± 2.4

Discussion

Mean CTR in patients without echocardiographic cardiomegaly was 46.9 ± 7 percent that had no considerable difference compared to previous studies that reported it as 44-50%.Considering CTR 50 percent criterion as the normal upper limit, there was 28.2 percent false-positive result and 9.2 percent false-negative results; besides, the sensitivity and specificity for diagnosis of cardiomegaly was 87.6 and 71 percent, respectively.

Considering CTR 60 percentcriterion, the specificity test increased and reached to 98.9 percent; however, this case was associated with sensitivity test reduction; and vice versa, considering 45 percent criterion as the normal upper limit of CRT, the sensitivity test increased and reached to 96.9 percent.[9,15]

In a study by Gibson and Raphaet,[7]by determining 55% as the normal upper limit of CTR the false-positive results werereduced to 8%butit increased the false-negative cases to 41.5%. In addition, considering 60%as the CTR normal limit that was suggested by Baron et al.,[1] the false-positive and false-negative results were 1.1% and 78.5%, respectively.Therefore, it is recommended that if the main goal of CXR screening is to diagnose cardiomegaly, in order to increase the sensitivity test, 50% and *preferably* 45% be used as the normal upper limitof CTR.

Mean TD of the individuals without cardiomegaly was 13.7 ± 1.9 cm and its normal upper limit was 15.6 cm which had no substantial difference with the findings of Raphael and Donaldson.[10]In the present study, considering 16 cm criterion as the normal upper limit of TD, the false-positive and false-negative results were 8.8% and 58.5%, respectively.Consequently, the sensitivity and specificity test were obtained 40% and 91%, respectively. The sensitivity test increased to 90.8% with reduction of the normal upper limit of TD to 13 cm. Therefore, it is recommended to use the 13 cm as the normal limit in TD rather than 16 cm to define cardiomegaly. To compare CTR and TD, it seems that if the main goal of using CXR in diagnosis of cardiomegaly is screening, CTR is preferable.

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Conflict of Interests

Authors have no conflict of interests.

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