Predictive value of cardiothoracic ratio as a marker of severity of aortic regurgitation and mitral regurgitation

Kardiyotorasik oranın aort yetersizliği ve mitral yetersizliği derecesini öngörmedeki güvenilirliği

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ABSTRACT

Objective: In this study we compared cardiothoracic ratio on chest radiography and left ventricular dimensions from echocardiography in patients with left heart valvular regurgitation.

Methods: The studied population consisted of 107 patients (55 male, 52 female) aged 7 to 25 years (11.6±4.7 years) with isolated mitral or aortic regurgitation. Chest radiography and echocardiographic examination were performed on the same day in every patient.

Results: Among 26 patients with moderate mitral regurgitation, cardiac enlargement was found in 4 (15%) patients on chest radiography, and in 7 (27%) patients on echocardiography. Among 25 patients with severe mitral regurgitation, cardiothoracic ratio was normal in 20 (80%) patients whereas cardiac enlargement was documented in 17 (68%) patients on echocardiography. Although there was no patient with cardiac enlargement (CE) on chest radiography in the groups of mild and moderate aortic regurgitation, 50% of patients in the group of severe aortic regurgitation had CE on chest radiography; cardiac enlargement was detected in 62% patients with moderate and 100% patients with severe aortic regurgitation on echocardiography. We found a good relation between the severity of valvular regurgitation, especially for aortic regurgitation, and CE on echocardiography; however only a poor relation was detected between the severity of valvular regurgitation and CE on chest radiography.

Conclusion: In conclusion, prediction of severity of valvular regurgitation using chest radiography may lead to false interpretations and so, plain chest radiography may not be an essential part of the routine evaluation of such patients. *(Anadolu Kardiyol Derg 2007; 7: 146-9)*

Key words: Chest radiography, echocardiography, cardiothoracic ratio, aortic regurgitation, mitral regurgitation, children

ÖZET

Amaç: Bu çalışmada aort ya da mitral yetersizliği olan hastalarda telekardiyografideki kardiyotorasik oran ile ekokardiyografik incelemede ölçülen sol ventrikül çapları kıyaslanmıştır.

Yöntemler: Çalışma kapsamına izole mitral ya da aort yetersizliği olan, yaşları 7-25 yıl arasında değişen (11.6±4.7 yıl) toplam 107 hasta (55 erkek, 52 kız) alınmıştır. Telekardiyografik ve ekokardiyografik inceleme her hastada aynı gün içinde değerlendirilmiştir.

Bulgular: Telekardiyografide ve ekokardiyografide kardiyomegali saptanma oranı orta derecede mitral yetersizliği olan grupta sırasıyla %15 ve %27, ciddi mitral yetersizliği olan grupta ise %20 ve %68 olarak bulunmuştur. Hafif ve orta derecede aort yetersizliği olan grupta hiçbir hastada telekardiyografide kardiyomegali saptanmazken ciddi aort yetersizliğinde %50 oranında kardiyomegali saptanmıştır. Ekokardiyografideki kardiyomegali oranı ise orta derecede aort yetersizliği olan grupta %62,ciddi aort yetersizliği olan grupta ise hastaların tamamında (%100) saptanmıştır.

Sonuç: Sonuç olarak bu çalışmada, özellikle aort yetersizliğinde kapak yetersizliğinin derecesi ile ekokardiyografideki sol kalp boşluklarının genişlemesi arasında iyi bir ilişki kurulabilmesine rağmen telekardiyografi ile bu ilişki gösterilememiştir. Bu nedenle göğüs radyografisindeki kardiyotorasik oran ile kapak yetersizliğinin derecesini öngörmek hatalı yorumlara yol açabilir. *(Anadolu Kardiyol Derg 2007; 7: 146-9)*

Anahtar kelimeler: Telekardiyografi, ekokardiyografi, kardiyotorasik oran, aort yetersizliği, mitral yetersizliği, çocuk

Introduction

The chest radiography is widely available and frequently performed as a screening test for cardiac chamber enlargement. One of the methods used to quantify the heart size on chest radiography is the cardiothoracic ratio (1). Although the usefulness of the chest radiogram in detecting cardiac enlargement has been known for decades, we noticed a mismatch between chest radiography, and clinical/echocardiographic findings in the setting of the left heart valvular regurgitation in our daily practices. So, we decide to compare cardiothoracic ratio on chest radiography and left ventricular dimensions from echocardiography with left heart valvular regurgitation in this study.

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Methods

Patient selection

The studied population consisted of 107 patients (55 male, 52 female) aged 7 to 25 years (11.6±4.7 years) with isolated mitral or aortic regurgitation. The diagnosis was made at least 6 months ago. Exclusion criteria were other valvular heart diseases including aortic stenosis, mitral stenosis, combination of mitral and aortic regurgitations or other cardiac disease, acute phase of rheumatic fever, and documented sustained arrhythmias. All of the patients had normal cardiac systolic function (fractional shortening>28% and ejection fraction >54%).

The etiology of valvular regurgitation was thought to be rheumatic fever in 74%, mitral valve prolapsus in 15% and a congenital bicuspid aortic valve in 11%. Chest radiography and echocardiographic examination were performed on the same day in every patient.

Chest radiography

Standard postero-anterior chest radiography was performed in the radiology department. The cardiothoracic ratio was measured as described by Danzer (1): A vertical line is drawn on the frontal film through the spinous procardiac enlargements of the vertebrae. The sum of the maximal distance from this line to the right and left borders of the heart is the transverse diameter. This value is divided by the greatest width of the thorax, as measured from the inner margins of the ribs, to give the cardiothoracic ratio. Cardiothoracic ratio was corrected for the inspirium phase as described by Onat (2). Cardiac enlargement was defined as cardiothoracic ratio>0.50.

Echocardiography

Left ventricular internal dimensions (end-systolic and end-diastolic diameters) were acquired from standard M-mode echocardiographic image in the parasternal long axis view at the mitral valve tips. These dimensions were indexed to body surface area and every patient's measurements were defined as normal or enlarged comparing to the basic reference values (3). The patients were grouped by the degree of valvular regurgitation. Mitral regurgitation was defined as mild, moderate, or severe on the basis of whether the regurgitant signals were localized only up to the proximal third of the left atrium (4-6). Aortic regurgitation was considered mild if the signals were recorded only from localized area in the left ventricular outflow just below the aortic valve; aortic regurgitation was considered moderate when the signals extended to the level of the tip of the anterior leaflet of the mitral valve; it was severe when the signals extended well into the apical portion of the left ventricular cavity (7-9).

Statistical analysis

Data are expressed as mean ± standard deviation. In group comparisons, we used ANOVA for continuous variables, Chi-square test and Fisher's exact test for categorical variables. A value of $p<0.05$ was considered significant.

Results

Mitral regurgitation

Left ventricular M-mode echocardiographic measurements and cardiothoracic ratio values are shown according to severity of mitral regurgitation in the Table 1.

There were no statistically significant differences in left ventricular end-systolic diameter, index of left ventricular end- systolic diameter, and index of left ventricular end-diastolic diameter between groups except left ventricular end-diastolic diameter and cardiothoracic ratio values (Table 1).

The relation of cardiac enlargement on chest radiography and on echocardiography according to the severity of mitral regurgitation is shown graphically (Fig.1). Among 26 patients with

Table 1. Echocardiographic measurements and cardiothoracic ratio in patients with mitral regurgitation

Variables	Grade of mitral regurgitation			p
	Mild (n=17)	Moderate (n=26)	Severe (n=25)	
Age, years	11.0±4.5	10.0±4.0	11.1±5.1	0.962
BSA, m^2	1.2±0.3	1.0±0.3	1.2±0.3	0.146
CTI	45.2±4.6	45.7±4.8	48.8±5.7	0.014
LAD, mm	25.5±4.6	28.0±4.1	35.0±7.1	<0.001
LAD, mm/m^2	21.2±4.4	29.1±11.5	30.9±12.4	0.015
FS, %	36.1±6.3	35.8±4.7	35.2±5.1	0.657
LVEDd, mm	44.4±5.2	43.0±5.5	49.1±6.9	0.020
LVEDd, mm/m^2	37.3±8.2	41.6±17.9	43.0±13.7	0.265
LVEDs, mm	29.0±3.5	27.6±4.4	29.6±4.8	0.302
LVEDs, mm/m^2	24.5±6.0	29.1±11.6	26.1±8.8	0.276
Enlarged LVEDd, n(%)	3 (17)	7 (27)	17 (68)	<0.001
CTI>0.50, n (%)	1 (6)	4 (15)	5 (20)	0.399

BSA- body surface area, CTI- cardiothoracic ratio, FS- fractional shortening, LAD- left atrium diameter, LAD, mm/m^2- index of left atrium diameter, LVEDd- left ventricular end-diastolic diameter, LVEDd, mm/m^2- index of left ventricular end-diastolic diameter, LVEDs- left ventricular end-systolic diameter, LVEDs, mm/m^2- index of left ventricular end-systolic diameter

Table 2. Echocardiographic measurements and cardiothoracic ratio in patients with aortic regurgitation

Variables	Grade of mitral regurgitation			p
	Mild (n=13)	Moderate (n=16)	Severe (n=10)	
Age, years	13.0±4.5	14.2±5.0	15.2±2.8	0.152
BSA, m^2	1.2±0.3	1.4±0.3	1.3±0.3	0.020
CTI	45.3±3.2	44.7±2.0	48.7±3.5	0.010
LAD, mm	24.9±4.2	30.5±5.9	33.8±4.4	0.010
LAD, mm/m^2	25.6±7.3	22.6±7.3	27.0±8.1	0.425
FS, %	37.3±4.6	36.8±3.6	34.9±4.1	0.578
LVEDd, mm	39.9±5.6	49.5±6.5	60.1±8.7	<0.001
LVEDd, mm/m^2	40.7±10.1	36.5±9.8	47.5±18.1	0.102
LVEDs, mm	26.0±5.6	31.8±6.2	35.5±6.5	0.004
LVEDs, mm/m^2	5.4±6.3	22.0±6.0	28.2±12.6	0.202
Enlarged LVEDd, n (%)	1 (7)	10 (62)	10 (100)	<0.001
CTI>0.50, n (%)	0	0	5 (50)	<0.001

BSA- body surface area, CTI- cardiothoracic ratio, FS- fractional shortening, LAD- left atrium diameter, LAD, mm/m^2- index of left atrium diameter, LVEDd- left ventricular end-diastolic diameter, LVEDd, mm/m^2- index of left ventricular end-diastolic diameter, LVEDs- left ventricular end-systolic diameter; LVEDs, mm/m^2- index of left ventricular end-systolic diameter

moderate regurgitation, cardiac enlargement was present in 4 (%15) patients on chest radiography, and 7 (27%) patients on echocardiography. Among 25 patients with severe regurgitation, cardiothoracic ratio was normal in 20 (80%) patients whereas cardiac enlargement was found in 17 (68%) patients on echocardiography.

Aortic regurgitation

The echocardiographic findings and cardiothoracic ratio values are shown in Table 2. Left ventricular end-systolic diameter, left ventricular end-diastolic diameter and cardiothoracic ratio values were significantly different according to the degree of aortic regurgitation, but index of left ventricular end-systolic diameter and index of left ventricular end-diastolic diameter did not differ between groups.

Although there were no patients with cardiac enlargement on chest radiography in the groups of mild and moderate aortic regurgitation, 50% of patients in the group of severe aortic regurgitation had cardiac enlargement on ches tradiography; cardiac enlargement was detected in 62% patients with moderate and 100% patients with severe regurgitation on echocardiography (Fig. 2).

When all patients were evaluated, among 15 patients with cardiac enlargement on chest radiography, 11 (73.3%) had cardiac enlargement on echocardiography, while among the 92 patients without cardiac enlargement on chest radiography, 37 (40.2%) had cardiac enlargement on echocardiography (Table 3).

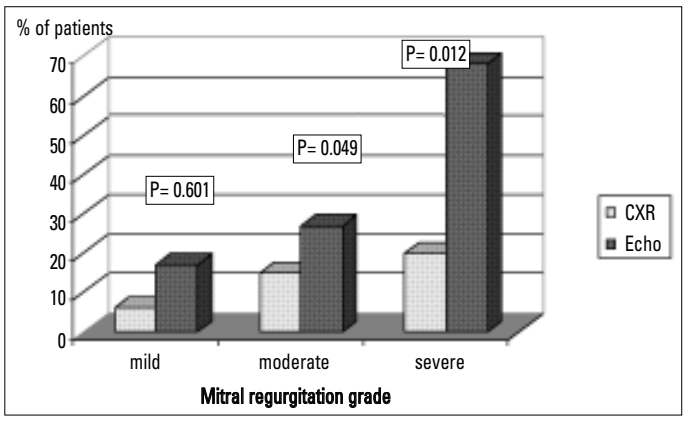

Figure 1. Comparison of cardiac enlargement on chest radiography and echocardiography in patients with mitral regurgitation

CXR- chest radiography, Echo- echocardiography

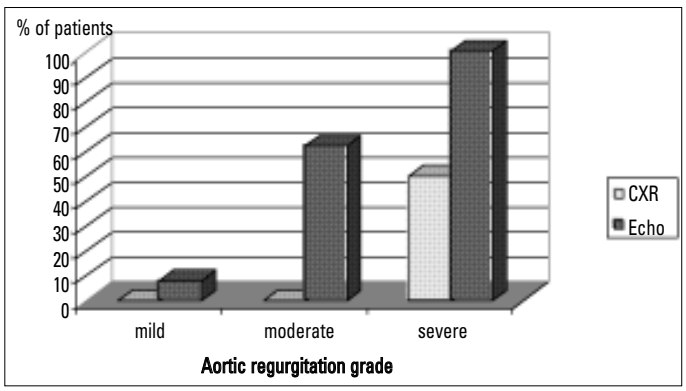

Figure 2. Comparison of cardiac enlargement on chest radiography and echocardiography in patients with aortic regurgitation

CXR- chest radiography, Echo- echocardiography

Discussion

Chest radiographies are commonly used as an initial test for the diagnosis of cardiac enlargement and heart failure. It is cheaper and easier method as compared to echocardiography.

Several studies in adults have compared radiographic and angiographic data and generally have found a good correlation between radiographic cardiac volumes and various angiographic left heart measurements (10).

We use serial echocardiogram and chest radiography examination to evaluate size and function of the heart in the follow-up aortic and mitral regurgitation in our daily practice. However in this study we found only a weak relation between echocardiographic dimensions and cardiothoracic ratio in patients with severe aortic and mitral regurgitation. We demonstrated that while only 50% of patients with severe aortic regurgitation had cardiac enlargement on chest radiography, 100% of these cases had cardiac enlargement on echocardiography; similarly 20% of patients with severe mitral regurgitation had cardiac enlargement on chest radiography while 68% had signs of chamber enlargement on echocardiography. Also, among the 92 patients without cardiac enlargement on chest radiography; 40.2% had cardiac enlargement on echocardiography.

There are contradictory results in the literature on comparison of echocardiographic to radiological cardiac dimensions. Satou et al. (11) found that chest radiography has a limited ability to detect accurately cardiac enlargement in children referred to a pediatric cardiac clinics. Davidson et al. (12) demonstrated that although there was a good correlation between the radiographic total cardiac volume and echocardiographic ventricular volumes; especially left-sided lesions in children; cardiothoracic ratio and cardiac frontal area did not correlate with echocardiographic measurements. However Levis (13) found a high correlation between radiographic cardiac frontal area and left ventricular end-diastolic volume in patients with pure aortic valve insufficiency. Also, Clark et al. (10) demonstrated that chest radiography is not a reliable indicator of the degree of left ventricular dysfunction in adults. They compared cardiothoracic ratio on chest radiography, left ventricular ejection fraction from radionuclide ventriculography, and left ventricular dimensions from echocardiography. They discussed echocardiography and radionuclide ventriculography were more appropriate investigations for assessing cardiac function. Our results supported Satou, Davidson and Clark's studies (10-12).

In our study, results of cardiac enlargement were found different between chest radiography and echocardiography in patients with mitral and aortic regurgitation. We suggested this may due to the different response and compliance capability of left ventricle to direct and indirect volume overload.

Table 3. Results of heart size on chest radiography vs heart size on echocardiography

	Echo (-)	Echo (+)	Total
CXR (-)	55 (59.8%)	37 (40.2%)	92
CXR (+)	4 (26.7%)	11 (73.3%)	15
Total	59	48	107

P=0.024

CXR- chest radiography; CXR (-)- no cardiac enlargement; CXR (+)- cardiac enlargement Echo- echocardiography; Echo (-)- no cardiac enlargement; Echo (+)- cardiac enlargement;

One limitations of this study is that measurements of the total cardiac volume and cardiac frontal area weren't calculated. As known the calculation of total cardiac volume requires both a frontal and a lateral film, however in this study we planned to compare the measurements, which we use routinely in our daily practices. The other limitations of this study are that the patients have wide age range and the duration of valvular insufficiency was not taken into consideration in this study, because duration of valvular insufficiency affects both echocardiographic and radiological cardiac dimensions.

Some implications of this study are:

1- There is a good relation between the severity of left heart valvular regurgitation, especially for aortic regurgitation, and echocardiographic enlargement of left ventricle; however only a poor relation was detected between the severity of valvular regurgitation and cardiothoracic ratio on chest radiography.

2- If there is cardiac enlargement on chest radiography, it may predict echocardiographic enlargement of left ventricle but the absence of cardiac enlargement on chest radiography cannot rule out the possibility of cardiac enlargement on echocardiography.

3- Prediction of severity of valvular regurgitation using chest radiography parameters may lead to false interpretations.

4- Plain chest radiography may not be an essential part of the routine evaluation of such patients.

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