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Original article

Comparative study of cardiac size by chest X-ray and echocardiography

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KEYWORDS

Cardiomegaly, Chest X-ray, Echocardiography, Left ventricular enlargement, Right ventricular enlargement.

ABSTRACT

Introduction: The study of cardiac size is important for the diagnosis of various types of cardiac diseases such as left ventricular enlargement due to aortic stenosis and right ventricular enlargement due to pulmonary stenosis. Although echocardiography is considered as gold standard for the diagnosis of cardiomegaly, it is costly and needs trained personnel for performing and interpreting the results of this diagnostic procedure. Chest X-ray is used as an alternative. *Materials and methods*: The present comparative study was carried on 35 males aged 25–60 years. On the basis of provisional clinical diagnosis, the patients were divided into three groups: (i) group A – 15 patients in whom clinical history did not suspect any cardiac enlargement; (ii) group B – 15 patients whose clinical history predisposed to left ventricular enlargement; and (iii) group C – 5 patients whose clinical history predisposed to right ventricular enlargement. All patients underwent chest X-ray (postero-anterior view) and 2D-echocardiography examinations. The findings of the two modalities were compared. *Observations*: The observations were very informative and showed that chest X-ray is useful for the diagnosis of cardiomegaly due to various types of cardiac diseases. On chest X-ray, the cardiothoracic ratio and transverse diameter showed a strong positive correlation with total ventricular dimension on echocardiography. Other parameters such as transverse diameter and transverse left diameter on chest X-ray also showed a positive correlation with right ventricular dimension on echocardiography. *Conclusion*: Chest X-ray is a reliable alternative for the diagnosis of cardiomegaly in the absence of echocardiography.

1. Introduction

Changing life style is causing an increased susceptibility to diabetes mellitus and hypertension. Hypertension is one of the major risk factors for cardiovascular mortality which accounts for 20–50% of all deaths. Prevalence of hypertension and diabetes is showing an increase in Indian population.[1]

Hypertension, diabetes, overweight, obesity, and other isolated cardiac diseases such as mitral regurgitation, aortic regurgitation, and pericardial effusion all increase the demand of body.[2] This leads to increased circulatory load which leads to cardiac enlargement (CE). This is evident on studying a chest X-ray (CXR) in relation to clinical finding.

Diagnostic modalities for detecting cardiomegaly include CXR and echocardiography (ECHO). Although 2D-ECHO is considered a gold standard for diagnosing CE,[3,4] several factors such as cost, availability, accessibility of the machine, and trained specialists in remote areas limit the use of this investigation. In contrast, the CXR is a cheaper and easily available alternative for the measurement of CE.[5] There is a paucity of studies which have compared the finding of CXR vis-a-vis ECHO.

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The present study intends to correlate the cardiac size measurements, as obtained on CXR and 2D-ECHO, and to investigate the implications of this information on the utility of CXR as a diagnostic tool for CE.

2. Materials and methods

The study has been conducted in a series of 35 male adult patients selected from those attending the Department of Radiology, Darbhanga Medical College and Hospital, Darbhanga, and a private clinic at Darbhanga. Patients with an abnormal body build, a spinal deformity, or a distended abdomen, and those with gross pulmonary disease of emphysematous changes have been excluded.

On the basis of provisional clinical diagnosis, the patients were divided into three groups: (i) group A – 15 patients in whom clinical history did not suspect any CE; (ii) group B – 15 patients whose clinical history predisposed to left ventricular enlargement; and (iii) group C – 5 patients whose clinical history predisposed to right ventricular enlargement. In all the patients, CXR were done in two views: postero-anterior (PA) view and lateral view, with film exposure at a distance of 6 ft and upright position. All the patients were subsequently subjected to ECHO.

Arithmetic mean, standard deviation, and coefficient correlation were used as statistical tests to compare the two diagnostic modalities.

2.1 *Radiographic measurements*

The cardiac size was assessed on a teleradiogram taken in two views (i.e., PA and lateral view) by measuring the transverse diameter (TD) and cardiothoracic ratio (CTR).[6,7] Following measurements were recorded (Fig. 1):

(i) A – long or oblique diameter on the PA view taken from the left cardiophrenic angle to the junction of right atrium and superior vena cava (normal range = 11–15.5 cm).
(ii) B – broad diameter on the PA view taken from the right cardiophrenic angle to the junction of pulmonary artery and left atrial appendage (normal range = 8–11.2 cm).
(iii) C – antero-posterior diameter on the lateral view from the point where the anterior border of the heart and sternum meet the point of maximum convexity on the posterior surface of heart (average value 9.4 cm approximately).
(iv) Transverse diameter – transverse diameter on the PA view taken as the widest diameter (WD) of the cardiac silhouette on each side of a central perpendicular line i.e., transverse left (TL) and transverse right (TR): TD = TL + TR; normal range = 9.2–14.5 cm.
(v) Widest diameter – the widest diameter of chest on the PA view taken a distance between the internal surface of the ribs on the right and left sides, superior to the costal attachment of the diaphragm (i.e., at the point where the width of the chest is the greatest).
(vi) Cardio-thoracic ratio – TD/WD × 100 (normal = 50% or less).

2.2 *Echocardiographic measurements*

For ECHO measurements, the transducer was placed in the left fourth intercostal space in the parasternal region, with patients in supine position. By adjusting the ultrasonic beam, the dimensions of both the ventricles were recorded, along with the interventricular septal wall (IVS) thickness and the posterior left ventricular wall thickness (PLVWT). Measurements were made on M-mode ECHO, 2D mode.

Following measurements were recorded (Fig. 2):
(i) Right ventricular dimension (RVD)
(ii) Left ventricular internal dimension (LVID)
(iii) Posterior left ventricular wall thickness (PLVWT)

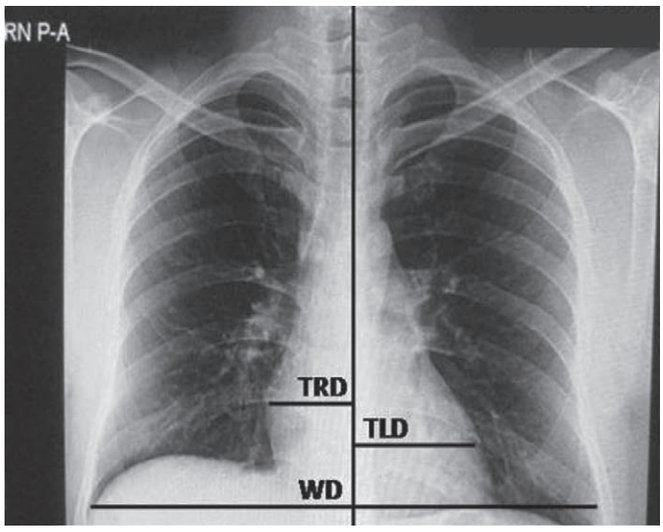

Fig. 1 – Chest X-ray PA: view showing various diameters of cardiac shadow (TLD: transverse left diameter, TRD: transverse right diameter, WD: widest diameter).

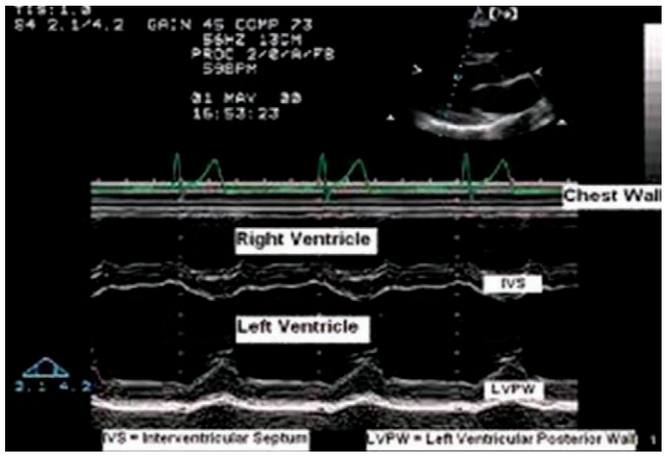

Fig. 2 – M-mode echocardiogram from group-A (normal) study participant (RV: right ventricle, LV: left ventricle, IVS: interventricular septum, LVPW: left ventricular posterior wall).

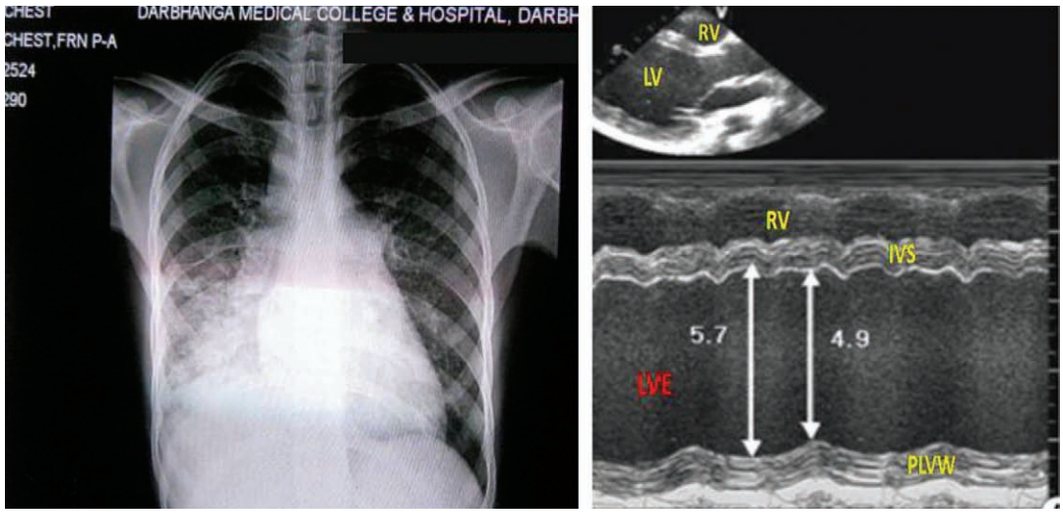

Fig. 3 – Chest X-ray and M-mode echocardiogram of a group-B participant showing left ventricular enlargement (LVE: left ventricular enlargement).

(iv) Interventricular septal wall (IVS)
(v) Left atrial dimension (LAD)
(vi) Total ventricular dimension (TVD):
TVD = RVD + LVID + PLVWT + IVS.

3. Results

Observations as recorded on CXR and ECHO groups and their comparison are as follows. Table 1 shows the normal distribution of different study groups in the study population. The study population comprised all male participants.

Table 1 – The distribution of cases (all males).

	No. of cases	Age range (years)	Height range (cm)	Weight range (kg)
Group A	15	26–60	153–162	43–65
Group B	15	28–55	155–164	46–65
Group C	5	25–38	153–165	45–60
Total	35	25–60	153–170	43–68

Group A: Table 2 shows the mean values of different study variables as observed on CXR and ECHO in group A. Table 3 shows correlation coefficients observed between study variables as obtained from CXR and ECHO. A positive but a weak correlation was observed between the findings of ECHO and CXR. However, a strong positive correlation was observed between the TVD and TL diameter.

Group B: Table 4 shows the mean value of different study variables as observed on CXR and ECHO in group B. Figure 3 showing left ventricular enlargement observed on CXR and ECHO. Table 5 shows the correlation coefficient between different variables obtained on CXR and ECHO. A very strong positive correlation was observed between the TVD and CTR. However, the LVID showed a very poor correlation with different parameters of CXR.

Group C: Table 6 shows the mean values of different study variables as observed on CXR and ECHO in group C. Table 7 shows the correlation coefficient between different study variables as observed in CXR and ECHO. The right ventricular dimension (RVD) and the total ventricular dimension (TVD)

Table 2 – The mean values of different study variables as observed on chest X-ray and echocardiography in group A.

Chest X-ray				Echocardiography			
S. No.	Variable	Range	Mean ± SD	S. No.	Variable	Range	Mean ± SD
1	A (cm)	11.8–15.2	13 ± 1.12	1	RVD (cm)	1.3–2.3	1 ± 0.269
2	B (cm)	9.3–13.2	10 ± 1.03	2	LVID (cm)	4.2–5.4	4 ± 0.389
3	C (cm)	8.6–11	9 ± 0.64	3	PLVWT (cm)	0.8–1.1	0.97 ± 0.108
4	TL (cm)	7.5–8.6	8 ± 0.33	4	IVS (cm)	0.8–1	0.9 ± 0.079
5	TR (cm)	3.0–4.5	3 ± 0.41	5	TVD (cm)	7.3–9.2	8 ± 0.540
6	TD (cm)	11.4–12.8	12 ± 0.45	6	LAD (cm)	1.9–2.9	2 ± 0.339
7	WD (cm)	23.4–29.9	25 ± 1.43	7	AD (cm)	1.9–2.8	2 ± 0.282
8	CTR (%)	45.2–51.3	47 ± 2.07				

SD: Standard deviation; TL: Transverse left; TR: Transverse right; TD: Transverse diameter; WD: Widest diameter; CTR: Chest X-ray; RVD: Right ventricular dimension; LVID: Left ventricular internal dimension; PLVWT: Posterior left ventricular wall thickness; IVS: Interventricular septal wall; TVD: Total ventricular dimension; LAD: Left atrial dimension; AD: Atrial dimension.

Table 3 – Pearson correlation coefficients (r), as observed in group A, between different study variables of chest X-ray with total ventricular dimension on echocardiography.

	TL	CTR	TD	TR
TVD	0.66	0.35	0.29	0.25

TL: Transverse left; CTR: Chest X-ray; TD: Transverse diameter; TR: Transverse right; TVD: Total ventricular dimension.

Table 5 – Pearson correlation coefficient (r) between different variables obtained on chest X-ray and echocardiography in group B.

	CTR	TD	TL	TR
TVD	0.93	0.61	0.52	0.14
LVID	0.19	−0.22	−0.07	0.45

CTR: Chest X-ray; TD: Transverse diameter; TL: Transverse left; TR: Transverse right; TVD: Total ventricular dimension; LVID: Left ventricular internal dimension.

Table 4 – The mean value of different study variables as observed on chest X-ray and echocardiography in group B (Fig. 3).

Chest X-ray				Echocardiography			
S. No.	Variable	Range	Mean ± SD	S. No.	Variable	Range	Mean ± SD
1	A (cm)	18.2–22.6	19.6 ± 1.26	1	RVD (cm)	1.4–2.2	1.9 ± 0.22
2	B (cm)	10.8–12.2	11.53 ± 0.49	2	LVID (cm)	5.7–6.2	5.9 ± 0.13
3	C (cm)	10.4–11.6	11.01 ± 0.34	3	PLVWT (cm)	1.2–1.7	1.5 ± 0.14
4	TL (cm)	9.7–12.2	10.76 ± 0.94	4	IVS (cm)	1.1–1.6	1.4 ± 0.14
5	TD (cm)	13.2–15.6	14.7 ± 0.93	5	TVD (cm)	10.1–11.2	10.6 ± 0.31
6	WD (cm)	24.1–28.8	25.74 ± 1.2				
7	CTR (%)	53.2–61.4	57.1 ± 2.1				

SD: Standard deviation; TL: Transverse left; TD: Transverse diameter; WD: Widest diameter; CTR: Chest X-ray; RVD: Right ventricular dimension; LVID: Left ventricular internal dimension; PLVWT: Posterior left ventricular wall thickness; IVS: Interventricular septal wall; TVD: Total ventricular dimension.

Table 6 – The mean values of different study variables as observed on chest X-ray and echocardiography in group C.

Chest X-ray				Echocardiography			
S. No.	Variable	Range	Mean ± SD	S. No.	Variable	Range	Mean ± SD
1	A (cm)	15.8–17.3	16.7 ± 0.61	1	RVD (cm)	2.4–3.2	2.7 ± 0.31
2	B (cm)	11.4–12.3	11.9 ± 0.40	2	LVID (cm)	4.4–5.1	4.7 ± 0.30
3	C (cm)	9.8–10.2	10 ± 0.16	3	PLVWT (cm)	1.1–1.2	1.2 ± 0.04
4	TL (cm)	9.9–10.7	10.3 ± 0.36	4	IVS (cm)	1.1–1.3	1.2 ± 0.07
5	TD (cm)	15.3–16.5	15.8 ± 0.49	5	TVD (cm)	9.3–10.8	9.8 ± 0.67
6	WD (cm)	25.5–27.7	26.8 ± 0.86				
7	CTR (%)	56.5–68.7	59.3 ± 5.25				

SD: Standard deviation; TL: Transverse left; TD: Transverse diameter; WD: Widest diameter; CTR: Chest X-ray; RVD: Right ventricular dimension; LVID: Left ventricular internal dimension; PLVWT: Posterior left ventricular wall thickness; IVS: Interventricular septal wall; TVD: Total ventricular dimension.

Table 7 – Pearson correlation coefficient (r) between different study variables as observed in chest X-ray and echocardiography in group C.

	CTR	TD	TL	TR
RVD	0.96	0.83	0.78	0.41
TVD	0.96	0.75	0.90	0.15

CTR: Cardiothoracic ratio; TD: Transverse diameter; TL: Transverse left; TR: Transverse right; RVD: Right ventricular dimension; TVD: Total ventricular dimension.

showed a very strong positive correlation with CTR and TD. The right ventricular dimension and total ventricular dimension showed a stronger correlation with TL diameter than the TR diameter on CXR.

4. Discussion

A comparison of study variables obtained from CXR and ECHO in group A shows a positive but weak correlation of TVD with TD and CTR. A strong positive correlation was however observed between TVD and TL.

In group B patients i.e., patients with suspected left ventricular enlargement, a very strong positive correlation was observed between TVD and CTR. However, the LVID showed a poor correlation with TL, CTR. A probable reason for the poor correlation might be that the left ventricular chamber forms a very little part of cardiac shadow. The major part of left ventricle occupies the left and the diaphragmatic surface of the heart. Hence, any dilatation of left ventricular cavity is unlikely to manifest in the form of enlargement of cardiac shadow. Wide discrepancies exist between different studies

regarding the specificity, sensitivity, and the predictive value of the CXR. Lupow et al[8] and Shareef and AL-Doori[9] suggest that although the CXR can be a valuable tool for diagnosing cardiac size in cases of left ventricular enlargement (LVE) or left ventricular dysfunction, it is not accurate because of low sensitivity. In a study carried out on children, Satou et al reported a sensitivity and specificity of 59% and 92%, respectively, in predicting the CE by CXR.[3] On the other hand, Kadhum et al reported a high sensitivity (86%) and very low specificity (14%).[4] Shirani et al[10] concluded that CTR is more sensitive than TD but TD is more specific than CTR for estimating cardiomegaly. The cardiothoracic ratio is a useful screening method to detect cardiomegaly, but is reliable only on PA view chest radiography. [11]

The present study suggests that there exists a weak positive correlation in group A (normal) but a strong positive correlation in group B (suspected LV enlargement) between CTR and TVD meaning thereby that any abnormal increment in cardiac size is reflected in the CXR. Although sensitivity and specificity were not calculated in the present study for the want of adequate sample size, authors believe that CTR coupled with the clinical history is a reasonably good tool for diagnosing LVE, especially in cases where an ECHO is not feasible.

The comparison of parameter in group C patient shows a fairly good correlation between the CXR parameter and RVD. This shows that CXR is a good indicator of right ventricular enlargement (RVE). However, a notable fact is that the TL diameter correlates better with the RVD as compared to the TR diameter. These discrepancies may be explained by the anatomical arrangement of the chambers of the heart. The right part of the heart is occupied mainly by right atrium and enlargement of right ventricular cavity is expected to be inclined toward the left rather than right. No studies could be found for comparison.

The present study differs from earlier studies in the fact that group C i.e., right ventricular enlargement, was also included as a separate study group. This facilitated the comparison of various parameters of CXR with the relevant parameters of ECHO, besides the cardiac size alone. The study also reflected the pattern in which increment in the size of different chambers is reflected in cardiac shadow.

5. Conclusions

- Cardiothoracic ratio is a good indicator of left ventricular enlargement and right ventricular enlargement.
- Transverse diameter is a good indicator of right ventricular enlargement and a fair indicator of left ventricular enlargement.
- Transverse left diameter correlates more with right ventricular enlargement than left ventricular enlargement.
- Transverse right diameter is a poor indicator of right ventricular enlargement and left ventricular enlargement.

According to the present study, the CXR can be a reliable tool for diagnosing CE in the absence of ECHO facilities.

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