Med. J. Cairo Univ., Vol. 87, No. 2, March: 1227-1232, 2019
www.medicaljournalofcairouniversity.net

Value of the Chest X-Rays in Diagnosis of Children with Heart Disease in the Age Group 1-4 Years

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Abstract

Background: Chest X-ray continues to have an important role in diagnosis of heart diseases.

Aim of Study: We aim by this the study to evaluate the use of chest X-ray in the Pediatric Cardiology Unit in Assiut University Children Hospital for children (1-4 years old) with suspected heart disease.

Patients and Methods: This was a six-month, case series clinical study undertaken in the inpatient Pediatric Cardiology Unit, Assiut University Hospital, Assiut City, Egypt; between 1 of April 2016 to 30 of September 2016.

Results: Chest X-ray is an important tool in evaluating heart disease in children. Noninvasive imaging such as echocardiography and cardiac MRI provide valuable and detailed assessment of the cardiovascular system; however, the cost incurred from these diagnostic procedures is significant making their routine use difficult.

Conclusion: Auditing the guidelines of interpretation of the chest radiograph for children aged one year to four years at the Pediatric Cardiology Unit of Assiut University Hospital for Children, it could be concluded: Chest roentgenogram is accurate in detecting cardiac site and situs.

Key Words: *Congenital heart disease– Heart failure– Cardiomyopathy – Chest radiography– Electrocardiogram – Echocardiography.*

Introduction

CHEST radiography is the most frequently performed radiological study. It remains one of the prime methods for investigation of diseases of the heart despite recent advances in other non-invasive techniques [1].

Chest X-ray provides important information including heart size, pulmonary blood flow, and any associated lung disease. The size and shape of the heart as well as pulmonary vascular markings, pleura and parenchymal lung marking provide helpful information regarding the heart/lung pathology [2].

Rapid technological advances and new clinical applications in cardio vascular imaging technology, coupled with increasing therapeutic options for cardiovascular disease, have led to explosive growth in cardiovascular imaging [3]. Echocardiography, Cardiac Magnetic Resonance (CMR), and Cardiac Computed Tomography (CCT) are the primary modalities used for noninvasive cardiac imaging [4].

Patients and Methods

This was a six-month, case series clinical study undertaken in the inpatient Pediatric Cardiology Unit, Assiut University Hospital, Assiut City, Egypt; between 1 of April 2016 to 30 of September 2016.

The study included 45cases (16 boys and 29 girls). All patients were recruited from the Pediatric Cardiology Unit. A total of 60 patients were screened for eligibility, and 45 were enrolled. The diagnosis of pediatric heart diseases and assessments of all cases were established in Assiut University Children's Hospital.

Inclusion criteria:

Children from 1-4 years old with suspected heart disease (congenital heart disease, cardiomyopathy, heart failure) were enrolled in the study.

Exclusion criteria:

Children with a history of other chronic disorders including; anemia, renal, hepatic and chronic pulmonary diseases were excluded. In addition; patients were excluded if they had a clinically significant malnutrition disorders.

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Investigated patients were evaluated according to the following:

1- *Detailed history:* Paying attention to age, sex and time at onset of complaint, any history of cardiac manifestation.

2- *Clinical examination:*

A- General examination.

B- Cardiac examination.

C- Chest examination.

D- Abdominal examination.

E- Neurological examination.

3- *Investigations:*

A- *Chest X-ray films:* All cases had CXR, PA view in the erect position.

The following points were reported:

- The view.
- Cardiac site.
- Cardiac size.
- Cardiac configuration.
- Cardiac chamber size.
- Thymus shadow.
- Pulmonary vasculature.
- Associated pulmonary diseases.

B- *Echo cardiogram:* The echocardiographic examinations were performed at the Pediatric Cardiology Unit, Assiut University Children Hospital. Detailed echocardiographic examination was done using Philips Envisor C with M-mode, 2 Dimensional (2D), Pulsed Wave (PW) Continuous Wave (CW), and Color Flow Mapping (CFM) using electronic sector-scanner with 3 to 7MHz transducers under ECG screening.

Measurements were taken according to standard methods described by the American Society of Echocardiography. And include:

- Right and left ventricular dimensions and thickness.
- Left atrial dimension.
- Ascending aorta dimension.
- Main pulmonary artery diameter.

Doppler measurements included:

a- Tricuspid regurgitation.

b- Continuous wave Doppler recording of the pulmonary regurgitation.

c- Pulmonary and aortic velocities.

d- Mitral diastolic flow.

Value of echocardiography:

- Definite detection of cardiac site and visceroatrial situs.
- Accurate measurements of chamber diameters and wall thickness with referral of these measurements to the standard for age.
- Detection of anatomical abnormalities within the heart or proximal parts of great vessels.
- Estimation of pulmonary pressure.
- Evaluation of the pericardium.
- Detection of the thymus gland and its size.

C- *Electrocardiogram:* Rhythm, rate, cardiac axis, P-wave, QRS complex and T-wave for detection of cardiac site and cardiac size.

ECG criteria of specific chamber enlargement:

- Right atrial hypertrophy: Tall P-waves (>3mm) indicate P pulmonale.
- Left atrial hypertrophy: A widened and often notched P-wave (with the P duration >0.08 second in infants) is seen in P mitrale.
- Biatrial hypertrophy: A combination of increased amplitude and duration of the P-wave is present.
- Ventricular hypertrophy: Produces abnormalities in one or more of the following: The QRS axis, the QRS voltages, the R/S ratio, the T axis, and miscellaneous areas [5].

Data obtained from the CXR film were compared with those from clinical data, ECG and echocardiography data, where the echocardiogram was considered the gold standard in diagnosing site, situs, anatomical configuration and size of the heart and its chambers, and the most sensitive in detecting the pulmonary pressure.

Results

According to chest X-ray, cardiac site of all cases were normal except one was shifted to left. Clinical examination shows that all cases had normal cardiac site. Also ECG shows all cases with normal cardiac site. In case of ECHO all cases had normal cardiac site.

According to chest X-ray, cardiac situs of all cases were normal except one was with dextrocardia. Clinical examination shows that all cases had normal cardiac situs except one was with dextrocardia. Also ECG shows all cases normal cardiac situs except one was dextrocardia. In case of ECHO

all cases had normal cardiac situs except one was dextrocardia.

In the echocardiogram, enlarged cardiac size was detected in 38 cases, 33 cases (86.8%) from them had enlarged cardiac size in CXR; 22 cases (57.8%) were detected to have enlarged cardiac size in clinical examination.

In the echocardiogram, enlarged right atrium size was detected in 16 cases, out of those 11 cases (68.8%) had enlarged right atrium size in CXR; where in ECG 9 cases (56.2%) from them had enlarged right atrium size. The sensitivity in right atrium enlargement was 68.8% for chest X-ray and 56.2% for ECG, which mean chest X-ray is better predictor than ECG for positive cases. Where the specificity was 48.3% and 89.7% for chest X-ray and ECG respectively which means ECG was good predictor for negative cases. Generally from the accuracy was 77.8% for ECG and 55.6% for chest X-ray, which means the good predictor of positive and negative cases was ECG compared with ECHO results of enlarged right atrium.

In the echocardiogram, enlarged left atrium size was detected in 18 cases, 10 cases (55.6%) from them had enlarged left atrium size in CXR; where in ECG 7 cases (38.9%) from them had enlarged left atrium size. The sensitivity in left atrium enlargement was 55.6% for chest X-ray and 38.9% for ECG which mean chest X-ray is better predictor than ECG for positive cases. Where the specificity was 74.1% and 96.3% for chest X-ray and ECG respectively which means ECG was good predictor for negative cases. Generally accuracy was 73.3% for ECG and 66.7% for chest X-ray that means the good predictor of positive and negative cases was ECG compared with ECHO results of enlarged left atrium.

In the echocardiogram, enlarged right ventricle size was detected in 21 cases, 16 cases (76.2%) from them had enlarged right ventricle size in CXR; where in ECG 11 cases (52.4%) from them had enlarged right ventricle size. The sensitivity in right ventricle enlargement was 76.2% for chest X-ray and 52.4% for ECG that mean chest X-ray is better predictor than ECG for positive cases. Where specificity was 62.5% and 95.8% for chest X-ray and ECG respectively that means ECG was good predictor for negative cases. Generally from accuracy 75.6% for ECG and 68.9% for chest X-ray that means the good predictor of positive and negative cases was ECG compared with ECHO results of enlarged right ventricle size.

In the echocardiogram, enlarged left ventricle size was detected in 20 cases, 12 cases (60%) from them had enlarged left ventricle size in CXR; where in ECG 6 cases (30%) from them had enlarged left ventricle size. The sensitivity in left ventricle enlargement was 60% for chest X-ray and 30% for ECG that mean chest X-ray is better predictor than ECG for positive cases. Where specificity was 84% for both chest X-ray and ECG. Generally accuracy was 60% for ECG and 73.3% for chest X-ray that means the good predictor of positive and negative cases was chest X-ray compared with ECHO results of enlarged left ventricle size.

Table (1): Demographic data of our studied cases.

	No.	%
Age:		
Children: 1-4 years	45	100
Gender:		
Boys	16	35.6
Girls	29	64.4

Table (2): Data gained by the CXR in our studied cases.

	No.	%
Normal cardiac site	44	97.8
Normal cardiac situs	44	97.8
C/T ratio:		
‹_50%	7	15.6
>50%	38	84.4
Enlarged cardiac chamber:		
Rt. atrium	26	57.7
Lt. atrium	17	37.7
Rt. ventricle	25	55.5
Lt. ventricle	16	35.5
Thymus shadow (present)	7	15.6
Pulmonary vasculature:		
Normal	29	64.4
Pulmonary congestion	14	31.2
Pulmonary oligemia	2	4.4
Radiological evidence of pulmonary disease	9	20

Table (3): Data gained by the clinical examination in our studied cases.

	No.	%
Displaced cardiac apex	22	48.8
Clinical manifestations of PHT	6	13.3
Pulmonary disease	13	28.8

Table (4): Data obtained from the ECG in our studied cases.

Item	No.	%
Enlarged cardiac chamber:		
Right atrium	12	26.6
Left atrium	8	17.7
Right ventricle	12	26.6
Left ventricle	10	22.2

Table (5): Data obtained from the echocardiography examination in our studied cases.

Item	No.	%
Normal cardiac site	45	100
Normal cardiac situs	44	97.8
Dilated right atrium	16	35.5
Dilated left atrium	18	40
Dilated right ventricle	16	35.5
Dilated left ventricle	19	42.2
Hypertrophied right ventricle	5	11.1
Hypertrophied left ventricle	1	2.2
Increase pulmonary pressure	13	28.8

Table (6): Percentage frequency of cases with normal and altered pulmonary vasculature in chest X-ray, in relation to clinical manifestation of Pulmonary Hypertension (PHT) in our studied cases: No significant difference in comparison between pulmonary vasculature of chest X-ray and clinical manifestations of PHT (p>0.05).

Clinical manifestations of PHT	Pulmonary vasculature (chest X-ray)						p-value
	Normal		Pulm. Congestion		Pulm. Oligemia		
	No.	%	No.	%	No.	%	
Absent	25	86.2	12	85.7	2	100	0.850
Present	4	13.8	2	14.3	0	0.0	
Total	29	100	14	100	2	100	

Table (7): Percentage frequency of cases with normal and altered pulmonary vasculature in chest X-ray, in relation to increase estimated pulmonary pressure by echocardiography in our studied cases: No significant difference in comparison between pulmonary vasculature of chest X-ray and increased estimated pulmonary pressure in the echocardiogram.

Pulmonary pressure (echocardiogram)	Pulmonary vasculature (chest X-ray)						p-value
	Normal		Pulm. Congestion		Pulm. Oligemia		
	No.	%	No.	%	No.	%	
Normal	22	75.9	8	57.1	2	100	0.292
Increase	7	24.1	6	42.9	0	0.0	
Total	29	100	14	100	2	100	

Table (8): Percentage frequency of cases with signs of pulmonary disease in chest X-ray and in clinical examination of our studied cases: There is no significant difference in comparison between pulmonary disease in chest X-ray and in clinical examination.

Pulmonary disease in clinical examination	Pulmonary disease in chest X-ray				p-value
	No		Yes		
	No.	%	No.	%	
No	27	75	5	55.6	0.459
Yes	9	25	4	44.4	
Total	36	100	9	100	

Discussion

Regarding cardiac site, in all our cases, this item was diagnosed completely by the chest roentgenogram; cardiac site, in all of cases, were normal except one was shift to left. It could be concluded that the chest roentgenogram is accurate in excluding abnormal cardiac site.

The air bronchogram pattern is the most accurate method of diagnosis of visceroatrial situs; visceral (abdominal) situs is determined by the sidedness of the liver and stomach. All these signs are clear in chest roentgenogram and in turn the situs of all our cases was diagnosed accurately by chest X-ray film; cardiac situs all of cases were normal except one was dextrocardia.

In this study, we prospectively evaluated the diagnostic performance characteristics of CXR to detect cardiac enlargement. We used ECHO as the gold standard.

It was observed that the percentage frequency of cases with true chamber enlargement and/or hypertrophy among cases diagnosed as having C/T ratio of >50% in the chest radiograph was 86.8% (33 cases out of 38 cases). In spite of the fallacies regarding the use of C/T ratio in this age group like horizontal position of the heart, difficulty in obtaining midinspiratory film in this age group and the frequent presence of thymus [6], C/T proved to be of value in determining cardiac dilation and/or hypertrophy. This is in contradiction with Satou et al., 2001.

Satou et al., 2001; evaluated 95 consecutive outpatients children to determine the usefulness of heart size on CXR in predicting cardiac enlargement in children, CXR and echocardiography performed for all cases. Their median age was 5 years (2 days to 19.9 years). All patients underwent CXR assessment by a pediatric radiologist, with classi-

fication of cardiac silhouette as normal, borderline, or enlarged. Echocardiographic assessment of cardiac enlargement was performed by a pediatric echo cardiographer. In contradiction of our results the sensitivity of the CXR to identify cardiomegaly was 58.8%, with a positive predictive value of 62.5%. Specificity (92.3%) and negative predictive value (91.1%) were higher to our results (28.6% specificity) and (28.6% negative predictive value).

In our study, CXR sensitivities for cardiac chambers enlargement in comparison with the gold standard test (ECHO) were 68.8% for the right atrium, 55.6% for the left atrium, 76.2% for the right ventricle and 60% for the left ventricle. The CXR specificities for cardiac chambers enlargement in comparison with ECHO were 48.3% for the right atrium, 74.1% for the left atrium, 62.5% for the right ventricle and 84% for the left ventricle. There is no statistically significant difference between chest X-rays and echocardiography in detecting left atrium enlargement, right ventricle enlargement and left ventricle enlargement where there is statistically significant difference between chest X-rays and echocardiography in detecting right atrium enlargement. We could not find similar studies in the literature; however, the sensitivities and specificities of CXR in diagnosing specific chamber enlargement are still inadequate and depending on echocardiography in such data is the most accurate.

Regarding pulmonary vascularity, our results showed that 24.1% of normal pulmonary vasculature in CXR had increased pulmonary pressure in ECHO and 42.9% of congestion in X-ray had increased pulmonary pressure in echocardiogram. Tumkosit et al., 2012 reported that the sensitivity of CXR to interpret decreased pulmonary vascularity patterns was low (24-68%), whereas the sensitivity to interpret normal and increased pulmonary vascularity patterns were high (84-94%).

Conclusion:

Auditing the guidelines used for interpretation of the chest radiograph for children from one year to four years at the Pediatric Cardiology Unit of Assiut University Hospital for Children, it could be concluded:

1- Chest roentgenogram is accurate in detecting cardiac site.

2- Chest radiography is also accurate in detecting cardiac situs.

3- Enlarged C/T >50% is useful for diagnosing cardiomegaly because of cardiac chamber dilation and/or hypertrophy. However, decreased C/T <50% does not exclude cardiac chamber dilation and/or hypertrophy.

4- The sensitivities and specificities of CXR in diagnosing specific chamber enlargement are still inadequate and depending on echocardiography in such data is the most accurate.

5- The chest radiograph has little value in the diagnosis of pulmonary pressure changes and echocardiography is the method to be used in this regard.

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قيمة آشعة إكس التشخصية فى تشخيص آمراض قلب الآطفال فى السنوات العمرية (١-٤ سنوات)

قد آجريت الدراسة على ٤٥ طفل (الذين تتراوح آعمارهم بين ١-٤ سنوات) فى وحدة طب القلب للآطفال، مستشفى آسيوط الجامعى.

تمت مقارنة البيانات التى تم الحصول عليها من فيلم آشعة إكس مع تلك من بيانات تخطيط صدى القلب، حيث تم إعتبار مخطط صدى القلب المعيار الذهبى.

وقد تم إستنتاج الآتى:

١- التصوير الشعاعى الصدر دقيق فى الكشف عن موقع القلب.

٢- التصوير الشعاعى الصدر هو آيضا دقيق فى الكشف عن القلب.

٣- التصوير الشعاعى الصدر مفيد لتشخيص ضخامة القلب بسبب تمدد غرفة القلب و/آو تضخم.

٤- إنخفاض حسا سية وخصوصيات آشعة إكس فى تشخيص توسيع غرفة معينة لا تزال غير كافية، وهذا يتوقف على تخطيط صدى القلب فى هذه البيانات هو الآكثر دقة.

٥- التصوير الشعاعى للصدر له قيمة ضئيلة فى تشخيص التغيرات الرئوية الضغط وتخطيط صدى القلب هو الطريقة التى سيتم إستخدامها فى هذا الصدد.