The Egyptian Journal of Hospital Medicine (July 2020) Vol. 80, Page 615-618

Value of Chest Radiography and Electrocardiography in Diagnosis of Congenital Heart Diseases in Pediatrics in Comparison with Echocardiography

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ABSTRACT

Background: Advances in echocardiographic technology have made a revolution in the quality of image and acquisition of data; however, it has also increased the cost of this diagnostic test.

Objective: To determine if chest x ray (CXR) and electrocardiography (ECG) are still valuable in evaluation of new patients with heart murmurs in presence of echocardiography (ECHO).

Patients and Methods: This was a six month, prospective clinical study undertaken in the Outpatient Pediatric Cardiology Unit, Zagazig University Children Hospital, between April 2018 and October 2018. The study included 44 patients (boys and girls) between the ages of 1 month and 14 years. All cases were subjected to detailed history, full clinical examination and imaging modalities as CXR, ECG and ECHO.

Results: The highest accuracy of CXR was detection of right atrium (96.9%) followed by left ventricle (95.1%). The highest accuracy of ECG was detection of right atrium (98.5%) and left ventricle (95.5%). The agreement between CXR and ECHO in detection of pulmonary hypertension was 0.4 while that for ECG was 0.6. The agreement between CXR and ECHO in diagnosis of congenital heart diseases was 0.6 and that for ECG was 0.9. The accuracy of ECG in diagnosis of congenital heart disease was 95.4% while that for CXR was 70.4%.

Conclusion: ECG is more accurate than CXR in detection of cardiac chamber enlargement and heart diseases in general but echocardiography still the most accurate method in this regard. The chest radiograph and electrocardiogram had limited values in the diagnosis of pulmonary pressure changes and echocardiography is the method to be used in this regard.

Keywords: Congenital heart diseases (CHD), chest x ray (CXR), electrocardiography (ECG), echocardiography (ECHO).

INTRODUCTION

Referral for evaluation of heart murmurs accounts for the largest group of new patients seen by the pediatric cardiologist [(1)]. It was determined that clinical diagnosis of heart disease cannot be changed by diagnostic tests such as ECG, CXR, and M-mode echocardiography if it was based on accurate history taking and physical examination [(2)]. It was proved that CXR and ECG are effective in assessment of pediatric patients with heart murmur or chest pain referred to pediatric cardiologist for evaluation. In days of cost containment, routine ECG and CXR are still valuable tools for evaluation of patients with heart murmurs by the pediatric cardiologist [(3)]. Inaccurate diagnosis may result in unnecessary anxiety and psychological trauma when incorrectly identifying a child with an innocent murmur as having heart disease. On the other hand, false-negative assessment may expose children with undiagnosed minor and major cardiac lesions to dangerous complications. Advances in echocardiographic technology made a revolution in the quality of image and acquisition of data; however, it has also increased the cost of this diagnostic test [(2)]. The diagnostic accuracy of clinical assessment, CXR and ECG were determined in the complete evaluation of new patients with heart murmur to diagnose cardiac diseases in children. The most effective tool in diagnosis of cardiac diseases in children is clinical assessment while CXR and ECG can add an important value in diagnosis [(3)].

Aim of the work was to determine if CXR and ECG are still valuable in evaluation of new patients with heart murmurs in presence of echocardiography.

PATIENTS AND METHODS

This prospective clinical study was carried out between April and October, 2018 in the Outpatient Pediatric Cardiology Unit, Zagazig University Children Hospital. The study included 44 patients (boys and girls) between the ages of 1 month and 14 years. Written informed consents were obtained from parents of each child contributing in this study after telling them about the stages of study.

Ethical approval:

Approval from Ethical Committee, Faculty of Medicine, Zagazig University was also obtained. Inclusion criteria: Patients referred for the evaluation of heart murmur aged from one month through 14 years. Exclusion criteria include new patients referred for other reasons and patients with previously diagnosed cardiac lesions. All subjects included in this

Received:5 /4 /2020
Accepted:14 /5 /2020

study were subjected to complete history taking, full clinical examination and cardiac examination including inspection, palpation, auscultation, chest examination for signs of respiratory distress, breath sounds, air entry, adventitious sounds and investigations including chest x ray films, electrocardiogram (ECG analysis) and echocardiogram.

Statistical analysis

Recorded data were analyzed using the statistical package for the social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Data were expressed as frequency and percentage. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. Cohen's kappa was also calculated. The confidence interval was set to 95% and the margin of error accepted was set to 5%. P-value <0.05 was considered significant.

RESULTS

In our study, we evaluated the diagnostic performance characteristics of CXR and ECG in diagnosis of congenital heart diseases. The predictive ability of CXR in detection of cardiomegaly depending on CT ratio >60% was as follow; sensitivity 38.5 %, specificity 48.4% with accuracy 45.6 % (table 1). Regarding accuracy of CXR in diagnosis of cardiac chamber enlargement in comparison with gold test (ECHO) were 96.9% for RT atrium, 40.9% for RT ventricle and 95.1 % for LT ventricle (table 1). The accuracy of ECG in detecting isolated cardiac chamber enlargement in comparison with ECHO was as follows 98.5% for right atrium, 75% for right ventricle and 95.5% for left ventricle (table 2). There was moderate agreement between CXR and ECHO in detection of congenital heart diseases with k= 0.6 (table 5). There was high agreement (k= 0.9) between ECG and ECHO for diagnosis of congenital heart disease (table 6). Our study showed that the predictive ability of CXR in detection of congenital heart disease was as follows: sensitivity was 90.9%, specificity 9.9%, positive predictive value was 25%, negative predictive value 100% with accuracy 70.4% (table 7). Our results revealed that sensitivity of ECG in detection of heart disease in comparison with ECHO was 96.9% with positive predictive value 96.9%, specificity 90.9% with negative predictive value 90.9% and accuracy 95.4% (table 7).

Table (1): The predictive ability of X-ray in detection of cardiomegaly by C/T ratio, right atrium, and right and left ventricle enlargement with ECHO as a gold standard test**.**

X-ray	Sensitivity	Specificity	PPV	NPV	Accuracy
Cardiomegaly	38.5%	48.4%	23.8%	65.2%	45.6%
Right atrium	100.0%	95.0%	66.7%	97.6%	96.9%
Right ventricle	83.3%	34.2%	16.7%	92.9%	40.9%
left ventricle	37.5%	63.9%	18.8%	82.1%	95.1%

Table (2): The predictive ability of ECG in detection of Right atrium, right and left ventricle enlargement with ECHO as a gold standard test.

ECG	Sensitivity	Specificity	PPV	NPV	Accuracy
Right atrium	100.0%	97.7%	25.0%	97.7%	98.5%
Right ventricle	66.7%	76.3%	30.8%	93.5%	75.0%
left ventricle	50.0%	44.4%	16.7%	80.0%	95.5%

Table (3): Concordance (agreement) between X-ray and ECHO in detection of PHN.

Chest X-ray		ECHO		Kappa agreement	p-value
		Present No(6) %	Absent No (38) %		
PHN	Present (31)	5 16.1	13 83.9	0.4	0.6
	Absent (13)	1 7.7	23 92.3		

PHN: pulmonary hypertension

Table (4): Concordance (agreement) between ECG and ECHO in detection of PHN.

ECG		ECHO		Kappa agreement	p-value
		Present No (6) %	Absent No (38) %		
PHN	Present (4)	2 33.3	4 66.7	0.6	0.07
	Absent (40)	4 10.5	34 89.5		

PHN: pulmonary hypertension.

Table (5): Concordance (agreement) between X-ray and ECHO in detection of congenital heart diseases.

Variable		ECHO		Kappa agreement	p-value
		Diseased No (33) %	Normal No (11) %		
X-ray	Diseased(40)	30 75.0	10 25.0	0.6	0.3
	Normal (4)	3 75.0	1 25.0		

Table (6): Concordance (agreement) between ECG and ECHO in detection of congenital heart diseases.

Variable		ECHO		Kappa agreement	p-value
		Diseased No(33) %	Normal No (11) %		
ECG	Diseased (33)	32 96.9	1 3.1	0.9	0.4
	Normal (11)	1 9.1	10 90.9		

Table (7): The predictive ability of X-ray and ECG in detection of congenital heart diseases with ECHO as a gold standard test.

Congenital heart diseases	Sensitivity	Specificity	PPV	NPV	Accuracy
X-ray	90.9%	9.9%	25.0%	100.0%	70.4%
ECG	96.9%	90.9%	96.9%	90.9%	95.4%

DISCUSSION

In our study, the sensitivity, specificity, PPV, NPV of CXR in detection of cardiomegaly depending on CT ratio>60%, with ECHO as a gold standard test, were lower than those found by **Satou *et al.*** [4] that sensitivity of CXR to identify cardiomegaly was 58.8%, with positive predictive value of 62.5%, specificity 92.3%, and negative predictive value 91.1%. This discrepancy between them and us can be explained by many reasons as difference in sample size and selected age group, substantial amount of subjectivity in evaluation of CXR. From above studies, it could be concluded that normal CT ratio in chest radiograph in children does not exclude chamber dilatation. This is in agreement with **Ovitt** [5] who stated that CT ratio ≥60% in children is useful for diagnosing cardiomegaly because of cardiac chamber dilatation and /or hypertrophy. However, decreased CT ratio ≤ 60% does not exclude cardiac chamber dilatation and/or hypertrophy.

Regarding CXR accuracy in detecting cardiac chamber enlargement with ECHO as a gold standard test, was 96.9% for right atrium 40.9% for right ventricle and 95.1% for left ventricle. This differs from CXR accuracy in the study done by **Abdel-Hamid** [6] who found that accuracy of CXR in detecting chamber enlargement was 55% for right atrium, 53.3% for right ventricle and 65% for left ventricle. This difference can be explained by the difference in age group selected to participate in the study and the type of echocardiogram systems that were utilized to evaluate the patients. Our study showed that the predictive ability of CXR in detection of congenital heart disease in general was as follows: sensitivity was 90.9%, specificity 9.9%, positive predictive value was 25%, negative predictive value 100% with accuracy 70.4%. Our results and previous reports might be explained by the absence of significant hemodynamic disturbances in some of the children with heart abnormalities at the time of investigation (e.g., small atrial septal defect and small ventricular septal defect). However, proper identification of the heart defect is important, as many of the children will require precautions, such as endocarditis prophylactics and/or follow up examination [7].

In our study the accuracy of ECG in detection of chamber enlargement, with ECHO as a gold standard test, was 98.5% for right atrium, 75% for right ventricle and 95.5% for left ventricle. These results are higher than that obtained by **Abdel-Hamid** [6] as her results were 71.7% for right atrium, 53.3% for right ventricle and 60% for left ventricle. The difference in results can be explained by the difference in sample size, different age group participated in the study and subjectivity in interpretation of ECG. **Murphy *et al.*** [8] stated that the various criteria used in interpretation of ECG have different positive and negative predictive values in different patient populations so the value of multiple criteria may be additive. Our results revealed that, sensitivity of ECG in detection of heart disease, with ECHO as a gold standard test, was 96.9% with positive predictive value of 96.9%, specificity of 90.9% with negative predictive value of 90.9% and accuracy of 95.4%. **Danford *et al.*** [9] stated that ECG and CXR do not significantly mislead the examiner or degrade the accuracy of clinical diagnosis. ECG aids in detection of atrial septal defect (ASD) and may be helpful to the expert examiner in diagnosing pulmonary stenosis (PS). CXR promotes clinical detection of intermediate to large ventricular septal defect (VSD). The CXR and ECG are otherwise of limited use to pediatric

cardiologist for defect specific diagnosis of cardiac murmurs in children.

In our study, there was fair agreement between CXR and ECHO in diagnosis of pulmonary hypertension (k=0.4) while **Tumkosit *et al.*** [10] reported that agreement was moderate to good (k=0.53-0.67). They concluded that pediatric CXR exhibits good accuracy and reproducibility to identify significantly abnormal pulmonary vascularity in children with congenital heart disease. However, the sensitivity to detect decreased pulmonary vascularity pattern is low. We found that there was moderate agreement between ECG and ECHO in diagnosis of pulmonary hypertension (k=0.6).

Gregory *et al.* [11] had established a study on 61 patients with PAH and they found that 13% of patients with significant pulmonary hypertension had normal ECG findings, which cast serious doubt on the utility of the ECG as a general screening tool. Compared with patients with abnormal ECG findings, there was a trend toward less severe pulmonary hypertension. Their results showed also that traditional ECG measures of RVH do not correlate well with derangement of the pulmonary circulation. They concluded that ECG will have a limited role in ruling out PPH or pulmonary hypertension.

McGoon *et al.* [12] recommended that, in patients with a suspicion of pulmonary arterial hypertension (PAH), ECG should be performed to screen for a spectrum of cardiac anatomic and arrhythmic problems. Our study showed perfect agreement between ECG and ECHO in diagnosis of congenital heart disease (k= 0.9) while CXR showed moderate agreement (k=0.4). These results were against those of **Hussain *et al.*** [2] who found that CXR was more accurate than ECG in diagnosis of congenital heart disease. This difference may be due to the difference in selected age group and subjectivity in interpretation of CXR and ECG by the investigators.

CONCLUSION

ECG is more accurate than CXR in detection of heart diseases in general but echocardiography is still the most accurate method in this regard. So we recommend that CXR together with ECG are essential for initial evaluation of pediatric patients with heart murmur and when the initial diagnosis is possible or there is a definite heart disease, ECHO must be ordered. Also a small portable echocardiogram must be present at every pediatric department of any hospital for diagnosis of misleading cases.

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