ORIGINAL ARTICLE

COMPARISON OF CARDIAC COMPUTED TOMOGRAPHY AND ECHOCARDIOGRAPHY FOR THE DIAGNOSIS OF CONGENITAL HEART DISEASES

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Objectives: To compare the diagnostic accuracy of cardiac Computed Tomography (CT) and echocardiography for the diagnosis of congenital heart diseases (CHD) at Rehman Medical Institute (RMI), Peshawar.

Methodology: We conducted a cross sectional study at Rehman Medical Institute between January 2020 to July 2022. Patients of different ages referred for suspicion of congenital heart diseases were enrolled. The data was collected prospectively which included demographics, Echocardiography findings, CT scan results and procedure notes. Data was analyzed on SPSS the results of descriptive variables expressed as median and percentile. A p-value <0.05 was considered significant.

Results: We included 129 patients, with 73 male and 56 females having age from few days to 18 years. The malformations were divided into intra and extra cardiac groups. 665 malformations were confirmed and analyzed keeping surgical and conventional angiography findings as gold standard. Among these 283 were intra and 99 extra cardiac findings. The echo and CT scan missed 2 and 4 intracardiac anomalies respectively. In case of extracardiac anomalies echo missed 14 anomalies however CT correctly diagnosed all. Both intra and extracardiac results are significant with a p value <0.05.

Conclusion: We conclude that Echocardiography is preferred modality for intracardiac anomalies evident by 99.3% diagnostic accuracy while CTA provides better demonstration of extra cardiac abnormalities having diagnostic accuracy of 99.9%. Echocardiography and CTA are both complementary for assessment and evaluation of congenital heart diseases acting as guide to surgery.

Keywords: Congenital Heart Disease, Echocardiography, Computed Tomography

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INTRODUCTION

The congenital heart disease (CHD) is a common clinical occurrence and more than half the cases having a multitude of findings constituting complex CHD. Over the years imaging modalities have been developed to play a crucial role in correct diagnosis, treatment and follow up after surgery.[1] Currently imaging modalities such as transthoracic echocardiography (TTE), CT angiography (CTA), magnetic resonance angiography (MRA) and conventional catheterization angiography are used for aforementioned purposes.[2]

As part of the routine workup, echocardiography occupies a crucial role in diagnosis and management of CHD. Factors complementing this modality include noninvasive technique, easy availability, cost effectiveness, repeatability and portability due to which it is considered the imaging modality of choice in initial workup for evaluating children with CHD.[3] Recent advances and expansion in pediatric cardiac surgery have rendered other imaging modalities as complementary to echocardiography in acting as a guide to surgery.[4] Nevertheless, echocardiography has an important role in morphology assessment of cases with CHD before, during and after surgery.

Though TTE is well established and considered first line modality for evaluating of CHD, few limitations offset its value for detecting the extra cardiac anomalies. Noteworthy mentionable among them include operator dependency and limited window availability. Thus, echocardiography is often inadequate in cases of CHD with complex findings.

Over the years multiple imaging modalities have therefore been developed to enhance the diagnostic accuracy in pre op evaluation. CTA offers high spatial resolution for detecting both intra and extra cardiac abnormalities with an added benefit of needing less sedation, short scanning time (5-10 minutes), powerful image post-processing, high resolution, and clear definition of anatomic structures like cardiac chambers and great vessels.[5,6] The drawbacks include use of ionizing radiations and contrast media, both of which have their own risks and complications.

The purpose of our study was to compare the diagnostic accuracy of transthoracic echocardiography with 128 row Multidetector CT (MDCT) in diagnosis of congenital heart diseases taking surgical findings and conventional angiography as gold standard. Since not all patients underwent surgery, so two gold standards were selected. CTA and echocardiography both have an essential role in Diagnosis cardiac anomalies. Radiation free Echo is although excellent as initial screening tool, the shadowing from bone cage and lungs limits characterization of extracardiac vascular anomalies where CTA comes to play essential role. Both complement their findings and mostly both have to be done in planning treatment options.

METHODOLOGY

This study was performed in radiology department of Rehman Medical Institute. It was descriptive cross-sectional study done between January 2020 and July 2022. Prior approval from the ethical and academic committee acquired. Conventional angiography and surgical findings were taken as gold standard. Since all patients do not undergo surgery, so two gold standards selected.

All the patients with clinical suspected congenital heart diseases were included in the study after informed consent. All the post-op cases which showed up for follow up were excluded.

The echocardiography (echo) was performed using Toshiba Xario having two probes (3- and 6-MHz). Multiple echo images were acquired i.e. subcostal, parasternal, apical, and suprasternal views. Atrial situs, venoatrial situs, ventricular morphology, ventricular outflow, atrioventricular (A-V) connections, defects of intracardiac walls, position of the great arteries, and anomalies of extracardiac vessels were analyzed. An experienced cardiologist having an experience of 8 years analyzed the echo images.

CT scans were performed with a multidetector scanner (Aquilion®, Toshiba® 128 rows) using non-ECG gated and ECG-gated protocols using dose modulation technique for dose reduction. The patient's age was used to adjust the voltage and tube current. The study was conducted with intravenous (IV) injection of contrast agent iohexol (KOPAQ ®) with dose of 1-1.5 ml/kg with 1-3ml/s rate using power injector. CT scan performed by Senior CT Technician with experience of more than 15 years. The scan was done with oral sedation. Since the ECG of the patients showed sinus rhythm, no patient needed beta-blockers. All volume Images were acquired and reconstructed to 0.5-1 mm in thickness. They were viewed on a dedicated workstation (Vitrea®, Vital Images Inc®) having different options like multiplanar reformatting, maximum-intensity projection and volume rendering. Two senior radiologists with 10- and 9-years' experience prospectively reviewed and analyzed the multidetector CT images.

The echo findings and CT scan results were compared with surgery / angiography procedure notes. SPSS was used to classify and analyze the study variables. The results of descriptive variables were expressed as percentile and median. The diagnostic accuracy of Echocardiography (Echo) and CT scan were compared, keeping the surgical and conventional angiographic findings as the gold standard. The sensitivity, specificity, positive predictive value (PPV) negative predictive value (NPV) and accuracy for both the modalities were separately calculated. Other statistical tests like chi-square test, McNemar's test, and the kappa statistic used to compare the accuracy of ECHO and CT scan. A p-value of <0.05 was considered statistically significant. Congenital cardiac anomalies were divided into two groups: 1: Intracardiac congenital Anomalies: All those anomalies related to intracardiac structures i-e intracardiac septum and valves. They are Ventricular septal defect (VSD), Atrial septal defect (ASD), Pulmonary valve stenosis, Single Atrium, Tricuspid valve malformation, Aortic valve deformity, Pulmonary valve malformation, Over-riding of aorta and RVOT Narrowing. 2: Extracardiac cardiac Anomalies: All the anomalies relating to extracardiac structures including great vessels. It includes Patent ductus arteriosus PDA, Main pulmonary artery (MPA) Hypoplasia, Total anomalous pulmonary venous return (TAPVR), Transposition of great vessels (TGA), Aneurysmal dilation of coronary arteries, Aortic root dilatation, Aortic Coarctation, Interruption of aortic arch, Dilatation of pulmonary arteries, Double SVC and Interrupted IVC.

RESULTS

Our results showed among 129 patients in our study, total 665 malformations were confirmed on Echo and CTA Cardiac. 73 patients were male and 56 females with age varying from few days to 18 years with a mean of 8.3. The malformations were divided into two groups; intra and extra cardiac (Figure 1 A-C). Total 283 malformations were intracardiac and 99 were extracardiac as shown in Tables 1.

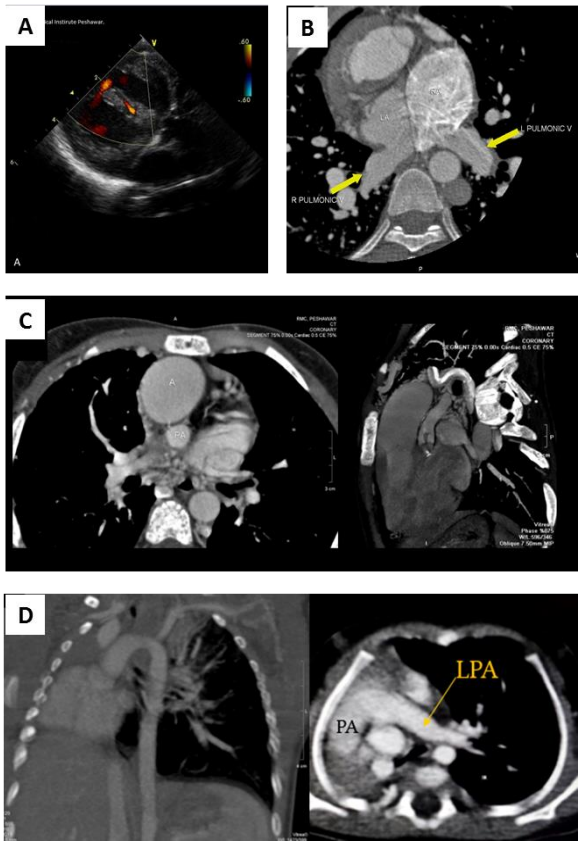

Figure 1: Images showing few examples of cardiac anomalies. A: echocardiogram of 2-year-old male patient through the two ventricles demonstrates a jet of flow through the septum consistent with a ventricular septal defect (VSD). **B:** Axial oblique cardiac CT image showing partial anomalous pulmonary venous return (PAPVR). Left pulmonary vein seen draining into right atrium (RA). **C:** Axial and sagittal oblique images of cardiac CT in a patient with Transposition of great arteries. Aorta (A) is seen anterior to pulmonary trunk (PA). Hypoplastic pulmonary trunk with valvular stenosis seen as thickened valve. **D:** Cardiac CT of a child with agenesis of right pulmonary artery. Left pulmonary artery (LPA) seen as continuation of main pulmonary artery (PA). Coronal image of the same patient showing hypogenesis of right lung with marked mediastinal shift to the right..

Intra Cardiac anomalies: The diagnostic accuracy of Echo and CT for intracardiac anomalies was 99.3% and 98.24% respectively. The results are significant with a p value of 0.003 and both tests have good correlation evident by McNemar's test value of 15.3. The echo missed 2 (0.7%) anomalies (False Negative / FN), while over-diagnosed 4 (1.4%) anomalies (False Positive / FP). The CT scan missed 9 (3.1%) anomalies (False Negative / FN) while over-diagnosed 11 (3.8%) anomalies (False Positive / FP).

Extracardiac anomalies: The diagnostic accuracy of Echo and CT for extracardiac anomalies was 83.73% and 99.04% respectively. The results are significant with a p value of 0.002. The echo missed 14 (14%) anomalies (False Negative / FN), while over-diagnosed 20 (20.2%) anomalies (False Positive / FP). The CT scan didn't miss any anomaly however over diagnosed 1 (1.01%) anomaly (False Positive / FP).

Overall Diagnostic accuracy of Echo and CT scan for congenital anomalies: Our results show that Echo and CT have overall diagnostic accuracy of 96.77% and 98.37% respectively for cardiac congenital anomalies. The sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV) and accuracy for each are given in table. The results were significant with p-value of 0.004. Both modalities have high concordance rate shown by McNemar's test value of 22.

Table 1: Table showing the individual details of the Cardiac Anomalies i.e A: Intracardiac, B: Extracardiac, C: Total cardiac anomalies

	Total No	Echo			MDCT		
		False Negative	False Positive	True Positive	False Negative	False Positive	True Positive
A:Intra Cardiac Anomalies							
Ventricular septal defect	67	0	1	66	0	2	65
Atrial septal defect	44	0	0	44	1	1	42
Pulmonary valve stenosis	25	1	1	23	2	1	20
Single Atrium	6	0	1	5	1	0	4
Tricuspid valve malformation	3	0	0	3	1	1	1
Aortic valve deformity	4	0	0	4	1	1	2
Pulmonary valve malformation	7	0	0	7	1	1	2
Over-riding of aorta	62	1	1	60	0	1	61
RVOT Narrowing	65	0	0	65	2	3	60
Total Intra Cardiac Anomalies	**283**	**2**	**4**	**277**	**9**	**11**	**257**

B: Extra Cardiac Anomalies							
PDA	18	1	2	15	0	0	18
MPA Hypoplasia	27	2	1	24	0	1	26
TAPVR	7	1	0	6	0	0	7
TGA	5	1	2	2	0	0	5
Aneurysmally dilated coronary arteries	4	0	4	0	0	0	4
Aortic root dilatation	12	1	1	10	0	0	12
Aortic Coarctation	9	0	1	8	0	0	9
Interruption of aortic arch	4	1	1	2	0	0	4
Dilatation of pulmonary arteries	3	1	1	1	0	0	3
Double SVC	8	1	1	6	0	0	8
Interrupted IVC	2	0	0	2	0	0	2
C:Total Extra Cardiac Anomalies	**99**	**14**	**20**	**65**	**0**	**1**	**98**

Table 2: Table showing the diagnostic accuracy of ECHO and CT (95% CI) mentioned for intracardiac, extracardiac and total anomalies

		Sn	Sp	PPV	NPV	Accuracy
Intracardiac	**Echo**	99.28%	99.36%	99.58%	99.68%	99.3%
	CT	96.62%	98.26%	36.0%	99.9%	98.25%
Extracardiac	**Echo**	82.28%	83.74%	4.86%	99.79%	83.73%
	CT	99.9%	99.03%	50.99%	99.9%	99.04%
Total	**Echo**	95.53%	96.77%	23.03%	99.95%	96.76%
	CT	97.53%	98.37%	37.72%	**99.97%**	98.37%

Sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV)

DISCUSSION

Over the past few years multiple studies have been carried out with results stating that transthoracic echocardiography has higher diagnostic accuracy in detecting congenital heart anomalies preoperatively. According to the study carried out by Bu et al the sensitivity and specificity of transthoracic echo (TTE) was 90.6% and 99.8% respectively for a sample size of 35 with ages varying between 3 days to 6.1 years.[7] In the same year another study published by Alghamdi et al. reported a small difference between echocardiography and surgical findings in 7 cases (1.8%) among total of 392. This had a minor effect on the surgical strategy.[3] Two years later, Mei et al. assessed 39 cases having 99 malformations, using echocardiography and reported an 88.1% diagnostic accuracy. [8] Marek et al. stated a 96% diagnostic accuracy for transthoracic echocardiography in 2788 cases.[9] Li A et al. concluded better effectiveness of echo over multislice CT in preoperative diagnosis of CHD establishing a diagnostic accuracy of 98.4% and 96.2% for echo and multislice CT respectively on a sample size of 32.[10] Guilin Bu et al. established a higher sensitivity of multislice CT (97% vs. 90.6%) as compared to Echo, both in overall diagnosis and specifically for diagnosis of extra cardiac anomalies (92% vs. 68%).[7] Another national study in Pakistan carried out in 2016 by Malik et al established that CT has better sensitivity in diagnosing extra cardiac findings with better definition of anatomy having sensitivity of 93.3 % as compared to TTE (78.7%).[11]

In our study the most common intra cardiac anomaly was VSD (n = 67) followed by RVOT stenosis (n= 65). In accordance with literature, we noticed that Echo was more effective in detecting and evaluating intracardiac anomalies having sensitivity of 98.5% and specificity of 99.6% as compared to MDCT having sensitivity of 95.9% and specificity 98.5%. The limitation of non-dynamic scanning, static images, insufficient data acquisition on valvular level and lack of detection of hemodynamic changes could explain this finding.

As far as the extracardiac anomalies were concerned the most common extra cardiac abnormality detected was MPA hypoplasia (n = 27). Similar to Bu and fellows[7] we also concluded better sensitivity (98.9% vs. 76.4%) and specificity (100% versus 98.6%) of CT over Echo.

The limitation of this study was being a single center study. Multicenter approach might have added to the sample size and more precision of results related to sensitivity and specificity.

Echocardiography and CTA Cardiac both have essential role in diagnosis of both cardiac and extra cardiac anomalies. Echocardiography and CTA are both complementary imaging modalities for assessment and evaluation of congenital heart diseases acting as a guide to surgery.

CONCLUSION

We conclude that Echocardiography is the preferred modality for intracardiac anomalies evident by its 99.28% accuracy while CTA provides better demonstration of extra cardiac abnormalities having accuracy of 99.9%. The overall accuracy of echocardiography for cardiac anomalies was 96.76% and of CT is 98.37%.

AUTHORS' CONTRIBUTION

MA and IH: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. ANK, USU, ZS, AS, HA, and MJ: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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