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Original Research Article

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

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Abstract: *Congenital heart disease (CHD) is a significant cause of morbidity and mortality worldwide. Accurate diagnosis is crucial for appropriate management and intervention. Echocardiography and cardiac computed tomography (CT) are commonly used for diagnosing CHD, yet their diagnostic reliability in a specific clinical setting requires evaluation. The objective of the study was to assess the diagnostic reliability of echocardiography and cardiac computed tomography (CT) for congenital heart disease (CHD) at Jinnah Hospital in Lahore. A cross-sectional study was conducted at the Department of Radiology, Chaudhary Pervez Ellahi Institute of Cardiology, from January 2022 to December 2022. One hundred patients suspected of congenital cardiac disorders were enrolled, spanning various age groups. Data were collected retrospectively, including procedure notes, CT scan results, echocardiograms, and demographic information. Descriptive statistics were used to analyse the data, with median and percentiles calculated using SPSS. A significance level of $p < 0.05$ was considered statistically significant. Of the 100 patients included in the study, 69 were men, and 31 were women, with ages ranging from a few days to eighteen years. Two categories of malformations were identified: intracardiac and extracardiac. Using surgical and conventional angiography results as the gold standard, 544 anomalies were confirmed and analysed, including 46 extracardiac and 196 intracardiac findings. Echocardiography demonstrated an overall diagnostic accuracy of 96.86%, while cardiac CT exhibited a diagnostic accuracy of 98.27% for cardiac congenital abnormalities. Based on the results, the cardiac computed tomography (CT) provides superior visualization of extracardiac abnormalities, with a diagnostic accuracy of 99.02%. In contrast, echocardiography remains the preferred modality for detecting intracardiac anomalies, boasting a diagnostic accuracy of 99.31%. The complementary use of echocardiography and cardiac CT enhances the assessment and evaluation of congenital heart diseases, facilitating surgical planning and intervention.*

Keywords: Congenital Heart Disease, Echocardiography, Computed Tomography, Diagnosis

Introduction

Congenital heart disease (CHD) presents a significant clinical challenge, with more than fifty percent of cases manifesting a spectrum of symptoms indicative of complex CHD (1). Imaging technologies have become paramount in achieving accurate diagnosis, guiding therapeutic interventions, and monitoring post-surgical outcomes (2). Currently, various imaging modalities, including transthoracic echocardiography (TTE), CT angiography (CTA), magnetic resonance angiography (MRA), and traditional catheterisation angiography are employed for these purposes (3).

Transthoracic echocardiography is a cornerstone in the initial assessment of CHD due to its non-invasiveness, widespread availability, cost-effectiveness, reproducibility, and portability (4). In pediatric cases, echocardiography is the primary imaging tool for evaluating children with CHD owing to its simplicity and utility (5). Despite recent advancements and the growing role of other imaging modalities in pediatric cardiac surgery, echocardiography remains pivotal in morphological evaluations throughout the pre-operative, intra-operative, and post-operative phases (6). However, limitations such as operator dependence and restricted acoustic windows can hamper echocardiography's effectiveness, particularly in identifying extracardiac abnormalities (7). Consequently, there is a need for complementary imaging modalities to enhance diagnostic accuracy, particularly in complex CHD cases.

CT angiography (CTA) offers superior spatial resolution, enabling precise localization of both intracardiac and extracardiac abnormalities while requiring minimal sedation and offering rapid scanning times (5-10 minutes), robust image post-processing capabilities, and detailed anatomical visualization (8). However, drawbacks such as exposure to ionising radiation and contrast media-associated risks exist, albeit mitigated by the advantages offered by CTA. In scenarios where echocardiography's efficacy is limited by bone and lung shadowing, CTA emerges as a valuable adjunct for characterising extracardiac vascular anomalies (9). CTA and echocardiography are pivotal in the diagnostic pathway for congenital heart abnormalities.

This study aims to assess the diagnostic efficacy of transthoracic echocardiography in conjunction with Multidetector CT (MDCT) in identifying congenital heart disorders, employing surgical outcomes and conventional angiography as gold standards. Given the variability in surgical interventions among patients, two gold standards were selected to ensure a comprehensive evaluation.

Methodology

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The study was conducted at the Radiology Department of Chaudhary Pervez Ellahi Institute of Cardiology from July 2022 to July 2023, with prior approval from ethical and academic committees. Conventional angiography and surgical outcomes served as the gold standards, considering the variation in surgical interventions among patients.

Informed consent was obtained from participants suspected of congenital cardiac disorders, excluding post-operative cases during follow-up. Echocardiograms (echo) were performed using Toshiba Xario equipment with various probes and perspectives, assessing cardiac anatomy comprehensively by a skilled cardiologist with eight years of experience.

CT scans were conducted with a multidetector scanner, adhering to non-ECG-gated and ECG-gated protocols to minimise radiation exposure. Intravenous contrast agent administration followed a dose modulation approach, adjusted based on patient age, and supervised by a senior CT technician with over 15 years of expertise. Oral sedation was provided as needed, and images were reconstructed and reviewed on a dedicated workstation by two experienced radiologists.

Data analysis was performed using SPSS version 21, presenting descriptive variables as percentiles and medians. The diagnostic reliability of echocardiography (Echo) and CT scans was assessed against surgical and angiographic findings, determining sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Additional statistical methods, including chi-square tests, McNemar's assessment, and kappa statistics, were employed, with significance set at $p < 0.05$.

For analysis, congenital cardiac abnormalities were categorized as intracardiac and extracardiac anomalies. The study aimed to evaluate the diagnostic accuracy of echocardiography and CT scans for congenital heart diseases, contributing valuable insights into their respective roles in clinical practice.

Results

Our findings revealed that among 100 participants in our research, 544 abnormalities were verified on Echo and CTA Cardiac. There were 69 male patients and 31 females, ranging from a few days to eighteen years old, with an average of 10.4 ± 7.3 years. SVD and 44% by C-section delivered 56% of the patients. 21% of the study cases were born pre-term, while 79% were born at term (Table 1).

The anomalies were split into two categories: intracardiac and extracardiac. There were 196 intracardiac abnormalities and 46 extracardiac.

The diagnosis accuracy of Echo and CT for intracardiac abnormalities was 99.31% and 98.15%, respectively. The findings are significant (p-value = 0.004), and the two tests have an excellent correlation, as seen by McNemar's test statistic 15.4. The echo missed two abnormalities (False Negative / FN) and overdiagnosed five (False Positive / FP). The CT scan missed eight abnormalities (False Negative / FN) and overdiagnosed 10 (False Positive /FP) anomalies.

The echo and CT diagnosis success rates for extracardiac abnormalities were 83.63% and 99.02%, respectively. The findings are significant, with a p-value of 0.001. The echo missed seven abnormalities (FN) and overdiagnosed eleven (FP). The CT scan did not miss any anomalies but overdiagnosed one anomaly (FP).

Table 1: Patient demographics

Variable	Results N=100 n.%
Age in years (Mean ± SD)	10.4 ± 7.3
Gender	
Male	69 (69)
Female	31 (31)
Type of delivery	
Svd	56 (56)
C section	44 (44)
Time of delivery	
Preterm	21 (21)
Term	79 (79)

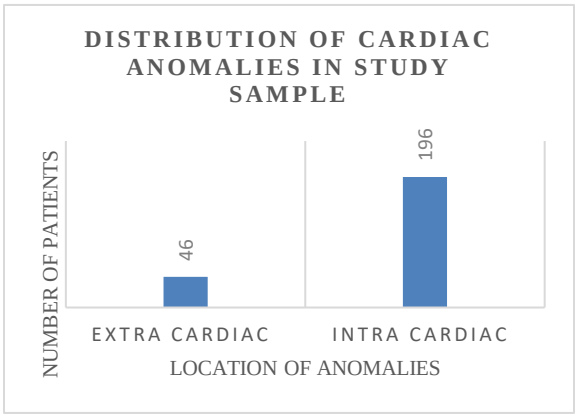

Figure 1 shows the distribution of cardiac anomalies in the study population.

Our findings indicate that Echo and CT had an overall diagnosis accuracy of 96.86% and 98.27% for cardiac congenital abnormalities. The following table shows the sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), and accuracy of both modalities. The findings were significant, having a p-value of 0.003. Both technologies have a high correlation rate, as evidenced by a McNemar test score 21.

Table 2: Displaying the specific features of the intracardiac Anomalies

Intracardiac anomalies	Total no	Echo results			Ct results		
		False Negative	False Positive	True Positive	False Negative	False Positive	True Positive
Ventricular septal defect	53	0	0	53	1	1	51
Atrial septal defect	31	0	1	30	0	2	29
Stenosis of the pulmonary valve	12	1	1	10	1	1	10

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Single Atrium	3	0	1	2	1	1	1
Tricuspid valve malformation	1	0	0	1	1	0	0
Aortic valve deformity	3	0	1	2	1	1	1
Pulmonary valve malformation	6	0	0	6	2	1	3
RVOT Narrowing	49	1	0	48	0	1	48
Over-riding of aorta	38	0	1	37	1	2	35
Total Intra Cardiac Anomalies	196	2	5	189	8	10	178

Table 3: Displaying the specific features of the extracardiac Anomalies

Extracardiac anomalies	Total no	ECHO results			CT results		
		False Negative	False Positive	True Positive	False Negative	False Positive	True Positive
PDA	10	1	1	8	0	0	10
MPA Hypoplasia	13	1	1	11	0	0	13
TAPVR	3	1	0	2	0	0	3
TGA	2	1	1	0	0	0	2
Aneurysmal dilation of coronary arteries	3	0	2	1	0	0	3
Aortic root dilatation.	4	1	1	2	0	1	3
Aortic Coarctation	3	0	1	2	0	0	3
Interruption of aortic arch	2	0	1	1	0	0	2
Dilatation of pulmonary arteries	1	1	0	0	0	0	1
Dilatation of pulmonary arteries	4	1	2	1	0	0	4
interrupted IVC	1	0	1	0	0	0	1
Total extra Cardiac Anomalies	46	7	11	28	0	1	45

Table 4: Shows the diagnostic precision of ECHO and CT.

Variables		Sn	Sp	PPV	NPV	Accuracy
Intra cardiac	ECHO	99.18%	99.26%	99.48%	99.58%	99.31%
	CT	96.52%	98.16%	36.2%	99.92%	98.15%
Extracardiac	ECHO	82.18%	83.64%	4.76%	99.89%	83.63%
	CT	99.91%	99.04%	50.89%	99.91%	99.02%
Total	ECHO	95.43%	96.67%	23.13%	99.85%	96.86%
	CT	97.44%	98.27%	37.62%	99.91%	98.27%

Discussion

In recent years, numerous studies have investigated the diagnostic accuracy of transthoracic echocardiography (TTE) in detecting congenital cardiac defects before surgery. For instance, one study involving a cohort of 35 patients aged from three days to 6.1 years reported TTE sensitivity and specificity at 90.6% and 99.8%, respectively (10). Similarly, Mei et al. found TTE to have a diagnostic accuracy of 88.1% in 39 patients with 99 anomalies (13). In comparison, Li A et al. observed a diagnostic success rate of 98.4% for TTE compared to multislice CT in a sample size of 32 (14). These findings are consistent with our study results, indicating high diagnostic accuracy for TTE.

In contrast, studies comparing TTE with multislice CT have shown varying results. Guilin Bu et al. reported higher sensitivity for multislice CT (97% vs. 90.6%) in overall diagnosis, particularly in detecting extracardiac abnormalities (11). Similarly, research conducted in Pakistan by Malik et al. in 2016 revealed superior sensitivity for CT in identifying extracardiac abnormalities compared to TTE (15). Our study corroborates these findings, demonstrating higher sensitivity and specificity for CT in detecting extracardiac abnormalities.

In our analysis, the most prevalent intracardiac abnormality was ventricular septal defect (VSD), followed by right ventricular outflow tract (RVOT) stenosis. Consistent with the existing literature, we found that TTE was more successful in identifying intracardiac abnormalities than MDCT, with higher sensitivity and specificity (16). However, MDCT demonstrated superior sensitivity and specificity in detecting extracardiac abnormalities, aligning with previous findings. One limitation of our study was its single-centre design, which may have constrained the sample size and generalizability of the results. A multicenter approach could enhance sample size and provide more robust sensitivity and specificity estimates. Nonetheless, our findings underscore the complementary roles of echocardiography and CT in assessing congenital heart disorders, guiding surgical interventions, and improving patient outcomes.

Conclusion

We conclude that while CT offers a better display of extracardiac abnormalities with a diagnostic accuracy of 99.02%, echocardiography is the favoured modality for intracardiac anomalies, which are evident with a diagnostic accuracy of 99.31%. Echocardiography and CTA work to assess and evaluate congenital heart diseases and assist surgery.

Declarations

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All data generated or analyzed during the study are included in the manuscript.
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Conflict of interest

The authors declared absence of conflict of interest.

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Data entry and Data analysis, drafting article..

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