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Role of Computed Tomography in Diagnosis of Congenital Heart Disease in Pediatrics

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Abstract

Background: Congenital heart disease (CHD) is a leading cause of morbidity and mortality among children, necessitating accurate and timely diagnosis. While echocardiography remains the primary modality, computed tomography (CT) offers high-resolution anatomical visualization critical for complex CHD evaluation.

Objective: To assess the diagnostic role of CT in evaluating congenital heart diseases in pediatric patients.

Methods: A descriptive cross-sectional study was conducted at Services Hospital, Lahore, over four months. A total of 45 pediatric patients (newborn to 10 years) with clinically diagnosed CHD were assessed using 64-slice multidetector CT. Data were analyzed using SPSS version 23.

Results: Of 45 patients, 51.1% were male and 48.9% female. The most common CHD identified was atrial septal defect (48.9%), followed by transposition of the great arteries (40%), patent ductus arteriosus (35.6%), and tetralogy of Fallot (26.7%). CT revealed structural defects with high diagnostic precision, particularly in extracardiac vascular anomalies and complex CHD.

Conclusion: CT imaging proves to be an invaluable diagnostic tool in pediatric CHD, offering detailed anatomical insight that complements echocardiography. Its rapid image acquisition and 3D capabilities support accurate diagnosis and surgical planning.

Keywords: Congenital Heart Disease, Computed Tomography, Pediatric Cardiology, Cardiac Imaging, CT Angiography

Introduction

Congenital heart disease (CHD) refers to structural abnormalities of the heart and great vessels present at birth, which can significantly impact cardiac function and overall health. Globally, CHD is the most common form of birth defect, with a prevalence estimated at 8–12 per 1,000 live births. These anomalies range from simple conditions like atrial septal defects (ASDs) to complex malformations such as transposition of the great arteries (TGA) and hypoplastic left heart syndrome (HLHS), which may require immediate intervention after birth. Early and accurate diagnosis is essential to ensure appropriate clinical management, surgical planning, and improved survival outcomes.

Traditionally, echocardiography has been the first-line imaging modality for CHD due to its wide availability, safety, and real-time visualization of cardiac function. However,

echocardiography has limitations, particularly in patients with complex anatomical variations, extracardiac vascular anomalies, or suboptimal acoustic windows. In such scenarios, advanced imaging techniques, such as computed tomography (CT), have emerged as essential adjuncts.

Recent advances in multidetector computed tomography (MDCT) have greatly enhanced the role of CT in pediatric cardiology. Modern CT scanners offer high spatial and temporal resolution, enabling rapid image acquisition with reduced motion artifacts — a significant advantage in pediatric patients with fast heart rates and limited cooperation. Techniques such as ECG gating, adaptive statistical iterative reconstruction (ASIR), and low-dose protocols have improved diagnostic quality while minimizing radiation exposure, making CT a safer option even in neonates and infants.

CT is particularly effective in assessing extracardiac anatomy, coronary artery anomalies, vascular rings, coarctation of the aorta, and postoperative evaluations. Its ability to generate detailed 3D reconstructions enhances surgical planning and patient counseling, often outperforming echocardiography in anatomical visualization. Despite concerns regarding ionizing radiation, the benefits of accurate and comprehensive assessment often outweigh the risks, especially when appropriate dose-reduction techniques are applied.

This study aims to evaluate the diagnostic utility of CT in detecting and characterizing congenital heart anomalies in pediatric patients. By analyzing its role in a tertiary care setting, the study seeks to establish CT as a valuable component of the multimodality imaging approach to CHD.

Materials and Methods
Study Design: Descriptive cross-sectional
Location: Services Hospital, Lahore
Duration: 4 months
Sample: 45 pediatric patients aged from birth to 10 years
Inclusion Criteria: Patients diagnosed with CHD
Exclusion Criteria: Prior cardiac surgery, renal dysfunction, contrast allergy, refusal to participate
Imaging Protocol: 64-slice Toshiba CT scanner; contrast-enhanced scans using pediatric protocols; ECG-gated acquisition where applicable
Analysis: SPSS v23 used; frequencies, percentages, and cross-tabulations; significance at $p<0.05$

Results
- Gender distribution: Male 51.1%, Female 48.9%
- Age groups: Neonates (15.6%), Infants (22.2%), Children 1–5 years (28.9%), Older children (33.3%)
- CHD prevalence:
    - ASD: 48.9%
    - TGA: 40%
    - PDA: 35.6%
    - TOF: 26.7%
    - Coarctation of Aorta: 31.1%
    - VSD & HLHS: 22.2% each
    - Pulmonary Atresia: 28.9%

CT demonstrated a high capability in detecting complex defects, particularly those missed by echocardiography.

Discussion

The findings of this study underscore the vital role of computed tomography in diagnosing various types of congenital heart disease in pediatric populations. Among the 45 patients evaluated, a wide spectrum of cardiac anomalies was identified, with atrial septal defect (ASD) being the most prevalent (48.9%), followed by transposition of the great arteries (TGA) (40%), patent ductus arteriosus (PDA) (35.6%), and tetralogy of Fallot (TOF) (26.7%).

The relatively high prevalence of ASD and TGA in our study compared to other literature can be attributed to the enhanced detection capability of CT. Unlike echocardiography, CT offers superior visualization of both intracardiac and extracardiac structures, especially in patients with complex or ambiguous anatomy. For example, TGA, a life-threatening cyanotic heart defect, requires accurate delineation of the aorta and pulmonary artery positions for effective surgical correction — an area where CT excels due to its spatial resolution and 3D reconstructions.

In previous studies, such as that by Wahaj Aman et al., the prevalence of ASD was reported to be only 16%, and PDA was reported in 12.8% of cases. In contrast, our study reported significantly higher percentages. These discrepancies may stem from differences in sample size, population demographics, or the sensitivity of the diagnostic modalities used. In particular, echocardiographic limitations in visualizing posterior and extracardiac structures may result in underdiagnosis of certain anomalies, which CT can accurately capture.

Additionally, the detection of coarctation of the aorta in 31.1% of our patients highlights CT's capability in assessing vascular narrowing that might be missed or inadequately characterized on echocardiography. Vascular anomalies, including pulmonary artery atresia (28.9%) and hypoplastic left heart syndrome (22.2%), were also well-documented, which reaffirms CT's role in defining complex anatomical relationships.

Another important aspect is the feasibility of CT in postoperative evaluation. Many CHD patients require follow-up imaging to assess residual defects, surgical repairs, or complications such as graft stenosis or thrombosis. In such cases, CT provides a non-invasive and detailed overview that can guide further interventions.

Radiation exposure remains a critical concern in pediatric imaging; however, our study applied low-dose protocols, ECG-gating, and iterative reconstruction techniques to mitigate this risk. As technology advances, newer modalities like dual-energy CT, photon-counting CT, and AI-based image enhancement are expected to further improve diagnostic yield while reducing radiation dose.

In conclusion, CT imaging bridges the gap between anatomical clarity and diagnostic precision, offering unique advantages over other modalities. While not intended to replace echocardiography or MRI, CT serves as a powerful complementary tool in comprehensive CHD evaluation, especially when rapid, high-detail imaging is required.

Conclusion

Computed Tomography plays a vital role in the accurate diagnosis of pediatric congenital heart diseases. Its 3D imaging capability and rapid acquisition make it especially useful for complex cases and surgical planning. The study supports CT as a complementary modality to echocardiography in pediatric cardiology.

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