Original Article

A radiological profile of congenital heart diseases in paediatric patients as detected by multidetector computed tomography

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Abstract

Background: Congenital heart diseases (CHD) are the leading cause of birth defect-related deaths. Multidedector computed tomography (MDCT) plays an important role for imaging CHD in addition to echocardiography and provides a comprehensive evaluation of complex heart malformations for the referring cardiologist. The aim of the study was to evaluate the utility of MDCT in the assessment of CHD. **Material and Methods:** In this prospective study, a total of 73 patients below the age of 12 years presented with symptoms of Congenital Heart Disease previously diagnosed by 2D Transthoracic Echocardiography were studied by MDCT. **Results:** MDCT detected 158 such anomalies. The most common intracardiac anomaly found on MDCT was ventricular septal defect in 51 (32.3%) of all the anomalies. A radiological profile of various congenital cardiac lesions seen in clinical practice were presented. **Discussion:** The evaluation of different anatomic structures such as heart, great vessels, lungs and abdomen is possible with MDCT.In patients with a complex cardiac abnormality or with a minor intracardiac abnormality and an abnormal communication, synchronization of the CT data acquisition with the ECG tracing is recommended.
Keywords: Congenital heart disease, multidedector computed tomography.

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INTRODUCTION

Congenital heart diseases (CHD) refer to structural or functional heart diseases which are present at birth or may be discovered later. These are primarily seen in neonates, infants and children[1]. Rapid advances have taken place in the diagnosis and treatment of CHD in the last six decades. There are diagnostic tools available today by which an accurate diagnosis of CHD can be made even before birth.Given the wide diversity of congenital lesions, the variety of surgical palliative techniques developed, subsequent modifications, and innovative transcatheter techniques, noninvasive imaging is essential to the assessment of CHD. Therefore, evaluation of the optimal noninvasive imaging tool has become an active and ongoing field of study in this expanding patient population. Echocardiography is the initial imaging method for the diagnosis and management of CHD. But it is operator dependent and unable to delineate great artery and intracardiac anomalies, pulmonary veins, and coronary arteries[2]. Although, conventional angiography is considered as the gold standard for diagnosing CHD, it is invasive and need for general anaesthesia, and the hypersensitivity reactions to radiation and iodinated contrast agent are other disadvantages of its use[3,4]. The intracardiac anatomy is well depicted by MRI, whereas MDCT provides exquisite images of the great vessels.

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MRI is time-consuming and may require patient sedation[2]. The use of multidetector computed tomography(MDCT) technology shortens examination times, increases spatial resolution, and enables superb reconstructions. It allows for a more complete evaluation of lung parenchyma than does MRI[5,6]. This study aimed at utility of MDCT in detecting CHDs in paediatric patients.

MATERIAL AND METHOD

In this prospective study, a total of 73 patients below the age of 12 years presented with symptoms of Congenital Heart Disease previously diagnosed by 2D Transthoracic Echocardiography were studied by MDCT. The procedure, possible adverse effects of contrast medium injection and radiation exposure was explained to the patients/parents and informed signed consent was taken prior to conducting the scan. Patients coming for postoperative follow up, complications and with renal insufficiency, hemodynamic instability were excluded from the study. Patients were kept NBM for at least 4 hours. CT was performed using SIEMENS SOMATOM DEFINITION AS 128 detector row CT Scanner. Fast multisectional CT with ECG gated biphasic protocol was used to obtain isotropic volume data, and high-quality two- and three-dimensional multiplanar reformatted images. Automated MedradStellant Power Injector was used to give low-osmolar intravascular non ionic contrast medium (iohexol 300mg/mL, Omnipaque) for CTA of children. The volume of contrast material injected is usually weight based, ranging from 1.5 to 2.0 mL/kg.The following parameters were applied: Tube current 50 mAs in infants and at 65 mAs in children 6–12 years old, Voltage down to 80 Kv to maximum of 120Kv (according to ALARA Principle), relatively fast table speed (pitch 0.18). Matrix: 1024 x 1024, X-ray tube rotation time: is 0.4 sec, Scan time ranged between 4-10 sec. Images were obtained in a single breath hold from angle of the mandible to lower edge of the liver in a cranio-caudal direction.Slice thickness and collimation: Images were acquired with a collimation of 0.6 mm and then latter reconstructed. Slice thickness of 0.6 mm and recon increment of 0.3 mm was used.

In infants and small children sedation times ranged between 2 and 10 min. Sedation was used using IV anaesthetics under the supervision of skilled anaesthetists. Most of the remaining patients above 5 years cooperated well without sedation.The patient was then placed on the gantry table in supine position. First of all, a plain scan (first phase) was performed from angle of the mandible to lower edge of the liver in a cranio-caudal direction.With power injection an automated bolus-tracking technique was used at an injection rate of 1.5 to 4 mL/sec through the suitable angiocatheters. Images were acquired using real-time contrast bolus tracking, in which the region of interest is placed within ascending aorta and repetitive low-dose images are obtained every 1–3 seconds at the same level after the contrast Injection. Diagnostic image acquisition (second phase) begins at a specified attenuation threshold 100 HU, from angle of the mandible to lower edge of the liver in a cranio-caudal direction. The optimal timing of CT image acquisition with respect to contrast administration varies depending on anatomy, age, hemodynamic status and the Clinical indication for imaging. Images were reconstructed with retrospective ECG gating to obtain optimal, motion-free image quality when coronary artery anomalies are suspected. Data sets were reconstructed immediately after the scan following a stepwise pattern. Initially, a two data sets were reconstructed during the mid to end diastolic phase and another in late systolic phase. If necessary, multiple data sets of a single patient were used separately to obtain optimal image quality of all available coronary segments, when required. The reconstruction algorithm uses data from a single heartbeat obtained during half-X-ray tube rotation, resulting in a temporal resolution of 165 ms.

RESULTS

Majority of patients in our study group belonged to the age group 1-5 years (34%). The majority of patients were males constituting 68.5% of cases.There were no procedure-related complications occurred in this study. Echocardiography detected 152 intracardiac anomalies but MDCT detected 158 such anomalies. The most common intracardiac anomaly found on MDCT was ventricular septal defect in 51 (32.3%) of all the anomalies (Table 1).

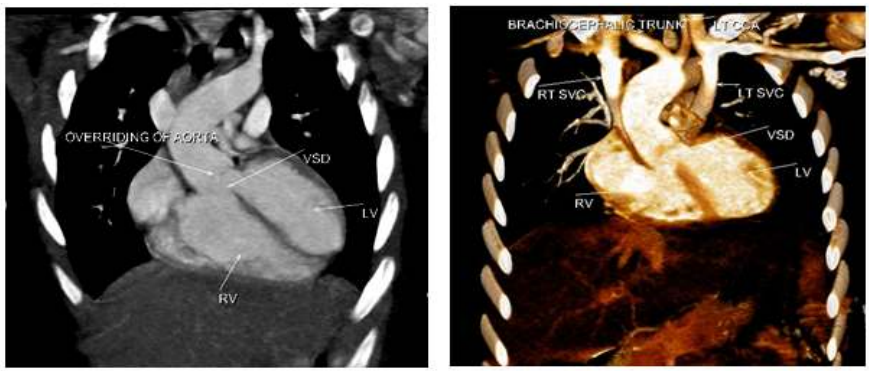
Table 1: MDCT detected intracardiac anomalies

Intracardiac Anomalies	No. of Anomalies
ASD	32
VSD	51
TOF	21
POF	5
Atrio-Ventricular Canal Defect	2
Tricuspid Atresia	3
Ebstein's Anomaly	1
Aortic Stenosis	2
Pulm Stenosis	35
DORV	4
DISV	1
DOLV	1
Total	**158**

Table 2: MDCT detected extracardiac anomalies

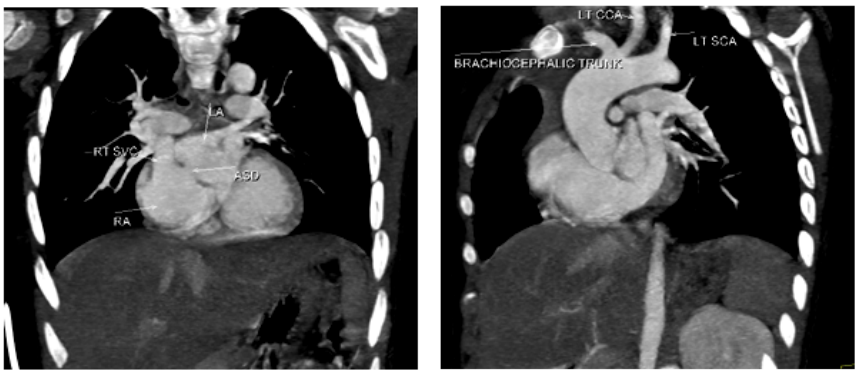
Extracardiac Anomalies	No. of Anomalies
SVC Related	12
IVC Related	8
Aortic Arch Anomalies	51
Patent Ductus Arteriosus	20
Pulm Venous Drainage Anomalies	12
MAPCA's	18
Pulmonary Artery Anomalies	10
Other Anomalies(like related to liver, kidney,etc)	17
Total	**148**

The VSD was seen in 51 patients (Fig. 1), Ostium secundum ASD in 21 patients (Fig. 2); Seven patients had Bovine aortic arch (Fig. 1, 2); SVC related anomalies were seen in 12 patients (Fig. 3, 7); 10 patients had pulmonary artery anomalies and 8 had IVC related anomalies (Fig. 4); 17 patients had other anomalies related with kidney (Fig. 5); 17 had PDA anomalies (Fig. 7).



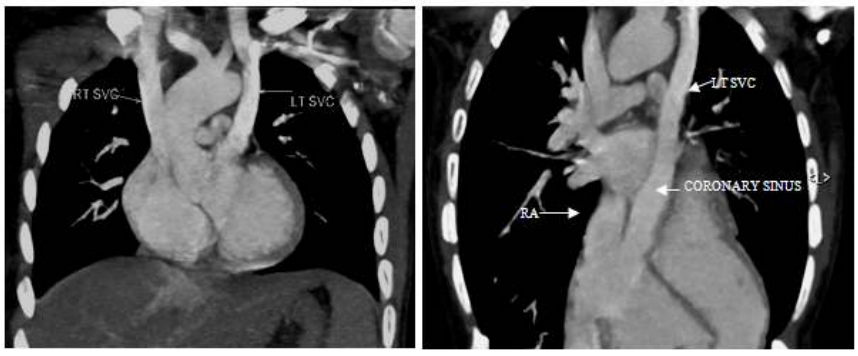
A B

Figure 1: Coronal maximum intensity projection image (A) and volume-rendered image (B) showing VSD with overriding of aorta, LSVC and bovine aortic arch [RV- Right ventricle, LV- Left ventricle, VSD- Ventricular septal defect, SVC- Superior vena cava]



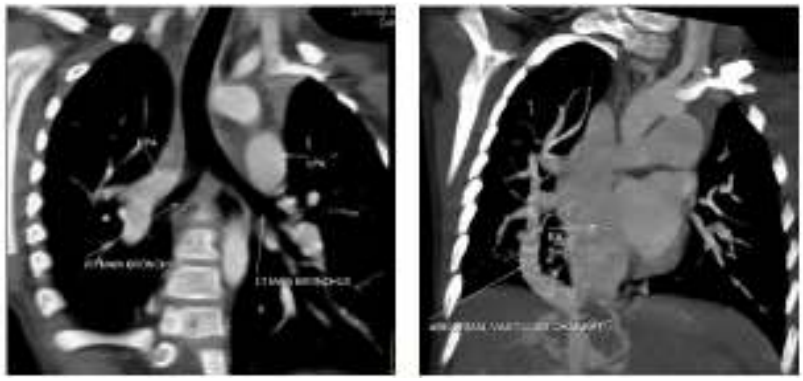
C D

Figure 2: Coronal maximum intensity projection images showing (C) Ostium secundum ASD; (D) Bovine aortic arch [RA and LA - Right and Left atrium, ASD- Atrial septal defect]



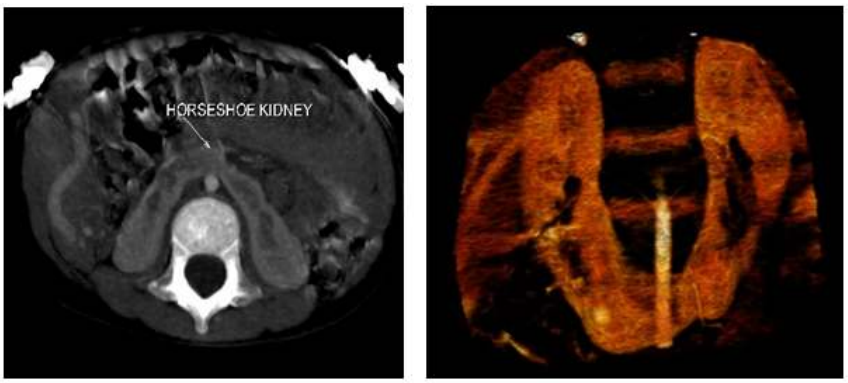
E F

Figure 3: Coronal maximum intensity projection images showing (E) Double SVC; (F) Left SVC draining in RA through coronary sinus



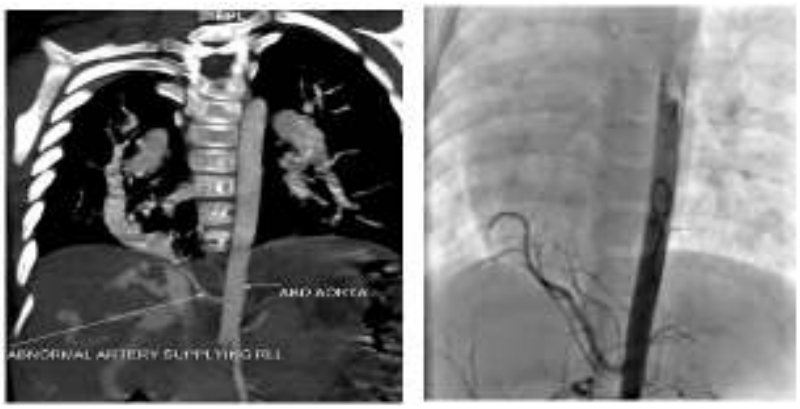
G H

Figure 4: Coronal maximum intensity projection images showing (G) Left isomerism with right pulmonary hypoplasia; (H) Abnormal vascular channel joining IVC[IVC- Inferior vena cava]



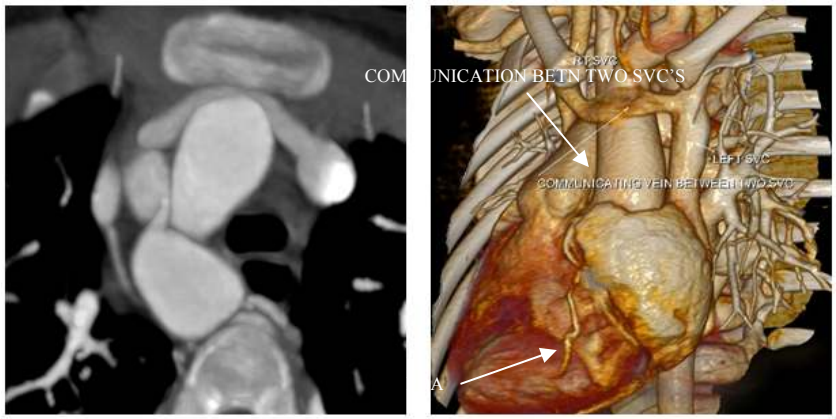
I J

Figure 5: Coronal maximum intensity projection images showing (I) Horseshoe Kidney; and volume-rendered image (J) Horseshoe Kidney



K L

Figure 6: Coronal maximum intensity projection image showing (K) Anomalous artery from abdominal Aorta; and DSA imageshowing (L) confirmation of same finding



M N

Figure 7: Coronal maximum intensity projection images showing (M) PDA and communication between; and volume-rendered imageshowing (N) Communication between two SVCs

DISCUSSION

Multidedector computed tomography (MDCT) has the ability to show these structures with the vessel walls and also provides better delineation of the airway, mediastinal abnormalities, and the pulmonary parenchyma. MDCT is rapid, with a reduced need for sedation, is efficacious in the setting of metallic hardware, pacemakers and coils and is widely available[7]. The results of Echocardiography were compared with the anomalies found on MDCT. On comparison, Echocardiography missed 6 intracardiac anomalies out of 158 on MDCT and was correctly able to diagnose 152 anomalies. Whilst out of 148 extracardiac anomalies on MDCT, it was able to pick up only 56 of them therefore precluding its role in extracardiac evaluation. On calculations the diagnostic accuracy of ECHO as compared to MDCT, for intracardiac anomalies was 96.2% and for extracardiac anomalies was 37.8%. MDCT provides better visualization of vessel wall along with delineation of the airway, mediastinal abnormalities, and the pulmonary parenchyma[8]. From our study we found that while the diagnostic accuracy of ECHO and MDCT for Intracardiac anomalies goes almost hand in hand whereas the diagnostic accuracy of MDCT for extracardiac anomalies was superior to that of ECHO. In patients with a complex cardiac abnormality or with a minor intracardiac abnormality and an abnormal communication, synchronization of the CT data acquisition with the ECG tracing is recommended to reduce motion artifacts, which may obscure abnormalities.

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