Original Article

A diagnostic efficacy of echocardiography versus multidetector computed tomography in congenital heart diseases of paediatric patients

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Abstract

Background: Cardiac imaging provides structural and functional information essential for treatment and follow-up complications after the treatment. Echocardiography, the initial imaging method is inadequate to show complex spatial relationships and provides incomplete visualisation of the extracardiac vasculature. Multidedector computed tomography has the ability to show extracardiac structures with the vessel walls. This study compares the diagnostic efficacy of Echocardiography versus Multidetector Computed Tomography in Congenital heart diseases of Paediatric patients. **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 were studied by Echocardiography and MDCT. **Results:** Echocardiography performed on all the 73 patients revealed a total of 208 anomalies with 152 intracardiac anomalies and 56extracardiac anomalies, whereas, MDCT detected 306 anomalies with 158 intracardiac and 148 extracardiac anomalies. **Discussion:** It was found that the diagnostic accuracy of ECHO and MDCT for intracardiac anomalies was similar whereas the diagnostic accuracy of MDCT for extracardiac anomalies was superior to that of ECHO.
Keywords: Congenital heart diseases, ECHO, MDCT, efficacy.

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Received Date: 04/10/2016 Revised Date: 21/11/2016 Accepted Date: 12/12/2016

Access this article online	
Quick Response Code:	Website: www.statperson.com
	DOI: 19 December 2016

INTRODUCTION

Congenital heart diseases (CHD) are the structural malformations of heart or great vessels present by birth[1]. CHDs account for about 30 percent of the total and has high mortality rate during infancy, depending on the type and severity of lesion[2]. About 25% of CHDs are life-threatening and may manifest before the first routine clinicalexamination[3,4]. Failure to identify these criticallesions immediately after birth leads to delay inreferral and increased mortality and morbidity[5]. Due to small size, complex cardiovascular morphology and rapid circulation, CHD remains troublesome in paediatric imaging. Several studies have documented the lack of sensitivity of routine neonatal examination in detecting CHD[6,7]. Cardiac imaging provides structural and functional information essential for treatment and follow-up complications after the treatment. Echocardiography (ECHO) is the initial imaging method and mainstay of diagnosis of CHD. Its strength includes an absence of radiation, the ability to evaluate intra-cardiac structure and function and the ability to perform hemodynamic assessment. However, it is limited by an acoustic window. Sometimes it is inadequate to show complex spatial relationships and provides incomplete visualisation of the extracardiac vasculature[8,9]. The recent developments in computed tomography (CT) techniques

How to cite this article: Sharad M. Malvadkar, Shilpa V. Domkundwar, Deepak Kamble, Madhuri S. Malvadkar, Shariq Mohd. A diagnostic efficacy of echocardiography versus multidetector computed tomography in congenital heart diseases of paediatric patients. *International Journal of Recent Trends in Science and Technology*. December 2016; 21(2): 169-172. http://www.statperson.com (accessed 22 December 2016).

are characterized by faster speed, longer anatomic coverage, a more flexible ECG-synchronized scan and a lower radiation dose. These advances have noticeably increased the cardiac applications of CT. Multidedector computed tomography (MDCT) has the ability to show extracardiac 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. Compared with CT of the past, 16-MDCT and newer scanners yield images with better temporal and spatial resolution, greater anatomic coverage per rotation, more consistent enhancement with a lesser volume of intravascular contrast material, and higher-quality 2D reformation and 3D reconstruction owing to acquisition of an isotropic data set[10,11]. This study was undertaken to assess the diagnostic efficacy of Echocardiography versus MDCT in Congenital heart diseases of 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 were studied by Echocardiography and 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 Medrad Stellant 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.

Table 1: Anomalies detected by ECHO and MDCT

Anomalies	ECHO	MDCT
Intracardiac Anomalies	152	158
Extracardiac Anomalies	56	148
Total	**208**	**306**

Echocardiography performed on all the 73 patients revealed a total of 208 anomalies with 152 intracardiac anomalies and 56 extracardiac anomalies. Of the 152 intracardiac anomalies ventricular septal defect (VSD) was the most common finding seen in a total of 48 patients. Ventricular septal defects were seen in patients which included isolated VSDs and VSDs associated with other lesions like Tetralogy of Fallot, Atrio-ventricular canal defects, Tricuspid atresia, Double outlet right ventricle etc. VSD was followed by pulmonary stenosis as a second most common finding, seen in a total of 36 patients. Pulmonary stenosis (PS) were seen in patients which included isolated PS and PS associated with Tetralogy of Fallot Pentalogy of Fallot, Double outlet right ventricle etc. PS was followed by Tetralogy of Fallot seen in a total of 23 patients. The spectrum of Tetralogy of Fallot includes pulmonary valve anomalies like pulmonary atresia, hypoplasia and stenosis, Overriding Aorta and a VSD (Intracardiac) or PDA (extracardiac) to decompress the circulation on the right side of heart. A maximum of 56 extracardiac anomalies were detected of which Aortic arch anomalies (n=19) contributed the most, followed closely by Pulmonary Venous Drainage anomalies (n=10), followed by Patent Ductus Arteriosus (n=8). MDCT detected 306 anomalies (158 intracardiac and 148 extracardiac). Of the 158 intracardiac anomalies detected by MDCT, VSD dominated as the most common finding (n=51) which was more as compared to ECHO by 3 cases. VSDs were present in 51 patients of which perimembranous type was present in 34 cases (66.7%) and Muscular type in 8 cases (15.7%). Inlet and Outlet VSD were seen in 2 cases (3.9%) and 7 cases (13.7%), respectively. Pulmonary stenosis was the next most common finding (n=35). PS was present in 25 patients of which infundibular type was present in 20 cases (57%), valvular type in 9 cases (26%) and Supravalvular type in 6 cases (17%). TOF was the next common anomaly after PS. There were 21 cases of TOF which was lesser as compared to ECHO by 2 cases. Those 2 cases also had associated ASD's which were missed on ECHO. Hence, those 2 cases were considered as Pentalogy of Fallot.

DISCUSSION

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%.

Table 2: Diagnostic accuracy of ECHO compared with MDCT

Anomalies	Diagnostic Accuracy of ECHO
Intracardiac	96.2%
Extracardiac	37.8%

Table 3: Test of significance for 2D ECHO Vs MDCT findings (for intracardiac anomalies)

Investigation	Identified	Unidentified	Total
MDCT	158	0	158
2D ECHO	152	6	158
Total	**310**	**6**	**316**

At 95% confidence interval, Z (tab) = 1.96; Z(cal) = 2.5; $p<0.05$ (Significant). The observed difference is significant, that means the ability to diagnose intracardiac anomalies is seen to be greater in MDCT than 2D ECHO in our study.

Table 4: Test of significance for 2D ECHO Vs MDCT findings (for extracardiac anomalies)

Investigation	Identified	Unidentified	Total
MDCT	148	0	148
2D ECHO	56	92	148
Total	**204**	**92**	**296**

At 95% confidence interval, Z (tab) = 1.96; Z(cal) = 15.6; $p<0.05$ (Significant). The observed difference is significant, that means the ability to diagnose extracardiac anomalies is seen to be much greater in MDCT than 2D ECHO in our study. Huang *et al.*[12] examined 83 patients with congenital heart diseases and multislice CT (MSCT) findings were compared with ECHO. In 80 intracardiac deformities, MSCT was as accurate as ECHO in revealing intracardiac deformities. In 153 extracardiac anomalies, MSCT was superior to ECHO in the identifying extracardiacde formties. They showed that combination of MSCT and ECHO could increase the definite diagnostic rate to 99.14%. Liang *et al.*[13] studied 48 patients with contrast-enhanced MSCT. The definite diagnosis rate of MSCT, ECHO were 97.4% (114/117), 76.9% (90/117) respectively. MSCT was superior to ECHO in the identification of extracardiac deformities. Zhou *et al.*[14] retrospectively analyzed the MSCTA data of 12 cases and compared their ECHO and surgical results. Total of 57 anomalies were diagnosed, including 26 intracardiac and 31 extracardiac anomalies. 21 (80.77%) of 26 intracardiac anomalies were identified by MSCTA while all of them were detected by ECHO. All extracardiac anomalies were demonstrated by MSCTA while only 18 (58.06%) were detected by ECHO. They concluded that MSCTA is superior to ECHO in the detection of pediatric complex congenital heart diseases, especially in the detection of extracardiac anomalies. Zhao *et al.*[15] analyzed extracardiac vascular abnormalities in 26 patients confirmed by surgery. All patients were examined by contrast-enhanced MSCT. Correlative evaluations were performed with 26 ECHO. MSCT and CAG were superior to ECHO in the identification of extracardiac vascular abnormalities. MSCT with 3D reconstruction were superior to ECHO for the assessment of extracardiac vascular abnormalities in patients with

CHD and could demonstrate the pathological morphology. 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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Source of Support: None Declared
Conflict of Interest: None Declared