European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 09, Issue 02, 2022

Original Research Article

Role of 64 detector row multislice computed tomography in evaluation of congenital heart diseases

[1]Dr. Ashwin Kumar TS, [2]Dr. Anusha B, [3]Dr. Shreedhar NK

[1,2]Assistant Professor, Department of Radiodiagnosis, Sri Siddhartha Medical College, Tumkur, Karnataka, India
[3]Associate Professor, Department of Radiodiagnosis, Sri Siddhartha Medical College, Tumkur, Karnataka, India

Corresponding Author:
Dr. Shreedhar NK

Abstract

There are many different types of congenital heart defects. They range from simple defects with no symptoms to complex defects with severe, life-threatening symptoms. Defects such as coarctation of the aorta may not cause problems for many years. Other problems, such as a small ventricular septal defect (VSD), may never cause any problems, and some people with a VSD have normal physical activity and a normal life span. The study was carried out after the approval from the ethics committee. All the patients were explained about the possible adverse effects of contrast medium injection and radiation exposure. Informed signed consent was taken. The sensitivity and specificity in diagnosing overriding of the aorta using MDCT was 100% and 60% respectively. The P value was 0.0013 which was statistically highly significant. In our study the specificity was 60% as compare to the specificity of 100% this indicates that it is relatively good value. This indicates that the number of cases interpreted as positive for overriding of the aorta were more in comparison to the peroperative findings.

Keywords: Multislice computed tomography, congenital heart diseases, MDCT

Introduction

Congenital heart disease refers to a problem with the heart's structure and function due to abnormal heart development before birth. Congenital heart disease (CHD) can describe a number of different problems affecting the heart. According to the American Heart Association, about 35,000 babies are born each year with some type of congenital heart defect. Congenital heart disease is responsible for more deaths in the first year of life than any other birth defects**.** Many of these defects need to be followed carefully. Some heal over time, others will require treatment [1].

There are many different types of congenital heart defects. They range from simple defects with no symptoms to complex defects with severe, life-threatening symptoms. Defects such as coarctation of the aorta may not cause problems for many years. Other problems, such as a small ventricular septal defect (VSD), may never cause any problems, and some people with a VSD have normal physical activity and a normal life span [2].

Some congenital heart diseases can be treated with medication alone, while others require one or more surgeries. The risk of death from congenital heart disease surgery has dropped from about 30% in the 1970s to less than 5% in most cases today. There are various imaging modalities available now for evaluation of the congenital heart diseases [3].

Echocardiography is the primary cardiac imaging modality in evaluation of the congenital heart diseases. Its strengths include an absence of radiation, the ability to evaluate cardiac structure and function, and the ability to perform hemodynamic assessment. Echocardiography is limited, however, in the evaluation of certain portions of the aorta (particularly the ascending aorta and the transverse arch), the distal pulmonary arteries, the right ventricle, the pulmonary veins & systemic veins. These are relative "blind spots" for the echocardiographer. Echocardiography is also limited by a small field of view, an acoustic window, and operator dependence [4].

Cross-sectional imaging with magnetic resonance (MR) or 64 slice multi detector computed tomography (CT) may help overcome the limitations of echocardiography, including a poor acoustic window and poor depiction of extracardiac vascular structures, as well as limitations of conventional angiography such as overlap of adjacent cardiovascular structures, difficulties in simultaneously depicting the systemic and the pulmonary vascular systems, and catheter-related complications. Despite the great capabilities of MR imaging for anatomic and functional assessment of the heart, an examination with this modality is time-consuming and may require a lengthy period of patient sedation; therefore, the use of MR imaging in seriously ill or uncooperative patients is often limited. In addition, the use of MR imaging is contraindicated in patients with a pacemaker or an internal cardioverter-defibrillator [5].

CT has the advantages of widespread availability and short acquisition times. The development of 64-slice CT, with increased scanning speed, higher spatial resolution, and enhanced capabilities for simultaneous evaluation of cardiovascular structures and lung parenchyma, has increased the clinical application of CT for the evaluation of patients with congenital heart diseases [6].

In addition, 64-slice CT may be used to obtain functional data about motion of the ventricular wall or cardiac valves. It plays a substantial role in the evaluation of patients after surgical intervention for congenital heart disease.

Methodology

Patients for the study were chosen from patient population referred to Department of Cardiology and Radiology.

Image acquisition and Analysis

The study was carried out after the approval from the ethics committee. All the patients were explained about the possible adverse effects of contrast medium injection and radiation exposure. Informed signed consent was taken.

The patients chosen for the study were scanned on a BRILLIANCE (C. T. VERSION 2.0) 64 MULTIDETECTOR ROW COMPUTED TOMOGRAPHY (PHILIPS MEDICAL SYSTEMS, NETHERLANDS).

CT Imaging of the thorax was performed using a tailor-made protocol. All CT examinations were performed with a 64-slice spiral CT scanner. It consists of low-dose CT protocol (120 kVp, 30-80 mA) with slice thickness of 0.9mm, slice increment of 0.5, pitch-0.984 and tube rotation time of 0.75 seconds. Scanning is performed from the thoracic inlet level to the L1-2 level. Nonionic contrast agent (2 ml/kg) is injected through the peripheral line at the rate of 2-4 ml/sec depending on the age of the patient. Sedation was used for the neonates and small children.

Various image reformatting techniques, including linear or curved planar reformatting, maximum intensity projection (MIP), minimum intensity projection, shaded surface display, and volume rendering (VR), are used depending on target structure and purpose. The plane of the reformatted image is adjusted to correspond to the long axis of the structure of interest. Curved planar reformation is used to evaluate curved structures such as the pulmonary artery system, MIP is used mainly for evaluation of the cardiovascular structures and minimum intensity projection is used to evaluate the airway and lung parenchyma.

Results

Total number of cases	MDCT	2D Echo	Peroperative
34	23	24	15

Table 1: Evaluation of overriding of aorta using MDCT in correlation with peroperative findings

Overriding of the aorta		Peroperative	
		Disease present	No disease
MDCT	Positive test	15	8
	Negative test	0	11

P value-0.0013 Sensitivity-100%, Specificity-60% PPV-65%, NPV-100%

Table 2: Evaluation of overriding of aorta using 2D Echocardiography in correlation with peroperative findings

Overriding of the aorta		Peroperative	
		Disease present	No disease
2DEcho	Positive test	11	13
	Negative test	4	6

P value-1.00 Sensitivity-73%, Specificity-32% PPV-31%, NPV-73%

Table 3: Evaluation of right sided aortic arch using MDCT in correlation with peroperative findings

Right arch	Sided	Aortic	Peroperative	
			Disease present	No disease
MDCT	Positive test		9	0
	Negative test		0	25

MDCT shows 100% agreement in evaluation of the right sided aortic arch as compared to peroperative findings with 100% sensitivity and specificity.

Table 4: Evaluation of right sided aortic arch using 2D Echocardiography in correlation with peroperative findings

Right sided aortic arch		Peroperative	
		Disease present	No disease
2DEcho	Positive test	2	0
	Negative test	7	25

P value-0.1 Sensitivity-22% Specificity-100% PPV-100%, NPV-78%

Table 5: Evaluation of MAPCAS using MDCT in correlation with peroperative findings

MAPCAS		Peroperative	
		Disease present	No disease
MDCT	Positive test	4	2
	Negative test	1	27

P value-0.00088, Sensitivity-80%, Specificity-93%, PPV-66%, NPV-96%

Table 6: Evaluation of MAPCAS using 2 D Echocardiography in correlation with peroperative findings

MAPCAS		Peroperative	
		Disease present	**No disease**
2DEcho	Positive test	2	0
	Negative test	3	29

P value-0.013, Sensitivity-40%, Specificity-100%, PPV-100%, NPV-100%

Table 7: Evaluation of PDA using MDCT in correlation with peroperative findings

PDA		Peroperative	
		Disease present	**No disease**
MDCT	Positive test	7	5
	Negative test	0	22

P value-0.00035, Sensitivity-100%, Specificity-81%, PPV-58%, NPV-100%

Table 8: Evaluation of PDA using 2 D Echocardiography in correlation with peroperative findings

PDA		Peroperative	
		Disease present	**No disease**
2DEcho	Positive test	2	0
	Negative test	3	29

P value-0.02 Sensitivity-40%, Specificity-100%, PPV-100%, NPV-90%

Table 9: Evaluation of Pulmonary aretery stenosis using MDCT in correlation with peroperative findings

Pulmonary aretery stenosis		Peroperative	
		Disease present	**No disease**
MDCT	Positive test	18	1
	Negative test	7	8

P value-0.0057, Sensitivity-72%, Specificity-89%, PPV-94%, NPV-53%

Table 10: Evaluation of Pulmonary aretery stenosis using 2D Echocardiography in correlation with peroperative findings

Pulmonary aretery stenosis		Peroperative	
		Disease present	**No disease**
2DEcho	Positive test	12	13
	Negative test	2	7

P value-0.34, Sensitivity-85%, Specificity-35%, PPV-48%, NPV-77%

Main pulmonary artery anatomy was evaluated using 2D Echo, MDCT and peroperatively the parameters considered for evaluation of the pulmonary arteries include normal caliber, adequate, small and prominent sized and the following analysis was made using the ANOVA test.

Table 11: ANOVA for Main Pulmonary Artery

Source of Variations	**df**	**Sum of Squares**	**Mean Squares**	**Ratio**	**Probability**	^{2}	**P**^{2}	^{2}
Investigations	2	24.843	12.422	16.928	0.000	0.255	0.255	0.191
Error (A)	99	72.647	0.734					
Total	101	97.490	0.965					
Comparison		**Std. Error**	**S. E. Difference**	**t value**	**C. Difference**			
Ai. -Aj.		0.147	0.208	1.984	0.412			

Discussion

Evaluation of the aorta and the aortic anomalies including overriding of the aorta, the side of the aortic arch, branching pattern and coarctation of aorta were studied using MDCT and the correlation was made with peroperative findings.

The sensitivity and specificity in diagnosing overriding of the aorta using MDCT was 100% and 60% respectively. The P value was 0.0013 which was statistically highly significant. In our study the specificity was 60% as compare to the specificity of 100% this indicates that it is relatively good value. This indicates that the number of cases interpreted as positive for overriding of the aorta were more in comparison to the peroperative findings. The cases with marginal overriding were also accurately demonstrated on MDCT where as these cases were considered normal peroperatively as this didn't change the plan of management and thus there is a difference in the sensitivity and specificity values but the P value being statistically highly significant indicates that MDCT is still accurate in demonstrating this finding.

Right sided aortic arch was observed in 14 cases in our study of which 9 cases were confirmed operatively or through cardiac angiography. This anomaly was most commonly associated with TOF cases in our case study. Other anomalies with this association were one case of transposition of great arteries (confirmed by cardiac catheterisatuion) and one case of persistent truncus arteriosus (not operated). MDCT showed 100% sensitivity and specificity in identifying the right sided aortic arch as compared to intra operative findings.

Study by Edward Y. Lee1, Marilyn J. Siegel, Charles F. Hildebolt *et al*. [7] also showed that MDCT had 100% accuracy. Our study showed similar results.

Oguz B, Haliloglu M *et al*. [8] in their review of cases demonstrated that right arch with mirror-image branching is commonly associated with tetralogy of Fallot, truncus arteriosus, and D-transposition. More than 95% of patients who have right arch with mirror-image branching have CHD. Our study is in agreement with their study.

MDCT with multiplanar reformation (MPR) and 3D imaging clearly show the area of stenosis and its length, poststenotic dilatation, collateral vessels, accompanying arch hypoplasia, aneurysm, and single or multiple layers of coarctation accurately. In our study we had 3 cases of coarctation of aorta of which two cases underwent cardiac catheterization and the MDCT findings were confirmed. Thus, MDCT showed 100% sensitivity and specificity in identifying this abnormality.

In both the cases MDCT could accurately depict the level and degree of stenosis. This information was helpful for the management for the cases.

Another study by Edward Y. Lee1, Marilyn J. Siegel, Charles F. Hildebolt *et al*. [7] showed with multiplanar and 3D volume-rendered images, there was near-perfect agreement among observers and with the truth standard ($p > 0.99$). Average accuracies were 90% for axial, 100% for multiplanar and 100% for 3D volume-rendered images. Sensitivities were 73% for axial, 100% for multiplanar and 100% for 3D volume-rendered images.

Ömer Önbaş, Mecit Kantarc, Mustafa Koplay *et al*. [7] showed that MDCT with MPR and 3D volume rendering can diagnose coarctation and the collaterals accurately. Our study showed similar results.

MDCT clearly demonstrate the origin, course and communications of the MAPCAs. In our study the sensitivity and specificity of MDCT in detection of MAPCAs showed 80% and 93% respectively, the P value is 0.0008 which is highly significant statistically.

Study by Jonathan R. Dillman1, Ramiro J. [9] Hernandez showed noninvasive evaluation of MAPCAS is useful in surgical planning and has a very high sensitivity and specificity. Our results are similar to their study.

Hiroyuki KANI, Isamu Narabayashi *et al*. [10] in their study showed MDCT accurately demonstrated systemic-pulmonary collateral arteries including PDA.

MDCT is 100% sensitive and 85% specific in identifying the PDA in our study. MDCT could clearly demonstrate the patency of the PDA, the caliber the measurements of the PDA which is important surgically. It could also depict the PDA anomalies in cases of TOF and right ventricular outflow obstruction.

Hiroyuki KANI, Isamu Narabayashi *et al*. [10] in their study demonstrated MD-CT detected hypoplasia of the pulmonary artery and increased pulmonary arterial blood flow due to the existence of PDA with good sensitivity and specificity rates of diagnosis. Our study is similar to their study.

Our study showed similar results as another study by Jonathan R. Dillman, Ramiro J. (26,38,39) in detecting PDA.

There are few limitations to this study. This study was not designed as a head-to-head comparison of 64-slice MDCT angiography with conventional imaging techniques.

Echocardiography and MDCT together provided the necessary information for the surgeons, and we considered it unethical to undertake additional cardiac catheterization in this population group. This approach has been used in other studies of echocardiography in neonate congenital heart diseases.

In our study MDCT was carried out with out ECG gating hence we could not comment on the functional data such as ventricular wall motion, ventricular ejection fraction, and motion of the cardiac valves. So, in our study the operating surgeons took these information from 2D Echocardiography.

Another limitation of our study is that We have not attempted to compare CT angiography with its major competitor, MRA.

Conclusion

- Echocardiography and MDCT together provide the necessary information for the surgeons.
- The 64-slice MDCT angiography obtained using the current technology is a major breakthrough in cardiovascular imaging for children.
- It is a non-invasive, very rapid image acquisition and is very suitable for unstable patient.
- The high spatial and temporal resolution provided by multidetector CT, combined with the short scanning times, enable the use of no sedation or only short-term sedation while evaluating patients with congenital heart disease.
- This study has shown the major diagnostic and decision-aiding role of this technique in the assessment of congenital heart disease, especially for answering questions not resolved by echocardiography.

References

1. David Zieve MD, MHA, Medical Director, A.D.A.M., Inc.; and Mark A Fogel, MD, FACC, FAAP Congenital heart disease.
2. Ratanaporn Pornkul MD, Suvipaporn Siripornpitak MD. MDCT of Congenital Heart Disease in Children Siriraj Med J, 2008.
3. Haramati LB, Glickstein FS, Issenberg HF, Haramati N, Crooke GA. MR imaging and CT of vascular anomalies and connections in patients with congenital heart disease: significance in surgical planning. Radio Graphics. 2002;22:337-349.
4. Standring S, Borley NR, Healy JC, Collins P, Crossman AR, Mahadevan V, *et al*. editors.
5. Gray’s anatomy. 40th ed. Spain: Churchill Livingstone, 2008, 472-9, 655-6.
6. Langman’s Medical Embryology. 9th edition.
7. Thomas A, Marino. Ph.D. Development of the Cardiovascular System Medical Embryology, 2006.
8. Edward Y Lee1, Marilyn J Siegel, Charles F Hildebolt, *et al*. MDCT Evaluation of

Thoracic Aortic Anomalies in Pediatric Patients and Young Adults: Comparison of Axial, Multiplanar and 3D Images AJR. 2004;182:777-784.

9. Oguz B, Haliloglu M, Karcaaltincaba M. Paediatric multidetector CT angiography: spectrum of congenital thoracic vascular anomalies. Br J Radiol. 2006;80:376-383.
10. Jonathan R Dillman, Ramiro J. Hernandez Role of CT in the Evaluation of Congenital Cardiovascular Disease in Children, AJR. 2009;192:1219-1231.
11. Hiroyuki KANI, Isamu Narabayashi, *et al*., Usefulness of Multidetector-row Computed Tomography (MD-CT) for Diagnosis and Evaluation of Cardiovascular Anomalies in Infants, Bulletin of the Osaka Medical College. 2005;51(1):23-34.

Accepted on 26/05/2022