

CT Pulmonary Angiography Findings in Children with Congenital Heart Disease in a Tertiary Care Hospital

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ABSTRACT

Background & objective: Computed tomography (CT) is claimed to accurately diagnose many forms of congenital cardiovascular disease in children, particularly in the diagnosis of extracardiac vascular anomalies. The present study is intended to describe the role of CT in the evaluation of congenital cardiovascular disease in children.

Methods: The study included children with congenital heart disease (CHD) who underwent CT pulmonary angiography in the Cardiac Imaging Department of Ibrahim Cardiac Hospital & Research Institute, Dhaka between 2015-2017 for investigations of various congenital heart diseases. CT scan was done on Multidetector scanner from Siemens or Philips. Routine preprocedure was done as per protocol of the CT angiography study. Breath holding technique was explained to the older patients who were able to follow breath holding instructions. Plain CT scans of thorax followed by early arterial phases were obtained after negative test dose of the non-ionic contrast by injecting 12 to 40 ml of intravenous contrast media (Iopamidol 350 mg) through antecubital vein by pressure injector at a rate of 1.5 ml/second. Scan was obtained 6 seconds after starting of the intravenous contrast.

Results: The mean age of the patients was 5.3 ± 0.5 years. Over 60% of the children were male giving a male to female ratio of roughly 3:2. Majority (92%) of children had levocardia with aorta being predominantly originated from the left ventricle (95%). Nearly two-thirds (65%) of the aortas had 50% overriding, 33% had > 50% overriding. Over three-quarters (76%) had left-sided arch and 21% had right-sided arch. Majority (87%) of pulmonary arteries originated from the right ventricle: 50% were of normal size and 44% were narrower than normal. In a few cases both right and left pulmonary artery were absent. In 90% cases right and left pulmonary arteries and veins were confluent. Nearly two-thirds (64%) of the pulmonary arteries were stenosed and 5% did not have any pulmonary valves. Presence of collaterals was commendably high (42%). Seventy percent of the patients had Tetralogy of Fallot (TOF) and over one-quarter (26%) had Patent Ductus Arteriosus (PDA). Interatrial septal defect was found in 21% and interventricular septal defect in 79% cases. Increased and decreased vascularity of the lungs were found in 13 and 15% of the cases respectively. Other cardiac anomalies were negligible.

Conclusion: The findings of the study suggest that the CT pulmonary angiography in the evaluation of CHD has a number of merits and could be done in the diagnosis of pulmonary vascular structures particularly the extra cardiac vascular anomalies.

Key words: CT Pulmonary Angiography, cardiovascular anomalies, children, congenital heart disease etc.

INTRODUCTION:

Computed tomography (CT), including CT angiography (CTA), is important in the evaluation of pediatric congenital heart disease (CHD). It can be used for accurate depiction of complex cardiovascular anatomic features, particularly in

the assessment of extracardiac systemic and pulmonary arterial and venous structures. It is, therefore, important for radiologists to have extensive knowledge of cardiovascular anatomy, physiology, and surgical techniques.¹ Although echocardiography and catheter-directed cardiac

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angiography are generally accepted as the primary imaging techniques for evaluation of CHD, CT and MRI are important complementary diagnostic tools. In addition to being highly operator dependent,² echocardiography may not be sufficient for evaluating extracardiac structures, such as the pulmonary arteries, pulmonary veins, and the aortic arch and great vessels due to acoustic window limitations.^{2,3}

Compared with CT, cardiac catheterization has a higher complication rate owing to its invasive nature.^{4,5} The latter frequently requires a larger volume of intravascular contrast material and general anesthesia.⁴ It often imparts greater radiation dose to the patient when appropriate pediatric CT protocols are used.¹ CT and MRI can be used as problem-solving tools, especially in the evaluation of preoperative and postoperative cardiovascular anatomical assessment and certain postoperative complications. Although MRI does not cause ionizing radiation and can be used for functional assessment of cardiovascular structures and for dynamic multiphasic contrast-enhanced imaging, it has several disadvantages compared with CT, which among others, include poorer spatial resolution;^{2,6} the presence of image-degrading artifacts from implanted metal, such as intravascular stents and embolization coils;⁷ higher cost;^{2,8} limited availability;^{2,6} and increased need for general anesthesia in younger children.⁶

CT offers excellent spatial resolution and relatively unrestricted access in much shorter acquisition times than MRI.⁹ It is well suited for imaging the epicardial coronary arteries and their relations to adjacent structures or conduits. New generation Multidetector Computed Tomography (MDCT) has important roles in overcoming these limitations. CT angiography is fast method to evaluate vascular structural anomalies by fast image acquisition times and their capacity to obtain volumetric data. For the complete evaluation of CHD high and spatial resolution is necessary which is possible with CT imaging.¹⁰ The present study is intended to illustrate and describe the CT

findings in patients with CHD (extra cardiac abnormalities, cardiac abnormalities, connection problems), and the advantages & disadvantages of CT in this setting.

METHODS:

The study included children with congenital heart disease who underwent CT pulmonary angiography in the Cardiac Imaging Department of Ibrahim Cardiac Hospital & Research Institute, Dhaka between 2015-2017 for investigations of various congenital heart diseases. CT scan was done on Multidetector scanner from Siemens or Philips. Written informed consent was obtained from the parents/guardians of the children with CHD. Routine preprocedure was done as per the protocol of the CT angiography study. Breath holding technique was explained to the older patients who was able to follow breath holding instructions. Plain CT scans of thorax followed by early arterial phases was obtained after negative test dose of the non-ionic contrast by injecting 12 to 40 ml of intravenous contrast media (Iopamidol 350 mg) through antecubital vein by pressure injector at a rate of 1.5 ml/sec. Scan was obtained 6 second after starting of the intravenous contrast. Scan parameters were as follows: Volumetric data were obtained from the vessels in axial plane and were reconstructed in sagittal and coronal plane. Slice thickness was 1 mm. Collimation: 0.6 mm. Pitch:-1.5, MAS=200, Kvp120.

RESULTS:

The mean age of the patients was 5.3 ± 0.5 years. Over 60% of the children were male giving a male to female ratio of roughly 3:2 (Table I). Majority (92%) of children had levocardia with aorta being predominantly originated from the left ventricle (95%). Nearly two-thirds (65%) of the aortas had 50% overriding, 33% had > 50% overriding. Over three-quarters (76%) had left-sided arch and 21% right-sided arch. Majority (87%) of pulmonary arteries originated from the right ventricle-50% were of normal size and 44% were

narrower than normal. Sixty percent of the right pulmonary arteries and 56% of the left pulmonary arteries were narrower. In a few cases both right and left pulmonary arteries were absent. In 90% cases right and left pulmonary arteries and veins were confluent. Nearly two-thirds (64%) of the pulmonary arteries were stenosed and 5% did not have any pulmonary valves (Table II).

One-quarter of the right atrium, 8% of left atrium, 23% of right ventricle and 10% of left ventricle were dilated. Small left atrium was found in 14% cases. However, single atrium and ventricle were rare. Presence of collaterals was commendably high (42%). Double superior vena cava and dilated coronary sinus were found in 11% and 12% cases respectively. Over one-quarter (26%) children had Patent Ductus Arteriosus (PDA). Interatrial septal defect was found in 21% and interventricular septal defect in 79% cases. Increased and decreased vascularity of the lungs were found in 13 and 15% of the cases respectively (Table III). CT diagnosis revealed that 70% of the patients had Tetralogy of Fallot (TOF) and 26% had PDA. Total anomalous pulmonary venous connection (TAPVC) and partial anomalous pulmonary venous connection (PAPVC) were 9 and 16% respectively, while coarctation of aorta and single ventricle were 3 and 2% cases respectively. Other anomalies were AP window (2%), single atrium (1%), Anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA) (2%), Atrial Septal Defect (ASD) with PLSVC (2%), Double outlet right ventricle (DORV) (2%), large VSD (1%) (Table IV).

TABLE I. distribution of patients by their demographic characteristics

Demographic variables	Frequency	Percentage	Mean ± SEM (range)
Age (yrs)	-	-	5.3 ± 0.5 (0.1 – 24)
Sex			
Male	62	62.0	-
Female	38	38.0	-

TABLE II. Features of aorta and pulmonary arteries

Features of aorta & pulmonary artery	Frequency	Percentage
Cardiac position		
Laevocardia	92	92.0
Dextrocardia	7	7.0
Mesocardia	1	1.0
Origin of aorta		
LV	95	95.0
RV	5	5.0
Overriding of aorta (%)		
50%	65	65.0
> 50%	33	33.0
No overriding	2	2.0
Arch		
Left-sided	76	76.0
Right-sided	21	21.0
Absent	3	3.0
Origin PA		
LV	8	8.0
RV	87	87.0
Single ventricular	5	5.0
Size of PA		
Normal	50	50.0
Narrow	44	44.0
Absent	6	6.0
Size of RPA		
Normal	38	38.0
Narrow	60	60.0
Absent	2	2.0
Size of LPA		
Normal	42	42.0
Narrow	56	56.0
Absent	2	2.0
Confluence of RPA & LPA	90	90.0
Pulmonary veins		
Normal	83	83.0
Abnormal	17	17.0
Pulmonary valve		
Normal	31	31.0
Stenosed	64	64.0
Absent	5	5.0

TABLE III. Anomalies of cardiac chambers

Cardiac chamber	Frequency	Percentage
Right atrium		
Normal	74	74.0
Dilated	25	25.0
Single	1	1.0
Left atrium		
Normal	77	77.0
Dilated	8	8.0
Small	14	14.0
Single	1	1.0
Right ventricle		
Normal	72	72.0
Dilated	23	23.0
Small	3	3.0
Single	2	2.0
Left ventricle		
Normal	83	83.0
Dilated	10	10.0
Small	5	5.0
Single	2	2.0
Presence of collaterals	42	42.0
SVC		
Single	89	89.0
Double	11	11.0
Coronary sinus (CS)		
Normal	86	86.0
Dilated	12	12.0
Not seen	2	2.0
PDA	26	26.0
Interatrial septum		
Intact	78	78.0
Defect	21	21.0
Absent	1	1.0
Inter ventricular septum		
Intact	19	19.0
Defect	79	79.0
Absent	2	2.0
Lungs findings		
Normal vascularity	63	63.0
Increase vascularity	13	13.0
Decrease vascularity	15	15.0
Infection	9	9.0

TABLE IV. Distribution of patients by diagnosis of congenital heart diseases

CT Diagnosis	Frequency	Percentage
TOF	70	70.0
TAPVC	9	9.0
PAPVC	4	4.0
PDA	26	26.0
Coarctation of the aorta	3	3.0
Single ventricle	2	2.0
Others		
AP window	2	2.0
Single atrium	1	1.0
ALCAPA	2	2.0
Long VSD with pulmonary artery atresia	1	1.0
ASD with PLSVC	2	2.0
DORV	2	2.0
Large VSD	1	1.0

DISCUSSION:

In the present study, pulmonary arteries were found to be predominantly originated from the right ventricle (87%). Half of them was of normal size and an almost half (44%) was narrower than normal. In a few cases both right and left pulmonary arteries were absent. In majority of the cases right and left pulmonary arteries and veins were confluent. Nearly two-thirds (64%) of the pulmonary arteries were stenosed with absence of valve in few cases. Presence of collaterals was indeed high.

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.^{11,12} Rapid imaging could be done with these CT scanners. Although the role of CT in the evaluation of pediatric CHD is continually being redefined and expanded, there are several generally accepted clinical indications for which the benefits of imaging outweigh the risks. First, CT can be used to evaluate patients with CHD

suspected on the basis of echocardiographic findings for which further imaging is needed to characterize extracardiac anomalies before intervention, for the pulmonary arteries, pulmonary veins, & aortic arch and great vessels, which are often inadequately characterized at echocardiography.³ Second, CT can be used in the postoperative evaluation of CHD patients who may have a variety of suspected treatment-related complications.⁷ Third, as CT facilitates rapid and comprehensive assessment of thoracic cardiovascular structures, the lungs, and potential spaces, it can be used in the preoperative and postoperative evaluation of CHD patients whose condition abruptly deteriorates.⁷ In this situation, CT quickly displays evidence of a variety of CHD-related complications and numerous other medical conditions, such as pulmonary embolism, pneumonia, pleural and pericardial effusion, and pneumothorax.⁷

Finally, CT could be useful before a reoperation to assess altered anatomic features related to previous surgery.⁷ CT can be considered as the first-line imaging technique for a few clinical indications. Examples are evaluation of suspected vascular ring or sling, suspected aortopulmonary collateral arteries in patients with severe right ventricular outflow tract obstruction, & individuals with implanted pacemakers and metal surgical hardware where MRI is contraindicated.^{6,7} The role of CT in the evaluation of intracardiac anomalies has been limited, although the situation is changing owing to advances in MDCT scanners and ECG-gating techniques. In a small study, Lee et al.,¹³ in which they used a 40-MDCT scanner (without ECG gating), detected 53 of 54 intracardiac & extracardiac anomalies in neonates with complex congenital heart disease. The pediatric thoracic CTA usually requires mild or no sedation. Unlike the practice for MRI and cardiac catheterization, general anesthesia is infrequently needed for CTA because quiet breathing rarely causes appreciable artifacts.^{3,8,14,15}

The findings of the present study suggest that CT pulmonary angiography could dependably diagnose CHD in children. The accumulating

evidences from other studies as well suggest that the CT pulmonary angiography in the evaluation of CHD has a number of merits and could be done in the diagnosis of pulmonary vascular structures with fair degree of accuracy.

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