Original Research Article

Correlation of 64 detector row multislice computed tomography with 2d echocardiography in evaluation of congenital heart diseases

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Abstract

With the speed of MDCT acquisition, most young children can be imaged either with sedation or unsedated with feed and wrap. Contrast medium injection should optimally be through a large (20g minimum) cannula with pump injection, but a hand injection may also produce adequate results. Contrast agent bolus timing is important and may be crucial for optimal image quality, vessel delineation and diagnostic confidence. 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. We can see that in our study MDCT has a very high sensitivity ranging from 80% to 100% and specificity ranging from 80 to 90%. The P value is highly significant.

Keywords: MDCT, congenital heart diseases, 2d echocardiography

Introduction

The fetal heart develops from a series of very complex and very rapid changes that occur between the second (total fetal length 2 mm) and eighth week of intrauterine life. It is during the third to fifth weeks of intrauterine life (when the forelimbs are developing) that the cardiac structures develop most actively and are therefore most susceptible to adverse external influence (e.g. rubella virus or drugs such as thalidomide), resulting in congenital heart disease (CHD). By 8 weeks, the heart has already assumed its definitive form [1].

With the development of multidetector CT (MDCT), it is now possible to acquire volumes of CT data that can be reformatted in any imaging plane. MDCT images of the entire thorax can be acquired in 3-10s, depending on the size of the patient. Using iodinated contrast agents, CT angiography (CTA) can now be rapidly performed and 3D imaging algorithms applied to create 3D images which considerably aid in the 3D appreciation of complex vascular anatomy. Cardiac CT images of intracardiac anatomy are often blurred and of limited value; however, with the advent of 64-and potentially 256-slice CT machines, this will improve in the near future [2].

With the speed of MDCT acquisition, most young children can be imaged either with sedation or unsedated with feed and wrap. Contrast medium injection should optimally be through a large (20 g minimum) cannula with pump injection, but a hand injection may also produce adequate results. Contrast agent bolus timing is important and may be crucial for optimal image quality, vessel delineation and diagnostic confidence. This is best achieved by triggering the data acquisition after visually watching contrast medium arrive in the appropriate vessel. Data are acquired in an axial spiral, with a reconstruction slice width of 0.75-1.5 mm, during a single breath-hold or, if not possible, shallow respiration. Images are then transferred to a workstation for the creation of 3D images [3].

Cardiac CT may be preferred, particularly for vascular imaging in young patients, who would otherwise require a general anaesthetic for adequate MRI, and in those for whom MRI is contraindicated or when additional information may be acquired from CT (e.g. airways and lung).

Sjirk J. Westra Jennifer A. Hil Juan C. *et al*. studied twenty patients and were examined with contrast-enhanced helical CT. Three-dimensional reconstructions were performed with multiplanar reformations, maximum intensity projection and shaded-surface display. Correlation was made with 19 echocardiograms and 14 cine angiocardiograms [4].

All imaging studies were reviewed independently for the following parameters: the caliber of the main and branch pulmonary arteries and their confluence, the presence of stenosis, the number and caliber of aortopulmonary collaterals, and the patency of vascular shunts and conduits. Surgical confirmation, which was used as the reference standard, was available in all patients.

Helical CT was as accurate as angiocardiography in revealing stenotic and nonconfluent central pulmonary arteries and in revealing aortopulmonary collaterals (overall CT test parameters: sensitivity, 90%: specificity, 100%: accuracy, 93%). Three-dimensional rendition did not improve the accuracy of CT. The patency of shunts was shown equally well with CT as with angiography, but CT showed thrombosis more directly. Echocardiography was the least accurate technique in revealing pulmonary artery anatomy (accuracy, 65%), primarily because a relatively large number of studies were technically unsatisfactory to assess the study parameters [5].

The study concluded that helical CT angiocardiography with three-dimensional reconstruction is superior to echocardiography for the noninvasive assessment of pulmonary artery anatomy in patients with complex congenital heart disease. Helical CT may be used as a complementary technique and occasionally as a substitute for the diagnostic imaging portion of cardiac catheterization with cineangiocardiography [6].

Methodology

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.

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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

Table 1: The statistical analysis of evaluation of various individual findings by the MDCT, 2D Echo and peroperatively

Sl. No.	Findings	MDCT					2 D Echocardiography				
		P value	Sensitivity	Specificity	PPV	NPV	P value	Sensitivity	Specificity	PPV	NPV
1.	Overriding of aorta	0.0013	100%	60%	65%	100%	0.001	73%	32%	31%	73%
2.	Right sided aortic arch	0.0001	100%	100%	88%	100%	0.1	22%	100%	100%	78%
3.	MAPCAS	0.0008	80%	93%	66%	96%	0.013	40%	100%	100%	90%
4.	PDA	0.0003	100%	81%	58%	100%	0.02	40%	100%	100%	90%
5.	Pulmonary stenosis	0.005	72%	89%	94%	53%	0.3	85%	35%	48%	77%
6.	Abnormal SVC	Shows 100% agreement with peroperative findings					0.2	25%	99%	100%	90%

From the above table we can see that in our study MDCT has a very high sensitivity ranging from 80% to 100% and specificity ranging from 80 to 90%. The P value is highly significant.

Discussion

Traditionally, cardiologists have relied on echocardiography and conventional angiography to establish the diagnosis of congenital heart disease. Both techniques have potential limitations. Echocardiography is a noninvasive method; thus, it is extremely effective in evaluating valvular heart diseases, septal anomalies and cardiac wall parameters. However, it is difficult to evaluate extracardiac vascular anomalies (pulmonary artery/vein, aortic anomalies and PDA) because the lungs obscure the view. Echocardiographic study is operator dependent and limited by an acoustic window, especially in older children and adults. Conventional angiography is an invasive procedure with its inherent risks. The new generation of 64-slice MDCT has changed the approach to noninvasive assessment of congenital heart disease.

Olejnik P, Boruta P *et al*. [7] recently reviewed the application of 3D CT scanning for congenital heart disease, concluding that it has become an invaluable diagnostic and decision aiding tool, a complement to echocardiography and often a substitute for diagnostic angiography.

Our study group included 52 cases of which 34 cases were operated and the findings were confirmed. The operated cases included the following groups. 27 cases of tetralogy of Fallot (TOF), 2 cases of total anomalous pulmonary venous connection (TAPVC), 2 cases of coarctation of aorta, 1 case of transposition of great arteries and 2 cases of complex anomalies. In all the above cases the MDCT gave a comprehensive diagnosis and correlated well to the one diagnosed intra operatively.

Our study group included 27 cases of surgically proven TOF. In all the above cases MDCT was performed prior to surgery and a systematic approach of evaluation of various findings was followed which included the septal defects, pulmonary artery anatomy and abnormalities, pulmonary venous anatomy, aorta, arch and arch vessels, major aortopulmonary collaterals (MAPCAS), patent ductus arteriosus (PDA), cardiac chambers and valvular abnormalities.

All these findings were first evaluated by 2D Echocardiography and then followed by

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surgical confirmation.

The ventricular septal defects (VSD) were well delineated by MDCT in all our cases with 100% sensitivity and specificity. Another study by Olejnik P, Boruta P *et al*. [7] also showed 100% sensitivity in detection of VSDs and all the cases were compared with the conventional angiography. Chip Gilkeson, MD [8] also found that CT is equally adept at visualizing ventricular septal defects.

The pulmonary artery anatomy and a spectrum of morphologic abnormalities of the pulmonary arteries, including atresia, stenosis, dilatation, anomalous origin and abnormal course were evaluated in detail on MDCT. The sensitivity and specificity for detection of pulmonary stenosis is 75% and 90% respectively with P value of 0.0057 which has very high significance statistically. We demonstrated that the diameters of the main, right and left pulmonary arteries were very well depicted on MDCT which had a correlation of around 95 to 98% in comparison to the peroperative findings.

Hiroyuki KANI, Isamu Narabayashi *et al*. [9] showed that MD-CT was also capable of detecting anomalies of the pulmonary artery at high accuracy rates equivalent to those of cardiac catheter angiography. Our study was different from their study in that they compared the results with the catheter angiography.

Another study by Sanjay Khatri, Suraj Kumar Varma *et al*. [10] concluded that for assessment of pulmonary arteries, MDCT angiography was particularly useful in demonstrating confluence or discontinuity of pulmonary arteries and extent of pulmonary artery stenosis. Thus, this technique helped to evolve a management algorithm based on the frequently asked questions about the pulmonary arteries.

Olejnik P, Boruta P *et al*. [7] in their case series demonstrated that high-resolution multi-slice CT-angiography excellently delineated the pulmonary artery anatomy and its anomalies with a high sensitivity of around 90% in comparison to the standard angiocardiography.

Hyun Woo Goo, In-Sook Park *et al*. [11] also reported that a spectrum of morphologic abnormalities of the pulmonary artery can be evaluated on multi-slice CT. Enhanced multi-slice spiral CT with thin collimation can precisely analyze the sub segmental pulmonary arteries.

Another study by Jonathan R. Dillman, Ramiro J. Hernandez [12] reported that MDCT is useful when the pulmonary arteries are not well seen at echocardiography and conventional angiography and the presence, confluence, patency or caliber of the pulmonary arteries must be established before definitive surgical repair because these findings can influence surgical decision making.

MDCT is also very helpful in evaluating the postoperative cases and the shunts in cases of TOF. In our case series we had three post-operative cases of TOF which included Blalock Taussig (BT) shunt. Out of the three cases MDCT could evaluate the functional status of the shunt in two cases and was confirmed on surgery. In one case MDCT showed the shunt as occluded but it was partially functioning as evaluated peroperatively.

Conclusion

- The clinical and technical feasibility of MDCT for diagnosing neonatal complex congenital heart disease is confirmed. Consequently, CT has become a useful imaging modality for the pre- and postsurgical evaluation of a wide variety of cardiac defects in pediatric and adult patients.
- After initial assessment with echocardiography, MDCT could replace diagnostic cardiac catheterization for clarification of the anatomy in neonates.
- Cardiac CT is not a radiation intensive study any more when the appropriate dose saving strategies are used.

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