Image post-processing techniques of 64-slice CT in the diagnosis of external cardiac malformations

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Abstract: Objective To discuss the value of Image post-processing techniques of 64-slice CT in the diagnosis of external cardiac malformations. **Materials and methods** Retrospective reviews of imaging data base were done which consisted of 59 patients with congenital cardiovascular malformations who presented to our hospital. The scanning data were carried on multiple planar reformation (MPR), maximum intensity projection (MIP) and volume rendering (VR) as needed. The operation results were taken as diagnostic standard to evaluate the diagnostic accuracy of 64-slice spiral CT. **Results** 69 external cardiac malformations (cardiovascular connection department and peripheral vascular malformations) were confirmed by operation in all 59 patients. 67 malformations correctly diagnosed and 2 malformations were incorrecty diagnos in 64-slice spiral CT. The accuracy in diagnosing cardiovascular connection department and peripheral vascular malformations were 97.10% (67/69). There was no significant difference in image scores compared with the three image post-processing techniques (P value were 0.612, 0.902 and 0.815, respectively). **Conclusions** 64-slice spiral CT may be used as a primary technique and as a substitute for the diagnosis imaging portion of cardiovascular connection and peripheral vascular malformations.

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Introduction

Being well informed about the form, position, size, and the relation with surrounding tissues in the patients with congenital cardiovascular malformations are very important before the operation. In recent years, with the multi-detector spiral computed tomography(MDCT) advance in technology, a variety of image reconstruction methods, such as planar reformation (MPR), maximum intensity projection (MIP) and volume rendering(VR) and so on can display complex cardiovascular anatomical structures clearly, intuitively and multi-dimensional. MDCT imaging can not being limited by the experience of the inspectors, which plays a more and more important role in the diagnosis of congenital heart disease[1,2,13,14]. The article uses the retrospective method to analyze the 69 lesions of external cardiac malformations diagnosed by MDCT and compared with the results of the operation in order to improve the diagnosis level of external cardiac malformations using MDCT.

1. Materials and methods

1.1 General information

Retrospective analysis the CT examination data of the 59 cases were confirmed by surgery. Those patients were collected between April 2008 and March 2011, including 30 cases of male, 29 cases of female, mean age :18.26 + / - 17.83 y(2 m ~ 60 y), the average weight: 34.51 + / - 22.52 kg (4 ~ 76 kg), the average height :1.31 + / - 0.37 m (0.52 ~ 1.78 m).

1.2 Methods

Scanning equipment was GE light speed VCT scanner and workstation was Advantage Workstation Aw4.4 version. All patients had the indwelling vein needle in the back of hand or scalp venous before the scan and retention after heparin anticoagulation. For the uncooperative children younger than age 4, 2-4 ml of 10% chloral hydrate was used orally before 30 minutes of the scan, no breathing training, no slowing the heart rate by drugs were done.

For the cases older than 15, using double-syringe power injector, 20ml nonionic contrast medium (Omnipaque, 300mgI/ ml) and 20 ml saline were injected through the elbow vein by the rate of 3ml/s. Delay in aortic root dimension after 8s for 15 consecutive scans, with a thick layer of 5 mm, scanning time 1s and interval of chosen. Then the ROI chosen within aorta area and measuring the time density curve, the peak time was the best scan delay time. Delay time (in seconds) = 8 + 4 +the scanning layer × 2, when the time up to peak, the scanning started and range was from the thoracic inlet under 1 cm to the diaphragmatic surface down about 2 cm of the heart. 70-80ml nonionic contrast medium (Concentration, injection rate as the pre-scanning) and 20ml saline were injected by double-syringe power injector. Scan parameters: frame rotation speed 0.35 s/r, thickness 0.625 mm, the reorganization of the interval is 0.625 mm, pitch of 0.18

~ 0.24:1, the outlook for 250 mm, matrix 512×512, tube voltage is 120 kv, tube current is 300 ~ 680 mAs.

The cases younger than 15, using double-syringe power injector, 10ml nonionic contrast medium (Omnipaque, 300mgI/ ml) and 10 ml saline were injected through the elbow vein by the rate of 0.5-2.0 ml/s, delay in aortic root dimension after 5 s for 15 consecutive scans, with a thick layer of 5mm, scanning time 1s and interval of 1s, layer thickness is 5 mm. Then choose the ROI within aorta area and measuring the time density curve, the peak time was the best scan delay time. Delay time (in seconds) = 5 + 4 +the scanning layer × 2, when the time up to peak, the scanning started and range was from the thoracic inlet under 1 cm to the diaphragmatic surface down about 1 cm of the heart. Nonionic contrast medium (concentration, injection rate as pre-scanning, contrast dose was 1.5 ~ 2.0 ml/kg) and 20 ml saline were injected by double-syringe power injector. Scan parameters: frame rotation speed 0.35 s/r, thickness 0.625 mm, the reorganization of the interval is 0.625 mm, pitch of 0.18 ~ 0.24:1, the outlook for 250 mm, matrix 512 x 512, tube voltage is 100 kv, tube current is 200 ~ 450 mAs.

1.3 Image analysis

After the scanning, the original image was carried on the cross-sectional reconstruction by the thickness 0.625mm and the data were transmitted to the post-processing Workstation after reconstruction (GE Advantage Workstation 4.4). An experienced radiologists make the reconstruction of multiple planar reformation (MPR), maximum intensity projection (MIP) and volume rendering (VR).

1.4 image analysis and data processing

With surgical results as the standard, 64 - row spiral CT diagnosis was correct when it was consistent with surgical results(three high qualification radiologists make the final diagnosis), was not consistent with the surgical results or did not provide a diagnosis that was thought as missed diagnosis. CT image quality was evaluated by 5 standard[3], scoring criteria was as follows: 1 point: image quality was very poor, you couldn't get useful information; 2 point: the image quality was poor. Some could display the anatomical structures, and some couldn't display. Needed further MRI or catheterization to provide clear anatomical information; 3 point: clear anatomical structure. After careful reading, anatomical relations could be identified for clinical need, no need to further examination; 4 point: anatomical structure showed good. You had confidence to identify all of the structure. Clinical problems could be explained clearly; 5 point: clear anatomical structure. Confidently identified all of the intra-cardiac structure and the extra-cardiac structure. Clinical problems could be explained clearly.

2. Statistical analysis

The statistical analysis was performed using commercially available software SPSS 17.0(SPSS. Inc.Chicago). Chi-square test was used to compare the subjective rating of any differences between groups and P-value of <0.05 was considered as significant.

3. Results

3.1The subjective image quality assessment

All patients CT images met the requirements of the diagnosis, the MDCT subjective image quality were three points or more, the 64 places of extra-cardiac malformation had excellent VR graph, 2 places showed better, 1 place showed good; for the MIP map, 62 places displayed excellent, 3 places displayed better, 2 places showed good; And MPR in 63 places displayed excellent, 1 place got well display, 3 places showed better. Image quality scores comparison between three groups of image post-processing technology had no significant difference (chi square values were 0.453, 0.152 and 0.453, P values were 0.612, 0.902 and 0.815). (table 1, figure 1-3)

Table 1 the comparison of VR, MIP map and the status of the CPR image shows

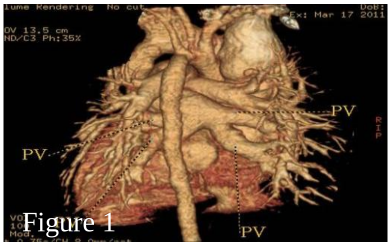
	VR(place)	MIP(place)	MPR(place)
3 point	64	62	63
4 point	2	3	1
5 point	1	2	3

3.2 The surgical results of the extra-cardiac malformation compared with the diagnosis of 64 row spiral CT

A total of 69 places of cardiovascular connection and peripheral vascular malformations had been found. Compared with the surgical results, 64-slice spiral CT diagnosed correctly 64 places and missed 2 places(1 leakage of coronary artery and 1 pulmonary atresia) respectively. Double outlet of left ventricle, double outlet of right ventricle, Interrupted aortic arch, coronary artery anomaly, patent ductus arteriosus, major aorto pulmonary collateral arteries, common artery trunk, pulmonary stenosis, anomalous pulmonary drainage, transposition of the great arteries etc lesions were all diagnosed correctly (table 2, figure 4-6).

Table 2: the surgical results and 64-slice spiral CT diagnoses about cardiovascular connection and peripheral vascular malformations

type	Surgical results (place)	Diagnosis of 64 row spiral CT	
		correct	misdiagnosis
double outlet of left ventricle	1	1	0
double outlet of right ventricle	5	5	0
Interrupted aortic arch	6	6	0
Coronary artery anomy	3	3	0
leakage of coronary artery	5	4	1
Patent ductus arterioss	12	12	0
Major aorto pulmonary collateral arteries	4	4	0
Common arterial trunk	5	5	0
pulmonary atresia	2	1	1
Pulmonary stenosis	4	4	0
Anomalous pulmonary venous drainage	15	15	0
transposition of the great arteries	7	7	0
total	69	67	2



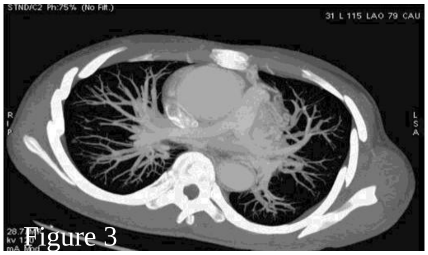


Figure 1: image of volume rendering(VR).Figure 2: image of multiple planar reformation (MPR). Figure 3: image of maximum intensity projection (MIP).

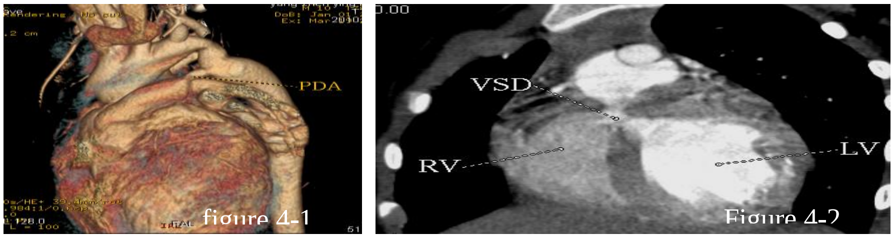


Figure 4: male, 10 years old. coarctation of the aorta, patent ductus arteriosus, ventricular septal defect.

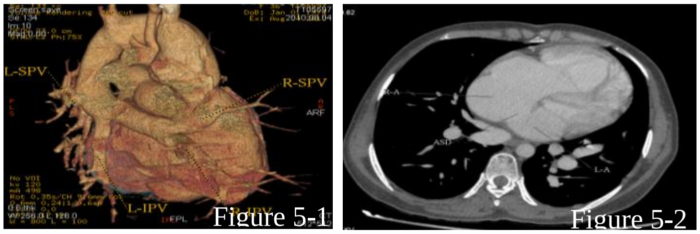


Figure 5: female, 36 years old. Complete drainage of pulmonary vein malformation (supracardiac pattern), atrial septal defect.

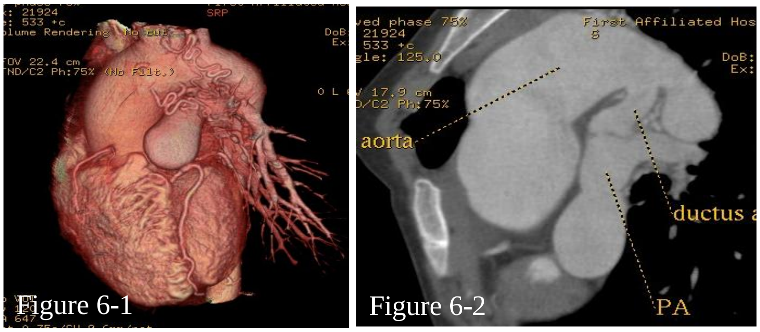


Figure 6:female, 15 years old. pulmonary atresia, patent ductus arteriosus .

4.Discussions

Complex congenital heart disease is point to all patients who have concurrent more than one pathophysiological change or several concurrent cardiovascular malformations [4, 5]. According to the related literature[6], accounts for about 29% of the congenital heart disease factor live birth baby. It is the leading cause of infant death and serious complications and becomes the most important reason to bring great burden to the society and family [13]. Therefore, preoperative early accurate diagnosis for the anatomical factors in the treatment of congenital heart disease and its prognosis is very important. At present, two-dimensional ultrasound is thought as the most accurate method for cardiovascular imaging evaluation in congenital heart disease. But the technology has the limitation such as diagnosis of cardiovascular connection and peripheral vascular malformations. MDCT, with the increased scanning speed and improved quality of the images and the development post-processing software, is increased gradually used in the diagnosis of congenital heart disease. But at present about 64-slice spiral CT in the diagnosis of extra-cardiac malformation has still less reports in the literature. Since 64-slice spiral CT was applied to clinical, many scholars studied the diagnostic value and method of MDCT in congenital heart disease[1, 7]. MDCT hardware and post-processing software development significantly improved their accuracy of diagnosis in congenital heart disease. Currently, the clinical main used the VR, MIP and MPR image post-processing to diagnose the congenital heart disease and achieved good results[2]. VR graph has many advantage to view images, cut original image slantly and freely, three-dimensional rotation, observe the three-dimensional anatomical relationship from any angle, make full use of volume data, more intuitive, avoid the misdiagnosis caused by overlap, and so on[8]. Chinese scholar Xiao Yi[9] didn't think VR graph could be well diagnosed heart malformation, this had difference with this research results. In this study, all the CT diagnosis of extra-cardiac abnormalities display very well in VR images. MIP map are susceptible to interference of high density structure such as the bone and calcification, having relatively poor space in obtaining the 3D images, choosing as far as possible the thick part of the volume data in favor of revealing the extra-cardiac malformation. MPR have 5 regular restructuring postures, including axial, coronal and sagittal, short-axis, long-axis. MPR is two-dimensional images can show the local situation of the blood vessels through different plane, but not perfectly in the outline of the blood vessels. The MPR is most suitable to observe the relationship between blood vessels and surrounding tissues, show vascular stenosis or expansion of the position, length and degree, and also is the first choose to observe the intra-cardiac malformation and heart vascular cavity structure joint malformation, which can view in the long axis and short axis of the heart, and in favor of the observation of atrial and ventricular septal defect, semilunar valve, and so on.

Due to MDCT has realized the isotropic scanning, it has completely changed the condition that the CT image only can be observed in cross-section instead of all-round display of each part of the heart anatomy. The powerful post-processing software can get the equal quality of reconstructed image and original cross-sectional image completely, which can make the MDCT display complex cardiovascular anatomical structure of cardiovascular connection department and peripheral vascular malformation excellently[10.11]. In this study, there were 69 places of cardiovascular connection department and heart peripheral vascular malformations, the 64-slice spiral CT made right diagnosis of 67 places and missed two places. One place of missing was coronary artery right ventricular fistula, due to the fistula was very small. Another was the pulmonary atresia, it didn't adopt the ECG-gate scanning technology because of infant and misdiagnosed as pulmonary stenosis because artifact of pulmonary valve. From this data, according to the result of 64-slice spiral CT used in examination of cardiovascular connection department and peripheral vascular malformation, the accuracy was 97.10% (67/69), the result had high accuracy which corresponded with the result of Chinese scholar Huang

Meiping (97.4%)[5,12]. The result further showed that 64-slice spiral CT could well display room and the connection part of the position, shape of atrioventricular and large vascular space position and also could show congenital heart disease combined with the coronary artery origination malformation clearly, which was helpful to the correct diagnosis of coronary artery lesions.

From what has been discussed above, when it was highly doubted the cardiovascular connection and peripheral vascular malformations, the 64-slice spiral CT could be used as modality examination of the extra-cardiac malformation in the complex congenital heart disease.

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