Assessment of Cardiovascular Malformation in Patients with Complex Congenital Heart Disease with Diminished Pulmonary Blood Flow by Dual Source Computed Tomography

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Abstract

This study aimed to investigate the clinical value of DSCT in the preoperational assessment of the cardiovascular malformation in patients with the complex congenital heart disease of diminished pulmonary blood flow in China.

130 patients' scheduled for operation because of suspected or definited complex congenital heart disease with diminished pulmonary blood flow were examined by DSCT and echocardiography. The intra-cardiac and extra-cardiac cardiovascular malformation were observed according to the Van Praagh Segment analytical method.

There were 493 places of malformation for all the 130 patients, of which 205 intra-cardiac malformation and 288 extra-cardiac malformation. (1)189 of 205 intra-cardiac malformation were diagnosed by DSCT, the diagnostic accuracy was 92.2%, and the echocardiography' was 95.61% (196/205), there was no significant difference between them ($\chi 2=2.087$, $P>0.05$). (2) Of the 288 places of extra-cardiac malformation, 276 places were directly diagnosed by DSCT and the diagnostic accuracy was 95.83% (276/288), and the echocardiography' was 82.99% (239/288), there was significant difference ($\chi 2=25.101$, $P<0.01$). (3)For all the 493 places of cardiovascular malformation, the diagnostic accuracy of DSCT and echocardiography were 92.90%, 88.24%, respectively, there was significant difference ($P<0.05$).

Compared with echocardiography, DSCT is superior in quantitative assessment of the extra-cardiac malformation but reverse for the intra-cardiac malformation, DSCT combine with echocardiography could positively improve the diagnostic accuracy of complex congenital heart disease with diminished pulmonary blood flow.

1. Introduction

The pulmonary blood flow decrement is characterized in patients with complex congenital heart diseases with diminished pulmonary blood flow, accounting for about one-third of congenital heart disease. There are 30-40 thousands children of complex congenital heart disease with diminished pulmonary blood flow born every year in China. The success of right ventricular outflow tract reconstruction (RVOFT recons) always depends on pre-operation diagnosis. It is very important for operation and prognosis to find out the anatomic morphology and changes of pulmonary homodynamic pre-operation, unnecessary surgery can be avoid, the risk of surgery will be reduced, and survival rate improved. In our study, 130 patients of complex congenital heart diseases with diminished pulmonary blood flow underwent both DSCT and echocardiography. DSCT would be assessed in clinical value.

2. Methods

2.1. Subjects

From February 2009 to February 2011, DSCT and ECHO were performed in 50 patients with complex congenital heart disease with diminished pulmonary blood flow at Guangzhou General Hospital of Guangzhou Military Command of PLA, Guangzhou, China. The patients including 72 males and 58 females, aged 4/12 to 19 years (mean 6.79 ± 4.13 years), heart rate 57-152 times/min (mean 112.55 ± 23.34 times/min). The clinical symptoms of the oral lip cyanochroia and acropachy could be seen, and Ⅲ-Ⅳ degree systolic murmur heard at cardiac auscultation region in all patients. The renal inadequacy was ruled out before examination.

2.2. Dual-source computed tomography

The scanning was completed with retrospectively electrocardio-gating scanning mode by DSCT (SOMATOM Definition, Simens). The patients less than six year or noncooperators must been mitigated before scanning and scanned under quiet breathing state, while more than six year or cooperators were trainned breath-holding before scanning and scanned under breath-holding state. The scanning ranged from superior aperture of thorax to 5.0 centimeter under diaphragm. Bolus tracking and smart trigger scanning were used during scanning. The threshold value was about 150-200Hu, delayed 3-6 seconds. Tube tension and tube current were definited according to age, weight of patients' individuation. The observation of scanning imaging should carry out by the horizontal axis, coronal and sagittal views after raw data transmitted to post-processing workstation, and the structures could be observed after imaging reconstituted through multi-planar reconstruction (MPR), maximum intensity reformation (MIP) and volume rendering technique (VR).

2.3. Echocardiography

All patients underwent echocardiography (Vivid7 color Doppler echocardiography, American GE, transducer frequency 3.5MHz) examination. The measurements of echocardiography were examined prostration or at left decubitus and operated by a senior physician. Heart structure was observed on parasternal long or short axis view, apical two chamber and four chamber views, parasternal short axis view of the great artery, and suprasternal short axis view.

2.4. Data and statistical analysis

The data acquired by DSCT and echocardiography were analyzed by a Chi-square test using SPSS 16.0. A P value of less than 0.05 was considered statistically significant.

3. Results

There were 493 places of malformation for all the 130 patients, of which 205 intra-cardiac malformation and 288 extra-cardiac malformation.

189 of 205 intra-cardiac malformation were diagnosed by DSCT, the diagnostic accuracy was 92.2%, and the diagnostic accuracy was 95.61% (196/205) using echocardiography, there were no significant difference between DSCT and echocardiography ($\chi 2$=2.087, P>0.05).

Of the 288 places of extra-cardiac malformation, 276 places were directly diagnosed by DSCT and the diagnostic accuracy was 95.83% (276/288), and the echocardiography' diagnostic accuracy was 82.99% (239/288), there was significant difference between DSCT and echocardiography ($\chi 2$=25.101, P<0.01).

For all the 493 places of the cardiovascular malformation, the diagnostic accuracy by DSCT and echocardiography were 94.32%, 88.24%, respectively, there were significant differences between DSCT and echocardiography in the assessment of cardiovascular malformation (P<0.05), see Table 1.

	DSCT accuracy	Echo accuracy	χ^2	P
Intro-	92.2%	95.61%	2.087	0.149
Extro-	95.83%	82.99%	25.101	0.000
All	94.32%	88.24%	11.465	0.001

Table 1. Diagnostic accuracy of DSCT and echocardiography.

4. Discussion and conclusion

Complex congenital heart disease with diminished pulmonary blood flow includes a variety of the complex malformation, which not only includes the malformation of heart structure itself, such as atrio-ventricular septal defect, atrial and ventricular abnormalities, but also the vascular development abnormalities, for example, aortic stenosis, interruption, overriding, pulmonary stenosis, occlusion, pulmonary arteriovenous fistula, patent ductus arteriosus, abnormal origin of coronary artery and venous anomalous drainage, etc. Besides the complex anatomical deformity, it often has severe homodynamic changes to make a diagnosis difficult. It is necessary to combine other examinations to make a correct diagnosis.

Angiocardiography used to be the gold standard for most complex congenital heart disease, as well as an indispensable examination in clinical. But it is invasive and radiation exposure, its application is limited in clinical settings [1].The echocardiogram is undoubtedly the preferred method of examination for CHD at present, which is identified by European Society of Cardiology association [2]. Especially, echocardiography has obvious advantages in the patent foramen ovale, valve leaflets, accessories and valves vegetation, etc. However, echocardiography is often affected by acoustic window and operators. Axis view of cardiovascular examinations such as MRI and CT is considered to have changed the diagnosis and follow-up in congenital heart disease [3]. MRI "one-stop shopping" scanning can fully assess the heart anatomy connection, ventricular function, cardiac activity, haemodynamics and vascular imaging, without ionizing radiation. However, MRI scanning is too long time. Many patients, especially children are difficult to hold on, and it is prohibited for adult patients with metal and magnetic materials such as pacemaker and

defibrillator. In addition, it is unsatisfied in observing the structure of valve cusp. MSCT has become one of the most potential and valuable non-invasive cardiovascular examinations, which is characterized of high-speed, large-scale, high temporal and spatial resolution, and wonderful post-processing techniques. It can display the cardiac and great vascular in one scan [4]. Currently, MSCT has been recognized in clinical diagnosis for infants with congenital heart disease [5-8]. The Asia association of cardiovascular imaging suggests that cardiac CT examination is the first choice and the follow-up means to Kawasaki disease and the complex congenital for Asian. In addition to some special cases, cardiac CT examination is a one-stop shopping proprietary assessment method for coronary artery disease [9].

In our study, the diagnostic accuracy for the intra-cardiac and extra-cardiac malformations orabnormalities by DSCT was significantly higher than that of ECHO. The combination diagnostic accuracy of DSCT and ECHO is higher than any one single method.

According to the literatures, the misdiagnosis mainly includes ASD (atrial septal defect), VSD (ventricular septal defect), and valve or valve ring lesions by DSCT. It is difficult to show less than 5mm septum defects in diameter by multi-slice CT [10, 11]. However, in our study 3 cases of 2mm ASD and 1 case of 2mm VSD have also been clearly demonstrated, but one case of 2mm ASD was missed by echocardiography.

The diagnostic accuracy rates of DSCT were 95.83% in extra-cardiac abnormalities. Foreign scholars have suggested that CT can be used to further clarify the anatomical structural abnormalities and alternate cardiac catheterization, due to that the diagnostic accuracy was higher by CT than by echocardiography [12] in children with congenital heart disease.

Our study contains 10 cases transposition of the great arteries (TGA), of which one of ten patients complete transposition of great arteries was misinterpreted as partial transposition of great arteries by DSCT, while two of ten patients were misdiagnosed by ECHO. In addition, one case with double outlet of right ventricle was misdiagnosed as single right cardiac ventricle by DSCT.

DSCT is a safe, convenient, fast, effective and non-invasive tool for children with CHD, which can clearly demonstrate the cardiac pathological morphology particular extra-cardiac vascular abnormalities in compared with ECHO. Therefore, it is important to be diagnosed by DSCT in CHD.

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