Study on the Pulmonary Artery Development 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 pre-operation in the assessment of the pulmonary arteries in the complex congenital heart disease with diminished pulmonary blood flow and compared with echocardiography in China.

79 patients scheduled for operation, who were suspected or definite complex congenital heart disease with diminished pulmonary blood flow were examined by both DSCT and ECHO. 3 aspects reflecting pulmonary artery' developmental capacity were concerned, including the pulmonary artery trunk, left pulmonary artery and right pulmonary artery, whose results were subjected to statistical analysis using Pearson's correlation and t-test analysis compared with that of echocardiography.

The pulmonary arteries could be clearly observed from original images and reconstruction images. There were no significant differences between DSCT and echocardiography for the non-invasive assessment of pulmonary artery anatomy (P>0.05). The measurement parameters correlate well by DSCT and echocardiography (P>0.05).

Compared with echocardiography, DSCT is superior in quantitative assessment of pulmonary artery' developmental capacity, therefore it would be helpful to evaluate the pulmonary development condition preoperation of the complex congenital heart disease with diminished pulmonary blood flow.

1. Introduction

The complex congenital heart disease with diminished pulmonary blood flow is a severe complex cyanotic congenital heart disease. The pulmonary artery and its branches often underdeveloped the reduction of the pulmonary blood flow and pulmonary artery pressure at long-term. Those congenital heart diseases could give rise to high mortality. Cardiac surgery can reduce mortality, which needs to evaluate the developmental condition of pulmonary artery as an important indicator of pre-operation.

The main contents of assessing development of the pulmonary artery trunk include main pulmonary artery, left and right pulmonary artery, its continuity and primary pulmonary collateral vessels.

In our study, to explore the quantitative assessment, the pulmonary artery development were analyzed by dual-source computed tomography (DSCT) in comparison of the echocardiography (ECHO) and the findings of the operation in 79 patients with the complex congenital heart disease with diminished pulmonary blood flow.

2. Methods

2.1. Subjects

From February 2009 to February 2011, 79 patients, who were suspected or definited with diminished pulmonary blood flow, were underwent DSCT and 2D-ECHO, of which 43 male and 36 female. Their age ranged from 4 months to 19 years (average 7.35 ± 5.95 years). Heart rate varied from 57 bpm to 152 bpm (average 115.59 ± 34.72 bpm), height from 57cm to 170cm (average 113.59 ± 34.98cm), and weight 6kg to 59kg (average 29.63 ± 1.69kg). The clinical symptoms and physical signs are as follows: cyanoderma, acropachy, grade III-IV systolic murmur could be heard at auscultation. The renal inadequacy was ruled out before DSCT examination.

2.2. DSCT

The DSCT (SOMATOM Definition, Simens) scanning was completed with retrospectively electrocardio-gating mode. The patients less than six-year-old or non-cooperators must to be sedative under quiet breathing state, while more than six-year-old or cooperators were trainned breath holding. The scanning ranged from the superior aperture of thorax to 5.0 centimeter under diaphragm. Bolus tracking and smart trigger scanning were used. The threshold value was about 150-200Hu, delayed 3-6 seconds. Tube tension and tube current were definited according to age, weight of individual. The DSCT scanning should carry out by horizontal axis, coronal and sagittal views after raw data transmitted to post-processing workstation, and the whole pulmonary artery development could be assessed through multi-planar reconstruction (MPR), maximum intensity reformation (MIP) and volume rendering technique (VR), including the pulmonary artery trunk, left pulmonary artery and right pulmonary artery.
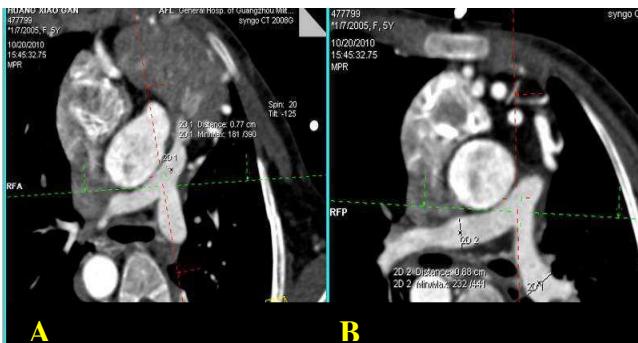

Figure 1. Illustration of assessing the whole pulmonary artery development by DSCT.

2.3. Echocardiography

All patients underwent echocardiography (Vivid7 color Doppler echocardiography, American GE, transducer frequency 2.5MHz) examination. To observe the pulmonary artery development, the connection of the right ventricular to the pulmonary artery, the blood flow from pulmonary artery trunk and it's branches could be shown on long and short axis, 2-chamber and 4-chamber views, as shown in Figure 2. Echocardiography was operated by the senior physician.

2.4. Data and statistical analysis

The index of the pulmonary artery trunk and branches acquired by both DSCT and ECHO were compared by a Chi-square test using SPSS 16.0, and the data with mean ± deviation. A P value of less than 0.05 was considered statistically significant.

(A)

(B)
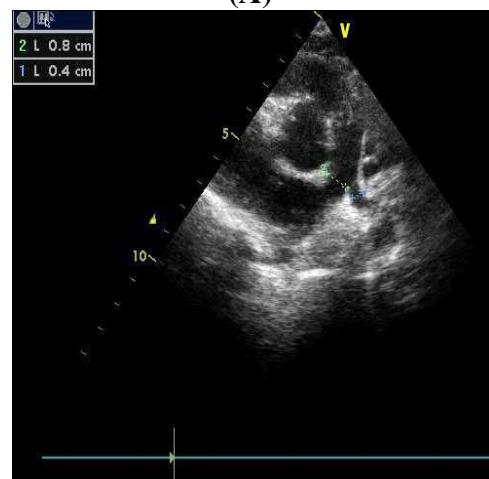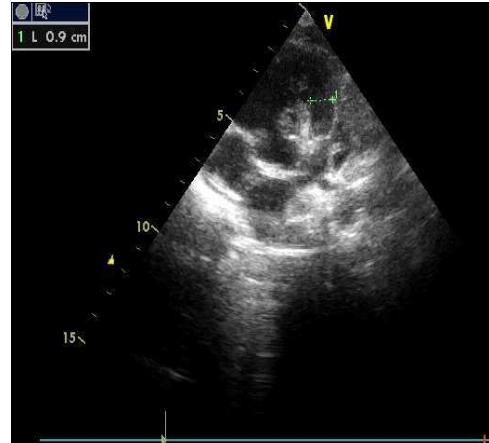
Figure 2. Illustration of assessing the whole pulmonary artery development by ECHO.

3. Results

Findings of the surgery indicated that the central pulmonary trunk were absent in 30 patients with pulmonary atresia and 3 in the left pulmonary arteries. These findings were correctly identified on CT in all patients and on ECHO in 77 patients. (In one patient, collaterals were misinterpreted as branch pulmonary arteries; in the other patient, severe pulmonary stenosis were misinterpreted as pulmonary artesia). ECHO confirmed the ductus and the lack of confluence of the branch pulmonary arteries. Neither DSCT nor ECHO detected the stenosis of the left branch pulmonary artery adjacent to the ductus that was found during the surgery.

The pulmonary arteries could be clearly observed from the original imaging and reconstruction imaging by DSCT. There were no significant difference between DSCT and that of intra-operation measured of pulmonary artery as well as its branches ($P > 0.05$), shown in Table 1 and 2.

	DSCT	surgery	t-test	
			t	P
PA	12.43±6.90	12.36±6.51	-1.49	0.1
LPA	9.38±4.30	8.96±4.22	-0.67	0.5
RPA	9.19±4.11	8.97±3.87	-0.59	0.6

Table 1. Comparative study on the diameter of pulmonary artery by DSCT and surgery.

*: MPA: The Main Pulmonary Artery; LPA: The Left Pulmonary Artery; RPA: The Right Pulmonary Artery.

	DSCT	ECHO	t-test	
			t	P
PA	12.43±6.90	11.35±6.54	-0.77	0.4
LPA	9.38±4.30	8.29±4.73	-1.11	0.3
RPA	9.19±4.11	8.30±4.01	-1.01	0.3

Table 2. Comparative study on the diameter of pulmonary artery by DSCT and ECHO.

*: MPA: The Main Pulmonary Artery; LPA: The Left Pulmonary Artery; RPA: The Right Pulmonary Artery.

4. Discussion and conclusion

The complex congenital heart diseases with diminished pulmonary blood flow mainly contain the tetralogy of Fallot, tricuspid atresia, pulmonary atresia with ventricular septal defect, and pulmonary atresia or stenosis associated with other complex malformations in clinical practice. It is a kind of the cyanotic congenital heart disease, which needs surgery. It is significant for formulating surgical methods to understand the pulmonary artery development, especially the development of distal pneumogngiogram. For pulmonary atresia, it has great influence on the selection of surgical program for central pulmonary artery, including the inner diameter of the left and right pulmonary artery in mediastinum, whether syzygium and accompanied by stenosis, which is an important medical modality at surgery and follow-up in prognosis [1-3].

The direct signs of pulmonary hypoplasia contain extensively pulmonary artery thinning, part absent, limited stenosis, atresia, and dilation, which are indicated in the diameter of pulmonary arterys. The main index of assessing the pulmonary artery development includes the pulmonary artery trunk, left or right pulmonary artery, and its continuity. The measured diameter of pulmonary artery should have to choose the distal part, and the part of the serious pulmonary stenosis is not in the same position. It is better to point out the narrowest part of the cross-sectional area of the pulmonary artery index to predict post-operation in process.

In our study, measurements of pulmonary artery and its branches referred to retrospective ECG-gated scan mode and selected the end-systolic images [4-5]. Inner diameters of the left and right pulmonary artery both selected the distal level of the first branch diameter of systolic pulmonary artery. In this study, DSCT could obtain good quality images, identify measurement position and detect the pulmonary edge clearly. ECHO has a higher detection rate of the pulmonary artery. The difference between the two methods in pulmonary artery and the left and right pulmonary artery measurements has no statistical significance. The results of our study resemble that of previous literatures [6-7]. But according to global assessment, in this study the average value measured from DSCT is greater than that of echocardiography, however, there are relatively slight differences between the results of surgery and DSCT. Two reasons are considered: Firstly, the literature indicated that pulmonary artery inner diameter measured by ultrasound has different degrees of underestimation than that of measured by cardiac angiography. Pulmonary artery displayed in echocardiography mainly relied on two-dimensional and Doppler flow imaging, which shows unclear pulmonary artery boundaries and is partly dependent on experience. Secondly, DSCT and ECHO choose different measurement points. DSCT cross-section can accurately choose distal pulmonary artery before the first branch to measure, however, ECHO can't show distal pulmonary or illustrate the blur imaging formost patients, In addition, the inner diameter of the distal pulmonary artery is slightly larger than that of the middle segment, therefore the measured diameter is relatively minor.

In general, the diameter of the pulmonary artery is closer to surgery findings in terms of DSCT than ECHO. The outcome of ECHO is relatively minor, so that, it is of great importance for pre-operation diagnosis, surgery, and follow-up by DSCT.

Acknowledgements

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