

Application of Dual Source Computed Tomography in the Assessment of Left Ventricular Function for Complex Congenital Heart Disease with Diminished Pulmonary Blood Flow

Shan-xing Ou¹, Li Zhang¹, Shu-fei Ou¹, Guang-ming Peng¹, Yuan-xing Guo¹, Bin Li², Xiao-rong Li¹, Song-na Li¹, Fang Long¹, Bin-bin Yuan¹, Ye-kuo Li¹, Min Qian¹, Hai-ling Liu¹

¹Department of Radiology, General Hospital of Guangzhou Military Command of PLA, Guangzhou, China

²School of Automation Science and Engineering, South China University of Technology, Guangzhou, China

Abstract

This study was to investigate the diagnosis of DSCT pre-operation about the left ventricular function in complex congenital heart disease with diminished pulmonary blood flow in comparison of 2D-echocardiography.

50 patients scheduled for operation because of suspected or definted complex congenital heart disease with diminished pulmonary blood flow were examined by DSCT. The images were quantitatively assessed. The ejection fraction (EF) and the fraction shortening (FS) of left ventricular function were obtained and statistically analyzed with that of 2D-echocardiography using Pearson's correlation and t-test analysis.

It revealed a strong correlation with DSCT and 2D-echocardiography regarding to the quantification of EF and FS: EF($r=0.825$), FS($r=0.718$). Statistical analysis revealed little systematic underestimation of EF and FS determined by DSCT compared with 2D-echocardiography.

DSCT allows for the accurate assessment of global left ventricular functional parameters disregarding heart rate, it could be a reliable pre-operation evaluation method for the complex congenital heart disease with diminished pulmonary blood flow.

1. Introduction

There are always changes of the hemodynamics of cardiovascular in patients with complex congenital heart disease with diminished pulmonary blood flow because of the dysplasia of the cardiopulmonary vasculature, which will change the cardiac morphology and the left ventricular function, then they will lose a chance to operation because of heart failure. That's why we should

alert the variance of left ventricular function. The purpose of our study is to compare the DSCT with the ECHO in 50 patients with complex congenital heart disease of diminished pulmonary blood flow.

2. Methods

2.1. Subjects

From February 2009 to February 2011, DSCT and 2D-ECHO were performed in 50 patients with complex congenital heart disease of diminished pulmonary blood flow at Guangzhou General Hospital of Guangzhou military Command of PLA, Guangzhou, China. The patients included 24 males and 26 females, aged 4/12 -19 years (mean 6.79 ± 4.13 years), heart rate 57 times / min-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 dual source CT (SOMATOM Definition, Simens). The patients of less than six-year-old or noncooperators must be mitigated before scanning and scanned under quiet breathing state, while more than six-year-old or cooperators were trained 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

defined 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 left ventricular function could be completed after imaging reconstituted through multiplanar reconstruction (MPR), maximum intensity reformation (MIP) and volume rendering (VR) technique. Figure 1 gives the illustration for assessing index of the left ventricular function from DSCT. As shown in Figure 1.



(A)



(B)

Figure 1. Illustration of assessing the index of the left ventricular function by DSCT, A is the diastolic phase, and B is systolic phase.

2.3. 2D-echocardiography

All patients underwent 2D-echocardiography (Vivid7 color Doppler echocardiography, American GE, transducer frequency 3.5MHz, AD-IBS monitoring system, S4 transducer frequency 2-4MHz) at left decubitus. Measurement index included the left ventricular ejection fraction (EF) and fractional shortening (FS), as shown in Figure 2. The examination and measurement of 2D-echocardiography were operated by a senior physician. As shown in Figure 2.

2.4. Data and statistical analysis

Results of the left ventricular function acquired by DSCT and 2D-ECHO were compared via a Pearson's Correlation and a simple Student paired *t* test using SPSS 16.0. A *P* value of less than 0.05 was considered statistically significant.

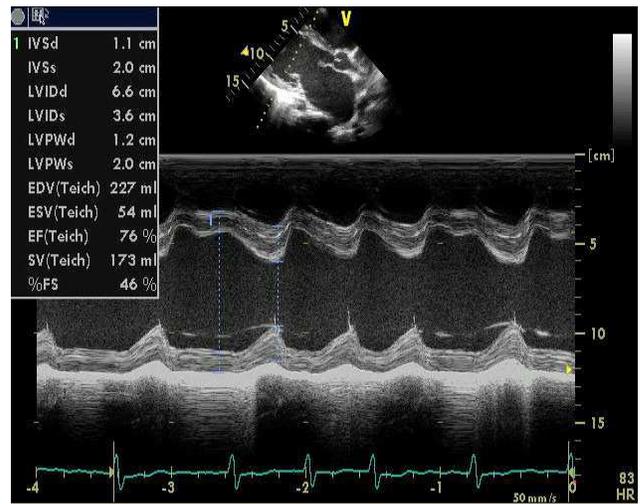


Figure 2. Illustration of assessing the index of the left ventricular function by 2D-ECHO.

3. Results

All the 50 patients underwent examination successfully. According to the Pearson's Correlation, it revealed a strong correlation with DSCT and 2D-echocardiography regarding the quantification of EF and FS: EF: $r=0.825$, DSCT: $(60.85\pm 12.2)\%$, 2D-ECHO: $(62.72\pm 12.20)\%$; FS: $r=0.718$, DSCT: $(30.19\pm 11.95)\%$, 2D-ECHO: $(32.40\pm 8.94)\%$, statistically.

However, according to the simple Student paired *t* test, statistical analysis revealed a little systematic underestimation of EF and FS determined by DSCT compared with 2D-echocardiography, the bias were about EF $(-1.86\pm 2.25)\%$ and FS $(-2.34\pm 2.60)\%$, statistically. See table 1.

| Index | DSCT | 2D-ECHO | <i>t</i> -test | |
|-------|-------------|-------------|----------------|----------|
| | | | <i>t</i> | <i>P</i> |
| EF | 60.85±12.26 | 62.71±12.20 | -0.828 | 0.4 |
| FS | 30.19±11.95 | 32.40±8.95 | -0.094 | 0.9 |

Table 1. Data for the subjects studied. Their means and standard deviations (SDs) are presented.

4. Discussion and conclusion

The index of the left ventricular function showed cardiac function and predicted the morbidity and mortality of the ischemic heart cardiovascular and congenital heart disease.

Generally, the EF and FS of the left ventricular is of great significance as the objective indicators, such as heart imaging diagnosis, which provides important information for physician and surgery. Assessment of the left ventricular function includes a variety of methods, such as ultrasound, angiography, CT, MRI, and radionuclide. With the rapid development of DSCT, it becomes one of the most potential and non-invasive modality [1-6].

The recent studies have showed that DSCT may be partly replaced of the cardiac MRI in the evaluation of cardiac function and left ventricular volume in the future, especially in patients with tetralogy of Fallot or cardiac pacemaker installed [7, 8]. In addition, in the assessment of left ventricular function, DSCT can continuously scan for the whole ventricle to obtain the global cardiac both left ventricular volume and ventricular shape, but echocardiography focus on the ventricular shape. It is very difficult to assess the left ventricular volume and the morphology of abnormal ventricle in patients with complex congenital heart disease. Cardiac function is evaluated as abnormal systolic dysfunction patients with congenital heart disease. There are a good correlation with DSCT and 2D-ECHO, although they quantified left ventricular function based on different principles.

Different assessment methods of the cardiac function, for instance, 2D-ECHO quantitatively evaluate EF by apical section Simpson method which assume geometry of the ventricular cavity and calculate the date in clinical setting, but this assumption in the abnormal form of the left ventricular has limitations. Especially for irregular heart chamber, when heart chamber was expanding or wall thickening, it is hard to assess the left ventricular volume in two-dimensional examination. Except that the accurate results are highly depended on operators' experiences and technique by imagining three-dimensional shape from multi-slice images in 2D-ECHO. Therefore, there is distinct bias of imaging diagnosis between operators.

The assessment of cardiac function based on the volume of region growing algorithm and the distribution of the contrast agent of left ventricular cavity was drawn

by DSCT in accordance with slice by slice without geometry on 2D-ECHO imaging. Recent years, the studies have shown that the cardiac function is evaluated to be more convenient and efficient by RT-3DE on the heart anatomy, pathology, and imaging diagnosis in pitfall of the sound transmission conditions and the quality of two-dimensional image on cardiac spatial information in more details. Besides, there are the width of narrow-angle real-time mode, three-dimensional in the field of view and the wide-angle full-volume imaging mode in respirative motion of the organ and translocation.

In general, the evaluation of the left ventricular function has well correlation between DSCT and 2D-ECHO, without cardiovascular angiography, cardiac catheterization, and MRI for left ventricular function, there are distinctive differences such as overestimate or underestimate by DSCT, which can not obtain the hemodynamic and ventricular pressure. In addition, the patients have to exposure to radiation during the CT scanning.

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Address for correspondence.

Dr Shan-xing Ou
General Hospital of Guangzhou military command of PLA
Liu Hua Road 111, Guangdong
Guangzhou
China, 510010
E-mail: oushanxing@sina.com