Evaluation of right heart function with use of retrospectively ECG-gated 64-slice low dose computed tomography in subjects with and without pulmonary hypertension

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Aims and objectives

Pulmonary hypertension (PH), Cor pulmonale, with a high case fatality rate, is the fourth highest cause of death in the world at present. It is usually complicated by changes of structure and function of the right ventricle and thus further affects functional changes of the left heart. Therefore, evaluation of left and right ventricular functions may provide a useful objective basis for treatment of pulmonary hypertension (PH), cor pulmonale patients for the final purpose of delaying disease progression, improving quality of life, and prolonging life of the patients.1

In recent years, retrospective electrocardiographic (ECG) gating has been extensively employed in non-invasive coronary CT angiography (CCTA).2,3 Using the helical scan technique, the image data of the whole cardiac cycle can be continuously acquired. Thus, the additional end-diastolic and the end-systolic images can be reconstructed retrospectively from the same group of data for the purposes of left and right heart function measurement.4 Previous reports have revealed that it is feasible to use multi-slice helical CT to assess left and right heart function.5-8 It is not known has been no study on CT for evaluating left and right heart functions in cor pulmonale patients. At the same time, the CT research community has made a significant effort to reduce the radiation dose. We present the initial performance evaluation of the iDose (Philips Healthcare) reconstruction algorithm because our institution was provided with a prototype of the iDose system. iDose is a hybrid iterative reconstruction algorithm that provides reduced image noise compared with the conventional filtered back projection (FBP) 9. Therefore, the purpose of this study was to take advantage of 64-slice multidetector computed tomography (MDCT) low dose angiography to diagnose right heart dysfunction. With the use of non-invasive assessment 64-slice MDCT, we compared the right heart function and pulmonary artery diameter in individuals with and without pulmonary hypertension (PH).
Methods and materials

Subject recruitment

For this prospective study, from April 2014 to November 2014, 46 consecutive patients (21 with PH and 25 without PH, mean age (63±45 years, range 43 to 99 years) determined by the pulmonary function test, clinical examination, chest radiograph, and echocardiogram, were referred for retrospective electrocardiographically (ECG)-gated 64-slice low dose Computed Tomography. The patients with clinical and instrumental evidence of chronic cor pulmonale and pulmonary arterial hypertension secondary to chronic obstructive pulmonary disease (COPD) defined by the American Thoracic Society classification10 were studied. The exclusion criteria of this study included primary heart disease, myocardial infarction, atrial fibrillation, heart failure, allergy to iodinated contrast agent, renal failure.

MDCT examination

21 patients with cor pulmonale and 25 patients without COPD or cor pulmonale were examined using a high-definition CT system (Philips Ingenuity core 128CT, Holland) according to the following protocol: non-contrast axial CT scan of the lung, followed by retrospective gating coronary CT angiography (CCTA) within a single breath-hold. No special medicine control of the heart rate the examination. The patient's ECG trace was simultaneously recorded. The cardiac scan parameters were as follows: 100 kV, 150-500 mA, with idose 4 iterative reconstruction technique to reduce the radiation dose. Number of detectors was 64, tube rotation time was 0.4 s/360° with an individual detector width of 0.625 mm, a total z-axis coverage of 40 mm per rotation, a pitch factor 0.2, and a scan range from the root of aortic to the level of costophrenic angle. The iodinated contrast media (CM) (Ultravist 370 mgI/ml) was administered intravenously using a double-head power injector through a 20-G venflon in the antecubital vein. In this study, a multiphase contrast/saline mixture injection with dual-flow technique was used to measure right ventricular function. First 50-60 ml CM bolus, followed by 50 ml contrast/saline mixture at a ratio of 80:20 biphasic injection, was used. The contrast media was diluted with saline in order to reduce the streak artifact in the right heart caused by a high concentration of contrast.

MDCT data analysis

In order to identify the maximum systolic contraction and diastolic relaxation phases, we reconstructed ten image sets#0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°#, the end-systolic phase was 40°, the end-diastolic phase was 90°. The slice thickness of the MPR was 3 mm without a gap, resulting in complete coverage of the right ventricles from the base to the apex. This required 16 slices.
Two radiologists evaluated all ten image sets volume of the right ventricle independently using commercially available software (Cardic Function, Philips Healthcare). The epicardial and endocardial contours of the RV (Figure 1) of all the systolic and diastolic short-axis reformation images were manually traced on the screen. Both papillary muscles and trabeculations were considered as a part of the RV cavity. The EDV, ESV, stroke volume (SV), and ejection fraction (EF) of RV were obtained from the graph using the analysis software. The measurement of the diameter of main pulmonary artery (MPA), left pulmonary artery (LPA), right pulmonary artery (RPA) and lower right pulmonary artery (LRPA) were performed from original axis film of the largest part of slice (Figure 2).

**Echocardiographic examination**

A M-mode, two-dimensional echocardiographic examination and Echo-doppler were attempted with patients to get the LVEF and RVEF.

**Statistical analysis**

The average value was analyzed with the SPSS statistical software package (SPSS for Windows, version 16.0; SPSS, Chicago, IL, USA). The results are expressed as mean ± standard deviation (SD). An independent sample t test was used to compare EDV, ESV, EF of RV and LV among the cor pulmonale group and control group. P values less than 0.05 were considered statistically significant. Linear correlation analysis was determined to compare the ejection fraction of RV and LV between CT and echocardiographic examination.
Fig. 1: RV diastolic short-axis reformation image

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Fig. 2: RV systolic short-axis reformation image

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Fig. 3: The diameter of main pulmonary artery (MPA) and right pulmonary artery (RPA) 

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Fig. 4: The diameter of left pulmonary artery (LPA)

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**Fig. 5:** The diameter of lower right pulmonary artery (LRPA)

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Results

We found RV end-diastolic volume (RVEDV), RV end-systolic volume (RVESV) were significantly larger in PH patients than in the control group (P < 0.05); however, the left ventricular EDV (LVEDV) and LVEF were significantly lower in PH patients than in controls (P < 0.01). The right ventricular ejection fraction (RVEF) was significantly lower in the PH patients than in controls (P < 0.01). In comparison with the control group, the PH group had significantly higher diameter of main pulmonary artery (MPA), right pulmonary artery (RPA) and left pulmonary artery (LPA) (P < 0.05). The lower right pulmonary artery (LRPA) was not significantly different. There were strong correlations between MDCT and echocardiography, rRVEF = 0.73 and rLVEF = 0.76, respectively. The effective dose of MDCT was (11.89±0.41) mSv.
Conclusion

MDCT can accurately quantify RV and LV function. The diameter of MPA, RPA and LPA might be useful during diagnosis in patients who have right heart dysfunction.
References


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