Mitral Valve Regurgitation: Assessment with Dual Source Computed Tomography

Liping Yao [1,4], Kun Sun [3], Xin Yang[4],Sun Chen[3], Linwei Yu[2], Ming Liu[2]

[1]Department of Ultrasound, Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China
[2]Department of Radiology, Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China
[3]Heart Center, Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Shanghai, China
[4]Biomedical Engineering Institution Affiliated to Shanghai Jiaotong University, Shanghai, China

Abstract

To evaluate diagnostic accuracy of dual source computed tomography (DSCT) for evaluation of mitral valve regurgitation (MR) with transthoracic echocardiography (TTE). We evaluated a total of 60 patients who underwent both DSCT and TTE. According to Doppler echocardiography, we divided the patients into two groups: 40 with MR and 20 without MR. We assessed the presence and severity of MR on the basis of systolic regurgitant orifice size on DSCT images and compared the results with two-dimensional Doppler echocardiography. We graded the morphology of the mitral apparatus of the 40 patients with MR using Real-time three-dimensional echocardiography（RT-3DE ）and DSCT. Features such as calcification, valve thickening, valve prolapse, flail leaflet movement and local limitation of stretching on DSCT images were used to diagnose each patient and the results were compared with RT-3DE findings. Diagnosis of MR by DSCT was in good agreement with traditional two-dimensional Doppler echocardiography (Kappa = 0.883, P < 0.01); for the severity of MR, the correlation coefficient between the two methods was 0.94. DSCT was able to diagnose five different types of pathologic morphology with no statistically significant difference to RT-3DE. DSCT can provide quick, multi-angle, multiphase observation of the mitral valve. Also DSCT can accurately assess the severity of regurgitation and pathologic morphology in MR disease.

1. Introduction

The mitral valve may be involved in various acquired or congenital conditions with resultant regurgitation or stenosis, and many of these conditions can be identified with CT imaging. At present, cardiac computed tomography is mainly used in the diagnosis of coronary artery disease, but in many studies, good results were observed for the evaluation of mitral valvular morphology and function. CT are increasingly important adjuncts to echocardiograph for the evaluation of mitral valve disease [1].

Many studies have demonstrated the use of CT technology to diagnose mitral valve disease [2,3,4,6,7,8]. Among these researches, more about mitral valve calcification and mitral valve prolapse. The aim of our study was to evaluate diagnostic accuracy of DSCT for evaluation pathological structures in the mitral valve and the severity of MR with TTE.

2. Materials and methods

2.1. Study population

The study involved 60 subjects. All subjects were referred to our clinic by their physicians for coronary CTA. In 40 MR cases (mean age: 64.24 ± 10.36 years), MR was diagnosed by 2D echocardiography (2DE); the remaining 20 were found not to have MR. The exclusion criteria for this study were: renal insufficiency, previous use of iodinated contrast history of allergy, serious arrhythmia, New York Heart Association class IV disease, mitral stenosis and poor echocardiographic acoustic window. For each patient, image acquisition was completed within 24 h.

2.2. TTE protocol

2DE was performed on all subjects. The severity of MR was defined according American College of Cardiology/American Heart Association guidelines. The regurgitant jet area (RJA) and left atrial area (LAA) were

measured three times in the same systolic frame and mean values calculated. RJA/LAA ratios less than 20% suggest mild regurgitation, 20–40% suggests moderate regurgitation and > 40% suggests severe regurgitation.

40 MR patients were examined on a Philips ie33 system (Philips Medical Systems, Andover, MA, USA). The cardiac image was obtained in full volume mode. Using QLAB 7.0 analysis software, we selected frames of interest and adjusted the original random plane to the following planes: (1) mitral annulus plane: shows the mitral annulus clearly, through the mitral valve closure line and two commissures; (2) closed line plane: perpendicular to the mitral annulus plane, through the mitral valve closure line and the apex; and (3) valve sagittal plane: vertical to (1) and (2), perpendicular to the mitral valve closure line, clearly shows the mitral valve closure point and both sides of the valve .

We froze the moving image when the mitral valve closure gap was clearly seen in its maximal position, then moved the mitral annulus plane in a parallel manner to view the minimal regurgitant orifice area (ROA); this was outlined and the ROA measured. The severity of regurgitation was classified as follows: mild, ROA < 0.2 cm2; moderate, ROA 0.2–0.39 cm2; or severe, ROA ≥ 0.4 cm2.

We used the images to determine whether any of the following conditions were present, as follows: 1) calcification 2) leaflet thickening 3) valve prolapse 4) leaflet flail-like movement and 5) valve stretching locally limited. The six mitral valve partitions (anterior leaflet: A1, A2 and A3; posterior leaflet: P1, P2 and P3) were observed and the pathological scallop recorded. (Fig.1)

2.3. DSCT image acquisition and processing

All cardiac CTA images were obtained using a DSCT system (Somatom Definition; Siemens Medical Solutions, Forcheim, Germany) with 64×0.6 mm collimation and a gantry rotation time of 330 ms (mA=560, kV=120). None of the patients was taking beta-blockers before the examination. Retrospective ECG-triggered images were obtained from the level of the carina to the diaphragm during one breath hold. Coronary and left ventricle enhancement was achieved by intravenous injection of contrast agent (350 mg I/ml Omnipaque; GE Healthcare, Shanghai, China) . Images were selected from 10 preview series at 10% intervals throughout the RR interval with 0.75 mm slice thickness. The reconstruction kernel was set to a B26f Heartview smooth kernel and the field of view was 180×180 mm2.

Syngo Circulation and Inspace processing software was used to process the images. The original coronal sections, sagittal sections and cross-sections were adjusted to mitral valve ring sections, closure line

sections and valve sagittal sections in CINE-MODE with slow playback of the 10 sequences. The best image appeared to freeze, and we then adjusted the section to measure the required parameters. The observations made were as for RT-3DE.
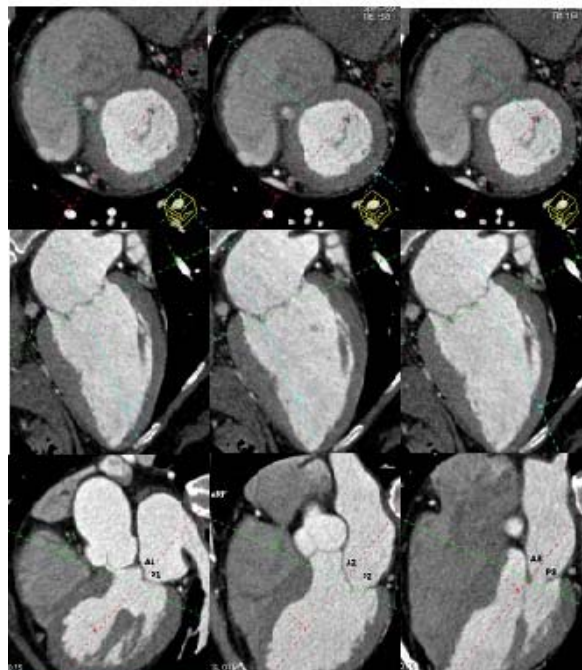

Fig. 1 The first row of the figures show the blue section line were placed in three corresponding region of the mitral valve, the second and third rows show the corresponding mitral valve scallops. anterior leaflet: A1, A2 and A3; posterior leaflet: P1, P2 and P3 were observed.

2.4. Statistical analysis

All data were processed using SPSS 12.0 statistical software. McNemar's test was used to compare diagnostic performance. The results of TTE and DSCT were evaluated using kappa statistics. Differences in the diagnosis of lesions between RT-3DE and DSCT were compared with Wilcoxon's rank test. Statistical significance was set at $P < 0.05$.

3. Results

The mean radiation dose in this patient cohort was 22.1 ±3.1 mSv.

43 cases were diagnosed by the ROA on DSCT images and three cases were misdiagnosed among 60 subjects; the specificity was 85.0% and the sensitivity 100%. Agreement between TTE and DSCT was good, with a kappa value of 0.883 for the identification of MR. There was also a good agreement between the severity of MR

determined by the ROA on DSCT and by RJA/LAA on 2DE, with a Spearman's rank correlation coefficient of 0.94 (P < 0.01).

According to Wilcoxon's rank test, there was no significant difference in two imaging methods to determine the pathologic scallop. In all cases, P < 0.05 and kappa values were > 0.4, indicating good consistency between RT-3DE and DSCT. There were also no significant differences between RT-3DE and DSCT in the diagnosis of the different types of pathology (Z = –0.271, P > 0.05).

4.　　　Discussion

This study assessed the ability of DSCT to characterize mitral valve morphology and conformed regurgitation using echocardiography as reference standards. Our results suggest that DSCT had good operating characteristics for identifying patients with MR.

Clinically, 2DE is the most widely used method for the diagnosis of mitral valve disease. Until the invention of the 3D volume probe, we were able to obtain views of the entire mitral apparatus from the atrial or ventricular side and to locate the mitral apparatus in three dimensions. Agreement between the depiction of lesions on 3DE and surgical results are up to 90–95%, which is much higher than the accuracy of 2DE diagnosis [10,11,12,13]. Therefore, examination of the mitral valve was conducted using RT-3DE as the standard, to test the accuracy of diagnosis by DSCT. We observed the mitral valve from the left atrial surface and the long axis of the surface, layer by layer [5,14]. The left atrial surface is suitable for observation of the whole valvular motion and pathologic scallop. The section of the left ventricular long axis perpendicular to the mitral valve closure line is adjustable and therefore can be used to evaluate the activity of the mitral valve leaflets. In addition, the shallow trench between the valve leaflets can be used to identify the anterior and posterior leaflet, and to locate the dislocation of the valve; thus, the most accurate regurgitation orifice can be identified and a comprehensive view of the 3D structure is ensured.

Using planimetric measurements of the regurgitate orifice area, Alkadhi et al [15] revealed 16-detector row CT enable quantification of MR. In our study, using regurgitation jets seen on 2DE as the reference standard, we misdiagnosed three cases of MR on DSCT images. Misdiagnosis may be due to the mitral annulus not being cut down enough, with the closed edge of the valve being misidentified as a regurgitation orifice. However, on the whole, the severity of MR evaluated by DSCT ROA and 2DE RJA/LAA were in a good agreement. At present, many studies have assessed the diagnostic accuracy of CT in detecting mitral valve disease. Nina Ghosh et al [3] revealed cardiac CT had excellent diagnostic accuracy for detecting the presence or absence of mitral valve prolapse.

The study of Smith et al [6] showed in patients with degenerative mitral valve disease, DSCT demonstrated excellent agreement with intraoperative findings. Aguilar et al [16] presented that CT and MRI were likely to provide greater insights into the pathophysiology of valvular heart disease. In our study, we also had good results in five pathologic morphology changes of mitral valve.

In this study, the number of valve thickening diagnosed by RT-3DE was greater than the number diagnosed by DSCT, which may be attributed to pseudo-thinning of valve because of accumulation of contrast agent during coronary imaging. However, valve thickness on ultrasound images is closely related to the NyQuest limit, and a large number of false positives will thus be generated when the adjustment is too low.

According to the study of Ghosh N [3], it has confirmed that the use of cardiac CT can identify mitral valve prolapse, and suggested that CT is limited to distinguish pathological scallop compared to echocardiograph. Our study also found no significant differences between RT-3DE and DSCT images in their validation of five pathological morphology of the mitral valve. Furthermore, the two modalities have a good agreement in distinguish pathological scallops in our study. The difference is that we used DSCT, while Ghosh used 64-detector CT to study, and the image quality of DSCT is superior to that one.

5.　　　Conclusions

DSCT is non-invasive and allows the use of multiple sequences for an accurate assessment of the degree of regurgitation and determination the mitral valve pathological changes.

Acknowledgements

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Address for correspondences.
sunkun@xinhuamed.com.cn ,itaa2004@sina.com.