ADDITIONAL DATA OF LEFT VENTRICULAR FUNCTION FROM 16 SLICED MDCT IN PATIENTS WHO UNDERWENT CORONARY CTA: COMPARING WITH ECHOCARDIOGRAPHY

Sutipong JONGJIRASIRI, MD,[1] Laorporn PAWAKRANOND, MD,[1] Mallika WANNAKRAIROT, MD,[2] Patcharee PAIJITPRAPAPORN, MD,[2] Jiraporn LAOTHAMATAS, MD,[1] Nithi MAHANONDA, MD.[2]

ABSTRACT

PURPOSE: To compare the left ventricular (LV) function data obtained from coronary computed tomography angiography (CTA) to the data obtained from echocardiography.

MATERIAL and METHODS: Twenty patients (15 males and 5 females) with mean age of 62.9 years (49 to 79 years) were performed coronary CTA using 16 sliced multi-detector computed tomography, with 8 cardiac phases of data collection and echocardiography within an average of 5.5 day period without intervening acute cardiac event or any intervention between CTA and echocardiographic study. The LV function data was calculated semiautomatedly using vendor software, including ejection fraction (EF), end systolic volume (ESV), end diastolic volume (EDV), and stroke volume (SV). The wall motion evaluation was obtained, using short axis CINE loop at the apical, middle, and basal segments. The study was reviewed by experienced cardiac radiologists. The data was compared with data from echocardiography.

RESULT: Good correlation of the EF was found between CTA and echocardiography, with concordance correlation coefficient of 0.7. Mean EF of CTA and echocardiography were 69.8+/-9.0 (48.5 to 83.5) and 68.3+/-7.9 (46.7 to 81.3), respectively.

High agreement of CINE LV wall motion evaluation between CTA and echocardiography was found, with overall agreement of 92.81% (297 in 320 segments), and negative predictive value of 98.66%(295 in 299 segments).

Additional data of LV function was also obtained from CTA, including EDV 94.1 +/-23.8 (53.4 to 146.5), ESV 29.3+/-13.1 (8.8 to 54.6), and SV 65.3+/-15.6 (44.6 to 93.9).

CONCLUSION: Good correlation of EF and high agreement of CINE LV wall motion evaluation between CTA and echo were found. LV function analysis data can be used as a reliable noninvasive imaging modality and also as an addition to noninvasive coronary CTA in single study.

MDCT = Multi Detectors Computed Tomography, **LV** = Left Ventricular, **CTA** = Computed Tomography Angiography. **EF** = Ejection Fraction, **ESV** = End Systolic Volume, **EDV** = End Diastolic Volume, **SV** = Stroke Volume

[1] Diagnostic Radiology Devision, Radiology Department, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand.

[2] Bangkok Heart Institute, Bangkok Hospital, Bangkok, Thailand.

INTRODUCTION

During the past few years, there is a leap in development of the computed tomography machine for cardiac imaging, from electron beam to 16 or even 64 sliced multi-dectector computed tomography (MDCT). This is an impressive method for evaluation of coronary arteries; the ability of the CTA in detecting stenosis of the coronary arteries is already well known.[1-6] The functional assessment of the left ventricle (LV) is also important for patient management. Sixteen-sliced MDCT has also proved to be one of the effective methods for evaluation of ejection fraction (EF), end systolic volume (ESV), end diastolic volume (EDV), stroke volume (SV), and left ventricular wall motion,[7-8] based on 17-segmented model according to recommendation from the American Heart Association.[9]

The aim of this study is to evaluate additional data in patients who are suspected of having coronary artery disease. The data obtained from 16-sliced multidetectors computed tomography (MDCT) is used to compare with the data obtained from echocardiography.

MATERIAL AND METHODS

The study was approved by the institutional committee at the Bangkok Heart Institute, Bangkok Hospital, Bangkok, Thailand.

PATIENTS

Coronary CTA and echocardiography had been performed on 20 patients within an average period of 5.5 days without intervening acute cardiac event or any interventional procedure or revascularization. Fifteen men (75%) and 5 women, with an average age of 62.9 (range from 49 to 79 years) participated in this study. The mean calcium score in this study group was 345.6 (range from 0 to 1559.1) and the mean heart rate was 75.9 (range from 53 to 91) beats per minute (BPM) during scan procedure.

TECHNIQUES OF MDCT

All patients were examined by 16-sliced MDCT Mx 8000 IDT (Phillips Medical Systems, the Netherlands). All images were acquired in inspiratory breathhold, from the aortic root to the diaphragms. First, non contrast study was performed for calcium score evaluation, using 75 % phase of cardiac cycle. Then, contrasted scans were done, with a scanning parameter of 420 msec gantry rotation time, a collimation of 0.8 mm, and tube voltage of about 140 kV and 450 mA. All scans were ECG gated, with retrospective reconstruction into 8 phases (0, 12.5, 25, 37.5, 50, 62.5, 75, and 87.5 percents of cardiac cycles). About 90 cc of Iopromide 370 mg/ml was used, followed by 50 cc of normal saline chaser. The injection flow rate was 3.5 to 4 cc/ sec.

IMAGE RECONSTRUCTION

The calcium score was calculated, using vendor software based on the Agatston system. Images reconstruction into three-dimensional (3D) volume rendering and multiplanar reformation was performed for coronary artery evaluation. The LV function analysis were performed, using cardiac review program and CINE wall motion display, which allowed dynamic evaluation, using the same source data of coronary CTA. Eight phases of the cardiac cycle were reconstructed into short, horizontal, and vertical long axes. The end systolic phase and end diastolic phase were chosen with cardiac review software. The images were re-oriented to the traditional short-axis planes before segmentation, using 3 mm sliced thickness, which yielded about 10-14 sectional images. The apical segment number 17 was excluded. The epicardial, endocardial, and detail endocardial contours delineation were semiautomatically created. Ventricular muscle measurements were additionally calculated based on the volume between the endocardial and epicardial borders as defined by a 2D active contouring algorithm. The result of EDV, ESV, SV, EF, and 16 segmented quatitative wall motion was automatically calculated.

All 8 cardiac phases were used to create the CINE movie of the short axes of the left ventricle, and subdivided into apical, middle, and basal segments. These represented 17 segmental models according to the American Heart Association. The segment number 17 was excluded. The motion of each segments was graded into normal, hypokinesia, akinesia, and dyskinesia.

DATA ANALYSIS

The end diastolic and end systolic phases used for cardiac review and quantitative data of EDV, ESV, stroke volume, and EF were recorded. The CINE movement of 4 segments of apical, 6 segments of middle, and 6 segments of basal parts were reviewed by experienced cardiac imaging radiologist, with unawareness of clinical data and coronary angiographic results.

ECHOCARDIOGRAPHY

For 2-dimensional echocardiography, patients were imaged in the left lateral decubitus position using commercially available systems (GE Vivid7 and Acuson Sequoia C256). Images were obtained using a 3.5 MHz transducer at a depth of 16 cm. in the parasternal and apical views (parasternal long- and short-axis, apical 2- and 4- chamber views). Regional wall motion of the 2-dimensional echocardiographic data was evaluated using a 17-segmented model suggested by the Cardiac Imaging Committee of the Council on Clinical Cardiology of the American Heart Association. Each segment was assigned a wall motion score of 1 to 4 : normal = 1, hypokinetic = 2 (decreased endocardial excursion and systolic wall thickening), akinetic = 3 (absence of endocardial excursion and systolic wall thickening), and dyskinetic = 4 (paradoxic outward movement in systole).

The LV ejection fractions were evaluated from the 2- and 4- chamber images using biplane Area length techniques and from parasternal long- and short-axis images using M-mode Teicholtz formula.

STATISTICAL ANALYSIS

The data of the ejection fractions from CTA and echocardiography were compared using concordance correlation coefficient. The data of CINE wall motion abnormality from CTA and echocardiography were compared using overall agreement. These wall motion data were also grouped into normal and abnormal to calculate positive and negative predictive values.

RESULTS

Good correlation of the EF between CTA and echocardiography was found, with a concordance correlation coefficient of 0.7. The mean EF were 69.8+/- 9.0 (range from 48.5 to 83.5) and 68.3 +/- 7.9 (range from 46.7 to 81.3), by CTA and ECHO, respectively. The mean difference of EF by CTA as compared with echocardiography was 4.7. (Figure 1)

The evaluation of LV wall motion using CINE compared with echocardiography revealed agreement in 92.81% (297 in 320 segments), were summarized in Table 1. The LV wall motion abnormality were subdivided with the results summarized in Table 3.

Other LV functional data were also acquired from CTA study, including end diastolic volume, end systolic volume, and stroke volume, which were 94.1 +/- 23.8(range from 53.4 to 146.5), 29.3 +/- 13.1 (range from 8.8 to 54.6), and 65.3 +/- 15.6 (range from 44.6 to 93.9), respectively.

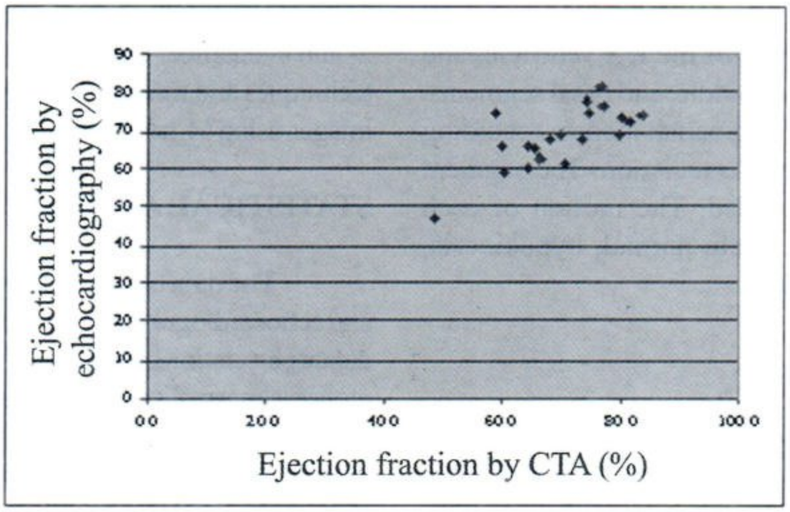

Fig.1 Left ventricular ejection fraction from CTA and echocardiography

Table 1 Correlation of EF between multi-modalities to the MDCT, comparing with other studies

Study	Number of slices of MDCT	Comparing modalities	Mean EF by MDCT (%(+/-))	Result of ejection fraction
Juergens[10]	4 slices	Biplane cineventriculography	60.1 (11)	Moderate correlation
Dirksen[13]	4 slices	Echocardiography	48 (12)	Good correlation
Hallingburton[14]	4 slices	MRI	26.7 (8.7)	Good correlation
Juergens[15]	4 slices	MRI	61 (10)	Good correlation
Our study	16 slices	Echocardiography	69.8 (9)	Good correlation

Table 2 Regional CINE LV wall motion assessment, comparing between CTA and echocardiography

CTA/ echocardiography	Normal	Abnormal
Normal	295	17
Abnormal	4	4

Table 3 Regional CINE LV wall motion evaluation, subdivision of abnormality into akinesia, hypokinesia, and dyskinesia, comparing of echocardiography and CTA.

CTA/ echocardiography	Normal	Hypokinesia	Akinesia	Dyskinesia
Normal	295	13	4	0
Hypokinesia	4	2	1	0
Akinesia	0	1	0	0
Dyskinesia	0	0	0	0

DISCUSSION

A leap in developing computed tomography machine for cardiac imaging was made this time as a new era for non-invasive coronary artery evaluation and also LV function analysis. There are many methods for the LV function evaluation, including echocardiography, nuclear scintigraphy, ventriculography,[10] and magnetic resonance imaging,[11] but CTA has proved to be one of the most promising choices, especially in patients who have to perform coronary arteries evaluation.[12]

The result of this study shows good correlation of EF, comparable with the study of Dirksen,[13] which compared biplane cineventriculography with 4 sliced MDCT. In other studies, moderate to good correlation of EF between multi-modalities and the MDCT has been revealed, as shown in Table 1. Moderate correlation of EF was found in the study of Juergens,[10] which compared EF result between 4 sliced MDCT with echocardiography; good correlation was revealed. Four-sliced MDCT was also compared with MRI study in the study of Hallingburton[14] and Juergens,[15] which revealed a good correlation in EF, respectively.

Although the patient group in our study contained risk factors of coronary arteries disease, the result of mean EF was still within normal limit (69.8 by CTA and 68.3 by echo), which is different from other studies.[10, 13-14, 16] This finding reinforces the validated use of the CTA, especially in patients with normal range of EF.

The wall motion evaluation of our study shows high agreement, but as we have mentioned before, most of our patients has normal range of mean EF, so most of the result of wall motion evaluation is normal. Another consideration is that we used only 8 cardiac phases to create CINE wall motion, which may not be as good as echocardiography that would have more phases and would therefore be more likely to be the real time. The results may be underestimated, seeing as we cannot detect any akinesia whilst the echocardiography did. In the study of Dirksen, 20 cardiac phases were used, which revealed akinesia.[13] We may conclude that the more cardiac phases as in the data collection, the more delicate the grading of the LV wall motion will be. In the future, if the scan time per rotation is decreased and the computer analysis has more capacity, more cardiac phases can be created. This could help in the CINE LV wall motion evaluation to be more accurated.

The data we used for LV function and CINE wall motion has the same source data for coronary artery evaluation. Important artifacts[17] such as high heart rate may cause degradation of the coronary artery, but this may not affect the LV function as seen in our study that the mean heart rate is rather high (about 75.9 BPM), and some patients have the heart rate of 91 BPM; the result of EF still can show a good correlation. Although this is not a good comment because as already known that if the patient has a high heart rate, premedication such as beta-blocker should be used, but this is our preliminary group of patients. In the study of Juergens, the same result occurs, which compared the result of LV function using CT and MRI in different groups of patients with heart rates of less or more than 65 beats per minute and show no significant change with volume and LV function in different heart rates.[15]

In the study of Juergens, although endocardial LV contours had to be corrected manually in some cases, there was not a relevant difference compared with CINE MRI.[15] However, in our study, the LV contour tracing for calculation was done only once, without any different method or re-measurement. The interobserver and intraobserver variation were not included in this study.

CONCLUSION

Good correlation of EF and high agreement of CINE LV wall motion evaluation between CTA and echo were found. LV function analysis data can be used as a reliable noninvasive imaging modality and also used as an addition to noninvasive coronary CTA in a single study.

REFERENCES

1. Pannu HK, Flohr TG, Corl FM, et al. Current concepts in multi-detector row CT evaluation of the coronary arteries: principles, techniques, and anatomy. Radiographics 2003; 23:s111-25.
2. Achenbach S, Giesler T, Ropers D, et al. Detection of coronary artery stenoses by contrast-enhanced, retrospectively electrocardiographically gated, multislice spiral computed tomography. Circulation 2001; 103:2535-8.
3. Schoepf UJ, Becker CR, Ohnesorge BM, et al. CT of coronary artery disease. Radiology 2004; 232:18-37.
4. Nieman K, Oudkerk M, Rensing BJ, et al. Coronary angiography with multi-slice computed tomography. Lancet 2001; 357: 599-603.
5. Nieman K, Cademartiri F, Lemos PA, et al. Reliable noninvasive coronary angiography with fast submillimeter multislice spiral computed tomography. Circulation 2002;106: 2051-4.
6. Mollet NR, Cademartiri F, Nieman K, et al. Multislice spiral computed tomography coronary angiography in patients with stable angina pectoris. JACC 2004; 43:2265-70.
7. Desjardins B, Kazerooni EA. ECG-gated cardiac CT. AJR 2004;182: 993-1010.
8. Chan FP. Cardiac multidetector-row computed tomography: principles and applications. Seminar in Roentgenology 2003; 38 (4):294-302.
9. Cerqueira MD, Weissman NJ, Dilsizian V, et al. Standardized myocardial segmentation and nomenclature for tomographic imaging of the heart. Circulation 2002; 105: 539-42.
10. Juergens KU, Grude M, Fallenberg EM, et al. Using ECG-gated multidetector CT to evaluate global left ventricular myocardial function in patients with coronary artery disease. AJR 2002; 179:1545-50.
11. Darasz KH, Underwood SR, Bayliss J, et al. Measurement of left ventricular volume after anterior myocardial infarction: comparison of magnetic resonance imaging, echocardiography, and radionuclide ventriculography. Int J Card Imaging 2002; 18:135-42.

12. Dirksen MS, Bax JJ, Roos A, et al, Dynamic multislice computed tomography of left ventricular function. Circulation 2004; 109: e25-6.
13. Dirksen MS, Bax JJ, Roos A, et al. Usefulness of dynamic multislice computed tomography of left ventricular function in unstable angina pectoris and comparison with echocardiography. Am J Cardiol 2002; 90: 1157-60.
14. Halliburton SS, Petersilka M, Schvartzman PR, et al. Evaluation of left ventricular dysfunction using multiphasic reconstructions of coronary multi-slice computed tomography data in patients with chronic ischemic heart disease: validation against cine magnetic resonance imaging. Int J Card Imaging 2003; 19:73-83.
15. Juergens KU, Grude M, Maintz D, et al. Multi-detector row CT of left ventricular function with dedicated analysis soft ware versus MR imaging: Initial experience. Radiology 2004; 230:403-10.
16. Mochizuki T, Murase K, Higashino H, et al. Two- and three-dimensional CT ventriculography: a new application of helical CT. AJR 2000; 174:203-8.
17. Choi HS, Choi BW, Choe KO, et al. Pitfalls, artifacts, and remedies in multi-detector row CT coronary angiography. Radiographics 2004; 24:787-800.