The purpose of this study was to evaluate the role of multi-slice computed tomography (MSCT) in assessing global left ventricular (LV) function. Twenty patients (16 male, 4 female) with angina were enrolled, the ages ranged from 42 to 78 years. Data from standardized 64-MSCT scan was analyzed with dedicated analysis software to evaluate the global LV function. Conventional angiography was used as the standard for comparison. Statistical analysis with Pearson’s correlation was used.

For LV volumes, there was excellent correlation for end-systolic volume (r = 0.83, p < 0.001) and moderate correlations for end-diastolic volume (r = 0.57, p = 0.014). Good correlation was also observed (r = 0.73, p < 0.001) in the evaluation of global ejection fraction.

Our result indicates that it is reliable to assess global LV function with 64-MSCT. Functional analysis in additional to anatomical evaluation may increase the clinical efficacy of MSCT.

MATERIALS AND METHODS

Subjects

From December 2005 to November 2006, a total of 20 patients who suffered from angina were enrolled in our study. The subjects included 16 men and 4 women with range of age from 42 to 78 years.
Figures 1-3. After identifying the a. end-systolic phase and b. end-diastolic phase, standard 1. short-axis, 2. four-chamber and 3. two-chamber views were created. Using the integrated computer software, the left ventricle volume was calculated with the Simpson’s method by slice summation. Semi automated contour detection and manual correction of contours were performed.
They underwent MSCT imaging for evaluation of coronary arterial condition, and all patients received CCA within two days after MSCT. Exclusion criteria included renal insufficiency (serum creatinine ≥ 2.0 mg/dl), previous allergic reaction to iodinated contrast media, and arrhythmia.

MSCT
All MSCT scanning were performed with a 64-slice multi-detector spiral CT scanner (Aquilion 64, Toshiba, Japan). Four of 20 subjects had oral administration of 10-30 mg of Propranolol to achieve targetted heart rate under 70 beats per minute. Sublingual nitroglycerin spray (0.4mg) was routinely administered 5-7 minutes before the scan. The parameters used for MSCT included 64 x 0.5 mm collimation, pitch 12.8 cm, 120 kV, and 400mA for coronary evaluation. Retrospectively electrocardiography gated analysis was performed. Region of interest was placed at the proximal descending thoracic aorta around the carina level for automated peak enhancement detection used for determining the time of starting scan. While continuous monitoring the ROI breaking through the presetted threshold of 180 Hounsfield Unit, 90 to 95 mL of non-ionic contrast media was administered via right antecubital vein at the rate of 5 mL/s followed immediately with 50mL normal saline chaser bolus. Scan was initiated 4 seconds after contrast medium injection. Patients were instructed to strictly hold their breath for about 10 seconds.

Imaging analysis
The same data set for CT angiography were retrospectively retrieved for evaluation of global LV function. The images were reconstructed with 1 mm thickness and retrospectively electrocardiography gated at every 10% of the RR interval. These ten reconstructed MSCT images data were transferred to off-line workstation (Vitrea v. 3.0, Vital images, Minnetonka, MN, USA) for evaluating LV function. Two chambers, four chambers, and short axis views were created for analysis of LV function. End-diastolic volume (EDV) and end-systolic volume (ESV) were calculated by slice summation using semiautomated contour detection with manual correction if necessary (Fig. 1-3). Papillary muscles were regarded as part of the LV cavity. Global ejection fraction (EF) was generated by an equation: EF = (EDV-ESV) / EDV.

Biplane Cineventriculography
Biplane cineventriculography was performed using standardized 30° right anterior oblique projection and 60° left anterior oblique, with injection of at least 30 mL of contrast medium at a flow rate of 12 mL/s, using a 6 French pigtail catheter. Semi-automatic contour-tracking was used to define the endocardial borders. The end-diastolic and end-systolic images are based on the EKG-guided frames on left ventriculograms. EDV and ESV were determined using area-length method.

Statistical Data
Data were expressed as mean ± SD, and compared with paired 2-tail Student’s t test. The Pearson’s coefficient r calculated according SPSS (Version 13.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL) analysis software was used to determine the correlation of parameters between MSCT and CVG. The

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MSCT</th>
<th>CVG</th>
<th>Pearson correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD*</td>
<td></td>
<td>r value</td>
</tr>
<tr>
<td>EDV (ml)</td>
<td>123.9 ± 26.3</td>
<td>120.7 ± 29.</td>
<td>0.57</td>
</tr>
<tr>
<td>Range</td>
<td>80-184</td>
<td>78-187</td>
<td></td>
</tr>
<tr>
<td>ESV (ml)</td>
<td>45.9 ± 26.4</td>
<td>60.0 ± 27.1</td>
<td>0.83</td>
</tr>
<tr>
<td>Range</td>
<td>17-138</td>
<td>21-144</td>
<td></td>
</tr>
<tr>
<td>EF (%)</td>
<td>64.6 ± 12.3</td>
<td>60.0 ± 12.7</td>
<td>0.73</td>
</tr>
<tr>
<td>Range</td>
<td>25-84</td>
<td>23-77</td>
<td></td>
</tr>
</tbody>
</table>

* SD = standard deviation

Table 1. Comparison of end diastolic volume (EDV), end systolic volume (ESV) and ejection fraction (EF) using multislice computed tomography (MSCT) and cineventriculography (CVG).
agreement was defined as follow: poor correlateion, \( r = 0 \); slight correlation, \( r = 0.01-0.2 \); fair correlation, \( r = 0.21-0.4 \); moderate correlation, \( r = 0.41-0.6 \); good correlation, \( r = 0.61-0.8 \); and excellent correlation, \( r = 0.81-1.0 \).

Bland-Altman analysis was performed for each pair of values of EDV, ESV and EF, to calculate limits of agreement and systematic errors between the two modalities. The software MedCalc (MedCalc Version 9.4.2.0, MedCalc Software, Mariakerke, Belgium) was used to perform this statistical analysis.

RESULTS

Sixteen out of 20 patients had coronary artery disease on conventional angiography, including single vessel disease in 7 patients, 2-vessel disease in 3 patients, and triple vessel disease in 6 patients. The imaging quality for MSCT was excellent to acceptable in all exams, and could also be used for evaluating function.

MSCT Data

For MSCT, the range of EDV and ESV were 80-184 (mean ± SD = 123.9 ± 26.3) ml and 17-138 (45.9 ± 26.4) ml, respectively. The range of LV ejection fraction was 25-84 (64.6 ± 12.3) %.

Conventional angiography data

For CVG, the range of EDV and ESV were 78-187 (120.7 ± 29.9) ml and 21-144 (60.0 ± 27.1) ml, respectively, and the range of LV ejection fraction was 23-77 (60.0 ± 12.7) % (Fig. 4).

Comparing MSCT and CVG

There was a significant correlation between the MSCT and CVG with respect to EDV, ESV, EF. Between the MSCT and CVG, there was good correlation with respect to the global LVEF (\( r = 0.73 \), \( P < \) 5\( \times \)10\(^{-5} \)).

\( Figure \) 4. Calculation of left ventricular volume with cineventriculography. The endocardial borders are traced semi-automatically.

\( Figure \) 5. Scatter plots showing correlation between left ventricular parameters – end diastolic volume (EDV) \( a \). end systolic volume (ESV) \( b \). and ejection fraction (EF) \( c \). as determined by CVG and multislice computed tomography.
Assessment of global left ventricular function with 64-MSCT

0.001), moderate correlation with EDV (r = 0.57, p = 0.014) and excellent correlation with ESV (r = 0.83, p < 0.001) (Table 1, Fig. 5).

The differences between MSCT and CVG in systolic, diastolic volumes, and ejection fraction are illustrated with Bland-Altman plots (Fig. 6). The mean differences were –15, 1.4, and 7.8; 95% confidence interval (1.96 SD = 95% CIs): -85 to 54.9, -41.1 to 44, and -22 to 37.5. The ESV was underestimated with MSCT with mean difference of 15 mL. For EDV and EF, both parameters were shown slightly overestimated by MSCT with mean difference of 1.4 and 7.8 mL. These differences were all within 95% confidence interval, and that means we could use the two measurement methods interchangeably [10].

DISCUSSION

The present study shows the potential clinical applications of 64-MSCT for functional evaluation. Previous studies had described the use of MSCT in evaluating LV function [2, 11-13]. Juergens et al. and Heuschmid et al. used 4-slice MSCT and demonstrated well correlation with CVG findings in EF values (r = 0.8 and r = 0.79) [14, 15] However, Heuschmid’s reported that the correlation between MSCT and CVG was less satisfactory with r = 0.81 for mean ESV and r = 0.51 for mean EDV. Such a correlation was also described by Martine et al. by using 16-slice MSCT (r = 0.74 and 0.41, respectively) [3, 15]. Schuifj et al. reported good correlation of 16-slice MSCT and 2-dimentional echocardiography in 70 patients, with a satisfactory correlation of EDV (r = 0.97), ESV (r = 0.98) and EF (r = 0.91) [16]. Similar findings were also found in comparing 64-MSCT and single photon emission CT (SPECT), with good correlation in EDV (r = 0.898), ESV (r = 0.956) and EF (r = 0.825) [17]. The global and regional LV function investigated by 64-MSCT and 2-dimentional echocardiography were comparable to that assessed by magnetic resonance imaging which was used as golden standard [18]. Our study demonstrated that between the 64-MSCT and CVG, there is an excellent correlation for ESV (r = 0.83), a moderate correlation for EDV (r = 0.57), and a good correlation for LVEF (r = 0.73).

In this study, the correlation for EDV is lower than ESV between the MSCT and CVG. This finding could probably be attributed to the volume calculation method. The marginal contour of the chamber could be over or under estimated with semiautomated detection. Such a volume’s discrepancy could be greater in diastolic phase than in systolic phase with slice summation.

For precise qualitative and quantitative evaluation of LV global function, imaging with high temporal and spatial resolution is needed. ECG-gated MSCT provides excellent spatial resolution to differentiate the LV cavity and myocardium [19-21]. In addition, differentiation between systolic and diastolic images is possible with a temporal resolution of 125-250 milliseconds [22]. The temporal resolution of echocardiography, cardiac MRI, and electron beam CT is approximately 50 milliseconds and optimal temporal resolution is mandatory for reproducible global LV function assessment [19]. The 64-MSCT scanner we used offers a temporal resolution of 40 milliseconds with partial-scan and multisegmental reconstruction algorithms and a spatial
resolution of 0.35 mm. The advancement of MSCT technology has gradually improved the diagnostic performance of CTA.

In cases of noninvasive coronary angiography with MSCT, the same dataset might be used for assessment of global LV function. This is particularly of benefit to obese patients that have poor acoustic window in sonography, or to patients that are contraindicated for MRI examinations, e.g. pacemaker placement, metallic devices implants. The valid data can be obtained without additional radiation exposure or administration of contrast media [1].

There are several limitations in this study. First, the case number is small. Second, oral beta-blocker was used for obtaining optimal image quality by reducing heart rate. It may have influence over the contractility of the myocardium and alter the functional parameters [19]. Third, routine usage of sublingual nitroglycerin may also alter LV function. However, nitroglycerin is routinely used during CCA as well, thus internal bias could be diminished.

In conclusion, our results indicate that the assessment of global LV function with 64-MSCT is feasible and reliable. There was a good correlation between MSCT and CVG with respect to global ejection fraction. Functional analysis in addition to anatomical evaluation with the same data-set may increase the clinical efficacy of MSCT without additional radiation exposure and administration of contrast media [19].

REFERENCE

2. Juergens KU, Fischbach R. Left ventricular function studied with MDCT. Eur J Radiol 2006; 16: 342-357


使用多層次 64 切電腦斷層評估左心室功能：
與傳統血管攝影心室造影測量之比較

蔡秉樺 1  林吉晉 1  劉尊彰 1  謝明哲 2  陳俊吉 2  溫明賢 2  萬永亮 1

長庚大學  林口長庚紀念醫院  影像診療科部 1  心臟內二科 2

本研究的目的是為了評估 64 切多層次電腦斷層在評估左心室功能所扮演的角色。

總共有 20 個 42-78 歲臨床上有心絞痛表現的病人（含 16 個男性及 4 個女性）接受此項檢
查。收集到的資料以專屬的軟體來分析，並使用傳統的血管攝影作為比較的標準，統計分析採
用 Pearson's 相關係數。

對於左心室的容量的評估，多層次電腦斷層得到的結果與傳統血管攝影相比，在收縮末期
容積得到極佳的相關性 (r = 0.83, p < 0.001)；在舒張末期的容積得到中度相關性 (r = 0.57,
p = 0.014)；在心臟的射出率則可觀察到好的相關性 (r = 0.73, p < 0.001)。

由此可知使用 64 切的多層次電腦斷層在評估左心室功能是可信賴的。所以多層次電腦斷
層除了可用來做心臟血管解剖上的評估，還可運用於功能性的評估，增加了多層次電腦斷層的
臨床應用。