Quantitative assessment of regional left ventricular wall thickness and thickening using 16 multidetector-row computed tomography: comparison with cine magnetic resonance imaging

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Abstract

Purpose. The purpose of this study was to investigate the feasibility of retrospective electrocardiography-gated multidetector-row computed tomography (MDCT) in the assessment left ventricular (LV) wall thickness and thickening and to test its validity compared to cine magnetic resonance imaging (MRI) as a standard of reference.

Materials and methods. We enrolled 19 patients who underwent both cardiac MDCT and cine MRI. End-diastolic wall thickness (EDWT) and end-systolic wall thickness (ESWT) were measured in 16 myocardial segments. Percent systolic wall thickening (%SWT) was generated from the EDWT and ESWT. Nondiagnostic myocardial segments were excluded. Correlation and agreement between MDCT and cine MRI were analyzed.

Results. Segmental assessability values were 86.2% (262/304) and 92.1% (280/304) for MDCT and cine MRI, respectively. In assessable segments by both modalities (80.9%, 246/304), a significant correlation between MDCT and MRI was found ($r = 0.89, 0.85$, and $0.61$, for EDWT, ESWT, and %SWT, respectively; all $P < 0.05$). Mean EDWT and ESWT values by MDCT were slightly lower than those by cine MRI ($9.8 \pm 3.6$ vs. $10.0 \pm 3.7$ mm and $13.8 \pm 4.4$ vs. $14.1 \pm 4.3$ mm, respectively; both $P < 0.01$). Bland-Altman analysis revealed acceptable limits of agreement between MDCT and Cine MRI.

Conclusion. MDCT is a feasible method to assess regional LV wall thickness and systolic thickening.

Key words Multislice computed tomography (CT) · Magnetic resonance imaging (MRI) · Left ventricular wall thickness · Systolic thickening

Introduction

Global and regional left ventricular (LV) functions are valuable indicators for predicting the prognosis of patients with heart disease.\textsuperscript{1,3} Therefore, reliable LV global and regional functional parameters are essential for clinical decision-making and follow-up of these patients. Several imaging techniques have been introduced to assess LV global and regional functions. Although echocardiography is widely used as a noninvasive clinical tool for LV functional assessment, there are some limitations, such as the existence of blind spots and operator dependence. Radionuclide imaging also has the limitations of relatively low spatial resolution and attenuation artifacts. During the past decade, several studies have shown that magnetic resonance imaging (MRI) is excellent for quantitative assessment of global and regional LV function, and MRI has emerged as the new gold standard for
quantifying LV function⁴; however, its availability for cardiac use is limited in most institutions. Recently, multidetector-row computed tomography (MDCT) has become a modality for coronary artery imaging in the clinical setting. Using the same data as for coronary CT angiography, we reported that MDCT is a feasible method for assessing LV volumes, ejection fraction, and wall motion.³ However, reports about the validation of MDCT in the assessment of LV wall thickness and thickening are mostly limited or absent.

In this study, we investigated the feasibility of using retrospective electrocardiography (ECG)-gated MDCT in the assessment of LV wall thickness and thickening. We tested its validity by comparing MDCT with cine MRI as the standard reference.

Materials and methods

Patient materials

We retrospectively enrolled 19 patients with various heart diseases who underwent both cardiac CT and cine MRI within 2 weeks: angina pectoris (n = 5), acute myocardial infarction (n = 3), chest pain of unknown origin (n = 3), old myocardial infarction (n = 2), hypertrophic cardiomyopathy (n = 1), dilated cardiomyopathy (n = 1), sarcoidosis (n = 1), amyloidosis (n = 1), Fabry’s disease (n = 1), systemic lupus erythematosus (n = 1). There were 15 men and 4 women ranging in age from 36 to 76 years (mean 62 ± 13 years). Informed consent for both MDCT and MRI examinations was obtained from all patients.

A total of 13 patients with a heart rate of more than 65 beats per minute (bpm) received a single dose of oral β-blocker prior to MDCT examinations to lower the heart rate. The mean heart rate at CT examination was 57.2 ± 7.0 (range 47–72 bpm). The β-blocker was not used prior to cine MRI examinations. The mean heart rate at cine MRI examination was 65.1 ± 10.0 (range 41–84 bpm).

MDCT imaging and assessment

Coronary CT angiography examinations were performed in all 19 patients enrolled using a 16-detector MDCT scanner (Light Speed Ultra 16; GE Healthcare, Milwaukeee, WI, USA). Scan parameters were as follows: retrospective ECG-gated acquisition, gantry rotation speed of 0.5 s/rotation, slice thickness of 0.625 mm, helical mode (pitch 0.25), tube voltage 120 kV, and tube current 350 mA. After test injection of 15 ml of contrast medium (300 mg iodine/ml, flow rate 3 ml/s) to investigate the best timing for data acquisition, a true scan was obtained with an intravenous injection of 80 ml of contrast medium at a rate of 3 ml/s followed by a 20-ml saline chaser. Ten phases of transaxial data sets were extracted (every 10% of the RR interval, reconstruction centers at 0%–90%) using a segment (= 180° half reconstruction) or multisegment reconstruction algorithm with a slice thickness of 0.625 mm, increment of 0.4 mm, matrix of 512 × 512, and field of view (FOV) of 25 cm. The estimated temporal window ranged from 0.15 to 0.25 s depending on the heart rate.

For CT examinations, multiplanar reformation in the short-axis orientation was generated from the apex to the base. Basal (middle of the base and mid-ventricle), mid-ventricular, and apical (middle of the apex and mid-ventricle) short-axis sections (Fig. 1A) of 5 mm thickness were prepared for measuring LV wall thickness. Corresponding MR sections were also prepared. For both CT and MRI studies, the appropriate image sets corresponding to the end-diastole and end-systole (ED the largest and ES the smallest cross-sectional LV cavity areas in short axis) were selected visually among all phases. By manually tracing endocardial and epicardial contours in short-axis images, the end-diastolic wall thickness (EDWT) and end-systolic wall thickness (ESWT) were measured in 16 myocardial segments⁶ (Fig. 1B). Papillary muscles and trabeculations were excluded from the myocardium for the measurement. If necessary, the window width and level were adjusted manually for clearer contour delineation. Endocardial and epicardial contours had to be corrected manually in some cases, most often owing to banding artifacts or rarely to inappropriate opacification or flow artifacts. All segments with severe artifacts were excluded for quantitative assessment. Percent systolic thickening (%SWT) was calculated as follows.¹⁰

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%\text{SWT} = \frac{\text{ESWT} - \text{EDWT}}{\text{EDWT}} \times 100 \%
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Among 304 segments prepared (16 segments × 19 patients), 58 were excluded because of inadequate image quality (CT 42, MRI 24, both 8); therefore, 246 segments were assessed.

MR imaging and assessment

MRI was performed on a 1.5-T whole-body scanner (Signa Excite; GE Healthcare) using a four-channel phased-array coil for signal reception. Multisection contiguous short-axis cine images—retrospective ECG-gated steady-state free-precession sequences (SSFP) (FIESTA)—which covered the entire left ventricle, were acquired with the following parameters: TR 3.3 ms, TE 1.4 ms, flip angle 45°, section thickness 8 mm with a