ELSEVIER

European Journal of Radiology 67 (2008) 481–486

EJR
EUROPEAN JOURNAL OF RADIOLOGY

www.elsevier.com/locate/ejrad

Assessment of left ventricular function with 16- and 64-slice multi-detector computed tomography

Suhny Abbara [a,*], Benjamin J.W. Chow [a,b], Antonio J. Pena [a], Ricardo C. Cury [a], Udo Hoffmann [a], Koen Nieman [a], Thomas J. Brady [a]

[a] *Department of Radiology, Massachusetts General Hospital and Harvard Medical School, 165 Cambridge Street, Suite 400, Boston, MA 02114, United States*
[b] *Division of Cardiology, University of Ottawa Heart Institute, United States*

Received 5 October 2006; received in revised form 25 July 2007; accepted 30 July 2007

Abstract

Background: Important to the risk stratification and management of cardiac patients is the assessment of left ventricular function (LVEF), thus imaging modalities which can provide both anatomical and functional data is desirable. Electrocardiographic (ECG) gated multi-detector computed tomographic (MDCT) images may provide accurate assessment of LV ejection fraction, volume and dimensions but have shown systemic errors in the past due to slow gantry rotation speed.

Methods: Between May 2004 and January 2005, 306 patients underwent ECG-gated cardiac CT studies at the Massachusetts General Hospital. Patients with available CT data sets and a recent (within 3 months) ECHO and/or SPECT perfusion imaging were included in the study. ECG-gated data sets were acquired either with a 16-slice or with a 64-slice MDCT. Functional MDCT data sets were reconstructed in 10 cardiac phases (5–95%) with 1.5 mm slices. Images were processed and interpreted by two observers blinded to ECHO and SPECT results.

Results: A total of 69 patients had MDCT and ECHO or SPECT within 3 months (33 had 16-slice and 36 had 64-slice MDCT).

There was fair correlation between LVEF measured by 16-slice MDCT and 'ECHO or SPECT' ($62 \pm 10\%$ vs. $62 \pm 10\%$; $r = 0.56$). There was poor correlation between LVEF measured by 16-slice MDCT and ECHO ($64 \pm 10\%$ vs. $59 \pm 11\%$; $r = 0.26$) and there was good correlation between LVEF measured by 16-slice MDCT and SPECT ($62 \pm 11\%$ and $64 \pm 9\%$, respectively; $r = 0.76$).

There was very good correlation between LVEF measured by 64-slice MDCT and 'ECHO or SPECT' ($57 \pm 15\%$ vs. $58 \pm 13\%$; $r = 0.86$). There was very good correlation between LVEF measured by MDCT and ECHO ($56 \pm 14\%$ vs. $54 \pm 15\%$; $r = 0.89$) and between LVEF measured by 64-slice MDCT and SPECT ($60 \pm 13\%$ and $60 \pm 14\%$, respectively; $r = 0.90$).

Conclusion: The assessment of LVEF and LV dimensions with 64-slice MDCT provide values which are similar to those obtained by echocardiography and Tc-99m gated SPECT. The accuracy of the 64-slice MDCT with a gantry rotation speed of 330 ms (when compared to ECHO and SPECT) may be superior to that of the 16-slice MDCT at 420 ms gantry rotation.

Keywords: Left ventricular function; MDCT; Echocardiography; SPECT; Semi-automated MDCT data analysis

1. Background

Cardiac multi-detector computed tomography (MDCT) is a rapidly evolving imaging modality. Computed tomographic angiography (CTA) may compliment other non-invasive imaging modalities for the diagnosis and risk stratification of patients with suspected or documented coronary artery disease (CAD). Cardiac MDCT is a unique non-invasive modality because it permits both the anatomical and functional assessment of cardiac structures [1–14]. This ability to provide both anatomical and functional information may significantly alter the future practice within Cardiology.

Important to the risk stratification and management of cardiac patients is the assessment of left ventricular function. Left ventricular ejection fraction has been demonstrated to have prognostic value in patients with CAD, arrhythmia, cardiomyopathy

Abbreviations: MDCT, multi-detector computed tomography; CTA, computed tomographic angiography; CAD, coronary artery disease; ECG, electrocardiographic; LV, left ventricular; LVEF, left ventricular ejection fraction; MGH, Massachusetts General Hospital; ECHO, echocardiogram; SPECT, single photon emission computed tomography

* Corresponding author. Tel.: +1 617 726 0796; fax: +1 617 724 4152.
E-mail address: Sabbara@partners.org (S. Abbara).

0720-048X/$ – see front matter © 2007 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ejrad.2007.07.022

and valvular heart disease [15–19]; thus imaging modalities which can provide both anatomical and functional data is desirable to both clinicians and patients. Since current mechanical CTs acquire retrospectively electrocardiographic (ECG) gated data, MDCT may provide accurate assessment of left ventricular ejection fraction (LVEF), volume and dimensions.

Previous studies comparing LVEF measured by 4-slice MDCT to other modalities have demonstrated good correlation [10–14]. However, recent advancements in spatial and temporal resolution have likely improved the accuracy of current MDCTs in the assessment of LVEF.

We hypothesize that LVEF measured by 16- and 64-slice MDCT correlate well with those measured with ECHO and SPECT, but LVEF measured with 64-slice MDCT, compared to 16-slice MDCT, will correlate better with ECHO and SPECT due to its improved temporal resolution.

2. Methods

2.1. Multi-detector computed tomography

Between May 2004 and January 2005, 306 patients underwent ECG-gated cardiac CT studies at the Massachusetts General Hospital (MGH). Patients with available ECG-gated CT data sets and a recent (within 3 months) ECHO and/or SPECT perfusion imaging performed at MGH were included in the study. Patients under the age of 18 years, with atrial fibrillation, and with ventricular septal defects were excluded. The study was approved by the Massachusetts General Hospital Internal Review Board.

ECG-gated data sets were acquired with either a Siemens Sensation 16 or Sensation 64 MDCT (Siemens Medical Solutions, Forcheim, Germany). With the Sensation 16 MDCT, images were acquired with 16 mm × 0.75 mm slice collimation with a gantry rotation of 420 ms (mAs = 350–500, kV = 120) and the contrast agent (Visipaque, GE Healthcare) infusion (4 cc/s) was timed to allow for optimal opacification of the coronary arteries. Using the Siemens Sensation 64, data were acquired with 32 mm × 0.6 mm slice collimation and a flying focal spot technology with a gantry rotation of 330 ms (mAs = 750–900, kV = 100–120). ECG-gated tube modulation was utilized at the discretion of the attending Radiologist. The same contrast agent (Visipaque, GE Healthcare) was infused at 5 cc/s followed by a saline bolus (40 cc) at 5 cc/s. The functional MDCT data sets were reconstructed in 10 cardiac phases (5–95%) with 1.5 mm slices. Intravenous beta blocker was administered if the heart rate was greater than 65 bpm (5–20 mg Metoprolol i.v.).

ECG-gated MDCT images were processed using the Aquarius Workstation (TeraRecon, Inc., San Mateo, CA) and interpreted by two observers blinded to the ECHO and SPECT results. Multi-planar reformations (1.5 mm slice thickness) were used to create LV long-axis planes in the 2, 3 and 4 chamber views with the longest LV dimension from the mid-mitral annular plane to the thin point of the apex. Short axis views were created perpendicular to the long-axis of the left ventricle. Left ventricular end-systolic (LVESD) and end-diastolic dimensions (LVEDD) were obtained from the short axis view at the chordal level (between the free edges of the mitral leaflets and tips of the papillary muscles) [20–23]. A semi-automated volumetric threshold based method (time volume analysis) was used to measure LV volumes and LVEF.

2.2. Echocardiography

Clinically indicated echocardiograms were performed according to the recommended guidelines of the American Society of Echocardiography [24]. All echocardiograms were reviewed by an experienced observer and LVEF was calculated (LV ejection fraction = [(LV EDD^2 − LV ESD^2)/LV EDD^2] × 100% + k; where k is an adjustment for apical function (normal apex = 10%, hypokinetic apex = 5%, akinetic apex = 0% and dyskinetic apex = −5%) [25].

2.3. Single photon emission computed tomography

Clinically indicated Tc-99m SPECT images were performed according to the recommended guidelines of the American Society of Nuclear Cardiology [26]. All gated SPECT images were reviewed by an experienced observer and LVEF was calculated using the 4D-MSPECT software (University of Michigan).

2.4. Statistical analysis

SPSS version 11.5 (Chicago, IL, USA) was used for statistical analysis. Paired continuous variables were evaluated using the t-test. The correlation of LVEF, LVEDD and LVESD measurements by CT, ECHO and SPECT were determined with the Pearson correlation coefficient and Bland–Altman plot analyses [27].

3. Results

Between May 2004 and January 2005, a total of 306 patients total had ECG-gated Cardiac CT imaging performed at the Massachusetts General Hospital. One hundred and sixty one patients were imaged with 16-slice MDCT, out of which 26 patients had SPECT data and 11 patients had echocardiography. The remaining 145 patients were imaged with the 64 MDCT, out of which 21 patients had echocardiography and 22 patients had SPECT.

A total of 33 patients had undergone 16-slice MDCT and either ECHO or SPECT, and 4 patients had undergone 16-slice MDCT and both ECHO and SPECT. For the "ECHO or SPECT" analysis in those four patients, we have chosen the SPECT LVEF values for correlation. There was fair correlation between LVEF measured by MDCT and 'ECHO or SPECT' (62 ± 10% vs. 62 ± 10%; $r = 0.56$) (Fig. 1A).

A total of 11 patients (mean age = 52 ± 12 years) had 16-slice MDCT and ECHO performed within 3 months (22 ± 29 days) of each other. There was poor correlation between LVEF measured by MDCT and ECHO (64 ± 10% vs. 59 ± 11%; $r = 0.26$) (Fig. 1B). Comparing these same modalities, there was fair correlation between the LV end-diastolic internal dimensions (EDD) (53 ± 8 mm vs. 48 ± 6 mm; $r = 0.59$) and good correla-