Impact of slice-thickness and convolution filter on quantitative assessment of left ventricular volumes using second generation DSCT coronary angiography: Performance evaluation of semiautomated quantitative software.

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Purpose

1. Correct and reproducible evaluation of left ventricular functional parameters underly appropriate decision making in cardiac and pulmonary diseases [1-7]. Recently, as a result of improved temporal resolution, numerous studies have explored the role of cardiac CT in providing LV functional parameters [14-32]; in fact it is important to have alternative tools to evaluate an important parameter, such as for example EF, when other techniques cannot be used. CT has some drawbacks in respect of Echo and MRI, such as radiation dose and contrast medium administration, but it is Important to demonstrate that in particular situations, like in patients with poor echocardiographic compliance, and contra-indications to MR, CT can offer a reliable alternative to assess ventricular function in a fast way and with contemporary information on the coronary artery tree status.

2. New CTCA technologies have opened the way to a new paradigm shift in diagnostic imaging. In particular, after the first paradigm shift induced by the noninvasive study of coronary arteries, a further paradigm shift lies in the potential extension of cardiac CT to all patients undergoing chest CT, without an additional dose of Radiation [8].

3. The purpose of this study was to compare the impact of slice-thickness and convolution filter in coronary angiography Dual-Source Computed Tomography (DSCT) imaging for assessing of left ventricular (LV) volumes, function and mass.
Methods and Materials

Study Population

Between February 2011 and April 2011 we prospectively enrolled 25 consecutive patients (14 men, 12 women; mean age±SD = 63.8±13.5 years) who underwent CT Coronary Angiography (CTCA) for various indication. Only patients with sinus rhythm and able to maintain a breath-hold for at least 5 s were included. Patients with absolute contraindications to intravenous administration of iodinated contrast material (e.g., known allergy, kidney failure or thyroid disorders) were excluded. The ethics committee approved the study, and all patients provided informed (Table 1).

Patient preparation

Patients with a heart rate (HR) >60 bpm and without specific contraindications received a 5-mg intravenous dose of betablockers (atenolol, Tenormin, AstraZeneca). In the absence of contraindications, sublingual nitrate (dinitrate isosorbide, Carvasin 5 mg, Wyeth Lederle) was administered prior to the scan.

CT scan protocol

The study was performed with a DSCT system with 128 (64×2×2) slices (Definition Flash, Siemens, Forchheim, Germany) [9, 10]. All patients underwent a scan without contrast enhancement for the quantification of coronary calcium followed by an angiography scan. The following parameters were used for the angiography scans [10, 11]: spiral scan protocol, number of slices per rotation 62×2×2; slice thickness 0.6 mm; gantry rotation time 280 ms; temporal resolution 75 ms; scan direction craniocaudal; reconstruction algorithm 180°; patient table feed/pitch variable and adapted to HR (range 0.16-0.35); tube voltage 100-120 kV [according to patient body mass index (BMI)]; tube current 320-370 mAs (according to patient BMI), effective slice thickness 0.6-0.75 mm; reconstruction increment 0.4 mm; FOV 150-160 mm; convolution kernel medium smooth with first-generation iterative reconstruction (126-146f; IRIS, Siemens, Germany). Prospective tube current modulation was used with a high-dose window from 65% to 80% of the RR interval and a MinDose protocol (Siemens, Germany) in the remaining phases of the cardiac cycle (i.e. 4% of maximum amperes; Fig. 1). Between 70 ml and 100 ml of iodinated contrast material (Iomeprol, Iomeron 400, Bracco, Milan, Italy) was administered at an injection rate of 5-6 ml/s using an automatic injector (Stellant, MedRAD, Pittsburgh, PA, USA) attached to an 18- to 20-gauge needle cannula positioned in an antecubital vein [10, 12]. Coronary artery enhancement was optimised by using the bolus-tracking technique (CARE bolus, Siemens, Forchheim, Germany) to synchronise contrast material arrival in coronary arteries with the beginning of the
scan [10, 13]. Angiography scan data were obtained during a single breath-hold of 4-7 s (according to HR and adaptive pitch). Retrospective reconstructions based on the ECG signal were done on the angiography scans to obtain images free from motion artefacts in the maximum-dose time window (65-80% of the RR interval). The optimal diastolic phase was automatically obtained within this time window (Best-Phase, Siemens, Germany). First, the phase with best image quality of coronary arteries was selected for for angiographic analysis and assessment of the coronary tree. Second, for the analysis of cardiac function, additional functional MPR (multiplanar reconstruction) images were reconstructed using dedicated CT software (Syngo CT-2007A; Siemens, Forchheim, Germany). Using the standard cardiac planes for orientation, MPR in a short-axis views (SA) were generated from the heart base to the apex such that they were perpendicular to the LV long axis in the 4CH view with the aim of acquiring 20 phases with 2-mm slice thickness and 1-mm increment throughout the cardiac cycle at 5% intervals (Fig. 2).

CT image reconstruction

For the study, additional MPR SA reconstructions were performer with the following parameters: effective slice thickness of 4 and 5 mm; reconstruction increment 1 mm; two different standard convolution kernels (B20-B26; FBP - B) and one comparable convolution kernel with first-generation iterative reconstruction (i26; IRIS - I, Siemens, Germany).

Data analysis

A total of 150 short axis datasets, 100 by FBP and 50 by multiphasic IRIS reconstruction, were transferred to a dedicated workstation (Syngo MMWP - Siemens, Forchheim, Germany) equipped with ARGUS Va60c analysis software (ARGUS, Va60c, Siemens, Forchheim, Germany), which is able to process DICOM images from images obtained using different techniques (Fig.3). One experienced observer (5 years in Cardiac CT) blindly and randomly analyzed all CT images to measure the end-diastolic volume (EDV) and end-systolic volume (ESV), and calculate the stroke volume (SV) and ejection fraction (EF) of left and right ventricle, as well as the end-diastolic wall mass (ED Wall Mass) on the left ventricle. [14]. Images acquired at the time of the R-wave of the ECG were considered to represent end-diastole (ED), while images showing the smallest detectable left ventricular cavity were considered as end-systolic (ES) [15]. Endocardial and epicardial contours were manually traced on the end-diastolic SAX images. Endocardial borders were automatically "propagated" on endsystolic phase images, and manually corrected when deemed necessary. Papillary muscles and trabeculations of the LV cavities were included in the LV volumes as previously described [16-18]. The most apical section with visible cavity was considered as apex and the most basal section with at least 50% surrounding myocardium was regarded as base [19]. EDVand ESV were calculated
without geometric assumptions, using the Simpson's rule. All parameters were indexed for body surface area (BSA).

**Statistical analysis**

Data are reported as mean±standard deviation (SD). For data analysis we used commercially available software (MedCalc v9.2.1.0, Mariakerke, Belgium). The correlation between measurement was tested by two-variable linear regression analysis including calculation of Pearson's correlation coefficient. Differences were investigated with Student's T test (2 tails) for paired samples and a p<0.05 was considered as significant. The comparison of the intra-observer variability between measurements was assessed by calculating the coefficient of variability equal to the standard deviation of the difference between two measurements over the mean of the two measurements and expressed as percentage [20,21].
Table 1: Description of the study population. SD, standard deviation; M/F, males/females; BMI, body mass index; bpm, beats per minute; LVEF, left ventricle ejection fraction

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Fig. 1

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Fig. 2: Short Axis views of the Left Ventricle by CT. End-diastolic Short Axis views of the Left Ventricle by CT (MPR 2 mm thick reconstructions). Short axis views for left ventricular volume calculation. CT, Computed Tomography

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Fig. 3: Screenshot of software platform used to analyse left ventricular function parameters. a Display used for defining the endocardial and epicardial borders; b display showing results.

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Results

No complications occurred during CT imaging. No patient was excluded due to ECG triggering artifacts. All patients had a regular sinus rhythm with a mean HR of 58±10 (range: 42-88 bpm). The time required for analysis was 3.5+/−1.9min (B26-B20) vs. 3.0+/−1.4min (I26) (r=1.0; p<0.05). LV cavity had good visual quality on all CT images, with sufficient cavity enhancement. The mean values and standard deviation for LV volumes and the analysis of the respective differences between slice thickness and convolution kernels are given in Table 2. A very high correlation was observed for EF, ESV and LVM (r=1.0; p>0.05) for both slice thickness and convolution filters (Fig.4). Comparing 4 vs 5mm, EDV showed statistically significant differences, using B26 and I26 (p<0.05). The intra-observer variability for left ventricular volumes were calculated with Deming regression and are summarized in Table 3.
Table 3: Left Ventricular parameters measured. MPR datasets used for LV volumes evaluations were reconstructed with different slice thickness and convolution kernels. Body, FBP kernel

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Fig. 4: The Graph shows the LV parameters values based on slice thickness

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Table 2: Intra-observed variability

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Conclusion

In the real-world, slice-thickness does not significantly affect assessment of LV parameters. The recently introduced iterative filter determines a significant improvement in LV image quality and contrast resolution with DSCT, for a faster LV analysis.


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