Journal of Cardiovascular Computed Tomography 7 (2013) 32–38

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.JournalofCardiovascularCT.com

Original Research Article

Very low-dose coronary artery calcium scanning with high-pitch spiral acquisition mode: Comparison between 120-kV and 100-kV tube voltage protocols

Mohamed Marwan MD, MSc, Carina Mettin, Tobias Pflederer MD, Martin Seltmann MD, Annika Schuhbäck MD, Gerd Muschiol RT, Dieter Ropers MD, Werner G. Daniel MD, Stephan Achenbach MD*

Department of Cardiology, University of Erlangen, Ulmenweg 18, 91054 Erlangen, Germany

ARTICLE INFO

Article history:
Received 24 July 2011
Received in revised form
20 August 2012
Accepted 7 November 2012
Available online 18 January 2013

Keywords:
Calcium score
CT
Low-dose protocols

ABSTRACT

Background: Effective radiation dose from a single coronary artery calcification CT scan can range from 0.8 to 10.5 mSv, depending on the protocol. Reducing the effective radiation dose to reasonable levels without affecting diagnostic image quality can result in substantial dose reduction in CT.

Objectives: We prospectively compared tube voltages of 120 and 100 kV in a low-dose CT acquisition protocol for measuring coronary artery calcified plaque with prospectively electrocardiogram (ECG)–triggered high-pitch spiral acquisition.

Methods: In 150 consecutive patients, measurement of coronary artery calcified plaque was performed with prospectively ECG-triggered high-pitch spiral acquisition. Imaging was first done with tube voltage of 120 kV voltage and subsequently repeated with 100 kV and otherwise unchanged parameters. CT was performed with a dual-source CT system with 280 milliseconds of rotation time, 2 × 128 slices, pitch of 3.4, triggered at 60% of the R–R interval. Tube current for both protocols was set at 80 mAs. With the use of a medium sharp reconstruction kernel (Siemens B35f), cross-sectional images were reconstructed with 3.0-mm slice thickness and 1.5-mm increment. Agatston scores were determined per patient for both scan settings by 2 independent readers with the use of a standard threshold of 130 HU for calcium detection. In addition, the Agatston score was calculated with a previously proposed threshold of 147 HU for 100-kV acquisitions.

Results: Mean image noise was 20 ± 5 and 27 ± 7 for 120 and 100 kV, respectively ($P < 0.0001$). Mean dose length product was 24 ± 6 cm · cGy for the 120-kV protocol and 14 ± 4 cm · cGy for the 100-kV protocol, corresponding to average estimated effective doses of 0.3 and 0.2 mSv ($P < 0.0001$). Five patients were excluded from the analysis. In the remaining 145 patients, using the standard tube voltage of 120 kV, any coronary calcium was detected in 76 identical patients by both observers. In 75 of these patients, calcium was also identified by both observers in 100-kV data sets, whereas 1 patient was scored negative by

Conflict of interest: S. Achenbach has received research support from Siemens and Bayer Schering Pharma. The other authors report no conflicts of interest.

The study was supported by grant BMBF 01 EV 0708 from Bundesministerium für Bildung und Forschung (BMBF), Bonn, Germany.

* Corresponding author.
E-mail address: mohamedmarwan@yahoo.com (M. Marwan).

http://dx.doi.org/10.1016/j.jcct.2012.11.004

1 reader and was assigned an Agatston score of 0.7 (threshold, 130 HU) and 0.2 (threshold, 147 HU) by the other. Interobserver disagreement for assigning a patient a zero Agatston score was the same for both scan settings (each 4 patients). The mean Agatston scores for 120-kV and 100-kV (threshold, 147 HU) scans were 105 ± 245 (range, 0–1865) and 116 ± 261 (range, 0–1917), respectively ($P < 0.0001$). Bland-Altman analysis indicated a systematic overestimation of the Agatston score with tube voltage of 100 kV and threshold of 147 HU (mean difference, 11; 95% limits of agreement, 62 to -40). Similar results were observed for coronary calcium volume scores.

Conclusion: High-pitch spiral acquisition allows coronary calcium scoring with effective doses below 0.5 mSv. The use of 100-kV tube voltage further reduces effective radiation dose compared with the standard of 120 kV; however, it leads to significant overestimation of the Agatston score when the standard threshold of 130 HU is used. Adjusting the threshold to 147 HU leads to a better agreement compared with standard 120 kV protocols yet with a remaining systematic bias toward overestimation of the Agatston score. For high-pitch spiral acquisition mode, effective radiation dose reduction when using a 100-kV setting is minimal compared with the standard 120-kV setting and may be considered nonsignificant in a clinical setting.

1. Introduction

The detection of coronary calcification (coronary Agatston score) with electron beam tomography and computed tomography (CT) provides a method for coronary risk stratification.[1,2] Coronary calcium can be assessed with high sensitivity and can be quantified by various methods (Agatston score,[3] volume, or mass). The amount of coronary calcium roughly correlates to the amount of coronary atherosclerotic plaque,[4] and a large number of prospective studies have shown that the absence of coronary calcium clearly indicates a low risk of cardiovascular event, whereas greater amounts of calcium are associated with a higher event risk[5–12] as applied within asymptomatic persons with intermediate risk of coronary artery disease.[13,14]

The effective radiation dose from a single CT scan to determine coronary artery calcification can range from 0.8 to 10.5 mSv (median, 2.3 mSv), depending on the protocol used.[15] Hence, optimizing imaging protocols to reduce the effective radiation dose to reasonable levels without affecting diagnostic image quality is of utmost importance. Lowering tube voltage can result in substantial dose reduction in CT. Nevertheless, data that compare different tube voltages for the detection and quantification of coronary artery calcium are scarce.[16] In this study, we prospectively compared 120-kV and 100-kV tube voltage in low-dose acquisition protocols for measurement of coronary artery calcified plaque with the use of prospectively electrocardiogram (ECG)–triggered high-pitch spiral acquisition.

2. Methods

Between October 2009 and January 2010, we prospectively included 150 consecutive patients referred for measurement of coronary artery calcified plaque in this study. All scans were performed with a dual-source CT system with rotation time of 280 milliseconds, 2 × 128 slices, a pitch of 3.4, triggered at 60% of the R–R interval. Imaging was first done with tube voltage of 120 kV and subsequently repeated with 100 kV with the use of prospectively ECG-triggered high-pitch spiral acquisition and otherwise unchanged parameters. Tube current for both protocols was set at 80 mAs and scan direction was craniocaudal. All patients were in sinus rhythm. No patients were excluded because of weight or body mass index (BMI; calculated as weight in kg/height in m^2). All patients signed an informed consent, and the study was approved by the institutional review board.

2.1. *CT image reconstruction*

For image reconstruction, a half-scan reconstruction algorithm was used which provided a temporal resolution of 75 milliseconds in the center of gantry rotation. Although the data window of the topmost cross-sectional image started at 60% of the R-peak to R-peak interval, subsequent images were reconstructed progressively later in the data acquisition window. With the use of a medium sharp reconstruction kernel (Siemens B35f), cross-sectional images were reconstructed with 3.0-mm slice thickness and 1.5-mm increment.

2.2. *Agatston scoring*

CT data sets were analyzed on a dedicated workstation (MultiModality Workplace; Siemens Healthcare, Forchheim, Germany). Measuring calcified plaque was performed with commercially available software (Syngo CaScore; Siemens Healthcare) with a minimum threshold of 3 pixels for calcium detection. Two different scoring methods were used: Agatston scoring and volume scoring.[17] Calcium scores were calculated per patient for both acquisitions by 2 readers with the use of a standard threshold of 130 HU for calcium detection. In addition, the calcium score was determined with a recently published adjusted threshold of 147 HU for 100-kV scans.[16] Agatston scores were described in the following categories: