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Original Research Article

Prospectively ECG-triggered high-pitch coronary angiography with third-generation dual-source CT at 70 kVp tube voltage: Feasibility, image quality, radiation dose, and effect of iterative reconstruction

Michaela M. Hell MD[a,*], *Daniel Bittner MD*[a], *Annika Schuhbaeck MD*[a], *Gerd Muschiol RT*[a], *Michael Brand MD*[b], *Michael Lell MD*[b], *Michael Uder MD*[b], *Stephan Achenbach MD*[a], *Mohamed Marwan MD*[a]

[a] *Department of Cardiology, University of Erlangen, Erlangen, Germany*
[b] *Department of Radiology, University of Erlangen, Erlangen, Germany*

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ABSTRACT

Background: Low tube voltage reduces radiation exposure in coronary CT angiography (CTA). Using 70 kVp tube potential has so far not been possible because CT systems were unable to provide sufficiently high tube current with low voltage.
Objective: We evaluated feasibility, image quality (IQ), and radiation dose of coronary CTA using a third-generation dual-source CT system capable of producing 450 mAs tube current at 70 kVp tube voltage.
Methods: Coronary CTA was performed in 26 consecutive patients with suspected coronary artery disease, selected for body weight <100 kg and heart rate <60 beats/min. High-pitch spiral acquisition was used. Filtered back projection (FBP) and iterative reconstruction (IR) algorithms were applied. IQ was assessed using a 4-point rating scale (1 = excellent, 4 = nondiagnostic) and objective parameters.
Results: Mean age was 62 ± 9 years (46% males; mean body mass index, 27.7 ± 3.8 kg/m^2; mean heart rate, 54 ± 5 beats/min). Mean dose-length product was 20.6 ± 1.9 mGy × cm; mean estimated effective radiation dose was 0.3 ± 0.03 mSv. Diagnostic IQ was found in 365 of 367 (FBP) and 366 of 367 (IR) segments (*P* nonsignificant). IQ was rated "excellent" in 53% (FBP) and 86% (IR) segments ($P = .001$) and "nondiagnostic" in 2 (FBP) and 1 segment (IR) (*P* nonsignificant). Mean IQ score was lesser in FBP vs IR (1.5 ± 0.4 vs 1.1 ± 0.2; $P < .001$). Image noise was lower in IR vs FBP (60 ± 10 HU vs 74 ± 8 HU; $P < .001$).

Conflict of interest: Mohamed Marwan, Stephan Achenbach, Michael Lell, and Michael Uder have received speaker's honoraria from Siemens Healthcare. The remaining authors report no conflicts of interest.

* Corresponding author.
E-mail address: michaela.hell@uk-erlangen.de (M.M. Hell).

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Conclusion: In patients <100 kg and with a regular heart rate <60 beats/min, third-generation dual-source CT using high-pitch spiral acquisition and 70 kVp tube voltage is feasible and provides both robust IQ and very low radiation exposure.

1. Introduction

Coronary CT angiography (CTA) has been established as a reliable noninvasive image modality to detect and rule out coronary artery stenoses. It can be used to avoid invasive coronary angiography in symptomatic patients with low-to-intermediate pretest probability.[1,2] For the latest generation of dual-source CT scanners, a sensitivity of 99% and specificity of 95% have been reported for the detection of significant coronary artery disease.[3] Owing to the growing use of CT imaging in clinical practice, including coronary CTA, and the concern of radiation-induced malignancy, strategies to lower radiation exposure are constantly being developed and evaluated.[4] Progressive technical improvements include better use of collimators, wider detector coverage, prospectively electrocardiogram (ECG)-triggered and high-pitch spiral acquisition, and tube current modulation and reduction of tube current in combination with iterative reconstruction.[5–7] For example, radiation doses below 1 mSv and preserved image quality have been reported for nonobese patients with a low and stable heart rate in whom high-pitch acquisition and 100 kVp tube voltage were used.[8]

One of the most effective methods to lower radiation exposure is the reduction of tube voltage, as the dose grows with the square of the tube voltage.[5] Although acquisitions at 80 kVp have been reported,[6,7,9,10] the use of even lower voltages has so far been limited because X-ray tubes in previously available CT systems are unable to provide sufficiently high tube current at low peak voltages. In this study, we investigated a new (third generation) dual-source CT system which is capable of producing a high tube current at a tube voltage of 70 kVp. Feasibility, image quality, and radiation exposure were evaluated in a selected patient population.

2. Materials and methods

Between February and May 2014, 40 consecutive patients referred for coronary CTA to rule out significant coronary artery stenoses without previously known coronary artery disease and scheduled for imaging at a day when the third-generation dual-source CT system was available were screened for participation. Individuals with a body weight >100 kg (6 patients) and 8 patients who did not achieve a heart rate ≤60 beats/min after beta-blocker premedication were excluded. Thus, 26 consecutive patients were enrolled in our prospective study. Patients provided written informed consent. The institutional review board approved retrospective evaluation of data acquired for clinical purposes.

Covariates, including cardiac history and risk factors, were obtained by a structured interview. Hypertension was defined as a systolic blood pressure >140 mmHg, a diastolic blood pressure >90 mmHg, or treatment with antihypertensive drugs. Dyslipidemia was classified as presence of a total cholesterol level ≥200 mg/dL or treatment with lipid-lowering agents. Smoking was defined as the consumption of at least 1 cigarette per day over the last year. A family history for coronary artery disease was defined as a documented myocardial infarction, revascularization, or sudden death in a first degree related male (<55 years) or female (<65 years).

2.1. Patient preparation for coronary CTA

Patients with a heart rate >60 beats/min at rest and no contraindication for beta-blockers received an oral dose of 50 to 100 mg atenolol 60 minutes before the CT examination. Additional repeated doses of intravenous metoprolol (5–20 mg) were injected if the heart rate remained above 60 beats/min on the CT table.

Sublingual nitrates (0.8 mg) were administered to all patients immediately before CT data acquisition. Patients were thoroughly instructed to follow the breathing commands and all acquisitions were performed in deep inspiration.

2.2. CT data acquisition

Imaging was performed using a third-generation dual-source CT system (SOMATOM Force; Siemens Healthcare, Forchheim, Germany). The system provides 2 × 192 × 0.6 mm collimation and a gantry rotation speed of 250 ms. In all patients, tube voltage was set at 70 kVp and tube current at 450 mAs. A prospectively ECG-triggered high-pitch spiral (flash) acquisition was performed. Pitch was 3.2, corresponding to a table feed of 737 mm/s. Contrast agent transit time was measured using a test bolus technique, by injecting 10 mL contrast agent (350 mg iodine/mL; contrast agent Imeron, Bracco Imaging, Konstanz, Germany) followed by a saline flush of 50 mL, both at a flow rate of 5 mL/s using a dual-head power injector (Stellant CT, Medrad Inc., Indianola, PA). For coronary CTA, 60 mL of contrast agent was injected in an antecubital vein, followed by a 60 mL flush consisting of 80% saline and 20% contrast agent, all at 6 mL/s.

2.3. Effective radiation dose

The mean estimated effective radiation dose was calculated from the dose-length product, applying a conversion factor of 0.014 for chest CT in adults.[11] In addition, volume CT dose index was obtained for each CT examination.