Short Communication

Feasibility of ultra low-dose coronary computed tomography angiography

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ABSTRACT

There is an urgent need to develop new protocols to reduce radiation dose of coronary computed tomography angiography (CTA). The aim of this pilot study was to demonstrate the feasibility of an ultra-low dose CTA scanning.

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Coronary computed tomography angiography (CCTA) has an excellent negative predictive value to exclude coronary artery disease in patients presenting with chest pain. Advances in scanner technology and image reconstruction have led to significant radiation dose reduction without compromising image quality.[1] Societal guidelines recognize that high radiation doses constitute a significant barrier to its widespread implementation, and hence establish standards to avoid high radiation exposure within the limits of the currently available technology.[2] The aim of our pilot study was to demonstrate the feasibility of an ultra-low dose sub-millisievert (mSv) CCTA scanning, while maintaining an adequate and readily interpretable level of image quality.

Patients referred to the University of Minnesota for a CCTA were prospectively screened and enrolled in an ultra-low dose (ULD) protocol versus standard practice. Inclusion criteria comprised of age between 18 and 55 years, body mass index (BMI) ≤25 kg/m² and heart rate (HR) ≤60 beats per minute (BPM); exclusion criteria included presence of coronary artery calcium (CAC) or any arrhythmia. All images were acquired on a 128-detector dual-source Siemens FLASH scanner (ECG-gated prospectively triggered high pitch spiral acquisition, 80–100 kV tube voltage, 50–100 mA tube current, $2 \times 128 \times 0.6$ mm collimation). Patients received beta blockers for heart rate control per institution protocol (upto 100 mg oral and 40 mg iv metoprolol) and sublingual nitroglycerin 0.4 mg. 100–115 mL bolus of nonionic iodinated contrast material (Iopamidol 370 g/cm³, Isovue 370, Bracco Diagnostics, Princeton, NJ USA), was administered at a flow rate of 6 mL/s into an antecubital vein, followed by 40 mL saline flush at a matching rate, during a single breath-hold at end-inspiration. Tracking bolus method was used to trigger the scan. Image reconstruction was done using a sonogram affirmed iterative reconstruction algorithm (SAFIRE, Siemens). Radiation dose was measured in dose length product (DLP) and mSv (DLP X 0.014). Non-diagnostic scans were repeated using a standard protocol. Patients who underwent standard protocol CCTA with matched baseline characteristics served as a control group. All scans were reviewed independently by two experienced Level 3 CT readers and graded on an image quality scale. Coronary segments were scored using a five-point ordinal grading scale. Segments not visible, or with large discontinuities impairing the vessel assessability were classified as non-assessable (score, 1). Assessable segments were classified as fair (score, 2) when they had blurred borders or fair contrast opacification or minor vessel discontinuity; average (score, 3) when they had moderately blurred borders and adequate contrast opacification; good (score, 4) when they had slightly blurred borders and good contrast opacification or minor vessel discontinuity; and excellent (score, 5) when they had sharply defined borders and excellent contrast opacification with no vessel discontinuity.

Table 1
Baseline characteristics of ultra-low dose (ULD) and control groups, with average and interquartile ranges in parenthesis.

	ULD Group (n = 17)	Control Group (n = 17)	p-value
Age	39 (25–52)	42 (29–61)	0.356
Body Mass Index	22 (17–25)	23 (20–26)	0.244
Average Heart rate	58 (49–60)	54 (50–57)	0.136
Coronary Calcium Score	0	0	ND

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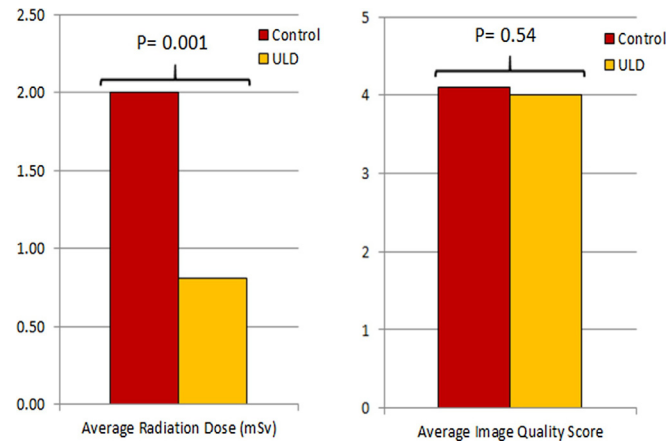
Fig. 1. Average radiation dose and image quality score for ultra-low dose (ULD) and control CCTA scans.

Fig. 2. Representative 5 mm MIP images of the RCA from ultra low dose (top image) and control (bottom image) groups.

Seventeen patients were enrolled in the ULD protocol (10 females). The mean age was 39 years, mean BMI was 22, and mean HR was 58 BPM. There was no difference in baseline characteristics of age, gender, BMI, HR, or CAC between ULD and control group (Table 1). Three patients (18%) in the ULD group had repeat scans due to poor image quality. The average radiation dose for the ULD group (including repeat scans) was 57 DLP or 0.81 mSv; and for the control group was 142 DLP or 2.0 mSv (p = 0.001). The average image quality score for the ULD group was 4.0 and for the control group was 4.1 (p = 0.54)(Fig. 1). There was no significant inter-observer variability in image quality scoring. Fig. 2 shows representative images from ULD and control groups.

In summary, ultra-low dose CCTA with sub-mSv radiation dose is feasible in a selected population while maintaining diagnostic image quality. There was a 60% reduction in radiation dose with an ultra-low dose protocol compared to standard protocol. These findings are important in the continued effort to minimize radiation exposure with CCTA.

Conflict of interest

None.

Funding

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