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ORIGINAL ARTICLE

Effect of low tube kV on radiation dose and image quality in retrospective ECG-gated coronary CT angiography

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KEYWORDS

Coronary;
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Abstract *Introduction:* Coronary computed tomography angiography (CCTA) has emerged as a useful diagnostic imaging modality in the assessment of coronary artery disease. However, the potential risks due to exposure to ionizing radiation associated with CCTA have raised concerns.
Objectives: CCTA can be done with low dose technique to reduce radiation exposure, without compromise of image quality or diagnostic capabilities.
Material and methods: Forty patients referred for CCTA were examined with low kV (100 kV for patients ⩽85–61 kg and 80 kV for patients ⩽60 kg). The dose length product (DLP) were compared with other group (40 patients) with comparable body weight, scan length and acquisition parameters. The second group was selected from PACS database, for which CCTA was done with standard 120 kV.

Abbreviations: CCTA, coronary computed tomography angiography; PACS, picture archiving and communication system; VR, volume rendering; MPR, multiplanar reformat; MPCR, multiplanar curved reformat; mSv, millisievert; ATCM, automatic tube current modulation; ECTCM, electrocardiographically controlled tube current modulation; BMI, body mass index; kVp, peak kilovoltage

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Results: There was considerable reduction of radiation dose about 40% with 100 kV and 60% with 80 kV compared to standard 120 kV CCTA protocols with preserved image quality.
Conclusion: The use of lower tube voltage leads to significant reduction in radiation exposure in CCTA. Image quality in non-obese patients is not negatively influenced.

1. Introduction

With the introduction of 64-slice computed tomography, CCTA has emerged as a useful diagnostic imaging modality for the assessment of coronary artery disease. It is considered appropriate for selected indications (e.g., in patients with a low-to-intermediate pretest probability for obstructive coronary artery disease) (1,2). In addition, CCTA has been proposed to be useful in the rapid evaluation of patients with chest pain in the emergency department (3). With the constantly increasing number of CCTA capable scanners worldwide, the volume of CCTA scans performed is likely to show substantial further increase (4). The clinical usefulness of CCTA for the assessment of coronary artery disease has to be weighed against the radiation exposure of CCTA and the small but potential risk of cancer induction. Many clinicians may still be unfamiliar with the magnitude of radiation exposure that is received during CCTA in daily practice and with the factors that contribute independently to radiation dose. This information is of vital importance for the development of strategies that will allow a reduction of patient exposure to ionizing radiation (5).

1.1. Strategies for reduction of radiation dose

1.1.1. Automatic tube current modulation (ATCM)

Automatic tube current modulation (ATCM) may be defined as a set of techniques that enable automatic adjustment of the tube current in the x–y plane (angular modulation) or along the z-axis (z-axis modulation) according to the size and attenuation characteristics of the body part being scanned and achieve constant CT image quality with lower radiation exposure. Hence, ATCM techniques are analogous to the automatic exposure-control used in conventional radiography (6). Although additional algorithms are available to modulate the tube current online during noncardiac scanning, the adapted tube current usually remains constant for the entire scan range in the cardiac automated exposure-control mode (5).

1.1.2. Electrocardiographically tube current modulation (ECTCM)

Electrocardiographically controlled tube current modulation (ECTCM) has been shown to effectively reduce radiation dose during retrospective electrocardiographically (ECG) gated cardiac spiral CT (7). Because cardiac motion is greatest during systole and least during diastole, diastolic image reconstructions are most likely to provide motion-free data sets. Accordingly, this algorithm restricts the prescribed tube current to a predefined time window during the diastolic phase and decreases tube current in the systolic phase of the cardiac cycle. Because the algorithm increases or decreases tube current prospectively, a regular heart rhythm is required to avoid applying the wrong tube current to the cardiac phase of interest.

1.1.3. Tube voltage

Usually, CCTA is performed using a tube voltage of 120 kV. However, CCTA acquisition with 100-kV tube voltage is also possible and has been suggested as a means to lower radiation dose (7). Reducing tube voltage is a standard procedure in pediatric CT and it has been used in cardiac CT primarily in non-obese patients (body weight $\leqslant$ 85 kg or BMI $\leqslant$ 30) owing to increased image noise. In addition to increasing image noise, a lower tube voltage also increases contrast in scans performed with the use of iodinated contrast agents, because iodine absorption is higher at lower tube voltage settings (7–8).

1.1.4. Prospective ECG triggered sequential scan (step and shoot)

This has recently been reintroduced into CCTA. Compared with the conventional retrospective ECG-gated spiral scan technique, which applies radiation during the entire cardiac cycle, radiation is only administered at one predefined time window of the cardiac cycle within the sequential scan mode. The radiation tube is inactive during the remainder of the cardiac cycle, which leads to substantial reductions in dose. However, this scan mode allows minimal or no flexibility in retrospectively choosing different phases of the cardiac cycle for image reconstruction once the data have been acquired (9–10).

1.1.5. Bismuth shielding

This has been shown to reduce radiation dose while still producing diagnostic quality images. Bismuth breast shields have been shown to reduce breast dose by 26.9% to 52.4% in the

Table 1 Beta blocker dose according to baseline heart rate.

Heart rate	Dose (mg)
55–60	12.5–25
60–65	25–50
65–70	50–100
70–80	100–150
> 80	100–200

Redose with 25–50 mg after 30 min if needed.

Table 2 Number of patients, scan length and DLP in each group.

	1st Group	2nd Group	
kV	80	100	120
Weight (kg)	$\leqslant$60	$\leqslant$85–61	$\leqslant$85
Number	6	34	40
Scan length (mm)[a]	137 ± 26		135 ± 21
DLP (mGy-cm)[b]	440 ± 10	635 ± 20	1070 ± 75

[a] 2 patients in the 1st group subjected to extended scan length to include aorta (Figs. 2 and 3).
[b] DLP includes doses from bolus tracking + helical cardiac scan.