Impact on Image Quality and Radiation Dose of Third-Generation Dual-Source Computed Tomography of the Coronary Arteries

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The aim of this study was to assess the image quality (IQ) and radiation dose of third-generation dual-source computed tomography (CT) coronary angiography (cCTA) in comparison with 64-slice single-source CT. This retrospective study included 140 patients (73 men, mean age 62 ± 11 years) with low-to-intermediate probability of coronary artery disease who underwent either third-generation dual-source cCTA using prospectively electrocardiography-triggered high-pitch spiral acquisition (n = 70) (group 1) or retrospective electrocardiography-gated cCTA on a 64-slice CT system (n = 70) (group 2). Contrast-to-noise and signal-to-noise ratios were measured within the aorta and coronary arteries. Subjective IQ was assessed using a 5-point Likert scale. Effective dose was estimated using specific conversion factors. The contrast-to-noise ratio of group 1 was significantly higher than group 2 at all levels (all p <0.001). Signal-to-noise ratio of group 1 was also significantly higher than group 2 (p <0.05), except for the distal left circumflex artery. Subjective IQ for group 1 was rated significantly better than for group 2 (median score [25th to 75th percentile]: 1 [1 to 2] vs 2 [2 to 3]; p <0.001). The median effective dose was 1.55 mSv (1.09 to 1.88) in group 1 versus 12.29 mSv (11.63 to 14.36) in group 2 (p <0.001) which corresponds to a mean radiation dose reduction of 87.4%. In conclusion, implementation of third-generation dual-source CT system for cCTA leads to improved IQ with significant radiation dose savings. **(Am J Cardiol 2017;119:1156−1161)**

Advancements in computed tomography (CT) technology have allowed coronary CT angiography (cCTA) to become a widely established technique for coronary artery assessment in selected patients with low-to-intermediate probability of coronary artery disease (CAD).[1−6] cCTA enables direct visualization of the coronary arteries, providing a fast, noninvasive assessment of atherosclerotic burden and, importantly, reliable exclusion of CAD with its high negative predictive value. cCTA utilization continues to increase with the advent of technical innovations that have both increased diagnostic accuracy and reduced radiation doses, the latter being particularly important given increasing recognition of and concern regarding ionizing radiation exposure.[7,8] Recently, third-generation dual-source 192-slice CT was introduced, with incremental improvements in detector width, gantry rotation time, and pitch settings which should improve both image quality (IQ) and radiation dose. Many clinicians may still be unfamiliar with the magnitude of radiation exposure arising from cCTA in daily practice and the tremendous progress in radiation dose reduction while maintaining or enhancing diagnostic IQ using high-end CT systems. Consequently, the purpose of this study was to assess the IQ and radiation dose of the third-generation dual-source cCTA in comparison with 64-slice single-source CT.

Methods

Our institutional review board waived the requirement for informed consent for this retrospective study. From October to December 2015, a total of 70 patients (median age 63.8 years; range 39.2 to 82.8 years), including 34 men (median age 61.5 years; range 39.2 to 75.5 years) and 36 women (median age 65.9 years; range 45.3 to 82.8 years), with low-to-intermediate probability of CAD underwent

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See page 1161 for disclosure information.

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Table 1
Patient demographics and characteristics

Patient characteristics	Group 1 Somatom Force (n=70)	Group 2 Sensation 64 (n=70)	p-value
Male-to-female ratio	34:36	39:31	n.s.
Age (years)	63.8 ± 8.7	59.9 ± 12.2	n.s.
Body weight (kg)	80.2 ± 14	78.4 ± 15.5	n.s.
Body mass index (kg/m^2)	27.5 ± 4.1	27.1 ± 4.6	n.s.
Average heart rate (beats/min)	61.8 ± 7.4	62.3 ± 6.3	n.s.
Dose-length product (mGycm)*	111.00 [77.75-134.00]	878.00 [836.00-1025.50]	<0.001
Effective dose (mSv)*	1.55 [1.09-1.88]	12.29 [11.63-14.36]	<0.001

Unless otherwise specified, data are mean ± standard deviations.
n.s. = nonsignificant.
* Medians [25th-75th-percentile].

Table 2
Objective image quality

Objective Image Quality		Group 1 Somatom Force (n=70)	Group 2 Sensation 64 (n=70)	p-value
CT-Signal (HU)	Aorta	499.8 ± 172.9	380.2 ± 78.0	<0.001
	LM	480.1 ± 167.8	393.1 ± 76.8	<0.001
	pLAD	464.5 ± 167.0	358.4 ± 81.6	<0.001
	pLCx	483.5 ± 180.1	390.5 ± 103.9	<0.001
	pRCA	471.1 ± 174.7	395.2 ± 74.9	<0.001
	dLAD	354.7 ±138.4	292.9 ± 83.9	0.002
	dLCx	378.2 ± 140.3	323.3 ±86.6	0.006
	dRCA	438.3 ± 164.9	333.1 ± 84.6	<0.001
Image noise (HU)		31.7 ± 7.1	31.2 ± 7.4	0.683
Contrast-to-noise ratio (CNR)	Aorta	50.0 ± 40.1	26.1 ± 11.2	<0.001
	LM	48.5 ± 38.2	27.0 ± 12.1	<0.001
	pLAD	46.9 ± 36.6	25.2 ± 12.0	<0.001
	pLCx	48.6 ± 37.9	26.8 ± 12.1	<0.001
	pRCA	48.1 ± 41.7	27.1 ± 11.7	<0.001
	dLAD	37.4 ± 26.0	21.1 ± 9.8	<0.001
	dLCx	39.2 ± 27.7	22.9 ± 10.5	<0.001
	dRCA	45.7 ± 39.8	23.6 ± 10.5	<0.001
Signal-to-noise ratio (SNR)	Aorta	15.9 ± 4.4	12.8 ± 4.0	<0.001
	LM	15.3 ± 4.5	13.3 ± 4.0	0.006
	pLAD	14.8 ± 4.6	12.1 ± 4.0	<0.001
	pLCx	15.4 ± 4.8	13.2 ± 4.7	0.009
	pRCA	15.0 ± 4.7	13.3 ± 3.9	0.025
	dLAD	11.3 ± 3.8	9.9 ± 3.6	0.006
	dLCx	12.1 ± 3.9	11.0 ± 4.1	0.117
	dRCA	14.1 ± 5.1	11.1 ± 3.7	<0.001

Unless otherwise specified, data are mean ± standard deviations.
dLAD = distal left anterior descending artery; dLCx = distal left circumflex artery; dRCA = distal right coronary artery; HU = Hounsfield units; LM = left main coronary artery; pLAD = proximal left anterior descending artery; pLCx = proximal left circumflex artery; pRCA = the proximal right coronary artery.

cCTA on a third-generation dual-source CT system at our institution (group 1). For comparison, data from a equivalent number of 70 patients with low-to-intermediate probability of CAD were used (median age 59.9 years; range 33.4 to 88.2 years), including 39 men (median age 58.9 years; range 33.4 to 88.2 years) and 31 women (median age 61.1 years; range 36.2 to 78.5 years) who had undergone cCTA on a 64-slice CT system from August to October 2015 at our institution (group 2). For both groups of patients with low-to-intermediate probability of CAD, patient selection was only chronological and no further inclusion and exclusion criteria were used. cCTA examinations were performed with a third-generation 2 × 192-section dual-source CT system (Somatom Force; Siemens Healthineers, Forchheim, Germany) (group 1) at 90 KV or with a 64-slice CT system (Sensation 64; Siemens Healthineers) at 120 KV (group 2). Before the cCTA study, a nonenhanced electrocardiography (ECG)-triggered CT acquisition was performed in all patients to obtain the coronary calcium score using scanner-specific scanning parameters as previously described.[9] Contrast enhancement was achieved using a bolus-tracking protocol with a threshold of 100 HU within a region of interest placed in the ascending thoracic aorta. A volume of 50 ml of Iomeprol (Iomeron 400; Bracco Altana Pharma, Konstanz, Germany) was used in group 1, and 90 ml of the same contrast agent was used in group 2. In all patients, contrast material was injected at a flow rate of 5 ml/s through an 18-gauge intravenous antecubital catheter, followed by 50 ml of saline at the same flow rate. Group 1 data sets were acquired through prospectively ECG-triggered high-pitch spiral acquisitions during diastole as previously described,[10] whereas group 2 data sets were acquired through retrospective ECG gating.[11] According to our institutional protocol, patients without contraindications and a heart rate >80 beats/min received up to 10 mg of bisoprolol (CONCOR tablets) oral and Beloc (AstraZeneca, London, England) intravenously in repeated 5-mg doses before image acquisition. All patients without contraindications received 0.4 mg of nitroglycerine spray sublingually before cCTA.

The calcium score was calculated using dedicated software (CaScore; Siemens Healthineers) according to the Agatston method.[9] All contrast-enhanced cCTA data were reconstructed with a section thickness of 0.5 mm in the axial plane. Third-generation dual-source CT data were reconstructed with a third-generation iterative reconstruction (IR) technique (advanced modeling iterative reconstruction [ADMIRE]; Siemens Healthineers) strength level 3 and a corresponding vascular kernel[12,13]; 64-slice CT system data were reconstructed from CTA raw data with traditional filtered back projection and corresponding vascular algorithm as previously described.[11]

Image evaluation was performed on a dedicated image-processing workstation (Syngo MMWP VE 36A; Siemens Healthineers). Both objective and subjective IQ were assessed for all patients in a blinded and randomized fashion by 2 blinded observers in consensus (GA, experience in cCTA: 6 years; PA, experience in cCTA: 7 years). All technical and personal identifiers were removed from the images. The CT attenuation (in Hounsfield units) was evaluated on the transverse images by drawing regions of interest (ROI) as large as possible inside the vessel lumen while avoiding arterial walls and artifacts.[14] Measures were taken in the mid-ascending aorta, left main coronary artery, proximal left anterior descending artery, proximal left circumflex artery, proximal right coronary artery, distal left