Original Investigation

ECG-gated Versus Non-ECG-gated High-pitch Dual-source CT for Whole Body CT Angiography (CTA)

Martin Beeres, MD, Julian L. Wichmann, MD, Claudia Frellesen, MD, Andreas M. Bucher, MD, Moritz Albrecht, MD, Jan-Erik Scholtz, MD, Nour-Eldin A. Nour-Eldin, MD, Tatjana Gruber-Rouh, MD, Clara Lee, MD, Thomas J. Vogl, MD, Thomas Lehnert, MD

Rationale and Objectives: To investigate motion artifacts, image quality, and practical differences in electrocardiographic (ECG)-gated versus non-ECG-gated high-pitch dual-source computed tomography angiography (CTA) of the whole aorta.

Materials and Methods: Two groups, each including 40 patients, underwent either ECG-gated or non-ECG-gated high-pitch dual-source CTA of the whole aorta. The aortic annulus, aortic valve, coronary ostia, and the presence of motion artifacts of the thoracic aorta as well as vascular contrast down to the femoral arteries were independently assessed by two readers. Additional objective parameters including image noise and signal-to-noise ratio were analyzed.

Results: Subjective and objective scoring revealed no presence of motional artifacts regardless of whether the ECG-gated or the non-ECG-gated protocol was used ($P > 0.1$). Image acquisition parameters (examination length, examination duration, radiation dose) were comparable between the two groups without significant differences. The aortic annulus, aortic valve, and coronary ostia were reliably evaluable in all patients. Vascular contrast was rated excellent in both groups.

Conclusions: High-pitch dual-source CTA of the whole aorta is a robust and dose-efficient examination strategy for the evaluation of aortic pathologies whether or not ECG gating is used.

Key Words: CT angiography; Aorta; High-pitch; Dual-source CT; Radiation dose.

INTRODUCTION

Various improvements in computed tomography (CT) technology are currently commonly used such as wide-detector, single-source, or dual-source systems, and have led to shorter image acquisition durations and less motion artifacts. With the introduction of the latest dual-source CT devices, CT angiography (CTA) of the aorta is feasible in seconds (e.g., a whole body aorta examination within 3 seconds) (1–5). Faster image acquisition has become possible because dual-source CT allows pitch values of up to 3.4 with or without electrocardiographic (ECG) synchronization (6). Other factors influencing image acquisition are the use of fast gantry rotation times, fast table movement, and wide detector systems. One major advantage of high-pitch dual-source CT imaging is its ability to virtually freeze motion for the evaluation of the thoracic aorta, as heart motion can lead to diagnostic difficulties (4,7).

Previous studies have been conducted on bolus timing in high-pitch dual-source CT, and there have been feasibilities comparing high-pitch CT to single-source CT techniques (7,8). Many of these studies showed advantages such as fast image acquisition, motionless imaging of the thoracic vessels, and the possibility of evaluating the coronary arteries without ECG gating (9).

However, to our knowledge, no explicit analysis of ECG-gated versus non-ECG-gated imaging of the aorta under normal circumstances has been performed until now. ECG gating in high-pitch dual-source CT defines the "starting point" of the examination and is therefore necessary in cardiac imaging to start the examination at the right moment of the cardiac cycle (10). A defined part of the cardiac cycle (e.g., diastole) is usually not necessary for imaging of the aorta. For imaging of the aorta, a motion-free thoracic aorta is essential, especially to rule out aortic dissection (11,12).

Motion artifacts of the thoracic aorta are rare in high-pitch dual-source CT and, following recent literature, might be independent of the use of ECG gating (4,7,9). The objective behind our study was to compare two identical high-pitch dual-source CT protocols in terms of image acquisition for the evaluation of the whole body aorta. The difference

Acad Radiol 2016; 23:163–167

From the Department of Diagnostic and Interventional Radiology, Clinic of the Goethe University, Theodor-Stern-Kai 7, 60590 Frankfurt, Germany (M.B., JL.W., C.F., AM.B., M.A., J-E.S., N-EA.N-E., T.G-R., C.L., TJ.V., T.L.); Department of Diagnostic and Interventional Radiology, Cairo University Hospital, Cairo, Egypt (N-EA.N-E.). Received June 13, 2015; revised August 31, 2015; accepted September 3, 2015. **Address correspondence to:** M.B. e-mail: beeres@gmx.net

http://dx.doi.org/10.1016/j.acra.2015.09.003

TABLE 1. Study Population and Evaluation of Examination Parameters

	Group 1	Group 2	*P* Value: Group 1 vs. Group 2
Patients	40	40	
Male	23	29	
Female	17	11	
Age (years)	63 ± 21.1 (39–82)	64 ± 24.2 (29–88)	0.72
BMI (kg/m^2)	27.8 ± 3.9 (18.9–31.5)	28.3 ± 3.8 (18.3–32)	0.24
Scanning range (cm)	71.6 ± 9.3 (64.2–84.1)	71.7 ± 10.5 (40.2–83.9)	0.61
Scanning duration (s)	1.7 ± 0.2 (1.2–2.2)	1.8 ± 0.5 (1.1–2.1)	0.97
CTDIvol (mGy)	3.7 ± 0.5 (2.9–4.2)	3.8 ± 0.6 (3.2–4.3)	0.44

BMI, body mass index; CTDIvol, volume CT dose index.
Values in brackets represent ranges.

between the two CT protocols was the activation or deactivation of ECG gating. Thus, the goal of our study was to investigate motion artifacts, image quality, and practical differences in ECG-gated versus non-ECG-gated high-pitch dual-source CTA of the whole aorta.

MATERIALS AND METHODS

Patients and CT Protocols

This study was performed as a single-center, observer-blinded, retrospective study. The local ethics committee of the Goethe University approved the study, and written informed consent were obtained from all patients. Our clinical database of unselected patients who underwent clinically indicated CT of the whole aorta on the same dual-source CT scanner between January 2013 and January 2015 defined our study population (Table 1).

A random sample of 80 patients was analyzed, randomly divided into two groups to reach a group size of 40 individuals.

Group 1 consisted of patients who had undergone CTA on a dual-source CT device operated in dual-source high-pitch mode (Definition Flash, Siemens Healthcare, Forchheim, Germany) with a pitch of 3.0, collimation of 2 × 128 × 0.6 mm, and a rotation time of 0.28 s, without ECG gating (Table 2).

Patients in group 2 had been examined on the same dual-source CT system operated in dual-source high-pitch mode with a pitch of 3.0, collimation of 2 × 128 × 0.6 mm, and a rotation time of 0.28 s, with activated ECG gating.

Automatic exposure control was used in all groups: automated tube potential selection and automated tube current modulation (Care kV and CARE Dose 4D, Siemens Healthcare). Data were acquired in craniocaudal direction during a deep inspiratory breath-hold. The imaging range extended from the upper thorax aperture to the inguinal ligaments.

Contrast enhancement was achieved by injecting a fixed amount (70 mL) of iodinated contrast material (iodine concentration of 400 mg/mL, Imeron 400, Bracco Imaging, Konstanz, Germany) followed by 50 mL of saline chaser. The bolus was injected through an 18–20G intravenous

TABLE 2. Examination Parameters

	Group 1	Group 2
Imaging mode	Dual-source	Dual-source
Machine	Definition flash	Definition flash
Slice × collimation	2 × 128 × 0.6	2 × 128 × 0.6
Pitch	3.0	3.0
ECG gating	On	Off
ROI	Descending aorta	Descending aorta
HU threshold	200	200
Delay (s)	7	7

ECG, electrocardiographic; HU, Hounsfield units; ROI, region of interest.

access on the patient's forearm at a flow rate of 4 mL/s using a double-syringe electronic power injector (Injektron CT2, Medtron, Saarbruecken, Germany). CTA was automatically started using a bolus tracking technique at the level of the descending thoracic aorta after a trigger threshold of 200 Hounsfield Units (HU) was reached. The start delay was set to 7 s in both groups.

Images were reconstructed using a matrix size of 512 × 512 and 2-mm slice thickness with 2-mm increments. A medium-soft convolution kernel (B30f), a matrix size of 512 × 512, and a CTA window (center: 100 HU; width: 700 HU) were used. Images were reconstructed using the filtered-back-projection technique. No iterative reconstruction algorithms were applied. For additional three-dimensional evaluations, we reconstructed coronal, axial angulated, and parasagittal images of 2-mm slice thickness with 2-mm increments for evaluation of the aortic valve and the coronary ostia. Postprocessing was performed on a TeraRecon Aquarius Workstation (TeraRecon, San Mateo, California, USA).

Image Analysis

The total CTA examination time was recorded in seconds. As measures of objective image quality, several measurements region of interest were performed by one radiologist with 6 years of experience in CT imaging on a regular