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Research paper

ECG-triggered high-pitch CT for simultaneous assessment of the aorta and coronary arteries

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ABSTRACT

Objectives: To study the image quality of ECG-gated-computed tomography (CT) acquisition with a high-pitch CT imaging for the exploration of both the aorta and coronary arteries.

Methods: Eighty-four patients underwent high-pitch ECG-gated aortic CT without β-blockers with iterative reconstruction algorithms. Contrast-to-noise ratio (CNR) between vessels and adjacent peri-vascular fat tissue were calculated on the aorta and the coronary arteries. Dose-length-products (DLP) were recorded. Two blinded readers graded image quality of the aorta and the coronary arteries on a 3-point scale. Coronary artery stenoses were compared with coronary angiograms in 24 patients. Kappa values were calculated.

Results: High-pitch acquisition resulted in a mean DLP of 234 ± 93 mGy cm(4.2 mSv) for an acquisition of the entire aorta, (mean 73 ± 16 bpm). CNR for ascending aorta was 10.6 ± 4 and CNR for coronary arteries was 9.85 ± 4.1. Image quality was excellent in 79/84 patients (94%), and excellent or moderate but diagnostic in 1087/1127 coronary artery segments (96%). 74 significant stenoses were observed, and 38/40 significant stenoses were confirmed by coronary angiography (K = 0.91, Sensitivity = 0.97, Specificity = 0.98).

Conclusion: High-pitch ECG-gated aortic CT with iterative reconstructions allows an accurate exploration of both aorta and coronary arteries during the same acquisition, with limited dose deposition, despite the lack of β-blockers and relatively high heart rate. Radiologists need to be aware of the necessity to analyze and report coronary artery disease in aortic examination.

1. Introduction

The computed tomography angiography (CTA) of the aorta is a technical imaging challenge. One of the most important points is image quality, i.e. absence of artifacts, presence of vascular attenuation and contrast-to-noise ratio (CNR). These factors are crucial to reach a high accuracy for the diagnosis of the aortic disease, but the management of motion artifacts in the ascending aorta is of critical importance. Indeed, up to 57% of false intimal flap leading to misdiagnosis of dissection are caused by motion artifacts.[1] This is mainly explained by an insufficient temporal resolution of conventional CT acquisitions.

Coronary-CT angiography has become a very useful technique for the depiction of coronary artery disease (CAD).[2–5] Identification of asymptomatic patients who are at high risk of developing CAD is of major importance. Such patients may undergo CT for other indications, for instance aortic diseases, and subsequently extraction of accurate coronary analysis from the aortic CTA would be of great

Abbreviations: CAD, coronary artery disease; CNR, contrast-to-noise ratio; CTA, computed tomography angiography; ECG, electrocardiogram; LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main coronary artery; RCA, right coronary artery.

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clinical value. However, CT acquisition parameters are different for aortic imaging and for coronary imaging. So, aortic exploration may not be optimal for the analysis of coronary arteries, and additional acquisition may be required. As a consequence, if the exploration of both the aorta and coronary arteries is required, the resulting dose deposition is significant.

The recent development of new generation dual-source CT, high-pitch CT and new iterative reconstructions have led to image improvement by decreasing movement artifacts, decreasing image noise and increasing CNR of vessels.[6,7] Published data addressing the ability of such protocols to allow accurate and combined explorations of both aortic and coronary arteries during the same acquisition are scarce, especially with low radiation deposition and regardless of the heart rate.[8–10]

The purpose of this study was to evaluate the image quality and CNR of uniquely thoraco-abdominal ECG-gated acquisition with a high-pitch and iterative reconstructions algorithm for the exploration of both the aorta and coronary arteries.

2. Material and methods

2.1. Patient selection

This retrospective study was conducted in the radiology department of _. It was approved by the local institutional review board, and informed consents were waived.

The study was based on the CT data of 84 subsequent patients who underwent a contrast-enhanced CT of the complete aorta on the dual-source MDCT system from April to December 2013. CTA was performed for a suspicion of or a follow-up for aortic disease such as a dissection (n = 20, M/F: 16:4, mean age: 57 ± 20); thoracic aortic (n = 15, M/F: 7:8, mean age: 66 ± 14) or abdominal aneurysm (n = 39, M/F: 35:4, mean age: 74 ± 10) or in order to plan a transcatheter aortic valve replacement (n = 10, M/F: 4:6, mean age: 82 ± 3). Patients therefore underwent coronary angiography when indicated for their management.

The final study population consisted of 84 patients (62 males) with a mean age of 70 ± 16 years.

2.2. CTA acquisition protocol

All examinations were performed on a second-generation, dual-source MDCT system (Somatom Definition Flash, Siemens Healthcare, Forcheim, Germany). CT acquisition parameters were as follows: pitch: 3.2; rotation time: 0.28 s; collimation: 64 × 2 × 0.6 mm. An automated tube potential selection algorithm was used according to patient attenuation on the scout scan (CarekV) with a reference of 120 kV–250 mA, generating a kilovoltage of 80–140 and modulated mAs according to patient attenuation on the scout scan. All patients received an injection of 120 mL intravenous contrast medium (Iohexol, 350 mg of iodine/ml, GE Healthcare) followed by 50 mL saline flush at a flow rate of 6 mL/s. The acquisition was initiated with a bolus tracking (region of interest (ROI) placed in the ascending aorta; threshold: 100 HU, scanning delay: 15 s). The thoracic, abdominal and pelvic CT acquisitions were performed in the cranio-caudal direction after synchronization to the ECG. Acquisition was designed to obtain diastolic images of the heart, i.e. by initiating the scanning so that the heart was scanned at 60% of the R-to-R-peak interval. No β-blockers or nitrates were administered for heart rate control or coronary vasodilation.[11] Supplementary unenhanced or delayed acquisitions were performed according to the clinical situation, especially for patients with treated abdominal aortic aneurysm or suspected dissection. But, only arterial phase was used to assess the feasibility of a combined assessment of both the aorta and the coronary arteries.

A thoracic and abdominal images data set was reconstructed with iterative reconstruction algorithms (SAFIRE®-strength 3–kernel I26f) with a section thickness and an increment of 1.5/1 mm for the aortic analysis and 0.6/0.3 mm for the coronary artery analysis, respectively.

2.3. CT imaging analysis

2.3.1. Mean attenuation, image noise and contrast-to-noise ratio

ROI were manually drawn to measure the attenuation in Hounsfield units (HU) and were made as large as possible but avoiding calcium plaques and stenoses. ROIs were placed: 1) in the ascending thoracic aorta, and abdominal aorta just previously mentioned the iliac bifurcation; 2) at the origin of coronary arteries i.e. left main coronary artery (LM), left anterior descending artery (LAD), left circumflex artery (LCX), and right coronary artery (RCA); and 3) in the adjacent perivascular fat tissue. Image noise corresponded to the standard deviation of the attenuation of the ascending aorta as previously described.[10,12]

CNR were also calculated at both the aortic levels and the origin of these four coronary arteries according to published data, as follows [10]:

$$CNR = \frac{(mean\ vessel\ attenuation - mean\ perivascular\ fat\ tissue\ attenuation)}{standard\ deviation\ of\ perivascular\ fat\ tissue\ attenuation}$$

with attenuations expressed in HU.

2.3.2. Image quality and artifacts

Coronary arteries were analyzed according to the 17 segments of the American Heart Association[13] using an external workstation (Vitrea® Workstation, Vital Image, Minnetonka USA). The RCA includes segments 1–4, and segment 5 was defined as the LM. The LAD includes segments 6–8. Segments 9 and 10 correspond to the first and second diagonal branches and segments 11–15 to the LCX. Segment 16 was assigned to the posterior left ventricular branch originating from the RCA. The intermediate artery, if present, was defined as segment 17. Because of normal anatomical variations, not all coronary artery segments were present in all patients.

All CT were reviewed by two independent radiologists (_ and _) with 6 and 20 years experience in cardiovascular imaging. Readers were asked to grade the image quality and presence of respiratory motion and heart motion artifacts using a semi-quantitative 3-point scale, as follows: a score of 1 indicated excellent image quality without motion artifacts; 2, a moderate image quality with minor blurring of the vessel wall but diagnostic image quality; and 3, non-diagnostic image quality with severe blurring of the vessel wall or doubling of vessel contours. This analysis was performed at the level of the aortic valve, ascending aorta, descending aorta,