Effect of Intracycle Motion Correction Algorithm on Image Quality and Diagnostic Performance of Computed Tomography Coronary Angiography in Patients with Suspected Coronary Artery Disease

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Rationale and objectives: We sought to explore the impact of intracycle motion correction algorithms (MCA) in the interpretability and diagnostic accuracy of computed tomography coronary angiography (CTCA) performed in patients suspected of coronary artery disease (CAD) referred to invasive coronary angiography.

Materials and Methods: Patients with suspected CAD referred to invasive coronary angiography previously underwent CTCA. Patients under rate-control medications were advised to withhold for the previous 24 hours. The primary end point of the study was to evaluate image interpretability and diagnostic performance of MCA compared to conventional reconstructions in patients referred to invasive angiography because of suspected CAD.

Results: Thirty-five patients were prospectively included in the study protocol. The mean age was 61.4 ± 9.4 years. Twenty-seven (77%) patients were men. A total of 533 coronary segments were evaluated using conventional and MCA reconstructions. MCA reconstructions were associated to higher interpretability rates (525 of 533, 98.5% vs. 515 of 533, 96.6 %; $P < .001$) and image quality scores (3.88 ± 0.54 vs. 3.78 ± 0.76; $P < .0001$) compared to conventional reconstructions. Although only mild, a significant difference was observed regarding the diagnostic performance between reconstruction modes, with an area under the curve of 0.90 (0.87–0.92) versus 0.89 (0.86–0.92), respectively, for MCA and conventional reconstructions ($P = .0447$).

Conclusions: In this pilot investigation, MCA reconstructions performed in patients with suspected CAD were associated to higher interpretability rates and image quality scores compared to conventional reconstructions, although only mild differences were observed regarding the diagnostic performance between reconstruction modes.

Key Words: Imaging; β-blockers; interpretability; multidetector.

During the past decade, computed tomography coronary angiography (CTCA) has gained a role in a number of diagnostic algorithms as a validated noninvasive diagnostic tool aimed at evaluating symptomatic patients at intermediate risk of coronary artery disease (CAD). This position has been obtained mainly on the basis of a high sensitivity and an excellent negative predictive value (1–3). Nevertheless, the positive predictive value of CTCA has yielded considerably lower results, particularly in patients with intermediate-to-high probability of CAD, driven by a larger prevalence of false-positive findings in such populations. Indeed, although CTCA has shown a high diagnostic accuracy in most clinical scenarios, it does not provide a significant incremental value over functional tests in patients with high pretest probability (4). Most false-positive findings in CTCA are associated to diffuse coronary calcification and/or motion artifacts (5). So far, the development of newer generations of CT scanners has failed to

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provide major improvements in the evaluation of diffusely calcified lesions. In turn, several hardware- and software-based approaches have demonstrated, with different success rates, to improve temporal resolution to diminish motion artifacts associated to high or irregular heart rates (6). Recently, intracycle motion correction algorithms (MCA) that use information from adjacent cardiac phases to compensate for coronary motion have been proposed as a potential means to scan patients with high or irregular heart rates without using rate-control medications (7). We therefore sought to explore the impact of MCA in the interpretability and diagnostic accuracy of CTCA performed in patients suspected of CAD referred to invasive coronary angiography.

METHODS

Study Population

The present was a single-center, investigator-driven, prospective study that involved patients with suspected CAD referred to invasive coronary angiography. All patients included were aged >18 years, in sinus rhythm, able to maintain a breath-hold for 15 seconds, without a history of contrast-related allergy, renal failure, or hemodynamic instability. Additional exclusion criteria comprised a history of previous myocardial infarction within the previous 30 days, previous percutaneous coronary revascularization or coronary bypass graft surgery, or chronic heart failure. Patients under rate-control medications were advised to withhold for the previous 24 hours. Coronary risk factors and clinical status were recorded at the time of the CT scan, and clinical variables were defined as indicated by the Framingham risk score assessment. No rate-control medications were administrated before the scan.

The primary end point of the study was to evaluate image interpretability and diagnostic performance of MCA compared to conventional reconstructions in patients referred to invasive angiography because of suspected CAD. For this purpose, we prospectively enrolled consecutive patients with suspected CAD to undergo CTCA before the invasive procedure.

Image Acquisition

Patients were scanned using a 64-slice high-definition scanner (Discovery HD 750; GE Healthcare, Milwaukee, WI), after intravenous administration of iodinated contrast (iobitridol, Xenetix 350; Guerbet, France) through an antecubital vein. A total of 60–80 mL of iodinated contrast was injected using a three-phase injection protocol, as follows. Phase 1: 50% of the total iodinated contrast volume being injected undiluted at a rate of 4.5–5.0 mL/s; phase 2: the other 50% of the contrast medium mixed at a 60:40 saline dilution, injected at a rate of 4.5–5.0 mL/s; and phase 3: a 30–40 mL saline chasing bolus at a rate of 4.5–5.0 mL/s. A bolus tracking technique was used to synchronize the arrival of contrast at the level of the coronary arteries with the start of the scan. Image acquisition was performed after sublingual administration of 2.5–5 mg of isosorbide dinitrate.

TABLE 1. Demographical Characteristics (*n* = 35)

Age (years ± standard deviation)	61.4 ± 9.4
Male (%)	27 (77)
BMI (kg/m^2)	28.0 ± 2.4
Heart rate (median; interquartile range)	62.0 (50.0–68.0)
Diabetes (%)	7 (20%)
Hypertension (%)	32 (91.4%)
Hypercholesterolemia (%)	21 (60.0%)
Previous smoking (%)	15 (42.9%)
Current smoking (%)	2 (5.7%)

The decision to perform retrospective or prospective acquisitions was left at discretion of the investigators, based on the body mass index and the heart rate before the scan. Briefly, in patients with a heart rate <65 bpm, a prospective ECG-triggered acquisition was performed using a 100-millisecond padding centered at 75% of the cardiac cycle; in patients with high or irregular heart rates, a retrospective acquisition was performed with dose modulation to reduce tube output during systole. Other scanner-related parameters were a collimation width of 0.625 mm and a slice interval of 0.625 mm. Maximum tube voltage and current were adjusted according to the acquisition mode (prospective or retrospective) and body habitus (100 or 120 kV for patients with body mass index <30 kg/m^2 or greater, respectively).

Image Analyses

CTCA image analyses were performed offline on a dedicated workstation, using a commercially available dedicated software tool (AW 4.6; GE Healthcare) by consensus of two experienced level-3–certified coronary CTCA observers (P.C. and A.D.), blinded to the clinical data and the reconstruction mode. The same observers were randomly assigned MCA or conventional reconstructions of each patient, with at least a 2-week window period between paired examinations. Briefly, the MCA multiphase reconstruction (Snapshot Freeze; GE Healthcare, Milwaukee, WI) algorithm, after automated coronary vessel tracking, uses information from adjacent cardiac phases within a single cardiac cycle to characterize vessel motion (vessel path and velocity) to determine the actual vessel position at the prespecified target phase and adaptively compensates for any residual motion at that phase. The time required for MCA reconstruction to be completed is 27 seconds, whereas conventional reconstructions entail 9 seconds.

Iterative reconstruction algorithms were applied in all cases at 40% adaptive statistical iterative reconstruction. Axial planes, curved multiplanar reconstructions, and maximum intensity projections were used at 1–5 mm slice thickness, according to the previously reported American Heart Association 17-segment model. Images were evaluated on a per-segment basis and a per-territory basis. Segments with a