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Atherosclerotic Plaque Characterization by Multidetector Row Computed Tomography Angiography

Marco A. S. Cordeiro, MD, PhD,*‡ João A. C. Lima, MD, MBA, FACC*†

Baltimore, Maryland; and Brasilia, Brazil

Multidetector row computed tomography angiography (MDCTA) is seen as a potential alternative to current imaging methods for the assessment of vessel anatomy and atherosclerotic plaque composition/morphology in a great variety of arterial beds. Recent advances represented by the increase in gantry speed to <500 ms per rotation and in the number of detector rows from 4 to 64, in addition to the decrease in slice thickness to submillimetric levels, brought significant improvement in diagnostic accuracy by coronary MDCTA. In general, it has a good correlation with both intravascular ultrasound (IVUS) and histopathology for discrimination between soft, intermediate, and calcified plaques. Plaque area and volume tend to be underestimated by 12-detector row MDCTA and overestimated by 16-detector row MDCTA, but the number of patients studied so far is relatively small. However, it seems that 64-detector row MDCTA can measure plaque area and volume with greater accuracy. Plaque remodeling is overestimated in small vessels by 12-detector row MDCTA, whereas 16- and 64-detector row MDCTA show a good correlation with IVUS. Although still under development, the potential of MDCTA to characterize atherosclerotic plaque composition as well as to precisely determine plaque area, volume, and remodeling in the future is quite promising. (J Am Coll Cardiol 2006;47:C40–7) © 2006 by the American College of Cardiology Foundation

Multidetector row computed tomography angiography (MDCTA) recently emerged as a potential alternative to current imaging methods for the assessment of vessel anatomy and atherosclerotic plaque morphology in numerous arterial beds, such as the aorta (1), the coronary arteries (2–27), the carotids (28), and the main peripheral arteries (29). In this review, we will mainly describe the ability of MDCTA to characterize atherosclerotic plaque composition and morphology within the coronary arteries.

EVOLUTION OF MDCTA

The increase in gantry speed to <500 ms per rotation (19,20) and in the number of detector rows from 4 to 64 (25–27), as well as the decrease in slice thickness to submillimetric levels (23,24), brought significant improvement in diagnostic accuracy by coronary MDCTA (Table 1).

Motion still causes most image artifacts currently found during coronary 16-detector row MDCTA (16). An increased number of detector rows allows image acquisition to occur during shorter breath-hold intervals and through a decreased number of heartbeats, potentially decreasing the frequency of motion artifacts. Our initial clinical experience with both 400/32 × 0.5- (24) and 400/64 × 0.5-MDCTA (Cordeiro et al., unpublished data, May 2005; Fig. 1) apparently confirms this assumption. However, the most important components of temporal resolution are in fact gantry rotation speed and special image reconstruction algorithms, whereas spatial resolution is basically dependent on slice thickness during image acquisition. Unfortunately, owing to implementation of different methodologies, the studies shown in Table 1 cannot be directly compared. Nevertheless, the evolution represented by the progressive increase in gantry rotation speed and implementation of dedicated image reconstruction algorithms, as well as by the decrease in slice thickness that was lately achieved by modern MDCTA systems, can be illustrated by the fact that initial studies performed with 500/4 × 1.0-MDCTA and using a half-scan reconstruction algorithm (temporal resolution of 250 ms) had to exclude up to 32% of the coronary segments because of image artifacts (5). On the other hand, a more recent study (30) performed by 370/16 × 0.75-MDCTA and also using a half-scan reconstruction algorithm (temporal resolution of 185 ms) excluded only 7% of the segments. Likewise, Dewey et al. (23), by using 500/16 × 0.5-MDCTA and a multisegment reconstruction algorithm (temporal resolution of up to 62.5 ms), had to exclude only 2% of the segments. However, Raff et al. (27) more recently excluded 12% of the segments while using 330/64 × 0.6-MDCTA, but this could have been influenced by the apparent enrollment of a larger number of patients with high coronary artery calcium (CAC) scores (26% of individuals with an Agatston score >400) in this particular study.

From the Division of Cardiology, Departments of *Medicine and †Radiology, The Johns Hopkins University School of Medicine, Baltimore, Maryland; and the ‡Department of Cardiology, Heart Institute (InCor-DF), Zerbini Foundation, Brasilia, DF, Brazil. Dr. Cordeiro is funded by the Brazilian National Research Council (CNPq, Brasilia, DF, Brazil) as a postdoctoral fellow (fellowship grant 202706/02-8) in the Division of Cardiology of The Johns Hopkins University School of Medicine (Baltimore, Maryland). Dr. Lima has received research grants from Toshiba Medical Systems Corporation, Otawara, Japan. Dr. William A. Zoghbi acted as guest editor.

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Abbreviations and Acronyms

ACS = acute coronary syndrome
CAC = coronary artery calcium
CAD = coronary artery disease
CT = computed tomography
EBCTA = electron-beam computed tomography angiography
IVUS = intravascular ultrasound
MDCTA = multidetector row computed tomography angiography

Calcified vessels still represent a strong limitation to most MDCTA systems. Hoffmann et al. (17) attributed to calcification 94% (18 of 19) of their false positive results for detection of ≥50% coronary stenoses in native arteries by 420/16 × 0.75-MDCTA. However, we recently obtained a sensitivity of 76%, a specificity of 94%, and a diagnostic accuracy of 91% for detection of ≥50% stenoses in native coronary arteries of patients with advanced coronary artery disease (CAD) and high calcium scores (63% of the patients had Agatston scores >400) by 400/32 × 0.5-MDCTA (24). Such good results even in this challenging subgroup of patients might have also been influenced by the new automated approach implemented for the analyses (31).

Unfortunately, contrary to what seemed to be logical in this new scenario of higher temporal resolution and shorter scanning time, effective radiation doses have actually increased from 8.0 to 11.0 mSv with 500/4 × 1.0-MDCTA (4) to 11.8 to 16.3 mSv with 375/16 × 0.75-MDCTA (20), and lately to 8.0 to 18.0 mSv with 400/32 × 0.5-MDCTA (24) and 13.0 to 18.0 mSv with 330/64 × 0.6-MDCTA (27). It is true that radiation doses might vary depending on the measurement tools, the MDCTA system's manufacturer, and the coronary imaging protocol used. However, it seems that thinner slice collimations lately achieved by modern MDCTA scanners represent the

Table 1. Studies Comparing Coronary MDCTA With Conventional Invasive Angiography on a Per-Segment Basis

	Patients (n)	Sensitivity (%)	Specificity (%)
		500/4 × 1.0-MDCTA	
Nieman et al. (3)	31	81	97
Knez et al. (4)	44	78	98
Achenbach et al. (5)	64	91	84
Nieman et al. (6)	53	82	93
Vogl et al. (7)	64	75	99
Giesler et al. (8)	100	91	89
Kopp et al. (9)	102	86*	96*
		93†	97†
Sato et al. (10)	54	94	97
		500/8 × 1.25-MDCTA	
Maruyama et al. (11)	25	90	99
		500/8 × 1.0-MDCTA	
Matsuo et al. (12)	25	75	96
		420/12 × 0.75-MDCTA	
Nieman et al. (13)	59	95	86
Ropers et al. (14)	77	92	93
Kuettner et al. (15)	60	72	97
		420/16 × 0.75-MDCTA	
Mollet et al. (16)	128	92	95
Hoffmann et al. (17)	33	70	94
Hoffmann et al. (18)	103	95	98
		375/16 × 0.75-MDCTA	
Kuettner et al. (19)	72	82	98
Mollet et al. (20)	51	95	98
Achenbach et al. (21)	50	94	96
		500/16 × 0.6-MDCTA	
Martuscelli et al. (22)	64	89	98
		500/16 × 0.5-MDCTA	
Dewey et al. (23)	34	88	91
		400/32 × 0.5-MDCTA	
Cordeiro et al. (24)	30	76	94
		375/64 × 0.6-MDCTA	
Leschka et al. (25)	67	94	97
		330/64 × 0.6-MDCTA	
Leber et al. (26)	59	73	97
Raff et al. (27)	70	86	95

*Reader 1. †Reader 2.
MDCTA = multidetector row computed tomography angiography.