64-slice scanners build case for coronary CTA

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Research focused on the causes, diagnosis, treatment, and prevention of cardiovascular disease is progressing rapidly.1 Radiology has always played a central diagnostic role, particularly in the coronary vessels. A technique for selectively catheterizing the coronary arteries was developed in 1959, and conventional x-ray coronary angiography is still considered the gold standard for detecting coronary artery disease.2

Noninvasive cardiac imaging is a demanding application for any radiologic modality,3 and the reliable noninvasive assessment of coronary artery lesions would constitute a major investment in clinical cardiology.4 Multislice CT has demonstrated its capacity for detecting coronary artery stenosis and extraluminal coronary plaques over the past five years, first with four-slice, then 16-slice, and now 64-slice scanners.5-9 Practitioners can use 16-slice CT angiography to study the coronary arteries of patients with a relatively low and regular heart rate.10 The clinical role of this technique is not yet well defined, however, and implementation remains limited. Effective temporal and spatial resolution are still insufficient for scanning patients with higher and irregular heart rates and for visualizing high-density structures such as large calcified plaques and stents.11 Research is therefore focused on hardware improvements that can expand and strengthen the applications for MSCT.

The latest generation of 64-slice MSCT technology provides high-resolution scanning of large sections in a short period of time. Our CTA scan protocol is based on our experience with a Sensation 64 scanner (Siemens Medical Solutions), which has one detector panel with 32 rows. We use an individual detector collimation of 0.6 mm, rotation time of 330 msec (effective temporal resolution 165 msec), 120-kV tube voltage, effective 900-mAs tube current, 3.84-mm table feed per tube rotation (pitch 0.2), and a craniocaudal scan direction. CTA scan time is about 12 seconds, and the study can be completed in a single breath-hold.

The core hardware technology that permits these specifications is based on the z-FFS flying focal spot in the z-axis (Siemens) and the new Straton x-ray tube (Siemens). The focal spot is continuously modified between two points aligned in the z-axis (Figure 1). The flying x-ray beam is directed onto a 32-row detector panel with an individual detector-row width of 0.6 mm. Voxel size following scanning and reconstruction is 0.3 x 0.3 x 0.4 mm3. The new x-ray tube is smaller and lighter, due to a novel cooling design. Rotation time can be increased to 330 msec/rotation. Effective temporal resolution using a single 180° segment is now 165 msec.

More slices can be acquired during the gantry's rotation and the patient's single breath-hold. Images from the cardiac cycle are effectively frozen. Acquisition of cardiac images during the same cardiac phase requires that images are reconstructed with retrospective ECG gating. The advantage of this method is that a period within the R-to-R interval with the fewest motion artifacts (usually during the diastolic phase) can be selected for image reconstruction. Intravenous injection of 100 mL iodinated contrast material (370 to 400 mgI/mL) at 4 to 5 mL/sec, preferably in the antecubital vein, provides enhancement, and an automatic bolus-tracking technique triggers the start of MSCT scanning. Postprocessing is an important part of our 64-slice MSCT coronary artery studies. We reconstruct images using 0.6-mm effective slice thickness and a medium-smooth to medium-sharp convolution algorithm. We keep the field-of-view as small as possible while still covering the heart and large vessels of interest.

Evaluation of the images requires a combination of multiplanar reconstruction, maximum intensity projection, and volume rendering (Figure 2). Although 3D volume rendering depicts vascular anatomy well, assessment of wall abnormalities and stenoses requires additional reconstruction
techniques (Figure 3). Curved MPR along the central lumen is mandatory to show vessels in a single plane and to detect coronary artery lesions. Dedicated software allows images to be rotated 360 degrees. The vessel's orthogonal plane is particularly useful for detecting the percentage of stenosis and the type of atherosclerotic plaque (Figure 4).

Evaluation of coronary arteries based on MSCT data requires that physicians apply appropriate tools and reconstruction planes. This operator dependency is a matter of concern for the widespread diffusion of coronary CT. The skills of the operator significantly affect the quality of the coronary CT scan, and, ultimately, of the corresponding report. Use of the American Heart Association's classification of coronary vessel anatomy aids diagnosis of coronary artery disease from MSCT scans and facilitates communication with cardiology colleagues. Stenoses are considered significant when the mean reduction in lumen diameter is greater than or equal to 50%. Plaque should be classified as either calcified, noncalcified, or mixed.

**CLINICAL SETTING**

Not all patients are suitable for coronary artery examination with MSCT. Ideal candidates are stable patients with a heart rate greater than 70 bpm and normal sinus rhythm, and without premature (extra-systolic) beats, contrast allergy, and severe renal failure. Unstable patients with heart failure should not be scanned because they cannot lie in a supine position. Patients with bradycardia and premature beats may not need to be excluded, however. Bradycardia and a regular heart rate reduce the likelihood of movement artifacts. Patients should, if possible, receive a beta blocker and benzodiazepine one hour before scanning to reduce heart rate. They should be advised about each step of the examination to minimize the chance of breathing artifacts and/or stress-induced increases to heart rate. Image acquisition is further aided by correct patient positioning in the gantry and a good venous access for contrast material. A retrospectively ECG-gated spiral examination performed without prospective tube current modulation should allow flexible positioning of the temporal windows throughout the cardiac cycle. MSCT coronary angiography is already being used in a variety of clinical settings, despite the absence of guidelines. The latest 64-slice CT scanners are improving on the ability of 16-slice CT to detect coronary artery stenosis and plaque. Sixty-four-slice MSCT can provide important information about coronary anatomy, stenoses, plaque, calcium, left ventricular function, and valves. Improved spatial resolution yields a higher diagnostic accuracy for coronary stenosis detection and extension of diagnosis into smaller vessels. Images acquired on 64-slice CT are less likely to suffer from blooming artifacts from coronary stents or calcium, and coronary plaques can be characterized more clearly. The higher temporal resolution reduces scan times and improves the ability to freeze images from the cardiac cycle.

In clinical practice, 64-slice CT should be performed in the early stages of diagnosis for coronary artery disease, and in the later stage of chronic ischemic heart disease follow-up. The first scenario would be of benefit to relatively young patients at high risk for coronary artery disease who present with atypical chest pain or borderline stress test (nuclear imaging or treadmill test), who would otherwise be scheduled for invasive coronary angiography. MSCT has a negative predictive value of 100% in patients with stable angina. It can also assist the diagnostic workup of patients with noncardiac thoracic pain such as aortic dissection, pericarditis, or mediastinum disease. Evaluation of plaque burden is another important application for 64-slice CT. Noninvasive coronary plaque characterization might become a relevant diagnostic tool for risk stratification in patients with known or suspected coronary artery disease. MSCT could also be employed to exclude an ischemic origin of dilated cardiomyopathy.

Patients requiring a coronary artery bypass graft may benefit from 64-slice CT, as it can visualize venous and arterial conduits with a high degree of sensitivity and specificity in patients who have undergone bypass grafting (Figures 5A-5C and 5G). It can also be used to evaluate the native vasculature.

MSCT is appropriate for patients with chronic multivessel disease and borderline stress tests. Its ability to detect chronic total occlusion adds important information about the morphology of the occlusion trajectory (Figures 5D-5F), which is generally not available with conventional coronary angiography.

The improvement in spatial resolution enables 64-slice CT to detect the coronary lumen inside a stent. MSCT could become a reference technique for follow-up after coronary stenting, and it could be used in patients not eligible for a treadmill and cycle-ergometer testing and those with a contraindication to stress testing.

**FUTURE OUTLOOK**

Sixty-four-slice CT coronary angiography may in some cases replace conventional coronary
angiography, which is an invasive and potentially harmful procedure that carries a small risk of serious adverse events.\textsuperscript{19}

Cardiologic diagnosis and follow-up with MSCT avoids hospital admission and reduces examination discomfort, providing benefits for patients and economic advantages for hospitals. Radiologists and cardiologists at the Erasmus Medical Center perform 64-slice CT coronary angiography on almost every patient before invasive coronary angiography. Our goal is to validate the technique and improve the scan protocol. The new generation of CT scanners is fast, relatively inexpensive, patient-friendly, and relatively harmless.\textsuperscript{20} MSCT should become the gold-standard technique for cardiologic diagnosis in a selected patient population.

**References**

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Disclosures:

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