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Multi-slice spiral CT (MDCT) is a noninvasive modality for visualization and evaluation of atherosclerosis in vivo in different arterial beds. Rapid technical advances led to a significant improvement of the diagnostic accuracy of coronary MDCT angiography. The most popular clinical application of MDCT with the best scientific evidence is the noninvasive detection and quantification of coronary calcifications. In particular, the concept of coronary age by evaluating an individual’s biological age (rather than chronological age) is attractive and currently under scientific evaluation. Additionally, when evaluating contrast-enhanced coronary arteries, different stages of atherosclerosis can be visualized. It could be shown by comparative studies with intracoronary ultrasound that echogenicity corresponds well with the density measured within atherosclerotic plaques expressed in Hounsfield units using MDCT. Continuously improving and still under development, the potential of MDCT to evaluate plaque composition and plaque volumes noninvasively in vivo is promising.

Introduction
Coronary artery disease (CAD) is still a leading cause of mortality and morbidity in the Western world. Despite primary prevention programs to detect atherosclerotic disease in an asymptomatic early stage of disease, the number of persons suffering from unheralded acute cardiovascular events is continuously rising. Screening for early-stage asymptomatic cancers (eg, cancers of breast and colon) to prevent late-stage malignancies has been widely accepted. However, although atherosclerotic cardiovascular disease (ASCVD; eg, heart attack and stroke) accounts for more deaths and disability than all cancers combined, there are no national screening guidelines for asymptomatic (preclinical) atherosclerosis [1–3].

Multi-slice spiral CT (MDCT) scanners have been available since 1999. This technology has the ability to 1) detect coronary calcifications on native, non–contrast-enhanced scans and 2) also visualize noncalcified lesions, when using intracoronary contrast attenuation.

This article presents an overview of the current scientific evidence, as well as the possible clinical applications of noninvasive MDCT plaque imaging.

Technical Improvements
MDCT has become a robust modality for noninvasive assessment of coronary arteries [4•].

In 1999, the first generation using four slices was introduced for cardiac imaging. Due to rapid technical improvements, with faster gantry rotation times and smaller voxel sizes, image quality could be considerably stabilized [5]. The quality and speed of cardiac CT examinations have increased dramatically as CT technology has evolved to multichannel (4-, 8-, 10-, 16-, 64-, and 254-slice) spiral CT systems (1998–2008) [6].

In 2006, dual-source CT technology (DSCT) became available. DSCT was primarily designed to increase the temporal resolution. With two tubes and two detectors mounted at orthogonal orientations in the gantry, the transmission data required for the reconstruction of one image slab can be acquired in half the time needed by a conventional CT system. Thus, at a gantry rotation time of 330 msec, the temporal resolution of DSCT is for a quarter of the rotation time (eg, 82.5 msec) [7]. In addition, 256-slice MDCT systems have become available recently [8]; their large coverage along the z axis (patient’s longitudinal axis) may allow imaging of the entire heart in a single cardiac cycle and make coronary CT angiography less susceptible to arrhythmias or heart rate variability.

In Vivo Plaque Imaging Using Multi-Slice Spiral CT
Detection and quantification of coronary calcium
Coronary calcium is a surrogate marker for the presence and amount of coronary atherosclerotic plaque [9,10].
Both electron beam CT and MDCT allow the accurate detection and quantification of coronary artery calcium. The radiation dose for a calcium scan is in the range of 1 to 2 mSv [11,12].

Half of the coronary deaths and most myocardial infarctions in the United States occur in persons characterized as low or intermediate risk. CT measurement of coronary arterial calcification in large groups of individuals has provided important epidemiologic statistics regarding the relationship between coronary arterial calcification and coronary events.

The amount of coronary calcium correlates moderately close to the overall atherosclerotic plaque burden. On the other hand, not every atherosclerotic coronary plaque is calcified, and calcification is neither a sign of stability nor of instability of an individual plaque [13]. Clinically, coronary calcium is detectable in most patients with acute coronary syndromes, and the amount of calcium in these patients is substantially greater than in matched control subjects without CAD [14–17].

Numerous prospective trials have demonstrated that the presence of coronary calcium in asymptomatic individuals is a prognostic parameter with strong predictive power for future hard cardiac events. All the same, patient management approaches based on calcium assessment have not been prospectively investigated. A beneficial contribution of coronary calcium assessment to risk stratification can most likely be expected in individuals who seem to be at intermediate risk for coronary events (0.6% to 2.0% annual risk) based on traditional risk factor analysis. Unselected “screening” or patient self-referral is uniformly not recommended [18,19,20•].

Although the coronary calcium score has been found to be progressive over time, only very preliminary studies are available that have linked progression of coronary calcium to cardiac event rates [21]. Results concerning the influence of lipid-lowering therapy on the progression of coronary calcium have been inhomogeneous [4•]. In addition, the variability of coronary calcification measurements is high. Therefore, there is no current indication for repeated coronary calcium score measurements.

Accuracy of calcium quantification

The widely used Agatston score based on the peak density measurement on electron beam CT yields 28% to 72% interscan variability, which jeopardizes the ability to detect any changes within this range. This variability has demanded large changes in an individual patient’s calcium score before investigators can be confident of the progression of coronary arterial calcification. Without the ability to measure coronary artery calcification in individuals with reasonable certainty and precision, as well as repeatedly over meaningful time intervals, the effect of treatment regimens on the progression of coronary arterial calcification in individual patients cannot be determined. MDCT holds promise to overcome this limitation: coupling the technique of retrospective gating with nearly isotropic volumetric imaging, the reliability of coronary calcium quantification (especially for small plaques) was found to significantly improve. Using ECG-gated volume coverage with MDCT and overlapping image reconstruction (2.5 mm collimation, 1 mm increment), an interscan variability of approximately 5% to 8% can be achieved. With the advent of multislice CT with significantly reduced interscan variability, we can now begin to define the effects of treatment regimens on coronary arterial calcification and to determine whether changes in coronary arterial calcification in individual patients have predictive value for future coronary events. If these differences in calcium score over time result in a difference in event rates, it is conceivable that serial measurements of calcium score by MDCT will provide a powerful and much needed predictive tool [22].

Determination of coronary calcium scores as a marker for cardiovascular risk

Coronary calcium is an accurate marker of atherosclerotic disease burden and is directly related to cardiovascular risk. The prevalence of coronary calcium is age dependent, ranging from 5% to 50% in elderly persons [23]. There are a number of studies indicating the importance of age- and gender-adjusted percentiles to predict the occurrence of cardiovascular events in subjects with a similar risk profile [24]. The implication of these studies was a greater risk of subjects with higher calcium scores as marker for disease burden.

One important study, the St. Francis Heart Study, was designed to evaluate the prognostic accuracy of CT calcium scoring of the coronary arteries and the relationship of coronary calcification to standard coronary disease risk factors in the prediction of ASCVD events in apparently healthy middle-aged persons [25]. In a prospective, population-based study, 4903 asymptomatic persons 50 to 70 years of age underwent CT scanning of the coronary arteries. At 4.3 years, follow-up was available in 4613 participants (94%), and 119 had sustained at least one ASCVD event. Subjects with ASCVD events had higher baseline coronary calcium scores (median [interquartile range], Agatston method) than those without events: 384 (127,800) versus 10 (0.86; P < 0.0001). For coronary calcium score threshold greater than 100 versus less than 100, relative risk (95% CI) was 9.6 (6.7–13.9) for all ASCVD events, 11.1 (7.3–16.7) for all CAD events, and 9.2 (4.9–17.3) for nonfatal myocardial infarction and death. The coronary calcium score predicted CAD events independently of standard risk factors, was superior to the Framingham risk index in the prediction of events (area under the receiver-operating characteristic curve of 0.79 ± 0.03 vs 0.69 ± 0.03, P = 0.0006), and enhanced stratification of those falling into the Framingham categories of low, intermediate, and high risk (P > 0.0001). Thus, CT coronary calcium score predicts CAD events independent