EDITORIAL COMMENT

Another Step Forward in CT Angiography*

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Coronary angiography has been the “holy grail” of noninvasive cardiovascular imaging. From the first attempts to image coronary arteries by noninvasive imaging (1,2), the complex motion of this arterial system in humans has been recognized as the most important challenge to be met. The small luminal diameter of the coronary vessel and its capricious trajectory in 3-dimensional (3D) space represent additional challenges to noninvasive imaging. Moreover, in the case of computed tomography (CT), calcification represents an additional obstacle to coronary angiography in patients with advanced coronary artery disease (CAD).

In this issue of JACC: Cardiovascular Imaging, Achenbach et al. (3) report that the increased temporal resolution of dual-source CT scanning may improve the CT’s ability to evaluate the severity of lesion stenosis, particularly in patients who do not achieve adequate heart rate control during the examination. These findings highlight the importance of the ratio imaging/diastolic time interval even when gating and short scanning times (10 to 12 s) are used. Although a previous study (4) had indicated such an effect, this is the first study to demonstrate it by random assignment of patients to single- or dual-source CT imaging with or without heart rate control. The investigators also demonstrate that an aggressive protocol to reduce heart rate with beta-blockers during imaging is only successful (by the stringent criterion of heart rate <60 beats/min) in up to 60% of patients with suspected CAD.

The appraisal of what have been the major technologic developments in CT angiography confirms the initial belief that motion control represents the most important requirement for noninvasive coronary imaging. In the case of CT, because spatial resolution in the z (or axial) direction is inversely proportional to slice thickness, the ability to image the coronary arterial system by multislice CT became feasible only when 12 to 16 slices separated by 1 mm or less could be rotated fast enough (0.5 s or less) to cover at least 6 to 8 mm each time (5). Moreover, further potential improvements related to greater coverage by 64-slice, 256-slice, and 320-slice multidetector computed tomography (MDCT) are also predicated on the ability to reduce (or eliminate) the time required to image 2 different cardiac slices (or a group of slices) in the axial direction, given the complex 3D coronary motion mentioned earlier (5,6).

Similarly, the use of cardiac gating, fast gantry rotation (300 to 500 ms), short breath-holds (12 s or less), and beta-blockers (oral and/or intravenous) to decrease motion and increase the diastolic period, all of which have become standard strategies in single-source 64 MDCT coronary angiography, have the same primary objective: to control coronary artery motion in 3D space during the cardiac cycle. Finally, the ability to combine partial images from different cardiac cycles (i.e., multisegmented reconstruction) has also been implemented for the same purpose, but does require synchronization of gantry rotation to the patient’s heart rate to be effective (7).

The optimal use of such advanced technology requires not only the identification of correct clinical indications for coronary CT angiography, but
also the standardization of imaging protocols and methods to process and interpret images by trained personnel. In this regard, the first reports of multicenter studies performed at different sites in the world (8,9) suggest that such implementation is possible and realistic. The recognition of coronary disease has obvious implications, given the widespread prevalence of CAD in both developed and developing countries (10). In this regard, the availability of noninvasive robust technology to guide the diagnosis and management of CAD is of paramount importance. On the other hand, the potential risks, including excessive radiation (11), represent concerns that require enhanced investigation and continued development.

The potential for improved performance facing the technical challenges mentioned earlier, and the need to achieve them at lower radiation exposure, continues to foster the unprecedented development of coronary CT angiography seen in the last few years. Prospective gating and single-beat exposure with complete coverage to decrease exposure time are promising strategies to reduce radiation. They have been implemented in different platforms and have enabled safer procedures of good quality. Given the recent acceleration in the development of cardiovascular CT, it is difficult to predict what will be the ultimate system to be employed in the assessment of CAD. From a cardiac standpoint, greater temporal resolution from multiple sources and complete coverage are both highly desirable. They will always have to be balanced against the concomitant need for radiation reduction. In this regard, it is important to notice that since the implementation of coronary CT angiography, a beneficial societal awareness relative to radiation risks in routine cardiology practice is leading us to re-evaluate the use of nuclear procedures and the appropriateness of routine coronary CT angiography (11).

These exciting developments and accompanying concerns lead us to believe that it is likely that coronary CT angiography procedures in the future will be tailored to different types of clinical presentations and preventive needs. On one side, symptomatic patients with low probability for CAD or asymptomatic individuals with multiple risk factors (such as strong family history of premature infarction or sudden death) will likely benefit most from procedures with low radiation levels below 1 to 2 mSv. For this purpose, measures of atherosclerotic load and plaque composition (12) will likely be coupled to the quantitative assessment of the degree of lesion stenosis (3–5,12,13). On the other end of the spectrum, patients with advanced CAD will likely benefit the most from examinations that would include not only the assessment of coronary anatomy and plaque morphology, but also from the evaluation of ventricular chamber size and function, myocardial perfusion (14,15), and viability (16,17). Therefore, it would be important to develop algorithms that limit test redundancy and unnecessary therapy, allow ultimate reductions in cost and radiation, and provide a reliable answer to both the physician and the patient. In this regard, the study by Achenbach et al. (3) represents another important step forward.

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