Low-Dose Computed Tomography Coronary Angiography With Prospective Triggering
A Promise for the Future*

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Computed tomography for coronary angiography (CTCA) has rapidly evolved into a valuable alternative to invasive coronary angiography for accurate noninvasive assessment of coronary morphology. Although increasing values of positive predictive values are continuously reported, it is generally accepted that the strength of this technology at present lies in its excellent ability to exclude coronary artery disease (CAD) (i.e., its high negative predictive value). In concordance, most recommendations (1) consider the use of CTCA mainly in low-to-intermediate probability populations. By its nature, such a population will turn out to have low prevalence of CAD and low risk for cardiovascular events. Consequently, it is unlikely that any diagnostic or therapeutic procedure will improve the outcome. Therefore, the bar seems to be very high for any technique to keep a positive balance of harms and benefits. It is in this context that the effective radiation dose administered to patients undergoing CTCA has evoked an ongoing vivid controversy on the potential cancerogenic risk of CTCA and its justification for a purely diagnostic test. This has induced the search for strategies to minimize the radiation dose while maintaining image quality. Several technical advances have allowed a decrease of the dose from 20 to 25 mSv originally to about 15 mSv by use of electrocardiogram (ECG)-gated tube current modulation and even below 10 mSv (2) by further optimizing scanning parameters. A recent milestone in dose reduction for CTCA has been achieved by introducing prospective ECG triggering, where scanning is limited to a narrow pre-defined end-diastolic phase resulting in a massive reduction in radiation exposure (3).

In this issue of the Journal, Maruyama et al. (4) present the first results comparing the accuracy of spiral CTCA versus prospective triggering computed tomography (CT) using invasive quantitative coronary angiography as a standard of reference. The study included 173 patients, of which 97 underwent spiral CT and 76 were scanned using prospective ECG triggering. The proportion of patients with an entirely assessable coronary tree was almost identical in both groups (i.e., 85% [spiral] and 86% [prospective]). As a result, the percentage of assessable segments was 95.5% in the spiral and 96.6% in the prospective group, confirming the pioneering first clinical experience of the feasibility of prospective ECG triggering for CTCA (3). Effective radiation dose was substantially reduced from 21 ± 6.7 mSv to 4.3 ± 1.3 mSv. Nevertheless, sensitivity and specificity for coronary obstructive and occlusive lesions in the assessable segments by prospective triggering were 96.4% and 98.5%, comparing well to the 97.0% and 97.6% by helical scan. These results underline for the present study population the noninferiority of the prospective ECG-triggering protocol versus the spiral acquisition mode and confirm that the former allows a substantial reduction in effective radiation dose at no cost of diagnostic accuracy. In the first clinical report on prospective triggering, the mean effective radiation dose was lower, averaging 2.1 ± 0.6 mSv most probably because the padding was set at 0 ms, while Maruyama et al. (4) have set it to 30.4 ms. In addition, the present study used a test bolus scan for timing of the scan start after contrast injection.

Interestingly, in the present study, the nonassessable segments were mostly due to calcifications while stair-step artifacts were not observed. This is in sharp contrast to the previous first clinical report, where stair-step artifacts accounted for 46% of nonassessable segments. Several factors may have contributed to this: first, the present study included patients referred for follow-up after coronary intervention. This may have lead to a higher prevalence of CAD with more calcifications in this study. Second, although the administered beta-blocker dose was not excessively high, the heart rate was lower than in previous studies, which reduces heart rate variability and lengthens the motion free diastolic phase. Thus, the applicability of the present results to a broad unselected patient population must be judged with caution. Another weakness of the study is that patients were not randomized to the 2 scanning protocols, but the decision to switch from spiral scanning to prospective triggering was taken rather arbitrarily. Thus, selection bias with regard to heart rate and other factors favoring the latter technique cannot be entirely excluded. This is underlined by the fact that from 113 patients assigned to prospective scanning only 76 were included, while from 116 assigned to spiral scanning 97 were in-

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cluded. A further weakness of the study is that data analysis was not performed in a blinded fashion. Further, the calculation of sensitivity and specificity only included the assessable segments, overestimating the diagnostic accuracy. This, however, applies to both scanning protocols. Finally, the question of which stable patients will benefit most from CTCA was not addressed and must remain unanswered with this study—very similar to the question of which chronic stable CAD patients will benefit most from the numerous percutaneous coronary interventions performed every year worldwide despite substantial radiation and procedural risks. Interestingly, the authors mention in the legend of Figure 3 that a moderate stenosis was treated medically because myocardial perfusion test did not reveal ischemia. Unfortunately, no data throughout the study are provided on the relation of anatomic CTCA findings to functional data, although CTCA has recently been shown to be of comparable value as invasive angiography in evaluating the hemodynamic relevance of coronary lesions (5).

In summary, despite some limitations mentioned above mainly with regards to study design, the results provided by Maruyama et al. (4) represent another important step forward to reducing effective radiation dose in CTCA and, thus, to shifting the benefit-to-harm ratio of this technique to the favorable side of clinical benefit. Even monitoring of CAD therapy with repeat low-dose CTCA may no longer be considered prohibitive for radiation concerns.

The beauty of prospective triggering lies in its universal applicability as it is not limited to the 64-slice scanners but can be implemented in the latest and future scanner generations; for example, in those with 320 slices allowing full coverage of the heart in 1 rotation (6). Thus, the concept of prospective triggering has set new standards and is a promise for the future.

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