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EDITORIAL COMMENT

IVUS detects more coronary calcifications than MSCT; matter of both resolution and cross-sectional assessment?

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Amongst the advanced cardiac imaging modalities, multi-slice computed tomography MSCT has emerged as a reliable non-invasive method for the assessment of coronary anatomy, coronary artery disease, and cardiac function [1–16]. Multiple studies involving over several thousands of patients have established that MSCT is highly accurate for delineation of the presence and severity of coronary atherosclerosis [17–30]. MSCT may also reveal the total plaque burden, i.e., both calcified and non-calcified components, for individual patients with coronary atherosclerosis [31–38]. The advent of prospectively gated acquisition techniques for 64-slice MSCT has deepened our insight in soft versus hard plaques together with a significant reduction in dose exposure [39–43]. Apart from MSCT, plaque calcifications can also be recognized by MRI and, in particular, by intravascular ultrasound (IVUS) [44–49]. However, smaller calcifications might be missed on MSCT due to its lower resolution and it is unknown to which extent calcifications can be detected with MSCT.

In the current issue of the *International Journal of Cardiovascular Imaging*, van der Giessen et al. [50] compared the detection of calcifications on contrast enhanced MSCT with IVUS. They randomly selected 23 patients (18 male, mean age 54 ± 11 years) from the subpopulation that was imaged for the PROSPECT trial. The authors aimed for 100 calcifications on IVUS, which was reached by inclusion of 23 patients. Of these patients only non-stented coronary arteries were included. The coronary arteries of patients with myocardial infarction or unstable angina were imaged by 64-slice MSCT angiography and IVUS. The IVUS and MSCT images were registered and the arteries were evaluated on the presence of calcifications on both modalities independently. The length and the maximum circumferential angle of each calcification on IVUS were measured. In 31 arteries, 99 calcifications on IVUS were found, of which only 47 calcifications were also detected on MSCT. A total of 107 calcifications were identified on either IVUS or MSCT. We identified calcifications on both IVUS and MSCT, 52 calcifications were identified on IVUS only and 8 were identified on MSCT only. The calcifications missed on MSCT ($n = 52$) were significantly smaller in angle (27° ± 16° vs. 59° ± 31°) and length (1.4 ± 0.8 vs. 3.7 ± 2.2 mm) than those detected by IVUS. Calcifications could only be detected reliably on MSCT if they were larger than 2.1 mm in length or 36° in angle. The authors concluded that more than half (53%) of the calcifications seen on the IVUS images could not be

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detected on contrast enhanced 64-slice MSCT angiography images because of their size.

This is the first study [50] that compares the ability to detect coronary calcifications in contrast enhanced 64-slice MSCT and IVUS on a cross-sectional basis. The authors claim the limited resolution of MSCT in combination with the obscuring effects of the contrast in the lumen as the main reason for missing small calcifications. The findings are at variance with previous comparisons between MSCT and IVUS which showed generally good to excellent correlations [51, 52]. The authors legitimate their findings by stating that the presence of calcifications by previous studies was examined on a vessel or segmental basis rather than on a cross-sectional basis. This difference might explain the discrepancy between previous and present findings. A cross-sectional approach might potentially detect more calcified lesions. However, the authors make a bigger case for the 'poor' resolution of MSCT versus IVUS as the main explanation for their findings.

In general, IVUS image quality can be described by two important resolution issues: (1) spatial resolution *(axial and lateral resolution),* and (2) contrast resolution *(grayscale/dynamic range)*. The spatial resolution (axial and lateral resolution) is the ability to discriminate small adjacent objects within the image. It depends on the MHz level: the lower the MHz, the deeper the image penetration, the higher the MHz, the higher the image quality. For a 40 MHz IVUS transducer the typical resolution is 80–100 microns axially and 200–250 microns laterally. The contrast resolution (dynamic range) offers the capacity to differentiate different tissues. Distribution of the gray-scale of the reflected signal; a low dynamic range "black and white" with only a few "in between" gray-scale levels versus a high dynamic range image which has more shades of gray, is often "softer" and has more preserved subtleties in the image presentation. Based on these parameters, IVUS technology is capable of 500–600 images per centimeter of artery. It also shows a 360° cross-sectional view allowing the visualization of lumen size and shape together with plaque topography and composition. In the present study [50], a 40MHz IVUS was used providing a stack of gated IVUS images with an axial spacing of approximately 0.5 mm.

Although the spatial resolution is excellent for IVUS compared to MSCT, the spatial resolution for MSCT is theoretically better than 'poor'. In a review article by the same group, both the spatial resolution and the temporal resolution for MSCT were called high. Mollet et al. [53] reported that the spatial resolution in the x/y axis of current MSCT scanners is 0.4×0.4 mm. The spatial resolution in the z axis is determined by the minimum slice thickness, which varies from 0.5 to 0.75 mm depending on the manufacturer. These features permit reconstruction of high quality images with a sub-millimeter, nearly isotropic (same size in every dimension) voxel size. This high spatial resolution reduces partial volume effects and also allows visualization of coronary segments down to diameters of 1.5–2 mm. In the present study [50], using a 64-slice MSCT scanner, the in-plane voxel size was 0.3 mm and the slice thickness 0.4 mm. This might be slightly improved by using 320-row MSTC scanners but the main advantage of 320-row MSCT is its improved temporal resolution [54–56]. Consequently, the spatial resolution of MSCT is inferior to that of IVUS but cannot be labeled as strictly 'poor'.

To conclude, the interesting study by van der Giessen et al. [50] clearly shows that 53% of the calcifications seen on the IVUS images cannot be detected on contrast-enhanced 64-slice MSCT angiography images because of their size. Both differences in spatial resolution and the evaluation by IVUS on a cross-sectional basis rather than on a vessel or segmental basis play a dominant role in explaining the observed phenomenon.

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