OCT Versus IVUS: Accuracy Versus Clinical Utility*

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The technology of optical coherence tomography (OCT) has evolved from time-domain to frequency-domain imaging. Time-domain OCT is most often performed using proximal balloon occlusion; as such, dimensions are smaller than measured using intravascular ultrasound (IVUS), presumably due to diminished perfusion pressure. Conversely, frequency-domain OCT does not require proximal balloon occlusion, theoretically resulting in more accurate measurements.

With this background, Kubo et al. (1) in this issue of iJACC, conducted a multicenter study to compare pre-intervention quantitative analysis and post-intervention qualitative analysis among frequency-domain OCT, IVUS, and quantitative coronary angiography (QCA). The mean minimum lumen diameter measured by QCA was smaller than by OCT, which was smaller than that by IVUS (1.81 ± 0.72 mm vs. 1.91 ± 0.69 mm vs. 2.09 ± 0.60 mm, respectively). The minimum lumen area measured by using IVUS was significantly greater than that according to frequency-domain OCT (3.68 mm² vs. 3.27 mm²; p < 0.001). Both techniques exhibited good interobserver reproducibility in a core laboratory setting. The lumen area by frequency-domain OCT was equal to the lumen areas of phantom models whereas IVUS overestimated phantom model lumen areas (8.03 mm² vs. 7.45 mm²; p < 0.001). Not surprisingly, OCT detected tissue protrusion (95%), incomplete stent malapposition (39%), dissection (13%), and thrombus (13%) much more frequently than did IVUS.

The data presented by Kubo et al. (1) are consistent with previous reports (2–6) except that the mean difference in lumen area between IVUS versus phantoms (0.58 mm²) was the largest among published studies. In previous studies, when OCT and IVUS were compared in vivo, the mean differences in lumen area varied from 0.19 mm² to 1.15 mm² and were consistently larger using IVUS than using OCT, especially in smaller lumens and in nonstented segments. Nonetheless, the integrated performance of both a bench and clinical study is a strength of the current report, and establishes that IVUS overestimates and QCA underestimates coronary diameter measurements (each by approximately 5% in vivo), with frequency domain OCT closest to “the truth.”

Although measurement accuracy is inherently desirable, even more fundamental clinical questions remain. First, what are the quantitative and qualitative OCT predictors of adverse events after bare-metal or drug-eluting stent (DES) implantation? Are they the same or different from IVUS? And, therefore, how should OCT be used to guide stent implantation? Second, does OCT guidance of coronary stent implantation reduce adverse events compared with angiography alone? Which is superior to guide stent procedures, OCT or IVUS? In this regard, the essential properties of OCT and IVUS are so different that dimensional accuracy is only the beginning of the story.

What are the advantages of IVUS? 1) IVUS has been used clinically for nearly 3 decades. 2) Pre-intervention IVUS imaging is almost always possible without pre-dilation. 3) Ultrasound penetration to...
the adventitia allows measurement of the true vessel size (external elastic membrane) and plaque burden, facilitating mid-wall or true vessel stent sizing to optimize stent dimensions and identifying a landing zone with the smallest plaque burden to minimize geographical miss. 4) IVUS predictors of stent failure (stent underexpansion, major edge dissections, and geographic miss but not acute malapposition) are well established. 5) A meta-analysis of 7 randomized IVUS versus angiography-guided bare metal stent implantation trials found that IVUS guidance reduces restenosis and repeat revascularization with no impact on death or myocardial infarction (7). 6) A meta-analysis of 11 IVUS versus angiography-guided DES studies found that IVUS guidance is associated with a reduced incidence of death, major adverse cardiac events, and stent thrombosis (8). This latter meta-analysis is supported by a recently published randomized trial (RESET [Real Safety and Efficacy of a 3-Month Dual Antiplatelet Therapy Following Zotarolimus-Eluting Stents Implantation]) from South Korea (9) as well as by a large-scale prospective observational study (ADAPT-DES [Assessment of Dual AntiPlatelet Therapy with Drug-Eluting Stents]) in more than 8,500 patients (10).

What are the advantages of OCT, especially compared with IVUS? 1) The resolution of OCT is 10 times greater than IVUS such that OCT detects fine details missed by IVUS (e.g., edge dissections, small amounts of malapposition, tissue protrusion, stent strut coverage, fibrous cap thickness), as shown both in the study by Kubo et al. (1) and by others. 2) OCT tissue characterization is better, and OCT may be the gold standard for thrombus detection. 3) The images are clearer and easier to interpret, in part because the obligatory flushing clears the lumen of blood. 4) Rapid automated pullback afforded by OCT minimizes ischemia. 5) One published study by Prati et al. (11) found that OCT-guided DES implantation may be better than angiographic guidance; OCT reduced repeat revascularization, myocardial infarction, and cardiac death.

The major drawback of OCT is lack of depth penetration. As such, the external elastic membrane and extent of plaque burden cannot typically be measured. Thus, with OCT procedural guidance, stent diameters are chosen to match the reference lumen (potentially resulting in smaller stent areas than with IVUS guidance), and avoiding geographic miss may be more difficult with OCT than with IVUS.

Do the advantages of OCT from its enhanced resolution outweigh these limitations? More than 20 years of experience using IVUS have shown that small amounts of tissue protrusion, minor edge dissections, and acute stent malapposition do not correlate with adverse outcomes as long as the minimum stent area is sufficient (12). A small randomized trial (n = 70) comparing OCT versus IVUS guidance showed that the final minimum stent area was significantly smaller after OCT guidance compared with IVUS guidance (6.1 mm² vs. 7.1 mm²; p < 0.05), with a larger plaque burden at the distal stent edge after OCT guidance (13). In other words, there was greater stent underexpansion and more geographic miss with OCT than with IVUS.

Kubo et al. (1) have established that OCT has greater measurement accuracy than IVUS. Whether OCT is superior to (or as good as) IVUS in improving clinical outcomes when used to guide coronary intervention will only be answered by an adequately powered randomized trial. Given the excellent results with contemporary DES, a very large (and expensive) trial would be required to detect relatively small differences. Conversely, given the fact that more than 4 million DES are implanted globally each year, can we afford not to identify the best way to optimize patient outcomes? Until such a trial is complete, it is likely that the OCT versus IVUS debate will continue.

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