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EDITORIAL COMMENT

# Optical Coherence Tomography

## A New Tool to Detect Tissue Coverage in Drug-Eluting Stents*

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The 1990s saw a parallel growth of intravascular ultrasound (IVUS) and stent implantation, heralded and explained by the seminal observations that stents implanted at low pressure under angiographic guidance alone are frequently underdeployed and have higher risk of thrombosis (1). With a high price to pay in terms of late hyperplasia in the first months after implantation, meticulous attention was paid to overexpansion as a potential remedy to reduce restenosis. Despite conflicting results of studies of IVUS-guided stenting (2,3), IVUS was largely applied to guide stenting in complex coronary lesions (4). The introduction of drug-eluting stents (DES) has reset the boundary of optimal stent expansion to prevent thrombosis and restenosis, with risk thresholds as low as 4.5 $mm^2$, achievable in most cases without ultrasound guidance (5). The new challenge for interventional cardiology became late stent thrombosis, and IVUS seemed inadequate to prevent this new evil, with late malapposition (6), but not post-procedural malapposition (7), correlated with late thrombosis.

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Unlike conventional stents that develop circumferential coverage with an average thickness of 500 $\mu$m or more, which are well-visualized with IVUS and angiography (1-mm late loss) (8), DES delay and prevent the hyperplastic response so that the average late lumen loss for sirolimus- or paclitaxel-eluting stents can be lower than 100 $\mu$m (9). Therefore, the amount of intimal thickening will not be detectable with IVUS because of its limited axial resolution and the presence of artifacts around struts.

In this issue of *JACC: Cardiovascular Interventions*, Suzuki et al. (10) suggest that another intravascular imaging technique may replace IVUS for the more refined assessment required by DES. In the 11 stents with a small hyperplastic response measured with histology, IVUS overestimated lumen area and underestimated in-stent hyperplasia. In this swine model of stent overexpansion, the optical coherence tomography (OCT) measurements were much closer to the histological measurements. The receiver operator curve of sensitivity/specificity showed a greater diagnostic accuracy, approaching unity as opposed to a disappointing 0.78 with IVUS (Fig. 5 in Suzuki et al. [10]). This was expected because OCT has a far greater resolution than IVUS and was initially introduced to study superficial plaque components (11), with studies claiming the technique is also able to detect macrophages in unstable plaques (12,13).

Several small studies have recently been published highlighting the application of OCT for the in vivo detection of stent tissue coverage at follow-up (14–16). The study by Matsumoto et al. (16) used both IVUS and OCT in 34 patients following sirolimus-eluting stent (SES) implantation. The mean neointimal thickness was 52.5 $\mu$m, and the prevalence of struts covered by thin neointima, which were undetectable by IVUS, was 64%. The average rate of neointima-covered struts in an individual SES was 89%. Nine SES (16%) showed full coverage by neointima, whereas the remaining stents had partially uncovered struts. This small series confirms the superiority of OCT over IVUS for the detection of thin layers of neointimal tissue following stent implantation.

The crisp OCT images obtained in swine by Suzuki et al. (10) in their experimental model are perfectly reproducible in patients in daily clinical practice. A cumbersome technique of proximal balloon occlusion and subselective intracoronary flushing with crystalloid solutions was used in this study. This strategy can be replaced by continuous injection of a viscous contrast medium via the guiding catheter (17). The OCT image wire is not steerable but can be inserted via an over the wire lumen larger than 0.019 inches using either a single lumen (e.g., Transit, Cordis, Johnson & Johnson, Miami, Florida) or a double lumen monorail–over the wire catheter such as the TwinPass 0.023 in (Vascular Solutions Inc., Minneapolis, Minnesota).

The use of the nonocclusive (flush-only) technique is compatible with OCT systems capable of acquisition speeds between 2 and 3 mm/s; therefore, it is fast enough to generate interpretable images in a safe and rapid manner and is perfectly tolerated with no chest pain or major ECG changes or arrhythmias if an iso-osmolar contrast agent such as iodixanol 320 (Visipaque, GE Health Care, Cork, Ireland) is used (8,18). The OCT procedure is also set to become greatly simplified with the introduction into clinical practice (within 1 to 2 years) of Fourier or optical frequency domain imaging technologies (19), with acquisition speeds of more than 20 mm/s enabling complete pullbacks in only

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a matter of 3 to 5 s and eliminating the need for proximal vessel balloon occlusion.

The scary picture of DES associated with increased mortality and myocardial infarction (20,21) has lost credibility (22–24). Still, the SES Cypher (Johnson & Johnson, Cordis) and the paclitaxel-eluting stent TAXUS (Boston Scientific Corp., Boston, Massachusetts), the only 2 DES with sufficient number of observations at late follow-up, show a small, but worrisome, increase in late thrombosis (22,25).

Trialists are faced with the challenge of studying a phenomenon so rare and so far in time from the initial treatment that they require prolonged studies of tens of thousands of patients to provide meaningful answers. Studies of the magnitude of the largest secondary prevention or thrombolytic megatrials are very difficult to carry out because of cost and availability of patients and suitable centers. The duration of these trials is an equally important problem because their results risk being invalidated by the availability of new antiplatelet treatments and new DES, the latter with the potential to offer greater safety because of thinner struts, more conformable designs, and biologically tissue friendly coatings and drugs. Therefore, OCT has the potential to offer surrogate end points to test the ability of new DES to promote consistent tissue coverage of all struts. Studies of new DES should include OCT substudies of adequate size and with serial examinations at well-selected time intervals after implantation. Such studies could identify the most promising DES and provide evidence to guide duration of antiplatelet treatment after different DES types.

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