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iVIEW

EDITOR'S PAGE

IVUS and OCT: Either or Survivor . . .

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Since its introduction over 20 years ago, intravascular ultrasound (IVUS) has become the dominant imaging technology, helping us to better understand vessel biology and guiding interventional procedures, and providing information on atherosclerosis progression or regression in clinical trials. During this time period, IVUS has survived many other intracoronary techniques that have fallen by the wayside. Recently, optical coherence tomography (OCT), a far higher resolution optical imaging technique, was approved for clinical use by the U.S. Food and Drug Administration. Suter et al. (1), in a State-of-the-Art review article in this issue of *iJACC,* have highlighted the relative merits of each technology currently available for intravascular imaging. However, in an era of rising medical costs and shrinking budgets, the increasing availability and presence of such a wide array of imaging technology in catheterization laboratories raises relevant issues about what exact role such modalities could play. It is particularly important to discuss whether OCT will complement IVUS or replace it, or will it be forgotten as many other intravascular imaging modalities have?

The introduction of grey-scale IVUS in the 1980s was accompanied by validation studies that produced highly reproducible volumetric measurements of plaque and vessel dimensions (2). An equally important contribution of IVUS has been the in vivo confirmation of the concept of expansive arterial remodeling (3). Positive vascular remodeling is now an accepted feature of high-risk coronary plaques (4). The insights about the dynamic nature of coronary lumen dimensions have also found a following among interventional cardiologists, and they have extended the use of IVUS to obtain accurate vessel dimensions for stent sizing and often to accurately define lesion significance (5).

IVUS has also been instrumental in understanding the natural history of atherosclerosis plaque progression. It has demonstrated the relationship between cholesterol levels and percent atheroma volume, and has established the role of statin drugs in plaque regression (6). The ability of the technique to measure plaque burden has permitted the use of IVUS-based surrogate endpoints to test the efficacy of new therapeutic agents, which has raised the prospect of speedy drug testing in sample sizes smaller than would be needed for trials using hard endpoints (7). Furthermore, development of methods to turn radiofrequency data into quantitative information with virtual histology and integrated backscatter, have gained popularity for characterization of plaque composition. The large multicenter PROSPECT (Providing Regional Observations to Study Predictors of Events in the Coronary Tree) study demonstrated a significant association between nonculprit IVUS-defined plaque characteristics and future coronary events (8), and that necrotic cores abutting lumen (NCAL) on virtual histology were representative of thin-cap fibroatheroma. In addition, the PROSPECT trial also revealed that the fateful plaques had evolved to be voluminous before they developed an acute event; this is a departure from the tacitly-held belief that plaque disruption almost always results from minimally stenotic plaques. Similar observations have been reported by the VIVA (Virtual Histology in Vulnerable Atherosclerosis) investigators (9). Even though both studies have demonstrated the value of NCAL, IVUS resolution of 100 to 150 μm is far from adequate for the evaluation of the plaque characteristics. Indeed, a recent histo-

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pathologic study in porcine coronary arteries did not find a correlation between necrotic core size determined by real and virtual histology, questioning the role of IVUS in detection of thin-cap fibroatheroma (10). There is thus a need for a superior imaging strategy that offers substantially incremental information, such as a more precise measurement of the thickness of fibrous cap, which is beyond the capability of conventional IVUS. This is where OCT, with its exquisite resolution might find a place. However, one also needs to keep in mind that while better image quality is a good start, newer techniques would need to help achieve better procedural outcomes to find universal acceptance (7).

OCT measures backscatter of light, or optical echoes, derived from an infrared light source directed at the arterial wall, and as such, can be regarded as a higher resolution analog of IVUS. A <10 μm resolution capability of OCT, validated in ex vivo experiments, has allowed superior definition of the thin fibrous caps and circumferential extent of the necrotic cores, and possibly the presence of macrophages in the fibrous cap; all of these features are indicators of high-risk plaques (1,4). The greater resolution of OCT also holds promise for the evaluation of short- and long-term vascular response to stent implantation (11–14). There has been a strong interest in the use of OCT for identifying stent strut coverage as a potential marker of endothelialization in a follow-up period. OCT has recently uncovered the likelihood of 2 types of in-stent restenosis, with and without neoatherosclerosis, which may carry prognostic information. While interventional studies are now using this technique more commonly, there are no long-term data to validate the use of this technique for the prediction of thrombotic events. Although OCT is a powerful tool for the assessment of vascular interior, relatively poor depth penetration is its most important drawback, which limits the role of OCT for evaluation of regression in percent atheroma volume that has required accurate estimation of vessel size and remodeling. However, the recent demonstration of OCT-verified increase in fibrous cap thickness in response to statin treatment has been proposed as a superior indicator of the efficacy of intervention, and should overcome the inadequate depth limitation (15). In addition, the need for optimal clearance of blood from the vessel lumen, often requiring extra doses of contrast, to generate interpretable images has also found some detractors. Furthermore, unlike operator-friendly translation of radiofrequency signals into color-coded maps to define plaque types, OCT interpretation of images relies heavily on the experience of the operator.

In the short-term it seems likely that IVUS will continue to remain an important player in the catheterization laboratory. It will continue to have a role for easily evaluating lumen dimensions, optimizing stent expansion, and examining post-procedure results. Its antiquity may have given it a temporary pass from the strict requirements of showing improved outcomes in well tested situations. Thus, even though studies did not find significant outcome improvements with its use in routine percutaneous coronary intervention, most still believe that the IVUS-guidance can be helpful during complex interventional procedures. On the other hand, OCT offers promise to transforming the examination of the coronary vessel wall. This technology unfortunately has suffered from a *protracted* infancy. Its drawbacks notwithstanding, potential niches of OCT, such as stent strut coverage and accurate fibrous cap thickness measurement, require a more rigorous validation of long-term value. Multicenter OCT registries have just begun and should allow formulating some consensus statements for its incorporation into interventional practice. With all the changes in our decision making strategies following recent randomized clinical trials and economics of a health care system asking for comparative effectiveness, superior resolution with OCT, while highly desirable, has come rather late in the day. It will be mandatory that the research in this area focuses on obtaining crucial outcome data rather than spend an IVUS-like course where *image quality* rather than *outcome quality* remained the focus for an inordinate amount of time (16).

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