EDITORIAL

Expansion of the Clinical Application of Optical Coherence Tomography to Percutaneous Coronary Intervention and Assessment of the Instability of Coronary Atherosclerosis

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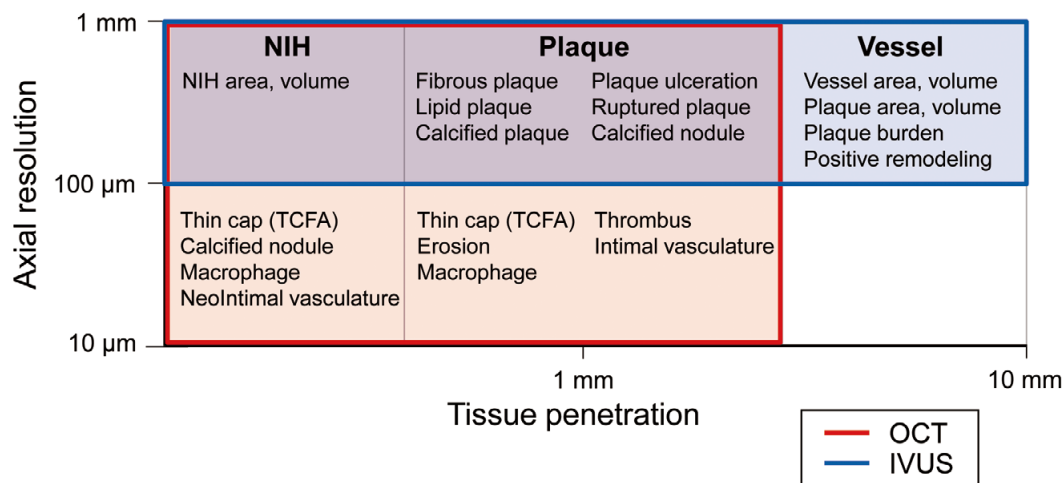
Optical coherence tomography (OCT) is an innovative intravascular imaging tool that can be used to examine coronary atherosclerotic lesions at a resolution (10–15 μm) that far exceeds that of existing methods such as intravascular ultrasonography (IVUS), by an order of magnitude. In the research field, on account of its superior resolution, OCT has been used for qualitative assessment of vulnerable plaque characterized by thin-cap fibroatheroma;[1,2] such plaque is the precursor of the ruptured thrombotic plaque, plaque containing calcium nodules, and plaque erosion.

Article p600

For some plaques, the adventitia, external elastic membrane, deep edge of the intima, and/or internal elastic membrane may be identified. However, for others, these features may not be seen because the very high resolution of OCT restricts the depth of penetration of the light beam through blood and tissue (to 1–3 mm), resulting in incomplete reflection from the deeper arterial layers.[3] Moreover, a necrotic core imaged by OCT is a signal-poor region within an atherosclerotic plaque, with poorly delineated borders, a fast OCT signal drop-off, and little or no OCT signal backscattering, within a lesion that is covered by a fibrous cap. Thus, because light does not penetrate well through the necrotic core, especially in large vessels, it is generally agreed that OCT is not capable of measuring the thickness, area, or volume of the necrotic core and thus the plaque burden in large vessels, when the external elastic membrane cannot be identified.

There are a number of compelling pieces of evidence that arterial outward remodeling (positive remodeling) is associated with vulnerability in the coronary artery. Previous IVUS

Figure. Tissue penetration vs. axial resolution comparison of optical coherence tomography (OCT) and intravascular ultrasound (IVUS). The ability to detect qualitative and quantitative parameters with OCT (red box) and IVUS (blue box) is presented schematically. NIH, neointimal hyperplasia; TCFA, thin-cap fibroatheroma.

studies reported that positive remodeling was detected more frequently in unstable coronary lesions.[4] Furthermore, autopsy studies have shown that positive remodeling is associated with underlying lesions with the histological characteristics of plaque vulnerability, such as a large lipid core and high plaque macrophage content.[5] Under these conditions, OCT is not suitable for assessment of positive remodeling because of its limited penetration depth in a large vessel with plaque containing a large lipid core. Gray-scale IVUS remains the standard for assessing vessel dimensions and plaque volume and is the modality of choice for evaluating vessel remodeling; however, it has limited value for evaluating plaque characteristics such as lipid content. Therefore, combined use of OCT and IVUS has been proposed as a potential method for accurate assessment of plaque characteristics and vulnerability (**Figure**).

As for the application of OCT in the clinical setting, a previous study comparing IVUS- vs. OCT-guided drug-eluting stent implantation found that less aggressive OCT-guided stent sizing was associated with more cases of stent underexpansion and larger reference segment plaque burden compared with IVUS, because of its limited penetration.[6] Previous IVUS studies showed that stent underexpansion was a predictor of early stent thrombosis or in-stent restenosis with both bare-metal and drug-eluting stents.[7] Moreover, larger residual plaque burden adjacent to the reference segment was a predictor of stent-edge restenosis.[7,8] From these findings, OCT-guided PCI seems to have a disadvantage compared with IVUS-guided PCI in terms of in-stent and stent-edge restenosis and stent thrombosis in the clinical setting, whereas there is no evidence of the clinical outcomes for OCT-guided PCI compared with IVUS-guided PCI.

As reported in this issue of the Journal, Kubo et al[9] are to be congratulated for their landmark contribution to the feasibility of OCT use in quantitative measurements in coronary arteries with lipid plaque, supporting expansion of the application of OCT from the research field to the clinical setting. The authors investigated the potential of OCT for measuring coronary vessel area irrespective of the amount of lipid plaque. Although OCT has the weakness of shallow penetration, the authors showed that a simple, interesting algorithm method could provide good performance in measuring coronary vessel area, comparable to that obtained with IVUS. The results of this current study have important implications. In the clinical setting, by using this simple measurement algorithm, the interventional cardiologist may be able to calculate coronary vessel area without recourse to IVUS. Thus, a bigger balloon and/or stent may be chosen and stents are implanted with less residual plaque burden in the adjacent reference segments. Furthermore, in the research field, use of this algorithm may lead to more accurate quantitative assessment of vulnerable plaque, and especially positive remodeling, in addition to qualitative analysis of thin-cap fibroatheroma, ruptured thrombotic plaque and plaque erosion.

This study has several important limitations. First, the approximating algorithm of vessel circumference is calculated based on a perfect circle. If this algorithm was performed when the actual vessel was elliptical, the calculated vessel area would be larger or smaller than the actual vessel area. Indeed, most vessels do not exhibit a perfect circular shape, but are shaped more as an ellipse, especially on OCT. This is a critical limitation of the algorithm, which therefore may not be adaptable

for measurement of vessel area in all situations. Second, the analyzed lesion in this study was a non-culprit coronary segment with mild stenosis on angiography. Thus, this method may not be adaptable for PCI of severe stenoses in the real world. Third, previous studies have reported that a coronary artery that has undergone positive remodeling is associated with vulnerability and accompanied by much more lipid-rich plaque.[4] Based on these findings, lipid-rich plaque with a wider lipid arc (eg, groups 3 and 4 in this study) might be often accompanied by larger vessel area with positive remodeling compared with lipid plaque that has a narrower lipid arc (eg, groups 1 and 2 in this study). Therefore, in the current study, mean difference and limits of agreement might increase with the increase in lipid arc, implying less accuracy of circular approximation in lipid-rich plaque with a wider lipid arc.

In conclusion, Kubo et al[9] have contributed importantly to our evidence base supporting expansion of the application of OCT in both the clinical and research fields. We look forward to their report of the assessment of clinical outcome in OCT-guided PCI using this approximating algorithm, as well as the assessment of adverse coronary events and OCT-derived positive remodeling from such a study.

Disclosures

The authors report no conflicts.

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