AsiaIntervention 2016;2:13-15

Opening the shell for better stent results

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Calcification is a hallmark sign of advanced atherosclerosis and increases with age. As age advances, the mean percent calcified area increases for plaques both with moderate and with severe narrowing[1]. In an autopsy study of patients with severe coronary disease, coronary calcification was present in 90% of men and women aged 50 to 60 and in 100% of men and women older than 60[2]. However, the distribution and magnitude of calcium are distinctly different in atherosclerotic plaques. Calcium can be fragmented or diffuse, different in thickness, arc, and distance from the lumen surface.

Whilst non-invasive coronary computed tomography angiography (CCTA) provides accurate measures of calcium score for more effective risk stratification of interventional procedures[3], the detection and quantification of coronary artery calcification in patients undergoing invasive angiography is problematic. Overall, angiography identifies calcium in less than half of the target lesions with ultrasound-detected calcification. In addition, angiography is not reliable for differentiating superficial from deep calcification[4]. If angiographic calcium is visible in multiple views, the arc of vessel involvement is probably larger.

Does calcification render a stent procedure more difficult or is it only a marker of advanced disease? Delivering a stent into a calcified lesion may be difficult, and full and symmetrical expansion of a stent may be impaired by extensive superficial calcification. Conversely, calcification deep within a plaque does not preclude effective stenting. Biomechanical studies based on computer models have suggested that calcium distribution within plaque could impact differently on stent expansion and apposition[5].

Distinguished patterns of calcification may require different treatment strategies for optimal coronary stent implantation. In the analysis of drug-eluting stents (DES) an arc of calcium ≥90 degrees or an area of calcium ≥1.58 mm^2 significantly reduced stent expansion[6]. In bioresorbable scaffolds (BRS), due to the limited radial force and the polymeric strut configuration not transfixing the coronary artery, significantly lower expansion and more scaffold eccentricity have been reported in the presence of superficial calcification (distance of calcified plaque to the lumen <180 microns), while the observed increase in the rate of malapposition correlates with the area of calcium[7,8].

Compared to intravascular ultrasound (IVUS), optical coherence tomography (OCT) has greater ability to provide accurate quantitative and qualitative evaluation of coronary artery calcifications[9]. Whilst OCT has been extensively used and promoted for lipid-rich plaque identification and characterisation, particularly in acute coronary syndromes, few studies have reported on OCT evaluation

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DOI: 10.4244/AsiaInterv_V2I1A3

of calcification. In fact, light can more easily penetrate calcium compared with lipid, where light scattering might limit the signal penetration.

The manuscript of Ishida and colleagues, published in this issue of AsiaIntervention 2016, attempts to fill this gap in knowledge, bridging the current era of standard angiography-guided PCI to a novel one of pre-interventional OCT-based procedural planning[10]. The most salient OCT finding reported in this study is the predominance of superficial calcium, mainly located within 100 microns from the lumen surface, the most accurate range for light-based measurements. In addition, superficial calcium is the key OCT factor for predicting difficult stent expansion. In total, pre-stent OCT at the target lesion displaying calcium close to the lumen significantly impacts on the stent strategy. Are we ready for prime-time use of pre-intervention imaging planning in daily practice?

Article, see page 36

Despite incredible progress of current-generation OCT in terms of the speed of acquisition, on-line automatic lumen measures and co-registration with angiography, we definitely think we are not ready for such a similar, systematic approach. Technical issues and missing clinical data are responsible. From a technical point of view, the imaging catheter plays a pivotal role. It has to be robust enough to go back and forth in rigid vessels, to overcome spotty and speckled superficial calcification without trapping and/or generating artefacts, and finally not to become fatigued with multiple passes (before stent/scaffold for lesion type characterisation; post-stent/scaffold to optimise the implantation). This type of catheter is not available to interventional cardiologists as yet and must represent a true priority for all companies interested in PCI-guided procedures. Recently, OCT co-registration with angiography has been made available to interventional cardiologists, in order to project plaques immediately on the operative fluoroscopic monitor. If superficial calcium is so important for stenting and easy to detect by OCT, dedicated software for automatic identification, measures and display of calcified plaques along the artery has to be rapidly implemented into OCT systems.

From a clinical perspective, we are still missing convincing evidence of the benefit of pre-interventional imaging on PCI outcome. Prospective studies using intracoronary imaging for stent optimisation in different lesion types (ADAPT-DES, ILUMIEN I) have demonstrated the clinical benefit of a change of strategy guided by either IVUS or OCT, with pre-PCI imaging impacting more substantially on procedural planning and physician decision making compared to post-stent optimisation[11,12]. However, no large prospective, randomised studies comparing angiography versus intracoronary imaging stent guidance are available as yet.

Why do we need to continue to devote attention to accurate calcium detection and characterisation before PCI if there is still no clinical evidence and the optimal tools for imaging are not yet available? First, there is an exponential growth of all factors promoting calcium deposits in lesions undergoing PCI (age, diabetes, multivessel disease [MVD], chronic renal failure). Some of these factors (e.g., diabetes, MVD) are already heading the clinical profile of patients treated by PCI in the emerging countries. Second, calcium remains a major determinant of periprocedural complications and negative outcome. Third, the novel generation of fully bioresorbable scaffolds, when fully developed, will probably change the way we currently perform PCI. In complex, fibro-calcific plaques, accurate imaging-based interrogation and effective lesion preparation will maximise the potential of the scaffolds.

Finally, Ishida's article has major limitations that need to be considered. These data are based on too small a group of procedures conducted with OCT evaluation before and after stenting (only 8% of the total number of procedures), in the presence of essentially mild to moderate calcified lesions (mean arc of calcium 149°, the majority of cases with only one quadrant involved), without exploring alternative treatment strategies for plaque modification with athero-ablative devices (e.g., scoring balloons or rotational atherectomy).

Nevertheless, understanding the contents of the shell before opening with a permanent metallic cage or a more susceptible plastic scaffold will limit any unwelcome surprises for doctors (under-expansion) and patients (adverse events).

Conflict of interest statement

G. Guagliumi has received consulting fees from Boston Scientific, St. Jude Medical, AstraZeneca, and the Italian Society of Invasive Cardiology, and has received grant support from St. Jude Medical, Medtronic Vascular, Boston Scientific, and Abbott Vascular. V. Sirbu has received grant support from St. Jude Medical. K. Shimamura has no conflicts of interest to declare.

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