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Editorial

Between a Rock and a Hard Place: A Consensus Statement on the Management of Calcified Coronary Lesions

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Since first described by Andreas Grüntzig more than 40 years ago,[1] coronary artery calcium (CAC) remains one of the greatest challenges of contemporary percutaneous coronary intervention (PCI). An aging population and the associated burden of comorbidities have led to a substantial increase in the number of PCIs performed in patients with severe CAC.[2,3] Since PCI of severe CAC is associated with higher rates of procedural failure, stent underexpansion, periprocedural complications, and adverse clinical outcomes,[3] multiple modalities have been developed for lesion preparation to facilitate and optimize stent implantation. Unfortunately, the results to date have been disappointing.

CAC lesions are, by definition, stable atherosclerotic plaques. When comparing the natural history of CAC lesions, adverse event rates are almost 6-fold lower compared with lipidic lesions;[4] however, following PCI, event rates in CAC lesions are substantially higher than in non-CAC lesions.[5] Given that the major variable between the lower preintervention and higher postintervention event rates is the performance of PCI, there is clearly room for improvement.

There are 3 fundamental barriers to the optimal management of CAC lesions. The first barrier is diagnosis. Although angiographically severe CAC is a recognized predictor of stent underexpansion and increased adverse events following PCI,[3,6] angiography is limited in its ability to identify features of CAC that may be relevant to PCI outcomes. In this regard, intravascular imaging (IVI) can significantly improve the sensitivity and specificity to detect CAC[6] and help identify morphologic features of CAC that predict stent underexpansion. Simplified dedicated scoring systems for both optical coherence tomography and intravascular ultrasound have been developed to assist the practicing interventionalist on when to consider advanced lesion preparation.[7,8] Unfortunately, although use of IVI has increased over time, its use still remains relatively infrequent globally.[9] Moreover, even with liberal IVI use, large registries have failed to show improvements in clinical outcomes in CAC lesions.[10]

The second major barrier is poor adoption of advanced calcium modification therapies. Although noncompliant and specialty balloons may adequately modify CAC lesions, more advanced therapies, including atherectomy, are sometimes required. Limited access and a lack of familiarity, dedicated training, and on-site surgical backup have limited the widespread use of these technologies. Recently, intravascular lithotripsy (IVL) has emerged as an alternative therapy for the treatment of heavily calcified coronary lesions, overcoming many of these barriers. Interestingly, since the approval of IVL in the United States, the frequency of advanced lesion preparation has increased by ≈ 40%, while the use of atherectomy has remained relatively stable, suggesting that IVL has facilitated more widespread adoption of advanced lesion preparation.[11]

The third major barrier is the lack of a universal algorithm integrating solutions for the first 2 barriers. When IVI and advanced lesion preparation algorithms are applied, clinical outcomes may be improved. Recently, algorithmic approaches for lesion preparation, guided by IVI, were used in the RENOVATE-COMPLEX-PCI and ILUMIEN IV randomized controlled trials, with both studies showing strong trends toward improved outcomes in this patient subset.[12,13] Meanwhile, registries without dedicated algorithms have failed to show this benefit.[10]

In this issue of *JSCAI*, Riley et al present the SCAI expert consensus statement on the management of calcified coronary lesions.[14] The consensus document is focused around a central treatment algorithm that emphasizes the following: (1) use of IVI to understand the severity of CAC and determine the need for advanced calcium modification therapies; and (2) appropriate lesion preparation prior to stent implantation in the presence of a 360° arc of calcium or >270° arc of calcium and >5 mm length. Critically, the document overcomes the previously described barriers, relying heavily on information gained from IVI to guide advanced lesion preparation. Moreover, the document is written for the practicing interventional cardiologist, with focused "consensus tips" as high-yield information, and furthermore provides details of specific lesion subtypes such as calcified nodules and calcific neoatherosclerosis.

Although the value of IVI in the management of CAC lesions is clear, the sobering reality that >80% of all PCIs are done without IVI in the

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United States necessitates an algorithm that accommodates the masses. In this regard, the algorithm indirectly directs the operator to study the behavior of the noncompliant balloon. This critical feature of lesion response has been undervalued, particularly the utility of assessing expansion in 2 views. Moreover, advanced fluoroscopy tools such as Angio+ device detection (Philips), StentBoost (Philips), StentViz (GE Healthcare), and CLEARstent (Siemens) can be particularly useful to rule out eccentric expansion by assessing wire bias. If the noncompliant balloon has any residual stenosis, the algorithm redirects the operator to use IVI or advanced lesion preparation.

Algorithms must reach a delicate balance between being comprehensive and practical. IVI assessment in the current algorithm does not consider the depth of calcium, where, for example, atherectomy devices would be less effective. Moreover, the device-specific considerations are largely based on consensus opinion due to a lack of available evidence. For example, long and diffuse lesions may now be managed with IVL catheters with additional pulses, and atherectomy is highly effective in concentric calcium and even eccentric calcium depending on wire bias.[15] Finally, the goal of the algorithm is technical success without adjustment for safety.[16]

This consensus document is a call from our interventional society to optimize PCI for 1 of the most challenging subsets of coronary artery disease. While there will always be a need for algorithms within algorithms, the interpretability and practicality of the expert consensus statement is a meaningful step in getting us out of being stuck between a rock and a hard place.

Declaration of competing interest

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