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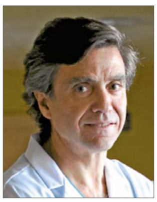
How should we treat "undilatable" coronary stents?



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Coronary calcification remains the main cause of underexpanded stents[1]. Severely underexpanded stents represent a major underlying cause of stent failure, including stent thrombosis and in-stent restenosis (ISR)[1]. Although adequate lesion preparation, particularly in heavily calcified vessels, is advocated to prevent the occurrence of these complications, stent underexpansion is still frequently seen in routine clinical practice, especially when the procedure is not guided by intracoronary imaging. Aggressive post-dilation with a non-compliant balloon at very high pressures may solve this problem but, unfortunately, this a posteriori solution is not always successful[1]. Treatment of a severely underexpanded stent unresponsive to high-pressure dilation remains a rare yet formidable technical challenge with very limited therapeutic alternatives.

Rotational atherectomy (stent ablation) has been reported with successful results in selected cases[2]. However, it should be kept in mind that this uniquely aggressive strategy is not free of major complications (including burr entrapment, stent disruption, vessel perforation) and there is a strong possibility that publication bias impedes a comprehensive assessment of the risks associated with this drastic procedure. More recently, intravascular lithotripsy (IVL) has proven to be safe and effective to tackle calcified lesions[3]. The value of this novel and user-friendly technology to treat ISR caused by an underexpanded stent has been also suggested, although the information in this regard is still preliminary[3]. Super high-pressure balloons (allowing up to 40-50 atm) may also be of value in some cases. Excimer laser coronary angioplasty (ELCA) has classically been considered to be able to treat undilatable lesions[4], and a relatively large body of evidence, stemming from clinical practice and observational studies, suggests its value to treat underexpanded stents[5-8]. However, the best treatment modality for undilatable stents remains largely unsettled.

Present study

In this issue of AsiaIntervention, Adikari et al[9] report their experience with the use of ELCA to treat undilatable stents. A total of 31 undilatable stents (24 patients) were treated during a 5-year period in a single referral institution. Only 2 stents were treated "early"

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after initial deployment (1 after suffering stent thrombosis), and 29 presented as late ISR (mean elapsed time from stent implantation: 13.5 years). The mean number of previous interventions for ISR was 3; half of the patients had multiple stent layers. Previous dilatation failure was documented in all patients after the use of very high-pressure inflations. Importantly, a uniform protocol was followed. Initially, ELCA was sequentially performed with saline, blood and contrast-enhanced trains (as required). Subsequently, all lesions were post-dilated at high pressures (≥26 atmospheres) before finally being treated with drug-eluting balloon (DEB) therapy. Notably, procedural success with ELCA (≥50% increase in minimum stent diameter by quantitative coronary angiography) was obtained in all patients. Likewise, adequate stent expansion (minimum stent diameter ≥70% of reference vessel diameter) was also achieved in all lesions. Acute gain was actually very large (1.81±0.62 mm). Importantly, no arterial perforations occurred. However, there were 6 cases of procedural-related myocardial infarction as a result of slow-flow. Finally, during clinical follow-up (mean 21 months), 5 patients required target lesion revascularisation for recurrent ISR and 3 patients experienced cardiac death[9]. This report confirms the efficacy of ELCA, when performed by experienced operators, to tackle undilatable stents. However, some methodological issues should be discussed.

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First, in this study, great care was taken to progressively modulate the effects of ELCA, with saline, blood or contrast (sequentially implemented as needed to increase efficacy) according to the degree of stent expansion. This strategy is currently advocated by most ELCA experts to ensure that only the required amount of energy is delivered to the vessel wall. Second, despite the aggressive procedures needed to overcome resistant stent underexpansion, the final strategy was always DEB (as planned), with no patient requiring bailout stenting. This is of interest and suggests that once the underlying stent can be expanded, a DEB strategy is sufficient to achieve good final results. Avoiding additional metal layers may be very important in patients suffering from the "onion skin" phenomenon, which remains a major cause of stent underexpansion and recurrent ISR[10]. Third, optical coherence tomography (OCT) was only used in 5 cases but this technique was able to recognise 2 distinct mechanisms of lumen gain by ELCA: ablation of neointimal tissue and fractures of peri-stent calcium. Fourth, in spite of the careful use of ELCA, slow-flow was detected in some patients, leading to procedure-related myocardial infarctions. Further studies are required to identify factors associated with this untoward event, which could clearly jeopardise the potential of ELCA in this setting. Fifth, in this series, the initial success of ELCA did not always prevent late recurrences. In patients presenting with recurrent ISR it would have been of major interest to see if the stent remained widely expanded at follow-up (with the presumed mechanism of recurrence being neointimal growth), or whether the stent eventually collapsed or was crushed due to heavy peri-stent calcification. In the event of this second scenario, it is possible that an additional metal layer following ELCA (i.e., the use of a new drug-eluting stent rather than DEB) might have been of potential benefit. Last but not least, these high-risk patients, with advanced coronary artery disease (CAD), had previously required multiple interventions. The 3 patients with cardiac death during follow-up had severe left ventricular dysfunction and while the authors felt that the death was unlikely to be related to the treated stent, this cannot be ignored. This serves as an important reminder that a holistic treatment strategy (looking beyond the stent), including evidence-based medications (and eventually defibrillators), which are recognised to improve prognosis in patients with severe CAD and poor left ventricular function, should always be implemented.

Previous studies

SYSTEMATIC USE OF ELCA IN PATIENTS WITH ISR

Classical intravascular ultrasound (IVUS) studies demonstrated that in patients with ISR, ELCA provided superior lumen gain compared with plain balloon angioplasty[11]. Acute lumen gain after ELCA was the result of not only tissue ablation and extrusion but also additional stent expansion[11]. Ambrosini et al[12] used ELCA+DEB in 80 patients with ISR with favourable long-term results. In another study with 42 patients with ISR, Miyazaki et al[13] compared ELCA+scoring balloon+DEB vs scoring balloon+DEB and found similar long-term angiographic and clinical results. Hashimoto et al[14] used OCT to characterise the underlying tissue in 53 ISR lesions treated with ELCA+DEB and found that the minimal lumen area after ablation was larger in mixed lesions than in those with a homogeneous pattern. Alternatively, Ishihara et al[15] compared results of 47 ISR lesions treated with ELCA+DEB with 161 ISR lesions treated with DEB only. The acute lumen gain was significantly larger after ELCA+DEB, but the benefit was more pronounced in patients showing a homogeneous neointimal pattern on OCT.

USE OF ELCA TO TREAT "UNDILATABLE" STENTS:

The use of ELCA in the treatment of undilatable stents is based on observational studies. However, the results of these studies are uniformly favourable and clearly demonstrate the value of this technology in highly selected cases where other strategies have failed[5-8]. This information is indeed highly reassuring for the interventional cardiologist facing an undilatable stent. Historical data also suggest the value of ELCA to treat undilatable lesions that were resistant to high-pressure balloon dilatation[4]. Subsequently, the value of ELCA for undilatable stents was demonstrated. Yin et al[5] reported a patient with napkin-ring peri-stent calcium presenting with recurrent ISR due to an underexpanded stent, in whom full balloon expansion could be only obtained after ELCA with saline infusion. Ashikaga et al[6] successfully used ELCA with contrast in a patient with undilatable ISR caused by a circumferential-calcified atherosclerotic plaque beneath the stent struts that could not be dilated by high-pressure balloon inflations and rotational atherectomy. In the ELLEMENT registry, Latib et al[7] systematically assessed the value of ELCA in improving stent expansion when high-pressure non-compliant balloon inflation was ineffective. The primary endpoint was an increase ≥1mm^2 in minimal stent cross-sectional area or an increase ≥20% in minimal stent diameter. Twenty-eight patients were included; laser catheter size was 1.2±0.4 mm and a mean fluency of 62±12 mJ/mm^2 at 62±21 Hertz were required for optimal expansion. ELCA-assisted stent dilatation was successful in 27 cases (96%), with an improvement in minimal stent diameter of ~1 mm. Periprocedural myocardial infarction occurred in 7.1%, transient slow-flow in 3.6%, and ST-segment elevation in 3.6%. During follow-up, there was 1 cardiac death, and target lesion revascularisation occurred in 6.7%. In a more recent mechanistic study, Lee et al[8] analysed OCT findings in 81 ISR lesions with stent underexpansion and severe peri-stent calcium, comparing the results in patients treated with (n=23) and without ELCA (n=58). ELCA use was associated with more calcium fracture, a larger final minimum lumen area and a larger minimum stent area. Interestingly, contrast injection during ELCA was associated with multiple fractures and fractures in thick calcium[8].

Conclusion

The effectiveness of ELCA to tackle undilatable ISR lesions represents a well-established niche application for this technology[4-9,16]. However, treatment of these complex patients is cumbersome as it frequently requires experience with a combination of expensive therapeutic modalities. Intracoronary imaging provides unique insights into these complex anatomical scenarios and allows the operator to unravel the underlying mechanism of stent failure[1]. The relative role of ELCA vs IVL in patients with severely underexpanded stents currently remains unsettled. Experience with IVL in undilatable stents is scarce[3] but this balloon-based technique is user friendly and does not require special expertise or sophisticated technology[3]. However, the crossing profile of IVL is suboptimal and the deliverability of ELCA appears better suited for tight undilatable lesions. IVL balloons may also rupture and cause significant arterial damage, including vessel perforation[17], but ELCA may also induce threatening complications in resistant lesions. Further studies (ideally randomised clinical trials) are required to elucidate the best strategy, first, to tackle undilatable stents, and then, to ensure optimal long-term results in these challenging patients, in whom preventing new recurrences remains a major unmet clinical need.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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