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CASE REPORT

When rotational atherectomy is not enough

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Abstract
Extreme coronary calcification may require rotational atherectomy to create a navigable intravascular lumen followed by intravascular lithotripsy to fracture areas of deep calcification to allow for successful percutaneous coronary intervention.

KEYWORD
Cardiovascular disorders,

1 | INTRODUCTION

Calcified coronary lesions are more likely to result in stent malapposition and expansion resulting in higher rates of restenosis, thrombosis, and myocardial infarction.[1] In this patient population, fastidious lesion preparation is critical to ensure that calcium fracture is sufficient to allow for stent expansion. Commonly used tools include noncompliant (NC) balloons, cutting balloons, scoring balloons, and atherectomy. Recently, intravascular lithotripsy (IVL) has been used for recalcitrant lesions and may supplant atherectomy owing to its ease of use, risk profile, and long-term risk profile.[2] Atherectomy, on the other hand, is best reserved for specialized, high-volume centers. However, even in these settings, atherectomy is a time-consuming and costly procedure associated with an increased risk of procedural complications.[2,3] However, IVL is only effective if it can be delivered to the site of coronary calcification. Thus, atherectomy and IVL may not be mutually exclusive techniques, and some lesions require atherectomy to gain intimal passage for IVL to fracture deeper layers of calcium for successful revascularization.[4,5]

2 | CASE 1

A 68-year-old man with a history of coronary artery disease with previous PCI to the right coronary artery in the setting of a non-ST elevation myocardial infarction (NSTEMI), diabetes mellitus, hypertension, dyslipidemia, and gout presented with chest pain and a peak high-sensitivity troponin of 204 ng/L. He was diagnosed with a NSTEMI. Left ventricular function was normal. Angiogram and left heart catheterization demonstrated left ventricular end-diastolic pressure (LVEDP) of 11 mm Hg, and the interventionalist identified a 80% mid-left anterior descending (LAD) heavily calcified lesion (Figure 1A). There was no other obstructive coronary artery disease. Thus, revascularization of the LAD lesion was attempted. Balloon angioplasty was performed with compliant and NC balloons with failure to yield (Figure 1B). Optical coherence tomography (OCT) identified a minimal lumen area of 1.04 mm^2 and an area of stenosis of 83.9% with 360 degrees of calcification with a depth of >1 mm (Figure 1C). The interventionalist concluded that conventional PCI would not be successful and that atherectomy would be required. Given that the

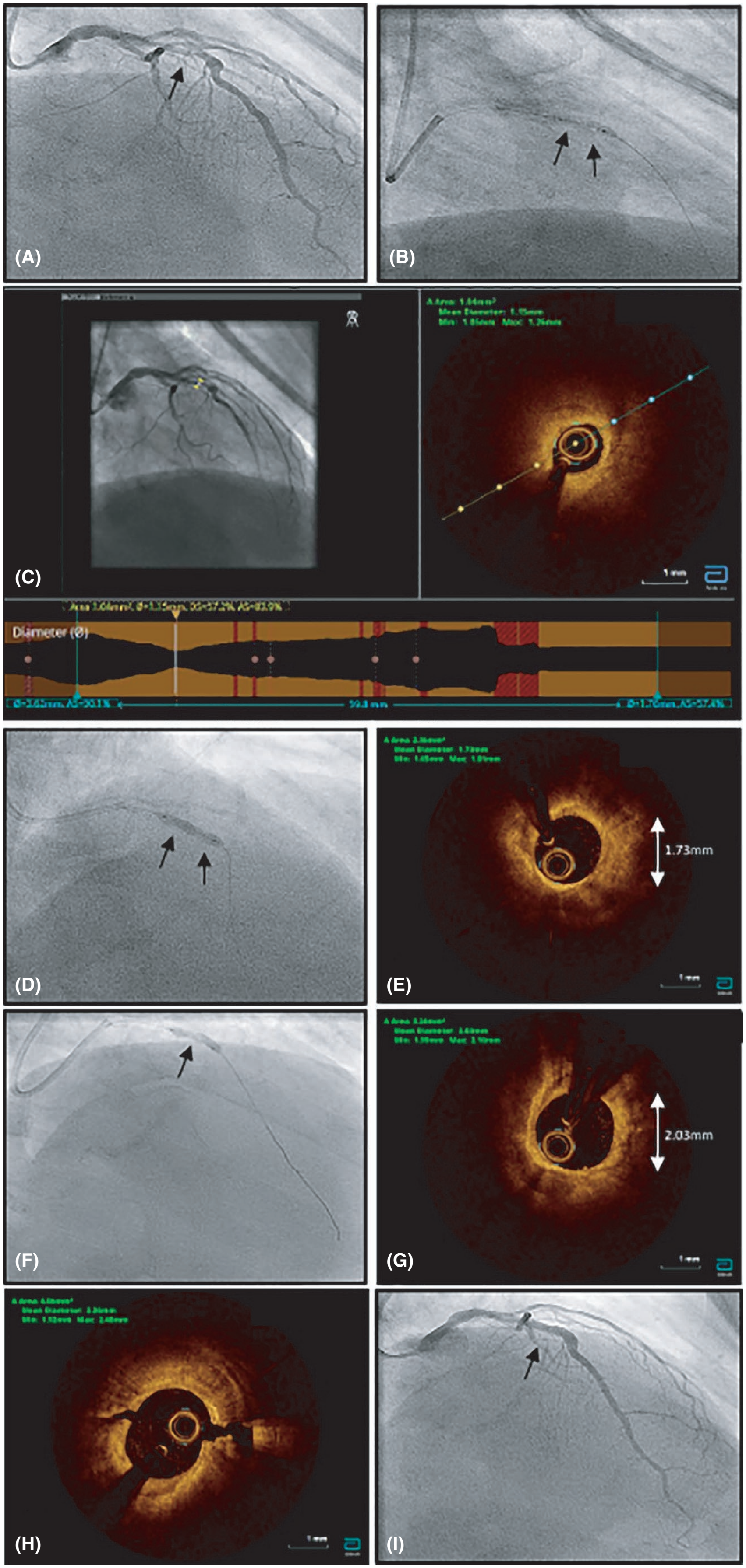

FIGURE 1 A, Preprocedure angiogram of mLAD lesion (arrow) in anterior-posterior (AP) cranial view. B, Failure to expand with a 3.5-mm NC balloon to high pressure (arrows). C, Angiogram and OCT of the narrowest point in the lesion. D, Failure to expand with a 3.5-mm NC balloon after rotational atherectomy with a 1.75-mm burr (arrows) (E) OCT post 1.75-mm burr rotational atherectomy confirming formation of a 1.73-mm-diameter lumen. F, Failure to expand with a 3.5-mm NC balloon to high pressure (arrow) after 2.0-mm burr rotational atherectomy and G, Repeat OCT confirming 2.0-mm lumen with dense calcification H, OCT image post-IVL demonstrating fractures in the lesion. I, Post-PCI angiogram showing successful revascularization in mLAD (arrow)

patient was stable and had consented to a procedure with a 1% complication risk (vs a 4% risk of complications associated with atherectomy), and a need to balance against competing staffing and emergent needs, the procedure was stopped. The patient was brought back 5 days later for a dedicated, higher-risk procedure of atherectomy and possible IVL. A 7 French radial system was used to perform rotational atherectomy with a 1.75-mm and a 2.0-mm burr. Despite this, the lesion would not yield in spite of high-pressure balloon inflation after each run (Figures 1D and

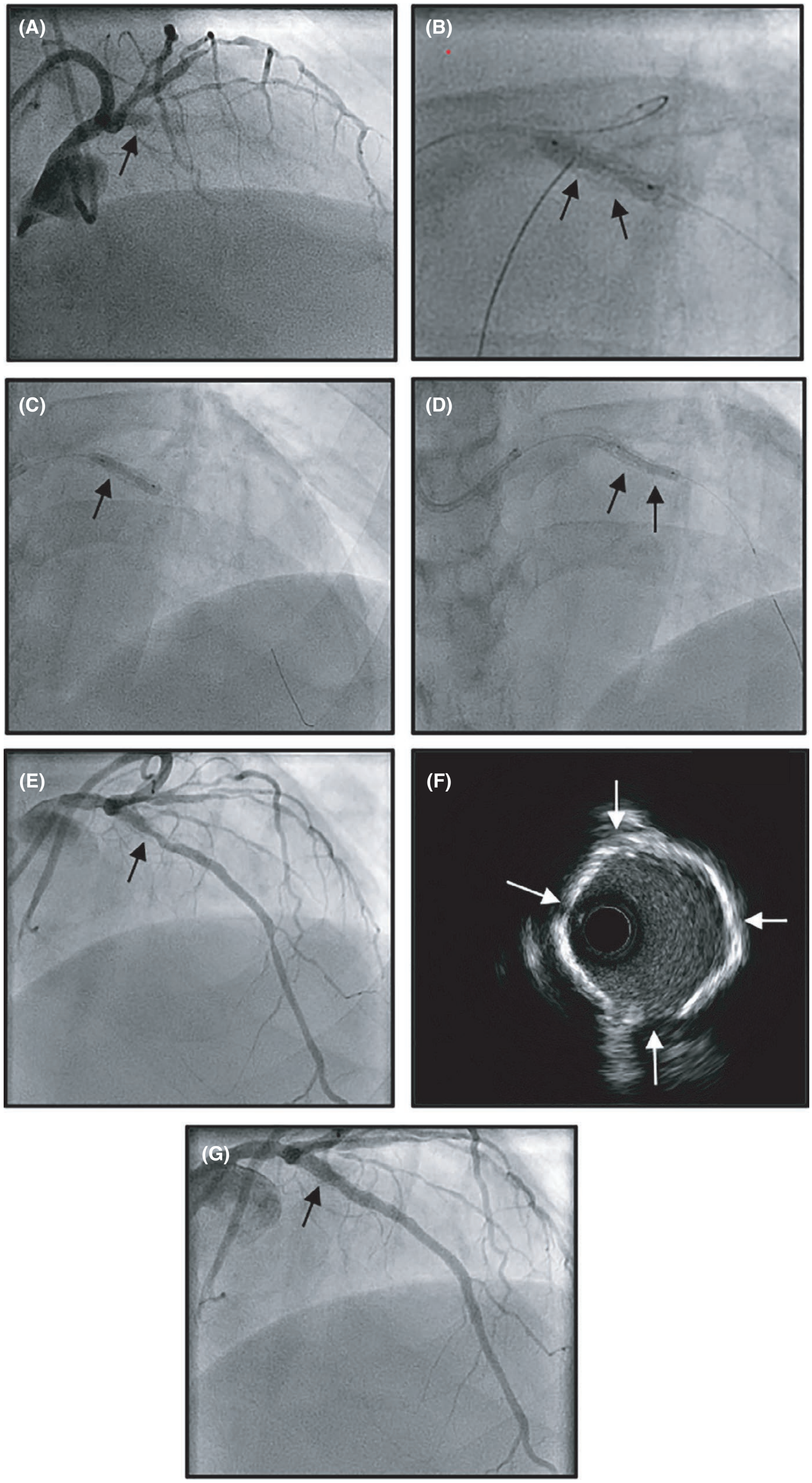

FIGURE 2 A, Primary angiogram of pLAD showing ISR (arrow) in the right anterior oblique (RAO) cranial view. B, Failure to expand the lesion with 2.5, and 3.5 mm cutting and NC balloons (arrows). Failed atherectomy with C, 1.5-mm burr and D, 2.0-mm burr (arrows). E, Angiogram post-PCI of mLAD dissection revealing persistent pLAD lesion, F, Post-IVL IVUS showing fractures in the lesion (arrows), and G, final angiogram after PCI showing successful revascularization of pLAD (arrow)

2F). OCT was performed after each attempt and confirmed the presence of a 1.75-mm and 2.0-mm lumen surrounded by dense circumferential calcification (Figures 1E and 2G). Therefore, IVL (Shockwave Medical) was performed. A 3.5-mm Shockwave IVL balloon was delivered, and 8 rounds of lithotripsy were performed. Subsequent OCT confirmed multiple fractures within the lesion (Figure 1H). A Promus Premier (Boston Scientific) 3.5 × 32-mm drug-eluting stent was delivered and postdilated using a 4.0 × 20 mm NC balloon proximally and a 3.75-mm NC balloon distally with excellent results (Figure 1I).

3 | CASE 2

A 79-year-old man with a prior history of PCI to the proximal LAD, hypertension, dyslipidemia, and chronic kidney disease presented with NSTEMI. Echocardiogram demonstrated an ejection fraction of 35%-40%. He was referred for left heart catheterization and coronary angiography, which was performed via the radial technique with a 6-Fr sheath. The LVEDP was 13 mmHg. The culprit lesion was the proximal LAD with total occlusive in-stent restenosis (ISR) (Figure 2A). Other lesions present included a 90% proximal right coronary artery in a small, co-dominant vessel and an 80% second obtuse marginal. Successful antegrade wiring of the LAD occlusion was performed. Despite multiple NC balloons and cutting balloons, the lesion remained resistant to expansion (Figure 2B). Intravascular ultrasound (IVUS) confirmed highly calcified lesion within the previous stent. Atherectomy was performed using a 1.5-mm and a 2.0-mm burr. However, the lesion was resistant to expansion with NC and cutting balloons (Figure 2C and D). A distal dissection developed and was covered with a 2.5 × 28 mm Promus Premier drug-eluting stent (Figure 2E). At this point, the procedure was stopped and the patient brought back for IVL on the following day. The LAD was wired with a BMW Universal II wire, and IVL was performed using a 3.5-mm shockwave balloon for 6 cycles. This allowed for successful predilatation of the calcified lesion with a 4.0-mm NC balloon at high pressure. This allowed the placement of a 4.0 × 24 mm Promus Premier drug-eluting stent with excellent results (Figure 2G). IVUS imaging confirmed excellent final result.

4 | DISCUSSION

The cases discussed above demonstrate that even large burr rotational atherectomy in heavily calcified lesions may not sufficiently prepare the lesion for expansion. In both cases, multiple rounds of atherectomy were attempted after the failure of traditional lesion preparation techniques. IVL was not initially attempted as the imaging and introduction of smaller devices demonstrated that the IVL balloon could not be delivered to the lesion. Atherectomy was required to develop an accessible lumen, but was not sufficient to fracture the dense circumferential calcification. In both cases, intravascular imaging was critical to the identification of the true vessel size and the burden of calcification resulting in use of IVL to fracture the residual lesion. The Disrupt CAD I and II studies have demonstrated that IVL is particularly suited for lesions with circumferential calcification; it results in multiple planes of fracture and is not prone to wire bias, a known limitation of atherectomy.[3,6] These studies also demonstrated a favorable procedural complication rate and good longer-term outcomes. While the Disrupt CAD I and II trials are promising, approval of IVL for calcified coronary lesions is contingent on the results of the larger, multicenter Disrupt CAD III and IV studies.[7,8] The Disrupt III study of severe de novo calcified lesions demonstrated that IVL has a favorable learning profile with comparable results at the beginning and end of the study period despite limited previous experience with IVL. Overall, the study demonstrated a 92.4% procedural success rate and a 30-day major adverse cardiovascular event (MACE) rate of 7.8%. Notably, MACE was driven by and highly dependent on the definition of periprocedural myocardial infarction that was used; for the sensitive definition of creatinine kinase MB (CKMB) >3 upper limit of normal (ULN), it was 6.8%, when using the more clinically relevant CKMB ≥10 ULN or troponin ≥70 ULN, it was 2.6%. Remarkably, high rate of procedural success and low 30-day MACE was despite the mean calcified lesion being almost 50mm in length and having an arc of calcium of almost 300 degrees and a depth of 1mm representing the most severely calcified lesions enrolled in a trial to date.[9] The Disrupt IV study has yet to be presented. Nevertheless, IVL is available in some markets via special access programs. The use of IVL and rotational atherectomy can be complementary to one another and may occasionally be used in combination to provide better results in patients with severely calcific lesions.[10] Indeed, this very question is the focus of a retrospective cohort study expected to be completed by the end of 2021.[11] Rotablation ablates calcium in the intima and allows for an accessible passage for balloons and stents, and IVL utilizes this passage and treats the circumferential deep calcium layers of the lesion. Proficiency in both techniques is required when handling lesions of this subset.

5 | CONCLUSION

Extreme calcification may require atherectomy and IVL to achieve optimal revascularization results, and interventional cardiologists should be familiar with the use and limitations of each technique.

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Published with written consent of the patient.

CONFLICT OF INTEREST

No funding or conflict of interest to disclose for Mrs Atefi, Dr's Elbarouni, Ravandi, or Allen.

AUTHOR CONTRIBUTIONS

NA: wrote the manuscript. DWA and BE: contributed the presented cases. AR and DWA: contributed to the design and critically reviewed and revised the manuscript.

ETHICAL STATEMENT

Published with written consent of the patient.

DATA AVAILABILITY STATEMENT

All data are available for review after approval from local research ethics boards.

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