Overcoming very late severe calcific stenosis due to two layers of under-expanded stents with intravascular lithotripsy treatment: a case report

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ABSTRACT

Under-expanded stents in heavily calcific coronary stenoses have become a common challenge for interventional cardiologists as we undertake more complex coronary interventions for older population cohorts. It results in short-term and long-term stent failure and adverse patient outcomes. These complex lesions can be treated after many years with intravascular lithotripsy (IVL-Shockwave Medical Inc.®). We report a case of a patient with severe stenosis at the site of two-layer under-expanded coronary stents implanted 17 years prior. Intravascular ultrasound scan depicted presence of calcium deposits under the old stent struts as the likely mechanism of stent under-expansion. Intravascular lithotripsy fractures the thick calcium ring under the stent struts leading to a complete stent expansion of the old stents.

Key Words:

PCI - Percutaneous Coronary Intervention (PCI)

SRES - Stent Restenosis

IDI - Interventional Devices/Innovation

NEWD - New Devices (in general)

SFRA - Stent Fracture/Failure

Learning points

- Percutaneous treatment of calcified coronary lesions requires dedicated devices.
- Intracoronary lithotripsy could be an option to correct under-expanded stents due to severe calcification.
- Intravascular imaging is very useful for analysing the mechanism of in-stent failure.

INTRODUCTION

Percutaneous coronary intervention on heavily calcified lesions remains challenging and have significant procedure-related and patient related adverse outcomes. It is associated

with stent under-expansion, stent thrombosis, restenosis and subsequently major adverse cardiac events (1,2). Multiple treatment strategies have been developed over the last three decades to overcome this hurdle including cutting/scoring balloons, high pressure balloons and rotational or orbital atherectomy (3). Intravascular lithotripsy (IVL-Shockwave Medical Inc.®) is a new modality for calcium modification and preparation of calcified lesions but its use after the stent implantation remains uncertain (4,5). We report a case of a patient admitted at our department after acute myocardial infarction. Coronary angiography showed severe in-stent restenosis in mid left anterior descending (LAD). Intracoronary imaging highlighted struts under-expansion in the middle of two-layered old stents surrounded by thick circumferential calcification. Intravascular lithotripsy created calcium micro-fractures beyond the stent struts with final good stent expansion.

CASE PRSENTATION

A 73-year-old male with past medical history of ischemic heart disease, acute myocardial infarction (2003) with percutaneous intervention (PCI) and stent implantation in proximal to mid left anterior descending artery (LAD), type 2 diabetes mellitus, hypertension, dyslipidaemia, obesity, and smoker was admitted at our institution with an acute coronary syndrome. He underwent stent implantations at another institution in the proximal to mid LAD for non-ST segment myocardial infarction 17 years ago, and also 7 years later.

The cardiovascular and respiratory examinations on admission were normal. Blood pressure was 100/75 mmHg, hear rate 50 bpm, electrocardiogram showed sinus bradycardia with first degree heart block, and T wave inversion in leads V2-V6. Initial blood test showed elevated troponin I level at 1261 ng/L (normal level <26 ng/L). His medical therapy on admission was aspirin 100 mg/day, ramipril 10 mg/day, bisoprolol 10 mg/day, and Rosuvastatin 40 mg/day, Frusemide 40 mg/day, prazosin 1 mg/day and Metformin 2 gr/day.

Coronary angiography showed severe in-stent stenosis and under-expanded stent struts in mid-LAD (*Figure 1A*, *supplementary material online*, *Video S1*). Optical coherence tomography (OCT - Abbott®) was attempted but images were suboptimal as the OCT catheter was obstructing the flow and contrast opacification at the site of severe stenosis (*Figure 2A*, *supplementary material online*, *Video S2*). Therefore, intravascular ultrasound (IVUS - Boston Scientific®) was performed confirming the severely under expanded two-layer stents with heavy and diffuse calcification burden.

Multiple prolonged and high-pressure inflations in under-expanded site with non-compliant balloon were performed (2.0/15 mm + 2.5/12 mm at 20 atm for 30 seconds) (*Figure 2D*, *supplementary material online*, *Video S3*). Hourglass images persisted during all inflations (*Figure 1B*). Therefore, two cycles of 10 impulses of IVL were performed (3.0/12 mm balloon inflated at 6 atm) which resulted in better expansion stents struts (*Figure 1C*). A repeat IVUS pullback image was obtained which highlighted the crushed calcium under the old stent struts and good stent expansion (*Figure 2E*, *supplementary material online*, *Video S4*).

Since there were already two layers of stents, it was decided to proceed with a drug coated balloon angioplasty (3.5/17 mm SeQuent® Paclitaxel Coated Balloon – B/BRAUN). Final OCT scan showed the crushed calcium under the old struts with appropriate expansion of stent struts with mean diameter of 3.01 mm and luminal area of 7.19 mm^2 (*Figure 2B and C*, supplementary material online, *Video S5*) and confirming the very good angiographic result (*Figure 2D*). No major complications during the procedure or hospitalization occurred. Dual antiplatelet therapy with ticagrelor and aspirin was prescribed for 12 months. At 6-month follow-up, the patient was free of angina and on good clinical status.

DISCUSSION

Percutaneous coronary intervention in calcific lesions is challenging and evidence suggests stent implantation following an optimal lesion preparation. This has been attempted for decades with cutting or scoring balloons, and atherectomy (rotational, orbital or laser)(3). Underutilization of these modalities has provided the current evidence of under-expanded stents (1). Traditionally, it has been proposed to use stent ablation in treatment of these situations (6).

Intravascular lithotripsy is a new technique based on calcium fracture by ultrasound waves. Recent reports support the off-label use of IVL as a bail-out therapy for under-expanded stents (7,8). However, little is known about its utilization on layers of stents implanted many years earlier.

Intracoronary imaging is very beneficial in detecting the site and mechanism of stent failure and reference coronary diameters to plan for appropriate intervention. In our case, the OCT and IVUS image analysis permitted to describe the mechanism of stent under-expansion due to the presence of severe calcification under the old struts. It is recommended to maintain 1:1 ratio between IVL balloon and vessel diameter (9). Thus, we chose a 3.0/12 mm IVL balloon.

In this case, intracoronary lithotripsy acted by creating calcium fractures and consequently better expansion of stent struts and transmission of the radial force of stents implanted 17 years prior. The circumferential stent expansion significantly improved after IVL (pre-IVL IVUS mean lumen diameter of 1.52 mm with luminal area at 1.79 mm^2 vs. post-IVL mean lumen diameter of 3.03 with luminal area 7.37 mm^2).

CONCLUSION

Percutaneous treatment of heavily calcified coronary lesions remains challenging. Acute and late procedural failure due to stent under-expansion is common. Intracoronary imaging is essential to evaluate the mechanisms of the stent failure. Intravascular lithotripsy in under-expanded stents implanted many years before was performed safely and effectively in this patient. Intracoronary lithotripsy creates calcium fractures under the stent struts allowing better stent expansion.

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Figure 1 - (*A*) Diagnostic angiogram. Severe in-stent stenosis in the mid part of left anterior descending artery (arrow). (*B*) Balloon angioplasty with a non-compliant balloon (2.5/15 mm inflation at 20 atmospheres showing un-dilatable segment (arrow). (*C*) Coronary angiography illustrated resolution of severe focal stenosis post IVL therapy. (*D*) Full expansion of IVL shockwave balloon inflated at 6 atm and two cycles of treatment provided (arrow).

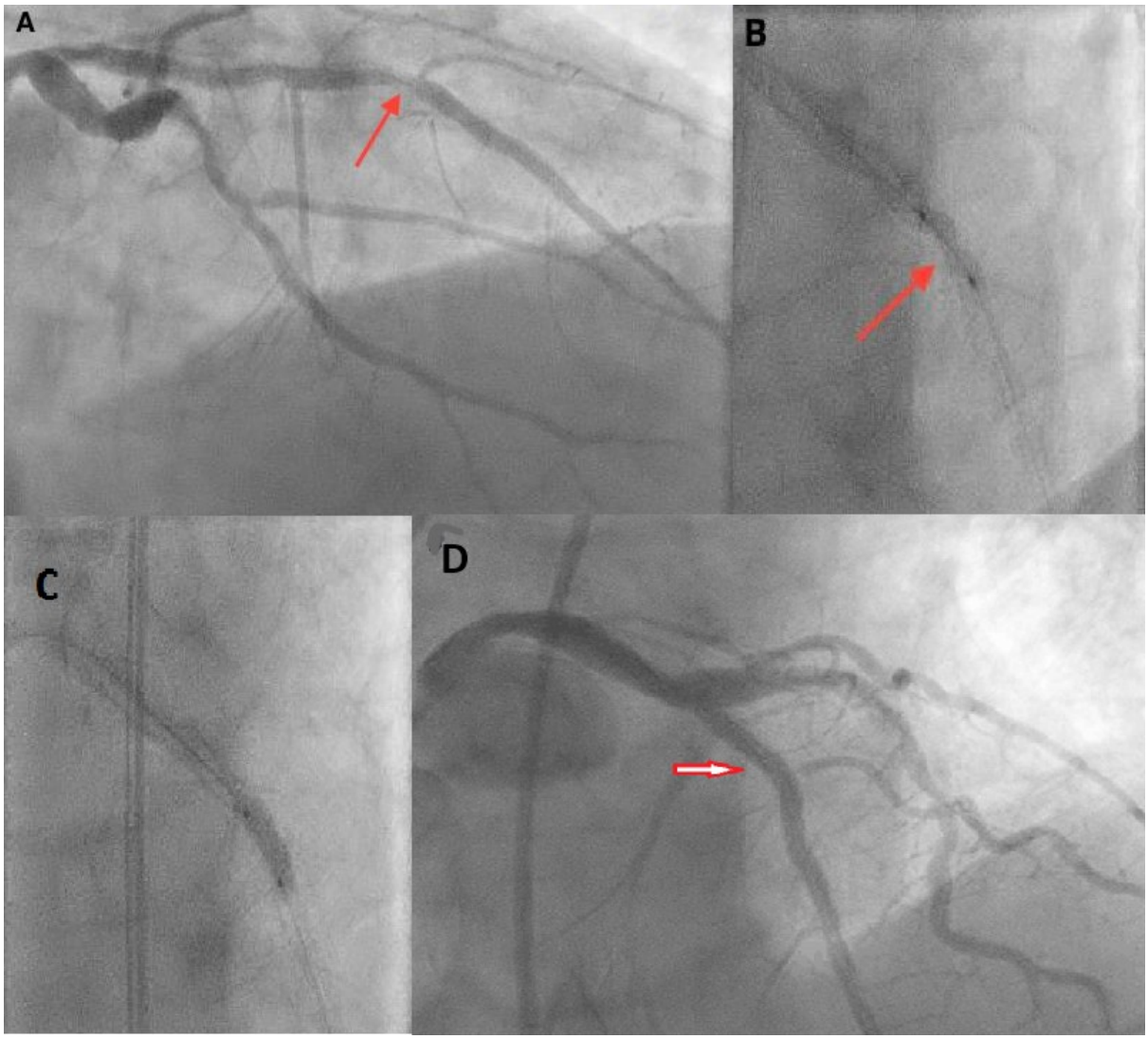
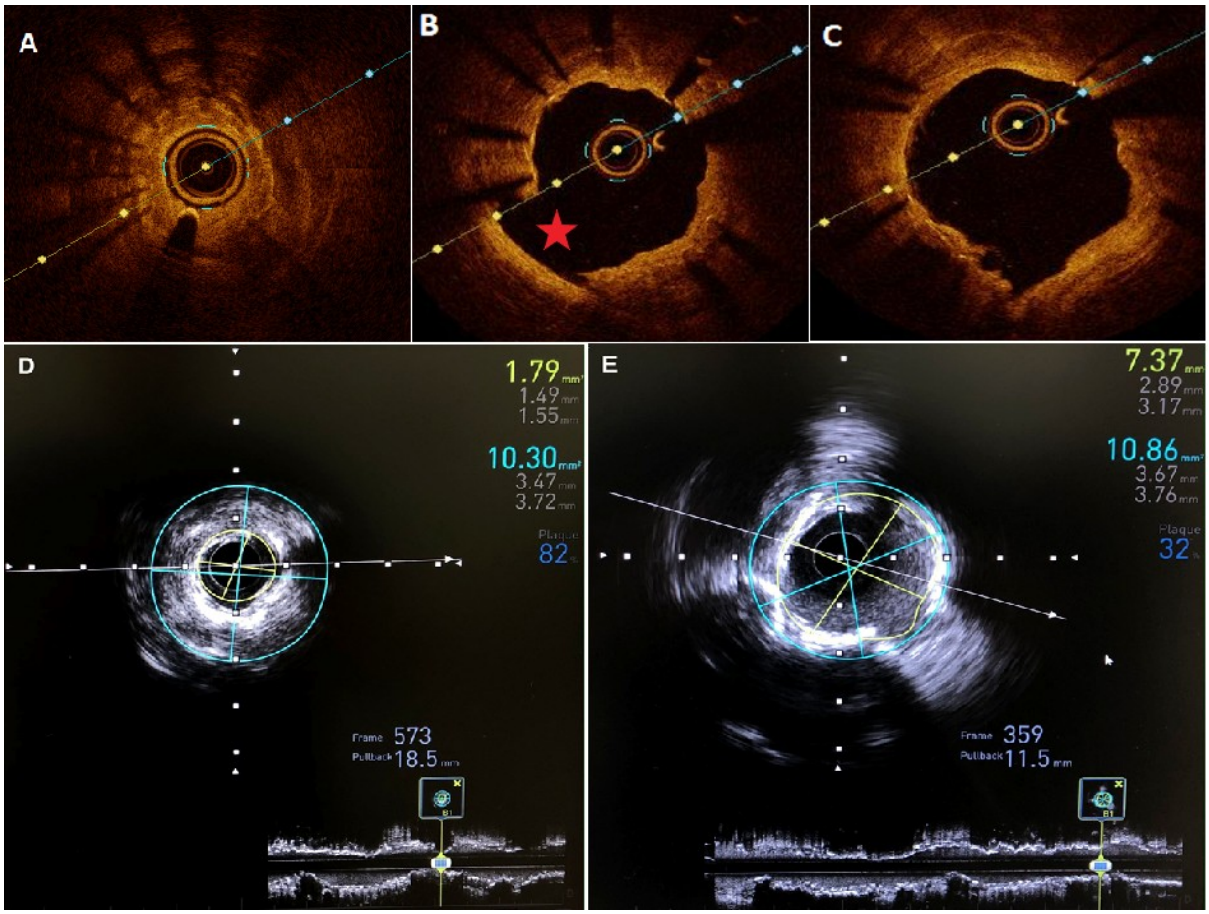


Figure 2 - (*A*) Pre- and post-lithotripsy OCT scan of under-expanded stents with mean diameter 0.92 mm and luminal area 0.66 mm^2 (*B*) Post-lithotripsy OCT showing fractured calcium (asterix) (*C*) Final OCT imaging following drug coated balloon angioplasty showing mean diameter 3.01 mm and luminal area 7.19 mm^2 (*D*) Pre-lithotripsy IVUS scan of under-expanded stents with luminal area 1.79 mm^2 (*E*) Post-lithotripsy IVUS scan showing luminal area 7.37 mm^2.



Video S1 - Coronary angiography in the cranial/right anterior oblique view demonstrating the focal in-stent stenosis in mid left anterior descending artery at the bifurcation of second diagonal branch

Video S2 – Pre-IVL optical coherence tomography pullback imaging of left anterior descending artery with suboptimal images as the catheter is obstructing the flow and contrast opacification at the site of severe stenosis

Video S3 – Pre-IVL intravascular ultrasound pullback imaging of left anterior descending artery confirming the severely under expanded two-layer stents with heavy and diffuse calcification burden

Video S4 – Post-IVL intravascular ultrasound pullback imaging of left anterior descending artery highlighting the crushed calcium under the old stent struts and good stent expansion

Video S5 – Post-IVL optical coherence tomography pullback imaging of left anterior descending artery showed the crushed calcium under the old struts with appropriate expansion of stent struts