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Intracoronary Lithoplasty in Percutaneous Treatment of Challenging Calcified Coronary Lesions

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ABSTRACT

Unexpanded stents in calcified coronary stenosis is a problem where intravascular lithotripsy could be effectively employed. In these 2 cases, we report possible issues associated with the use of this technology. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:1679–83) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Un-dilatable and severely calcified lesions are independent predictors of in-hospital and late major adverse cardiac events. Despite the availability of dedicated devices, stents implanted in calcified lesions do not always achieve an optimal expansion. Use of rotational atherectomy, high-pressure noncompliant balloons, cutting balloons, and scoring balloons are the most widely used tools to appropriately prepare severely calcified plaques. Nevertheless, the use of these devices is occasionally associated with complications, and an optimal result is not always guaranteed.

LEARNING OBJECTIVES

- Undilatable lesions are particularly challenging and expose the patient to high risk of under-expanded stents, especially under bail-out conditions.
- When dealing with an acute or chronically under-expanded stent, IVL may become the standard of care if high-pressure balloons fail.
- Recognizing the likelihood that IVL could induce a vasoconstriction immediately after or during procedures.

Complications associated with the need for aggressive lesion preparation are no-reflow, vessel rupture, and extensive dissection. The recent introduction of the coronary intravascular lithotripsy (IVL) system (Shockwave Medical, Fremont, California) seems to effectively correct stent under-deployment. Some concerns exist regarding the bulky profile of the device and its cross-ability when a high degree of stent under-expansion is present (1).

A second challenging subset is the need to deliver IVL in multivessel calcified stenosis simultaneously. Current experience with the IVL system has proven to be safe. However, some recent reports have warned about the evidence of coronary vasoconstriction (2) and electrophysiological side effects (3). This paper describes the feasibility of IVL in 2 clinical cases highlighting potential issues that could arise.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the *JACC: Case Reports* author instructions page.

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ABBREVIATIONS AND ACRONYMS

IVL = intravascular lithotripsy

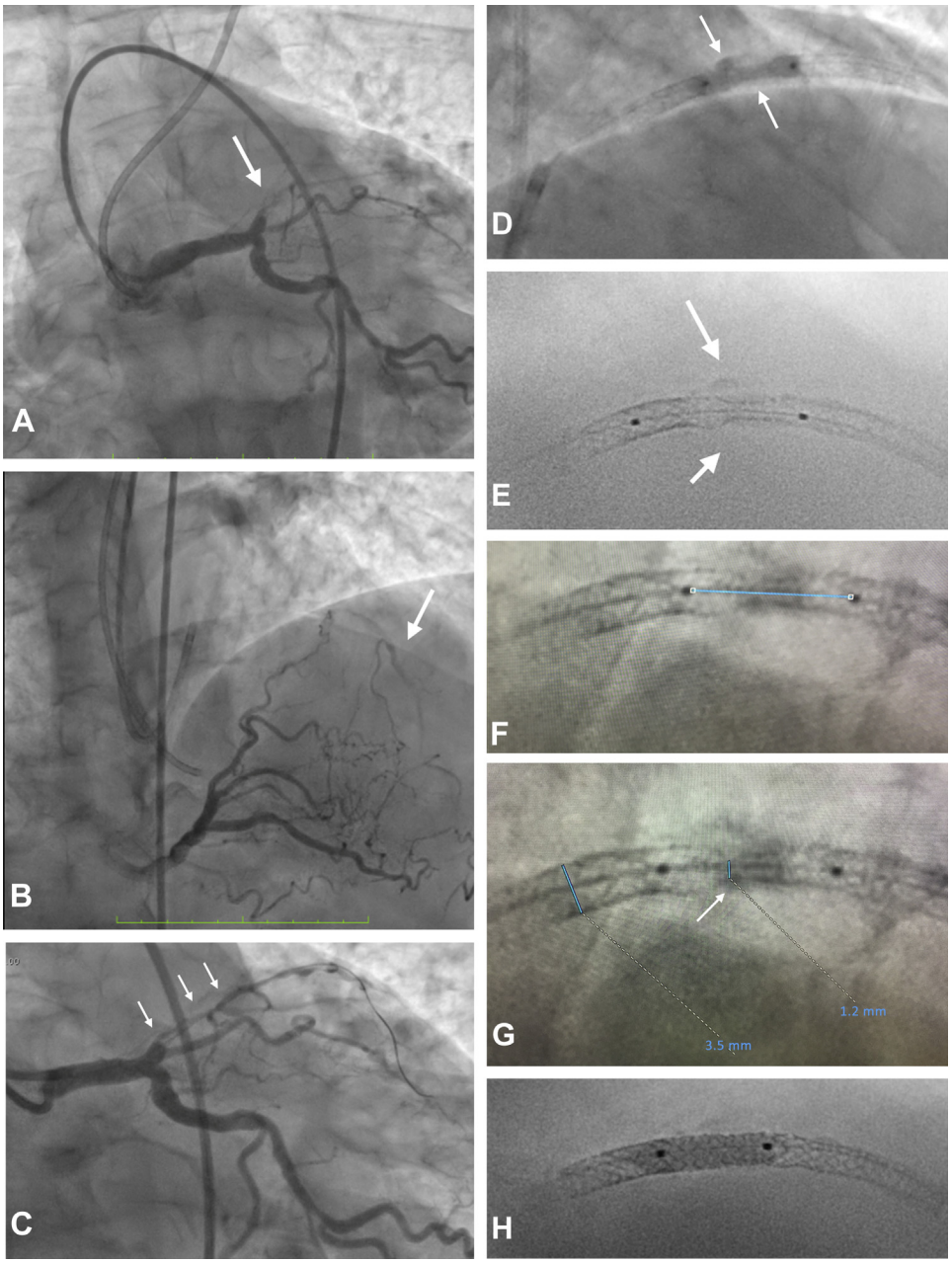
LAD = left anterior descending artery

NC = noncompliant

DEALING WITH ACUTE STENT UNDER-EXPANSION. A 67-year-old man, hypertensive and diabetic, with angina on effort, had a chronic total occlusion of the proximal left anterior descending artery (LAD) with a heavily calcified mid-segment and a proximal blunt stump (Figures 1A and 1B).

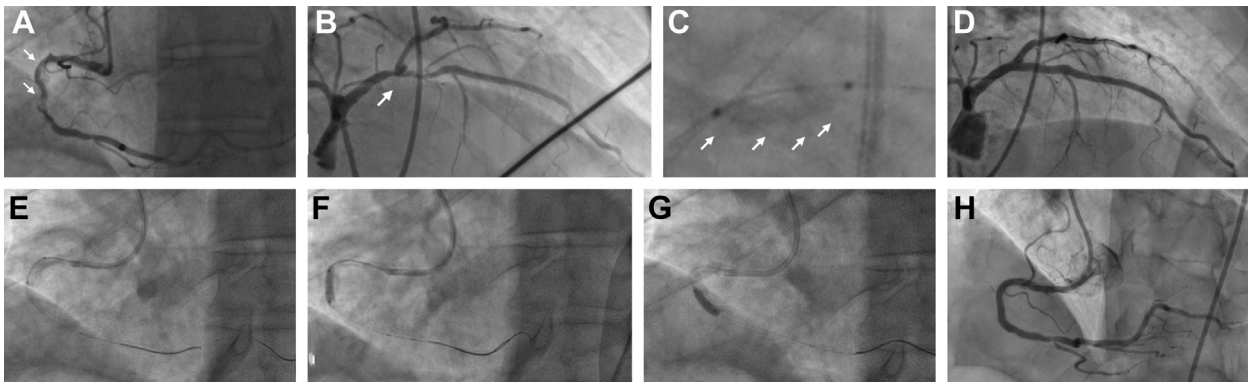
The setup was the left radial access for collateral opacification and the right femoral access for the target lesion. The parallel wire technique, supported

FIGURE 1 Bail-Out Handling of Stent Under-Expansion



(A) Left anterior descending artery chronic total occlusion with ambiguous cap. **(B)** Right-to-left collateral filling. **(C)** Extensive coronary dissection. **(D)** "Dog-boning" effect at the narrowest under-expanded stents and contrast-dye staining. **(E)** Stent boost shows circumferential calcification with severe stent under-expansion. **(F, G)** Minimal luminal diameter at the narrowest steel obstruction. **(H)** Intravascular lithotripsy balloon inflation showing full stent expansion.

FIGURE 2 Multivessel Delivery of IVL



(A) Multiple right coronary artery (RCA) calcified stenosis. **(B)** Long calcified left anterior descending coronary artery (LAD) bifurcation lesion (Medina classification: 1-0-1). **(C)** Intravascular lithotripsy (IVL) at the site of the severely calcified LAD lesion. **(D)** Optimal LAD final angiographical result. **(E to G)** Multiple IVL deliveries on RCA. **(H)** Final angiographic result after 2 overlapped stents.

by a FineCross (Terumo, Tokyo, Japan) microcatheter and wire escalation to a Pilot 200 (Abbott Laboratories, Chicago, Illinois) crossed successfully. The lesion was prepared with 2.0/20-mm low-profile balloon and high-pressure noncompliant (NC) balloons of 3.0/15 mm, followed by a 3.25/15-mm balloon up to 25 atm to achieve a 1:1 balloon/artery ratio without optimal balloon expansion. These aggressive dilation maneuvers caused a dissection with a large flap and contrast dye in the false lumen extending backwards up to the ostium of the LAD (Figure 1C).

The patient complained of chest pain associated with hemodynamic instability and marked ST-segment depression. Two overlapped stents were urgently implanted. Despite resolution of the coronary occlusion, the patient still complained of chest pain. One of the stents appeared to be under-expanded despite post-dilation with a NC balloon 3.5/15 mm up to 28 atm (Figure 1D).

Stent boost magnification (Philips Medical System, Best, the Netherlands) confirmed severely under-expanded and distorted stent struts distal to the overlapped segment (Figure 1E). Despite the fact that coronary flow was recovered, the hemodynamic status got slightly better with persisting chest pain and a faint collateral perfusion.

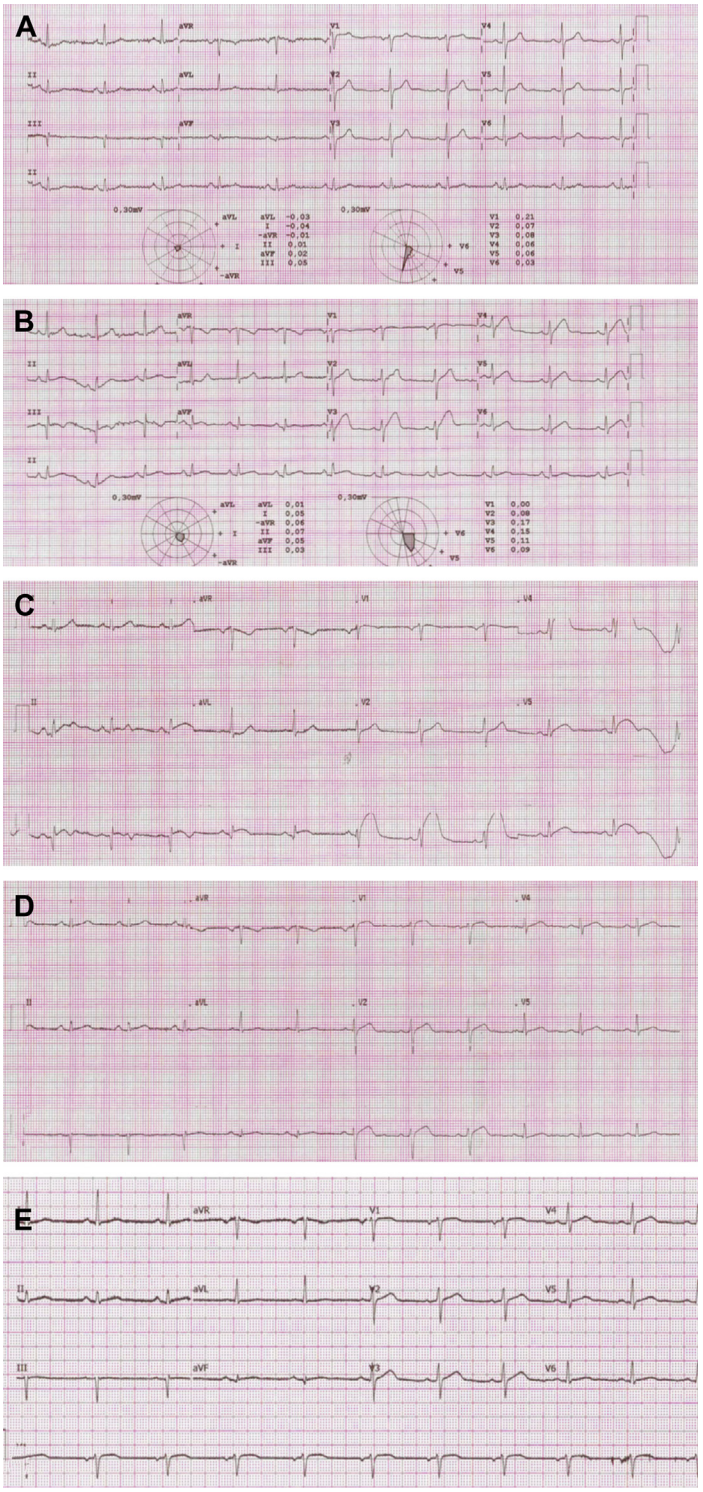
A 3.5-mm Shockwave lithoplasty balloon (Shockwave Medical Inc., Fremont, California) crossed the narrowest under-expanded segment, and a rescue treatment was immediately delivered. The Shockwave balloon inflation fully expanded after 2 cycles of 10 impulses inflated up to 4 and then further to 6 atm (Figures 1F and 1G). Stent Boost after IVL showed a well-expanded stent without any distortions (Figure 1H). Final optimization with an NC balloon 3.5/15 mm at 16 atm was performed with an immediate recovery of the patient's clinical status.

DIFFUSE ST-SEGMENT ELEVATION AFTER IVL AT MULTIVESSEL SEVERE CALCIFIED LESIONS. A 73-year-old man, presented with effort angina and multiple reversible perfusion defects. Angiography showed a long calcified Medina 1.0.1 bifurcation lesion involving the proximal LAD and the first diagonal branch (D1). Moreover, multiple tandem stenoses on a severely bent and calcified right coronary artery were present (Figures 2A and 2B).

The LAD stenosis was dilated using a 3.0/20-mm NC balloon up to 12 atm, but incomplete balloon expansion occurred. The balloon waist resolved after 2 cycles of 10 impulses with a 3.0/12-mm balloon inflated to 6 atm of IVL delivery (Figure 2C). A T-and-protrusion stenting technique was then performed to treat the bifurcation lesion (Figure 2D).

The right coronary artery issue was undertaken by the femoral access using an AL1 guiding catheter and multiple buddy wires. After pre-dilation with a standard 2.5/20-mm balloon, the IVL was easily advanced, and the complete balloon expansion (3.5/12 mm

FIGURE 3 Electrocardiographic Changes



(A) At admission. **(B)** Post-percutaneous coronary intervention mild ST-segment elevation in leads V_3–V_5. **(C)** 15 min later, diffuse severe ST-segment elevation. **(D)** During verapamil infusion. **(E)** At discharge.

inflated to 6 atm) was achieved after 3 cycles of 10 impulses (Figures 2E to 2G). Multiple overlapped stents were implanted followed by high-pressure NC balloon dilation (Figure 2H).

An optimal result was obtained with a thrombolysis in myocardial infarction flow grade III. However, in the recovery room, the patient complained of chest discomfort associated with diffuse ST-segment elevation in multiple leads without reciprocal ST-segment changes (Figures 3B and 3C).

Urgent angiography showed the treated vessels were fully open with good distal flow without any side branches occlusion. There was new milking appearance in the mid-LAD mimicking myocardial bridging (Figures 4A to 4C). Intracoronary nitroglycerin was avoided in order to not worsen the bridging, and the complete resolution of the ST-segment elevation was obtained after 40 min, during which verapamil was intravenously infused (10 mg/h) (Figure 3D). The patient completed an uneventful hospital stay without new pathological Q waves (Figure 3E) but with a negligible rise of troponin-I.

DISCUSSION

These cases illustrate both the feasibility and the drawbacks of using IVL in 2 complex scenarios, such as the bail-out treatment of unexpanded stents and the effects of erogations delivered on multivessel severely calcified lesions.

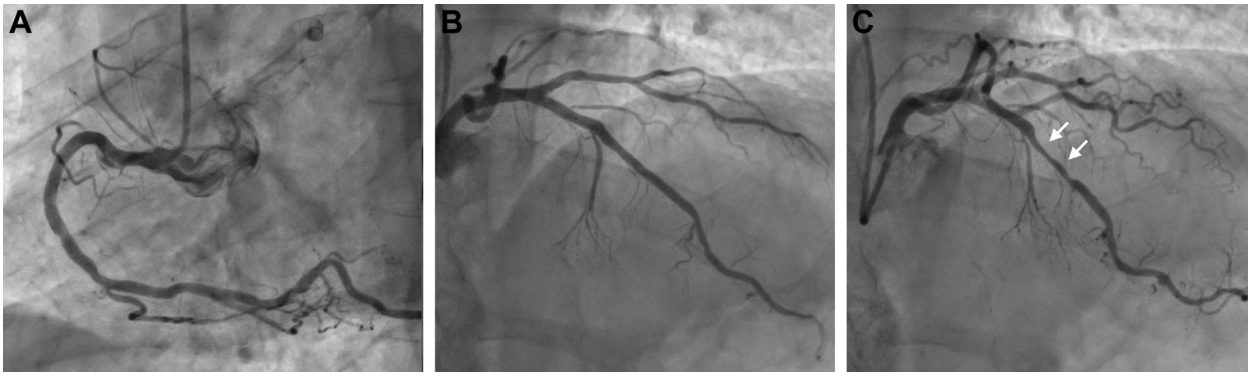
Regarding the former case, several reports illustrated the safety and the efficacy of IVL used in stable, chronically under-expanded stents. A recent report discussed the feasibility of IVL compared with general NC or new generation cutting balloons and highlighted the concern about the relatively bulky profile of lithotripsy balloons (1).

In the first case, the IVL balloon easily crossed the under-expanded segment because no angulation or tortuosity was encountered, and the minimal luminal diameter at the narrowest steel obstruction resulted in larger minimal luminal diameter (MLD) of 1.20 mm than the reported crossing profile of 1.12 mm of the 3.5-mm IVL balloon (Figures 1F and 1G).

In the second case, the occurrence of ST-segment elevation following multiple IVL deliveries is an unexpected finding, and the following final considerations may arise:

- Even if there are no compelling data to support the fact that vasoconstriction is more likely to occur in multivessel IVL delivery compared to the single-vessel delivery, it is worth mentioning that only 1 lesion per patient was treated in previous studies (4).

FIGURE 4 Urgent Angiography



(A and B) All vessels are patent. **(C)** Myocardial bridging on the mid-left anterior descending artery segment.

- The prompt resolution of both the myocardial bridging and of the diffuse ST-segment elevation by the administration of verapamil strengthens the hypothesis of vasoconstriction.
- Alternatively, the diffuse electrocardiography changes that occurred could be attributed to the capacity of coronary IVL to trigger ventricular ectopies and cellular depolarization in response to a mechanoelectrical coupling between the energy generated by the sonic pressure of the IVL and the local stretch-activated cellular ionic channels, as previous studies have reported (3).

CONCLUSIONS

The adoption of IVL as a bail-out procedure for underexpanded stents seems to be a promising option. When multivessel calcified target lesions are undertaken in the same setting, some potential new drawbacks could be encountered.

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KEY WORDS coronary angiography, myocardial ischemia, percutaneous coronary intervention