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CASE REPORT

INTERMEDIATE

CLINICAL CASE

Intravascular Lithotripsy for Treatment of Severely Calcified Mesenteric Stenosis

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ABSTRACT

Intravascular lithotripsy (IVL) is an emerging approach for modification of calcified atherosclerotic plaque. We report 2 cases of IVL used for calcific mesenteric stenosis, one in de novo superior mesenteric artery stenosis and another in celiac artery in-stent restenosis. In both cases, IVL was used successfully, reducing stenosis without any complications. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;■:■-■) © 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/).

Severely calcified vascular stenoses remain a challenge for traditional percutaneous transluminal angioplasty because of suboptimal vessel expansion, and a higher rate of dissections (1). Intravascular lithotripsy (IVL) is an emerging approach for modification of calcified plaque. Analogous to urologic extracorporeal lithotripsy for the treatment of renal stones, IVL uses a balloon angioplasty catheter mounted with multiple lithotripsy emitters, which generate circumferential acoustic pulses to modify and disrupt calcified plaques. IVL was first described as a means to modify calcified plaques in femoropopliteal disease (2). Later, its use was expanded to treat calcified coronary artery lesions. The safety and efficacy of IVL use in lower extremity peripheral artery disease (PAD) and coronary artery disease (CAD) was demonstrated in recently published DISRUPT PAD I and II (3) studies and the DISRUPT CAD II (4) studies, respectively. However, reports of IVL for treatment of mesenteric artery stenosis are lacking. We report our initial experience with IVL in this vascular bed.

LEARNING OBJECTIVES

- Two patients of severe calcified mesenteric stenosis.
- IVL can be considered for plaque preparation in patients with calcified mesenteric stenosis.
- IVL seems to be a useful modality for reducing severe calcified de novo stenosis and for optimizing stent expansion in previously underexpanded stents secondary to severe underlying calcification.

CASE 1: IVL IN DE NOVO STENOSIS

PRESENTATION. A 73-year-old woman with diabetes, chronic kidney disease, CAD, bilateral subclavian stenosis, and extensive PAD involving bilateral common iliac and superficial femoral arteries underwent multiple percutaneous interventions in the past. Two

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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

CAD = coronary artery disease

ISR = in-stent restenosis

IVL = intravascular lithotripsy

PAD = peripheral artery disease

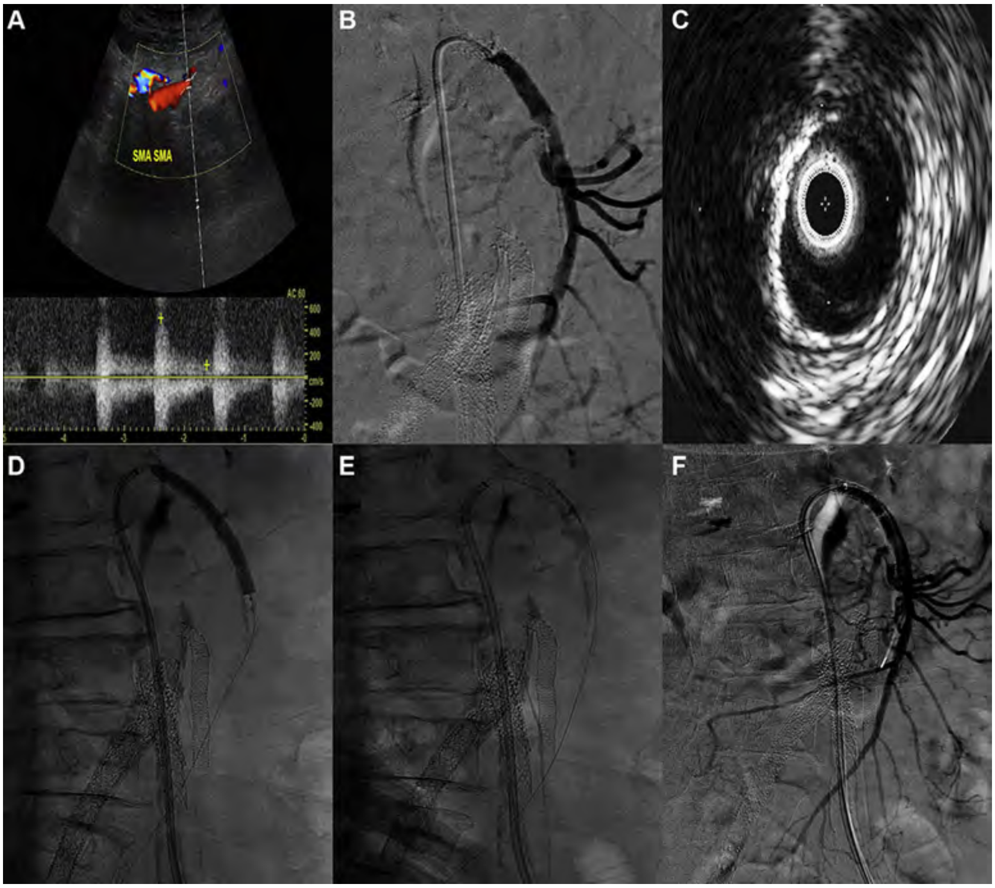
SMA = superior mesenteric artery

years prior, she was found to have occluded celiac artery and high-grade stenosis of superior mesenteric artery (SMA) and inferior mesenteric artery for which she underwent stenting with covered stent. At follow-up, she presented with symptoms of post-prandial abdominal pain, episodes of non-bloody vomiting, decreased appetite, and weight loss for 3 months.

INVESTIGATIONS. A duplex ultrasound demonstrated significantly elevated velocities in the SMA with a peak systolic velocity = 513 cm/s (Figure 1A).

MANAGEMENT. Using fluoroscopic and ultrasound guidance, left common femoral artery was cannulated with a 5-F sheath. Lateral abdominal aortography and selective celiac and SMA angiography was performed, which confirmed patency of the previously placed proximal SMA stent and severe concentric calcification and high-grade stenosis (approximately 80%) of the proximal to mid SMA (Figures 1B and 1C). Vessel diameters were confirmed with intravascular ultrasound and a 5 × 60 mm lithotripsy balloon (Shockwave Medical, Fremont, California) was then used to deliver 300 pulses (Figure 1D). To optimize the durability of the intervention 2 Resolute Onyx drug-eluting stents (Medtronic, Santa Rosa, California) 4.5 × 30 mm and 5 × 15 mm were placed, overlapped and post-dilated with 5-mm Cordis Aviator balloon (Cordis, Fremont, California) (Figure 1E). Repeat angiography demonstrated excellent results with less than 10% residual stenosis and no evidence of dissection or contrast extravasation (Figure 1F). Repeat intravascular ultrasound demonstrated

FIGURE 1 IVL for De Novo SMA Stenosis



(A) Duplex ultrasonography showing stenosis of superior mesenteric artery with significantly elevated velocities. **(B)** Preprocedural angiography showing severe stenosis of proximal to mid superior mesenteric artery. **(C)** Pre-procedural intravascular ultrasound showing calcification. **(D)** Treatment of stenosis with shockwave intravascular lithotripsy system. **(E)** Placement of 2 Resolute Onyx drug-eluting stents. **(F)** Post-treatment angiography showing resolution of stenosis. SMA = superior mesenteric artery.

symmetric expansion of the stents with an excellent luminal cross-sectional area with full apposition of the stent struts and improvement in the diameter of the SMA from 2.5 to 5.1 mm. There was no evidence of distal embolization on repeat angiography. The patient was discharged home on dual antiplatelet therapy the following day.

FOLLOW-UP. At 6-week follow-up, the patient reported resolution in post-prandial pain and positive weight gain.

CASE 2: IVL IN IN-STENT RESTENOSIS

PRESENTATION. A 65-year-old woman presented with recurrent post-prandial pain and decreased appetite. She had a history of CAD, aortoiliac and femoropopliteal PAD, and had undergone multiple prior percutaneous interventions including stent placement. Six months prior, she was diagnosed with chronic mesenteric ischemia for which she underwent placement of a 6 × 24 mm bare-metal stent in the celiac artery and a 7 × 24 mm bare-metal stent in the SMA.

INVESTIGATIONS. A duplex ultrasound demonstrated evidence of severe restenosis of both celiac artery and SMA stents.

MANAGEMENT. Left common femoral artery was accessed under fluoroscopic and ultrasound guidance with placement of 5-F sheath at mid common femoral artery level. Lateral aortography and selective celiac and SMA angiography was performed, which revealed 70% in-stent restenosis (ISR) of the SMA stent and 90% ISR of the celiac stent. In addition, the celiac stent was underexpanded in its midportion secondary to deep wall calcification (**Figure 2A**). After successfully cannulating the celiac ostium with 0.014-inch Command wire (Abbott Vascular, Santa Clara, California), IVL of the celiac ISR was performed using a 6 × 60 mm lithotripsy balloon (Shockwave Medical) with administration of 300 pulses (**Figure 2B**). The previously underexpanded stent expanded fully and was well apposed to the artery. To reduce the risk of recurrent restenosis, a 6 × 18 mm iCast polytetrafluoroethylene balloon expandable covered stent (Atrium Medical Corporation, Hudson, New Hampshire) was placed (**Figure 2C**). Repeat angiography demonstrated an excellent result, with less than 10% residual stenosis and no evidence of contrast extravasation, dissection, or embolization (**Figure 2D**). Following this, the SMA was cannulated, followed by pre-dilation with a 5 × 20 mm Fortex high pressure balloon (Medtronic). A 7 × 19 mm Gore VBX balloon expandable polytetrafluoroethylene-covered stent (Gore Medical, Flagstaff, Arizona) was then delivered. Repeat angiography demonstrated satisfactory results with no evidence of complications. The patient was discharged home on dual antiplatelet therapy the following day.

FOLLOW-UP. Eight weeks later, during outpatient follow-up, she reported resolution of abdominal pain and positive weight gain.

DISCUSSION

The first case highlighted the effectiveness of IVL in reducing de novo calcific stenosis and the second case demonstrated its effectiveness in managing ISR caused by stent underexpansion in a severely calcified lesion. These observations are important given the lack of safe and effective techniques available to optimize stent expansion in the setting of calcified stenoses in this vascular bed.

Optical coherence tomography substudies of DISRUPT CAD I and II have provided insight into the mechanism of action of IVL in disrupting calcific plaques (4,5). These studies have demonstrated that IVL causes multiple circumferential fractures within the plaque leading to improved vessel compliance and allowing for luminal gain with percutaneous interventions. The frequency of fractures increases with increasing severity of calcification (5). IVL offers several advantages over other currently available techniques for calcified plaque modification: 1) it is an easy to learn technique and requires little specialized training; 2) it allows more uniform and controlled disruption of plaques, unlike atherectomy in which plaque modification may be influenced by guidewire course and vessel architecture; 3) it minimizes vascular injury by using low balloon inflation pressures, which may be associated with lower risk of vessel dissection and rupture; and 4) it is associated with lower risk of distal embolization. There are very limited options for treating underexpanded stents. High pressure inflations may be ineffective or induce dissections or rupture. The second case illustrates the potential ability of IVL to treat underexpanded stents. One disadvantage of IVL is that it is a higher profile device than a balloon, and may be more challenging to pass through tortuous vessels and severely stenotic lesions.

Although these cases demonstrate the value of IVL in treating calcific mesenteric stenosis, feasibility and safety of IVL needs to be demonstrated in larger patient populations in this vascular bed. Use of the Shockwave IVL system for management of ISR is outside its current instruction for use.

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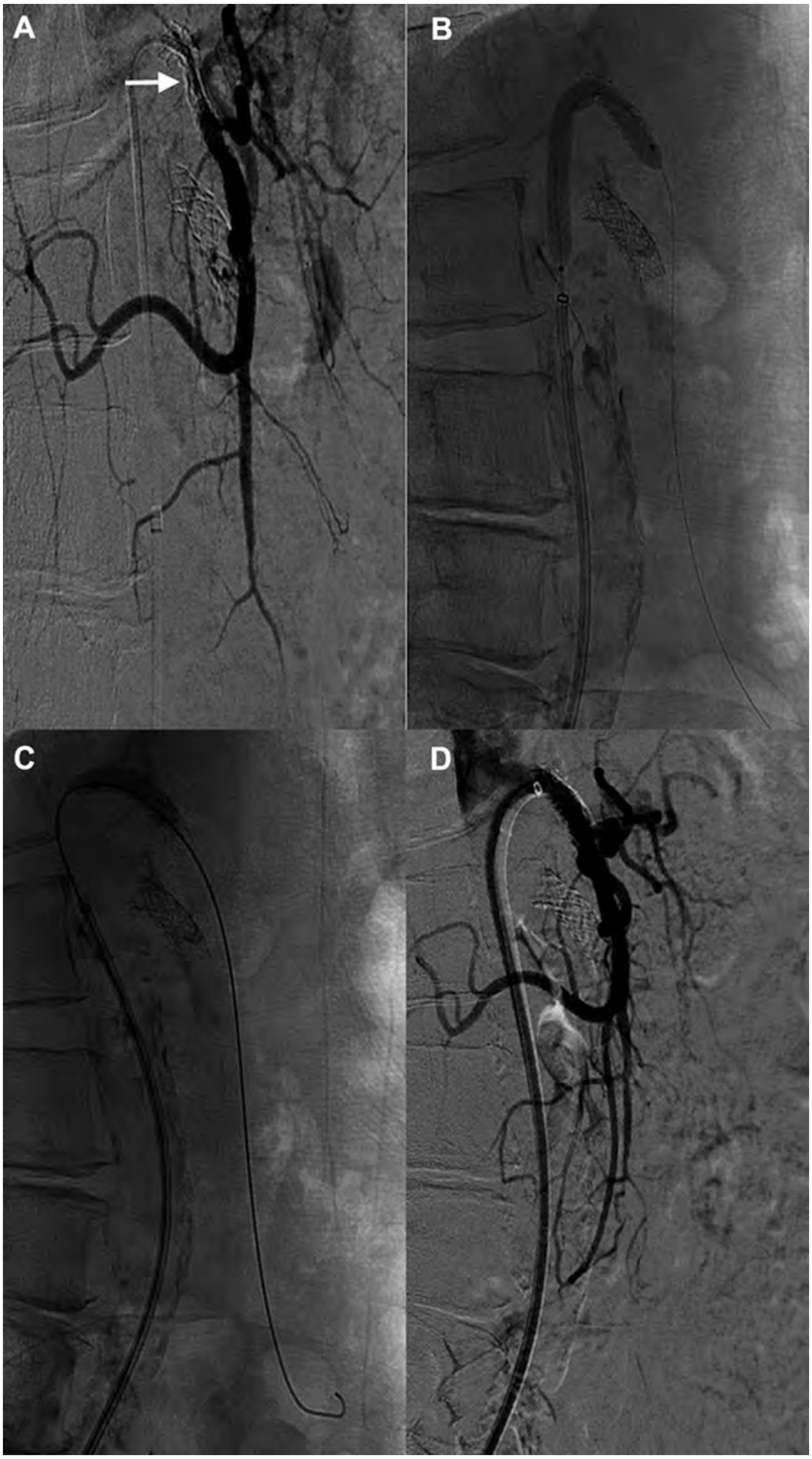
FIGURE 2 IVL for Treatment of SMA ISR



(A) Pre-procedural angiography showing severe in-stent restenosis of previously placed celiac stent along with underexpansion in its mid-portion **(arrow)**. **(B)** Treatment of celiac in-stent restenosis with intravascular lithotripsy. **(C)** Placement of polytetrafluoroethylene balloon expandable covered stent. **(D)** Post-treatment angiography showing resolution of stenosis and full expansion of previously placed celiac stent.

CONCLUSIONS

IVL was successfully used in reducing severe calcified de novo and ISR without complications in 2 patients with mesenteric artery disease.

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KEY WORDS disorders of calcium metabolism, peripheral circulation, peripheral vascular disease