JACC: CASE REPORTS VOL. 2, NO. 2, 2020

CASE REPORT

ADVANCED

CLINICAL CASE/TECHNICAL CORNER

Coronary Artery Perforation After Shockwave Intravascular Lithotripsy

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ABSTRACT

Severely calcified coronary lesions remain a challenge in current percutaneous coronary interventions. Shockwave intravascular lithotripsy (Shockwave Medical, Inc., Santa Clara, California) is an alternative for rotational atherectomy in such lesions that supports stent deliverability and achieves optimal results. We describe a case of coronary artery perforation after use of this lithotripsy device. (**Level of Difficulty: Advanced.**)

The treatment of severely calcified coronary lesions with percutaneous techniques is still complex in current daily interventional practice. Although success rates have improved with the use of advanced guidewires, high-pressure balloons, cutting balloons, improved stents, and rotational atherectomy, there remains a high burden among aging patients with recalcitrant calcified plaques that are not suitable for treatment with these conventional techniques. Shockwave intravascular lithotripsy (S-IVL) (Shockwave Medical, Inc., Santa Clara, California) is an emerging therapeutic option for the treatment of severely calcified coronary lesions (1). By creating intravascular sonic pressure waves, it selectively fractures intimal and medial calcium and leads to increased vessel compliance. The S-IVL device is a monorail, balloon-based catheter, with a standard length of 12 mm and a range from 2.5 to 4.0 mm in diameter, connected to a high-voltage power source. The lithotripsy is performed for a maximum of 8 10-s cycles while maintaining low-pressure inflation (4 atm) to ensure balloon apposition to the vessel wall. This device has proved to be safe and to limit conventional risks associated with rotational atherectomy, such as microembolization and bradycardia. Safety data of the DISRUPT-CAD (Shockwave Coronary Lithoplasty Study) showed that none of the 60 treated patients had any dissections, perforations, abrupt closures, or no-flow or slow-flow phenomena (2). In this report, we present the first case of a coronary artery perforation after use of the S-IVL device.

LEARNING OBJECTIVES

- Clinicians should understand that intravascular lithotripsy can lead to a coronary artery perforation.
- Clinicians should be able to treat the coronary perforation by inflating a balloon proximal to the perforation site and, if not successful, consequently implanting a covered stent.
- Clinicians should call for help in case of a coronary perforation (e.g., cardiothoracic surgeon, anesthesiologist, or echocardiographic imager). Be prepared for pericardiocentesis.

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Informed consent was obtained for this case.

Manuscript received August 26, 2019; revised manuscript received October 16, 2019, accepted October 24, 2019.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2019.10.045

JACC: CASE REPORTS, VOL. 2, NO. 2, 2020
FEBRUARY 2020:247-9

ABBREVIATIONS AND ACRONYMS

CTO = chronic total occlusion

LAD = left anterior descending

PCI = percutaneous coronary intervention

S-IVL = Shockwave intravascular lithotripsy

HISTORY OF PRESENTATION

A 68-year-old woman was seen in the outpatient clinic (Amphia Ziekenhuis, Breda, the Netherlands) for symptoms of angina and shortness of breaths for the past month. Cardiac auscultation revealed a clear holosystolic apical cardiac murmur. There were no other abnormal findings during physical examination. The electrocardiogram showed sinus rhythm with a heart rate of 70 beats/min and pathological anterior Q waves (leads V_1 to V_3). Her echocardiogram showed a moderately reduced left ventricular ejection fraction (40%) combined with mild aortic valve stenosis (maximum velocity of 2.8 m/s; aortic valve area of 1.7 cm^2) and moderate mitral valve insufficiency. Myocardial scintigraphy confirmed an old anteroseptal myocardial infarction, including significant anterior ischemic defects with myocardial viability. On the basis of these findings, we decided to perform coronary angiography.

PAST MEDICAL HISTORY

Her medical record included hypertension, asthma, and arthritis.

INVESTIGATIONS

Coronary angiography showed a chronic total occlusion (CTO) of the proximal left anterior descending (LAD) coronary artery with partial collateral flow (**Figure 1A**, Video 1). No significant stenoses were present in the other coronary arteries. The patient's case was discussed by the Heart Team, and the patient was approved to undergo a percutaneous coronary intervention (PCI) of the LAD artery.

MANAGEMENT

The procedure was performed using the right femoral and radial artery with 6-F extra backup 3.5 and 6-F Judkins right 4 guiding catheters. The CTO was successfully recanalized with an anterograde wire escalation technique, using a GAIA-2 guidewire (Asahi Intecc, Nagoya, Japan) and Turnpike spiral catheter (Teleflex, Morrisville, North Carolina) (**Figure 1B**, Video 2). After pre-dilating the lesion, 3 stents were implanted in an overlapping pattern (Direct Rx stents, Svelte Medical, New Providence, New Jersey) (2.5 × 18 mm, 3.0 × 18 mm, and 3.5 × 18 mm, from distal to proximal). Despite post-dilating with a 4.0-mm noncompliant balloon, the proximal stent was underexpanded as a result of severe vessel wall calcifications (**Figure 1C**, Video 3). Therefore, an additional 40 intracoronary S-IVL pulses were delivered with a 4.0 × 12 mm balloon. Although this procedure resulted in good expansion of the proximal stent, it also led to a coronary artery perforation behind the stent struts (**Figure 1D**, Video 4). Immediate sealing of the coronary perforation with the Shockwave balloon for 10 min (4 atm) and intravenous protamine 50 mg did not stop the leak. Consequently, a covered stent (Graftmaster, Abbott, Abbott Park, Illinois; 3.5 × 16 mm) was successfully implanted (**Figure 1E**, Videos 5 and 6). An echocardiogram showed a nonprogressive, minimal amount of pericardial effusion. The patient remained hemodynamically stable in the next hour and was admitted to the coronary care unit.

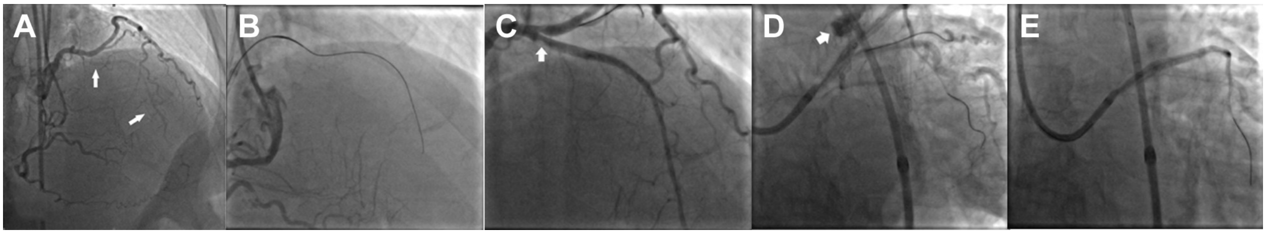
FOLLOW-UP

After the procedure, the patient was admitted to the coronary care unit to be monitored overnight. Pulse, blood pressure (arterial line) and laboratory tests were performed according to hospital protocol. Additional multiple transthoracic echocardiograms ensured that the pericardial effusion remained stable. She was discharged from the hospital on the next day. An additional angiogram was not deemed necessary.

DISCUSSION

The S-IVL procedure offers several theoretical advantages compared with rotational atherectomy. First, it does not require specific training. Second, it diminishes the risk of embolization. Third, the circumferential location of the calcium is uniformly attacked with the inflated balloon and therefore is not subject to guidewire bias. Fourth, S-IVL is possible after stenting, in contrast to rotational atherectomy. The recently published DISRUPT-CAD trial results showed no cases of dissection, perforation, abrupt closure, or no-flow or slow-flow phenomena in the included 60 patients (2). Moreover, the first real-world findings of 26 patients in Auckland, New Zealand, showed no procedural or in-hospital complications, and clinical success was achieved in all cases (3). Although barotrauma is minimized with low-pressure inflation (4 atm) during S-IVL, the high-intensity sonic pressure waves still can lead to coronary perforation, even behind stent struts. The occurrence of coronary perforation has been described with all interventional techniques and therefore was also suspected to occur with S-IVL. Until now, none of the possible complications of S-IVL have been described. This complex CTO clinical case describes the occurrence of a coronary artery perforation after S-IVL and the therapeutic management of this complication. However, it is

FIGURE 1 **Sequence of Events Leading to Coronary Artery Perforation**



(A) Coronary angiogram showing a chronic total occlusion of the left anterior descending coronary artery **(arrows)**. **(B)** Recrossing of the chronic total occlusion with the anterograde wire escalation technique. **(C)** Severe calcification of the proximal left anterior descending coronary artery **(arrow)** leading to underexpansion of the stent. **(D)** Coronary artery perforation behind the stent struts **(arrow)** after use of the Shockwave intravascular lithotripsy (Shockwave Medical, Inc., Santa Clara, California) catheter. **(E)** Implantation of a covered stent to seal the perforation successfully.

noteworthy that the S-IVL device was used in an off-label manner because it has not been formally tested for use behind the struts of a previously placed coronary stent. In addition, no intracoronary imaging was performed during this case. Intracoronary imaging pre-PCI is highly beneficial to guide appropriate lesion preparation and stent selection, especially in highly complex lesions, such as CTOs.

CONCLUSIONS

Intravascular lithotripsy can be a useful tool in severely calcified lesions. However, it may lead to coronary artery perforation, as described in this case. The treatment of this complication consists of the usual management, namely, sealing of the perforation site with a balloon or consequently a covered stent. The interventional cardiologist should be aware of this potentially lethal complication while performing S-IVL.

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KEY WORDS calcified lesions, coronary artery perforation, intravascular lithotripsy, percutaneous coronary intervention

APPENDIX For supplemental videos, please see the online version of this paper.