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CASE REPORT

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Bail out lithotripsy to treat delayed valve-in-valve TAVR-related coronary obstruction

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Abstract

Coronary access difficulty and stent compression by the juxtaposed aortic valve leaflet hamper percutaneous management of delayed coronary artery obstruction (CAO) after valve-in-valve (Edwards Sapien 3 in St. Jude Trifecta) transcatheter aortic valve replacement (TAVR). Here, we present a case of delayed post-TAVR CAO treated with intravascular lithotripsy and multistenting to overcome stent compression by the adjacent calcified leaflet.

KEYWORDS

aortic valve disease, coronary artery disease, interventional devices/innovation, percutaneous coronary intervention, stenting technique

1 | INTRODUCTION

Transcatheter aortic valve replacement (TAVR) has become a safe and efficacious alternative to surgical aortic valve replacement in high- or intermediate-surgical-risk patients.[1,2] This has been a result of significant improvements in preprocedural planning/imaging and operator experience in the past decade.[1,2] Still, a subgroup of patients experiences a major adverse event, of which post-TAVR coronary artery obstruction (CAO) remains one of the most feared, carrying a 30-day mortality rate of 40%–50%.[3,4]

CAO can occur acutely within 7 days after TAVR as a consequence of native valve displacement during deployment. In addition, delayed CAO, occurring 7 days after TAVR placement, has been described, which occurs as a consequence of minor leaflet displacement combined with bioprosthetic valve endothelialization and endofibrosis or endocalcification.[4] Delayed TAVR CAO, especially, presents a clinical dilemma as surgical treatment is ill-favored because of high surgical risk (evidenced by the a priori choice for TAVR), while percutaneous treatment may be hampered by left main coronary artery (LMCA) access difficulty or stent compression by the displaced calcified leaflet. As a consequence, no consensus exists on the best treatment for delayed CAO.

Intravascular lithotripsy (IVL) has been recently introduced as a novel modality utilizing sonic pressure waves to disrupt intravascular calcium, which are applied for the preparation of severely calcified coronary lesions with good outcomes.[5] As the shockwaves emitted from the IVL balloons are known to penetrate to approximately 7 mm of tissue,[5] even calcium outside the vessel architecture may be fractured. As such, IVL balloons may in theory provide an interesting means of alleviating stent compression in delayed CAO. Hence, IVL might improve the percentage of patients with TAVR CAO that can be successfully managed percutaneously. In this manuscript, we report the first case of delayed TAVR CAO, which was successfully managed percutaneously with lithotripsy after initial mainstem access difficulty and stent compression caused by a pinned calcified leaflet in front of the LMCA.

Abbreviations: AVR, transcatheter aortic valve replacement; CCTA, coronary computed tomography angiography; CAO, coronary artery obstruction; IVL, intravascular lithotripsy; IVUS, intravascular ultrasound; LMCA, left main coronary artery; PET-CT, positron emission tomography-computed tomography; PCI, percutaneous coronary intervention; TAVR, transcatheter aortic valve replacement.

2 | CASE DESCRIPTION

A 74-year-old Caucasian male presented in the outpatient clinic of a referring hospital with dyspnea on exertion. The patient was known to have advanced chronic obstructive pulmonary disease. Moreover, he was treated for severe aortic stenosis through surgical aortic valve replacement (St. Jude Trifecta) as well as transapical valve-in-valve TAVR (Sapien 3; Edwards Lifesciences) in a different hospital 10 and 4 years before presentation, respectively.

Echocardiogram showed normal left and right ventricular function with a moderate aortic valve stenosis (mean gradient 30 mmHg, aortic valve area 1.4 cm^2). Rubidium positron emission tomography-computed tomography showed abnormal perfusion in the basal and mid-anterolateral and inferolateral segments. Coronary angiography was attempted in the referring hospital, but a selective engagement of the coronary ostia was considered impossible using both Judkins Left (Figure 1A) and Multipurpose (Figure 1B) diagnostic catheters. A second coronary angiography performed in our center revealed a critical ostial stenosis of the LMCA (Figure 1C,D and Supporting Information: Video 1). A coronary computed tomography angiography showed a calcified aortic valve leaflet pinned up in the sinus of Valsalva by the TAVR struts, causing stenosis of the LMCA ostium (Figure 2A–F). After evaluation by the institutional heart team, which considered the surgical risk unacceptable, the patient was scheduled for percutaneous coronary intervention (PCI) of the ostial LMCA stenosis.

After engaging the LMCA with a 6 Fr. Judkins Left 4.0, a workhorse coronary guidewire was carefully advanced into the left anterior descending artery (LAD), entering the LMCA cranial from the TAVR struts (Figure 1E–J). The transition of the sinotubular junction (STJ) to the LMCA (containing the pinned calcified leaflet) was predilated with 2.5 mm and 4.0 × 15 mm noncompliant balloons inflated up to 20 atm (Figure 1E). Because the balloons expanded inadequately, a 4.0 × 12 mm IVL balloon (Shockwave C2; Shockwave Medical) was inflated at 4 atm and 80 pulses were delivered at the site of stenosis (Figure 1F). Thereafter, a 5.0 × 15 mm drug-eluting stent (Resolute Onyx; Medtronic) was placed at 16 atm and ostial flare was performed with the stent balloon at 18 atm (Figure 1G,H). However, control angiography showed significant stent recoil (Figure 1I). To maximize radial strength and overcome the stent recoil induced by the calcified aortic leaflet (in the absence of a stent platform with higher radial strength than Resolute Onyx in our

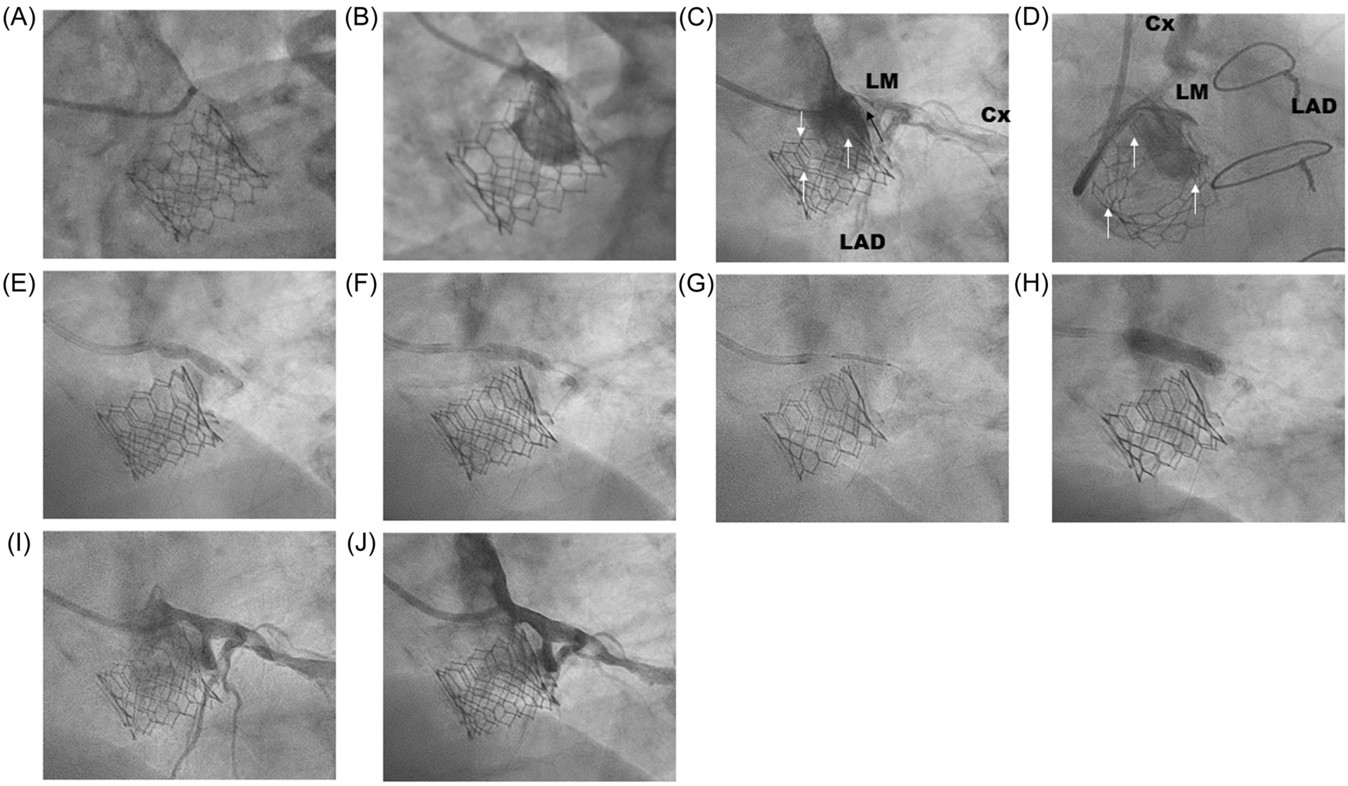

FIGURE 1 Failed engagement of the LMCA ostium with (A) Judkins Left 4.0 and (B) Multipurpose two diagnostic catheters. (C) Left and (D) right superior oblique view showing supra-TAVR LMCA engagement with a Judkins Left 4.0 guide catheter. Notice the calcified structure (pinned leaflet) in front of the LMCA (black arrow) and the position of the commissural posts (white arrows). Left superior oblique view of the LMCA (E) during predilation with 4.0 × 15 mm NC balloon at 20 atm (F) during inflation of a 4.0 × 12 mm IVL balloon at 4 atm, (G) just before deployment of the first stent (H) during flaring of the first 5.0 × 15 mm stent at the STJ–LMCA transition at 18 atm, (I) after deployment of the first stent and (J) after multistenting. Cx, circumflex; IVL, intravascular lithotripsy; LAD, left anterior descending; LMCA, left main coronary artery; TAVR, transcatheter aortic valve replacement; STJ, sinotubular junction.

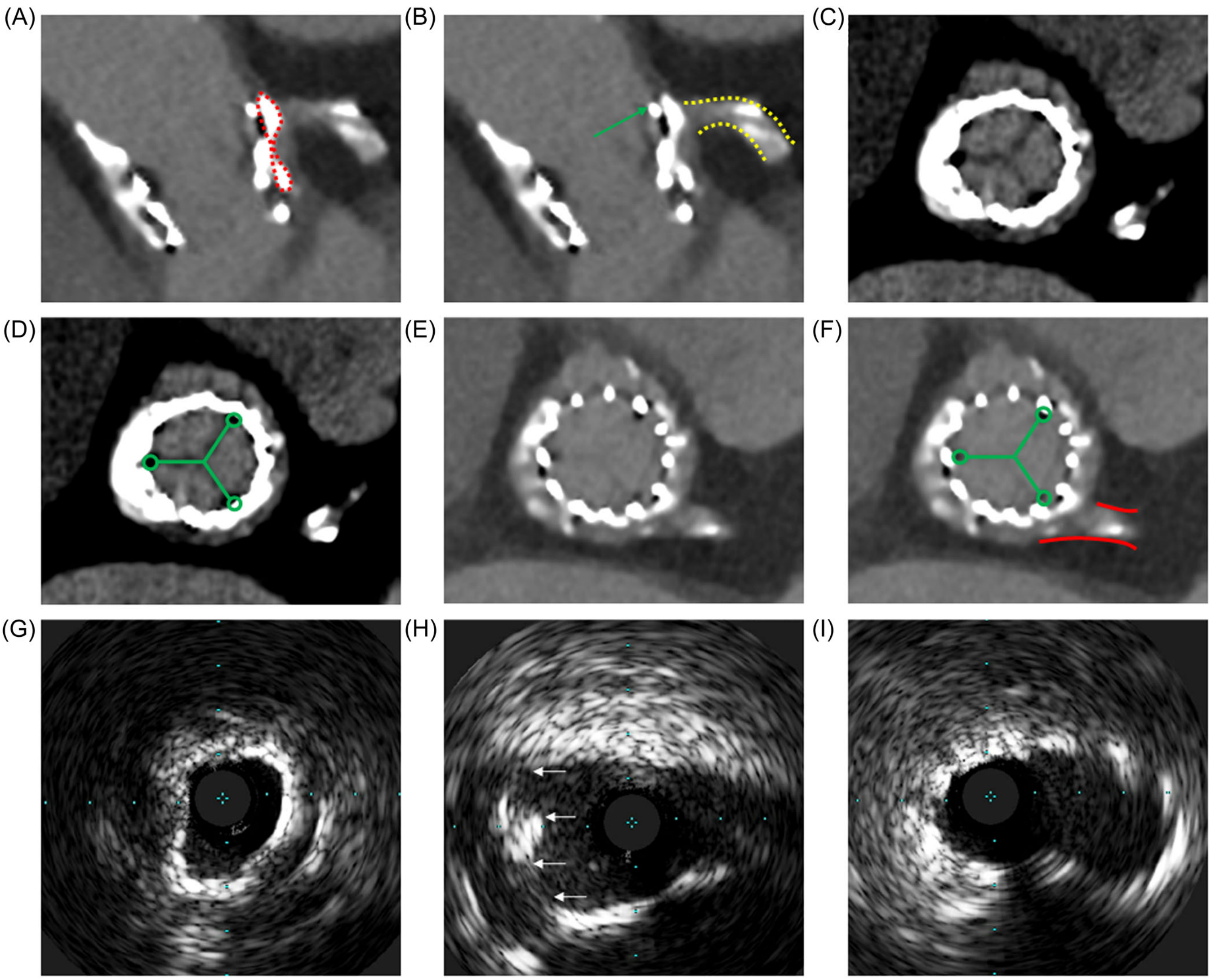

FIGURE 2 (A, B) Computed tomography frontal plane view of the aortic root and LMCA, showing the pinned down calcified AVR leaflet (red dotted outline) in front of the LMCA (yellow dotted outline). Notice that the TAVR frame (green arrow) height is at the same level as the superior aspect of the LMCA. Computed tomography transverse plane view at (C, D) TAVR commissure/leaflet level and (E, F) LMCA ostial level. Notice the juxtaposition of the commissural posts (green circles) and the LMCA (red outline). IVUS images of the LMCA minimum lumen (G) after predilation with a 2.5 mm balloon (H) after IVL and (I) after multistenting. Notice the calcium fractures after IVL; the white arrows demarcate the edges of fractured calcium. AVR, aortic valve replacement; IVL, intravascular lithotripsy; IVUS, intravascular ultrasound; LMCA, left main coronary artery; TAVR, transcatheter aortic valve replacement. [Color figure can be viewed at wileyonlinelibrary.com]

institution), two additional 5.0 × 12 and 5.0 × 15 mm DES were placed at the same location at 16 atm. After placement of the third stent, there was a clear angiographic improvement of the minimum lumen diameter at the STJ–LMCA transition (Figure 1J and Supporting Information: Video 2). Intravascular ultrasound (IVUS; Eagle eye platinum ST; Philips) evaluation was performed, which confirmed a substantial lumen gain (minimum luminal area increased from 4.1 mm^2 after the first predilation to 11.8 mm^2 after multistenting) after PCI. (Figure 2G–I and Supporting Information: Videos 3–5. NB: as the IVUS jumped from the narrowest part before stenting, the minimum lumen in 2G is probably overestimated.) Moreover, IVUS exemplified calcium fracturing after IVL as the mechanism underlying the effect of IVL (Figure 2H and Supporting Information: Video 4).

The patient was discharged the next day on apixaban (5 mg twice daily), acetylsalicylic acid (80 mg, once daily for 1 month), and clopidogrel (75 mg, once daily for 6 months). At 24 months follow-up, the patient remained free of anginal complaints or adverse cardiovascular events. Echocardiography showed a stable normal LV function without wall motion abnormalities.

3 | DISCUSSION

Careful patient selection, leaflet preparation using the BASILICA technique, snaring of the displaced TAVR, preemptive coronary wiring, and snorkel/chimney stenting and use of contemporary valve systems made acute TAVR CAO, occurring within 7 days of TAVR implantation, a clinical rarity.[3] In the present case, the use of a valve system that employs externally mounted leaflets (St. Jude Trifecta) in the initial AVR may have increased the risk of acute CAO after a valve-in-valve TAVR, which in hindsight may have prompted preventive strategies such as BASILICA. However, when confronted with delayed CAO occurring 7 days after TAVR placement, the aforementioned techniques in the context of acute CAO, are self-evidently defeated by its delayed occurrence. Moreover, delayed TAVR CAO, like its acute counterpart, presents a clinical dilemma as surgical treatment is ill-favored because of high surgical risk, while percutaneous treatment may be hampered by difficult LMCA access or balloon/stent under expansion. Both PCI stumbling blocks are exemplified by the case described here.

First, LMCA access is impeded by four factors: (1) the LMCA ostium is partially covered by a pinned aortic valve leaflet (Figures 2A), (2) the STJ bends inward at the LMCA ostium (Figure 1C), (3) the TAVR stent frame height is at the same level as the superior portion of the LMCA (Figure 2B), (4) one of the TAVR commissural posts partially overlaps with the LMCA ostium (Figure 2C–F). If the stent frame of a balloon expandable TAVR protrudes over the coronary ostium or, when the commissures misalign, the coronary is usually engaged through the closest stent strut to allow coaxiality. Coronary angiography or PCI can then proceed normally.[6] However, if stent frame protrusion and commissural misalignment are combined with a pinned leaflet in front of the coronary orifice, engagement through the struts as per usual is precluded. We show that in this setting, engagement of the LMCA cranial from the stent struts is possible, despite the similar height of the TAVR frame and the LMCA. This may be an important notion as a trend toward higher TAVR implantation may be observed considering data showing higher TAVR positions decrease the need for post-TAVR pacemaker implantation.[7]

Second, in our case, balloon/stent under expansion and stent recoil seems to be determined, at least in part, by compression caused by the heavily calcified aortic valve leaflet pinned in front of the LMCA ostium. Technical options in this scenario are limited. While rotational, orbital, and laser excimer atherectomy may provide debulking of the calcified leaflet in front of the LMCA, the calcium that can be modified remains confined to the dimensions of the atherectomy device. The fact that the pinned trifecta leaflet resides in front of the LMCA ostium requires forward abrasion to debulk the calcium, which may preclude the use of (lateral abrasion by) orbital atherectomy. The lack of catheter engagement and the inability to wire the LMCA using more supportive catheter shapes (other than the Judkins Left), due to the difficulties mentioned before, may also hamper the success of forward abrasion found in rotational or laser atherectomy in the present case. Also, as coaxial alignment of the catheter was precluded, the advancement of an atherectomy device inside the LMCA may imply an increased risk of aortocoronary dissection as well as wire fracture. Moreover, as the target for debulking lies in front of the LMCA, the debris released from this target will inevitably end up in the aorta, which could possibly lead to serious thromboembolic events. In contrast, IVL may, as a consequence of its 7 mm penetration depth and its delivery through a semicompliant balloon, circumvent these respective issues. Still, dilating a calcified structure that lies in front of the LMCA ostium carries a risk of debris embolization, although deemed smaller than this risk using aforementioned atherectomy devices. In the present case, IVL was indeed used successfully to treat delayed TAVR CAO. IVUS images showed evident calcium fracturing after IVL (Figure 2H). Moreover, the difference in balloon expansion before (Figure 1E) and after IVL treatment (Figure 1H) strongly suggests that IVL-induced calcium fracture contributed to the success of the case. However, the intravascular images cannot provide proof as to whether or not this is caused by the fracturing of calcium deposits inside the LMCA or inside the pinned calcified aortic valve leaflet. Hence, further research is needed to confirm the efficacy and mechanism of IVL in the treatment of TAVR CAO.

4 | CONCLUSIONS

IVL may be used to treat delayed TAVR CAO, especially in the context of underpinned TAVR leaflets combined with commissural misalignment and high TAVR implantation.

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CONFLICTS OF INTEREST

Frank van der Kley received consultancy fees from Edwards Lifesciences en Abbott Vascular. Jose M. Montero received a research grant from Shockwave Medical. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Smith CR, Leon MB, Mack MJ, et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med*. 2011;364:2187-2198.
2. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med*. 2016;374:1609-1620.

3. Ribeiro HB, Webb JG, Makkar RR, et al. Predictive factors, management, and clinical outcomes of coronary obstruction following transcatheter aortic valve implantation. *J Am Coll Cardiol*. 2013;62:1552-1562.
4. Richard J, Jabbour RJ, Tanaka A, Finkelstein A, et al. Delayed coronary obstruction after transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2018;10:1513-1524.
5. Kereiakes DJ, Virmani R, Hokama JY, et al. Principles of intravascular lithotripsy for calcific plaque modification. *JACC Cardiovasc Interv*. 2021;14:1275-1292.
6. Arshi A, Yakubov SJ, Stiver KL, Sanchez CE. Overcoming the transcatheter aortic valve replacement Achilles heel: coronary re-access. *Ann Cardiothorac Surg*. 2020;9(6):468-477.
7. Mauri V, Reimann A, Stern D, et al. Predictors of permanent pacemaker implantation after transcatheter aortic valve replacement with the SAPIEN 3. *JACC Cardiovasc Interv*. 2016;9:2200-2209.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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