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CASE REPORT
Coronary intervention

A case report on intravascular lithotripsy to facilitate retrograde wire passage from the subintimal to the luminal space in a calcified chronic total occlusion

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Background Severe calcifications are a major reason for failures in chronic total coronary occlusions, as they can obstruct the wire passage both in the antegrade and retrograde technique.

Case summary The proximal occlusion of the left anterior descending artery in a 75-year-old man presented with a completely concentric calcified ring all along the segment proximal to the occlusion. The antegrade wire could not pass the calcified occlusion, and in a retrograde approach *via* the right posterior descending artery the retrograde wire was not able to enter the lumen from a subintimal position outside of the calcified ring. Intravascular lithoplasty in the proximal segment led to a crack in this ring to enable the same retrograde wire now to pass into the true lumen with then successful conclusion of the case. Intravascular ultrasound demonstrated the modification of the calcified ring and the passage of the wire with only a very short subintimal pathway.

Discussion Intravascular lithoplasty is a new option to modify severely calcified vessel segments to facilitate the reverse controlled antegrade and retrograde tracking approach. In the present case, this helped to avoid a long subintimal pathway and preserved the vessel anatomy.

Keywords Case report • Percutaneous coronary intervention • Chronic total occlusion • Intravascular lithotripsy

ESC curriculum 3.1 Coronary artery disease • 3.3 Chronic coronary syndrome • 3.4 Coronary angiography

Learning points

- The extent of severe calcification as an obstruction to the planned retrograde technique must be recognized by intravascular imaging, which is helpful in understanding the problems in reverse controlled antegrade and retrograde tracking wire connection in order to choose the right technique.
- A complete calcific ring can be disrupted by lithoplasty to enable retrograde wire passage.

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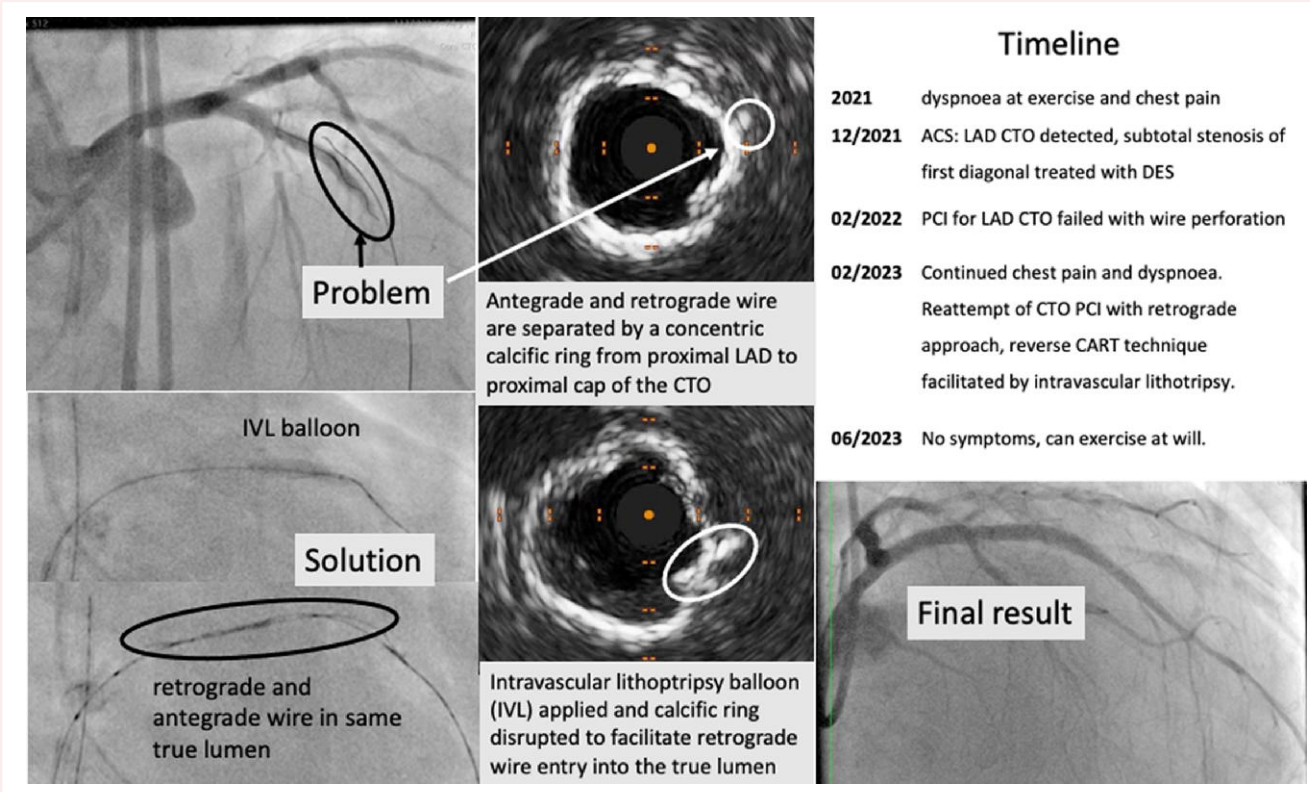
Introduction

Severe calcifications are a major obstacle in the successful opening of a chronic total coronary occlusion (CTO)[1] as highlighted by several scores for prediction of a successful procedure.[2,3,4] In the setting of the reverse controlled antegrade and retrograde tracking (CART) approach, calcifications can prevent the connection of the antegrade and retrograde wire within the occlusion, and therefore extensive subintimal passage would be needed to connect the wires outside of the calcified segment. Intravascular lithotripsy (IVL) could be a way to overcome such severe calcifications and enable the connection of antegrade and retrograde wires.

Summary figure



Abbreviations: ACS: acute coronary syndrome; CART: controlled antegrade and retrograde tracking; CTO: chronic total coronary occlusion; IVL: intravascular lithotripsy; LAD: left anterior descending coronary artery; PCI: percutaneous coronary intervention.

Case summary

A 75-year-old man presented with a proximal occlusion of the left anterior descending artery. He had a history of arterial hypertension and medically treated diabetes mellitus. He reported chest pain and dyspnoea on exercise persistent for at least 2 years prior. No clinical findings were observed on the initial physical examination. Two-vessel disease was detected on coronary angiography. The initial clinical presentation was an acute coronary syndrome which was attributed to a subtotal obstruction of the first diagonal, while the mid-left anterior descending artery (LAD) had a CTO of about 20 mm length with collaterals arising from the posterior descending artery (PDA) of the right coronary artery (RCA) (*Figure 1*). The patient underwent *ad hoc* treatment of the diagonal lesion with a drug-eluting stent (DES). An attempt to pass a wire through the LAD CTO failed at that time. The patient was discharged and readmitted to treat the LAD CTO 3 months later which failed again, with perforation by a stiff wire (Gaia 3rd, ASAHI Intecc, Japan) but without pericardial effusion.

The patient was admitted to our hospital in February 2023, 1 year after the first attempt with persistent symptoms of exercise dyspnoea. Global and regional left ventricular functions were normal as assessed by transthoracic echocardiography. With no radial access available a bifemoral approach was chosen with two 7F sheaths. An EBU 3.75F guide catheter was advanced from the right femoral artery to the left coronary artery and an AL1 7F catheter from the left to the RCA. A bilateral angiography showed the collateral supply and the length of the occlusion (*Figure 1*, Supplementary material online, *Video S1*). It appeared that there could be connecting channels, but this was due to an overlay of septal branches. The occlusion was about 20 mm long with a blunt entry. Both J-CTO score[2] and CASTLE score[4] were 3 points.

A Teleport microcatheter (Orbus-Neich, Hong Kong) was used, and first a Fielder XT (ASAHI Intecc, Japan) and then a Gaia 2nd wire (ASAHI Intecc, Japan) was introduced to penetrate the proximal cap, which failed, but finally was advanced into a septal branch. With the experience of the previous stiff wire perforation, no further escalation was done, and the retrograde approach started with a Caravel microcatheter (ASAHI Intecc, Japan) and a Suoh03 wire (ASAHI Intecc, Japan) through a septal connection from the PDA (see Supplementary material online, *Video S2*). Eventually, the Caravel was positioned close to the septal take-off. Then, a Gaia 3rd wire could be directed from the distal cap towards proximal but outside the true lumen (*Figure 2A*). An

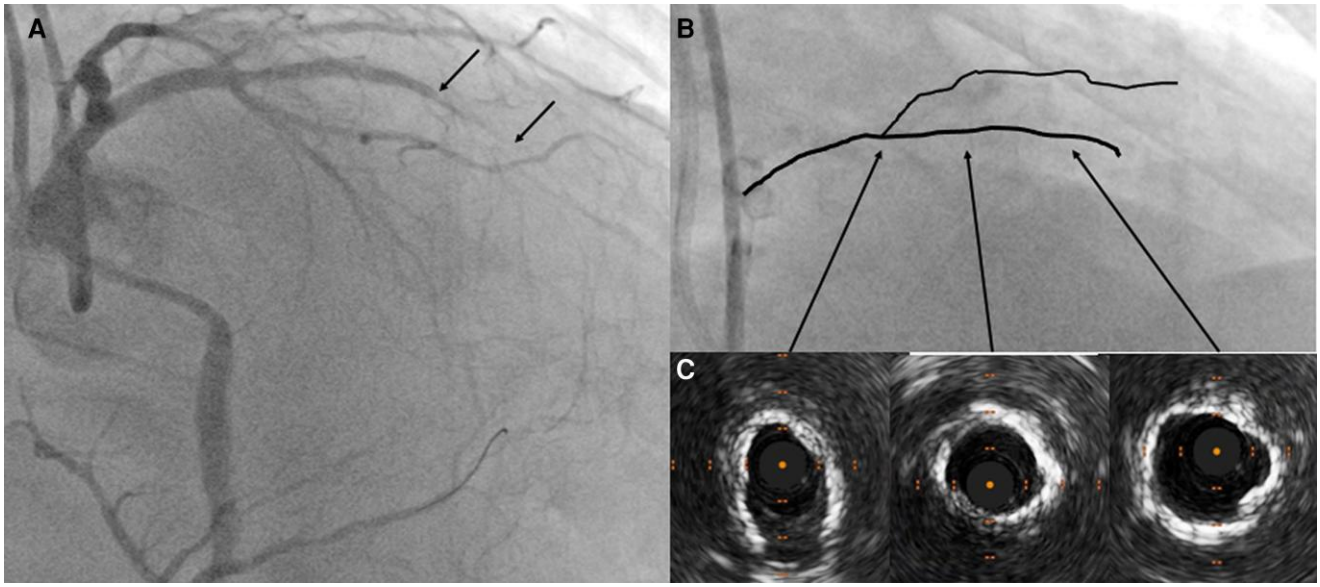


Figure 1 (*A*) Mid-left anterior descending coronary artery (LAD) occlusion between arrows. (*B*, *C*) LAD circular calcification from the bifurcation with first diagonal to the proximal cap as visualized by intravascular ultrasound.

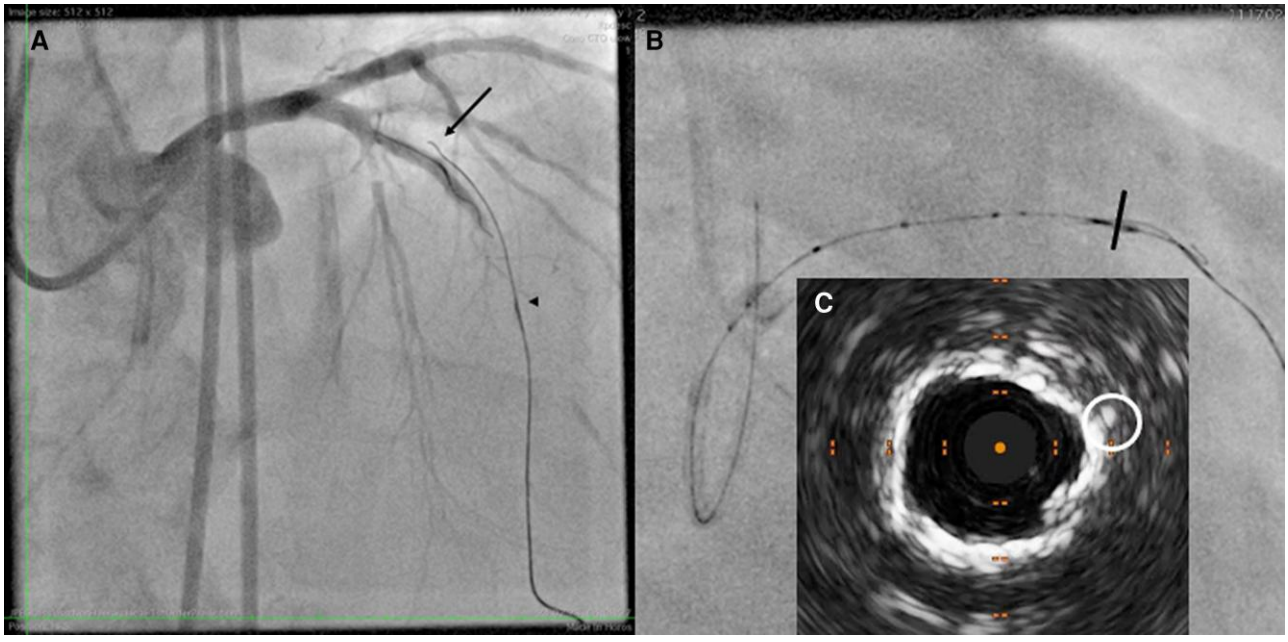


Figure 2 (*A*) Retrograde wire (arrow) through the septal pathway outside the contrast filled lumen on a Caravel microcatheter (arrowhead). (*B*, *C*) Intravascular ultrasound shows retrograde wire (circled) outside the calcified ring.

antegrade Gaia 3rd wire was advanced to achieve an overlapping position with the retrograde wire to setup the reverse CART approach but could not cross the proximal cap. The retrograde wire overlapped proximal to the proximal cap (see Supplementary material online, *Video S3*). After inflation of a 2.5 mm Ryurei balloon (Terumo, Japan) the wire could not cross, and intravascular ultrasound (IVUS) (EagleEye, Philips, the Netherlands) revealed a complete concentric calcification of the LAD before the take-off of the first diagonal branch until the proximal cap. The retrograde wire could be visualized in the space outside the calcific ring (*Figure 2B* and *C*; Supplementary material online, *Video S5*) with no gap in the calcific ring to facilitate the retrograde wire passage as visualized by IVUS (*Figure 3A–C*).

A large sized non-compliant balloon could be an option to create a disruption at high inflation pressures with some risk of extensive dissections.

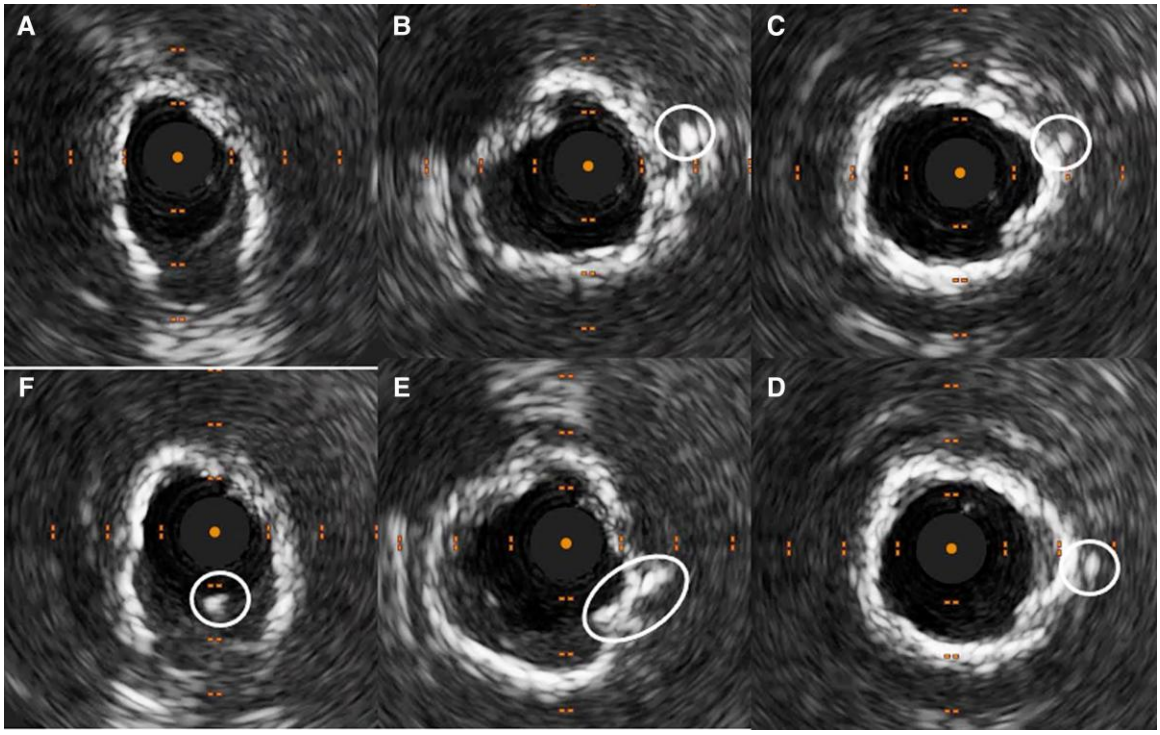


Figure 3 (*A–C*) Intravascular ultrasound cross-sections from proximal to distal with the retrograde Gaia 3rd wire (circled) outside calcified left anterior descending coronary artery throughout. (*D–F*) Identical cross-sections show after intravascular lithotripsy that the same wire in distal subintimal position (*D*) then transits through the calcium (*E*) into the proximal lumen (*F*).

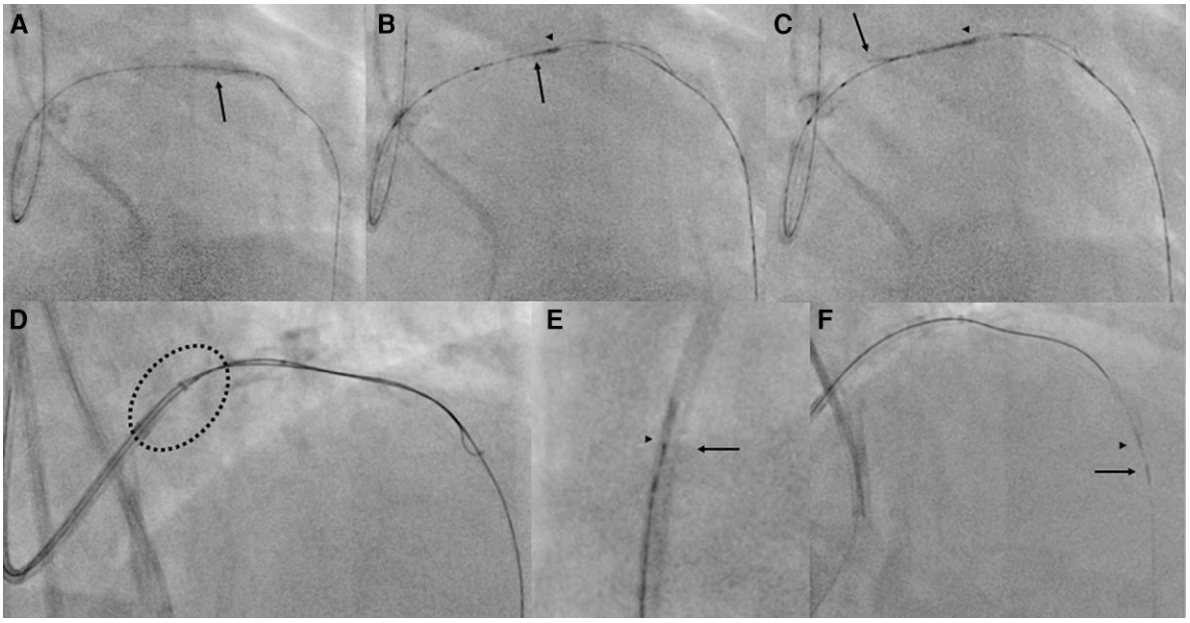


Figure 4 (*A*) The retrograde wire tip (arrow) with inflated intravascular lithotripsy balloon. *(B)* After the wire passes to the true lumen intravascular ultrasound catheter (arrowhead) is advanced for confirmation (see *Figure 3*). *(C)* The wire is then advanced proximally. *(D)* The wire enters the guide extension (circled). *(E)* Tip-in manoeuvre with the wire from retrograde (arrow) and the antegrade microcatheter (arrowhead) within the guide extension. *(F)* Antegrade microcatheter (arrowhead) advanced up to the retrograde microcatheter (arrow).

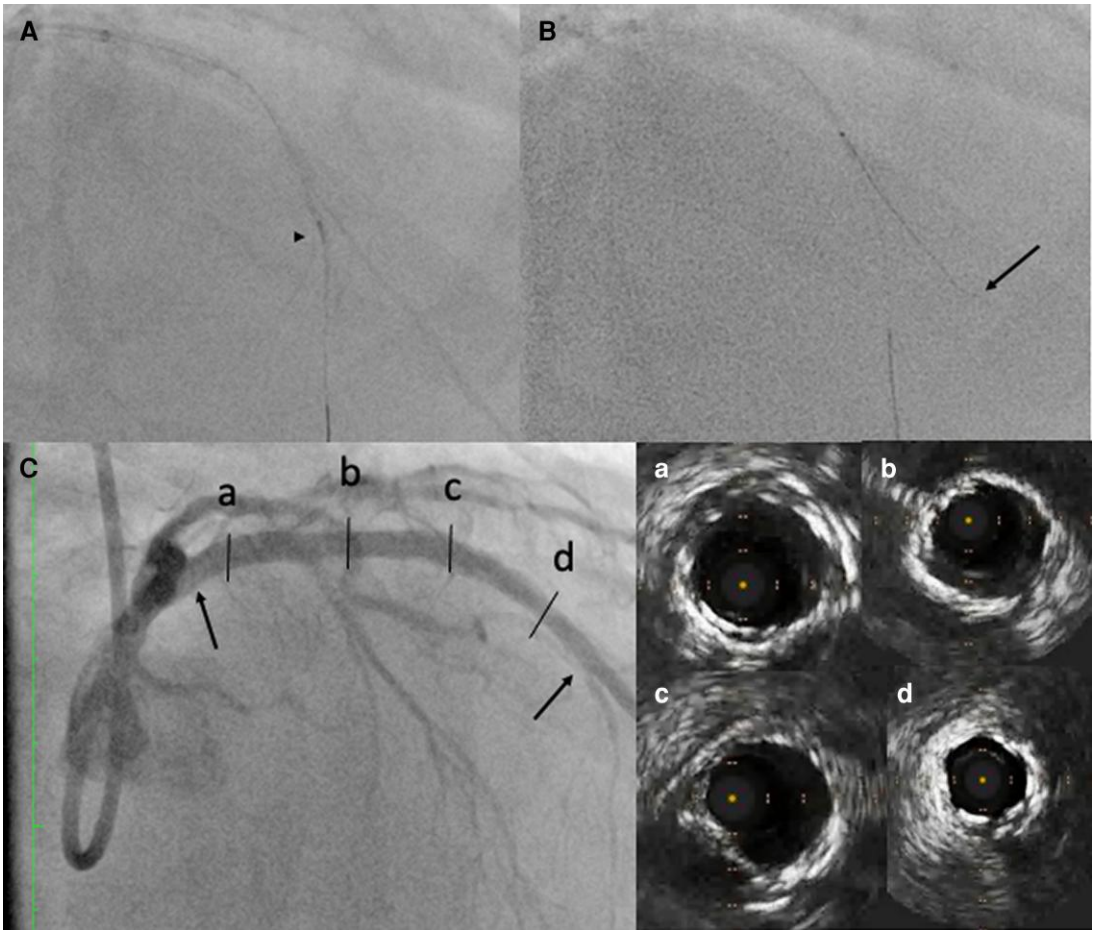


Figure 5 (*A*) A dual-lumen catheter (arrowhead) positioned at the septal take-off with contrast injection through the over-the-wire side port showing the course of the distal left anterior descending artery. (*B*) This catheter facilitates a soft wire (arrow) to enter the distal vessel through the side port. (*C*) Result after three drug-eluting stents (between arrows). The cross-sections a–d refer to the final intravascular ultrasound images shown next to it.

Therefore, we opted to test intravascular lithotripsy (IVL) (Shockwave Medical, USA) to create a controlled disruption of this calcified 'pipe'. A 3.0 × 12 mm Shockwave balloon was advanced to the tip of the retrograde wire and 80 pulses were administered at 6 atm. Then the retrograde wire was redirected towards the inflated IVL balloon and slipped inside the true lumen (*Figure 4A and B*; Supplementary material online, *Video S4*) and confirmed by IVUS (*Figure 3D–F*; Supplementary material online, *Video S5*). The retrograde wire was directed into the guide with the help of a 7F Guidezilla guide extension (Boston Scientific, USA) (*Figure 4C*). When the Caravel could not follow despite trapping of the guide wire inside the guide extension with a 2.0 balloon (*Figure 4D*), a tip-in manoeuvre was performed with the Teleport microcatheter from antegrade and advanced on the retrograde wire into the septal branch beyond the distal cap (*Figure 4E and F*; Supplementary material online, *Video S6*). The retrograde wire was removed, and a Sion wire (ASAHI Intecc, Japan) advanced from antegrade into the septal branch. After balloon inflation, a Sasuke dual-lumen catheter (ASAHI Intecc) was advanced into the septal branch to facilitate the access to the distal LAD through slowly moving it back and advancing a Sion black wire (ASAHI Intecc, Japan) through the second catheter lumen forward into the distal LAD (*Figure 5A and B*; Supplementary material online, *Video S7*). Finally, three DES [Xience 2.25 × 23 mm, Xience 3.25 × 23 mm and Xience 3.5 × 8 mm (Abbott Vascular, USA)] were implanted under IVUS guidance with adequate expansion with non-compliant balloons, 3 mm distal, 3.5 mm in the mid-LAD and 4 mm as proximal optimization at the bifurcation with the first diagonal (*Figure 5C*; Supplementary material online, *Video S8*).

Fluoroscopy time was 60.8 min, AirKerma was 753 mGy, with 168 cc contrast media used. On the following day the exercise limiting symptoms had completely disappeared and the patient was discharged after 48 h without periprocedural MI. At clinical follow-up 4 months later, the patient reported persistent freedom of angina and no exercise limitations.

Discussion

The reverse CART manoeuvre is the most frequent modality to achieve a successful recanalization when a retrograde transcollateral approach is required.[5] Aside from the difficulty to pass a collateral with a wire, the subsequent direction of a retrograde wire into the true lumen of the occluded vessel is the major challenge.[6] This is particularly difficult when the ante- or retrograde wire are not in the same space, as in our case with the retrograde wire being subintimal, and the antegrade wire in a luminal position. A complete concentric calcific ring in the occluded segment can prevent the connection of the wires. Intravascular lithoplasty can disrupt both superficial and deep calcium by acoustic energy through the balloon inflated at low pressure

and has already found increasing application during recanalization of a CTO, but in most cases, to prepare the lesion after wire passage.[7,8] The present case demonstrates the efficacy of IVL to create a disruption in the calcified continuity enabling a re-entry of a wire from subintimal to the luminal space. To our knowledge one previous case of IVL in the setting of reverse CART was reported.[9] In that case of a RCA recanalization, however, a long subintimal pathway was involved due to the application of knuckle wiring. In our case, we could avoid extensive subintimal passage outside the body of the CTO through IVL immediately at the proximal cap in a case of extended reverse CART.[10] Both cases demonstrate that severe circular calcifications can be tackled by IVL to facilitate subintimal wire passage. To perform it successfully, it is required to advance the IVL balloon to where the retrograde wire overlaps to facilitate the retrograde wire entry.

Conclusion

IVL can be a feasible option in case of extensive circumferential calcification to facilitate the wire passage from a subintimal to an intimal position in the setting of reverse CART.

Lead author biography

Professor Gerald Werner is Director of Cardiology and Intensive Care at the Klinikum Darmstadt GmbH, a teaching hospital of the University of Frankfurt, since 2005. His research interests focus on the interventional therapy of coronary artery disease, including intravascular ultrasound, chronic total occlusions and collateral physiology. He is a pioneer of coronary imaging by ultrasound since 1991, and he was among the first to describe the phenomenon of intramural coronary haematoma and subintimal vessel pathways during recanalization of a chronic coronary occlusion. He received the Franz Groedel Award of the German Cardiac Society for his work on collateral physiology in chronic total occlusions.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

Consent: The authors confirm that written consent for submission and publication of this case report including images has been obtained from the patient in line with COPE guidance.

Conflict of interest: G.S.W. reports speaker honorarium from ASAHI Intecc, Daichii-Sankyo, Orbus-Neich, Terumo, Philips-Volcano, Shockwave Medical, Siemens Healthineers.

K.Y. has no conflict to report.

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Data availability

The data underlying this article are available in the article and in its online supplementary material.

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