Case Report: Intravascular Ultrasound-Guided Wiring Re-entry for a Total Occlusion Intervention in the Right Coronary Artery

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Abstract

The recanalization of a chronic total occlusion (CTO) after failed antegrade and retrograde approaches remains challenging. Under such circumstances, intravascular ultrasound (IVUS)-guided re-entry may be useful. However, without proper landmarks IVUS-guided re-entry will still be very difficult. Herein, we present a case of CTO treated by IVUS-guided re-entry, using the 3-dimensional position of the IVUS catheter and wire as a fluoroscopy landmark.

Key words: chronic total occlusion, IVUS-guided wiring re-entry technique, percutaneous coronary intervention

Introduction

With technological advances and the development of hybrid techniques for the crossing of chronic total occlusions (CTO), the success rate of CTO recanalization has greatly increased over the past decade, reaching up to 93.8% for high-volume CTO operators.[1] Intravascular ultrasound (IVUS)-guided wiring is considered the first choice to identify the occlusion point and may facilitate the passage of guidewires (GW) in stumpless CTO with a side branch arising from the occlusion. By contrast, IVUS-guided wiring has only been seen as a bail-out strategy for the repeated antegrade approach in several algorithms if both the antegrade and retrograde approaches have failed.[2] IVUS can provide cross-sectional images of the coronary vessels, which are useful to identify the exact location of the guidewires within a coronary artery, to discriminate a false lumen from the true lumen and to reveal the transition point from true to false lumen before GW crossing. However, several limitations of real-time IVUS-based wiring techniques remain problematic. First, IVUS insertion always requires expansion of the subintimal space by small balloon dilatation which may increase the risk of perforation. Second, the presence of an IVUS catheter in a vessel usually restricts the manipulation of the second guidewire. Third, the direction and the relative position between the wire and the true lumen in the cross-sectional

Received: May 20, 2023; Accepted: Jul. 1, 2023
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view afforded by IVUS are difficult to correlate with the 2-dimensional (2D) angiographic findings. Given the situation of lacking the help of real-time IVUS, we report a novel application of general IVUS for a right coronary artery (RCA) CTO without a proper landmark, whereby a 3D fluoroscopic landmark was created in the 2D angiogram.

Case Report

A 65-year-old man with hypertension presented to our outpatient clinic complaining of chest pain which had occurred about one week prior. Computed tomography angiography (CTA) was performed and revealed a 95% stenosis in the middle segment of the RCA. Due to the symptoms and positive findings on the CTA, he was admitted for coronary angiography which revealed double vessel disease with CTO at the RCA-middle segment (Figure 1A) and a 70% stenosis over the proximal to middle part of the left anterior descending (LAD) artery (Figure 1B). There were collaterals from the septal branch of the LAD and the anterior marginal branch of the left circumflex (LCX) artery to the RCA distal bifurcation. The J-CTO score was 3 points, including blunt entry, scattered calcification and long lesion > 20 mm. PCI was indicated and conducted with simultaneous access obtained through the right femoral artery and right radial artery in preparation for dual angiography.

A 7 Fr SAL 1.0 (Medtronic, MN, USA) was selected for RCA engagement to enhance strong backup support. A 7 Fr XB 4.0 (Cordis, FL, USA) was selected for left main coronary artery engagement. The initial antegrade wiring strategy with escalated GWs failed even using a Conquest pro12 GW (Asahi Intecc, Aichi, Japan) under the support of an APT 2.6 Fr 130cm microcatheter (MC) (APT Medical Inc., Hunan, China). A secondary retrograde approach with a surfing technique was adopted but also failed due to the tortuous and fragile collaterals even using the SUOH 03 GW (Asahi Intecc, Aichi, Japan). The retrograde approach ended with mild extravasation of the septal branches.

In this situation, we tried the antegrade

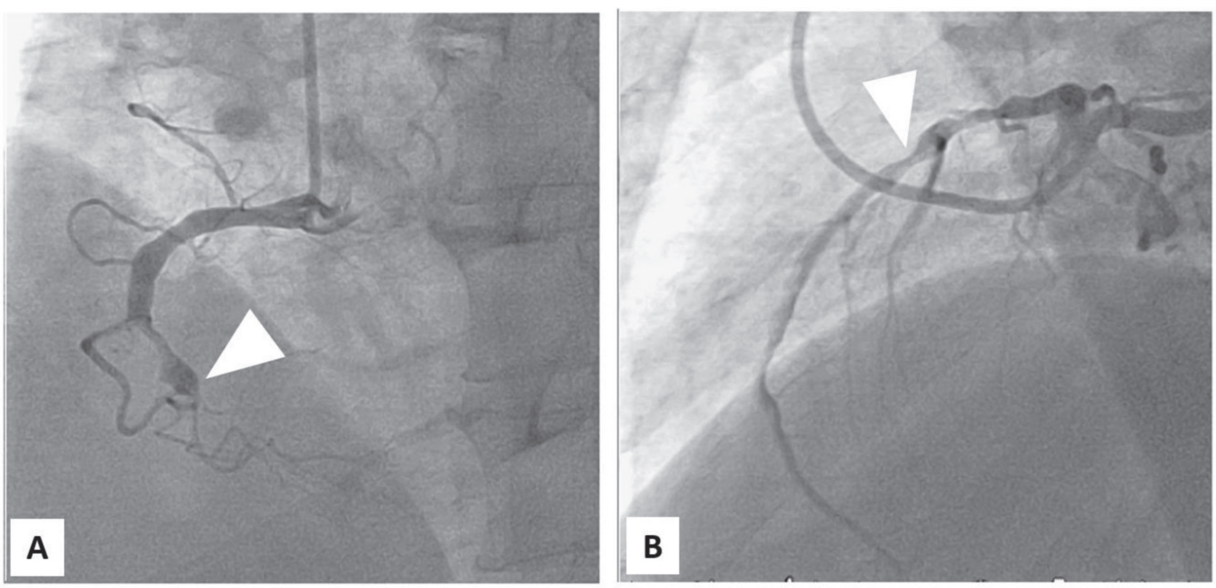

Figure 1. Diagnostic coronary angiography.
A. A chronic total occlusion without proper landmark at the right coronary artery-middle segment. B. A 70% stenosis over the proximal to the middle part of the left anterior descending artery.

approach again by escalating the GW to Hornet 14 (Boston Scientific, Heredia, COSTA RICA) and we successfully advanced it into the 2nd posterior descending artery (PDA) branch of the RCA. Injecting contrast through the antegrade MC we were able to confirm that the distal GW had entered into the true lumen (Figure 2). IVUS (OPTICROSS HD, 60MHz, Boston Scientific, Alajuela, COSTA RICA) was pulled back from the 2nd PDA branch to the RCA distal segment. Although the wire was within the true lumen of the PDA branch (Figure 3A), the posterolateral (PL) branch did not enter the route where the IVUS was. Instead, the IVUS remained in the subintimal space of the totally occluded segment until it touched and went through the calcification beneath the true lumen (Figure 3D).

We decided to perform IVUS-guided parallel wiring as a bail-out strategy in this dilemma. The 1st wire in the subintimal space served as a fluoroscopic landmark for wiring the 2nd wire. To make the 2D fluoroscopic landmark provide more spatial information to guide the 2nd wire re-entry, we used IVUS to study the relative position between the IVUS transducer, the 1st wire and the location of the true lumen in the cross-sectional images of the re-entry point. Figure 4 illustrates the cross-sectional image at this indicated level and its corresponding 2D angiogram projected on the green plane perpendicular to the x-ray tube and image intensifier. By adjusting the angle to the right anterior oblique (RAO) to 44° and caudal 24°, the image intensifier, the 1st guidewire, the IVUS transducer and the x-ray tube were arranged along the green dashed line. In this specific RAO view, the 1st guidewire and the IVUS transducer were intentionally overlapping in the 2D angiogram. With the spatial information the IVUS provided, we knew that the true lumen was located at either the left or right side of the 1st wire and perpendicular to the 1st wire on the fluoroscopy (the green dashed line, Figure 5). This information allowed us to puncture the 2nd Progress 200 T wire into the true lumen upon only the second attempt (Figure 6). IVUS-guided wiring re-entry was performed successfully without real-time IVUS guidance after rechecking the IVUS images (Figure 7).

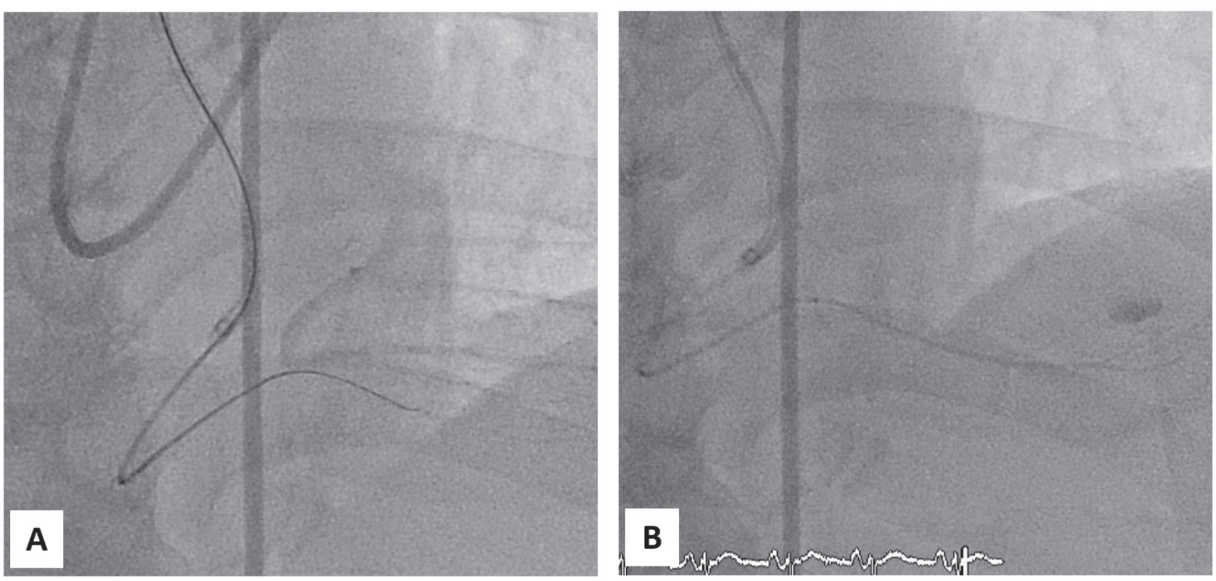

Figure 2. 2nd antegrade approach.
A. A Hornet 14 guidewire successfully entered into the 2nd posterior descending artery branch. B. Distal true lumen confirmation by microcatheter contrast injection.

After successful IVUS-guided wiring re-entry, we tracked the PL branch and the 1st PDA branch with the Gaia Second GW. The post-dilatation angiogram showed no side branch had been lost, at the expense of a severe vessel dissection with a long false lumen caused by the first pre-dilatation after repeated antegrade wire manipulation (Figure 8A). A Resolute Onyx drug-eluting stent, 3.0 x 38 mm (Medtronic, Galway, Ireland), and another Resolute Onyx, 4.0 x 34 mm were placed contiguously from the PL branch to the RCA-middle segment with 16 atm. The final angiogram showed no residual stenosis with TIMI-3 antegrade blood flow and all side-branches preserved (Figure 8B).

Discussion

A prompt change of strategy increases the chances of success of CTO recanalization.[3] In this case, even for experienced operators, the recanalization of a CTO after failed antegrade and retrograde approaches was challenging. Various IVUS-guided wiring re-entry techniques including side branch marker technique, wire navigation technique and IVUS-guided parallel wire technique have previously been reported in several algorithms but have their limitations. Sometimes there was no suitable side branch or pericardium beneath the entry point for the IVUS to guide the wire re-entry. Recently, the development of

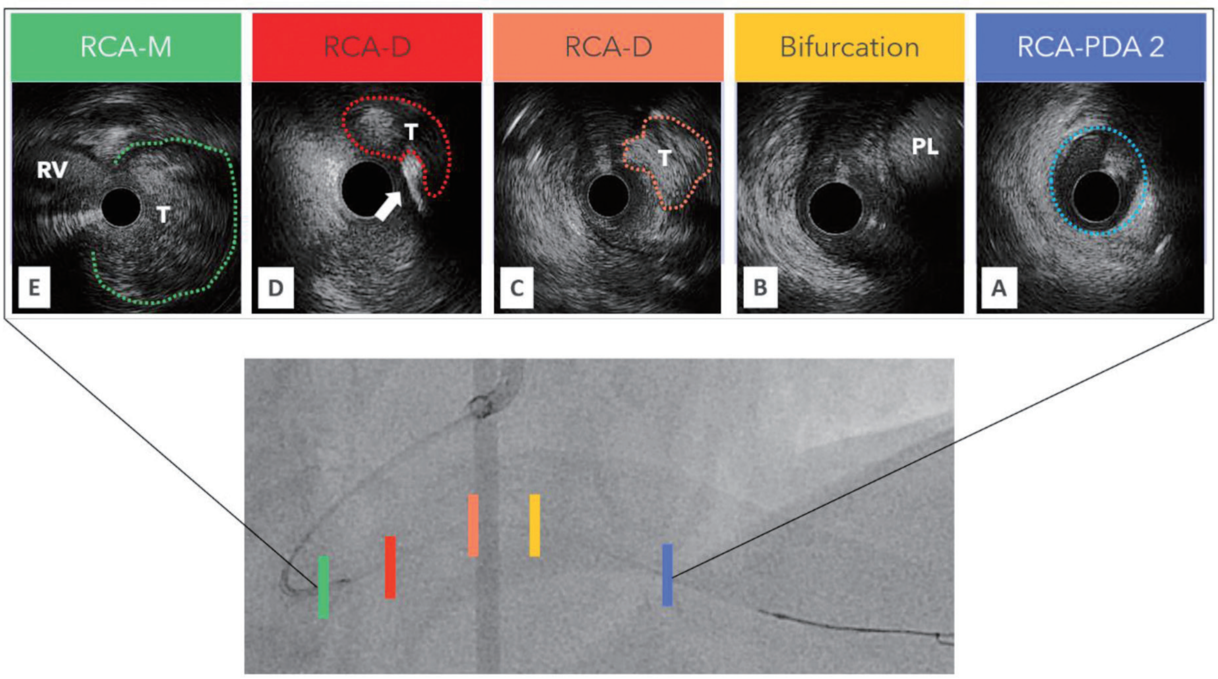

Figure 3. Intravascular ultrasound (IVUS) imaging following the dilatation with a Ryurei 2.0 mm balloon catheter.
The IVUS was pulled back from the 2nd posterior descending artery (PDA) branch to the middle segment (The order of the image is from A to E). A. The image represents the cross-section at the blue line in the lower figure. The IVUS was within the true lumen (T) of the 2nd PDA branch (blue circle). B. The PL branch is going to converge at the location where the yellow line is marked in the lower Figure. C. The route of the IVUS did not enter the posterolateral (PL) branch (orange circle). D. the IVUS remained in the false lumen and was separated from the true lumen (red circle) by the calcification (white arrow). E. The IVUS went through the calcification beneath the true lumen and returned to the true lumen (green circle).

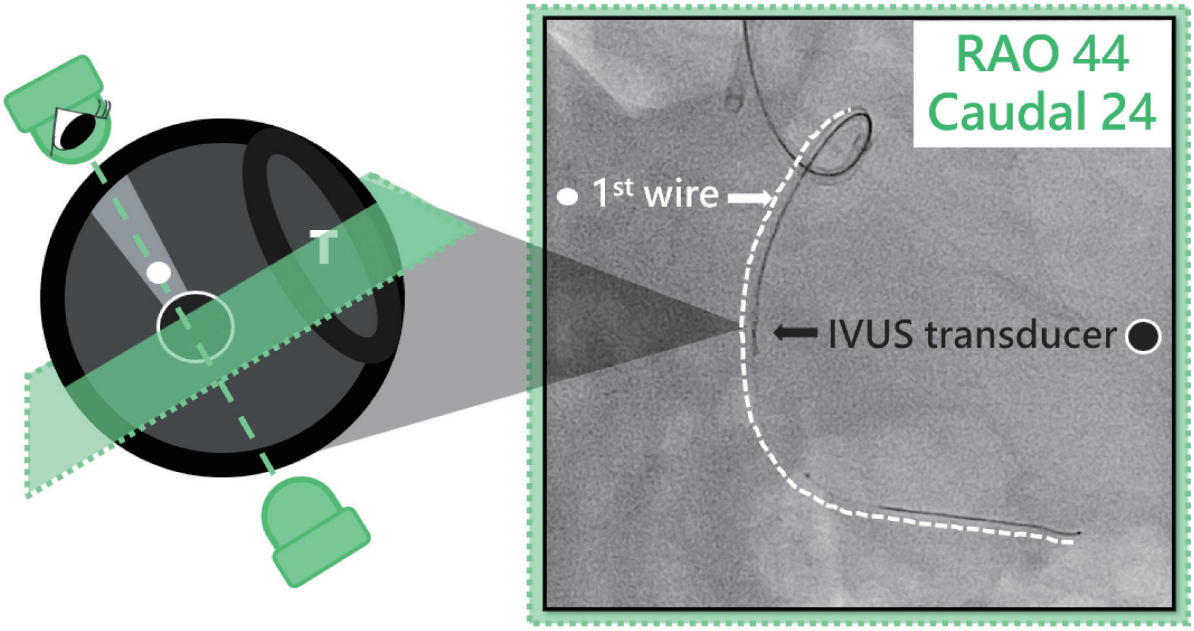

Figure 4. Illustration of relative position between wire, IVUS, x-ray plane and true lumen in cross-sectional IVUS image and its corresponding 2D angiogram at the entry point.

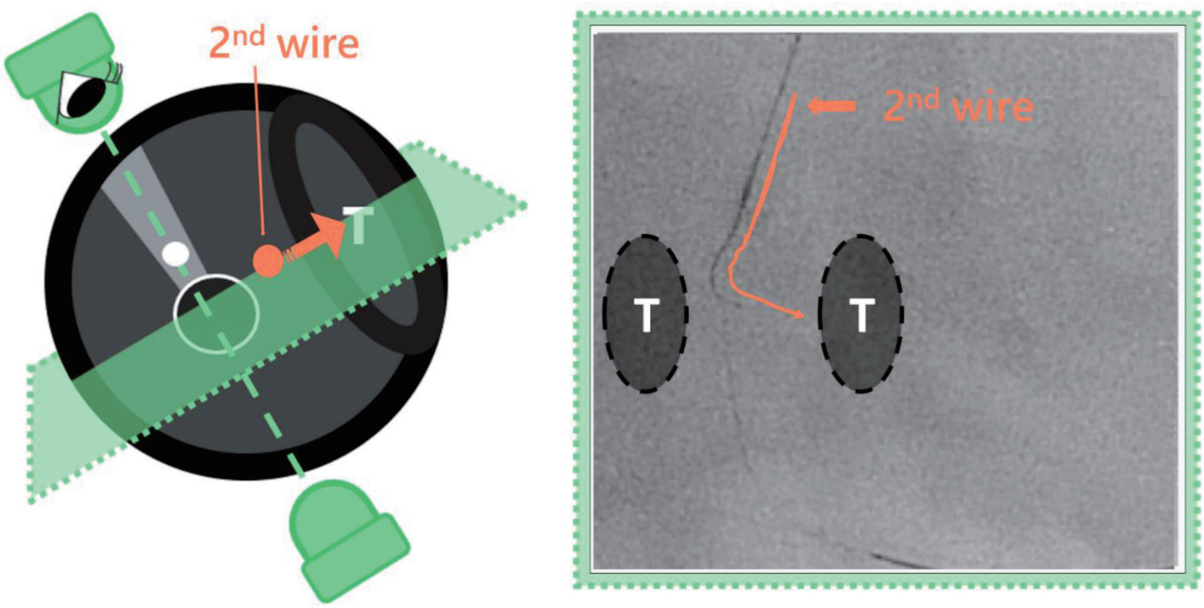

Figure 5. Illustration of how to use a fluoroscopic landmark to guide 2nd wire re-entry into the true lumen.

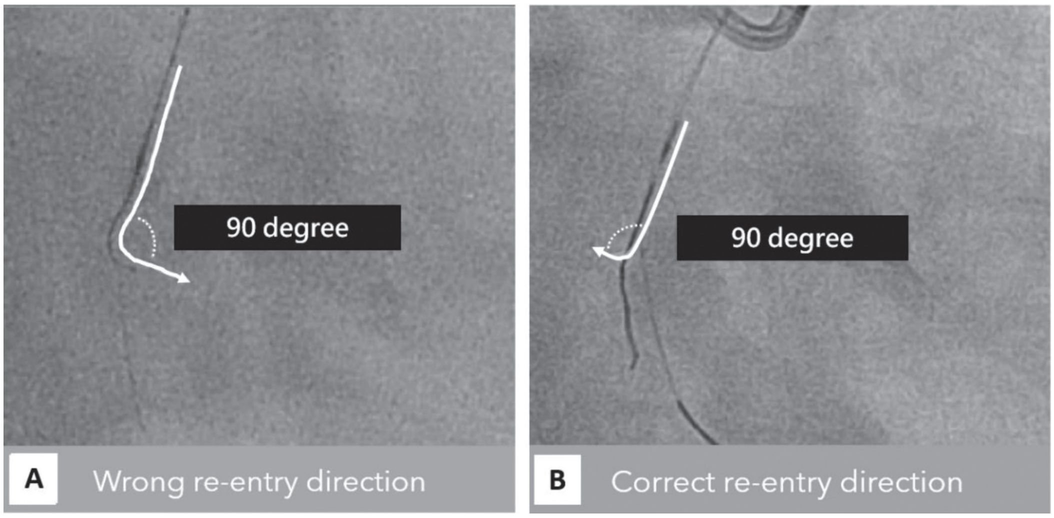

Figure 6. Successful IVUS-guided wiring re-entry without real-time IVUS observation.

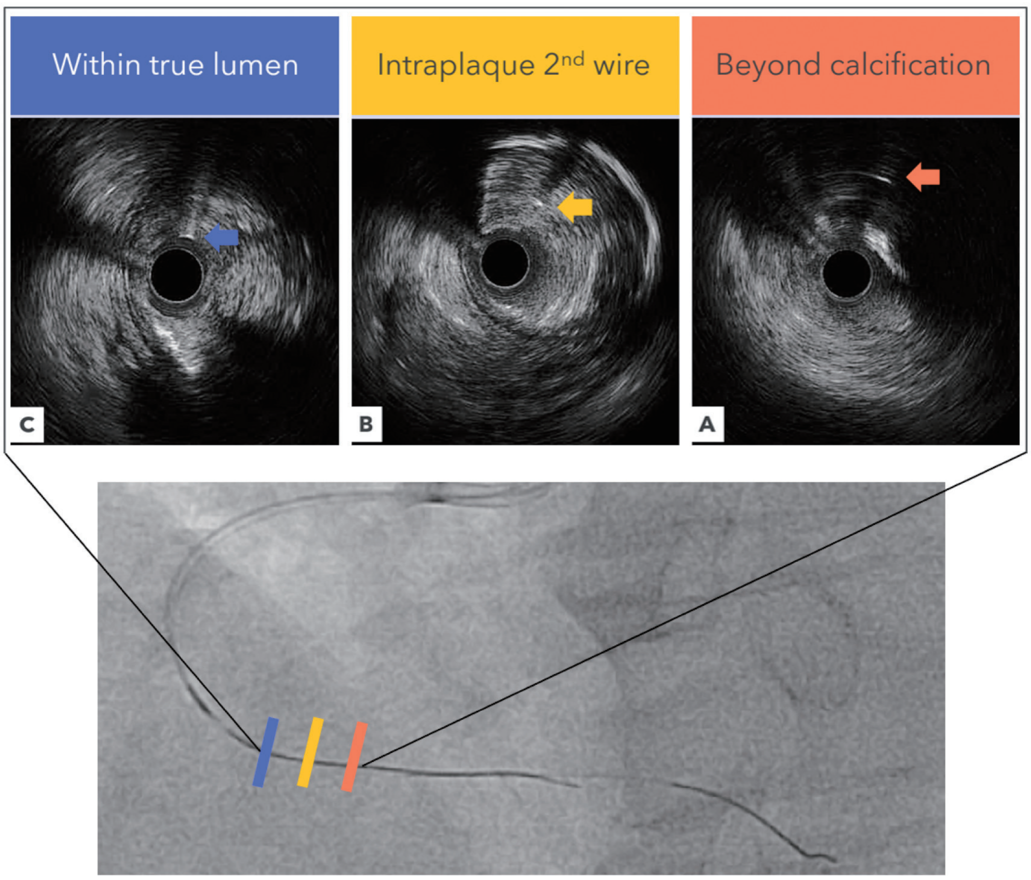

Figure 7. Rechecking IVUS images after 2nd wire re-entry.
As confirmed by the IVUS, the 2nd wire, indicated by the arrows in Figures A to C, was within the true lumen and on top of the calcification in Figure A. Meanwhile, the IVUS was within the false lumen below the calcification. Then the 2nd wire went through the plaque in Figure B and finally arrived in the true lumen of the RCA-M in Figure C.

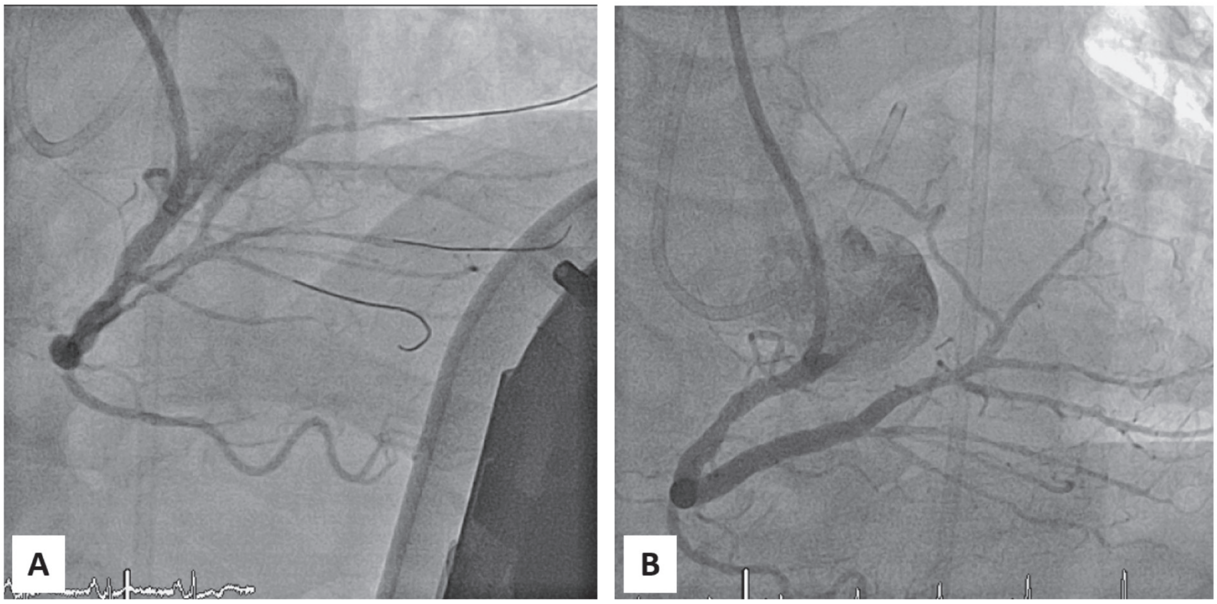

Figure 8. Final angiogram before and after stent deployment.
A. Angiogram after post-dilatation showed a severe vessel dissection with a long false lumen from the RCA-distal segment to bifurcation. B. The final angiogram showed TIMI-3 flow without branch loss.

the new CTO IVUS system plus the tip detection method has enabled real-time IVUS-based 3D wiring, significantly reducing crossing time and the number of punctures, but the new device is not accessible in most facilities.[4,5] Even where an advanced device has been available, several cases have been reported with placement of IVUS in the subintimal space, which may interfere with the manipulation of the second stiff guidewire.[3,6] Therefore, we always pull back the IVUS catheter during the second guidewire manipulation. With the spatial information provided by IVUS, intentionally taking advantage of the plane of the IVUS transducer/guide wire, we can visualize the position of the true lumen, even without other landmarks such as side branches or pericardium, and without real-time IVUS observation.

Proper revascularization by optimizing true lumen tracking can minimize side branch losses, decrease target lesion failure rate, preserve vasomotor function and yield a better clinical outcome. A meta-analysis including 12 cohort studies compared the long-term outcomes between dissection and reentry (DR) techniques and conventional wire escalation technique and revealed that the extensive DR techniques were associated with increased risk of long-term negative clinical events, including a higher incidence of target vessel revascularization (TVR), in-stent restenosis, in-stent re-occlusion and the composite outcome of death/myocardial infarction/TVR.[7] Therefore, the IVUS-guided wiring re-entry technique might be an ideal option to optimize whole true lumen tracking and achieve a favorable long-term clinical outcome.[8] However, this IVUS-guided wiring re-entry technique should be performed with caution because displacement of the landmark after withdrawing the IVUS catheter is possible. The decision to adopt the IVUS-guided wiring re-entry technique should be assessed carefully due to the potential risks of false lumen or intramural hematoma expansion and coronary perforation. Alternative bail-out strategies, including real-time IVUS-guided re-entry by ping-pong guiding catheters or staged PCI, should also be considered.

IVUS is a powerful tool and is always reserved as a bail-out strategy for complex CTO PCI, but requires comprehensive IVUS knowledge as well as sophisticated technical skills for its safety and effectiveness. Making good use of IVUS may produce valuable information to overcome difficulties during CTO recanalization.

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