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Intravascular ultrasound-guided "extended" reverse controlled antegrade and retrograde subintimal tracking technique using a cutting balloon for recanalizing chronic coronary total occlusion with a side branch

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Percutaneous coronary intervention (PCI) of chronic total occlusion (CTO) represents the most technically challenging procedure in contemporary interventional cardiology.[1] Blunt lesions and presence of proximal side branch are considered to be strong predictors of reduced technical success.[2,3] For such lesions, the antegrade approach may not be feasible or desirable, and the retrograde approach can be used as the initial crossing strategy. However, when treating the blunt CTO with a large side branch proximal to the occlusion, the side branch might be occluded after stent implantation if the retrograde guidewire passed the occluded segment through the subintimal space and re-entered into the true lumen at the opposite side of the side branch.[4] We reported a useful method to solve the above issue which utilizes intravascular ultrasound (IVUS) to guide "extended" reverse controlled antegrade and retrograde subintimal tracking (CART) technique with a cutting balloon.

A 44-year-old man with diabetes and hypertension was admitted due to class II angina. Coronary angiography demonstrated a CTO with a blunt end at the proximal segment of the left anterior descending artery (LAD). There are a large diagonal artery with a significant stenosis and a septal branch at the occlusion site (Figures 1A & 1B). Good epicardial collaterals from the left circumflex (LCX) to the distal LAD were observed (Figure 1C). There was a significant stenosis at the mid portion of right coronary artery (RCA), and epicardial collaterals from RCA to LAD (Figure 1D) were seen as well. We decided to perform PCI for the CTO lesion. We used a 7 Fr BL3.5 guiding catheter (Terumo, Japan) to engage the left main via the femoral approach. We tried antegrade wiring with Miracle 3 (Asahi, Japan), Miracle 12 (Asahi, Japan) and Pilot 150 guidewire (Abbott, USA) with the support of 150 cm Finecross microcatheter (Terumo, Japan). However, all the guidewires failed to cross the lesion since they always slipped into the proximal side branches. Then, we changed to the retrograde approach. A Sion guidewire (Asahi, Japan) was advanced into the LCX and passed through one of the epicardial collaterals and the Finecross microcatheter was successfully advanced into the distal true lumen of LAD. Dual injection with guiding catheter and retrograde microcatheter showed the lesion length < 20 mm (Figure 2A). The Sion guidewire was changed to a Pilot 150 guidewire, but the guidewire moved back and forth aggressively due to myocardial contraction and could not enter the distal cap. Then the retrograde guidewire was exchanged to a Progress 200T guidewire (Abbott, USA) and the guidewire crossed the CTO segment but could not enter the proximal true lumen (Figure 2B). Subsequently, a Runthrough NS guidewire (Terumo, Japan) was antegradely placed in the first diagonal (D1) branch, and IVUS (40 MHz Opticross, Boston Scientific, USA) probe was pulled back from the D1 to evaluate if the direction of the retrograde guidewire was correct and to identify the proper penetration point of the proximal cap (Figure 2C). IVUS showed that the retrograde guidewire crossed the bifurcation at the site very close to the carina, which was considered favorable to keep D1 open after stenting. However, the guidewire was located in the superficial intimal layer of the proximal portion of LAD (Figures 2D & 2E & 2F & 2G & 2H). Therefore, we decided to use a cutting balloon to release the guidewire from the intimal layer. A 2.75 mm × 10 mm cutting balloon (Boston Scientific, USA) was delivered over the antegrade guidewire in the D1 to the bifurcation site and inflated at 6 atm (Figure 3A). IVUS demonstrated that the retrograde guidewire was released from the intimal layer and entered

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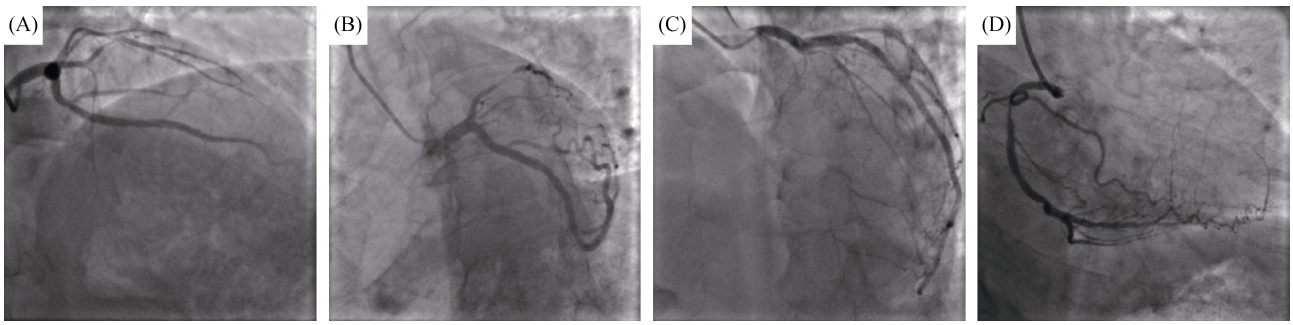

Figure 1. Coronary angiography results. (A): Coronary angiography showed a blunt CTO at proximal LAD; (B): there were a large diagonal artery with significant stenosis and a septal branch at the occlusion site; (C): the good epicardial collaterals from the LCX to the distal LAD were observed; and (D): there was significant stenosis of the mid portion of RCA and RCA also provided septal and epicardial collaterals to the LAD. CTO: chronic total occlusion; LAD: left anterior descending; LCX: left circumflex; RCA: right coronary artery.

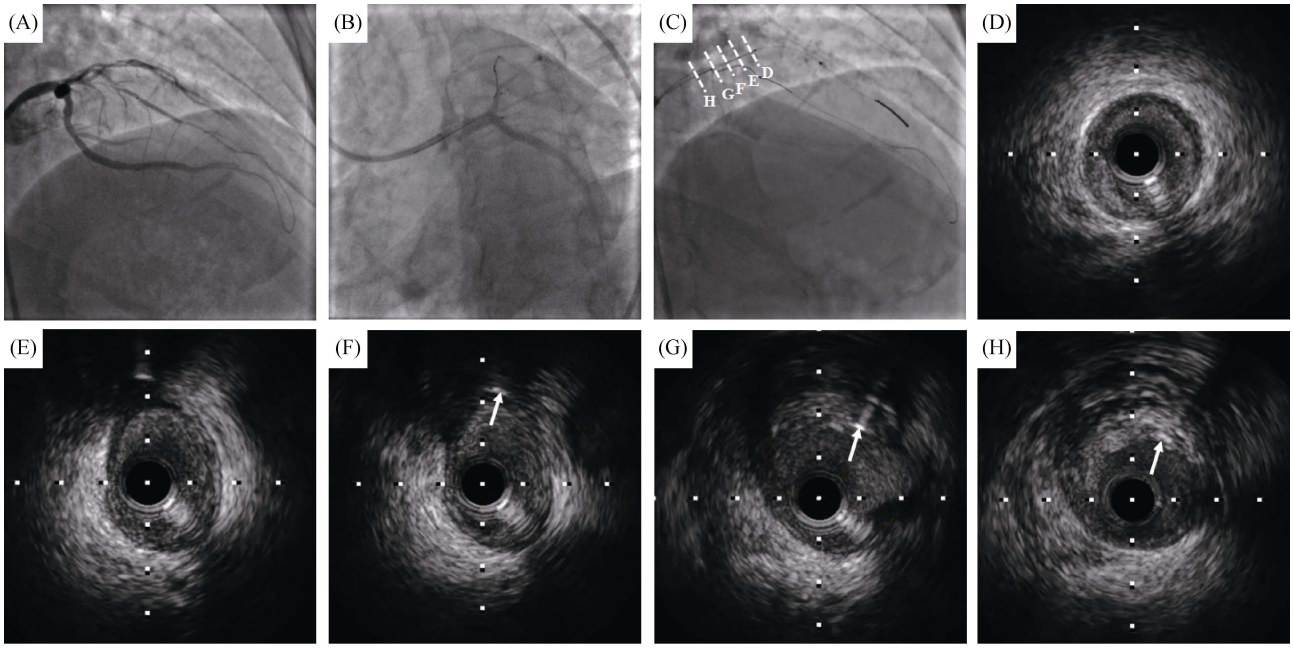

Figure 2. Retrograde guidewire position as assessed by IVUS. (A): Dual injection with guiding catheter and retrograde microcatheter; (B): retrograde Progress 200T guidewire crossed the CTO segment but could not enter the proximal true lumen; (C): IVUS probe was pull-backed from the first diagonal branch; and (D & E & F & G & H): IVUS showed the retrograde guidewire crossed the bifurcation at the site very close to the carina, but in the proximal portion of LAD, the guidewire located in the superficial intimal layer. Arrow indicated the retrograde guidewire. CTO: chronic total occlusion; IVUS: intravascular ultrasound; LAD: left anterior descending.

into the proximal true lumen (Figures 3B & 3C & 3D & 3E & 3F). Then, we used the "ping-pong" guide catheter technique, and another 7 Fr BL3.0 guiding catheter (Terumo, Japan) was engaged to the left main via the radial approach. After the retrograde guidewire and microcatheter entered the second guiding catheter (Figure 4A), the retrograde guidewire was exchanged to a RG3 guidewire to complete externalization. Subsequently, the occluded LAD was successfully predilated and two Promus Element drug-eluting stents (Boston Scientific, USA) (2.5 mm × 24 mm, 2.75 mm × 32 mm) were deployed in the D1 and LAD with the DK-Crush technique, and the final kissing-balloon inflation and proximal optimization technique were performed. The final angiographic result was excellent (Figures 4B & 4C).

CTO-PCI is one of the most challenging procedures in the field of interventional cardiology.[1] Over the past two decades, important development in devices and techniques has significantly increased the success rate of CTO-PCI.[5] One of the most important advances is the introduction and subsequent evolution of retrograde techniques. In the treatment of blunt CTO, especially with the presence of a side branch at the blunt occlusion, puncture of the proximal cap is very difficult, and the retrograde techniques will be of use.[6] Currently, the reverse CART is the most commonly

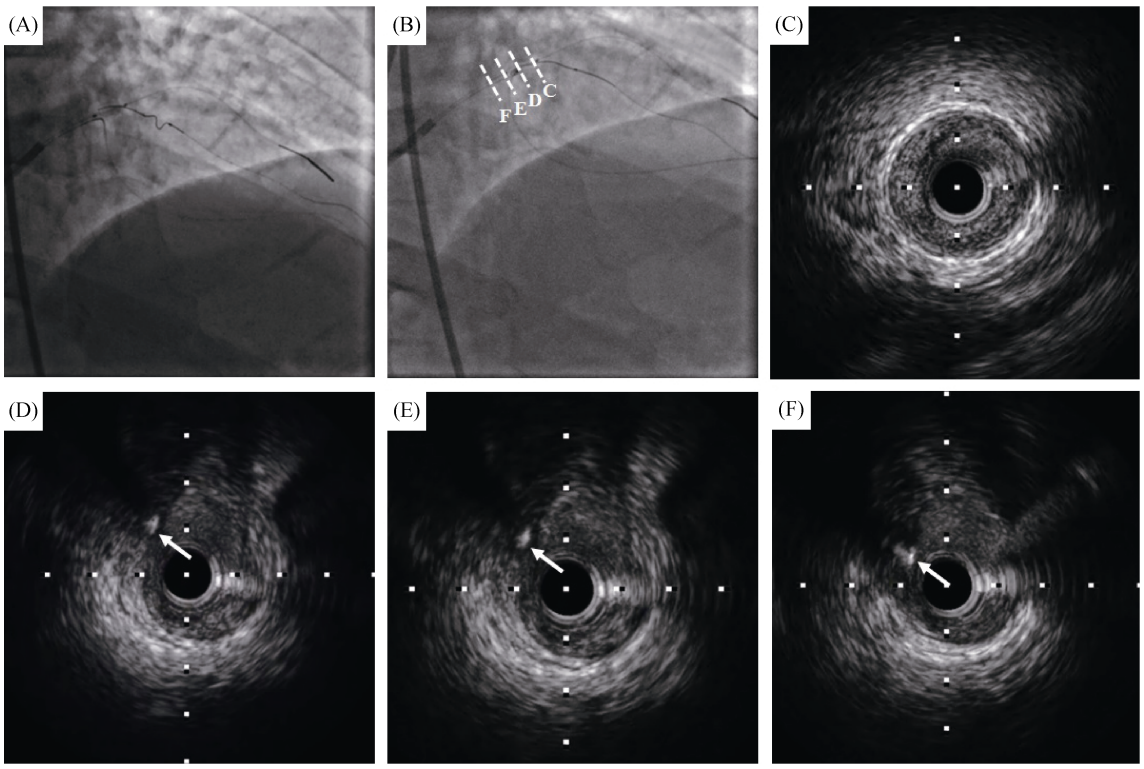

Figure 3. Cutting balloon inflation released the guidewire from the intimal layer. (A): 2.75 mm × 10 mm cutting balloon was inflated at the bifurcation site; (B): IVUS probe was pullbacked from the first diagonal branch; and (C & D & E & F): IVUS imaging demonstrated that the retrograde guidewire was released from the intimal layer and entered into the proximal true lumen. Arrow indicated the retrograde guidewire. IVUS: intravascular ultrasound.

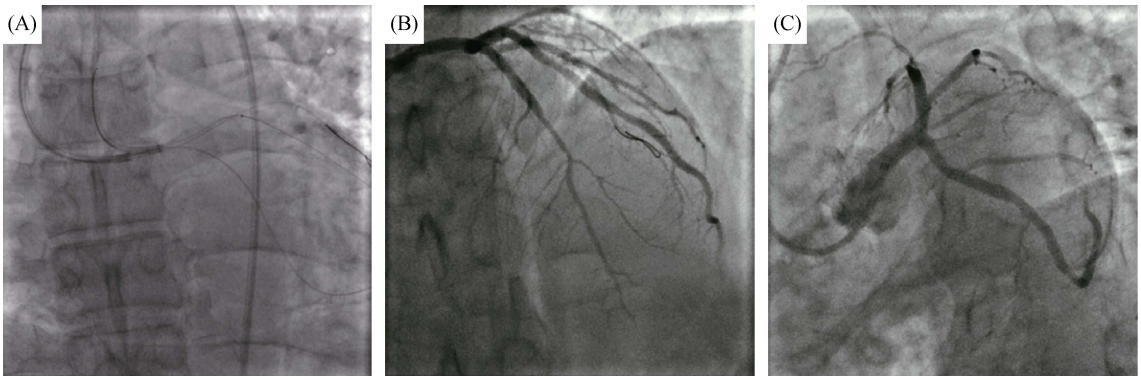

Figure 4. The final angiographic result. (A): The "ping-pong" guide catheter technique was used and the retrograde guidewire entered the second guiding catheter; and (B & C): the final angiographic result was excellent after deployment of two drug-eluting stents.

used technique to cross the lesion once the collateral branch has been successfully wired and the retrograde microcatheter has been advanced to the distal cap. In the reverse CART technique, a balloon is advanced into the CTO segment over the antegrade guidewire and inflated to create a space, the retrograde guidewire is then advanced from the distal true lumen into the proximal true lumen through this subintimal space. In the conventional reverse CART technique, the intimal/subintimal space is created within the CTO segment. However, the antegrade balloon is inflated proximal to the CTO segment in this case, and the intimal dissection is extended beyond the CTO segment. Thereafter, the retrograde guidewire is advanced through the connection created between the proximal true lumen and the retrograde intimal/subintimal space beyond the CTO segment, which is called the "extended" reverse CART as proposed by Matsuno, *et al*.[7] However, if there is a side branch at the point of the proximal cap, the branch may be occluded after the retrograde guidewire re-enters into the proximal true lumen.[7] To keep the side branch open after stent implantation,

the optimal re-entry point of the proximal cap with the retrograde guidewire should be close to the bifurcation carina.[4] In this setting, IVUS is vital to identify the optimal re-entry of the proximal cap with the retrograde guidewire and to evaluate if the direction of the retrograde guidewire is correct.

Previous reports have demonstrated the feasibility and efficiency of the cutting balloon in the reverse CART technique.[8,9] Compared with a semicompliant or non-compliant balloon, the cutting balloon could create a limited subintimal dissection via its hard blades and improve the fenestration force of the retrograde guidewire.[8,9] In the present case, IVUS showed that the retrograde guidewire was located in the superficial intimal layer in the proximal portion of LAD. Thus, we decided to use the cutting balloon to create tiny incisions and release the guidewire from the intimal layer. As the antegrade guidewire is in the true lumen, we used a cutting balloon with the size equal to the reference diameter without risking vessel rupture or large dissection.

In conclusion, we first described the IVUS guided "extended" reverse CART technique using a cutting balloon, which facilitates the entry of retrograde guidewire into the proximal true lumen at the optimal re-entry point during PCI for blunt CTO with a side branch.

Acknowledgments

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