The success rate of a chronic total occlusion (CTO) procedure depends on the morphologic features of the lesion. The abrupt type of CTO, which has a blunt stump with a side branch at the site of occlusion, is suggested to be a predictor of procedure failure. We report a successful recanalization of the abrupt type of CTO by using real-time intravascular ultrasound (IVUS)-guided wiring technique in a 51-year-old gentleman. By IVUS imaging, the stiff guide wire was guided to penetrate a presumed proper site of the proximal cap, in this case the central calcified part, instead of the more marginal non-calcified portion of the proximal cap. IVUS is useful not only to look for the proper entrance of the proximal cap of CTO from a sideways view, but also to decide the stent size and distal landing zone after recanalization of CTO.

**Key Words:** Chronic total occlusion • Coronary intervention • Intravascular ultrasound

**INTRODUCTION**

Chronic total coronary occlusion (CTO) is defined as an obstruction of a native coronary artery without luminal continuity and with Thrombus In Myocardial Infarction (TIMI) flow grade of 0 or 1 of > 4 weeks’ duration.1 Olivari et al. have reported that patients with successful percutaneous coronary intervention (PCI) of CTO had a lower incidence of death or MI (1.05% vs. 7.23%) at 12 months.2 However, the success rate of a CTO procedure depends on the morphologic features of the lesion. The abrupt type of CTO (as opposed to the tapered type), which has a blunt stump with a side branch at the site of occlusion is suggested to be a predictor of procedure failure.

We report a successful recanalization of the abrupt type of CTO by using real-time intravascular ultrasound (IVUS)-guided wiring technique. IVUS is useful not only to find the entry point of the proximal cap of CTO, but also to evaluate the remodeling of the chronic occlusive coronary vessel after successful recanalization of the CTO.

**CASE REPORT**

A 51-year-old man with a risk factor for hypertension visited our clinic for work-up of atypical chest pain. He had been suffering from compressive chest discomfort during emotional stress on occasion for half a year. The biochemistry study showed no hyperglycemia or hyperlipidemia, and treadmill exercise test showed borderline result. Computed tomography coronary angiography (CTCA) was then arranged after discussion with the patient. CTCA revealed total occlusion of the middle portion of the left anterior descending artery (LAD), obstructive plaque at distal right coronary artery (RCA) and possibly obstructive plaque at left circumflex artery (LCX),
A heavy calcified plaque, measured as 1206 HU, was noted at the proximal cap of the lesion of LAD CTO. One large diagonal branch was present at the site of occlusion.

The patient underwent coronary angiography from the right femoral approach under the impression of CTO of LAD. Coronary angiography showed the abrupt type of CTO in the middle portion of the LAD with the presence of a large second diagonal branch (D2) at the site of occlusion. From angiography, the estimated total occlusive length was 6 mm. There were collaterals from the RCA, diagonal branch and LCX to the LAD artery with Rentrop grade 2 flow. Obstructive plaque at distal RCA and LCX were also noted. An attempt to reopen the CTO of LAD was decided upon, and if this proved unsuccessful, the patient would be referred for coronary artery bypass graft surgery (CABG).

We changed the femoral sheath to an 8F Terumo sheath and engaged an 8F VL 3.5 guiding catheter in the left main coronary artery because we needed strong backup force and large inner lumen for possible IVUS-guided wiring technique. After a dose of 7500 IU of unfractionated heparin was given, we kept the activated clotting time (ACT) between 300 and 350 seconds during the whole procedures. Simultaneous bilateral coronary angiography was not obtained at initial stages due to adequate unilateral collateral to guide the wire. A Fielder FC (Asahi Intecc, Aichi, Japan) was chosen as the first guide wire (GW) with Excel-14 microcatheter (Boston Scientific, Fremont, CA) to see if there was any micro-channel to recanalize the CTO. Failure to cross the lesion by this hydrophilic wire prompted a switch to the second guide wire Conquest Pro 12 (Asahi Intecc, Aichi, Japan), a stiffer one with tapered tip, according to the information from the CTCA. An attempt was made to cross the lesion by Conquest Pro 12 GW while the Fielder FC GW was placed in D2. However, it was still difficult to find the optimal entry point angiographically.

The IVUS (40-MHz Atlantis SR Pro, Boston Scientific, Fremont, CA) catheter was put to D2 and manual pullback imaging performed (Figure 1). After the optimal entry point from IVUS image around 10 o’clock was found (the middle portion of the proximal calcified cap), we kept the IVUS transducer in that position. An attempt was made to torque the Conquest Pro 12 GW to get the right direction by the real-time IVUS images. The two bright points indicating the two guide-wires in the IVUS images are evident (Figures 1A, 1B). At the same time, the screen of fluoroscopy image needed to be watched. The Conquest Pro 12 GW was easily slipped into D2. The wire tip was shaped again and again to increase the secondary curve incrementally. Finally, the Conquest Pro 12 GW penetrated the proximal cap a few millimeters. Before further advancement of the wire, IVUS check from D2 distal to the bifurcation to the proximal LAD was performed. The IVUS images revealed that the Conquest Pro 12 wire had penetrated the optimal entry site of calcified part of the proximal cap of CTO rather than the non-calcified part of the proximal cap (Figure 1E). Continued advance of the wire carefully encountered no strong resistance. An adequate collateral flow to ensure the distal end of the wire proved difficult. Contra-lateral injection from the RCA was performed via right radial approach thereafter. After being sure the wire was in the distal true lumen, a Tornus catheter (Terumo, Shizuoka, Japan) was used to penetrate the le-
sion and to change the guidewire to a Grand Slam wire (Asahi Intecc, Aichi, Japan) for better wire support. Predilatation was performed with the 1.25 × 15-mm Ryujin Plus balloon catheter (Terumo, Shizuoka, Japan). After additional dilatation with a 2.0 × 30-mm Ryujin Plus balloon catheter, IVUS for the LAD was performed to decide the stent size and distal landing zone. Two Cypher Plus stents (Cordis, USA), 2.5 × 24-mm and 3.5 × 28-mm, were implanted successfully (Figure 2). The femoral arteriotomy was closed by the Perclose suture device. The patient could be moved 4 hours later and was discharged the next day. PCI of the other two vessels was performed smoothly 2 months later after this procedure via trans-radial approach. Follow-up angiography and IVUS both showed nice results of the left anterior descending artery intervention (Figure 2F).

DISCUSSION

Despite advances in the device and strategy of PCI, the success rate of PCI of CTO remain 60-90% in comparison with success rates of more than 90% in non-CTO PCIs.¹⁻⁴ The most common reason for failure of recanalization of CTO is inability to cross the lesion with a guidewire.⁵⁻⁶ Penetration at the optimal site of proximal cap is essential to cross CTO with a guidewire. In the setting of the abrupt type of CTO, which has blunt stump with the presence of side branch at the site of occlusion, it may be difficult to recognize the proper entry point just from angiography. If there is a side branch large enough to accommodate the IVUS catheter, it is possible to use real-time IVUS images to guide the wire to penetrate the optimal site of the proximal cap. A procedure can be performed with the following steps: (1) a floppy wire is placed in the side branch. (2) Pull back and push forward with the IVUS catheter around the proximal cap to decide the optimal entry point (usually 1-2 mm proximal to the carina) and keep the IVUS transducer in that position. (3) Using a stiffer wire, or even tapered tip wire, advance the wire tip to the proper location. Torque the wire in the right direction and make several quick pushes with the wire to penetrate the lesion. (4) Perform an IVUS pullback from the side branch to the parent vessel to check if the wire has penetrated the optimal site before further advancement of the wire.

The spatial resolution of IVUS is better than that of CT coronary angiography (150 μm vs. 400 μm).⁷⁻⁸ The artifact caused by calcium is also more prominent in CT coronary angiography than on IVUS images. In this case, IVUS images provided views of the non-calcified part of the proximal cap of CTO, which CT coronary angiography could not detect due to the blooming artifact of the calcium. CT coronary angiography only showed the heavily calcified proximal cap of the CTO in this case (Figure 2A). We decided to penetrate the calcified part of the proximal cap in the middle portion of the plaque that was near the center of the occluded lumen (Figure 1E). It was thought that if the wire penetrated eccentrically to the occluded lumen, the wire would probably go into the sub-intimal space rather than re-enter into the true lumen.

Figure 2. (A) Computed tomography coronary angiography showed total occlusion of mid-LAD with dense calcification at the proximal cap. (B) Conventional coronary angiography showed abrupt type of chronic total occlusion. (C) Real-time IVUS-guided wiring technique. (D) Bilateral coronary angiography confirmed the wire was in the distal true lumen. (E) After two Cypher stents, left anterior descending artery restored antegrade TIMI 3 flow. (F) Follow-up left coronary angiography 2 months later after recanalization.
If the IVUS catheter left in the proper entry site interferes with manipulation of the stiffer guide wire, we suggest taking a cine for reference image while the IVUS transducer is positioned at the proper entry point. Then pull back the IVUS catheter and manipulate the stiffer wire. Sometimes, parallel wiring technique is useful in this situation. Once the guidewire has penetrated the proper entry point of proximal cap, it is easier to advance the wire to cross the CTO. However, the guide-wire may still enter the false lumen despite penetration at the proper entry site if the occlusive segment is long or tortuous. It is useful to guide the wire to do the contra-lateral injection. Again, parallel wiring will be a great help if the first wire enters the false lumen. Guide re-entry of wire to distal true lumen by placing the IVUS catheter into a previously created false lumen has been reported. The operator should keep in mind that serious complication including vessel perforation may occur while manipulating the device in the dilated false lumen.

Once the wire is in the distal true lumen, attempt to predilate the lesion with a penetration device (like Tornus catheter) or balloons. After predilatation with balloons, IVUS is also useful to decide the stent size and distal landing zone due to the negative remodeling of the prolonged occlusive coronary artery.

REFERENCES