

Novel Technique Using Intravascular Ultrasound-Guided Guidewire Cross in Coronary Intervention for Uncrossable Chronic Total Occlusions

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The experience of using a novel application of intravascular ultrasound (IVUS)-guided percutaneous coronary interventions for chronic total occlusions is reported in 2 cases. In the first case, an IVUS catheter was advanced into a side branch to identify the entry point of the major branch. In the second case, IVUS-guided penetration of the guidewire from the false lumen to the true lumen after causing a dissection was successful. (*Circ J* 2004; 68: 1088–1092)

Key Words: Chronic total occlusion; Coronary angiogram; Coronary dissection; IVUS-guided percutaneous coronary intervention

Guidewire crossing is the most important component of a successful percutaneous coronary intervention (PCI) for chronic total occlusions (CTO). Several special guidewires, such as the Magnum wire,^{1–3} Laser wire^{4–6} and hydrophilic wire,⁷ have been developed and favorable results have been reported. Other than these guidewires, some Japanese products, such as the Athlete, Miracle, and Conquest wires (Asahi Intecc, Seto, Japan)⁸ are used in some countries and constitute a range of stiff products. In particular, the Conquest wire is a tapered spring coil wire with a very stiff tip (9 g) that gives good torque control and penetrating ability even in hard fibrous plaque. This type of guidewire may be the last choice for uncrossable, very old CTOs.⁸ Although the Athlete wires will advance into a false lumen at the end of the procedure in unsuccessful cases, we can also use them to penetrate the flap to re-enter the true lumen as a second step.

Coronary angiography is limited as a guide for guidewire crossing in PCI for CTOs. On the other hand, by showing the cross-sectional anatomy of the coronary vessels, intravascular ultrasound (IVUS) can provide information on the plaque morphology and distribution,⁹ and the exact location of the guidewires within a coronary artery, discriminating a false lumen from the true lumen before guidewire crossing. We report here a novel application of IVUS for very old and hard CTOs (abrupt occlusion with a side branch in case 1 and bending occlusion with severe calcification in case 2) in which the use of very stiff guidewires caused dissections, decreasing the collateral flow.

Case Reports

Case 1: Side Branch Method

A 68-year-old Japanese man had experienced chest oppression on effort since May 2000. He visited hospital in July 2000, and coronary angiography revealed a CTO in the proximal segment of the large left circumflex coronary artery (LCX). There was no significant stenosis in the left anterior descending coronary artery (LAD) or the right coronary artery (RCA). His coronary arteries were left dominant. He had not had any episodes suggestive of acute myocardial infarction. Cardiac catheterization revealed left ventricular dysfunction and moderate mitral regurgitation. PCI for the CTO was unsuccessful at that time. He was treated medically and his condition improved. However, he complained of chest oppression on effort again in October 2001. We attempted to re-open the CTO of the LCX. The age of this CTO was unknown, but was thought to be more than 18 months, based on the angiographic record. We obtained the consent of the patient after fully explaining the efficacy and risks associated with our new technique using IVUS before the PCI.

The occlusion was severely calcified and flush with the orifice of the vessel, tapering nicely into a large obtuse marginal artery (Fig 1a). A 10Fr JCL 4.0 with a side hole (Bright Chip, Cordis, Miami, FL, USA) was used in order to prepare for the possible use of a rotablator with a 2.5-mm burr. A 2.9Fr IVUS catheter (Ultracross, Boston Scientific/SCIMED, Maple Grove, MN, USA) was advanced into the obtuse marginal artery to identify the entry point of the major branch (Figs 1b, 2a). Using IVUS imaging as a guide (Fig 2b, c), a Conquest guidewire (Asahi Intecc, Seto, Japan) was advanced through the proximal entry point (Figs 1b, 2d). With no IVUS images available distal to the proximal entry point, the wire crossed the entire occlusion, but entered the false lumen beyond the distal end of the occlusion (Fig 1c). Then, using the tandem wire technique with a Miracle 12 g (Asahi Intecc), the wire

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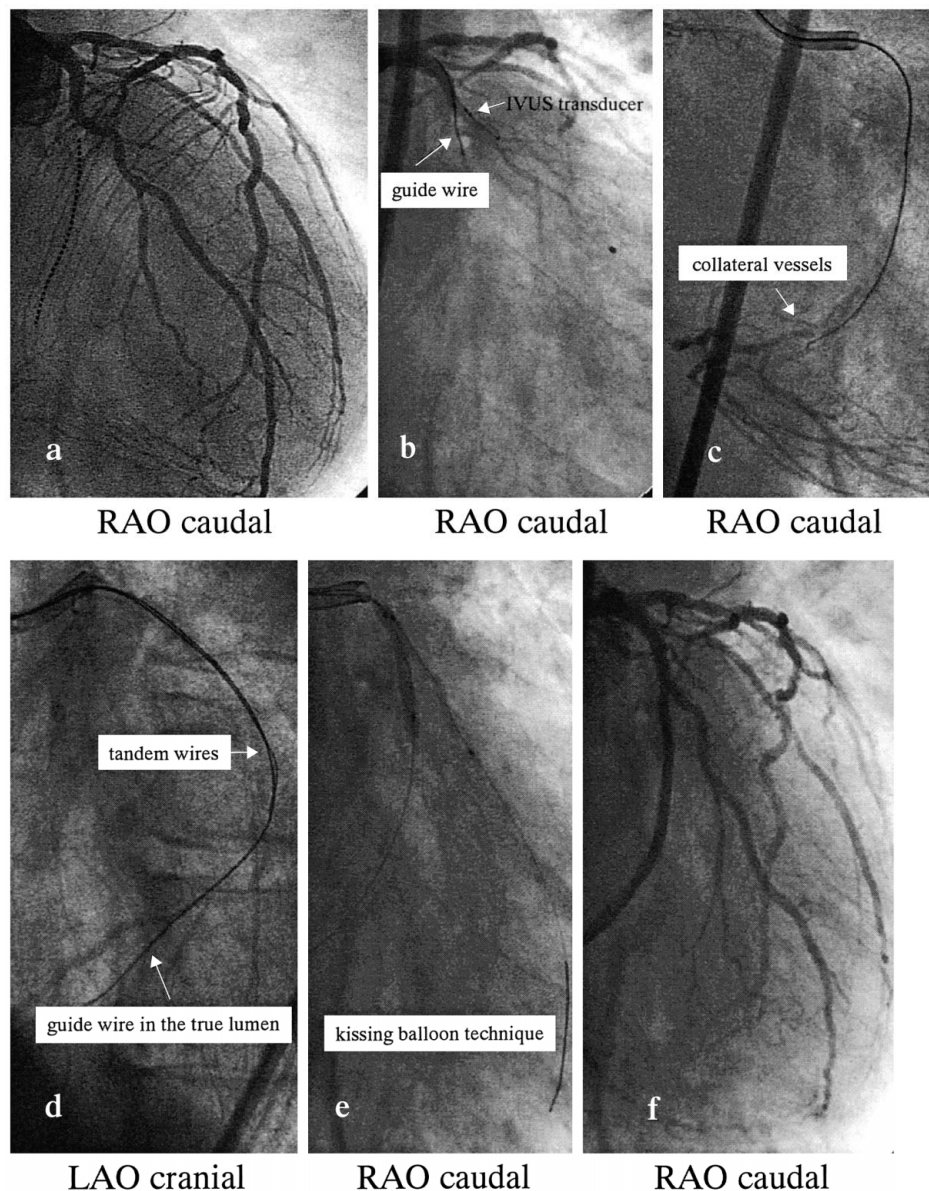


Fig 1. (a) Baseline coronary angiograms in the caudal right anterior oblique view. (b) IVUS-guided wire manipulation. An IVUS catheter (2.9Fr Ultracross, Boston Scientific/Scimed) advanced into the obtuse marginal branch and guidewire after crossing the proximal obstruction are shown. (c) Guidewire is in the subintimal area beyond the distal obstruction. (d) Angiogram after re-entry of the guidewire into the true lumen. (e) Angiogram showing the kissing balloon technique at the proximal point of obstruction. (f) Final angiogram in the caudal right anterior oblique view after balloon dilatation.

crossed into the distal true lumen after penetration from the false to the true lumen (Fig 1d). The occluded segment was dilated incrementally with balloon catheters (1.5–20 mm Maverick (Boston Scientific/SCIMED), 2.5–28 mm PowerSail (Guidant Corp, Temecula, CA, USA), and 3.5–20 mm Maestro (Jomed Inc Rancho Cordova, CA, USA) including the kissing balloon technique performed at the proximal occlusion (Fig 1e). The final angiogram revealed excellent results without the need for stent implantation despite passage of the into the false lumen (Fig 1f). Restenosis had occurred by the 6-month angiographic follow-up and 2 stents were deployed.

Case 2: False Lumen Method

A 68-year-old Japanese man who had suffered an anteroseptal myocardial infarction 16 years ago, underwent

PCI for 90% stenosis in the mid-RCA and subtotal occlusion with severe bending in the proximal LAD in April 2000. An NIR stent (Boston Scientific/SCIMED) was implanted successfully in the RCA, but guidewire crossing had been unsuccessful in the PCI for the CTO of the LAD at that time. His clinical course had been uneventful until he experienced chest oppression on effort in February 2002. Sublingual administration of nitroglycerine was relieved the symptoms and he underwent coronary angiography, which revealed the absence of restenosis in the mid-RCA. The LAD stenosis was totally occluded, with good collaterals from the RCA. PCI for this 18-year-old CTO was performed after obtaining the consent of the patient for our new technique.

Baseline coronary angiograms of the left coronary artery with contralateral injection from the RCA revealed that the

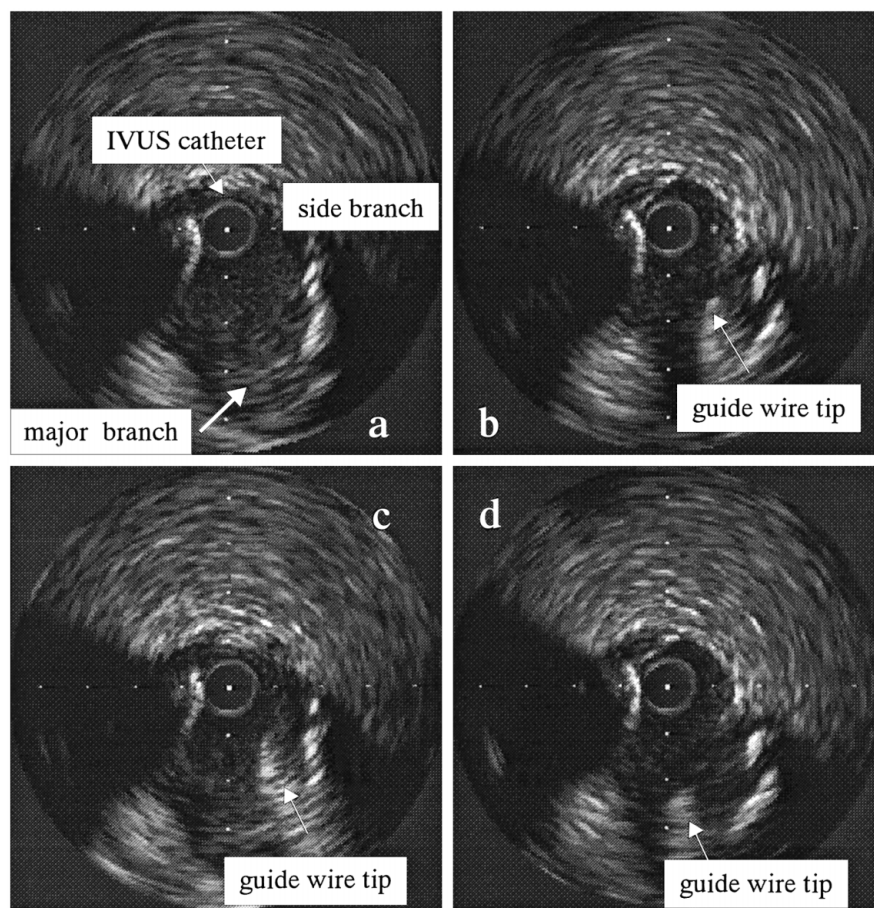


Fig 2. (a–d) Intravascular ultrasound imaging before (Panel a) and after wire crossing of the proximal obstruction (Panels b and c). An IVUS catheter is in the obtuse marginal branch and the origin of the major branch can be identified (Panel a). The crossed wire can be detected in the true lumen of the major branch (Panel d).

occlusion was approximately 15 mm long, but the stump was abrupt, tapering nicely into the diagonal branch. There was bending in the occluded segment (Fig 3a,b). An Athlete plus Conquest guidewire (Asahi Intecc) was chosen. An 8Fr Wiseguide catheter (Boston Scientific/SCIMED) with a 0.086-inch inner diameter was used. First, the side branch method using IVUS, described in case 1, was used to enter the proximal fibrous cap (Fig 3c). However, a single guidewire alone could not cross into the distal true lumen, resulting in advance into the false lumen distal to the occlusion. Thus, the tandem guidewire technique was used to penetrate to the true lumen from the false lumen (Fig 3d). However, collateral flow from the RCA decreased (Fig 3e) because the subintimal space enlarged, associated with the wire manipulation, compressing the distal true lumen. At this stage, we introduced a 2.9Fr IVUS catheter (Ultracross, Boston Scientific/SCIMED) into the false lumen after dilatation with 1.5-mm balloon to precisely determine the location of the true lumen and the tip of the guidewire (Figs 3f,4a). With a Choice PT Graphics standard guidewire (Boston Scientific/SCIMED), we succeeded in IVUS-guided penetration (Figs 3g,4b). Despite balloon inflation of the formerly occluded segment, distal run-off was poor, probably because of dissection (Fig 3h). Re-entry formation with balloon inflation was performed and 2 stents (Tristar 3.5–33 mm and 2.5–23 mm, Guidant Corp) were implanted to cover the occlusion site and distal subintimal pathway (Fig 3i,j). There was no restenosis at 4-month angiographic follow-up.

Discussion

A successfully revascularized CTO confers a significant 10-year survival advantage compared with failed revascularization¹⁰. Thus, although PCI for CTOs is more expensive and time-consuming, it has the significant advantage of avoiding the pain associated with recanalizing CTOs in selected cases, even if the use of an IVUS catheter is necessary before guidewire crossing. The method described here, the last choice in our catheter laboratory, increases the likelihood of technical success in PCI for uncrossable CTOs.

New Stiff Guidewires and Tandem Wire Technique in PCI for CTOs

The guidewire will be advanced into a false lumen at the end of the procedure in unsuccessful cases of PCI. In this situation, Japanese groups have added a second guidewire and used it with the first one to cross the occlusion, a method called the 'tandem wire technique'. In this technique, the first guidewire works as a fluoroscopic landmark during creation of another channel in the occlusion by the second wire, stretching the tortuous vessel, or creating a new force in another direction. Puring tandem wire technique in order to penetrate the wall from the false lumen to the true lumen, a stiff guidewire with high penetrating ability, such as the Conquest guidewire (Asahi Intecc), is necessary.

Good Candidates for This Technique

For the side branch method, the side branch should origi-

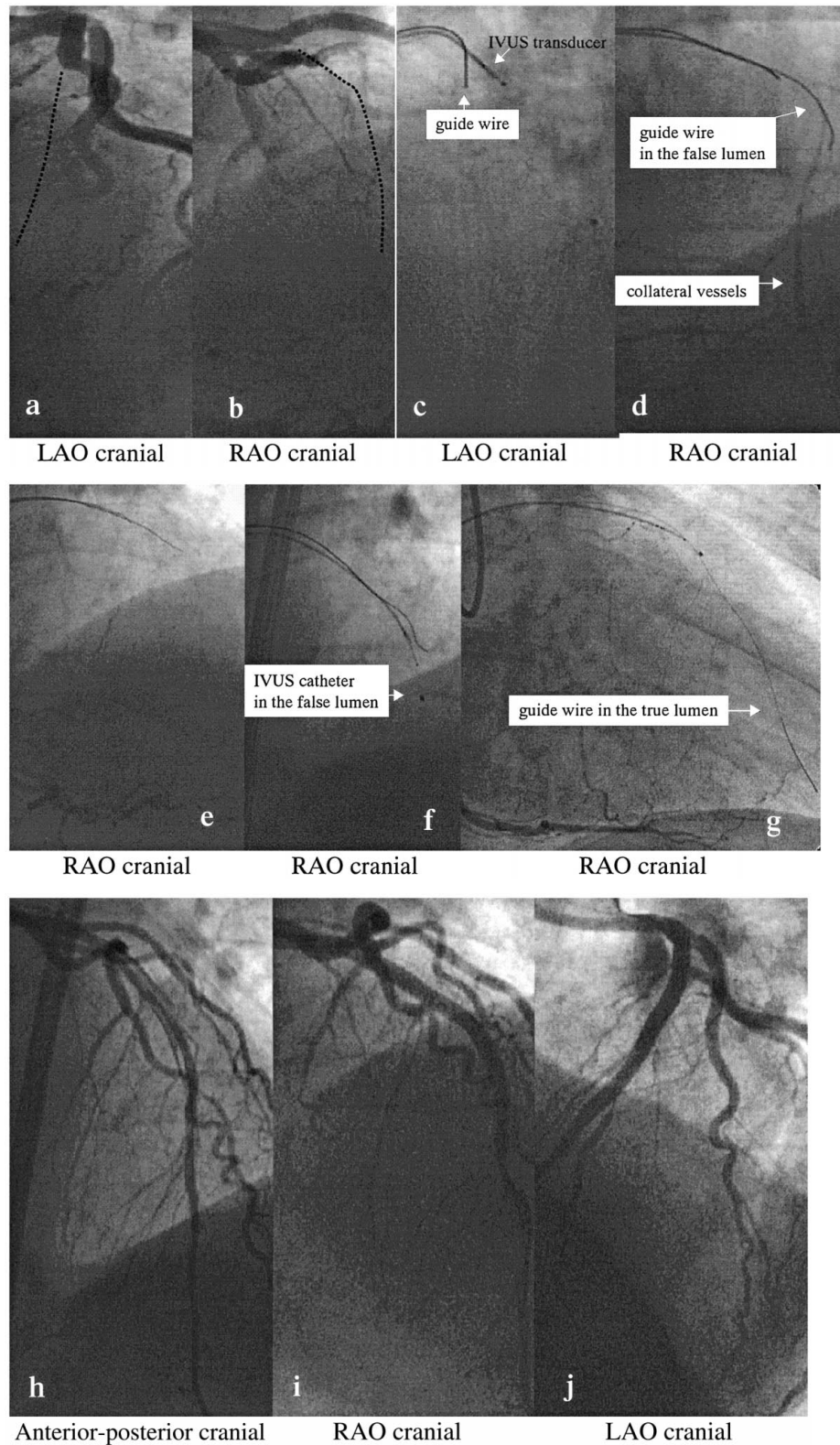


Fig3. (a and b) Baseline coronary angiogram in the cranial left anterior oblique view (a) and cranial right anterior oblique (RAO) view (b). (c) An IVUS catheter has advanced into a diagonal branch. (d) Angiogram showing that the guidewire is located in the false lumen distal to the occlusion, confirmed by contralateral injection. (e) Tandem-wire technique to penetrate the false lumen. Collateral flow from RCA decreased, because the subintimal space enlarged, compressing the true lumen. (f) An IVUS catheter progressed into the false lumen. (g) Guidewire located in the distal true lumen after penetration guided by IVUS imaging. (h) Coronary dissection in the former total occlusion after balloon dilatation. (i and j) Final coronary angiograms in the RAO cranial (i) and cranial left anterior oblique (j) views. Two stents were inserted by subintimal wire passage to cover both the formerly occluded segment and the dissected segment.

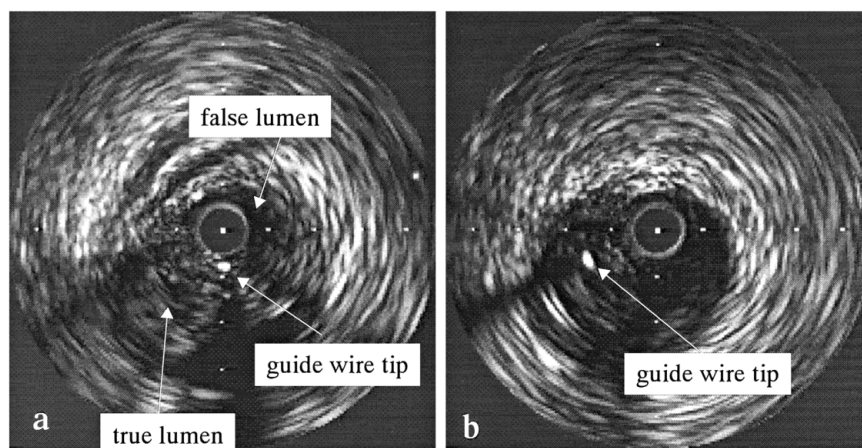


Fig4. (a and b) IVUS imaging before (a) and after (b) wire crossing into the distal true lumen.

nate near the stump and be of adequate size for advancement of the IVUS catheter, but not sharply angled, preventing the development of spasm, dissection, thrombosis or, as the worst case scenario, occlusion. Furthermore, IVUS cannot always detect the origin of the main branch because it depends on the anatomy; that is, the angles formed only during penetration of the proximal part of the occlusion. Thus, the second IVUS method is needed once the guidewire advances into the false lumen and must be started before the false lumen becomes too enlarged and the true lumen collapses, because then it becomes very difficult to create another path with the second wire. Lesions with a severe bend or calcification in the occluded segments or distal lesions are not candidates because an IVUS catheter cannot be advanced into the false lumen.

Potential Complications and Limitations of this Method

There are potential risks of perforation associated with this technique. A catheter or balloon used in combination with a very stiff wire is very strong and so the risk of penetrating the wall is very high. Even a small-sized balloon dilatation and/or IVUS catheter advancement (not guidewire alone) to a false lumen may cause coronary perforation that requires a subsequent procedure such as pericardiocentesis. However, because the false lumen is quite often dilated by wire manipulation at the time of introduction of the IVUS catheter, IVUS catheter advancement per se may not increase the risk of perforation. In our experience, perforation has occurred only once in approximately 20 cases in which we have attempted to use the new technique and it was not caused by the IVUS catheter, but rather by passage of the guidewire. However, care must be taken throughout the entire procedure and performance of the technique should be limited to very experienced interventionists with good skills in pericardiocentesis and the management of cardiac tamponade. No other complications related to this method have been observed. An 8Fr guidewire catheter, preferably with an inner diameter of more than 0.088 inches, is required to manipulate the guidewire with a probing catheter in association with an IVUS catheter. In the false lumen method, manipulation of the second guidewire may sometimes be disturbed by the IVUS catheter itself. On the other hand, the IVUS catheter can help direct the guidewire tip into the true lumen, covering the enlarged false lumen and stretching the tortuous vessel.

In PCI for very difficult CTOs several guidewires are

needed, as well as balloon catheters and stents to open the occluded coronary artery. The cost of the PCI for one CTO sometimes is almost equal to or even higher than that of coronary artery bypass grafting based on the current Japanese medical insurance system. Patients undergoing PCIs for CTOs might be exposed to more radiation than with a non-CTO. In addition to these potential shortcomings, previous procedures had been unsuccessful in the presented cases and therefore coronary artery bypass grafting was an option in both cases. However, we selected PCI for these lesions because we thought that our procedure using the new technique was still less invasive than coronary artery bypass grafting, and because both patients preferred PCI.

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