I. Introduction

Intravascular ultrasound (IVUS) imaging is a user-friendly technique widely used during percutaneous coronary intervention (PCI). However, IVUS catheter entrapment is an infrequent but serious complication associated with PCI. Case 1 was an 87-year-old woman on hemodialysis who had non-ST elevation myocardial infarction with total occlusion in the middle left anterior descending artery (LAD). PCI was performed with two drug-eluting stents (DESs) under IVUS guidance, but the IVUS catheter was entrapped at the implanted stent, leading to stent deformation. Case 2 was an 86-year-old woman on hemodialysis who had stable angina with severe calcified stenosis in the middle LAD. IVUS-guided rotational atherectomy was performed, but the IVUS catheter was stuck in the implanted DES with stent deformation. In both patients, we attempted to use a 0.010-inch guidewire and compatible balloon catheter system that can pass through a 6-Fr guide catheter simultaneously with the IVUS catheter, and the entrapped IVUS catheters were successfully removed from the implanted stents. This retrieval method is very convenient to apply during bailout and should be recommended especially in PCI using a 6-Fr guide catheter.

KEY WORDS: complications, drug-eluting stent, intravascular ultrasound catheter entrapment, percutaneous coronary intervention, 0.010-inch guidewire and compatible balloon catheter system
(EESs) (Synergy, 2.5 × 20 mm, 2.25 × 28 mm, Boston Scientific) were deployed distally with minimal overlap with the old stent in the proximal LAD, completely covering the diffuse plaque (Fig. 1D). The stents were subsequently post-dilated with a non-compliant balloon catheter (Hiryu Plus, 2.25 × 12 mm, Terumo, Japan) (Fig. 1E). The IVUS image showed relatively good stent apposition and expansion in the calcified lesion (Fig. 1F); however, the IVUS catheter was trapped at the distal stent strut, and the distal portion of the stent appeared to be deformed on fluoroscopy (Fig. 2A). In order to rescue the situation, the entrapped IVUS catheter could be pushed forward, but could not be pulled back. Although we cut the proximal IVUS shaft and inserted a guide extension catheter (GuideLiner, 6 Fr, Teleflex, USA) over the IVUS shaft, the guide extension catheter was unable to advance beyond the previous stent in the proximal LAD. Then, after the IVUS imaging core was removed, a 0.021-inch guidewire was inserted into the tube, and the entrapped IVUS catheter was pushed and rotated. But the IVUS catheter could not be removed. Next, we carefully passed a 0.014-inch tapered guidewire (XT-R, Asahi Intecc) through the crushed stent, using the double-guide catheter technique via the left femoral artery; however, the microcatheter (Corsair Pro, Asahi Intecc) and the 0.014-inch guidewire-compatible small balloon catheter (Sapphire II Pro, 1.0 × 5 mm, OrbushNeich, Hong Kong) were unable to traverse through the stent (Fig. 2B). Finally, we cautiously passed a 0.010-inch guidewire (Athlete Eel Slender, Japan Lifeline, Japan) through the stent (Fig. 2C). After a 0.010-inch guidewire-compatible balloon catheter (IKAZUCHI X Hyper, 1.5 × 9 mm, Kaneka) was successfully passed through the crushed stent, the IVUS catheter was retrieved conveniently (Fig. 2D). The deformed distal stent was re-dilated with a non-compliant balloon (Hiryu Plus, 2.25 × 12 mm) (Fig. 2E), and the proximal stent was post-dilated using another non-compliant balloon (Hiryu Plus, 3.0 × 8 mm, Terumo). Final angiography revealed satisfac-
tory stent expansion without residual stenosis and TIMI grade 3 flow in the LAD (Fig. 2F).

III. Case 2

An 86-year-old woman with ESRD on hemodialysis was admitted to our hospital due to stable angina. CAG and IVUS (AltaView, Terumo) findings revealed severe calcified stenosis in the middle LAD (Fig. 3A). Rotational atherectomy with a 1.5-mm burr (RotaLink Plus, Boston Scientific) was performed using a 6-Fr guide catheter (Hyperion SPB3.5, Asahi Intecc) (Fig. 3B). After dilation using a cutting balloon (Wolverine, 2.5 × 10 mm, Boston Scientific) (Fig. 3C), a sirolimus-eluting stent (SES) (Orsiro, 3.0 × 40 mm, Biotronik, Switzerland) was implanted to fully cover the tandem plaques (Fig. 3D). The IVUS image after post-dilation with a non-compliant balloon (NC Kamui, 3.5 × 12 mm, Asahi Intecc) showed adequate stent apposition and expansion (Fig. 3E, F); however, the IVUS catheter was stuck at the distal stent strut, and the distal edge of the stent appeared to be deformed on fluoroscopy (Fig. 4A). In order to rescue the situation, the entrapped IVUS catheter could be pushed forward, but could not be pulled back. Then, after the IVUS imaging core was removed, a 0.021-inch guidewire was inserted into the tube, and the entrapped IVUS catheter was pushed and rotated. But the IVUS catheter could not be removed. Therefore, we attempted to use a 0.010-inch guidewire system that can be inserted in parallel with the IVUS catheter through a 6-Fr guide catheter, referring to the previous case. A 0.010-inch Athlete Eel Slender guidewire and a 1.5-mm IKAZUCHI X Hyper balloon catheter were successfully passed through the crushed stent (Fig. 4B). After the deformed stent was re-dilated with the 0.010-inch compatible balloon (Fig. 4C), the IVUS catheter was retrieved successfully (Fig. 4D). The stent was post-dilated by another non-compliant balloon catheter (Tasuki, 2.5 × 12 mm, Kaneka) (Fig. 4E). Final angiography showed good stent expansion with-
out residual stenosis (Fig. 4F).

IV. Discussion

IVUS is an invasive imaging technique used to visualize coronary cross-sectional anatomy and is superior to CAG in assessing vessel size, lesion severity, plaque volume, and calcium content\(^7, 8\). It also provides complementary procedural information on lesions requiring PCI when determining adequate stent sizing and confirming optimal stent deployment in real time\(^9\). Moreover, IVUS can assess stent underexpansion, malapposition, and edge dissection after stent implantation, which may lead to stent thrombosis and restenosis\(^10, 11\). With the advent of drug-eluting stents (DESs), IVUS-guided DES implantation has been associated with a significant reduction in target vessel revascularization, cardiac death, and stent thrombosis compared with angiography-guided implantation\(^12\).

However, the entrapment of an IVUS catheter is an infrequent but serious complication associated with PCI, and a surgical procedure may be required to retrieve the catheter\(^13\). The IVUS catheters used in our patients, an OptiCross IVUS and an AltaView IVUS, incorporated a single 40- and 60-MHz transducer within a 3.2- and 3.0-Fr short monorail system, respectively. When advancing the catheter through a stented vessel, catheters that do not completely encapsulate the guidewire may engage the stent between the junction of the catheter and guidewire, resulting in catheter/guidewire entrapment, catheter tip separation, and/or stent dislocation. The primary potential mechanism of IVUS catheter entrapment is that the guidewire exit port of the IVUS catheter gets caught at the stent strut when the IVUS catheter is pulled back after stent implantation\(^13, 14\). Previous reports demonstrated that the IVUS catheter was almost stuck in tortuous and/or calcified lesions\(^13, 16\). Similarly, our cases also suggest that tortuous vessels and calcified lesions would be a high-risk factor of IVUS catheter entrapment. In such cases, a special attention...
should be paid to the removal of the IVUS catheter as follows. Before the removal of the IVUS catheter, it is important to return the imaging core to the original position in a live mode. Operators should then carefully remove the IVUS catheter under fluoroscopy. Nevertheless, operators should stop the removal procedure if they feel any resistance.

Several percutaneous bailout techniques have been reported, including the rotation technique, buddy wire technique, double-guide catheter technique, covering the exit port of an IVUS catheter with a balloon catheter on the guidewire with which the IVUS catheter is delivered, replacing the IVUS imaging core with a larger diameter (OptiCross, 0.025 inch or AltaView, 0.021 inch) guidewire, and covering the IVUS catheter with a guide catheter extension system2-4). The double-guide catheter technique requires a different access route. Covering the exit port of an IVUS catheter with a balloon catheter is considered during PCI with a 7-Fr or 8-Fr guide catheter. The imaging core of an AltaView IVUS can be removed without cutting the shaft, but the imaging core of an OptiCross IVUS cannot be removed without cutting the shaft. Moreover, the shaft of both IVUS catheters must be cut to be covered by a guide extension catheter. Finally, there is a method to pull the guidewire with which the IVUS catheter is delivered and separate the guidewire from the IVUS catheter; however, it may be difficult to re-cross the guidewire through the crushed stent. The retrieval methods are limited especially during PCI using the well-known 6-Fr guide catheter.

In contrast, a 0.010-inch guidewire and compatible balloon catheter system is considered as a key component of the “slender system” that was first introduced in Japan, and it is mostly used for 5-Fr transradial PCI. It has been shown to be useful for treating bifurcation lesions when there is a need to cross a stent-jailed side branch and when simultaneous kissing balloon inflation is

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**Fig. 4** Retrieval of an entrapped IVUS catheter in Case 2. A: The IVUS catheter was stuck in the distal stent edge with stent deformation (white arrow). B: A 0.010-inch guidewire and a 0.010-inch compatible balloon catheter (white arrow head) were able to cross the deformed stent through a 6-Fr guide catheter. C: Dilatation of the deformed stent with a 0.010-inch compatible balloon catheter (black arrow head). D: The entrapped IVUS catheter (black arrow) was successfully removed. E: Re-dilation of the deformed stent with a non-compliant balloon. F: Final CAG after PCI.
performed in a 5-Fr guide catheter\(^5,6\). The 0.010-inch guidewire-compatible balloon catheter (IKAZUCHI X Hyper) has a very low profile in terms of the balloon tip and catheter shaft. The outer diameter of the entry profile of the 1.5-mm IKAZUCHI X Hyper balloon catheter is 0.012 inches, which is smaller than the outer diameter of the standard 0.014-inch guidewire (Fig. 5A). The very low entry profile of the balloon enables it to cross microchannels in chronic total occlusions, bifurcation, and tortuous/bent lesions\(^17,18\). In addition, the distal shaft outer diameter of the 1.5-mm IKAZUCHI X Hyper balloon catheter is smaller (2.1 Fr) than that of a 0.014-inch compatible balloon catheter. Although a conventional guidewire and balloon catheter cannot pass generally in parallel with an IVUS catheter through a 6-Fr guide catheter, a 0.010-inch guidewire and a 1.5-mm IKAZUCHI X Hyper balloon catheter can pass through simultaneously with an IVUS catheter. IVUS: intravascular ultrasound, GW: guidewire

V. Conclusion

A 0.010-inch guidewire and compatible balloon catheter system can pass through a 6-Fr guide catheter simultaneously with an IVUS catheter. The retrieval method using a 0.010-inch guidewire system is very convenient to perform during bailout and should be recommended when an IVUS catheter is entrapped in an implanted stent with a 6-Fr guide catheter.

Conflicts of interest

The authors declare that they have no conflict of interest.

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