Trends in CTO-PCI Dedicated Intravascular Ultrasound

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3.1 Introduction

Previously, intravascular ultrasound (IVUS) catheters had large diameters and a long distance between the tip and the transducer, which limited their usefulness in percutaneous coronary intervention (PCI) for chronic total occlusion (CTO). Recently, a new IVUS catheter has been introduced, with a smaller diameter and a shorter distance between the tip and the transducer. Since then, this improved IVUS catheter has been used in various situations in CTO-PCI. The specific uses of IVUS in PCI for CTO include:

(1) Assessing the condition of angiographically undetectable vessels
(2) Confirming the route of a guidewire passing through CTO without cineangiography.

This chapter describes the use of IVUS in PCI for CTO.

3.2 Operation Using Antegrade Approach

For simultaneous wiring using IVUS guidance, it is desirable to set the antegrade system to 7 Fr or more. When the antegrade guide is an 8 Fr catheter, wiring to the site of CTO is possible, even if the IVUS catheter is positioned in the side branch of the affected coronary artery.

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3.2.1 Search for the Entry Point from the Side Branch

In this approach, angiography-guided antegrade wiring is usually initiated in patients with a taperd-type entry of CTO that is more easily identifiable. However, in patients with a blunt-type entry of CTO, it is often hard to identify the exact point of CTO entry. In such cases, the position of CTO entry may be identified by inserting the IVUS catheter into the side branch of the occluded coronary artery, provided the side branch (which may occasionally be the main vessel) is present at the site of the blunt-type obstruction. These approaches might be made in all cases except for the entry of the left main trunk (LMT) and the entry of the right coronary artery (RCA).

The IVUS catheter is inserted into the side branch and pull-back is performed by manual manipulation while confirming a live image. The entry of CTO can often be found in an area with an increased diameter of the side branch vessel; this area should be carefully observed to identify the site of entry. In cases where it is difficult to insert the IVUS catheter into the side branch and the catheter is made to enter from the proximal area for observation, the entry of CTO may often be present in an area where the vessel diameter is small. If the entry of CTO can be identified, it is important to record the position of the IVUS catheter using cine angiography for reference during wiring. In patients with calcification of the entry and occluded vessels behind the calcification, it may be difficult to identify the point of entry even if the IVUS catheter is used. By changing the depth and gain settings of the catheter, the entry of CTO may become observable.

Currently, various types of IVUS catheters are available. However, the position of the transducer on the catheter may vary depending on IVUS. Therefore, confirming the position of each transducer according to the IVUS catheter is required.

When wiring is initiated by antegrade approach and the guidewire is inserted 5–10 mm into the occluded vessel after having identified the blunt-type entry of CTO in IVUS, it is desirable to confirm whether the wire has entered from the assumed entry by performing IVUS from the side branch again. The steps to identify the route of the guidewire inserted into CTO are as follows:

(1) Confirm whether the guidewire is present inside the blood vessel at the entry of CTO
(2) Confirm the positional relationship between the side branch bifurcation and the guidewire
(3) Confirm whether the guidewire is positioned at the center of the occluded vessel using short axis view

3.2.2 IVUS-Guided Rewiring in Antegrade Approach

IVUS-guided rewiring is a procedure that identifies the true lumen of the vessel by inserting a second wire from the subintimal space along with inserting a guidewire under IVUS guidance. This procedure is used in cases where the guidewire cannot aim at the true lumen and instead locates the CTO entry point in the subintimal

space. It is used as a last resort when the guidewire cannot be inserted into the true distal lumen after trying various methods such as antegrade parallel-wire technique and retrograde approach.

It is essential to understand that IVUS-guided rewiring is not a technique for re-entry of the wire into the true lumen from the subintimal space. Even if the true lumen can be confirmed in IVUS, it is structurally and physically challenging to penetrate it by inserting the second wire from inside the subintimal space. Therefore, the site where the second wire is guided into the true lumen (intimal space) should either be the site of aberration created when the first wire entered into the subintimal space or a site that is moderately proximal to it. Thus, the most important thing is to confirm the position of aberration of the first wire on angiography or IVUS and to confirm the position and direction of the true lumen on IVUS under fluoroscopy imaging.

For the insertion of the IVUS catheter into the subintimal space, it is important, as far as possible, to make an effort not to enlarge the subintimal space. A microcatheter may be inserted into the subintimal space first, after which passing the IVUS catheter may be easier. In spite of this, if it is still hard to insert the IVUS catheter into the subintimal space, the subintimal space can be dilated incrementally using a 1.5 mm balloon. Figure 3.1 shows the findings of IVUS in a case where the guidewire entered the subintimal space; A: both the first and second wires are located in the true lumen, B: both the first and second wires are located in the intimal space, C: the first wire is located in the subintimal space and the second wire is located in the intimal space, D: the first wire is located in the subintimal space, the second wire is located in the intimal space, and the true distal lumen can be confirmed, E: the first wire is located in the subintimal space and the second wire is located in the true distal lumen. The steps of IVUS-guided rewiring are as follows:

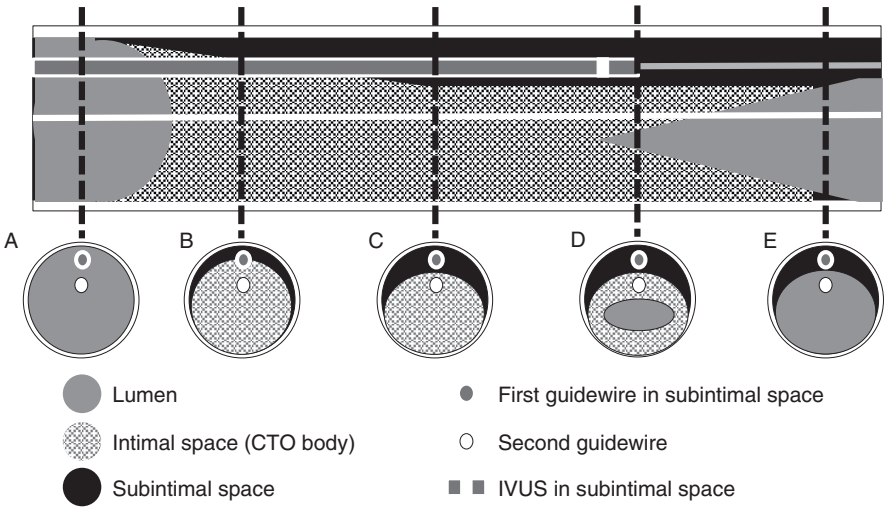

Fig. 3.1 Images during antegrade IVUS-guided rewiring

(1) Identify Part B by IVUS, and then try to penetrate the CTO using the second wire from the site between Part A and B which is different from the site of the first IVUS guidewire
(2) Insert the second wire carefully while confirming that it is located in the intimal space using the IVUS image obtained from the subintimal space by the first wire. *An important consideration during this step is to understand that the direction that the guidewire should be originally advanced in is positioned on the short axis view of the distal part. The direction that the second wire should be advanced in is the area of the plaque as seen on short axis view.*
(3) Try to identify the true lumen using the second wire by confirming the position that indicates the true distal lumen as seen on the IVUS image obtained from the subintimal space by the first wire. When the condition of Part D is achieved, changing the direction by pulling the second wire may be effective occasionally.
(4) Finally, make sure that the condition of Part E is achieved.

Once you can understand in which direction the IVUS image corresponds to fluoroscopy imaging, the insertion of the guidewire is enabled under fluoroscopy. Therefore, first, insert both the IVUS catheter and the second wire into the subintimal space to align the plaque, IVUS catheter, and guidewire into a linear shape; then, angle them such that the longest possible distance between the IVUS catheter and the guidewire. This orientation is applied to visualize the straight line linking the plaque, the IVUS catheter, and the guidewire from the side under fluoroscopy. Once the guidewire is advanced to the other side of the IVUS catheter, it can be guided into the plaque. An alternative approach includes confirming the positional relationship of the occluded artery with the branch, confirming the state of the epicardium, and using wire bias and lumen bias. It is useful to estimate the direction of the catheter and the guidewire on IVUS corresponding to fluoroscopy imaging by using these approaches as much as possible.

For the second wire, it is better to choose a wire with a higher torque transmission than that of the first wire and with an increased penetration ability. Currently, GaiaNext2 or Next3 is often chosen, and Conquest Pro is also used in some cases. To avoid re-aberration of the guidewire into the subintimal space once it is inserted into the plaque, consider performing step down of the wire if the microcatheter can be inserted into CTO.

3.3 Utilization of IVUS After Retrograde Approach

Recently for retrograde CTO-PCI, the reverse CART approach for the guidance of the retrograde guidewire into the true proximal lumen has been chosen in many cases. However, even if antegrade balloon dilatation is repeated, the retrograde guidewire cannot often reach the true proximal lumen. In such a case, confirmation of the positional relationship between the antegrade and retrograde guidewires

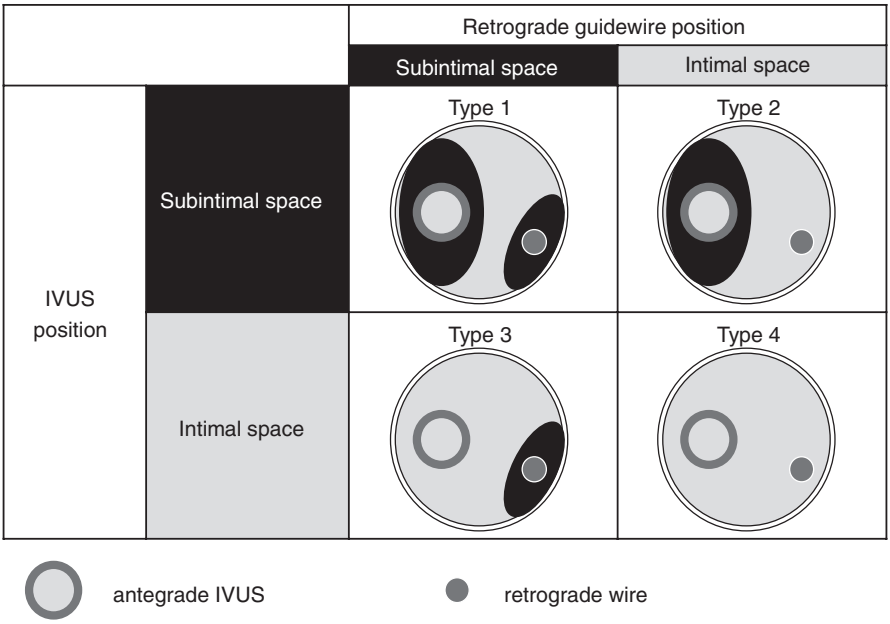

Fig. 3.2 IVUS findings from antegrade guidewire during reverse CART procedure

using IVUS may be useful to resolve the issue. Navifocus WR (Terumo Medtronic) or Eagle Eye (Volcano Corporation), both of which have a short distance between the catheter tip and the transducer, are recommended for use as IVUS catheters. Unless there is severe calcification, the positional relationship between the antegrade and retrograde guidewires can be identified by inserting the IVUS catheter. Each wire will be present either in the intimal space or the subintimal space, and there are four patterns in this relationship (Fig. 3.2).

3.3.1 Type 1: Both the Antegrade IVUS Catheter and the Retrograde Guidewire Are Located in the Subintimal Space

In such a case, it is relatively easy to create a connection by the reverse CART approach depending on the length of the occlusion. The communication between the subintimal spaces is established by antegrade dilation of the balloon, which is almost the same size as the blood vessel diameter measured by IVUS. The communication is relatively easy to establish even if there is a large distance between the antegrade IVUS catheter and retrograde wire because subintimal spaces are usually oriented in a spiral. If no communication can be established, it may often be necessary to choose a larger balloon. It may also be useful to choose a retrograde wire with a flexible and smooth tip.

3.3.2 Type 2: The Antegrade IVUS Catheter Is Located in the Subintimal Space and the Retrograde Guidewire Is Located in the Intimal Space

As compared to the other three types, this pattern is often hard to achieve by the reverse CART approach. Dilatation of the antegrade balloon usually only results in enlargement of the subintimal space. However, in some cases, the true proximal lumen can be accessed by retrogradely inserting a wire with high penetration ability and control (e.g., GaiaNext2/3) toward a balloon with a relatively small diameter intentionally during its deflation (contemporary reverse CART).

In IVUS, it is required to develop a strategy depending on the situation. For example, the usual reverse CART approach can be used by guiding the wire into the subintimal space by intentionally trying to change the position for trial reverse CART approach or by switching the retrograde wire into the knuckle wire, in which case it can be penetrated toward the direction of dilation of the balloon at a sharp angle using a stiff wire such as Conquest Pro.

3.3.3 Type 3: The Antegrade IVUS Catheter Is Located in the Intimal Space and the Retrograde Guidewire Is Located in the Subintimal Space

In this type, the procedure is similar to the Type 1 procedure, theoretically. By antegrade dilation of a large balloon, which is almost the same size as the blood vessel diameter, a crack leading to the subintimal space from the intimal space may be formed. However, it would be most difficult to make a connection between antegrade intimal space and retrograde subintimal space in this type. If this cannot be achieved, the usual reverse CART approach is performed, provided the antegrade wire has been advanced into the distal subintimal space.

3.3.4 Type 4: Both the Antegrade IVUS Catheter and the Retrograde Guidewire Are Located in the Intimal Space

The antegrade approach to penetrate the intimal lumen can be used when the antegrade guidewire seems to be present in the intimal space; however, shifting will be required depending on the site and timing of switching to reverse CART approach, because usually in such a case the antegrade wire cannot be operated thoroughly. Similar to Type 2, contemporary reverse CART approach can be tried by enlarging the subintimal space using a balloon with a relatively small diameter, such that the wire can be inserted into the true proximal lumen by retrogradely inserting a wire with high penetration ability and control such as GaiaNext2/3 towards the balloon intentionally during deflation of balloon. In many cases, by antegrade dilation of a large balloon, which is almost the same size as the blood vessel diameter, the wire

can be guided into the obtained lumen, however, when there is a large distance between the antegrade retrograde wires, some inventiveness is required. For example, the balloon can be dilated as close as possible to the position of the wire, and the curve of the retrograde wire tip can be strengthened and penetrated towards the lumen dilated by the balloon. In this case, GaiaNext2/Next3 or Conquest Pro is often useful as a guidewire.

3.4 Conclusion

IVUS provides a lot of valuable information on CTO-PCI, in addition to information obtained from angiography. It seems possible to raise the initial success rate of the treatment by appropriately using IVUS in PCI for CTO with understanding specific IVUS findings in PCI for CTO and choosing appropriate wires to operate based on the theory.