

CTO: Current Technique Overview

A look at today's strategies used to treat coronary chronic total occlusions.

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Controversy has long surrounded the realm of chronic total occlusion (CTO) of coronary arteries. As a result, much literature has been published examining the diagnostic relevance, work-up, management, utility of percutaneous coronary intervention (PCI), and risk-to-benefit ratio of PCI for CTOs.¹⁻⁴ Studies have concluded that CTOs can be found in one fifth to one third of patients undergoing diagnostic cardiac catheterization.⁵ Frequently, these patients have been referred for coronary angiography due to clinical symptoms or abnormal results of a stress test demonstrating ischemia. Increasingly, data from numerous studies suggest that, in the appropriate patient subset, successful CTO recanalization confers a significant survival advantage.⁶ A comprehensive discussion regarding patient selection, risk-to-benefit ratio, advantages to CTO recanalization, and background information is beyond the scope of this article and should be sought elsewhere. Persistence in the realm of CTO, at our center and from other leaders in the field around the world, has created significant excitement about the future of treating CTOs and is the focus of this article.

ACCESS

After all preparatory measures have been completed and the patient has been identified as an individual who would potentially benefit from the procedure, determination of catheter access site and guiding catheter size are of initial importance. We have found that early preparation and anticipation will provide the operator with a maximum number of options in the face of the unexpected. Hence, it

is recommended that an 8-F femoral arterial sheath and a contralateral 5- or 6-F arterial sheath should be used initially to achieve access before anticoagulation. The strategies to be discussed require a large enough sheath and guide catheter to provide for multiple wires, catheters, balloons, and devices. Bilateral arterial access is desired so that simultaneous coronary injection can be performed (Figure 1). Central femoral venous access is recommended but not required and should be considered on a case-by-case basis.

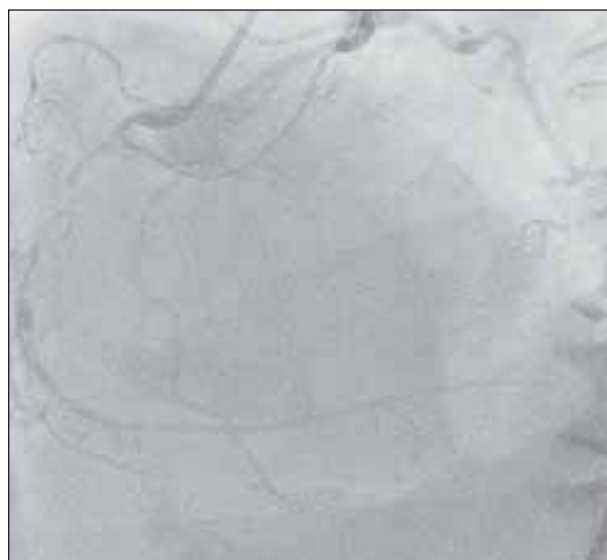


Figure 1. Angiography utilizing simultaneous injection of the left and right coronary arteries. CTO of the proximal right coronary artery and left-to-right collaterals are clearly visualized.

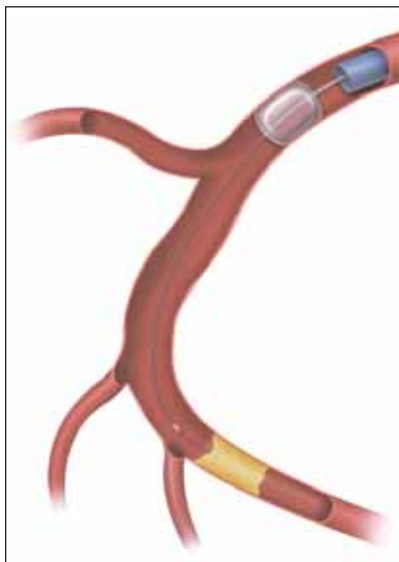


Figure 2. The balloon-anchoring technique showing the balloon inflated in the proximal part of the main vessel with the wire at the CTO.

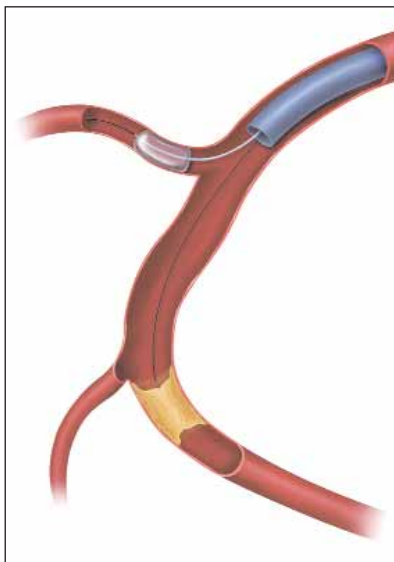


Figure 3. Side branch anchoring technique with the balloon inflated in a proximal side branch and the wire unobstructed at the CTO.

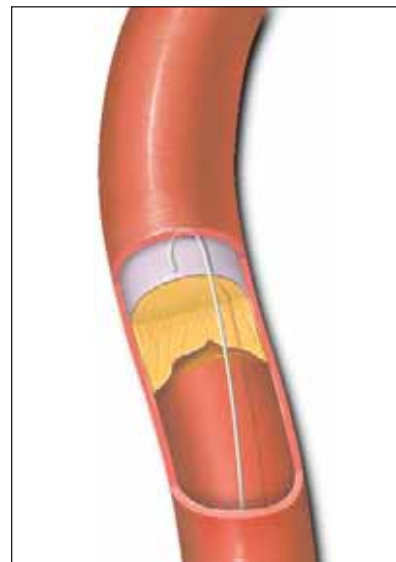


Figure 4. A J-tipped hydrophilic wire demonstrating a reverse STAR technique and controlled antegrade retrograde subintimal tracking (CART) technique.

ANTICOAGULATION

It is customary to use unfractionated heparin due to its ease of use and available antidote in the event of hemodynamic compromise secondary to perforation or tamponade. Dosing is weight dependent and should be administered before transit of interventional equipment.

ANGIOGRAPHY

Initial coronary angiography must be performed such that it is technically adequate and useful for the attempted recanalization. For initial diagnostic angiography and set-up views, we recommend at least a 5-F diagnostic catheter to ensure adequate filling of the coronary arteries. Multiple working views should be obtained to reduce point-specific radiation dose and also to provide confirmatory information in another plane. Some literature suggests that evaluating the percentage of transluminal calcification by CTA before attempted CTO recanalization may help to predict a successful outcome.⁷ Currently, we do not commonly utilize preprocedure CTA.

GUIDE SELECTION

Anatomical variations of coronary arteries are common in practice. As such, it is of paramount importance that adequate guide catheter selection is made. Many operators are well aware that poor guide support can easily be the cause of procedural failure. As such, a common strategy is to use a larger-sized guide catheter that will provide increased stiffness and more surface area to transmit and

absorb force during wire and device manipulation.

Selecting a guide that will permit the most coaxial position with the ostium, as well as aortic wall support, is highly desired. Of course, this is not always possible. We will subsequently describe methods to further back up the guide catheter.

INITIAL CROSSING TECHNIQUE

There are many opinions regarding the best strategy to employ when embarking on attempted CTO recanalization. Operator comfort, center volume, and available equipment are some factors to consider when looking at initial technique. At our center, we begin by selecting a standard .014-inch hydrophilic wire and a Transit catheter (Cordis Corporation, Warren, NJ). To begin, the wire is carefully advanced to the site of occlusion. Very fine torquing movements and slight pressure are applied in an attempt to cross the lesion on first attempt. The Transit catheter is advanced such that it follows almost immediately behind the wire. Doing so provides extra support for the wire and can aid in centering the wire in the lumen. However, significant caution must be used given the increased likelihood for dissection with a hydrophilic wire. Current limitations in standard angiographic resolution make it difficult to reliably predict which lesion will be successfully traversed on a first attempt. A narrowing to the CTO seen on angiography rather than a blunt cut-off generally suggests a better likelihood of crossing the CTO.⁸ Commonly, the wire will not cross and attempts to increase force on the wire result in

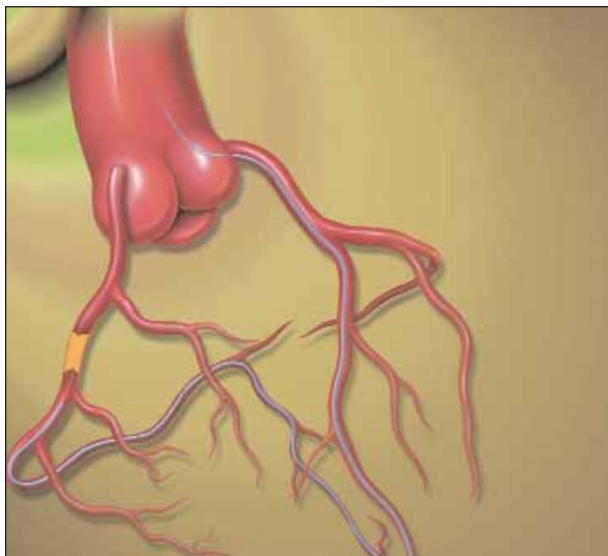


Figure 5. A Transit catheter over a wire is seen traversing the LAD, septal collaterals, and into the distal right coronary artery up to the occlusion. Positioning of the catheter in this fashion facilitates wire exchange frequently needed to cross the CTO.

the guide backing out. It is for this reason that the balloon-anchoring technique has been developed.

BALLOON-ANCHORING TECHNIQUE

The balloon-anchoring strategy utilizes a standard com-

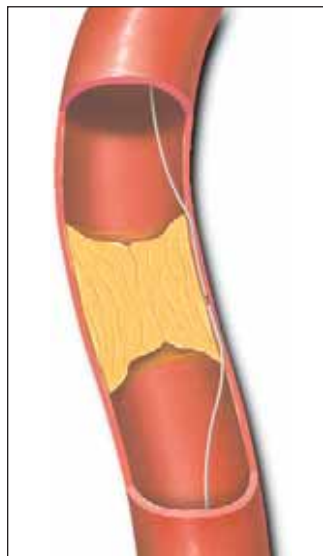


Figure 6. Retrograde and antegrade wires meeting each other in the subintimal plane at the CTO. Both wires can be advanced to gain entry into the true lumen.

pliant over-the-wire balloon. Size and specific balloon type are operator and lesion dependent. The wire and balloon are initially advanced together, similar to the previously described technique using the Transit catheter. Once the balloon is adequately placed proximal to the lesion, the balloon is inflated. At this point, the balloon serves as an anchor that provides support for the wire and the guide. Gentle withdrawal pressure applied to the balloon and forward pressure on the guide can allow for better coaxial positioning and deeper seating of the guide in the selected vessel. With this added support, the wire can be more forcefully directed at the CTO (Figure 2). Another variation of this anchoring technique is to have the balloon inflated in a

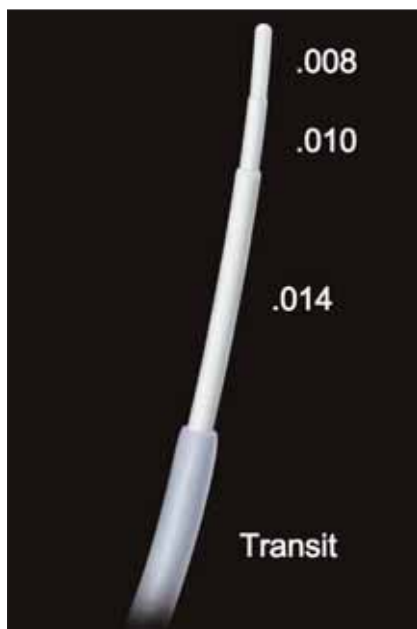


Figure 7. A cartoon depiction of a wire-in-wire system. It is a prototype that could be applied in the coronaries. In this case, it is passed over a transit catheter.

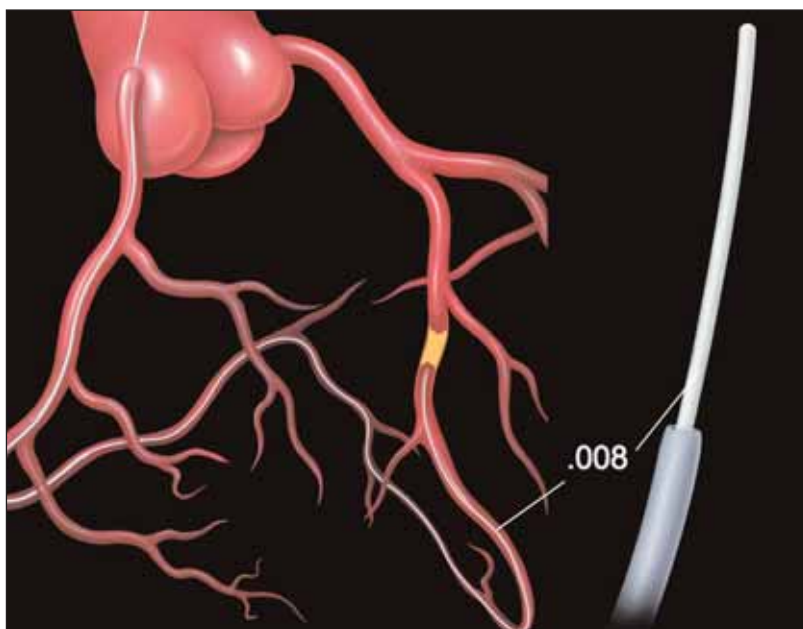


Figure 8. An example of this very small .008-inch wire passed in a transit catheter. If the lesion is not crossed in this retrograde approach, then the larger .010-inch or .014-inch wire could be passed over this wire.

TABLE 1. CTO WIRING PROGRESSION

Complex Chronic CTOs

- Miracle Bros 3 (Abbott Vascular)
- Miracle Bros 6 (Abbott Vascular)
- Confianza (Abbott Vascular)
- Terumo Gold (after partial crossing; Terumo Interventional Systems, Somerset, NJ)

Recent or Short CTOs

- Whisper Wire (Abbott Vascular)
- Miracle Bros 3 (Abbott Vascular)
- Miracle Bros 6 (Abbott Vascular)
- Confianza (Abbott Vascular)

side branch (Figure 3). This has the obvious advantage of allowing for contrast injection and free, unobstructed access to the CTO. Another variation of this is the Anchor-Tornus technique.⁹ This technique utilizes the side branch balloon inflation technique coupled with the Tornus device (Abbott Vascular, Santa Clara, CA), which is a wire-braided microcatheter that facilitates crossing-resistant lesions by using corkscrew action to penetrate the lesion. Clearly, the balloon-anchoring technique can be used with the full spectrum of wires ranging from nonhydrophilic to special radiofrequency-emitting wires, such as the Safe-Cross wire (Spectranetics Corporation, Colorado Springs, CO).

SPECIAL WIRES

When standard nonhydrophilic and hydrophilic wires of increasing stiffness are not effective in crossing the CTO in

an antegrade fashion, other options can be entertained. The Safe-Cross is a unique wire that uses optical coherent reflectometry to assist the operator in discerning the position of the distal wire tip.¹⁰ The wire is connected to a console, which by means of green and red alternating signal provides the operator with immediate feedback and knowledge of being in or out of the true lumen. Based on the feedback from the wire, a decision to use radiofrequency can be made. Low, medium, and high radiofrequency settings are available and should be used in ascending order. Failure in each of the three power settings should not be taken as failure of the entire procedure. Frequently, placement of a hydrophilic wire is possible after the Safe-Cross device has made a minimal inroad into the proximal fibrous cap. Standard wires should be used interchangeably with the Safe-Cross wire in the event that further manipulation may have created a partial channel by which to proceed.¹¹ At our center, such is often the case, and using the full armamentarium of wires and tools will greatly enhance the chance for success. We usually proceed in a step-wise fashion with stiffer and stiffer wires (Table 1). In cases refractory to the aforementioned maneuvers, sometimes an extraluminal course is required.

SUBINTIMAL TRACKING AND RE-ENTRY TECHNIQUE

The subintimal tracking and re-entry (STAR) technique represents the next step in the antegrade effort to cross the CTO and is commonly performed by using a hydrophilic wire that has a J-shaped loop at the tip.¹² In order to gain access to the subintima, the operator may need to use an accompanying stiff or nonhydrophilic wire to initially

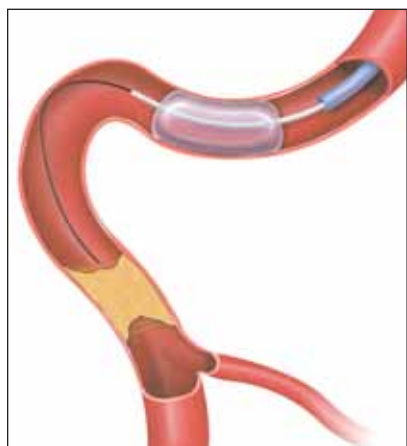


Figure 9. This cartoon depicts a standard balloon placed to help support the guiding catheter.

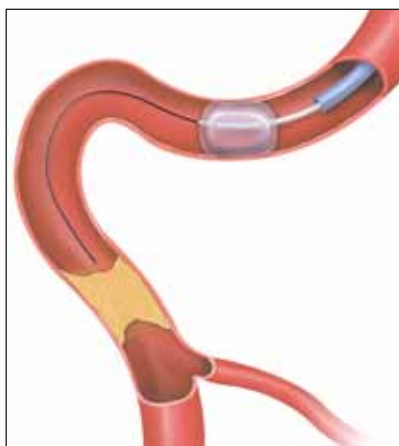


Figure 10. A cartoon depiction of our short balloon prototype. Unlike a standard balloon, it has a shorter tip and an elastomeric surface, making it less traumatic.

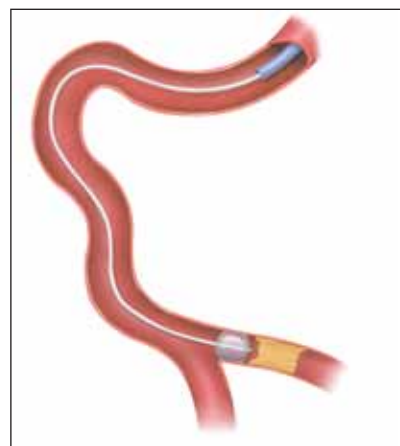


Figure 11. This cartoon depicts a standard balloon placed at the site of a CTO. Notice the long tip.

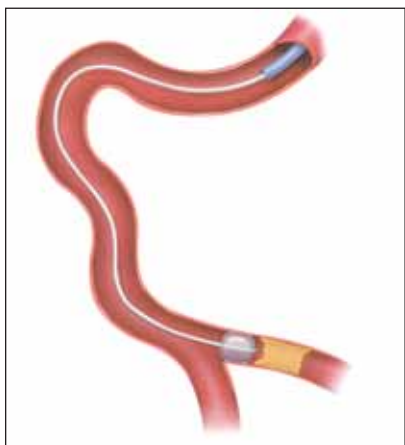


Figure 12. A depiction of our prototype. Notice we are able to place the balloon adjacent to the CTO.

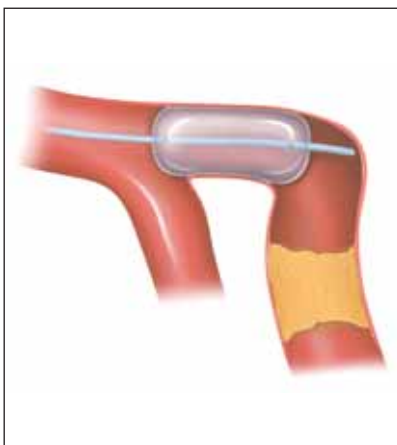


Figure 13. A magnified view depicting the standard balloon with a long tip.

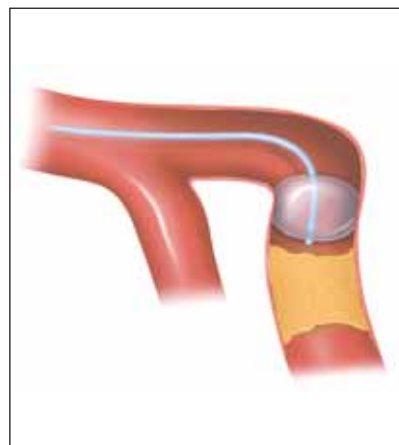


Figure 14. A depiction of the short-tipped balloon with apposition to the CTO.

become subintimal. A Transit catheter or over-the-wire balloon may also help getting the wire into the subintima. Often, once the wire is subintimal, it can easily be advanced distal to the CTO. Once this is accomplished, distally, the wire will usually enter the true lumen distally at the site of vessel bifurcation.¹³ A variation of this technique involves advancing the over-the-wire balloon or Transit catheter into the perceived extraluminal space and then injecting <2 mL of contrast to confirm being in the subintimal space before advancing the wire distally.¹⁴ In retrograde cases, a reverse STAR method can also be used (Figure 4).

The retrograde approach can be an elegant solution to a stubborn CTO. The CART technique brings together elements of many of the previously discussed techniques. Using a soft .014-inch hydrophilic wire and a Transit catheter, the collateral circulation is negotiated with the eventual desire to place the wire across the distal CTO (Figure 5). The Transit catheter should be advanced as far as possible into the collateral circulation so that the wire can be exchanged for a stiffer wire if needed to cross the CTO. Intermittent, <2 mL test injections can be performed to verify position during the retrograde approach. Occasionally, the wire will cross the CTO without difficulty. In such cases, retrograde passage and inflation of sequentially larger balloons can be used to predilate the lesion such that antegrade efforts can be undertaken. Obviously, if retrograde passage into the CTO is not possible, the CART technique can be used by entering into the subintimal plane.¹⁵ With the retrograde wire subintimal and across the CTO, a small over-the-wire balloon can be advanced and then inflated subintimally to create a small dissection. An antegrade wire can then be placed into the dissection plane and brought into the true lumen distal to the CTO and alongside the retrograde wire (Figure 6).

NEW CTO DEVICES OR AUXILIARY EQUIPMENT

One of the issues in crossing CTOs in the US is that smaller diameter balloons are sometimes available in Europe and Japan, but are not approved for use on this side of the Atlantic. Invatec, Inc. (Bethlehem, PA), as well as other companies in Japan and Europe, make 1.25-mm or even 1-mm balloons. These balloons make it possible to cross otherwise uncrossable lesions, or to use them in a retrograde fashion when performing the CART technique.

One common issue with wires is that one wire is not stiff enough to cross the lesion, requiring an abandonment of position in the vessel to pass another wire. An alternative to this, would be to use wires inside wires. We have designed some wires within wires (wire-in-wire technique), with which it is possible to go in with an initial wire and, if it crosses, there is no need for further intervention. If it does not cross, this wire is hollow and allows for the passage of a second, or even third, wire. These wires could be connected to RF energy or they could be used with variable stiffness (Figures 7 and 8).

We have been using support balloons; however, the support balloons that are currently available tend to be too stiff, too long, and therefore, are not ideal. The other problem with the support catheters is that there is a possibility that dissection can occur due to the barrel trauma of the balloon. We have obviated this with a new, short balloon that we have built as a prototype (Figures 9 through 14). These support balloons may make it possible for us to more easily and more aggressively pass stiffer and stiffer wires across CTOs.

CONCLUSION

The techniques discussed in this article are used in the majority of CTO recanalization efforts at our center.

Worldwide, leaders in the field of CTO use strategies with which they are most comfortable and have had the most success to date. Because all centers differ with which equipment they are equipped and permitted to use, it is important to share information on a global scale such that continued progress can be made. Clearly, the techniques for PCI of CTO are improving, as is the technology to perform such elegant procedures. It is exciting to consider the future of CTO recanalization, when increasingly smaller equipment is available and our ability to traverse the tiniest of collaterals unthwarted is a reality and is routinely possible to perform. ■

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