

# Guidewire Selection in Critical Limb Ischemia: Road Map to Success

Strategies for wire escalation and techniques to successfully cross and treat chronic total occlusions.

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Critical limb ischemia (CLI), characterized by nonhealing extremity ulcers and rest pain, represents the most severe form of peripheral artery disease (PAD). Patients diagnosed with CLI are often faced with the grim prospect of limb amputation.<sup>1</sup> Those who undergo limb amputation often have a morbid prognosis with high 1-year mortality. CLI involves a variety of complex pathologies and is technically challenging to treat, requiring interventionists to be familiar with a variety of tools and techniques. Patients with CLI often present with multilevel disease extending both above and below the knee, chronic total occlusions (CTOs), and calcified arteries and lesions, which adds complexity to the case.<sup>2</sup>

The PRIME registry<sup>3</sup> is the first CLI registry in the United States with the primary goal of understanding disease patterns in CLI patients. This registry recently examined the demographics of the first 328 patients and showed that 51% of the lesions were categorized as CTOs, 30.3% of the population had isolated below-the-knee lesions (eg, tibials), and 45.2% of the population had multilevel disease (ie, above- and below-the-knee lesions). To manage this complex pathology, a thorough understanding of wire characteristics provides a foundation for the endovascular interventionist to personalize care and develop an algorithm for success. A wide range of guidewires are available to interventionists. Length, diameter, gram strength, and hydrophilic coating are important wire characteristics that should be taken into account when crossing a lesion. This article presents a few strategies for wire escalation as well as techniques to successfully cross and treat CTOs encountered when treating patients with CLI.

## LENGTH

Typical wire lengths are 180 and 300 cm. A simple adage to keep in mind is: You can't go wrong with long. This implies that using a 300-cm wire leaves the option to use any device off the shelf regardless of the disease location and access site. However, a shorter wire requires the lesion to be close to the access site or could require rapid exchange of equipment. For example, a right external iliac lesion can be effectively treated with a short wire (180 cm) with right common femoral artery access. On the other hand, a longer wire (300 cm) is needed to effectively treat a mid-left anterior tibial artery lesion from a contralateral retrograde right common femoral artery access.

## DIAMETER

The most common wire diameters are 0.014, 0.018, and 0.035 inch. Typically, smaller-diameter wires (0.014 and 0.018 inch) are used below the knee, and any diam-

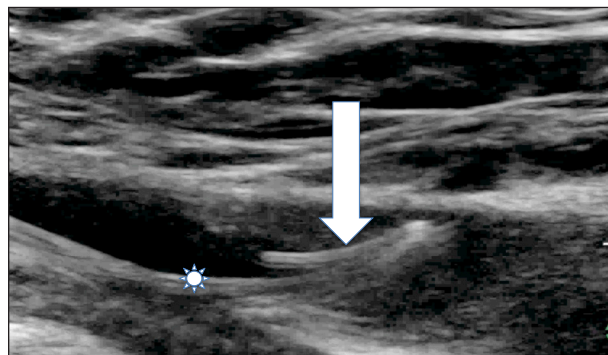


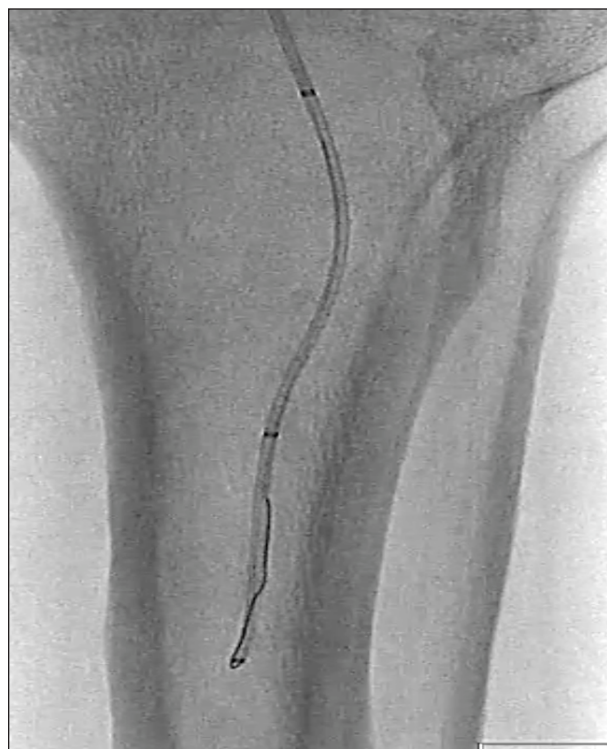
Figure 1. Ultrasound image showing the wire (arrow) wrapped around the catheter (asterisk).

eter wire (0.014, 0.018, and 0.035 inch) can be used above the knee. Larger-diameter wires provide more support in crossing calcific CTOs and delivering treatment devices to their intended location (ie, 0.018 and 0.035 inch). It is important to keep in mind that larger-diameter wires are not benign, and dissections and perforations resulting from these wires are larger and more severe. Subintimal cannulation commonly occurs with a 0.035-inch wire and may warrant an alternative approach to cross the lesion (eg, retrograde) and/or the use of a reentry device. Smaller-diameter wires (0.014 and 0.018 inch) can be used just as effectively as larger wires for crossing and support. In fact, they can support larger-diameter devices and may be a safer alternative. Additionally, for extraluminal crossing, it is easier to pull a smaller-diameter wire back into true lumen and redirect without entering the false lumen again. Smaller-diameter wires are also better at finding and crossing microchannels than larger wires, which tend to bend and loop on themselves.

With respect to devices available for crossing and treatment, virtually all are able to go over a 0.014-inch guidewire. Careful attention is recommended when using an 0.014-inch wire looped on a 0.035-inch crossing catheter to avoid distal embolization. When the case necessitates escalating to a 0.018-inch wire, approximately one-third of devices can no longer be used. Similarly, escalating further to a 0.035-inch wire leaves few devices available for crossing and treatment. Compatibility of treatment devices with size of wire is an important consideration, and a wire should be carefully selected to fit the pathology of the lesions being treated.

### WIRE TIP STRENGTH (GRAM STRENGTH)

Wires have a variety of tip strengths. Floppy-tipped wires (< 1 g) are used to cross nonocclusive blockages or traverse through a collateral to prevent trauma to the vessel. Stronger-tipped wires (ie, 3–40 g) are used to cross CTOs. Plaque morphology of the CTO helps determine which stronger-tipped wire to use. For example, if the plaque is heterogeneous, a 3- to 18-g wire may suffice. However, if the plaque is calcific, a 25- to 40-g wire may be warranted to traverse through the lesion. On occasion, if the interventionist knows the spatial location of the wire and is unable to cross a lesion, a 650-g tip (back end of an 0.018-inch wire) may be needed to successfully cross the occlusion. Additionally, the interventionist can increase the tip strength almost fourfold by bringing a support catheter within 10 mm from the tip of the wire. Wires with higher gram strength are not benign and should be used with extreme care.



Courtesy of J.A. Musapha, MD.

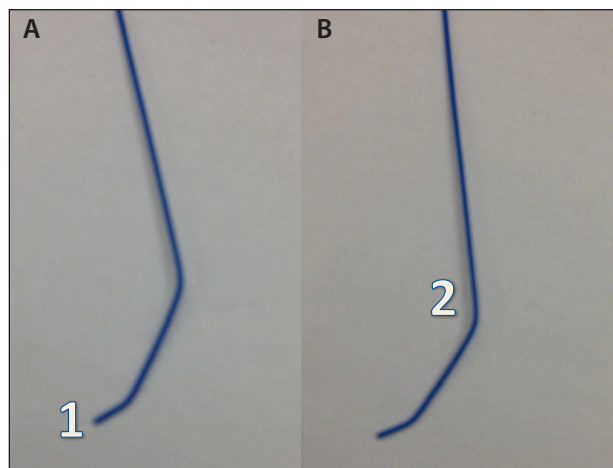
**Figure 2.** Fluoroscopic image of the controlled loop dissection technique crossing a peroneal CTO in an antegrade fashion.

### WIRE COATING

Wires may have hydrophilic coatings to help penetrate microchannels or slide through tight lesions. Hydrophilic coatings may sacrifice tactile sensation to slide through lesions with ease. The coating on these wires may swell after prolonged time within the body and can lead to difficulty moving devices over the wire. Therefore, it is important to work quickly with these wires and/or switch them out when the lesions have been crossed. Noncoated wires are used in a rotating fashion to help drill through the caps of CTOs. Of note, noncoated wires are typically used with atherectomy devices instead of hydrophilic wires because hydrophilic wires tend to stick to the devices, and the forces generated by atherectomy devices tend to shear off the polymer coating.

### WIRE ESCALATION

Appropriate recognition of CTOs can influence guidewire selection. A systematic approach of pairing appropriate wires with techniques can optimize success and improve efficacy of treatments and minimize complications. A combination of CTO wires should be used in conjunction with a systematic approach to wire escalation. For example, a nonhydrophilic wire that is 300-cm long, has a 0.014-inch diameter, and an



**Figure 3.** The double-bend strategy, showing primary (A) and secondary (B) bends.

18-g tip is used first. If unsuccessful, this can be escalated to a hydrophilic wire of the same size and gram strength. Next, a 30-g nonhydrophilic wire would be appropriate. Finally, the back end of an 0.018-inch nonhydrophilic wire (650-g tip) can be used.

### COMPLEMENTARY DEVICES AND TECHNIQUES

There are several devices that complement wire crossing in CTOs. The first is the Spinr high-performance guidewire controller (Merit Medical Systems, Inc.), which cinches on the end of the wire and rotates the wire five times in a clockwise and then counterclockwise direction with a trigger mechanism. This movement decreases orthogonal friction, allowing the wire to traverse a long total occlusion with ease. Support catheters are important for wire support and can be used to increase the gram strength of the wire up to fourfold. Once the CTO wire crosses, the support catheter is used to inject dye and confirm true vessel entry. If it is not possible to cross the proximal cap of a CTO with a wire, a laser fiber can be used to cross the proximal cap of a CTO using the step-by-step technique. Once past the proximal cap, the wire is extended to cross the rest of the occlusion. The last device is extravascular ultrasound, which can be used to traverse CTOs by observing the outline of the vessel and manipulating the wire across the lesion (Figure 1).

There are some integral techniques that each interventionist should master to successfully cross CTOs. The first is the wrapping wire technique. Wires have a natural affinity for each other and tend to cross talk. This technique is especially useful in flush occlusions. Crossing the CTO from a retrograde location allows

visualization of where the artery originates. A second wire can be taken from the antegrade access and wrapped around the retrograde wire to successfully cross from above.

The double-balloon technique, also known as the finger of god or CART technique, is used to successfully bring two wires into a common lumen when in two different subintimal planes. One balloon is traversed from a retrograde fashion, and a second balloon is traversed from an antegrade fashion in the CTO. The balloon tips approximate each other and are inflated simultaneously, which results in fenestration of the lumens such that the retrograde wire can enter the same lumen as the antegrade wire.<sup>4</sup> The retrograde wire can then be advanced through the CTO. Once out of the CTO, the wire is externalized through an angled catheter in a flossing fashion. To do this, the interventionist must understand that a radiographic image is a two-dimensional image in a three-dimensional world. To successfully place the wire into the catheter without a snare, an angled catheter is pointed in the same direction as the angle on the wire. This serves as a guide to triangulate the position of the devices. The wire is then advanced into the catheter and externalized.

The controlled loop dissection technique is another useful strategy for crossing CTOs. A benign (< 3-g tipped, 0.014/0.018-inch wire) wire wraps around the tip of the catheter (0.018 or 0.035 inch). Figure 2 shows a fluoroscopic image of the controlled loop dissection technique crossing a CTO in an antegrade fashion. The controlled loop dissection technique uses a workhorse wire in an antegrade or retrograde fashion. The helical wrapping will maintain a relatively small profile of the wire/catheter combination, which will allow for controlled advancement of the wire/catheter combination, minimizing the size of the subintimal space. With the controlled loop dissection technique, the operator must be prepared to create subintimal recanalization of the CTO. The retrograde controlled loop dissection technique may be more forgiving because the dissection is retrograde in nature.

Another technique for crossing CTOs requires the use of the tip of the wire. Physicians use a heavy-gram-tipped wire to penetrate the CTO cap and navigate the course of the vessel. The operator may choose to use an angled or straight support catheter. A double-angled bend is created at the tip of the wire (Figure 3), which allows the wire point to penetrate the calcified, resistant CTO cap. The primary bend engages the CTO cap, while the secondary bend controls the direction of wire advancement. A triaxial system is used to support

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the wire, starting with a braided 5- to 7-F sheath and placing a 0.035-inch support catheter inside it, followed by placing a 0.014- or 0.018-inch lumen catheter within the 0.035-inch catheter. This triple layer supports a 0.014-inch CTO wire and directs the kinetic energy delivered from the physician's hand to the wire tip. It is important to maintain a short distance (5–7 mm) between the CTO wire tip and the most inner supporting catheter of the triaxial system. For longer distances, the wire tends to buckle and wire support is lost.

## CONCLUSION

There are many technical challenges in treating a patient with CLI. Successful revascularization can be limb saving for many patients and requires knowledge of patient anatomy, potential pathology, and proficiency with a variety of devices and techniques. CTOs and calcific lesions are often the most difficult to treat and require experience and a systematic approach that includes appropriate wire selection and escalation to maximize the possibility of procedural success. ■

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