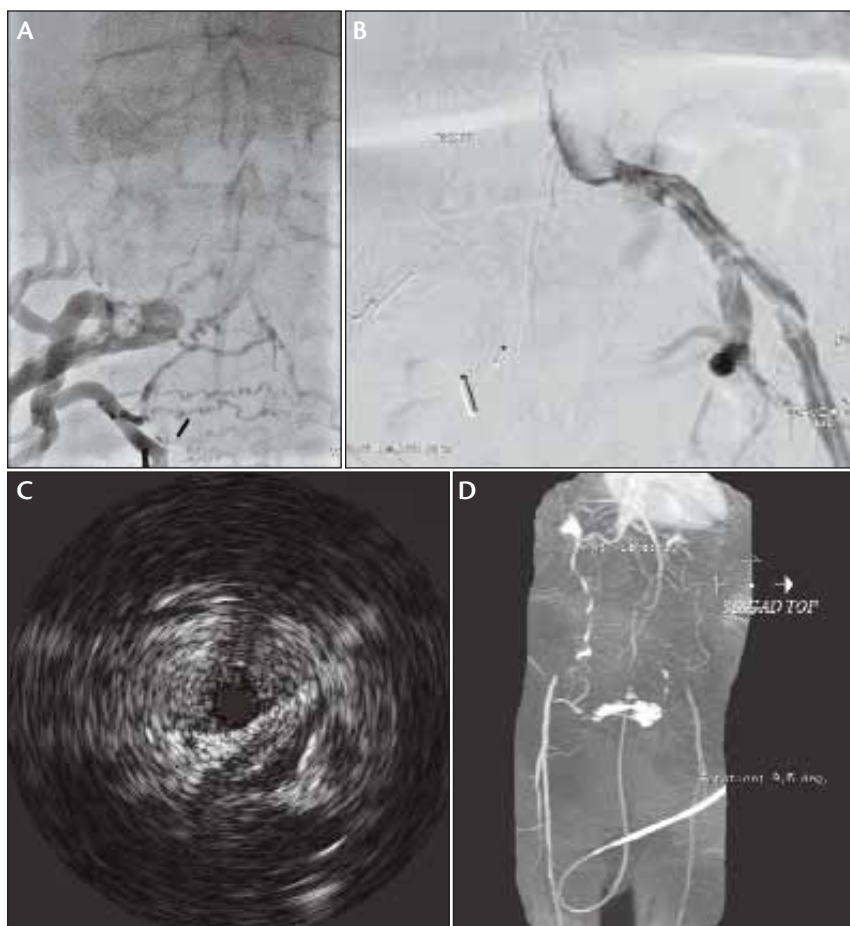


# CTOs: What Not to Do

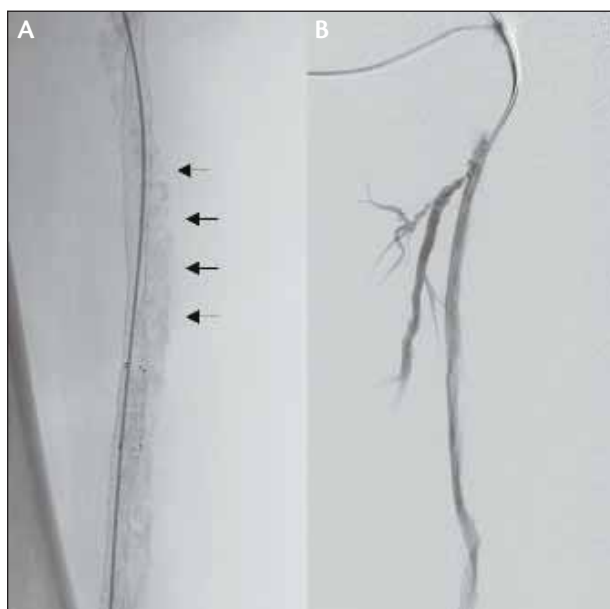
Recognition of potential technical problems can help produce favorable outcomes and a more widespread dissemination of endovascular therapies.

BY ADAM ZYBULEWSKI, BA; JOHN H. RUNDBACK, MD; AND STUART MILLER, MD

**C**hronic total occlusions (CTOs) of lower extremity arteries are a common occurrence in patients who have been diagnosed with peripheral arterial disease. The TransAtlantic Inter-Society Consensus (TASC) II guidelines classify CTOs of the femoropopliteal arteries and proximal trifurcation vessels as TASC II type C or D.<sup>1</sup> Although surgery has been the traditional recommendation for the treatment of TASC II type C and D lesions, there have been a number of developments in endovascular technology and techniques, such as subintimal recanalization, which have made the traversal of lower extremity CTOs viable by endovascular means. Because successful recanalization rates of up to 97% have been achieved in limbs with TASC II type C and D occlusions of the femoropopliteal arteries, there is convincing evidence for endovascular intervention as the primary form of treatment for CTOs of the lower extremity arteries.<sup>2</sup> Although low morbidity and mortality rates are associated with endovascular intervention, there are a number of technical errors that should be avoided when managing a patient



**Figure 1.** An aortic occlusion referred for endovascular treatment. Multiple attempts at recanalization from both femoral approaches (A, B) did not result in successful re-entry into the patent aortic lumen. Intravascular ultrasound (IVUS) also did not show any area of patent arterial flow (C). Subsequent imaging (D) showed a long-segment infrarenal aortic CTO not amenable to percutaneous recanalization. With advance knowledge of this pattern of disease, an axillary approach for thrombolysis would have been used.



**Figure 2.** Subintimal recanalization of a densely calcified femoral CTO. Although successful re-entry could be obtained, the vessel wall calcification (arrows, A) deforms the stent and compromises the patency of the subintimal lumen (B).

with CTO of the iliac, femoropopliteal, and tibioperoneal arteries (Table 1).

There are two primary strategies for CTO crossing: intraluminal and subintimal. Intraluminal passage (ie, through the plane of the plaque-filled or chronically thrombosed arterial lumen) can be difficult. In these

cases, recanalization success has been achieved with catheter and guidewire techniques as well as specialized devices, including the Frontrunner XP catheter (Cordis Corporation, Warren, NJ), the Crosser catheter (FlowCardia, Inc., Sunnyvale, CA), and the SafeCross catheter (Spectranetics Corporation, Colorado Springs, CO). Blunt microdissection technique using the Frontrunner XP catheter provides the operator with more pushability and control than traditional 0.035-inch guidewires. Despite its large size (0.039 inches closed and 2.3 mm open), the Frontrunner XP has also had some success in crossing CTOs of the tibioperoneal vessels.<sup>3</sup>

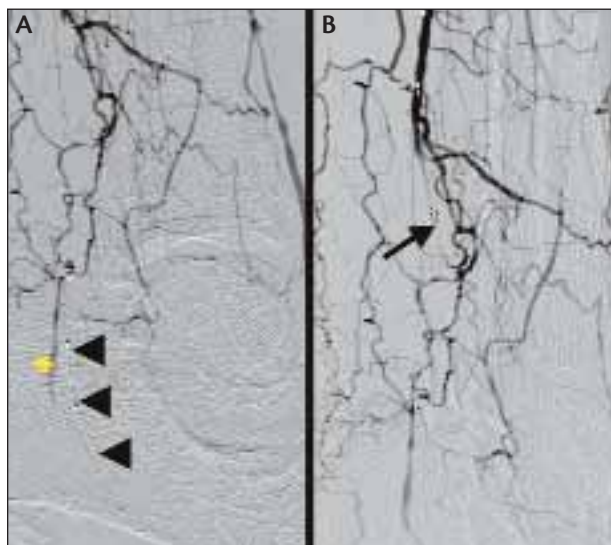
Subintimal recanalization involves the intended or intraprocedurally occurring creation of a tissue plane within the arterial wall, with re-entry into the patent arterial lumen at the point of reconstitution beyond the occlusion that is being treated. Subintimal techniques have provided a breakthrough strategy, expanding the utilization of endovascular procedures for CTOs.

#### FAILURE TO PLAN EFFECTIVELY

A complete preinterventional vascular assessment is critical for procedure planning. Preprocedural knowledge of each patient's unique vascular anatomy is important for determining whether an endovascular strategy is possible (Figure 1). In addition, pretreatment planning allows for the selection of the most appropriate puncture site. For example, a steep aortic bifurcation or previous iliac stenting may indicate the need for an ipsilateral common femoral artery puncture as opposed to a contralateral



**Figure 3.** Inadvertent extraluminal recanalization of a femoropopliteal CTO. Despite successful re-entry into the popliteal artery (curved arrows, A, B), there is extravasation of contrast (C). Although the vessel rupture was promptly treated with a stent graft (D), the patient subsequently needed a fasciotomy for severe compartment syndrome.



**Figure 4.** Perforation of the distal posterior tibial artery during attempted CTO recanalization. The wire and micro-catheter (arrowheads) are outside the opacified inframalleolar posterior tibial artery (asterisk) (A). The perforation was successfully coil embolized (arrow), and the anterior tibial artery was subsequently revascularized without further complication. Prompt recognition and treatment of the arterial injury prevented serious clinical sequelae (B).

one when planning recanalization of a femoropopliteal CTO. Proximal and distal levels of the occlusion, as well as the exact pattern of the disease and collaterals, should also be obtained to properly choose an intraluminal or subintimal strategy for the traversal of the lesion. For example, dense femoral calcification can serve as a relative contraindication for subintimal stenting because this can affect the eventual result (Figure 2). Revascularization should be planned to limit collateral compromise, particularly when using stent grafts, so as to avoid catastrophic ischemia in the event of interventional failure or reocclusion.

### AVOIDING EXTRAVASATION IN PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY

The most critical component of attaining successful revascularization of the vessel is traversal of the occlusion. Coaxial catheter systems and low-profile (0.014 to 0.018 inch) specialty wires have been developed to maximize device control during lesion passage. Hydrophilic wires, such as the Glidewire (Terumo Interventional Systems, Somerset, NJ), are particularly useful but should be used with caution when desiring an intraluminal strategy due to an intrinsic tendency to create a subintimal dissection plane. In some cases, increasing the guidewire

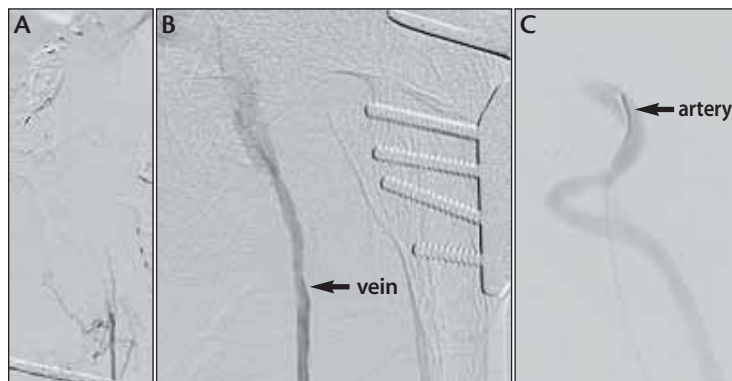
to 0.035 inches can provide the operator with greater torque response and forward pushability when traversing resistant segments of an occlusion. Avoiding excessive forward pressure is important for preventing unintentional extraluminal passage of the guidewire into the perivascular space or fascial planes. If this occurs, it may be difficult or impossible to regain an intraluminal position for traversal of the lesion. Although guidewire perforations will generally seal, the unrecognized passage of a catheter or balloon outside of the artery may result in serious extravasation and/or compartment syndrome (Figure 3). Therefore, prompt recognition of extraluminal positioning is important so that the arterial channel can be coil embolized if needed (Figure 4).

### AVOIDING COMPLICATIONS DURING SUBINTIMAL TRAVERSAL OF THE CTO

To facilitate the traversal of longer lesions, a subintimal tract is frequently created. Generally, safe subintimal passage is achieved through the advancement of a hydrophilic 0.035-inch guidewire into and through the subintimal space adjacent to the occlusion while maintaining a tight, J-shaped loop with the guidewire. A catheter—usually a 4-F angled hydrophilic catheter—is also advanced along with the guidewire. Subintimal angioplasty has been deemed technically successful in 87% (n = 439) of cases when occlusion affected the superficial femoral artery (SFA), popliteal, and tibial arteries, with slightly higher technical success rates observed in the treatment of popliteal and tibial arteries. The most common complication was perforation of the arterial wall, which occurred in 3% (n = 15) of cases.<sup>4</sup> The utilization of oblique images can minimize the number of passes for successful re-entry and also ensures that the guidewire remains in the subintimal space and does not perforate the vessel, causing extravasation.

**TABLE 1. FIVE MISTAKES TO AVOID DURING CTO RECANALIZATION**

1. Too-distal re-entry, particularly converting an above-the-knee occlusion into a below-the-knee revascularization.
2. Extraluminal wire passage and extravasation.
3. Collateral compromise.
4. Lack of preprocedural vascular imaging for treatment planning.
5. Lack of multiple oblique imaging when subintimal arterial re-entry is performed.



**Figure 5.** Unintended entry into the femoral vein during retrograde recanalization of a proximal femoral CTO with the Pioneer catheter (Medtronic, Inc.) (A). Flow was identified on the IVUS image, but because the Pioneer catheter was too proximal (eg, not positioned beyond the point of the patent artery), the Pioneer cannula was advanced into the vein (B). There was eventual redirection into the proximal common femoral artery allowing satisfactorily restored flow (C).



**Figure 6.** Successful distal re-entry beyond an SFA CTO. Although the point of re-entry in this case was above the knee, optimal re-entry would have been at the most proximate portion of the patent SFA (arrowhead).

Successful subintimal revascularization is dependent on the effective traversal of the lesion with re-entry into the true lumen at the most proximal, disease-free portion of the vessel. Subsequent balloon angioplasty is then performed to establish antegrade flow through the newly created lumen.

A too-proximal re-entry into the vessel will not achieve effective traversal of the lesion and will not allow for effective balloon angioplasty to achieve revascularization. Re-entering

the true lumen too distal to the occlusion can present a number of problems for revascularization. A too-distal re-entry potentially compromises patency, may limit surgical options for treatment, and can compromise collaterals in the intervening patent segment. For example, the geniculate collaterals may be compromised when re-entering the vessel below the knee in a patient with

above-the-knee occlusive disease. It is important to review preprocedural vascular imaging, as well as to obtain delayed angiographic images, to ascertain the actual point of reconstitution through collaterals to prevent overestimation of the lesion length.

## RE-ENTRY DEVICES

Failure to re-enter the true lumen presents the most significant compromise to the technical success of subintimal angioplasty, whereas failure to enter the subintimal plane, cross the lesion, or establish an antegrade flow after balloon angioplasty have a less significant impact on technical success.<sup>4</sup> If the true lumen cannot be re-entered through the use of a hydrophilic 0.018- or 0.035-inch guidewire and a 4-F angled catheter, a re-entry device is often utilized to assist in true lumen re-entry.

There are two devices currently available for this purpose. The Outback LTD re-entry catheter (Cordis Corporation) uses a single-wire lumen and a directionally controlled, deployable, distal 27-gauge needle (extendable cannula) for re-entry, through which a 0.014-inch guidewire is passed into the disease-free vessel segment. The Pioneer catheter (Medtronic, Inc., Minneapolis, MN) has two wire lumens (one of which is monorail) and is equipped with IVUS, which is capable of obtaining an image of the vessel wall for identification of blood flow in the true lumen using the color-flow feature.<sup>5</sup> The integrated re-entry needle is then guided to the point of visualized flow. When utilizing the IVUS color-flow feature, it is important to obtain multiple orthogonal images and use the plaque as a guide to avoid extravasation and the unintended puncture of a neighboring vein. An early evaluation of the Outback LTD catheter for use in crossing chronic segmental occlusions of the SFA and popliteal artery showed effective recanalization in eight out of 10 patients, with failure in cases when heavily calcified vessels obstructed rotation of the catheter.<sup>6</sup>

It is important to accurately determine the true distal extent of the occlusion when using the re-entry catheters to avoid re-entering the lumen either too distally or too proximally. A 0.014-inch guidewire needs to be advanced into the subintimal space to approximately 1 cm beyond the point of reconstituted arterial patency to allow positioning of the re-entry cannula lumen adjacent to the re-entry site. With the Pioneer catheter, if the device is too proximal and is not positioned adjacent to the distally patent arterial lumen, there can be inadvertent IVUS-guided recognition of and cannula re-entry into accompanying veins (Figure 5).



A too-distal re-entry should be aggressively avoided (Figure 6). The creation of a subintimal dissection plane too distally beyond the point of restored arterial patency results in extension of the occlusion and collateral compromise, which can jeopardize patency and risk worsening ischemia. A major potential error is extension of an above-the-knee CTO by re-entering the patent popliteal artery at or below the knee joint. This not only affects patency, but more importantly, it dramatically reduces surgical options for bypass. In the event that re-entry cannot be achieved at a more proximate reconstituted patent segment, either the subintimal tract should be coiled to allow a redirected attempt at re-entry, or the patient should be considered for a different approach. For poor surgical candidates, a retrograde transpopliteal approach has been utilized.<sup>7</sup>

## CONCLUSION

Catheter-based techniques for CTO revascularization are extremely promising and will continue to grow. As with all procedures, careful attention to technical detail is important for optimal success. Although CTOs can be successfully treated in most cases, recognition of potential technical pitfalls can help ensure reliably favorable outcomes and a more widespread adoption of endovascular strategies. ■

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