Journal of the American Heart Association

EDITORIAL

# Crossing Peripheral Chronic Total Occlusions: More Tolls and More Questions

J. Antonio Gutierrez, MD, MHS; Manesh R. Patel, MD

Femoropopliteal chronic total occlusions (FP-CTOs) are encountered in 40% to 50% of patients presenting for endovascular management of symptomatic peripheral artery disease.[1] Because of their ubiquity, the technical skills for navigating these lesions are required by all interventionalists who perform peripheral procedures. However, even with experienced clinicians, a long occlusion with a heavy calcium burden can make crossing an FP-CTO challenging, which is why they are associated with a crossing failure rate as high as 30%.[1] For this reason, both meticulous patient selection and procedural planning are key for a successful FP-CTO crossing.[2]

See Article by Tomoi et al.

## AN ALGORITHMIC APPROACH

Several techniques have been described for crossing FP-CTOs. Knowing not only how, but also when, to use them is crucial. For this reason, an algorithmic approach akin to what is used in the coronary CTO landscape is recommended, as it can yield success rates as high as 90%.[3,4] Presently, an evidenced-based algorithm has been developed by a multidisciplinary group of expert FP-CTO operators, representing the fields of interventional cardiology, vascular surgery, and interventional radiology, which allows interventionalists to use the optimal FP-CTO crossing strategy based on intraprocedural findings.[1] This algorithm centers on careful assessment of the following lesion characteristics: proximal and distal cap morphological features, segment length, calcium burden, and target vessel quality.[5] These components will influence decision making on approach (antegrade, retrograde, or both), vascular access (radial, femoral, and/or pedal), and crossing technique (guidewire escalation versus dedicated device). Last, how the lesion is crossed and the level of trauma delivered to the target vessel will dictate final treatment strategy used (ie, angioplasty versus stent).

## CROSSING STRATEGIES AND TECHNIQUES

Ultimately, the crossing of an FP-CTO, whether antegrade or retrograde, will fall under 1 of 2 categories, intraluminal or subintimal approach (IA or SA, respectively). The former may focus on wire escalation and/or dedicated crossing devices, whereas the latter often incorporates use of subintimal dissection and reentry strategies, many of which were adapted from the coronary CTO space and are often considered "advanced" techniques. These include but are not limited to the following: subintimal tracking and retry, advancement of a knuckled, tight-looped, polymer-jacketed wire via the subintimal plain at the occlusion site until distal reentry into the true lumen is achieved; limited antegrade subintimal tracking, similar to subintimal tracking and retry but reentry into the lumen occurs in close proximity to occlusion; controlled antegrade and retrograde subintimal tracking, involves balloon inflation in the true lumen with advancement of a guidewire in the subintimal plan from the opposite direction into the

**Key Words:** Editorials ■ chronic total occlusion ■ endovascular treatment ■ intravascular ultrasound

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

Correspondence to: Manesh R. Patel, MD, Duke University Health System, 2301 Erwin Rd, Durham, NC 27710. E-mail: manesh.patel@duke.edu

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*JAHA* is available at: www.ahajournals.org/journal/jaha

true lumen; and last, subintimal arterial flossing with antegrade-retrograde intervention, refers to retrograde subintimal recanalization into an antegrade catheter proximal to the occlusion.[6,7] However, going through or around an FP-CTO can often be a matter of chance and not by choice. For this reason, many procedures that start off with an intraluminal wire escalation approach are pivoted to a hybrid approach. It is this flexibility that is considered one of the key factors in obtaining high CTO crossing success rates.[8]

## INTRALUMINAL VERSUS SUBINTIMAL APPROACH TO CTO CROSSING

Studies have demonstrated that with experienced operators, coronary CTO crossing rates using IA and SA can be comparable, 93% versus 94%, respectively (*P*=0.43).[9] The subintimal space is frequently used in the setting of more complex lesions that often require treatment with longer and/or more stents. This may be the reason why long-term outcomes tend to favor the intraluminal techniques. For example, a meta-analysis comparing IA versus SA for coronary CTO crossing found dissection and reentry methods to be associated with higher rates of 1-year target vessel revascularization (relative risk [RR], 1.61; 95% CI, 1.29–2.01), in-stent restenosis (RR, 1.62; 95% CI, 1.26–2.10), and myocardial infarction (RR, 1.59; 95% CI, 1.06–2.04).[10] These trends appear to be mirrored in the peripheral arteries. Most studies comparing IA and SA techniques for FA-CTO crossing during the past 2 decades are retrospective and come from single-center experiences. One of the few contemporary multicenter studies to evaluate these methods comes from ELLA (Korean Vascular Intervention Society Endovascular Therapy in Lower Limb Artery Diseases Registry). This study of 461 patients found increased crossing success rate associated with SA when compared with IA, 95.1% versus 89.8%, respectively (*P*=0.04). Primary patency rates were similar at 1 year between SA (67.5%) and IA (73.4%), *P*=0.09.[11] For the most part, long-term patency rates in the peripheral arteries are lower than those seen in coronary arteries and likely explained by the fact that patients with peripheral artery disease often have greater number of comorbidities than their counterparts with coronary artery disease.[12]

## THE IVORY REGISTRY

In the current issue of the *Journal of the American Heart Association* (*JAHA*), Tomoi et al present a prospective observational cohort study from the IVORY (Intravascular Ultrasound-Supported Endovascular Therapy in Superficial Femoral Artery Disease Prospective Multicenter) registry, shedding light on clinical outcomes following intraluminal versus subintimal approaches for crossing FP-CTOs.[13] In total, 500 patients across 33 Japanese centers were enrolled in the study. Of these patients, 433 (86.6%) underwent an IA for FP-CTO crossing and 67 (13.4%) underwent an SA. One-year follow-up was modest, occurring in 389 patients (77.8%). In terms of the overall population, patients treated via the SA were less likely to have a history of chronic heart or renal failure but had a higher percentage of the inter-society consensus for the management of peripheral artery disease (TASC) II class C or D lesions and only 1- or 2-vessel below-the-knee runoff. For definitive treatment, both cohorts saw high rates of stent implantation, IA (85%) and SA (91%). However, the use of more novel therapies, such as atherectomy or paclitaxel-coated devices, was low. The primary end point was 1-year incidence of restenosis, and key secondary end points included all-cause mortality and major adverse limb events (defined as reintervention or major amputation). After implementing propensity score matching, both IA and SA demonstrated similar 1-year restenosis rates of 43.4% and 41.0% (*P*=0.40), all-cause mortality of 8.7% and 9.4% (*P*=0.68), and major adverse limb events of 15.0% and 19.1% (*P*=0.83), respectively.

The present study is unique in that it adds to a limited body of evidence on use of intravascular ultrasound (IVUS) in the setting of peripheral vascular intervention (PVI). Clinical end points were also assessed according to wire passage (intraluminal versus subintimal) route, which were confirmed via IVUS. Following propensity score matching, both intraluminal and subintimal wire passages found similar 1-year restenosis rates of 40.8% and 48.2% (*P*=0.40), all-cause mortality of 8.6% and 5.5% (*P*=0.70), and major adverse limb events of 17.6% and 18.8% (*P*=0.55%), respectively. A major takeaway from these findings is that both an intraluminal and subintimal approach, regardless of whether wire passage occurs through the plaque itself, appears to yield similar long-term results in the periphery.

## A POTENTIAL ADDITION TO THE FP-CTO ALGORITHM

As previously mentioned, many techniques developed in the coronary CTO space have been applied and/or adapted for FP-CTO. To that effect, the authors should be commended for the use of IVUS in the peripheral arena. Evidence is mounting that use of intravascular imaging optimizes percutaneous coronary intervention and is associated with improved clinical outcomes.[14] Perhaps IVUS guidance is the next logical step in the evolution of PVI. Potential areas where IVUS may provide an advantage over angiography alone include the following: (1) identification of calcific burden to guide adjunct therapies, such as atherectomy or intravascular lithotripsy; (2) detection of arterial dissections requiring stenting; and (3) evaluation of appropriate stent expansion and apposition. Currently, evidence on the utility of IVUS-guided therapy in the peripheral space is both limited and unclear. For example, a recent meta-analysis of 8 observational studies found similar long-term primary patency rates among IVUS-guided and non–IVUS-guided PVIs.[15] However, this was composed of only 1733 IVUS-guided PVIs, of which nearly 75% of these presented with either critical limb ischemia or acute lime ischemia. Furthermore, there was a significant amount of variability on anatomic location, TASC classification, and use of atherectomy or paclitaxel-coated devices. As such, clinical findings from such a heterogeneous cohort make it difficult to draw any firm conclusions in terms of guiding clinical practice.

## CONCLUSIONS

The landscape for endovascular management of peripheral artery disease has witnessed tremendous growth over the past decade in terms crossing techniques, definitive treatment strategies, and postprocedural medical therapy. Despite these advances, the present study by Tomoi et al adds to the paucity of data on optimal long-term strategies across a large spectrum of disease that encompasses peripheral artery disease. The present study serves as a reminder for the need to marry established FP-CTO crossing algorithms with treatment strategies. Many of these latter strategies, such as the use of IVUS guidance to optimize PVI, require prospective randomized controlled trials so they may be incorporated into consensus guidelines and provide clinical guidance for providers.

## ARTICLE INFORMATION

### Affiliations

Division of Cardiology, Duke University School of Medicine, Durham, NC (J.A.G., M.R.P.); Durham VA Medical Center, Durham, NC (J.A.G.); and Duke Clinical Research Institute, Durham, NC (J.A.G., M.R.P.).

### Disclosures

Dr Patel reports advisory board/research grants from Bayer, Janssen, Heartflow, and Novartis. Dr. Gutierrez discloses the following relationships - consulting Janssen Pharmaceuticals, Amgen Inc, and Medicure Inc; research funding - Veterans Health Administration Career Development Award.

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