Coronary Chronic Total Occlusion

John M. Galla, MD, Patrick L. Whitlow, MD*

KEYWORDS

• Coronary artery disease • Coronary intervention
• Chronic total occlusion

Chronic total coronary occlusions (CTOs) are a frequent finding in patients with coronary disease and when clinically indicated, remain one of the most challenging target lesion subsets for intervention. Comprised of a combination of fibrocalcific and thrombotic elements, CTOs have been reported in approximately one-third of patients undergoing diagnostic coronary angiography.[1] By nature of their complexity, CTO percutaneous interventions (PCI) are associated with lower rates of procedural success, higher complication rates, greater radiation exposure, and longer procedure times compared with interventions in non-CTO stenoses. Despite these obstacles, reported benefits of successful CTO PCI include a reduction in symptoms and improvement in both ventricular function and survival.[2–5]

Defined angiographically as a complete occlusion—thrombolysis in myocardial infarction (TIMI) grade 0 or 1 antegrade flow—the chronicity to qualify as lesion as a CTO has ranged from 1 to 3 months. A universal CTO classification system has recently been proposed that grades lesions on both the technical challenges of and risk associated with attempted recanalization.[6] Factors associated with higher success of recanalization include a stem of patent vessel longer than 10 mm, no branches within 5 mm of the occlusion, a tapering configuration or visible track through the lesion, and no evidence of calcification on fluoroscopy. A CTO occurring at the coronary ostium, at a bifurcation point, with significant calcification, or a long lesion evidenced by retrograde filling of the distal vessel all portend a high level of difficulty with a reduced likelihood of success. The risk of adverse outcomes during attempted percutaneous revascularization is highest for patients with bridging collateral vessels and aneurysmal appearance at the point of occlusion. Consideration of the technical challenges of recanalization and the risk associated with attempted reopening are valuable when planning CTO PCI.

APPROACH TO PERCUTANEOUS CORONARY INTERVENTION OF CHRONIC TOTAL OCCLUSIONS

Given the technical challenges, most operators who specialize in CTO revascularization recognize the importance of planning prior to any attempted PCI. Although an experienced interventionalist may elect to pursue a straightforward occlusion, strong consideration should be given to deferring ad hoc CTO PCI to allow for patient discussion and determination of the appropriate strategy and equipment. Novel imaging techniques such as 3-dimensional cineangiography or computed tomographic angiogram offer the opportunity to more completely analyze a candidate lesion, and may significantly benefit CTO PCI outcomes.[7,8] In addition, imaging studies to determine distal myocardial viability might be needed to estimate the benefit versus risk of CTO PCI. Once the CTO anatomy has been delineated, additional considerations include choice of devices and approach whereby development of new devices and technical variations has given the CTO operator a list of highly functional choices when planning a CTO PCI. The ultimate decision to offer CTO PCI to patients may be based on several factors including technical difficulty, chances for successful outcome, and the amount of viable myocardium supplied by the CTO vessel. Appropriate patients should have the possibility of significant benefit in limiting chest discomfort or have

Division of Interventional Cardiology, Heart and Vascular Institute, Cleveland Clinic J2-3, 9500 Euclid Avenue, Cleveland, OH 44195, USA
* Corresponding author.
E-mail address: whitlop@ccf.org (P.L. Whitlow).

Cardiol Clin 28 (2010) 71–79
doi:10.1016/j.ccl.2009.10.003

a significant amount of viable myocardium at risk, and proceed only after a thoughtful consideration of either continued aggressive medical therapy or surgical revascularization.

Choosing an approach is an appropriate first step in CTO PCI. Broadly characterized as either antegrade or retrograde, several successfully employed variations have been described on both techniques. The antegrade approach may be performed in a similar way to standard PCI whereby the lesion is wired, dilated, and stented with standard equipment. As with any PCI, proper guide selection is critical to ensure a successful outcome. Guide support is paramount in CTO PCI whereby the ability to push wires and equipment through long tortuous or occluded segments is essential for success. Larger guides, 7F or 8F lumen, are frequently employed for their increased stiffness and ability to handle adjunctive equipment (ie, intravascular ultrasound). Guide shapes for CTOs arising from the left coronary tree are typically the Amplatz or Extra Backup, and either traditional or modified Amplatz for those in the right system. The Amplatz guides are particularly useful in that they provide excellent support even when seated in the coronary sinus noncoaxial with the proximal vessel, thus lowering the chances of dissection. For particularly challenging lesions, additional guide support can be achieved through the use of an anchor balloon, typically a small over-the-wire (OTW) balloon placed in a small side branch and inflated to low pressure to provide counterforce for firm engagement of the guide catheter.[9]

Advances in guidewire design have played a significant role in the improved success in CTO PCI. It is reasonable to attempt CTO PCI with standard workhorse wires and select progressively stiffer wires as necessary to reenter the distal true lumen. Several wire families are particularly useful in attempting CTO PCI, and offer choices in hydrophilicity and varying tip stiffness. Hydrophobic wires (Miracle Bros/Confianza, Abbott Vascular Inc, Abbott Park, IL) offer better tactile response when attempting to penetrate the CTO and are favored when blunt dissecting through a fibrocalcific cap or organized thrombotic core. Hydrophilic wires (Fielder/Whisper, Abbott Vascular Inc) are preferred when navigating microchannels or tortuous segments where increased tip lubricity is helpful in overcoming frictional forces.

The addition of an OTW balloon or support catheter offers reinforcement when attempting to penetrate demanding lesions. By providing a fulcrum for the wire, these devices, when advanced close to the lesion, increase the buckling load on the wire tip, thus allowing for maximum penetrating force. The authors generally prefer microcatheters to angioplasty balloons for this purpose because of reduced wire bias and optimal wire torque response. In addition, these devices improve maneuverability by reducing friction along the length of the wire and permitting guidewire exchanges without loss of progress through the lesion. Catheters currently approved for use and with widespread popularity in the CTO community are primarily marketed as neurovascular devices, and include the Transit (Cordis Corp, Warren, NJ), Tracker (Boston Scientific, Natick, MA), and the Finecross (Terumo Medical Corp, Somerset, NJ) catheters. An adaptation of the standard support catheter, the Tornus (Abbott Vascular Inc) is a braided stainless steel catheter with a tapered threaded tip that allows the catheter to be advanced through a lesion while twisting to provide additional penetrating force. Commonly used guidewires and devices for CTO PCI are listed in **Table 1**.

A novel modification of the support catheter concept by BridgePoint Medical Systems (Minneapolis, MN) has produced a complete CTO PCI crossing system particularly applicable to an antegrade approach. The system is comprised of 3 elements: the CrossBoss CTO catheter, the Stingray CTO orienting balloon catheter, and the Stingray reentry guidewire with a tapered tip. The CTO catheter has a highly torqueable coiled-wire shaft and an atraumatic 1-mm rounded tip that tracks in advance of a guidewire via the facilitated antegrade steering spin technique (see Video 1, available in the online version of this article at http://www.cardiology.theclinics.com). Depending on whether the crossing catheter remains within the true lumen during penetration of the lesion, the CrossBoss may be removed, leaving a guidewire in place to allow either balloon angioplasty and stenting or implementation of the second element, the Stingray reentry balloon catheter. To facilitate reentry into the true lumen, the Stingray balloon is advanced within the subintimal space adjacent to or just past the distal cap and inflated, which provides a fulcrum with orthogonal orientation of 2 exit holes within the balloon (see Video 2, courtesy of Dr Etsuo Tsuchikane, available in the online version of this article at http://www.cardiology.theclinics.com). Then, using a proprietary reentry guidewire, the distal true lumen is entered via the adluminal exit hole. In its first-in-man all-comers registry, this system was used to place a guidewire in the distal true lumen in 87.5% of patients, with no in-hospital major adverse cardiac events (Whitlow, personal communication, 2009).

A compilation of these antegrade techniques can be seen in the case of a 61-year-old man with refractory angina and a known left anterior descending artery (LAD) CTO (**Fig. 1**). The patient