

Cardiovascular Update

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Chronic Total Occlusions

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Clinical Vignette

Patient is a 72-year-old female with hypertension, hyperlipidemia and tobacco use, presents with several months of progressive angina. She underwent a myocardial perfusion stress test which demonstrated a moderate to large reversible inferior wall defect and an ejection fraction of 45 percent. The patient was treated with aggressive medical therapy, but had persistent angina so underwent coronary angiography. *Figure 1* and *figure 2* represent two potential outcomes of an angiogram on this patient.

Treating the Angiogram

In *figure 1*, there is a distinct critical lesion for which there is little debate about revascularization, and the patient would likely undergo PCI at most institutions. However, in *figure 2* there is a total occlusion, which leads to significant operator and institutional variability in the care for this patient. Although the distal myocardial bed is just as ischemic in either scenario, many operators let the angiogram dictate the strategy instead of patient's symptoms. In addition, there's variability in the data supporting the optimal treatment strategy for this lesion.

What Are Chronic Total Occlusions?

Coronary chronic total occlusions (CTOs) are defined as 100 percent occlusions with TIMI (thrombolysis in myocardial infarction) 0 flow of at least a three-month duration, based on clinical history of previous angiograms.¹ CTOs are prevalent in approximately 20 percent of the patients that undergo cardiac catheterization and can be as high as 50 percent in patients with a previous history of bypass. Traditionally, treatment for patients with coronary CTO include lifestyle changes and medications (as is appropriate for all patients with coronary artery disease). Historically, percutaneous revascularization was successful approximately 50-60 percent of the time or less, depending on institutional and operator variability. Brilakis et al¹ reviewed data from the National Cardiovascular Data Registry (NCDR). CTO PCI was only 4 percent of procedures (22,365 of 594,510 procedures). CTO PCI success rates were lower than non-CTO success (59 vs 96 percent) and had twice as many complications (1.6 vs 0.8 percent).²

The most frequently cited barriers to CTO PCI are incomplete evidence for efficacy and concerns about safety. Because of the ongoing controversy about the risks and benefits of CTO PCI, it remains a class IIa indication in current American and European practice guidelines.³ In addition, these procedures remain technically challenging and time



Figure 1

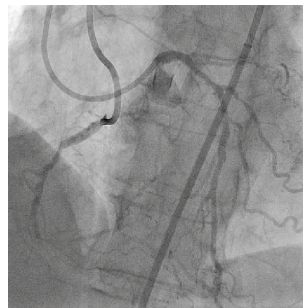
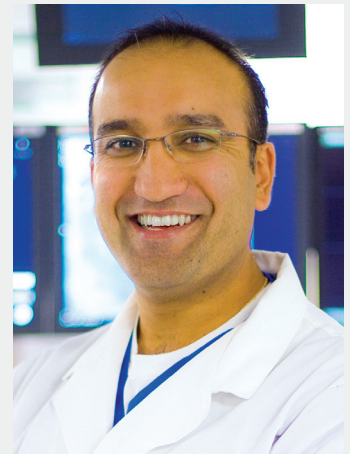


Figure 2



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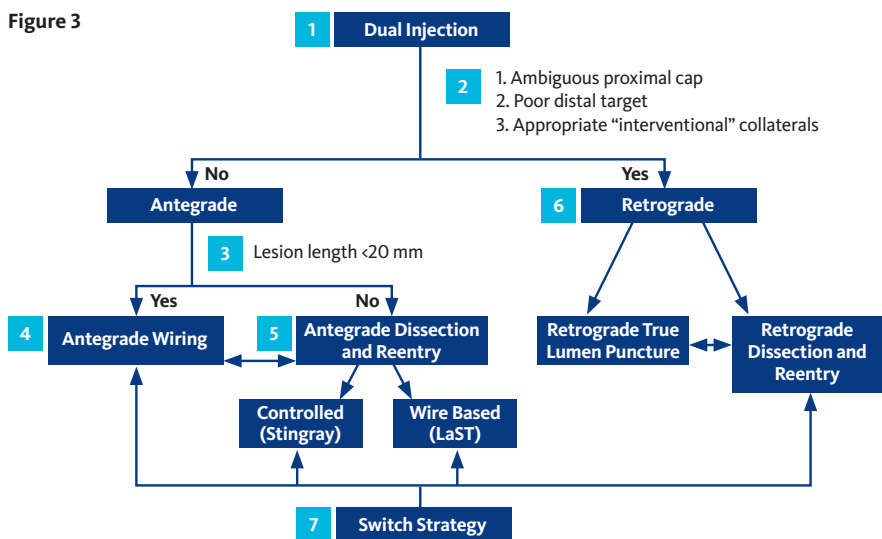


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consuming, and thus variability in local expertise can influence the decision to manage patients medically or refer for CTO PCI or surgery. Patients are often advised that CTOs are benign. It's generally accepted that the vessel is already 100 percent occluded and therefore cannot get worse. In addition, the subtended myocardium is collateralized. However, the myocardium affected by a CTO is ischemic. Collateral vessels do not provide adequate flow reserve. FFR data collected from CTOs that were successfully crossed and subsequently interrogated with a pressure wire prior to stenting, show that the myocardium supplied by the reconstituted distal bed remains ischemic. This ischemic burden appears to be independent of the size and quality of collaterals.^{4,5} In addition, a moderate stenosis in a donor coronary artery supplying collateral vessels to a CTO may result in an ischemic FFR as a consequence of coronary “steal” from the donor artery to the collateral vessels. The ischemic FFR in the donor artery can be corrected by treating the recipient CTO vessel.

Technical advances in balloons, stents, microcatheters, guidewires and crossing strategies has led to success rates exceeding 90 percent in high-volume centers. Historically, percutaneous revascularization was performed with antegrade wire escalation (continued use of stiffer wires to try to penetrate the proximal cap and wire into the lumen) with occasional retrograde wiring (traversing a collateral to the reconstituted portion of the vessel) through the distal cap. The current hybrid approach (*figure 3*) uses a combination of these techniques and results in four approaches to cross the lesion: 1) antegrade wire escalation, 2) antegrade dissection re-entry, 3) retrograde wire escalation, and 4) retrograde dissection re-entry. The hybrid algorithm focuses on four angiographic characteristics (proximal cap ambiguity, distal target vessel, interventional collateral and lesion length) to determine the initial and subsequent crossing strategy.⁶

Figure 3



Why Revascularize a CTO

The presence of a CTO is associated with an adverse prognosis, implying the importance of incomplete revascularization. The Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) trial used a scoring system to direct surgical vs percutaneous revascularization strategies in patients with complex or multivessel CAD. A post hoc analysis of the SYNTAX trial showed that incomplete revascularization was associated with significantly higher rates of four-year mortality and major adverse cardiac events (MACE).⁴ This was likely from the ischemic burden remaining from incomplete revascularization. The presence of CTO was the strongest independent predictor of incomplete revascularization in the SYNTAX PCI arm and approximately one-third

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of the CTO referred for bypass were not revascularized. Similarly, the negative prognostic impact of having a CTO has been observed in a large population of patients followed prospectively after undergoing coronary angiography.⁵ Furthermore, the presence of CTO in a non-infarct-related artery at the time of ST-elevation myocardial infarction appears to be an independent predictor of death at 30 days, with a persistent negative prognostic impact lasting for up to 36 months of follow up.⁷

Clinical Benefits of CTO PCI

In patients with significant ischemic burden, CTO PCI has multiple clinical benefits. Symptomatic relief based on the Seattle Angina Questionnaire appears to be similar to that obtained with coronary artery bypass grafting (CABG) at one-month follow up. Successful CTO PCI can have a positive impact on the risk of mortality in prospective and retrospective observational studies. CTO intervention may also have beneficial effects on left ventricular systolic function in patients with viable myocardium in the corresponding coronary territory.^{8,9} This improvement in systolic function appears to be sustained at three years of follow up. Meta-analysis of observational data in symptomatic and ischemic patients who underwent successful CTO PCI shows reduced rates of all-cause mortality and MACE and a reduced need for subsequent CABG. This is in contrast to the frequently cited Occluded Artery Trial (OAT) trial, which showed no clinical benefit of PCI for a subacutely occluded infarct-related artery.¹⁰

CTO PCI remains a specialized procedure unique from patent vessel PCI. There is little correlation between total PCI volume and CTO success rates, and correlated more with CTO PCI volume. CTO PCI success is dependent on operator expertise, and the unique techniques and equipment are associated with a higher MACE. Therefore, the decision to revascularize a CTO should be based on the risk/benefit ratio. The main and best documented-to-date benefit of CTO PCI is symptom improvement (i.e. improvement in angina or angina equivalents). Consequently, for truly asymptomatic patients, there should be a high threshold for doing CTO PCI for other indications, such as ischemia reduction or improvement in ejection fraction. The risk of major procedural complications is as high as 3 percent, and depends on patient age, lesion complexity and crossing techniques (in particular the retrograde approach). It should be a tool used in conjunction with optimal medical therapy, patent vessel PCI and CABG.

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