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Review Article

“Putting it all together”: A global approach to chronic total occlusion revascularization

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ABSTRACT

Percutaneous coronary intervention (PCI) of chronic total occlusion (CTO) represents a common and significant management dilemma for the interventionist. The optimal approach to CTO PCI continues to evolve. Currently, success rate of CTO PCI seems markedly improved due to new techniques and dedicated device developments. Retrograde recanalization devised by Japanese proved to be one of the most significant amendments of the technique. However, there are barriers that could limit widespread dissemination of Japanese techniques. Long case duration, financial constraints, radiation overdose and contrast overload in protracted cases may be concerns outside Japan. Moreover, various CTO crossing techniques such as antegrade wire escalation, antegrade dissection/re-entry, and retrograde enjoy relative merits and priority in isolated cases. Putting it all together or global approach involves a standard, simplified process to target CTO PCI dictated by anatomy, harmonizing antegrade and retrograde techniques, harmonizing lesion wire or device-based crossing with dissection and re-entry methods.

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1. Introduction

Percutaneous coronary intervention (PCI) of chronic total occlusion (CTO) is a well accepted revascularization procedure representing 10% of PCI procedure.^{1–3} Effective wiring technique is

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critical to success of CTO PCI.⁴ Although CTO PCI is technically demanding and challenging, it is also rapidly evolving field benefitting from remarkable technology and technique developments during the past decade.^{4–6} This led to significant improvement in both procedural success and complication rates,^{7,8} as well as increased efficiency.⁹ The major reason for failure is the inability to cross the occlusion with a guidewire. The three major CTO wiring techniques currently being used are: antegrade wire escalation, antegrade dissection/re-entry, and retrograde; each with its own merits and limitations.^{10,11}

In this review the author elaborates the putting it all together or global approach focusing on opening the CTO embarking on all available techniques (antegrade, retrograde, true-to-true or intra-plaque lumen crossing or re-entry) tailored to the specific case safely, effectively and efficiently.¹⁰

2. Clinical and procedural consideration

A detailed and careful clinical assessment is critical before proceeding for PCI. There is growing body of evidence to suggest that CTO PCI can provide relief in anginal symptoms,^{11,12} decrease anti-anginal medication intake, improve exercise capacity,¹³ improve left ventricular function,¹⁴ reduce the need for coronary artery bypass graft (CABG) surgery,¹⁵ and improve survival.¹⁶ The success depends on careful evaluation by multiple detector computed tomography (MDCT) and dual catheter angiography of stump morphology, occlusion length, calcification and presence and extent of collateral channels (CCs). Traditional factors predicting lower procedural success rate include longer occlusion (>20 mm), presence of calcification, native vessel CTO after CABG and presence of bridging collaterals.¹⁷

The developed Multicenter CTO Registry in Japan (J-CTO) score is a numerical score with higher values indicating greater procedural complexity. It correlates with the duration required for successful intimal wire crossing.¹⁸ An “ad hoc” approach to CTO PCI is discouraged to facilitate understanding the vessel course and presence, quality and location of CCs which can allow flexibility for rapid adjustments and change of strategies during the procedure and maximizes the success rate. MDCT coronary angiography in some cases provides additional morphological features of the CTO such as vessel course, tortuosity and calcification.¹⁹

The author prefers to use routine dual large-bore (7- to 8-F) guide catheter strategy, with a shortened (90 cm long) catheter in the retrograde vessel for seamless and efficient transition between antegrade and retrograde techniques. Experienced transradial interventionists can successfully perform the procedure using smaller 6-F catheters. Dual arterial access (bifemoral, biradial, femoral-radial) is the key to global approach. The methods to augment guide catheter support include large bore catheter, “mother and child” extensions, such as the Guideliner catheter (Vascular Solutions, MN, Minnesota), Guidezilla (Boston Scientific, Natick, Massachusetts, USA) or Guidion (IMDS, Netherlands) and various balloon anchoring techniques.²⁰

Simultaneous dual injection is critical to determine the characteristics of the CTO including lesion length, proximal and distal cap morphology, site of side branches and extent of CCs. This is also crucial for clarifying the location of the guidewire or other gears during attempts at CTO crossing. It is best performed at low magnification with prolonged imaging exposure, and without table panning, to allow for optimal delineation of CTO segment and CC location and course. The donor vessel is injected first followed by the injection of occluded vessel. Septal CCs are best evaluated in a combination of right anterior oblique (RAO) or anteroposterior cranial (AP) and RAO projections. The tailored views are often needed to assess epicardial CCs. The left anterior oblique and RAO cranial views are often the best to image distal lateral wall CCs

between obtuse marginal arteries and posterolateral arteries and diagonal to diagonal/obtuse marginal connection; and RAO and AP caudal views are the best for CCs connecting more proximal obtuse marginal arteries and those arising in the atroventricular groove between the circumflex and right coronary arteries.

3. The base of operations for global approach

The base of operations usually commences at or near the distal cap for antegrade direction and proximal cap for retrogradely directed procedure. This operation may have to be shifted to a different location within the vessel (beyond the distal cap for re-entry) or elsewhere in CTO segment for controlled antegrade and retrograde subintimal tracking (CART) and reverse CART. The flexibility of the base operations as well as strategic changes are critical to the application of putting it all together or global approach.²¹

4. Crafting strategy based on anatomy

The algorithm starts with MDCT and dual catheter angiography for evaluation of four key parameters to decide the initial procedural strategy such as proximal cap ambiguity, length of occlusion, distal vessel, interventional CCs (Fig. 1). Global approach to CTO PCI exploits the situation of conditional probability and attempts to use the procedure that is most likely to be successful, and in case of failures, endorses rapid change to alternative strategies.

4.1. Proximal cap location and morphology

Meticulous understanding of the CTO starting point is critical for both success and safety. A clearly defined and unambiguous proximal cap favors upfront use of an antegrade approach, whereas a poorly defined proximal cap with ambiguity favors a primary retrograde approach. In some inconclusive cases, MDCT and intravascular ultrasound (IVUS) can help elucidating the proximal part of the CTO in better way. Side branches at the proximal cap may hinder antegrade wiring, but could potentially be used for anchoring to increase guide catheter support. Also the side branch can be utilized for placing IVUS catheter to provide the information about proximal cap and assists in navigating the wire into the true lumen. Tapered proximal caps tend to be more favorable than blunt ones and are part of the J-CTO score for determining the difficulty of CTO crossing.¹⁸

4.2. Lesion length

The longer the lesion, the more challenging crossing is likely to be, especially when the occlusion is also tortuous and calcified.¹⁸ Also, longer lesions are unlikely to be crossed with an exclusive intra-plaque course, the wire almost invariably entering and exiting the sub-intimal plane. Lesions are dichotomized to <20 vs ≥ 20 mm. CTO with ≥ 20 mm long lesion may be best approached with a primary dissection/re-entry or retrograde technique, whereas <20 mm long lesions are usually approached with antegrade wire escalation.¹⁸ Lesion length can be accurately assessed only by using dual injections and MDCT.

4.3. Target coronary vessel beyond the distal cap

This pertains to the lumen size, presence of significant side branch, angiographic health of vessel at the reconstitution point and adequate visualization of the segment. The size and quality of the vessel distal to CTO segment significantly affects the success rate. Small, diffusely diseased vessels are associated with lower

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