Research Highlights

Highlights from the latest articles in chronic total occlusion percutaneous coronary intervention

Crossing the uncrossable: laser and rotablation for balloon uncrossable/resistant lesions

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Evaluation of: Fernandez JP, Hobson AR, McKenzie D *et al.* Beyond the balloon: excimer coronary laser atherectomy used alone or in combination with rotational atherectomy in the treatment of chronic total occlusions, noncrossable and nonexpansible coronary lesions. *EuroIntervention* 9(2), 243–250 (2013).

The most common reason for failure during chronic total occlusion (CTO) percutaneous coronary intervention (PCI) is failure of the wire to cross the occlusion segment. However, even after successful wiring of a CTO lesion, a balloon or microcatheter may fail to cross owing to the physical characteristics of the proximal cap (typically calcific) and/or inadequate guide catheter support. In such cases, operators can employ a hierarchical strategy of techniques to facilitate device passage on the original guidewire. These include deep seating of the guiding catheter; mother-in-child catheters (e.g., GuideLiner®; Vascular Solutions Inc., MN, USA); anchor wire or anchor balloons; Corsair® or Tornus® microcatheters (both Asahi Intecc Co., Nagoya-Shi, Japan); deliberate balloon rupture at the proximal cap; or combinations of these different options. Rotational atherectomy (RA) is a further possibility for uncrossable or undilatable lesions if the lesion can be crossed with a RotaWire™ (Boston Scientific, MA, USA), although this may entail giving up distal wire position. More recently, excimer laser coronary angioplasty (ELCA) has been proposed, since this technique can be performed over the initial crossing wire.

Fernandez and colleagues present a single-center retrospective analysis of patients who underwent ELCA (either alone or to facilitate passage of a RotaWire for subsequent RA) for instances of balloon failure (defined as failure to cross or to adequately expand). Over a 4-year period, 6882 patients underwent PCI and ELCA was used in 58 cases (0.84% of total cases; 62% for failure to cross; 38% for failure to expand). By comparison, RA was used in 187 cases (2.7%) during the same period. Balloon failure cases were subclassified according to whether the treated lesion was a CTO or non-CTO. In all cases a CVX-300® excimer laser system (Spectranetics, CO, USA) in conjunction with a Vitesse® CTM 0.9 mm laser atherectomy catheter (Spectranetics) was used and overall procedural success was 91%.

In CTO lesions, the balloon failed to cross in 16 cases and failed to expand in two cases. In the balloon-uncrossable CTO lesions, ELCA used alone was then successful in 13 cases and failed in one case. ECLA combined with RA was successful in one case and failed in one case. In the balloon-unexpandable CTO subset, ELCA used alone was successful in both cases.

For non-CTO lesions, the balloon failed to cross in 20 cases and failed to expand in 20 cases. In the balloon-uncrossable non-CTO lesions, ELCA used alone was successful in 10 cases and failed in three cases. ECLA used after failed RA was successful in three cases. ECLA combined with RA was successful in four cases and failed in zero cases. In the balloon-unexpandable non-CTO subset, ELCA used alone was successful in 18 cases, and after RA failure was successful in one case. There was one case where RA was successful after ELCA failure. There were three procedural

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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complications including a fatal coronary perforation.

Although RA remains the atherectomy device of choice for balloon-uncrossable lesions, ELCA is now finding utility as a primary or secondary adjunctive therapy in calcified lesions, particularly when no other devices will cross to permit exchange to a RotaWire. This scenario is rare during CTO PCI if support is optimized and appropriate microcatheters used, microcatheters used, but remains an important mode of failure. It is, however, important to understand the fundamental differences between RA and ELCA when deciding which device to employ. Unlike ELCA, RA differentially ablates nonelastic tissue, enabling its safe use in the subintimal space for those cases involving dissection re-entry techniques. In such situations, ELCA may pose a higher risk of perforation since it will also ablate elastic subintimal tissue. Further experience is required with ECLA in CTO PCI to firmly establish its position in the hierarchical approach to the balloon-uncrossable/unexpandable lesion. Currently, its main limitation is the limited availability of ELCA in the majority of catheter laboratories.

Influence of operator experience and wire strategy on transradial chronic total occlusion procedural efficiency

Evaluation of: Burzotta F, Trani C, Tommasino A *et al.* Impact of operator experience and wiring technique on procedural efficacy of trans-radial percutaneous chronic total occlusion recanalization performed by dedicated radialists. *Cardiol. J.* doi:10.5603/CJ.a2013.0063 (2013) (Epub ahead of print).

Transradial access (TRA) coronary intervention is a safe and effective method of percutaneous revascularization. Furthermore, the indications for transradial PCI are expanding [1]. PCI for CTO typically requires good guide catheter support and frequent exchanges of equipment on standard length wires. Combinations of some adjunctive devices (microcatheters and intravascular ultrasound) and trapping balloons can only be achieved with larger guiding catheters. This has limited the adoption of the radial approach for CTO PCI, even among dedicated radial operators. Hence, there are limited data on the efficacy of TRA for CTO PCI and on whether vascular complications can be reduced by using the radial route [2].

Burzotta and colleagues present their single-center, two-operator experience of TRA CTO PCI from January 2006 to May 2011. For the majority of patients, an antegrade approach using a 6 F guiding catheter was used. Each of the operators were experienced 'radialists' having a >90% TRA rate prior to the study period and both operators scrubbed for the majority of cases. The authors divided the study into two sequential phases:

- Period 1: no systematic adoption of TRA and no systematic wiring technique applied. During this phase, the operator selected cases for the transradial route and guidewire selection was made according to the anatomical features of the CTO lesion;
- Period 2: TRA was systematically adopted for all cases and a hierarchical stepwise wire selection process was applied at the suggestion of a Japanese CTO mentor. During the earlier period 2a, the wire sequence comprised: intermediate (Abbott Vascular, CA, USA), Miracle 3, Miracle 6, then Confianza Pro 12 (all Asahi Intecc Co., Aichi, Japan). During the following period 2b, a Fielder XT wire (Asahi Intecc Co.) was used as the first wire, with the remaining wire sequence steps identical to that of period 2a.

The two operators attempted 167 TRA PCI CTO in 158 patients using either a single or double radial approach depending on the collateral circulation providing distal vessel visualization. Crossover to a femoral access route was only required in two cases (1.2%). PCI success was achieved in 124 procedures (74.3%) with a patient success rate (PCI success at first or second attempt) of 78.5%. A progressive increase in procedure efficacy was noted during the three study periods (57.1% in period 1 vs 76.5% in period 2a vs 80.5% in period 2b). A similar improvement was observed for patient success (62.5% in period 1 vs 77.8% in period 2a vs 86.1% in period 2b) The adoption of the Fielder XT wire (Asahi Intecc Co.) in period 2b led to an increase in successful crossing with the first wire (40.3 vs 23.6%), thus increasing procedural efficiency. In-hospital vascular complications were limited to a single forearm hematoma that was managed conservatively. Overall, major adverse cardiac events at a mean follow-up of 580 ± 305 days was 6.3%, comprising 1.9% cardiac death and 4.5% target vessel revascularizations.

This single-center, two-operator experience of a systematic approach to TRA CTO PCI provides evidence that, in experienced hands, TRA CTO PCI is feasible, safe and associated with excellent procedural success rates. While the results cannot be extrapolated to operators with less TRA experience, they will be encouraging to the great number of experienced CTO operators who only use femoral approaches for CTO cases, but are otherwise dedicated radialists. The TRA approach undoubtedly complicates the use of novel dissection–re-entry and some other devices when wire trapping is used for device exchange. However, these issues can be overcome using extension wires or if a 7 F radial catheter can be accommodated. The study also highlights three further ways to increase the success rate of CTO PCI. First, success increases with operator experience, suggesting that large PCI centers should concentrate

CTO cases in the hands of two or three operators only; second, the importance of mentoring by external operators and by colleagues to encourage adoption of new techniques and devices; and third, that even the most complex CTO cases can be 'proceduralized' using standardized algorithms to guide initial approach and wire selection.

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Long-term clinical and angiographic outcome after successful recanalization of chronic total occlusions with long stent lengths

Evaluation of: Isaaz K, Mayaud N, Gerbay A *et al.* Long-term clinical outcome and routine angiographic follow-up after successful recanalization of complex coronary true chronic total occlusion with a long stent length: a single-centre experience. *J. Invasive Cardiol.* 25(7), 323–329 (2013).

Approximately 15–30% of patients referred for coronary angiography have a CTO [1]. Patients with successful recanalization of their CTO with PCI have better symptom relief, better clinical outcome, improved left ventricular function and better long-term survival compared with patients in whom the attempt to recanalize has failed [2]. High rates of restenosis and reocclusion have been documented in the past after balloon angioplasty and bare-metal stent implantation for CTO lesions. More recently, several studies have shown that CTO PCI with drug-eluting stent (DES) implantation results in rates of restenosis (~11%) [3] similar to that for other off-label DES indications [4]. Case series with mandatory angiographic follow-up provide valuable insight into the outcome of 'real-world' CTO patients, many of whom have long lesions requiring multiple overlapping stents.

Isaaz and colleagues present the 6 month clinical and angiographic follow-up data of their single-center, single-operator CTO PCI experience from October 2008 to November 2011. Of the 164 CTOs in 156 successive patients, PCI was successful in 137 cases (83.5%). Three patients had short stent length (<20 mm), eight patients received bare-metal stent and 19 patients with >20 mm CTO lesions declined angiographic follow-up. The study population thus comprised 102 patients with 106 CTO lesions treated with DES of >20 mm length. Cypher® sirolimus eluting stents (SES; Cordis, NJ, USA) were used in 100 lesions (94%) and biolimus-eluting stents (BES) were used in six lesions (6%).

Quantitative coronary angiographic data were analyzed by an operator blinded to patient identities. Binary angiographic restenosis was defined as >50% diameter stenosis. In-stent restenosis was defined as diffuse if the length of restenosis was >50% of the total stent length. Patients received a mean of 3.9 ± 1.8 stents with a mean stent length of 78 ± 32 mm (range: 23–174 mm). There were 19 in-stent restenosis events (18%; 18 SES and one BES) including two total in-stent reocclusions (one in a SES and one in a BES). Only one in-stent restenosis patient was symptomatic, despite 62% of patients having symptoms of angina or dyspnea prior to PCI. Restenosis type was diffuse in three cases (16%), with total occlusion in two out of these three cases (11%). In-stent restenosis occurred exclusively at the site of CTO lesion in 26%, exclusively proximally or distally to the CTO lesion in 48%, and both at the site of CTO and outside the site of CTO in 26%. Patients with restenosis were younger (62 ± 8 vs 67 ± 10 years; p = 0.029) and had longer stent lengths (91 ± 28 vs 75 ± 33 mm; p = 0.059). Multivariate analysis of candidate predictors of restenosis revealed only that patient age and stent length were independent predictors of restenosis.

This study represents the largest registry of CTO cases treated with DES with mandated angiographic follow-up. Importantly, patients and lesions were well characterized and met the angiographic and clinical definitions for CTO lesions established by the Euro CTO club. The frequent use of long and overlapping stents is typical of 'real world' CTO lesions which are often in diffusely diseased vessels, though the number of stents per patient in this series was higher than perhaps expected. Interestingly, restenosis was just as likely to occur within the stented segment proximal or distal to the original occlusion site, suggesting that the occlusion segment is no more likely to be a site of restenosis than other areas of the artery. Subintimal stenting is more likely in the occlusion segment (either inadvertent or deliberate when retrograde and antegrade dissection re-entry techniques are used) and although further studies are needed, these data lend support to the hypothesis that limited subintimal stenting does not increase restenosis events. Perhaps the most important finding of this study is the low (2%) rate of reocclusion, particularly as >70% of CTOs were in nonleft anterior descending vessels. This

is close to the success rate of a left internal mammary artery graft to a left anterior descending artery CTO (0% reocclusion at 1 year) [5], and comes with lower procedural risk. By contrast, only 26% of grafts to a right coronary or circumflex coronary artery CTO remain patent at 12 months [5]. Although the presence of a CTO is the most common reason for selection of a surgical revascularization strategy in patients with multivessel disease [1], these data suggest that PCI should be the default revascularization strategy for patients with nonleft anterior descending artery CTOs.

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