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EDITORIAL

Chronic total occlusion percutaneous coronary intervention: the next chapter

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Chronic total occlusion (CTO) percutaneous coronary intervention (PCI) is evolving. Novel equipment has been introduced, and extensive training has been and continues to be performed throughout the world with encouraging results **(Table 1)**.

In this issue of EuroIntervention, Vadalà et al describe 8,673 CTO PCIs performed by 89 expert operators in the European Registry of CTO (ERCTO) from 2021-2022[1]. The technical success rate was 89.1%. The incidence of major adverse cardiac and cerebrovascular events (MACCE) was 1.7% and was higher in retrograde cases. High-volume operators (HVOs, defined as having 300 documented entries in the registry and >50 CTO PCIs per year as first operator) had a higher success rate (especially for retrograde cases) and a lower number of MACCE than mid-volume operators (MVOs; mean annual volume of 27 cases).

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The authors should be congratulated for increasing our understanding of contemporary CTO PCI. Improvements are needed in 4 areas: (a) safety, (b) success, (c) efficiency, and (d) availability.

Safety

Improving safety remains the highest priority for CTO PCI. The incidence of MACCE in ERCTO is slightly lower than in prior registries **(Table 1)**, a step in the right direction. How can the number of MACCE be reduced to zero? Of the 5 parameters associated with MACCE in multivariable analysis (age, sex, use of the retrograde approach, operator volume, and radial access), 3 can be influenced: (a) judicious use of the retrograde approach; (b) increased use of radial access (although radial access use was lower among HVOs, which was likely related to the complexity of the procedure); and (c) performance of CTO PCI by HVOs. Not only do HVO-performed CTO PCIs have lower complication rates, as shown by Vadalà et al, but HVOs are more adept in successfully managing complications when they occur.

Success

CTO PCI failed in approximately 1 of 10 patients in the ERCTO registry, similar to what has been published by other expert registries from around the world **(Table 1)**. HVOs had an absolute 3.3% higher technical success rate than MVOs, but the true difference is likely higher, as HVOs treated more complex occlusions. Is an 89% success rate good enough? It depends on the indication for the procedure and the baseline patient symptom severity. A high success rate is most important in highly symptomatic patients but may not be the highest priority in patients with mild/moderate symptoms. Success should also always be interpreted in the context of complications: a lower success rate may be preferred if it can be achieved with lower MACCE.

How could the success of CTO PCI improve further? The most obvious way is by having CTO PCI performed by HVOs.

Table 1. Contemporary outcomes of CTO PCI.

Studies	Years	N	Technical success	MACCE	Perforations	Tamponade	Death
Experienced centre registries							
Euro CTO	2021-2022	8,673	89.1%	1.7%	3.8%	0.4%	0.3%
PROGRESS CTO	2012-2022	11,684	86.4%	2.0%	4.8%	0.9%	0.4%
Japanese CTO PCI expert registry	2014-2015	2,846	89.9%	2.0%		0.4%	0.2%
PROGRESS MENATA	2018-2022	1,063	91.0%	1.6%	4.6%		0.5%
OPEN-CTO	2014-2015	1,054	86.0%	7.0%	8.8%		0.9%
LATAM CTO	2008-2020	1,040	82.5%	3.1%		0.9%	1.0%
RECHARGE	2014-2015	1,253	86.0%	2.6%		1.3%	0.2%
Population-based registries							
BCIS	2006-2014	28,050	67.0%	0.7%			0.2%
NCDR	2009-2013	22,365	58.5%	1.6%		0.3%	0.4%
BMC2	2010-2017	7,389	53.4%	3.3%		0.5%	1.4%

CTO: chronic total occlusion; MACCE: major adverse cardiac and cerebrovascular events; PCI: percutaneous coronary intervention

Improvements in equipment and techniques, and the implementation of improved crossing strategy algorithms (possibly through the use of artificial intelligence) could also help. Unfortunately, no major technological breakthroughs that could "democratise" CTO PCI are currently in sight.

Efficiency

CTO PCI is not a "quick and easy" procedure. The median procedure time in ERCTO was 96 minutes, the median fluoroscopy time was 41 minutes, and the mean contrast volume was 212 ml. Multiple microcatheters, wires and adjunctive wires were required in each case. The long procedural duration makes CTO PCI burdensome for the cardiac catheterisation staff and may result in the delayed treatment of other patients.

How can procedural efficiency be improved? Although data are not provided in the present manuscript, HVOs are likely to be more efficient than MVOs (and much more so than low-volume operators). Careful preprocedural planning could also help, as could novel devices and techniques.

Availability

ERCTO (as well as PROGRESS-CTO and the Japan Expert CTO registry) is a registry of expert operators. However, many, if not most, CTO PCIs are still performed by less experienced operators with much worse outcomes, in terms of both success and complications **(Table 1)**. How can the number of expert operators (ideally HVOs) be increased?

First, by encouraging CTO- and complex PCI-specific training: dedicated CTO and complex PCI programmes are currently available and can accelerate the learning curve. They do, however, prolong the already long clinical training trajectory, and there are are not enough to satisfy demand. Proctorship and the increasingly used teleproctorship are additional options.

Second, by educating non-complex operators about the specific demands of CTO PCI: CTO PCI has effectively become a subspeciality that requires mastery of multiple motor and cognitive skills. We currently do not expect an interventionalist to perform a MitraClip (Abbott) procedure without specialised dedicated training; why should we expect interventionalists who are not trained in CTO PCI to perform such procedures?

Third, by educating non-interventional cardiologists and non-cardiologists about what CTO PCI can and cannot achieve and about the importance of local expertise. CTO PCI can provide symptom relief with high success and low complication rates and can significantly improve the quality of life of many patients, especially those who are highly symptomatic.

The next chapter of CTO PCI requires development (and hopefully simplification) of techniques and equipment, and expansion of the pool of expert operators and centres that can deliver the procedure in an optimal way.

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Conflict of interest statement

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