

EDITORIAL

Learning curve, awareness, confidence and audacity: the perfect cocktail to tackle CTO-PCI

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In the field of interventional cardiology, as is the case in all medical specialties, the success rate of treated cases has been consistently linked to operator experience and institutional volume.¹ Numerous studies have established that cardiologists undertaking interventional procedures, including complex percutaneous coronary intervention (PCI), demonstrate enhanced outcomes with an increase in the annual number of procedures performed. These improved outcomes typically correlate with a significantly reduced risk of future adverse cardiovascular events.²

In contrast, this relationship is not entirely apparent in the context of chronic total occlusion (CTO) PCI.³ In 2019, an analysis from the National Cardiovascular Data Registry (NCDR) revealed that operators with higher procedure volumes exhibited higher success rates in CTO-PCI. However, this achievement was accompanied by increase in contrast volume and fluoroscopy time, with a similar occurrence of peri-procedural complications. Surprisingly, higher rates of major bleedings, perforations and tamponades were also observed.⁴ This unexpected finding can be elucidated by the fact that experienced CTO operators engage in more challenging CTO-PCI procedures, where the level of complexity is considerably greater than the variation in those procedures observed in standard PCI.

Thus, CTO represents the pinnacle manifestation of coronary artery disease, necessi-

tating the introduction of different technically demanding approaches. However, low-volume operators may sporadically encounter one or more of these challenging scenarios, impeding proficient management. The resolution of such complexities demands a substantially higher caseload of CTO PCI procedures annually, with threshold of >50 cases per year defined in previous studies.⁵

In this context, the importance of the learning curve is undeniable, and fortunately, the use of additional devices can provide valuable assistance. For example, a recent analysis by Choi *et al.*⁶ corroborated the fact that experienced PCI operators achieved superior outcomes. Nevertheless, when less-experienced operators incorporated intravascular ultrasound into coronary interventions, the results more frequently aligned with those achieved by high-volume operators, demonstrating the possible effect of using additional devices to shorten the gap with high-volume operators.

In the current issue of *Minerva Cardiology and Angiology* Januszek *et al.* have presented the results from the Polish National Registry of Percutaneous Coronary Intervention (ORPKI), examining a substantial cohort of 14,899 CTO-PCIs performed between 2014 and 2020.⁷ Of note, their analysis revealed a remarkable correlation between operator-volume and procedural success rates, initially demonstrating an intuiti-

tively linear increase. However, beyond a threshold of 40 CTO-PCI procedures per year, the trajectory of success rates shows a counterintuitive reversal, with a decline observed beyond this count. Intuitively, there should not be an upper limit in CTO-PCI success rates with increased CTO-PCI volume, suggesting that continuous improvement is possible, even among high-volume CTO-PCI operators.⁸ Unfortunately, the authors did not report in their manuscript the exact number of operators performing less or more than 40 CTO-PCI per year. Moreover, they did not report any other cut-off to categorize operators based on their annual caseload (for example, how many operators performed <20, 20-40, 40-60, >60 CTO PCI per year).

Nevertheless, this unexpected finding prompts an exploration of potential contributing factors. First, interventional cardiologists conducting a minimum of 40 CTO-PCI annually should still be considered as relatively high-volume operators. Despite a lower absolute procedure count, these operators may conduct a meticulous patient selection process, carefully choosing CTO lesions perceived to have a higher likelihood of successful crossing. Second, in high-volume centers with active CTO programs, experienced operators may allocate time to mentor young interventional cardiologists pursuing CTO fellow-

ships. Consequently, more advanced CTO-PCI experts may decrease their procedural activity to facilitate the training of new CTO specialists. In these cases, the double-operator approach merits also consideration, though one procedure does not count independently for both operators. Involving an attending operator is crucial for education, skill enhancement, and potential procedural improvement. Despite recent findings not showing significant benefits with multiple operators,⁹ this approach advocates its potential to boost operators volumes and interventional skills. Finally, the increasing number of procedures is often accompanied by a consequent increase in complexity of cases. As such, both reduced procedural success and increased risk of procedural complications may play a role, by potentially limiting the final success result of CTO-PCI procedures or requiring an unplanned procedure cessation.⁴

Despite the relatively modest procedural success observed in the overall population at a rate of 66.1%, there was a notable reduction in the incidence of peri-procedural complications, contrasting with findings in the existing literature.¹⁰ Initial impressions may suggest a potential under-reporting of events within the registry, contributing to the observed decrease in complication rates. However, an alternative explanation could

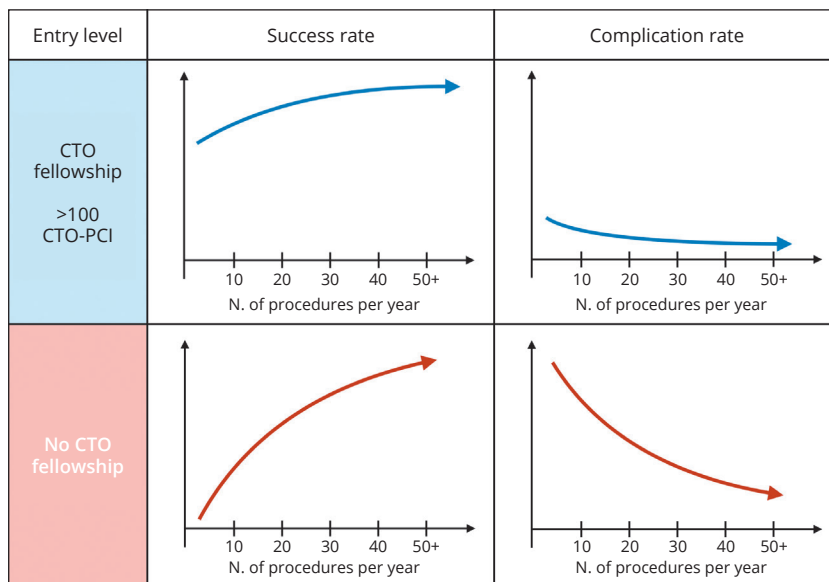


Figure 1.—The potential impact of a structured chronic total occlusion percutaneous coronary intervention (CTO-PCI) fellowship on proficiency in performing complex percutaneous interventions, with regard to both procedural success and complication rates.

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be associated with the operators' approach, particularly among less experienced ones, wherein a preference for stopping the procedure with a failure prior to facing harm to the patient may exist. This inclination is likely linked to the evaluation to pursue not only the immediate procedural success but also the overall patient's outcome and prognosis. Additionally, in recent years, the adoption of the investment procedure, as an alternative when a procedure is protracted or it may become too risky, has significantly changed the approach of even more proficient operators. Emphasizing this paradigm shift within the CTO community is essential, as the investment procedure may prove effectiveness in mitigating procedural complications and enhancing long-term success rates.¹¹

In conclusion, this analysis from the ORPKI registry provides a novel and updated perspective on the trends and performances of CTO-PCI operators, taking into account both individual and institutional volume. Despite the enhanced appeal and success rates of these procedures due to novel techniques and dedicated devices, every operator embarking into CTO-PCI should consistently uphold a patient-centered approach. Thus, the assessment of risks associated with anatomical challenges and the chosen strategy should always be balanced against the clinical need for revascularization. Ultimately, if an operator performs more than 100-150 CTO procedures per year during the initial two-three years, there is a potential for the operator's proficiency to remain solid, even in the presence of a subsequent reduction in the annual caseload to a consistently lower number (Figure 1). To the best of our knowledge, this concept has not been comprehensively investigated yet, and we believe that its significance may overcome that of the annual caseload itself.

Key messages

- The impact of operator/center volume on procedural outcomes in CTO-PCI is most pronounced at lower volumes, where a clear correlation is observed.

- As operator volumes increase, there is a transition towards attempting more complex lesions, which tends to level off the curve of procedural success rates, stabilizing at a consistent state.
- Exploring whether an initial boost in experience and volume during CTO fellowship training outweighs the benefits of establishing a robust, albeit lower volume, CTO program in the long term warrants further investigation.

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Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions

All authors contributed equally to the manuscript, Enrico Poletti, Pierfrancesco Agostoni and Imre Ungi have given substantial contributions to manuscript writing and critical revision. All authors read and approved the final version of the manuscript.

History

Article first published online: May 27, 2024. - Manuscript accepted: March 18, 2024. - Manuscript received: February 3, 2024.

Comment on: Januszek R, Bryniarski L, Mashayekhi K, Di Mario C, Siłka W, Malinowski KP, *et al.* Annual operator volume and procedural outcomes of chronic total occlusions treated with percutaneous coronary interventions: analysis based on 14,899 patients. *Minerva Cardiol Angiol* 2024;72:336–45. DOI: 10.23736/S2724-5683.23.06447-5.

(Cite this article as: Poletti E, Agostoni P, Ungi I. Learning curve, awareness, confidence and audacity: the perfect cocktail to tackle CTO-PCI. *Minerva Cardiol Angiol* 2024;72:332–5. DOI: 10.23736/S2724-5683.24.06558-X)