Scoring systems for chronic total occlusion percutaneous coronary intervention: if you fail to prepare you are preparing to fail

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While the benefit of chronic total occlusion (CTO) percutaneous coronary intervention (PCI) has not yet been demonstrated in randomized controlled trials, several observational studies have shown that, as compared with failed procedures, successful CTO PCI is associated with significant clinical benefit (1). It is, therefore, imperative to maximize the likelihood of CTO PCI success. Accordingly, the American College of Cardiology Foundation/American Heart Association/Society for Cardiovascular Angiography and Interventions PCI guidelines, have assigned a class IIa recommendation for CTO PCI to be performed in patients with suitable anatomy by operators with sufficient expertise (2). A key contributor to achieving success in CTO PCI is meticulous preparation; to aid with planning, operators and centers from around the world have created CTO PCI prediction scores (*Table 1*) (3-11).

Scoring systems can be useful in several ways. First, they provide a quantitative measure of the likelihood of success and complications that can be shared with the patient and help with clinical decision-making. Second, by providing the means for more objective assessment of anatomic and clinical complexity, CTO scores enable better case selection: while seasoned operators can tackle even the toughest of cases with high success rates (12), operators early in the CTO PCI learning curve can select "simpler" cases, referring the more unfavorable cases to specialized centers, or performing them with the guidance of a proctor. Within the heart team, the decision to revascularize and the optimal strategy can be tailored to each patient, taking into account the objective probability of achieving technical/angiographic success with PCI. Third, CTO scores provide a valuable template for guiding review of the coronary angiogram. At least 15 minutes of careful review and evaluation are essential to

understand the lesion and develop a "plan of attack" (primary retrograde *vs.* antegrade approach, intimal or sub-intimal and wire or crossing device based strategies) (13,14). Fourth, standardized classification of CTO lesion complexity allows comparison of outcomes with different approaches, between operators, centers, countries and even continents, for both quality improvement and clinical research.

The first CTO scoring system was the J-CTO (multicenter CTO registry in Japan) score, created by Morino *et al.* to predict successful guidewire crossing within 30 minutes (3). The J-CTO score is currently the most widely used score, and its inception sparked a series of scoring systems created to predict not only successful wiring and procedural efficiency, but also technical success, contrast induced nephropathy and even complications. Newer scores use various clinical, imaging and laboratory parameters. But is the creation of more than one score necessary and useful? The answer is definitely yes, and here is why:

First, development of new scoring systems helps validate previously published scores. For example, in the J-CTO score proximal cap morphology, coronary calcification and tortuosity are variables affecting the outcome of CTO PCI; as shown in the Table, these variables are included in most other scores, reinforcing their importance. The ability of the J-CTO score to predict quick guidewire crossing (15), the need for advanced crossing techniques (8,12), as well as mid- and long-term outcomes (16,17) has been confirmed in multiple studies; however, its ability to predict technical success was not consistent in all studies (6,8,15).

Despite similarities, newer scores often include different variables previously unexplored or found to not be predictive of outcome, highlighting the variety in approaches to CTO PCI. For example, the ORA (ostial location, Rentrop grade

Table 1 Currently available scoring systems for CTO PCI

Score variables	J-CTO score (3)	CL score (4)	PROGRESS-CTO score (5)	ORA score (6)	Chai et al. (7)	Wilson et al. (8)	Liu et al. (9)	CT-RECTOR score* (10)	Ito et al.* (11)
Number of cases (n)	494	1,657	781	1,073	228	1,156	728	240	263
Endpoint	GW crossing <30 min	Technical success	Technical success	Technical success	Technical success-retrograde	Technical success	CIN	GW crossing ≤30 min	MACE during follow-up‡
Age (years)	–	–	–	+ (≥75)	–	+ (>65)	+ (≥75)	–	–
Prior CABG	–	+	–	–	–	+	–	–	–
Prior failure	+	–	–	–	–	–	–	+	–
Proximal cap	+ (blunt)	+ (blunt)	+ (ambiguous)	+ (ostial)	–	+	–	+ (blunt)	–
Tortuosity	+ (>45° in lesion)	–	+ (moderate†, proximal)	–	–	+	–	+	–
Calcification	+	+ (severe)	–	–	–	+	–	+ (severe)	+ (severe)
Lesion length	+ (≥20 mm)	+ (≥20 mm)	–	–	–	+	–	–	+ (>25.4 mm)
Target vessel	–	+ (non-LAD)	+ (LCX)	–	–	–	–	–	–
Collateral quality	–	–	+ (lack of interventional)	+ (Rentrop <2)	+ (Werner, tortuous)	–	–	–	–
Other	–	Prior myocardial infarction	–	–	Distal segment diameter	BMI >30; non-proximal location	LVEF <40%; SCr >1.5 mg/dL	Multiple occlusions; duration ≥12 months	Minimal vessel area <11.9 mm^2

*, computed tomography angiography based; †, moderate tortuosity defined as 2 bends >70° or 1 bend >90° proximal to the lesion; ‡, defined as cardiac death, myocardial infarction, stent thrombosis or target lesion revascularization at median 4.0 years follow-up; +, variable included in score. CTO, chronic total occlusion; PCI, percutaneous coronary intervention; J-CTO, multicenter CTO registry in Japan; CL, clinical and lesion-related; PROGRESS CTO, Prospective Global Registry For The Study of Chronic Total Occlusion Intervention; CT-RECTOR, Computed Tomography Registry of Chronic Total Occlusion Revascularization; ORA, ostial location, Rentrop grade <2, age ≥75 years; BMI, body mass index; CABG, coronary artery bypass grafting; CIN, contrast induced nephropathy; GW, guidewire; LAD, left anterior descending artery; LCX, circumflex artery; LVEF, left ventricular ejection fraction; MACE, major adverse cardiovascular events; SCr, serum creatinine.

<2, age ≥75 years) score by Galassi *et al.* reflects the creator's extensive experience with retrograde techniques and may thus be more suitable for hybrid or retrograde operators (6). The clinical and lesion-related (CL) score by Alessandrino *et al.* was created based on primarily antegrade procedures and may thus perform better for antegrade-only operators (4). The PROGRESS CTO (Prospective Global Registry for the Study of Chronic Total Occlusion Intervention) score variables align with the hybrid algorithm for CTO PCI (5). In centers with high computed tomography angiography utilization, CT-based scores such as the CT-RECTOR (Computed Tomography Registry of Chronic Total Occlusion Revascularization) score may be of great value (10).

One disadvantage of scoring systems lies within the misconception that a high score (usually corresponding to complex coronary anatomy) is synonymous with failure. This is unfounded, since expert centers from around the world have reported very high success rates even with very complex CTOs (12).

In conclusion, CTO PCI scoring systems can be a tremendous resource for both the novice and experienced CTO operator, to aid with case and approach selection as well as to predict procedural efficiency and the probability for success and even complications. The creation of new scores to suit different CTO practices, and the validation of already existing scoring systems should be encouraged.

Acknowledgements

Footnote

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