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Comparison of various scores for predicting success of chronic total occlusion percutaneous coronary intervention

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ABSTRACT

Background: Various scoring systems have been developed to predict the technical outcome and procedural efficiency of chronic total occlusion (CTO) percutaneous coronary intervention (PCI).
Methods: We examined the predictive capacity of 3 CTO PCI scores (Clinical and Lesion-related [CL], Multicenter CTO registry in Japan [J-CTO] and Prospective Global Registry for the Study of Chronic Total Occlusion Intervention [PROGRESS CTO] scores) in 664 CTO PCIs performed between 2012 and 2016 at 13 US centers.
Results: Technical success was 88% and the retrograde approach was utilized in 41%. Mean CL, J-CTO and PROGRESS CTO scores were 3.9 ± 1.9, 2.6 ± 1.2 and 1.4 ± 1.0, respectively. All scores were inversely associated with technical success ($p < 0.001$ for all) and had moderate discriminatory capacity (area under the curve 0.691 for the CL score, 0.682 for the J-CTO score and 0.647 for the PROGRESS CTO score [p = non-significant for pairwise comparisons]). The difference in technical success between the minimum and maximum CL score strata was the highest (32%, vs. 15% for J-CTO and 18% for PROGRESS CTO scores). All scores tended to perform better in antegrade-only procedures and correlated significantly with procedure time and fluoroscopy dose; the CL score also correlated significantly with contrast utilization.
Conclusions: CL, J-CTO and PROGRESS CTO scores perform moderately in predicting technical outcome of CTO PCI, with better performance for antegrade-only procedures. All scores correlate with procedure time and fluoroscopy dose, and the CL score also correlates with contrast utilization.
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1. Introduction

Successful chronic total occlusion (CTO) percutaneous coronary intervention (PCI) has been associated with significant clinical benefit [1–3]. However, success of CTO interventions varies widely, depending on lesion complexity [4–8], patient characteristics [9] and operator

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experience [4,10]. Accurate pre-procedural assessment of how challenging a lesion is could help in procedural planning, to estimate the duration of the procedure and/or the need to refer the patient to another center with expertise in CTO PCI (for centers early in their CTO PCI learning curve), as well as in more accurate risk–benefit ratio assessment. Several scores have been developed to predict CTO PCI procedural success and efficiency, but no comparative analyses have been performed to date. We used a contemporary multicenter CTO PCI registry to perform a comparative analysis of three currently available CTO PCI scores: Clinical and Lesion-related (CL) score [7], Multicenter CTO Registry in Japan (J-CTO) score [5] and Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS CTO) score [6].

2. Methods

We examined the clinical and angiographic records of patients who underwent CTO PCI between May 2012 and February 2016 by experienced, high volume operators at 13 CTO PCI centers in the United States (Supplement). Data collection was performed prospectively and retrospectively and recorded in a CTO database (PROGRESS CTO, Clinicaltrials.gov Identifier: NCT02061436) [6,9,11–18]. Some centers only enrolled patients during part of the study period due to participation in other studies. The study was approved by the institutional review board of each site.

2.1. Definitions

Coronary CTOs were defined as coronary lesions with thrombolysis in myocardial infarction (TIMI) grade 0 flow of at least 3 months' duration. Estimation of the occlusion duration was based on first onset of anginal symptoms, prior history of myocardial infarction in the target vessel territory, or comparison with a prior angiogram. Calcification was assessed by angiography as mild (spots), moderate (involving ≤50% of the reference lesion diameter) and severe (involving >50% of the reference lesion diameter). Moderate proximal vessel tortuosity was defined as the presence of at least 2 bends > 70° or 1 bend > 90° and severe tortuosity as 2 bends > 90° or 1 bend > 120° in the CTO vessel. Interventional collaterals were defined as collaterals deemed amenable to crossing by a guidewire and a microcatheter by the operator. A procedure was defined as "retrograde" if an attempt was made to cross the lesion through a collateral vessel supplying the target vessel distal to the lesion; if not, the procedure was classified as "antegrade-only". Antegrade-only cases utilized antegrade wire escalation (AWE), or antegrade dissection re-entry (ADR), or both approaches. Technical success of CTO PCI was defined as successful CTO revascularization with achievement of <30% residual diameter stenosis within the treated segment and restoration of TIMI grade 3 antegrade flow. Procedural success was defined as achievement of technical success with no in-hospital major adverse cardiac events (MACE). In-hospital MACE included any of the following adverse events prior to hospital discharge: death, myocardial infarction (MI), recurrent symptoms requiring urgent repeat target vessel revascularization with PCI or coronary artery bypass graft surgery (CABG), tamponade requiring either pericardiocentesis or surgery, and stroke. Peri-procedural and late in-hospital MI were defined according to the Third Universal Definition of Myocardial Infarction [19]. Procedure time was calculated from administration of local anesthetic for vascular access to removal of last catheter. The CL-score was calculated as described by Alessandrino et al. [7], the J-CTO score was calculated as described by Morino et al. [5] and the PROGRESS CTO score as described by Christopoulos et al. [6] Procedures used for the derivation of the PROGRESS CTO score (n = 521) in the original study were excluded from the present analysis.

2.2. Statistical analysis

Categorical variables were expressed as percentages and compared using the Cochran–Armitage test for trend or Pearson's χ^2 test. Continuous variables were presented as mean ± standard deviation (normally distributed data) or median (interquartile range) (non-normally distributed data), and were compared using the Jonckheere–Terpstra test for trend. The effect of prediction scores on efficiency measures was tested using univariate linear regression; the unstandardized regression coefficient (B) was reported. The association between prediction scores and technical outcome was tested using univariate logistic regression; receiver operating characteristic (ROC) curve and area under the curve (AUC) were used to assess discriminatory capacity, and the Hosmer–Lemeshow (HL) test was used to assess calibration [20]. Differences in AUC between curves were tested as described by Hanley & McNeil [21]. Statistical analysis was performed with JMP 12.0 (SAS Institute, Cary, NC), MedCalc 16.4 (Ostend, Belgium) and SPSS 22.0 (IBM Corporation, Armonk, NY). A p value of <0.05 was considered statistically significant.

3. Results

From 1185 CTO PCIs that were enrolled between 2012 and 2016 in the PROGRESS CTO registry and had data for calculation of the CL, J-CTO and PROGRESS CTO score, 521 (44%) procedures that were used for derivation of the PROGRESS CTO score were excluded. The remaining 664 interventions were performed on 658 patients and were included in the present analysis. Table 1 shows the clinical and angiographic characteristics of the study patients and lesions; there was a high prevalence of diabetes mellitus (47%) and prior CABG (36%). The majority of the patients (59%) presented with stable angina. The most common target vessel was the right coronary artery (RCA, 54%). Mean CTO length was 34 ± 26 mm, and angiographic complexity was high (blunt stump: 53%, moderate/severe calcification 53%). Mean J-CTO score was 2.6 ± 1.2, mean CL score was 3.9 ± 1.9 and mean PROGRESS CTO score was 1.4 ± 1.0.

Overall technical success rate was 88%, and was most frequently achieved with antegrade wire escalation (48%, Table 2). A retrograde approach was used in 41% of procedures, and was the initial strategy selected in 19%. A major in-hospital adverse event occurred in 24 patients (3.6%).

All three scores exhibited good calibration in our sample: CL score Hosmer–Lemeshow (HL) $\chi^2 = 4.124$, p = 0.846; J-CTO score HL $\chi^2 = 5.888$, p = 0.117 and PROGRESS CTO score HL $\chi^2 = 5.403$, p = 0.067. Technical success was significantly lower for increasing strata of all three scoring systems (p for trend < 0.001 for all, Fig. 1). However, the difference in technical success between the smallest and highest strata of CL score (0–8) was the highest (Δ = −32%), followed by the

Table 1
Clinical and angiographic characteristics of the study patients and lesions.

Clinical characteristics	(N = 658)
Age (years)[a]	66 ± 10
Male (%)	85
Hypertension (%)	89
Hyperlipidemia (%)	95
Current smoking (%)	18
Diabetes mellitus (%)	47
History of myocardial infarction (%)	47
Prior PCI (%)	61
Prior failed CTO PCI (%)	19
Prior coronary artery bypass grafting (%)	36
History of stroke (%)	13
Peripheral arterial disease (%)	17
Heart failure (%)	27
Ejection fraction (%)[a]	51 ± 14
Clinical presentation	
Stable angina (%)	59
Acute coronary syndrome (%)	32
Asymptomatic (%)	9
Angiographic characteristics	**(N = 664)**
Target vessel	
Right coronary artery (%)	54
Left anterior descending artery (%)	25
Circumflex artery (%)	21
Estimated CTO length (mm)[a]	34 ± 26
Proximal cap ambiguity (%)	33
Blunt stump morphology (%)	53
Moderate/severe calcification (%)	53
Moderate/severe tortuosity (%)	37
Poor distal vessel (%)	36
Distal cap at bifurcation (%)	32
Lack of interventional collaterals (%)	46
In-stent restenosis (%)	13
Prediction scores	
CL score[a]	3.9 ± 1.9
J-CTO score[a]	2.6 ± 1.2
PROGRESS CTO score[a]	1.4 ± 1.0

CTO, chronic total occlusion; PCI, percutaneous coronary intervention.
[a] Values are mean ± standard deviation.