

# Percutaneous Coronary Revascularization for Chronic Total Occlusions



## A Novel Predictive Score of Technical Failure Using Advanced Technologies

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### ABSTRACT

**OBJECTIVES** The aims of this study were to describe the 10-year experience of a single operator dedicated to chronic total occlusion (CTO) and to establish a model for predicting technical failure.

**BACKGROUND** During the last decade, the interest in percutaneous coronary interventions (PCIs) of chronic total occlusions (CTOs) has increased, allowing the improvement of success rate.

**METHODS** One thousand nineteen patients with CTO underwent 1,073 CTO procedures performed by a single CTO-dedicated operator. The study population was subdivided into 2 groups by time period: period 1 (January 2005 to December 2009, n = 378) and period 2 (January 2010 to December 2014, n = 641). Observations were randomly assigned to a derivation set and a validation set (in a 2:1 ratio). A prediction score was established by assigning points for each independent predictor of technical failure in the derivation set according to the beta coefficient and summing all points accrued.

**RESULTS** Lesions attempted in period 2 were more complex in comparison with those in period 1. Compared with period 1, both technical and clinical success rates significantly improved (from 87.8% to 94.4% [p = 0.001] and from 77.6% to 89.9% [p < 0.001], respectively). A prediction score for technical failure including age  $\geq 75$  years (1 point), ostial location (1 point), and collateral filling Rentrop grade  $< 2$  (2 points) was established, stratifying procedures into 4 difficulty groups: easy (0), intermediate (1), difficult (2), and very difficult (3 or 4), with decreasing technical success rates. In derivation and validation sets, areas under the curve were comparable (0.728 and 0.772, respectively).

**CONCLUSIONS** With growing expertise, the success rate has increased despite increasing complexity of attempted lesions. The established model predicted the probability of technical failure and thus might be applied to grading the difficulty of CTO procedures. (J Am Coll Cardiol Intv 2016;9:911-22) © 2016 by the American College of Cardiology Foundation.

Percutaneous coronary interventions (PCIs) of chronic total occlusions (CTOs) represent the most technically challenging procedures in contemporary interventional cardiology (1,2). During the past decade, important developments in equipment and techniques have led to the achievement of high rates of success and low rates of complications, as shown in registries from around the globe (3-5). Similar to the setting of acute coronary syndromes (6), the success and outcomes of CTO percutaneous attempts have been reported to be closely correlated

with operators' procedural volumes and expertise, particularly with the retrograde approach (7-9).

Recently, the J-CTO Registry (Japanese Multicenter CTO) led to the development of the J-CTO score to predict the likelihood of successful guidewire crossing within 30 min (10). Although this latter score has been shown to correlate with lesion complexity, its role in predicting CTO PCI success remains debatable (11,12).

In the present paper, we report the 10-year experience of a single CTO-dedicated operator, assessing the impact of J-CTO score on procedural details and

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**ABBREVIATIONS  
AND ACRONYMS**

**AUC** = area under the curve  
**CI** = confidence interval  
**CTO** = chronic total occlusion  
**MACE** = major adverse cardiac event(s)  
**MI** = myocardial infarction  
**OR** = odds ratio  
**ORA** = ostial location, Rentrop grade <2, age ≥75 years  
**PCI** = percutaneous coronary intervention  
**ROC** = receiver-operating characteristic

success and trying to establish a prediction model for technical failure.

**METHODS**

**STUDY POPULATION.** We conducted a retrospective analysis of consecutive patients with at least 1 native coronary artery CTO subjected to percutaneous recanalization attempts performed by a single expert interventional cardiologist (A.R.G.) from January 2005 to December 2014 inclusive.

All procedures were scheduled (not ad hoc PCI), and patients were selected on the basis of the presence of symptoms, viability of the myocardium subtended by the CTO artery, and inducible ischemia (>10%) in the CTO artery territory, as demonstrated by functional imaging tests. In patients with more than 1 CTO, only 1 CTO vessel was attempted per procedure. All CTO lesions were attempted only once. The sequence of use of wiring techniques and the guidewire selection were left entirely to the operator's discretion.

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According to the date of CTO PCI attempt, our study population was subdivided into 2 groups by time period: period 1 (January 2005 to December 2009) and period 2 (January 2010 to December 2014).

Informed consent was obtained from all patients, and the study was carried out in accordance with the principles of the Declaration of Helsinki.

**DEFINITIONS.** Coronary CTOs were defined as angiographic evidence of total occlusions with TIMI (Thrombolysis In Myocardial Infarction) flow grade 0 and estimated durations of at least 3 months (13).

Visible calcifications and vessel tortuosity were defined as previously described (10). Collateral filling of the CTO artery from other patent vessels was graded using the Rentrop classification: grade 0 = no visible filling of any collateral channel; grade 1 = filling of the side branches of the occluded artery, with no dye reaching the epicardial segment; grade 2 = partial filling of the epicardial vessel; and grade 3 = complete filling of epicardial vessel by collateral vessels. Technical success was defined as angiographic success (final residual stenosis <20% by visual estimation and TIMI flow grade 3 after CTO recanalization). Clinical success was defined as angiographic success with no in-hospital major adverse cardiac events (MACEs) or contrast-induced nephropathy (3,8). MACEs included cardiac death, Q-wave and non-Q-wave myocardial infarction (MI), tamponade, recurrent symptoms requiring urgent repeat target vessel revascularization

(with either PCI or coronary artery bypass grafting). In all patients, creatine kinase-MB was evaluated 6 h after the procedure and until normalization if the levels were abnormal. Non-Q-wave MI was defined as creatine kinase-MB enzyme elevation >3 times the upper limit of normal (3,8). Contrast-induced nephropathy was defined as an increase of 25% or 0.5 mg/dl in serum creatinine level at 24 to 48 h after PCI in comparison with baseline values (3).

**ASSESSMENT OF LESION COMPLEXITY.** To classify the attempted CTO lesions according to their complexity, the J-CTO score was calculated as described by Morino et al. (10). Variability in J-CTO score reporting was assessed in a random sample of 10 CTO angiograms, which were evaluated by the same operator (for intraobserver variability) and another senior interventionalist (for interobserver variability). The lesions were classified as easy, intermediate, difficult, or very difficult if the J-CTO score was 0, 1, 2, or ≥3, respectively (10).

**STATISTICAL ANALYSIS. Descriptive statistics and comparisons.** Clinical characteristics, angiographic features, and in-hospital events were reported through standard descriptive analyses for large samples assumed to follow a normal distribution. Continuous variables are presented as mean ± SD and categorical variables as frequencies and percentages. Student *t* tests and chi-square tests (or Fisher exact tests when at least 25% of values showed expected cell frequencies <5) were used for comparison between the 2 time-period groups and among J-CTO categories. A *p* value <0.05 was considered to indicate statistical significance.

**Retrograde approach.** We tried to identify clinical and/or angiographic factors predicting the success of the retrograde approach through stepwise logistic regression analysis. Univariate analysis was initially performed; univariate variables with *p* values < 0.10 were thereafter included in the multivariate model. Student *t* tests and chi-square tests (or Fisher exact tests when at least 25% of values showed expected cell frequencies <5) were used for comparison between antegrade and retrograde CTO procedures. A *p* value <0.05 was considered to indicate statistical significance.

**J-CTO score association with procedural details and technical failure.** The association of J-CTO score with procedural time, fluoroscopy time, and contrast load was assessed in linear regression; regression coefficients with their 95% confidence intervals (CIs) were calculated for a 1-point increase in J-CTO score. To evaluate the association between J-CTO score and technical failure, receiver-operating characteristic

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