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EDITORIAL COMMENT

Do We Need Another Predictive Scoring Tool for Chronic Total Occlusion Percutaneous Coronary Intervention?*

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Virtually every paper devoted to percutaneous coronary intervention (PCI) of chronic total occlusions (CTOs) begins with a reference to these being the most challenging lesion subsets in the coronary vasculature. Although this remains true in 2015, it is also true that technical advances have translated into contemporary success rates among experienced operators of about 90% (1,2). Despite these advances, CTO PCI attempt rates remain very low (3). When failure is infrequent and attempt rates are low, it is appropriate to consider the relevance of developing new tools for predicting success and their optimal application to clinical practice.

SEE PAGE 1540

The report by Alessandrino et al. (4) in this issue of *JACC: Cardiovascular Interventions* attempts to formulate a new scoring system for CTO PCI, comparing it with the well-recognized standard of the Japanese chronic total occlusion (J-CTO) score. They analyzed 1,657 patients who underwent CTO PCI at a single center in France. Multivariate analysis identified 2 clinical and 4 angiographic correlates of failure, with the development of a weighted scoring system that divides patients into 4 groups ranging from high to very low probability of procedural success. Several strengths of their approach are notable: 1) they used a significantly larger cohort of patients than was evaluated for the J-CTO score (>1,600 vs. <500); 2) they used both a derivation and validation cohort and directly compared their model with the J-CTO score; 3) they included clinical variables (most importantly, previous surgical revascularization, which was assessed but not found to be significant in the J-CTO analysis); and 4) they weighted variables depending on their odds ratio. One might expect, for instance, that severe calcification would be a more important predictor of success than previous myocardial infarction.

Although the derived score was found to be equally predictive in the validation cohort and slightly more predictive than the J-CTO score, there are significant limitations to this analysis as well. 1) The overall success rates were low (72%) and are not representative of contemporary CTO PCI, as noted previously. This was despite a relatively less complex anatomic substrate (mean J-CTO score of 1.62), which may reflect operator-based case selection not accounted for in the model. 2) The prolonged period for data collection (10 years) represents a time of marked evolution in technique and devices around the world, yet despite these changes, there was only a slight increase in success rates in the "subgroup" analysis of the final 3 years. 3) The lack of a core laboratory for angiographic analysis lends itself to operator-dependent reporting bias, particularly with regard to lesion length, calcification, and proximal cap morphology. 4) The C statistic for the model (0.68) suggests only a moderately successful discriminatory capacity for success versus failure. 5) The very limited use of contralateral injections (36%), support catheters (~25% had either no support catheter or only a monorail balloon), retrograde strategies (<10%), and presumably antegrade dissection re-entry techniques (not reported) detract significantly from the general

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applicability to the modern CTO interventionalist's procedural construct.

Most of these limitations also apply to the recently reported CT-RECTOR (Computed Tomography Registry of Chronic Total Occlusion Revascularization) score, which used data from a multicenter coronary computed tomography registry in Germany and Poland to develop a scoring system for CTO PCI (5). The overall success rate was only 62%, and the retrograde approach used in only 11%.

What is a CTO predictive tool useful for in 2015 and beyond? Despite the wide acceptance of the J-CTO score as an accurate predictor, very few experienced CTO operators will actually calculate it on a case-by-case basis. As noted previously, with success rates in the 90% range among highly experienced operators, there is virtually no anatomic contraindication to intervention in a clinically appropriate patient. The hybrid approach, in particular, with its emphasis on efficiency and conditional probability in moving from a stalling technique to the next provisional strategy (6), has led to high success rates with no anatomic exclusions. The main concern is not with success or failure, but with procedural planning and efficiency. In fact, the original J-CTO score report by Morino et al. (1) focused more on procedural efficiency (i.e., guidewire crossing time of $<$30 min) than on overall success, although the score was predictive of the final outcome as well, with significantly lower success rates in the most difficult lesion subsets (73% for a J-CTO score of $\geq$3). In contrast, an analysis from a single Canadian center with an experienced hybrid operator (intervening on complex anatomy as evidenced by $>$41% of patients with a J-CTO score of $\geq$3) showed very similar correlations between guidewire crossing times and the J-CTO score as in the Morino et al. (1) paper, but no correlation with final success, as all J-CTO categories had similar high success rates of $>$87% (7). Similarly, the Hybrid Video Registry, in which independent abstracters retrospectively analyzed 144 live-taped interventions on anatomically challenging lesions (mean J-CTO score, 2.3) from hybrid training courses throughout the United States, demonstrated high rates of procedural success irrespective of the J-CTO score ($>$90% success with a score of $\geq$3), but increasing procedure time and an increasing need for provisional secondary and tertiary strategies with increasing J-CTO score (8).

With this in mind, I would suggest the following as the major benefits of any CTO predictive tool in the current era: 1) for experienced CTO operators, a system that can predict overall procedural efficiency and the most likely initial strategy (antegrade wire escalation, antegrade dissection re-entry or retrograde) for success. For example, a heavily calcified circumflex CTO in a post-bypass patient might be predicted to benefit from an initial retrograde strategy, despite other anatomic factors (e.g., tapered proximal cap) that would suggest an antegrade approach; 2) for less experienced operators, a system that could predict lesions that are either appropriate for attempts in relation to their skill sets or sufficiently complex to suggest a need for either proctoring or referral to an expert operator; 3) a system that is widely enough validated and accepted to be used as an index for, and comparator between, variable CTO research analytics (registry and otherwise); and 4) a system that could guide and inform discussions with patients about procedural efficiency, complications, and success.

How does the J-CTO score stack up in these respects? Clearly, it has been very useful in comparative analyses of lesion complexity. In addition, CTO operators-in-training with limited skill sets, who represent the vast majority of interventional cardiologists (CTO success rates of ~60% from National Cardiovascular Data Registry reports [3]), can benefit from its use in case selection. The currently reported French system may be even better than the J-CTO score in this regard. However, as noted previously in both the U.S. and Canadian series, these systems are less useful in the context of experienced operators with broad skill sets using a hybrid approach in which there is a systematic algorithmic strategy progression, no anatomic exclusions, and an emphasis on efficiency.

I believe that the answer to the title question is yes: in the current era of CTO PCI, we would benefit from the development of a new CTO score, likely incorporating both clinical and anatomic factors that would predict not just success and failure, but more importantly procedural efficiency and the likelihood of one strategy's success over another. Development of such a model would depend on: 1) a detailed, comprehensive, and unbiased data collection from a large cohort of patients enrolled over a short period of time by 2) experienced operators who include a very high percentage of their CTO interventions, without anatomic exclusion, using contemporary CTO PCI tools and techniques, and 3) the use of a core laboratory for angiographic and procedural analysis. In fact, the OPEN-CTO (Outcomes, Patient Health Status, and Efficiency in Chronic Total Occlusion) trial (NCT02026466), a recently completed registry that enrolled 1,000 patients over 18 months, meets all of these criteria and will be a fertile dataset for the development of a relevant and clinically useful CTO score, along with many other research opportunities.

Finally, in the bigger picture and in light of the continued low attempt rates cited earlier (3), our ultimate goal should be that more patients with CTOs and the appropriate clinical indications obtain successful revascularization. What is the role of a scoring system in attaining this goal? Although the current systems are helpful for less experienced operators with limited skill sets, we must be wary of their potential for providing additional "excuses" not to intervene. A new and more sophisticated CTO score, derived from analysis of consistently high success rates across all lesion subsets, would hopefully expand awareness that *all* patients with clinical indications should be revascularized, regardless of anatomy, and with an understanding of the need for appropriate training and, when necessary, referral.

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