Chronic Total Occlusions: Re-defining the Predictors of Success?

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Keywords: Chronic Total Occlusions, Percutaneous Coronary Intervention, Angiography

1. BACKGROUND

About 20% of all patients with diagnosed coronary artery disease (CAD) suffer from one or more coronary chronic total occlusions (CTOs) (1). A CTO is a lesion of a native coronary artery which exhibits thrombolysis-in-myocardial-infarction (TIMI) antegrade flow 0 (i.e. no antegrade flow) and which has been present for at least 3 months (2).

CTOs are considered as the most complex lesions to treat via percutaneous coronary intervention (PCI), due to the indications, costs and technical difficulties related to these procedures. As a consequence, only about 10% of all CAD patients, clinically eligible for CTO-PCI, are currently being treated via PCI (3). The majority is treated either medically or via coronary artery bypass graft (CABG) surgery (4).

Most commonly, the limiting step towards successful revascularization is guidewire crossing, which is related to the presence of certain (negative) angiographic characteristics such as a “blunt stump” of the proximal CTO cap, the presence of calcifications, a long lesion length (≥ 20mm), a tortuous anatomy and/or a previously failed attempt, etc. Based on these characteristics, Morino et al. developed a Japanese scoring system (J-CTO score) intended to predict the probability of successful antegrade crossing within 30 minutes. This score is currently applied internationally for grading CTO difficulty (5). However, due to the continuous developments of new algorithms (e.g. hybrid algorithm), techniques, materials and devices, the impact of some predictors on procedural outcome may have altered (6). Consequently, it is necessary to investigate the influence of these variables and assess the applicability of the J-CTO score in the current era of CTO-PCI.

2. METHODS

From December 2013 to February 2015, 492 CTO-PCI patients were included consecutively in the multicentre Registry of CrossBoss and Hybrid procedures in FrAnce, The NethErlands, BelGuim and UnitEd Kingdom (RECHARGE). Data was collected on demographic, clinical and angiographic characteristics by experienced CTO operators. Both descriptive and regression analyses were performed using SPSS Statistics. Univariate and multivariate logistic regression analyses were conducted to assess the relationship between procedural success and any of the demographic, angiographic and/or clinical characteristics. The level of significance was set at 95% or higher.

3. RESULTS

427 out of 492 patients (86.8%) had a successful PCI. Univariate analyses showed no significant differences for any demographic variable with respect to procedural outcome. Concerning medical history, significant univariate correlates of procedural failure included a “history of CABG” (12.7 vs. 29.7%, p=0.001), “previous CABG on CTO target vessel (TV)” (9.6 vs. 21.5%, p=0.006) and if the “previous bypass graft of TV was occluded” (5.5 vs. 16.1%, p=0.003). Angiographically,
a “blunt stump” (47.5 vs. 67.7%, p=0.003), “calcifications” (49.9 vs. 66.2%, p=0.016), “tortuosity” (23.0 vs. 50.8%, p<0.001), “CTO length” (57.6 vs. 86.2%, p<0.001) and a “re-attempt” (16.9 vs. 30.8%, p=0.009) all had a significant negative impact on procedural outcome. In addition, also “no clear stump” (25.5 vs. 41.5%, p=0.008) and the “presence of a significant side-branch ≥2mm” were significant negative predictors (34.3 vs. 47.7%, p=0.037).

All significant variables were entered in a multivariate regression analysis. A “history of bypass surgery”, “tortuosity”, “CTO length”, “presence of a side branch” and “no clear stump” remained as significant independent predictors of procedural failure. Although a tendency for significance is clearly visible, a history of a previous attempt is no longer significant. Table 1 provides an overview including the corresponding levels of significance, odds ratios and confidence intervals.

### Table 1: Independent negative angiographic predictors of procedural failure, identified via multivariate regression analysis.

<table>
<thead>
<tr>
<th>Variables</th>
<th>P value</th>
<th>β-coefficient</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG history</td>
<td>0.023</td>
<td>0.812</td>
<td>2.253 (1.118-4.540)</td>
</tr>
<tr>
<td>Bending</td>
<td>0.000</td>
<td>1.143</td>
<td>3.135 (1.734-5.667)</td>
</tr>
<tr>
<td>CTO length (≥20mm)</td>
<td>0.004</td>
<td>1.115</td>
<td>3.051 (1.421-6.552)</td>
</tr>
<tr>
<td>Re-attempt</td>
<td>0.065</td>
<td>0.611</td>
<td>1.843 (0.963-3.527)</td>
</tr>
<tr>
<td>Presence of a side branch</td>
<td>0.038</td>
<td>0.616</td>
<td>1.852 (1.035-3.312)</td>
</tr>
<tr>
<td>No clear stump</td>
<td>0.027</td>
<td>0.682</td>
<td>1.978 (1.082-3.615)</td>
</tr>
</tbody>
</table>

CABG: coronary artery bypass grafting, CTO: chronic total occlusion, CI: confidence interval.

As a “history of CABG” remained significant, specific interest was given to this subpopulation. 73 out of 489 patients (14.9%) had a history of bypass surgery. A comparison was made between patients with and without previous CABG. Several demographic characteristics were associated with prior CABG such as smoking habits (25.3 vs. 9.6%, p=0.005), hypertension (59.9 vs. 76.7%, p=0.007) and hypercholesterolemia (64.4 vs. 87.7%, p<0.001). Stable angina (57.9 vs. 76.7%, p=0.003) was also associated with previous bypass surgery. Angiographic characteristics such as multivessel disease (41.6 vs. 79.5%, p<0.001), TV (RCA or CX) (59.4 vs. 71.2% and 14.7 vs. 20.5% respectively, p<0.001), additional stenosis ≥50% in TV (41.8 vs. 58.9%, p=0.007), calcifications (48.1 vs. 74.0%, p<0.001), bending ≥ 45° (23.4 vs. 45.2%, p<0.001), CTO length ≥ 20mm (58.2 vs. 78.1%, p=0.002) were all significantly associated with a history of bypass surgery indicative for the higher lesion complexity. The J-CTO score was also higher in patients with prior CABG as compared to patients without CABG (2.7±1.2 vs. 2.0±1.2; p<0.001). Procedural success (89.2 vs. 74.0%, p=0.001) was significantly lower in patients with previous bypass surgery.

### 4. DISCUSSION

In this study, preliminary data of 492 patients of the RECHARGE database were used and procedural success was selected as the primary end point. The overall success rate, achieved with the hybrid algorithm, was 86.8% which is high compared to other studies (3). The univariate analysis showed all five J-CTO characteristics were significant despite new technical advancements. Other angiographic characteristics such as an “unclear stump” and the “presence of a side branch” also showed significance. The clinical characteristics “history of CABG”, “previous CABG on TV” and “bypass graft occluded on TV” were also significant.

The selected independent variables of the final model were “CABG history”, “blunt stump”, “bending ≥45°” and “CTO length ≥20mm”. The presence of “calcification” and “previously failed attempt” were not included in the final model. This could be due to sample size, operator experience and/or new technical advancements and developments. Previous CABG on TV and bypass graft of TV occluded were no longer significant. We believe this result could be devoted to the sample size as you would expect that a “previous CABG on TV” and “bypass graft of TV occluded” would have a higher impact on procedural outcome as compared to a history of bypass surgery, which is less specific with regards to the TV. A blunt proximal cap is not in the final model,
possibly due to the presence of the variable no clear stump. These two variables are related to one another. The presence of tortuosity and a long lesion length increase the chance for procedural failure 3.1 and 3.0 times respectively. Furthermore, a history of bypass surgery increases the chances for procedural failure 2.2 times. Finally, an unclear stump and the presence of a side branch could increase procedural failure with 1.9 and 1.8 times respectively. Because of these differences in significant variables and odds ratios compared to Morino et al., we believe that the impact of certain J-CTO characteristics should be re-considered. However, the sample size of the population first needs to increase to have sufficient discriminative power.

Additionally, our data revealed that 14.9% of patients had prior CABG, of which the procedural success rate is significantly lower. The lower success rate of patients with prior CABG could be associated with the presence of a more complex coronary anatomy and elaborate disease process. In turn, this could be explained by several CAD risk factors that are often seen in these patients. Hypertension, hypercholesterolemia and smoking habits are features that were also significantly higher in patients with prior CABG. Furthermore, patients with CABG often have a higher degree of negative angiographic characteristics. In our study, calcific nodes, tortuosity, CTO length and multivessel disease were significantly higher for patients with bypass grafts. These characteristics may hinder CTO crossing attempts and could explain the higher procedural failure in CABG patients.

5. CONCLUSION

The J-CTO score remains preserved since all five J-CTO characteristics remained significant in the regression analysis. Our study also showed an additional important characteristic of influence, namely a history of bypass surgery. However, a larger population series is first needed, which might also indicate that a “previous CABG on the TV” has a larger influence on procedural outcome as compared to a general history of CABG. If such results are achieved in the full study population, we strongly believe the Japanese scoring system should be adapted accordingly.

REFERENCES