

# Does the effectiveness of recanalization of chronic occlusion depend on the location of the obstruction?

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## Abstract

**Introduction:** In past studies, it has been questioned whether success of recanalization of chronic total occlusion (CTO) depends on the location of the occlusion – the circumflex artery (Cx) was considered as the most difficult to open.

**Aim:** To determine whether the effectiveness of recanalization of CTO depends on the location of the obstruction.

**Material and methods:** From January 2011 to January 2016, a single operator dedicated to chronic total occlusions performed in our center 357 procedures on 337 patients.

**Results:** Among 337 patients included in the study, 83.4% were male. Mean age was 62.8 ± 9.3 years. Most of the patients had hypertension (86.4%) and hyperlipidemia (99.4%), and 28.8% of them had diabetes. The most frequently opened artery was the right coronary artery (RCA; 52.4%), followed by the left anterior descending artery (LAD; 29.4%), and last the Cx (18.2%). The mean J-CTO score was comparable between the three groups. The success rate of recanalization of CTO was similar for all arteries: 84.5% in the RCA, 81.9% in the LAD and 89.2% in the Cx (overall  $p = 0.437$ ). Neither procedural complications nor adverse events depended on the location of the CTO.

**Conclusions:** Our study shows the same efficacy of CTO procedures of all epicardial arteries. We did not observe that effectiveness of recanalization of CTO depends on the location of the obstruction.

**Key words:** chronic total occlusion, percutaneous coronary intervention, lesion characteristics.

## Summary

In the past studies it has been questioned whether success of recanalization depends on the occlusion location, and commonly the circumflex artery was considered as the most difficult to open. In our study, we confirmed similar success rate regardless of occluded artery. Importantly, we showed that when performed by experienced operator, these procedures are not associated with increased risk for patients.

## Introduction

In recent years there has been significant progress in chronic total occlusions (CTO) recanalization – often described as the final frontier in interventional cardiology. Constant development of technology and equipment together with progress in skills of dedicated operators has led to substantial improvement in outcomes [1].

In the past studies it has been questioned whether success of recanalization depends on the occlusion location, and commonly the circumflex artery (Cx) was considered as the most difficult to open [2].

## Aim

Thus, in this study we tried to determine whether the effectiveness of recanalization of chronic occlusion depends on the location of the obstruction.

## Material and methods

From January 2011 to January 2016 a single operator dedicated to chronic total occlusions performed in our center 357 procedures on 337 patients. Coronary CTOs were defined as angiographic evidence of total occlusions with thrombolysis in myocardial infarction (TIMI)

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flow grade of 0 and estimated durations of at least 3 months. Time of occlusion has been defined according to the Euro CTO Club terminology as certain (occlusion confirmed in previous angiograms) or probable (clinically confirmed with documented myocardial infarction in the area of the occluded artery without any other possible myocardial related arteries) or possible (undated CTO with TIMI flow 0 and stable coronary artery disease within the last 3 months) [3]. A successful procedure was defined as angiographic success (final residual stenosis < 30% by visual estimation and TIMI flow grade of 3 after CTO recanalization).

Several techniques were used: antegrade parallel wire, antegrade dissection reentry (ADR), retrograde wire crossing, touching wire, CART and reverse CART (Controlled Antegrade and Retrograde sub-intimal Tracking). All of these techniques have been described in detail in previous publications [4–7]. After predilatation drug-eluting stents (DES) were implanted. The J-CTO Score was calculated for all of the CTO lesions [8]. In-hospital major adverse cardiovascular events were defined as death, emergency repeat revascularization at the previously opened artery, emergency coronary artery bypass grafting (CABG), myocardial infarction or stroke. Complications of general and specific CTO included perforation, damage to the proximal part of the artery, dissection or a blood clot in a contralateral vessel. Non-Q-wave MI was defined as myocardial necrosis marker elevation > 3 times the upper limit of normal. When new pathological Q waves, in addition to enzyme elevation, were observed on the electrocardiogram, the event was defined as a Q-wave MI.

### Statistical analysis

Continuous variables are presented as means with standard deviation (SD) and discrete variables as numbers and percentages. Student's *t*-test, the Mann-Whitney *U* test and the  $\chi^2$  test were used to compare appro-

priate variables. All tests were two-sided and a *p*-value < 0.05 was considered statistically significant.

### Results

The baseline characteristics were comparable between patients with different arteries revascularized (Table I). Diabetes was most frequent in the circumflex (Cx) group, whereas patients in the right coronary artery (RCA) group had the highest prevalence of peripheral artery disease. The most frequently occluded artery was the RCA (52.4%), then the left anterior descending artery (LAD; 29.4%) and last the Cx (18.2%).

We did not observe any difference in duration of the occlusion, but there was a significance difference in length between groups (Table II). The mean J-CTO score was comparable between the three groups. The group with the occluded RCA had the longest procedure as well as fluoroscopy time, but it did not influence radiation exposure. On the contrary, the highest dose of contrast was used in the LAD group. The retrograde technique was most commonly used in RCA occlusions. Occlusions in the RCA tended to be the longest (Table III). The RCA was also the artery with the highest number of previous attempts.

Neither procedural complications nor adverse events depended on the location. One patient had a stroke after RCA PCI, and 1 patient had a procedure-related myocardial infarction after RCA PCI. We observed several perforations: 4 in the RCA, 4 in the LAD and 1 in the Cx.

The success rate of recanalization of CTO was similar for all arteries: 84.5% in the RCA, 81.9% in the LAD and 89.2% in the Cx (overall *p* = 0.437).

### Discussion

In our study, we confirmed the safety and efficacy of CTO procedures performed by an experienced operator in a high volume center. Our results are similar to

**Table I.** Patients' characteristics

Parameter	LAD (n = 101)	Cx (n = 62)	RCA (n = 174)	P overall
Male, n (%)	80 (79.2)	54 (87.1)	147 (84.5)	0.361
Age [years]	63.1 ± 9.8	63.2 ± 9.3	62.5 ± 9.1	0.834
BMI [kg/m <sup>2</sup> ]	29.7 ± 7.4	28.4 ± 4.0	29.4 ± 5.0	0.307
Hypercholesterolemia, n (%)	101 (100.0)	62 (100.0)	172 (98.9)	0.390
Hypertension, n (%)	85 (84.2)	56 (90.3)	150 (86.2)	0.537
Diabetes, n (%)	36 (35.6)	22 (35.5)	39 (22.4)	0.001
Current smoker, n (%)	17 (16.8)	12 (19.4)	36 (20.7)	0.582
Peripheral artery disease	2 (2.0)	6 (9.7)	20 (11.5)	0.020
COPD	5 (5.0)	6 (9.7)	13 (7.5)	0.506

Values are mean ± standard deviation (SD) or n (%). BMI – body mass index, COPD – chronic obstructive pulmonary disease, Cx – circumflex coronary artery, LAD – left anterior descending artery, RCA – right coronary artery.

**Table II.** Chronic total occlusion characteristics

Variable	LAD (n = 105)	Cx (n = 65)	RCA (n = 187)	P overall	P Cx vs. LAD	P Cx vs. RCA	P LAD vs. RCA
Occlusion duration [months]	13 ±25	9 ±15	16 ±34	0.316	0.735	0.194	0.257
Length [mm]	25.7 ±9.6	22.7 ±9.7	29.9 ±14.3	< 0.001	0.273	< 0.001	0.017
Mean J-CTO score	2.4 ±1.0	2.4 ±1.3	2.3 ±1.1	0.622	0.595	0.815	0.852
Procedural time [min]	64.9 ±27.4	55.7 ±25.0	76.3 ±35.6	0.001	0.157	0.001	0.009
Fluoroscopy time [min]	24.5 ±16.0	20.1 ±12.1	30.7 ±19.3	< 0.001	0.253	< 0.001	0.009
Radiation [Gy]	2.0 ±1.4	1.7 ±1.5	1.9 ±1.8	0.302	0.766	0.749	0.999
Contrast media [ml]	368 ±150	277 ±143	351 ±162	0.001	0.001	0.003	0.643
Retrograde, n (%)	18 (17.1)	5 (7.7)	56 (29.9)	< 0.001	0.080	< 0.001	0.016
Stents used	1.4 ±0.6	1.2 ±0.4	1.9 ±0.9	< 0.001	0.260	< 0.001	< 0.001

Values are mean ± standard deviation (SD) or n (%). Cx – circumflex coronary artery, LAD – left anterior descending artery, RCA – right coronary artery.

**Table III.** J-CTO score characteristics

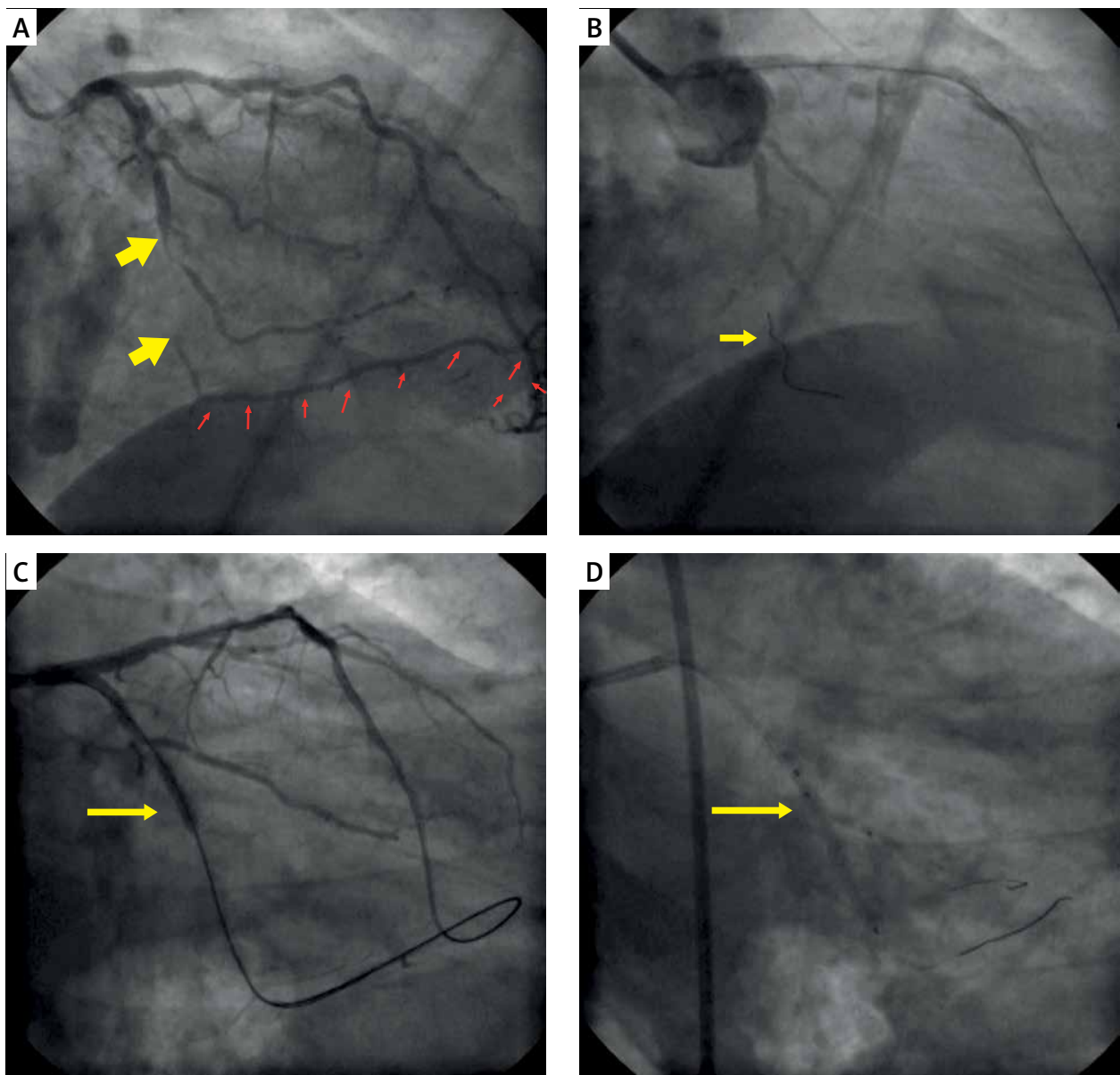
Variable	LAD (n = 105)	Cx (n = 65)	RCA (n = 187)	P overall
Category of difficulty:				0.857
Easy – intermediate	21 (20.0)	15 (23.1)	42 (22.5)	
Difficult – very difficult	84 (80.0)	50 (76.9)	145 (77.5)	
J-CTO score variables, n (%):				
Blunt stump	69 (65.7)	35 (53.8)	114 (61.0)	0.304
Calcification	37 (35.2)	12 (18.5)	54 (28.9)	0.064
Bending > 45°	8 (7.6)	43 (66.2)	18 (9.6)	< 0.001
Occlusion length > 20 mm	79 (75.2)	41 (63.1)	147 (78.6)	0.045
Re-try lesion	44 (41.9)	27 (41.5)	103 (55.1)	0.042

Values are mean ± standard deviation (SD) or n (%). Cx – circumflex coronary artery, LAD – left anterior descending artery, RCA – right coronary artery.

those from American, Japanese and European registries [9–13]. According to the unpublished data of the Polish Cardiac Society for the years 2009–2012 the success rate in Poland was 63.6% for the antegrade technique. In our center the success rate in recanalization of CTO was 87.9% (antegrade technique) and altogether for both techniques (ante- and retrograde) was 88.2% (135 vessels out of 153 occlusions) [14]. In the past studies the highest prevalence of CTO was in the RCA, followed by the Cx and LAD. On contrast, in our study the CTO was located least frequently in the Cx. However, similarly to worldwide data, the RCA had the highest prevalence of CTO.

Data from previous studies suggest a lower success rate in CTO PCI of the Cx. The recently published PROGRESS-CTO score included Cx as one of the independent predictors of technical failure [15]. Moreover, in a systematic review and meta-analysis Joyal *et al.* presented data showing a relatively low success rate of Cx recanalization [16]. Contrary to those findings, we did not ob-

serve any differences in procedural success depending on the location of the CTO. The reported lower success rates for the circumflex CTO (example of successful recanalization of CTO in Cx artery is shown in Figures 1 and 2). target vessel in previous studies are likely related to the increased tortuosity of this vessel and the less frequent presence of “interventional” collaterals [2]. In a recent study Elias *et al.* showed that in patients presenting with ST-elevation myocardial infarction and concomitant CTO, the Cx was an independent predictor of poorly developed collaterals [17]. Although in our study the J-CTO score for all arteries was similar, occlusions in the Cx were shorter, which might have influenced our results. Interestingly, these procedures also had the lowest contrast usage and most rarely the retrograde technique was used. One of the reasons for the disparity between past studies and ours may be that patients in the current study were carefully selected for the procedure by the operator, which in consequence could have resulted in a smaller selection bias. More-



**Figure 1.** Percutaneous coronary intervention of chronic total occlusion of circumflex artery via ipsilateral approach. **A** – Occlusion of circumflex coronary artery (yellow arrows); retrograde filling of marginal branch via collaterals from left anterior descending coronary artery (red arrows). **B** – Retrogradely introduced wire by Corsair microcatheter into the body of the occlusion (arrow). **C** – Inflated balloon (arrow) introduced antegradely after externalization of retrograde wire. **D** – Kissing inflation balloons in bifurcation (circumflex coronary artery/marginal branch); at this stage of the procedure both wires were introduced antegradely, and the retrograde system was withdrawn

over, many of them had already undergone failed procedures in other, peripheral centers.

Several limitations of the study should be emphasized. First, post-procedure myocardial necrosis markers were only measured in patients who had post-procedural clinical or ECG signs of MI. Second, although the mean J-CTO was similar in the three arteries, the calcification was less frequent in the Cx artery and the occluded segment was shorter. This observation could influence the recanalization success rate in the Cx artery.

## Conclusions

Our observations show the same efficacy of chronic total occlusion procedures of all epicardial arteries. Even though the length of the occlusion in the circumflex was the shortest, the J-CTO score was similar. Moreover, the amount of contrast media, fluoroscopy time and total time of the procedure were the shortest in circumflex artery PCIs. Even though statistical significance was not met, it is worth mentioning that the success rate for CTO



**Figure 2.** Final result of percutaneous coronary intervention of chronic total occlusion of circumflex artery via ipsilateral approach. Note the preservation of the side branch

Cx was the highest. Our results confirm the high efficacy of chronic total occlusion procedures, and, when performed in experienced centers, these procedures are not associated with increased risk for patients.

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Leszek Bryniarski and Łukasz Klima contributed equally.

### Conflict of interest

The authors declare no conflict of interest.

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