

## Clinical and angiographic predictors of successful percutaneous coronary intervention in chronic total coronary occlusions

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### Abstract

Percutaneous coronary intervention (PCI) of chronic total occlusions (CTO) is considered one of the most challenging procedures in interventional cardiology & may lead to multiple complications. Multiple factors may adversely influence the success rate of the procedure however the benefits of the revascularization usually outweigh the risks of the procedure. Is to assess the clinical and angiographic predictors of successful PCI in CTO of native coronary artery. 100 patients who have referred to Damanhur teaching hospital for elective PCI of CTO, mean age was  $53.9 \pm 8.49$ , were assessed clinically & angiographically with reporting the procedure outcome among them. The overall success rate was 83% mostly in LAD (82%) less in the LCX (75%), there was no significant affection of the clinical & demographic factors on the success rate of the PCI however angiographic characteristics including stump shape, calcifications, presence of bridging collaterals, side branch at occlusion point, vessel tortuosity, site of the lesion, length of the lesion and vessel diameter were strong predictors for success in the study. The duration of occlusion, length of the lesion, vessel diameter, stump shape, presence of bridging collaterals, side branch at occlusion point, calcifications, vessel tortuosity and lesion location were independent predictors of successful CTO revascularization, whereas patient's characteristics and clinical risk factors are not.

**Keywords:** Revascularization, Chronic total occlusions, Lesion characteristics, Procedural success.

### 1.Introduction

The incidence of coronary chronic total occlusions (CTO) among patients performing diagnostic coronary angiography is nearly 20% [1]. Nonetheless, according to the available data, percutaneous coronary intervention (PCI) rates for CTOs are as low as 10–15% and most of these patients are treated with medical therapy or coronary artery bypass grafting surgery (CABG) [2]. Successful recanalization of CTOs can reduce the ischemic burden and symptoms as well as electrical instability, improves exercise capacity and tends to show a positive effect on left ventricular (LV) remodeling and ejection fraction (LVEF) [3,4].

PCI for CTO is considered to be one of the most challenging procedures of interventional cardiology, and in the earlier studies, successful recanalization rates of CTO ranged from 51% to 74% [5]. However, with improved operator experience and the development of novel equipment and techniques, procedural success rates have been increased [6, 7]. Large studies investigating patients with CTO in different clinical settings had demonstrated short- and long-term survival advantages in patients with successfully re-vascularized when compared with failed procedures and have tried to determine clinical and procedural predictors of the success and outcome [8]. However, debate continues in regard to which factors adversely influence the success rate of PCI and whether the benefits of revascularization of CTO outweigh the risks and challenges [9].

### 2.Aim of the work

The purpose of the present study was to assess the clinical and angiographic predictors of successful percutaneous coronary intervention (PCI) in chronic total coronary occlusions (CTO) of native coronary artery.

### 3. Patients and methods

#### Study design and patient population

During the period from September 2018 to August 2019, 100 consecutive patients who underwent PCI for CTO of a native coronary artery were included in this study.

The indication for coronary angiography in all patients and subsequent PCI for CTO was the presence of angina and the demonstration of viable myocardium or silent reversible ischemia in the territory of the occluded artery on myocardial perfusion imaging. Patients with recent myocardial infarction (MI) or unstable hemodynamics, total occlusion of bypass grafts and patients with renal impairment were excluded from the study.

After taking detailed medical history and complete physical examination, each participant was questioned for major cardiovascular risk factors such as age, sex, diabetes mellitus (DM), smoking status, dyslipidemia and hypertension (HTN). The Institutional Ethics Committee approved the study protocol and each participant provided written informed consent.

Coronary CTOs were defined as angiographic evidence of a total occlusion with Thrombolysis In Myocardial Infarction (TIMI) grade 0 or 1 and estimated duration of at least 3 months [10]. Estimation of occlusion duration was based on the first onset of angina pectoris, a history of myocardial infarction in the target vessel territory,

or comparison with a previous angiogram [11]. Technical success was defined as successful CTO recanalization with achievement of < 30% residual diameter stenosis within the treated segment and restoration of TIMI grade-3 antegrade flow [12].

### 3.1 Definitions and lesion characteristics

Severe tortuosity was defined as there being one or more bends of 90° or more, or three or more bends of 45–90° proximal of the diseased segment. Presence of calcification was assigned to two categories according to severity. Moderate-severe calcification was accepted as multiple persisting opacifications of the coronary wall visible in at least one projection surrounding the complete lumen of the coronary artery at the site of the lesion, or mild calcification if it did not. The angiographic structure of the occlusion was defined as tapered stump (funnel shape narrowing of the proximal cap with or without a clear microchannel), blunt stump (abrupt occlusion with no microchannel), or stumpless (proximal cap could not be angiographically defined). Intracoronary microchannels at the site of the occlusion were considered to be bridging collateral vessels that established the chronicity of the occlusion [13]. SYNTAX score was calculated using the SYNTAX score algorithm on the baseline diagnostic angiogram [14]. Moreover, the Multicenter Chronic Total Occlusion Registry of Japan (J-CTO) scoring system was calculated using parameters of lesion complexity such as prior failed attempt, angiographic evidence of heavy calcification, bending within the occluded segment, blunt proximal stump, and occlusion length > 20 mm [15].

The interventional cardiologists were blinded to the clinical characteristics and laboratory results of the patients.

### 3.2 Interventional procedure

Aspirin and loading dose of clopidogrel (600 mg) were given to all patients before the

procedure, and dual antiplatelet therapy was prescribed for 12 months after discharge. A bolus of 80–100 U/kg unfractionated heparin was given before the procedure and followed by intravenous infusion to achieve an activated clotting time > 250 s during the procedure. Selection of the wiring techniques and the guidewires was based on the operator's opinion and the patient's coronary anatomy. The antegrade approach was used, and, depending on procedural progress, different strategies and the use of stiffer wires were considered.

Two experienced operators in our institution performed the CTO intervention procedures. The experienced operators met the criteria of "CTO operators" who had specific proctored experience of more than 100 CTOs [16].

### 3.3 Statistical analysis

All results & data were introduced into the computer, followed by tabulation & analysis. Statistical analysis was done using SPSS-20 (Statistical Package for Social Sciences version 20).

Statistical analyses were done at level of significance of  $P \leq 0.05$  [17].

### 4. Results

A total of 100 patients (71 men; mean age:  $53.9 \pm 8.49$  years) underwent PCI for CTO. There were 83 patients (58 men; mean age:  $60.6 \pm 12.3$  years) in the CTO success group and 17 patients (13 men; mean age:  $58.8 \pm 11.4$  years) in the CTO failure group. Demographic, clinical and laboratory characteristics of the study population are shown in Table (1).

More than 1/5 (24%) had a family history of coronary artery disease (CAD), 37% had diabetes, 60% had hypertension, 62% were smokers and 50% had a history of dyslipidemia.

The clinical and laboratory characteristics were similar between the success and failure groups with no statistically significant effect on the result of revascularization table (1).

**Table (1)** Clinical & demographic characteristics of the study population

Clinical & demographic characteristics	Total No.	Success (83)		Failure (17)		P value
Age	$53.9 \pm 8.49$	$60.6 \pm 12.3$		$58.8 \pm 11.4$		0.473
male	71	58	69.9%	13	76.6%	0.462
female	29	25	30.1%	4	23.5%	0.375
Hypertension	60	50	60.2%	10	58.8%	0.521
Smoking	62	52	62.6%	10	58.8%	0.451
DM	37	30	36.1%	7	41.1%	0.429
Dyslipidemia	50	41	49.3%	9	52.9%	0.384
Family history of IHD	24	19	22.8%	5	29.4%	0.266
previous attempt	24	21	25.3%	3	17.6%	0.237
No previous attempt	76	62	74.4%	14	82.3%	0.471

The incidences of severe calcification, severe tortuosity, absence of tapered stump, existence of bridging collaterals, J-CTO score and side branch at occlusion site were found to be higher in the CTO failed group ( $p < 0.05$ , for all), whereas large vessel diameter ( $> 3$  mm) and short lesion length were more frequent in the successful revascularization group ( $p < 0.05$ , for all) (table 2).

The majority of patients had multivessel disease, and the left anterior descending coronary artery (LAD) was the target vessel in most of the patients (46%). 24 patients had at least 1 previous failed attempt at CTO recanalization.

All PCIs were performed using an antegrade approach. The overall technical success rate was 83% and drug-eluting stents (DES) were used in all of the patients.

**Table (2)** Angiographic characteristics of the study population

Angiographic characteristic		Total No.	Success (83)		Failure (17)		P value
Stump shape	Tapered	52	48	57.8%	4	23.5%	< 0.001
	Blunt	48	35	42.1%	13	76.4%	
Side branch at occlusion point	Present	36	25	30.1%	11	64.7%	0.015
	Absent	64	58	69.8%	6	35.2%	
calcification	Mild	58	54	65%	4	23.5%	< 0.001
	Moderate- severe	42	29	34.9%	13	76.4%	
Bridging collaterals	Present	46	33	39.7%	13	76.4%	< 0.001
	Absent	54	50	60.2%	4	23.5%	
Lesion tortuosity	Present	40	26	31.3%	14	82.3%	< 0.001
	Absent	60	57	68.6%	3	17.6%	
Lesion location	Ostial	30	18	21.6%	12	70.5%	< 0.001
	Distal	70	65	78.3%	5	29.4%	
J-SCT score		$1.9 \pm 0.85$		$1.7 \pm 0.84$		$2.3 \pm 0.81$	< 0.001
Syntax score		$22 \pm 6.9$		$22.4 \pm 6.9$		$22.7 \pm 6.9$	0.830
Vessel diameter		$3.23 \pm 0.8$		$3.64 \pm 0.8$		$2.71 \pm 0.42$	< 0.001
Length of occlusion		$21.26 \pm 8.02$		$16.93 \pm 4.74$		$26.77 \pm 8$	< 0.001
Duration of occlusion		$6.23 \pm 2.93$		$4.98 \pm 1.85$		$7.82 \pm 3.31$	< 0.001

## 5. Discussion

Chronic total occlusive lesions are characterized by heavy atherosclerotic burden, uncertain course of the vessel at the site of occlusion and longer length of lesions within the artery, which cause a lower success rate in revascularization than that of non-CTOs [18].

The CTOs are the most complex and challenging coronary lesions for percutaneous revascularization, in several previous studies, the procedural success rates were reported between 58.9% and 75.2% [19].

Recently, the reported success rate of CTO-PCI has reached  $> 80\%$  owing to the use of new sophisticated techniques and development of specialized devices [20]. The overall technical success rate of the present study is 83% and is close to those reported in recent large United States and European CTO PCI registries (85.5% to 87.5%) [21]. This is likely because of application of novel crossing strategies, novel equipment and increasing operator experience [22].

The morphology of chronic total occlusive plaque is composed of dense, loose and cellular fibrous tissue, as well as calcium, foam cells, and lymphocyte infiltration without foam cells [23]. Therefore, this plaque morphology entails difficulties in crossing a total occlusion with a

guidewire, which is the most common reason for failure of CTO revascularization [24]. Thus, it is important to evaluate the probability of success before attempting percutaneous revascularization in CTOs.

Although several studies were designed to investigate the influential factors, debate continues in regard to the impact of various clinical and angiographic factors on success or failure of PCI [25].

In the present study clinical and laboratory characteristics of the patients as age, sex, DM, smoking status, dyslipidemia and HTN had no impact on the success rate of the study. This was consistent with other studies such as Mashallah et al (2008) [26] and Abbott et al (2006) [27]. However Baykan et al (2016) [28] and Salarifar et al (2014) [29] had reported that older age was a marker of decrease technical success and difference in gender was found to be statistically significant in Haji et al (2012) [30].

The results of the current study support that several angiographic factors as absence of tapered stump structure, presence of bridging collateral vessels, and the presence of a side branch at the occlusion site, severe tortuosity, moderate-to-severe calcification and ostial location have also been demonstrated to be predictors of technical failure.

This was consistent with the results of previous studies [15, 25, 31] although other studies disagree as Baykan et al (2016) [28] who showed that shape of the stump had no predictive value, Haji et al. (2012) [30] showed that side branches had no significant effect, Salarifar et al (2014) [29] showed degree of calcification and bridging collaterals had no impact on success rate.

Also in the current study lesions length more than 23mm and diameter less than 3.25 mm were predictors of failure of recanalization of CTO which was consistent with (Morino et al 2011) [32] and (Yamamoto et al 2013) [33], however Baykan et al (2016) [28] showed that there was no significant relation between success rate and vessel length.

In this study J-CTO score play important role in success of the procedure where score more than 2 is predictor of failure. This was consistent with studies done by with Morino et al (2011) [32] and Luo (2015) [34] that showed that calculation of J-CTO score is important before attempt CTO revascularization.

Several limitations of the present study should be mentioned. First, total number of patients in the study was relatively small. Second, the number of patients in failure group was relatively small and was 4 times lower than the number in the success group, which may influence the power of the study and the findings. Third only antegrade approach was used and retrograde approach hadn't been used. Forth, long-term clinical follow-up was not obtained.

## 6. Conclusions

CTO PCI is an effective therapeutic procedure, despite its difficulty; it can be done safely with relatively success rate. The duration of occlusion, length of occlusion, vessel diameter, stump shape, presence of bridging collaterals, presence of side branch at occlusion point, calcifications, vessel tortuosity and lesion location affect the success rate of PCI, whereas patient's characteristics and clinical risk factors had no significant effect on the success of the procedure.

### 6.1 Conflict of interest

The authors declare no conflicts of interest.

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