The Egyptian Journal of Hospital Medicine (October 2024) Vol. 97, Page 4354-4364

Registry for the Safety and Success of Percutaneous Coronary Intervention of Chronic Total Occlusion in Ain Shams University Hospitals

Walid Mohamed Sallam *, M. M. Ayman Elbaz, Nireen Khalifa Okasha, and Tarek Rashid Mohamed
Cardiology Department, Faculty of Medicine, Ain Shams University, Cairo Egypt.
*** Corresponding author:** Walid Mohamed Sallam, **Email:** walid-m-sallam@hotmail.com, **Telephone:** +20 106 958 3900

ABSTRACT

Background: Chronic total occlusion (CTO) of coronary arteries remains a challenging scenario in percutaneous coronary intervention (PCI), with success and safety highly dependent on the approach and lesion characteristics.

Objective: This registry was established to assess procedural strategies, success rates, and complications among patients undergoing CTO PCI at Ain Shams University Hospitals over an eight-month period.

Patients and methods: This registry included 62 patients who underwent CTO PCI through the period from July 1, 2020, to February 28, 2021. Comprehensive patient and procedural data including lesion and technical details, were collected and analyzed using SPSS version 26. Complications, major adverse cardiac events (MACE), and procedural success rates were assessed and compared between antegrade and retrograde approaches.

Results: Procedural success was achieved in 91.9% of cases, with 93.5% technical success. The retrograde approach was associated with longer procedure (120 vs. 63 minutes, P = 0.005) and fluoroscopy times (82 vs. 47 minutes, P = 0.002), as well as higher radiation (6909 vs. 3890 my, P = 0.018) and contrast doses (475 vs. 300 mL, P = 0.006). Complications occurred in 32.3% of cases, predominantly dissection (25.8%). In-hospital MACE was low, with only one death (1.6%) and one stroke (1.6%).

Conclusion: CTO PCI demonstrated high success rates in an experienced center, though procedural complexity, which remained significant, particularly with the retrograde approach. This registry highlighted lesion-specific risks and procedural factors that influence success and complication rates, guiding optimal strategy selection for CTO PCI.

Keywords: Chronic total occlusion, Percutaneous coronary intervention, Registry, Procedural success, Complications.

INTRODUCTION

Percutaneous coronary intervention for chronic total occlusion (PCI CTO) is a rapidly advancing field, often considered the last frontier in interventional cardiology [1]. In recent years, advancements in techniques and equipment, along with specialized personnel training, have significantly improved success rates [2, 3]. Although, the number of randomized controlled studies remains limited, results from large multicenter registries now allow us to offer this intervention safely as an additional treatment option alongside optimized drug therapy and myocardial revascularization surgery [1, 2].

CTOs are defined as coronary obstructions that produce a complete occlusion of the vessel lumen, with thrombolysis in myocardial infarction (TIMI) flow 0 persisting for longer than three months. Occlusions with limited contrast passage without distal vessel opacification are considered "functional CTOs" [4]. CTOs are found in 18-52% of patients undergoing coronary angiography who have coronary artery disease; however, recent registries indicate a prevalence between 16% and 20% [5].

Various scoring systems have been developed to predict the technical success, efficiency, and complications of CTO PCI. The first and most widely used scoring system was established by investigators from the J-CTO registry (Multicenter CTO Registry in Japan) and includes five baseline clinical and angiographic parameters in a 5-point system (Japan CTO / J-CTO score). Each of the following factors associated with a lower probability of successful guidewire crossing within 30 minutes is assigned one point: Blunt stump, calcification, lesion bending over 45 degrees, occlusion length exceeding 20 mm, and prior unsuccessful attempts at CTO revascularization [6]. Based on the score, cases were categorized as Easy (J-CTO=0), Intermediate (J-CTO=1), Difficult (J-CTO=2), or Very Difficult (J-CTO≥3).

Technical success is defined as the ability to cross the occluded segment with both a guidewire and balloon and successfully open the artery restoring antegrade TIMI flow of grade 2 or 3 with less than 30% residual stenosis [7]. Procedural success in CTO PCI is achieved when technical success is met with less than 30% residual stenosis in the treated segment and antegrade TIMI grade 2 or 3 flow, with no in-hospital major adverse cardiac events (MACE) before discharge [8]. MACE includes any of the following adverse events prior to discharge: Death from any cause, Q-wave myocardial infarction, urgent repeat target vessel revascularization via PCI or coronary bypass surgery, tamponade requiring pericardiocentesis or surgery, and stroke [9].

Although, mortality rates from cardiovascular diseases (CVD), particularly coronary artery diseases, have significantly declined globally, CVDs remain the leading cause of death. More people die annually from CVDs than from any other cause. In 2016, an estimated

Received: 10/07/2024
Accepted: 10/09/2024

17.9 million people died from CVDs, accounting for 31% of all global deaths. Of these, approximately 7.4 million deaths were due to coronary artery disease and 6.7 million were due to stroke [10].

This registry aimed to develop an electronic database for all patients who underwent PCI for CTOs at Ain Shams University Hospitals (ASUHs) over eight months. The registry collected data on treatment strategies and procedural outcomes, aiming to analyze procedural strategies, assess patient comorbidities and risk factors, identify predictors of in-hospital mortality, and evaluate technical and procedural success during the hospital stay.

PATIENTS AND METHODS

Our registry included 62 patients who presented over an eight-month period, from July 1, 2020, to February 28, 2021, at Ain Shams University Hospitals and subsequently underwent CTO PCI.

Inclusion criteria: Patients with viable CTO [11], defined as those presenting with either angina resistant to medical therapy or a large area of documented ischemia in the occluded vessel's territory.

Exclusion Criteria: Patients with non-viable CTO or those who declined to participate.

Data collection and patient assessment: Each case underwent comprehensive analysis, beginning with a detailed patient history. This assessment emphasized personal factors such as age, gender, and habits relevant to health (e.g., smoking). Presenting symptoms, especially chest pain and dyspnea, were examined thoroughly. Medical history was documented, including the presence of conditions such as diabetes mellitus, hypertension, dyslipidemia, chronic kidney disease, and previous cerebrovascular events. Additionally, ischemic history was recorded, covering prior myocardial infarctions and revascularization procedures like PCI or coronary artery bypass grafting (CABG). Family history of premature coronary artery disease was noted, as well as the patient's drug history, particularly anti-ischemic treatments.

Clinical examination and investigations: A comprehensive clinical examination, including general and localized assessments, was conducted for each patient. Baseline investigations included a twelve-lead surface ECG and transthoracic echocardiography. Routine laboratory tests were also performed, with special attention to serum creatinine levels.

Intra-procedural details: Intra-procedural data were meticulously collected to document lesion characteristics and assign a J-CTO score [12]. Key lesion parameters included target vessel, CAP morphology (tapered, blunt, or ambiguous), occlusion length, location, presence of bridging collaterals, and any prior attempts at CTO recanalization. Procedural characteristics recorded included the procedure time, fluoroscopy time, contrast dose, CTO crossing or attempt time, types of wires used, number of stents, use of micro-catheters, and crossing strategies (such as antegrade, antegrade dissection and re-entry, retrograde, and retrograde dissection and re-entry). Procedural complications were also recorded, specifically any dissection, perforation, rupture, or MACE events. Procedural outcomes were evaluated based on TIMI score, technical success, and procedural success [7, 8].

Follow-Up: Patients were closely monitored during their hospital stay for the occurrence of in-hospital MACE, ensuring thorough follow-up of outcomes and any complications.

Ethical considerations: The study was done after being accepted by The Research Ethics Committee, Ain Shams University. All patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of The World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis

Data were collected, coded, and analyzed using SPSS version 26 (IBM, Armonk, New York, United States). Qualitative data were presented as numbers and percentages, while quantitative data with parametric distribution were expressed as mean, standard deviation, and range. The Chi-square test was utilized to compare qualitative data between groups. For comparisons involving quantitative data with a parametric distribution, the Independent t-test was employed. The confidence interval was set at 95%, with an accepted margin of error of 5%. Statistical significance was deemed at $P \leq 0.05$.

RESULTS

Demographic, clinical, lesion, and procedural characteristics of patients undergoing CTO PCI were all presented in table (1).

Table (1): Demographic, clinical, lesion, and procedural characteristics of patients undergoing CTO PCI

Characteristic	Measure	Value
Demographic Data and Co-Morbidities		
Age (Years)	Mean ± SD	54.29 ± 9.98
	Range	36 – 78
Gender	Male	53 (85.5%)
	Female	9 (14.5%)
Risk Factors	Smoking	39 (62.9%)
	Diabetes mellitus	30 (48.4%)
	Hypertension	34 (54.8%)
	Ischemic Heart Disease	37 (59.7%)
	Cerebrovascular Stroke	1 (1.6%)
	Dyslipidemia	6 (9.7%)
	Family history of premature CAD	14 (22.6%)
Clinical Presentation and LV Function		
Clinical presentation at CTO diagnosis	Stable angina	31 (50.0%)
	LV dysfunction	7 (11.3%)
	ACS/MI related to another culprit	24 (38.7%)
LV Function	Impaired (< 40%)	9 (14.5%)
	Fair (40–50%)	26 (41.9%)
	Preserved (> 50%)	27 (43.5%)
Angiographic Anatomy		
Culprit artery	LAD	32 (51.61%)
	LCX	6 (9.68%)
	RCA	23 (37.10%)
	LIMA	1 (1.61%)
Number of diseased arteries	Single vessel	35 (56.5%)
	Double vessel	19 (30.6%)
	Triple vessel	8 (12.9%)
Lesion Characteristics and Crossing Strategies		
Cap Morphology	Tapered	10 (16.1%)
	Ambiguous	27 (43.5%)
	Blunt	25 (40.3%)
Lesion Complexity	Bridging collaterals	39 (62.9%)
	Occlusion length > 20mm	46 (74.2%)
	Bending > 45° within lesion	50 (80.6%)
	Calcification	34 (54.8%)
	Blunt stump	25 (40.3%)
	Prior attempt at recanalization	18 (29.0%)
J-CTO Score	Mean ± SD	2.79 ± 1.09
	Range	0 – 5
	Intermediate (1)	8 (12.9%)
	Difficult (2)	17 (27.4%)
	Very difficult (3–5)	37 (59.7%)
Crossing Strategies	Antegrade wire escalation	31 (50.0%)
	Antegrade Dissection & Reentry	11 (17.7%)
	Retrograde wire escalation	18 (29.0%)
	Retrograde Dissection & Reentry	2 (3.2%)
Cross Over	None	58 (93.5%)
	From antegrade to retrograde	3 (4.8%)
	From retrograde to antegrade	1 (1.6%)

CTO: Chronic Total Occlusion, PCI: Percutaneous Coronary Intervention, SD: Standard Deviation, CAD: Coronary Artery Disease, LV: Left Ventricular, ACS: Acute Coronary Syndrome, MI: Myocardial Infarction, LAD: Left Anterior Descending (artery), LCX: Left Circumflex (artery), RCA: Right Coronary Artery, LIMA: Left Internal Mammary Artery, J-CTO: Japan Chronic Total Occlusion (score).

Table (2): The use of microcatheters, devices, and guidewires in CTO PCI procedures.

Table 2: Use of Microcatheters, Devices, and Guidewires in CTO PCI Procedures

Characteristic	Measure	Value
Microcatheter and Device Usage		
Using Microcatheter	No	5 (8.1%)
	Yes	57 (91.9%)
Type of Microcatheter/Device	CORSAIR	11 (17.7%)
	SUPERCROSS	8 (12.9%)
	FINE CROSS	24 (38.7%)
	TURNPIKE LP	12 (19.4%)
	Caravel	15 (24.2%)
	RECROSS	1 (1.6%)
	OTB	2 (3.2%)
Number of Microcatheters/Devices	No	5 (8.1%)
	One	44 (71.0%)
	Two	10 (16.1%)
	Three	3 (4.8%)
Guidewires Used		
Number of Wires Used	One	8 (12.9%)
	Two	12 (19.4%)
	Three	13 (21.0%)
	More than three	29 (46.8%)
Median (IQR)		3 (2 – 5)
Range		1 – 11
Antegrade Approach	Median (IQR)	3 (2 - 4)
	Range	1 - 9
Retrograde Approach	Median (IQR)	5 (4 - 6.5)
	Range	2 - 11
Crossing Guidewires		
Pilot 50	n (%)	1 (1.7%)
Pilot 150	n (%)	1 (1.7%)
Pilot 200	n (%)	3 (5.1%)
ASAHI GAYA FIRST	n (%)	1 (1.7%)
ASAHI GAYA SECOND	n (%)	11 (18.9%)
ASAHI GAYA THIRD	n (%)	14 (24.1%)
ASAHI FILEDER XT	n (%)	2 (3.4%)
ASAHI FILEDER XT A	n (%)	2 (3.4%)
ASAHI FILEDER XT R	n (%)	1 (1.7%)
ASAHI MIRACLE bros	n (%)	6 (10.3%)
ASAHI CONQUEST PRO	n (%)	9 (15.5%)
Hornet 14	n (%)	2 (3.4%)
ASAHI SION Blue	n (%)	1 (1.7%)
ASAHI SION Black	n (%)	3 (5.1%)
ASAHI CONQUEST	n (%)	1 (1.7%)

CTO: Chronic Total Occlusion, PCI: Percutaneous Coronary Intervention, IQR: Interquartile Range, CORSAIR: (Microcatheter brand), SUPERCROSS: (Microcatheter brand), FINE CROSS: (Microcatheter brand), TURNPIKE LP: (Microcatheter brand), OTB: Over-the-Wire Balloon.

Data regarding the procedure time, fluoroscopy time, crossing time, contrast dose, and radiation dose were shown in (Table 3).

Table (3): Descriptive data regarding the Procedure time, Fluoroscopy time, crossing time, Contrast dose, and Radiation dose

		All	Ante-Grade	Retro-Grade
Procedure time (mins)	Median (IQR)	80 (50 - 130)	63 (40 – 120)	120 (75 – 169)
	Range	20 – 195	20 – 195	45 – 180
Fluoroscopy time (mins)	Median (IQR)	55 (33 - 94)	47 (25 – 77)	82 (55 – 120)
	Range	18 – 152	18 – 152	33 – 140
Radiation dose (my)	Median (IQR)	4375 (2826 - 7650)	3890 (2455 – 6130)	6909 (4088 – 10496)
	Range	1000 – 18676	1000 – 18676	1080 – 11764
Contrast dose (mL)	Median (IQR)	400 (250 - 500)	300 (250 – 450)	475 (390 – 550)
	Range	100 – 900	100 – 900	250 – 700
CTO crossing or attempt time (mins)	Median (IQR)	31 (16 - 50)	25 (15 – 35)	48 (35 – 60)
	Range	10 – 105	10 – 105	15 – 80

CTO: Chronic Total Occlusion, IQR: Interquartile Range, mins: Minutes, my: Milligray, mL: Milliliters.

Regarding the procedural complications, in-hospital MACE, and outcomes for 62 CTO PCI cases. Of these, 42 cases (67.7%) were free from complications, while 20 cases (32.3%) had complications, specifically including dissection in 16 cases (25.8%), perforation in 3 cases (4.8%), and CIN in 2 cases (3.2%). In terms of in-hospital MACE, there was one case of stroke (1.6%) and one death (1.6%). Regarding outcomes, the majority achieved a TIMI score of 3 (57 cases, 91.9%), with lower TIMI scores observed as follows: score 0 in 3 cases (4.8%), score 1 in 1 case (1.6%), and score 2 in 1 case (1.6%). Technical success was achieved in 58 cases (93.5%), with 1 case (1.6%) failing and 3 cases (4.8%) aborted for various reasons. Procedural success was noted in 57 cases (91.9%), while 5 cases (8.1%) did not reach procedural success. Patients with complications showed a significantly higher occurrence of procedures involving the RCA as the culprit artery compared to those without complications (55.0% vs. 28.57%, $P = 0.044$). Complicated cases were more likely to exhibit blunt CAP morphology (60.0% vs. 31.0%, $P = 0.029$) and lesions with bending > 45° (95.0% vs. 73.8%, $P = 0.048$). Additionally, blunt stump lesions were more frequent in complicated cases (60.0% vs. 31.0%, $P = 0.029$). Procedural times (120 vs. 60 mins, $P = 0.001$), fluoroscopy times (84 vs. 44 mins, $P = 0.001$), radiation dose (6401 vs. 3890 my, $P = 0.029$), and contrast dose (500 vs. 300 mL, $P < 0.001$) were significantly higher in complicated cases than in non-complicated cases (Table 4).

Table (4): Relation of complications with demographics, clinical presentation, lesion characteristics, crossing strategies, and procedural details in CTO PCI procedures

Characteristic	Non-complicated (No. = 42)	Complicated (No. = 20)	P-value
Demographics and Co-morbidities			
Age (Mean ± SD)	54.81 ± 9.09	53.20 ± 11.83	0.557
Gender - Male	35 (83.3%)	18 (90.0%)	0.486
Gender - Female	7 (16.7%)	2 (10.0%)	
Smoking	28 (66.7%)	11 (55.0%)	0.374
Diabetes Mellitus	21 (50.0%)	9 (45.0%)	0.713
Hypertension	25 (59.5%)	9 (45.0%)	0.283
Ischemic Heart Disease	22 (52.4%)	15 (75.0%)	0.090
Cerebrovascular Stroke	1 (2.4%)	0 (0.0%)	0.487
Dyslipidemia	5 (11.9%)	1 (5.0%)	0.390
Family History of Premature CAD	8 (19.0%)	6 (30.0%)	0.335
Clinical Presentation and LV Function			
Stable Angina	21 (50.0%)	10 (50.0%)	0.972
LV Dysfunction	5 (11.9%)	2 (10.0%)	
ACS/MI Related to Another Culprit	16 (38.1%)	8 (40.0%)	
LV Function - Impaired	7 (16.7%)	2 (10.0%)	0.619
LV Function - Fair	16 (38.1%)	10 (50.0%)	
LV Function - Preserved	19 (45.2%)	8 (40.0%)	
Angiographic Anatomy			
Culprit Artery - LAD	25 (59.52%)	7 (35.0%)	0.070
Culprit Artery - LCX	5 (11.90%)	1 (5.0%)	0.389
Culprit Artery - RCA	12 (28.57%)	11 (55.0%)	**0.044 ***
Culprit Artery - LIMA	0 (0.00%)	1 (5.0%)	0.144
Single Vessel Disease	25 (59.5%)	10 (50.0%)	
Double Vessel Disease	12 (28.6%)	7 (35.0%)	0.778
Triple Vessel Disease	5 (11.9%)	3 (15.0%)	
Lesion Characteristics and Crossing Strategies			
CAP Morphology - Tapered	8 (19.0%)	2 (10.0%)	0.365
CAP Morphology - Ambiguous	21 (50.0%)	6 (30.0%)	0.138
CAP Morphology - Blunt	13 (31.0%)	12 (60.0%)	**0.029 ***
Bridging Collaterals	27 (64.3%)	12 (60.0%)	0.744
Occlusion Length > 20mm	29 (69.0%)	17 (85.0%)	0.180
Lesion Bending > 45°	31 (73.8%)	19 (95.0%)	**0.048 ***
Calcification	22 (52.4%)	12 (60.0%)	0.573
Blunt Stump	13 (31.0%)	12 (60.0%)	**0.029 ***
Prior CTO Recanalization Attempt	15 (35.7%)	3 (15.0%)	0.093
J-CTO Score - Intermediate	8 (19.0%)	0 (0.0%)	
J-CTO Score - Difficult	12 (28.6%)	5 (25.0%)	0.081
J-CTO Score - Very Difficult	22 (52.4%)	15 (75.0%)	
Antegrade Wire Escalation	24 (57.1%)	7 (35.0%)	
Antegrade Dissection & Reentry	7 (16.7%)	4 (20.0%)	0.100
Retrograde Wire Escalation	11 (26.2%)	7 (35.0%)	
Retrograde Dissection & Reentry	0 (0.0%)	2 (10.0%)	
Procedure Time and Dosage Parameters			
Procedure Time (mins) - Median (IQR)	60 (40 - 110)	120 (90 - 145)	**0.001 ***
Fluoroscopy Time (mins) - Median (IQR)	44 (25 - 70)	84 (58 - 104)	**0.001 ***
Radiation Dose (my) - Median (IQR)	3890 (2455 - 6167)	6401 (4350 - 9550)	**0.029 ***
Contrast Dose (mL) - Median (IQR)	300 (250 - 450)	500 (400 - 625)	**0.000 ***

*Significant P-value, CTO: Chronic Total Occlusion, PCI: Percutaneous Coronary Intervention, SD: Standard Deviation, CAD: Coronary Artery Disease, LV: Left Ventricular, ACS: Acute Coronary Syndrome, MI: Myocardial Infarction, LAD: Left Anterior Descending (artery), LCX: Left Circumflex (artery), RCA: Right Coronary Artery, LIMA: Left Internal Mammary Artery, CAP: Coronary Artery Plaque, J-CTO: Japan Chronic Total Occlusion (score), IQR: Interquartile Range, mins: Minutes, my: Milligray, mL: Milliliters.

Procedural success in CTO PCI was significantly lower in patients with complications compared to those without (100% vs. 26.3%, P = 0.001). Procedural outcomes were notably affected by perforation (40.0% in unsuccessful cases vs. 1.8% in successful cases, P < 0.001) and contrast-induced nephropathy (20.0% vs. 1.8%, P = 0.027). In-hospital major adverse cardiac events were more common in unsuccessful cases, with both stroke and death occurring exclusively in this group (20.0% each, P = 0.001). TIMI scores of 0 and 1 were predominantly observed in unsuccessful cases (60.0% and 20.0%, respectively, P < 0.001), while TIMI 3 was achieved in 98.2% of successful cases (P < 0.001). Finally, technical success rates were significantly higher in successful cases, with all aborted procedures occurring in the unsuccessful group (60.0%, P < 0.001) (Table 5).

Table (5): Relation of procedural success with demographic data, clinical presentation, lesion characteristics, crossing strategies, procedural complications, and outcomes in CTO PCI

Characteristic	Unsuccessful (No = 5)	Successful (No = 57)	P-value
Demographic Data and Co-morbidities			
Age (Mean ± SD)	57.80 ± 10.89	53.98 ± 9.94	0.417
Gender - Male	4 (80.0%)	49 (86.0%)	0.717
Gender - Female	1 (20.0%)	8 (14.0%)	
Smoking	2 (40.0%)	37 (64.9%)	0.269
Diabetes Mellitus	3 (60.0%)	27 (47.4%)	0.588
Hypertension	2 (40.0%)	32 (56.1%)	0.487
Ischemic Heart Disease	5 (100.0%)	32 (56.1%)	0.055
Cerebrovascular Stroke	0 (0.0%)	1 (1.8%)	0.765
Dyslipidemia	1 (20.0%)	5 (8.8%)	0.416
Family History of Premature CAD	1 (20.0%)	13 (22.8%)	0.886
Clinical Presentation and LV Function			
Stable Angina	4 (80.0%)	27 (47.4%)	0.162
LV Dysfunction	0 (0.0%)	7 (12.3%)	0.405
ACS/MI Related to Another Culprit	1 (20.0%)	23 (40.4%)	0.370
LV Function - Impaired	0 (0.0%)	9 (15.8%)	0.336
LV Function - Fair	3 (60.0%)	23 (40.4%)	0.393
LV Function - Preserved	2 (40.0%)	25 (43.9%)	0.867
Culprit Artery - LAD	2 (40.0%)	30 (52.63%)	0.587
Culprit Artery - LCX	0 (0.0%)	6 (10.53%)	0.445
Culprit Artery - RCA	2 (40.0%)	21 (36.84%)	0.889
Culprit Artery - LIMA	1 (20.0%)	0 (0.0%)	**0.001 ***
Single Vessel Disease	1 (20.0%)	34 (59.6%)	0.086
Double Vessel Disease	2 (40.0%)	17 (29.8%)	0.636
Triple Vessel Disease	2 (40.0%)	6 (10.5%)	0.059
Lesion Characteristics and Crossing Strategies			
CAP Morphology - Tapered	1 (20.0%)	9 (15.8%)	0.103
CAP Morphology - Ambiguous	0 (0.0%)	27 (47.4%)	
CAP Morphology - Blunt	4 (80.0%)	21 (36.8%)	
Bridging Collaterals	4 (80.0%)	35 (61.4%)	0.409
Occlusion Length > 20mm	4 (80.0%)	42 (73.7%)	0.757
Lesion Bending > 45°	5 (100.0%)	45 (78.9%)	0.253
Calcification	4 (80.0%)	30 (52.6%)	0.238
Blunt Stump	4 (80.0%)	21 (36.8%)	0.059
Prior CTO Recanalization Attempt	2 (40.0%)	16 (28.1%)	0.573
J-CTO Score - Intermediate	0 (0.0%)	8 (14.0%)	0.552
J-CTO Score - Difficult	1 (20.0%)	16 (28.1%)	
J-CTO Score - Very Difficult	4 (80.0%)	33 (57.9%)	
Antegrade Wire Escalation	4 (80.0%)	27 (47.4%)	0.162
Antegrade Dissection & Reentry	1 (20.0%)	10 (17.5%)	0.890
Retrograde Wire Escalation	0 (0.0%)	18 (31.6%)	0.136
Retrograde Dissection & Reentry	0 (0.0%)	2 (3.5%)	0.671

Characteristic	Unsuccessful (No = 5)	Successful (No = 57)	P-value
Cross Over - None	4 (80.0%)	54 (94.7%)	0.198
Cross Over - Antegrade to Retrograde	0 (0.0%)	3 (5.3%)	0.599
Cross Over - Retrograde to Antegrade	1 (20.0%)	0 (0.0%)	**0.000**
Procedural Complications and Outcomes			
Complications - Not Complicated	0 (0.0%)	42 (73.7%)	**0.001 ***
Complications - Complicated	5 (100.0%)	15 (26.3%)	
Dissection	2 (40.0%)	14 (24.6%)	0.449
Perforation	2 (40.0%)	1 (1.8%)	**0.000 ***
CIN	1 (20.0%)	1 (1.8%)	**0.027 ***
In-Hospital MACE			
Stroke	1 (20.0%)	0 (0.0%)	**0.001 ***
Death	1 (20.0%)	0 (0.0%)	**0.001 ***
Outcomes and TIMI Score			
TIMI Score - 0	3 (60.0%)	0 (0.0%)	**0.000 ***
TIMI Score - 1	1 (20.0%)	0 (0.0%)	**0.001 ***
TIMI Score - 2	0 (0.0%)	1 (1.8%)	0.765
TIMI Score - 3	1 (20.0%)	56 (98.2%)	**0.000 ***
Technical Success - Failed	1 (20.0%)	0 (0.0%)	**0.001 ***
Technical Success - Aborted	3 (60.0%)	0 (0.0%)	**0.000 ***
Technical Success - Successful	1 (20.0%)	57 (100.0%)	**0.000 ***

*Significant P-value, CTO: Chronic Total Occlusion, PCI: Percutaneous Coronary Intervention, SD: Standard Deviation, CAD: Coronary Artery Disease, LV: Left Ventricular, ACS: Acute Coronary Syndrome, MI: Myocardial Infarction, LAD: Left Anterior Descending (artery), LCX: Left Circumflex (artery), RCA: Right Coronary Artery, LIMA: Left Internal Mammary Artery, CAP: Coronary Artery Plaque, J-CTO: Japan Chronic Total Occlusion (score), CIN: Contrast-Induced Nephropathy, MACE: Major Adverse Cardiac Events, TIMI: Thrombolysis In Myocardial Infarction.

In CTO PCI procedures, the retrograde approach was associated with a higher involvement of the LAD as the culprit artery (70.0% vs. 42.86%, P = 0.045) compared to the antegrade approach. Retrograde cases utilized more wires (median 5 vs. 3, P < 0.001) and more frequently required multiple microcatheters (P = 0.004). Procedural parameters were significantly higher in the retrograde group, with increased procedure time (median 120 vs. 63 mins, P = 0.005), fluoroscopy time (82 vs. 47 mins, P = 0.002), radiation dose (6909 vs. 3890 my, P = 0.018), contrast dose (475 vs. 300 mL, P = 0.006), and crossing/attempt time (48 vs. 25 mins, P < 0.001). Although, complication rates were not statistically different (45.0% in retrograde vs. 26.2% in antegrade, P = 0.139), dissection occurred more frequently with the retrograde approach (40.0% vs. 19.0%, P = 0.078). There were no significant differences in in-hospital MACE or TIMI flow, with TIMI 3 achieved in 100% of retrograde cases and 88.1% of antegrade cases. Technical success was high in both approaches, with 100% success in retrograde cases compared to 90.5% in antegrade cases (Table 6).

Table (6): Comparison of antegrade and retrograde approaches with angiographic anatomy, device usage, procedural parameters, and outcomes in CTO PCI

Characteristic	Antegrade (No = 42)	Retrograde (No = 20)	P-value
Angiographic Anatomy			
Culprit Artery - LAD	18 (42.86%)	14 (70.0%)	**0.045**
Culprit Artery - LCX	5 (11.9%)	1 (5.0%)	0.389
Culprit Artery - RCA	18 (42.86%)	5 (25.0%)	0.174
Culprit Artery - LIMA	1 (2.38%)	0 (0.0%)	0.487
Number of Diseased Arteries - Single	23 (54.8%)	12 (60.0%)	0.877
Number of Diseased Arteries - Double	13 (31.0%)	6 (30.0%)	
Number of Diseased Arteries - Triple	6 (14.3%)	2 (10.0%)	
Device Usage			
Use of Microcatheter - No	5 (11.9%)	0 (0.0%)	0.108
Use of Microcatheter - Yes	37 (88.1%)	20 (100.0%)	
Number of Microcatheters - None	5 (11.9%)	0 (0.0%)	**0.004 ***
Number of Microcatheters - One	33 (78.6%)	11 (55.0%)	

Characteristic	Antegrade (No = 42)	Retrograde (No = 20)	P-value
Number of Microcatheters - Two	4 (9.5%)	6 (30.0%)	
Number of Microcatheters - Three	0 (0.0%)	3 (15.0%)	
Number of Wires Used - One	8 (19.0%)	0 (0.0%)	**0.002 ***
Number of Wires Used - Two	11 (26.2%)	1 (5.0%)	
Number of Wires Used - Three	10 (23.8%)	3 (15.0%)	
Number of Wires Used - More than Three	13 (31.0%)	16 (80.0%)	
Number of Wires (Median, IQR)	3 (2 - 4)	5 (4 - 6.5)	**<0.001 ***
Crossing Wires			
Pilot 50	1 (2.4%)	0 (0.0%)	0.487
Pilot 150	1 (2.4%)	0 (0.0%)	0.487
Pilot 200	2 (4.8%)	1 (5.0%)	0.967
ASAHI GAYA FIRST	1 (2.4%)	0 (0.0%)	0.487
ASAHI GAYA SECOND	6 (14.3%)	6 (30.0%)	0.143
ASAHI GAYA THIRD	8 (19.0%)	6 (30.0%)	0.335
ASAHI Fielder XT	2 (4.8%)	0 (0.0%)	0.321
ASAHI FILEDER XT A	2 (4.8%)	0 (0.0%)	0.321
ASAHI FILEDER XT R	1 (2.4%)	0 (0.0%)	0.487
ASAHI MIRACLE Bros	3 (7.1%)	3 (15.0%)	0.328
ASAHI CONQUEST PRO	4 (9.5%)	5 (25.0%)	0.106
Hornet 14	2 (4.8%)	0 (0.0%)	0.321
ASAHI SION Blue	1 (2.4%)	0 (0.0%)	0.487
ASAHI SION Black	2 (4.8%)	1 (5.0%)	0.967
ASAHI CONQUEST	1 (2.4%)	0 (0.0%)	0.487
Procedural Parameters			
Procedure Time (mins) - Median (IQR)	63 (40 – 120)	120 (75 – 169)	**0.005 ***
Fluoroscopy Time (mins) - Median (IQR)	47 (25 – 77)	82 (55 – 120)	**0.002 ***
Radiation Dose (my) - Median (IQR)	3890 (2455 – 6130)	6909 (4088 – 10496)	**0.018 ***
Contrast Dose (mL) - Median (IQR)	300 (250 – 450)	475 (390 – 550)	**0.006 ***
CTO Crossing/Attempt Time (mins) - Median (IQR)	25 (15 – 35)	48 (35 – 60)	**<0.001 ***
Complications and Outcomes			
Complications - Non-Complicated	31 (73.8%)	11 (55.0%)	0.139
Complications - Complicated	11 (26.2%)	9 (45.0%)	
Dissection	8 (19.0%)	8 (40.0%)	0.078
Perforation	3 (7.1%)	0 (0.0%)	0.220
CIN	1 (2.4%)	1 (5.0%)	0.585
In-Hospital MACE			
Stroke	1 (2.4%)	0 (0.0%)	0.487
Death	1 (2.4%)	0 (0.0%)	0.487
Outcomes and TIMI Flow			
TIMI Flow - 0	3 (7.1%)	0 (0.0%)	0.459
TIMI Flow - 1	1 (2.4%)	0 (0.0%)	
TIMI Flow - 2	1 (2.4%)	0 (0.0%)	
TIMI Flow - 3	37 (88.1%)	20 (100.0%)	
Technical Success - Failed	1 (2.4%)	0 (0.0%)	0.361
Technical Success - Aborted	3 (7.1%)	0 (0.0%)	
Technical Success - Successful	38 (90.5%)	20 (100.0%)	
Procedural Success - Unsuccessful	5 (11.9%)	0 (0.0%)	0.108
Procedural Success - Successful	37 (88.1%)	20 (100.0%)	

*Significant P-value, CTO: Chronic Total Occlusion, PCI: Percutaneous Coronary Intervention, LAD: Left Anterior Descending (artery), LCX: Left Circumflex (artery), RCA: Right Coronary Artery, LIMA: Left Internal Mammary Artery, IQR: Interquartile Range, mins: Minutes, my: Milligray, mL: Milliliters, CIN: Contrast-Induced Nephropathy, MACE: Major Adverse Cardiac Events, TIMI: Thrombolysis In Myocardial Infarction.

DISCUSSION

Our registry was conducted on 62 patients with CTO lesions through the period from July 2020 to February 2021 at Ain Shams University Hospitals. It recorded an overall procedural success rate of 91.9%, which is aligning with Japanese and European registry data. The majority of patients were male (85.5%) and presented with stable angina (50.0%), and single-vessel disease (56.5%). An antegrade approach was used in 67.7% of lesions, while a retrograde approach was used in 32.2%, with success rates of 88.1% and 100%, respectively ($p = 0.108$). The retrograde approach was more time-consuming, with longer procedural and fluoroscopy times and a higher contrast dose requirement ($p < 0.006$). Among guidewires, ASAHI GAYA THIRD, ASAHI GAYA SECOND, and ASAHI CONQUEST PRO were the most effective in crossing lesions.

Complications were low, with RCA as the most frequently involved culprit artery ($p < 0.044$), and specific lesion characteristics (blunt stump, bending over 45°) significantly associated with complications. There was one case of stroke and one death, both in the same patient treated with the antegrade approach. Coronary perforation occurred in 7.1% of cases, all within the antegrade group. Overall, our findings suggest that while the retrograde approach requires longer procedure times and higher contrast, it may reduce the risk of coronary perforation compared to the antegrade approach.

Procedural success rates, in-hospital outcomes, and predictors of procedural failure:

In 2011, **Galassi and his colleagues** [13] launched the ERCTO (European Registry of Chronic Total Occlusion) registry, conducted across 16 centers in Europe beginning in January 2008. Over two years, the registry enrolled 1,914 patients with a total of 1,983 CTO lesions. Overall procedural success was achieved in 1,607 lesions (82.9%). Notably, anterograde procedures achieved higher success rates compared to retrograde procedures (83.2% vs. 64.5%, $p < 0.001$). Coronary perforation was more frequent in patients undergoing the retrograde approach (4.7% vs. 2.1%, $p = 0.04$). Additionally, the retrograde approach was associated with longer procedural and fluoroscopy times (156.9 ± 62.5 min vs. 98.2 ± 52.8 min and 73.3 ± 59.9 min vs. 38.2 ± 43.9 min, respectively, $p < 0.001$) and required a higher contrast load (402 ± 161 cc vs. 302 ± 184 cc, $p < 0.001$). These findings suggest that the retrograde approach involved extended fluoroscopy exposure, prolonged procedural times, increased contrast usage, and a higher incidence of coronary perforations. Multivariate logistic regression analysis indicated that severe calcification, a CTO length exceeding 20 mm, and the presence of a blunt stump were predictors of anterograde procedural failure, with these angiographic characteristics previously recognized as independent predictors in other studies.

Our study results, when compared to those from the ERCTO registry, showed an overall procedural success rate of 91.9% in 57 lesions. Interestingly, unlike the ERCTO registry, retrograde procedures in our study demonstrated higher success rates than anterograde ones (100% vs. 88.1%, $p = 0.108$). Coronary perforation was more frequent in patients undergoing the anterograde approach (7.1%, $p = 0.220$). In contrast to the ERCTO findings, a blunt stump and lesion bending greater than 45 degrees were associated with anterograde failure in our study. However, our results were consistent with the ERCTO registry in finding that the retrograde approach was associated with longer procedural and fluoroscopy times, as well as increased contrast usage.

In 2010, **Morino and his colleagues** [14] initiated the J-CTO Registry (Multicenter CTO Registry in Japan), a large-scale, multicenter registry that enrolled consecutive patients undergoing PCI for CTO across 12 Japanese centers. In-hospital clinical outcomes were evaluated in 498 patients with 528 CTO lesions. The retrograde approach was used in 136 procedures (25.7%). Regarding complications and in-hospital outcomes, cardiac death occurred in only 0.2% of cases. Post-procedure creatine phosphokinase was monitored in 420 patients (84.4%), among whom 10 met the criteria for myocardial infarction. There were no incidences of stroke or stent thrombosis during the hospital stay. Significant in-hospital complications, such as cardiac tamponade, emergent revascularization, access site surgery, and gastrointestinal bleeding, were rare. Despite relatively prolonged fluoroscopy times, no cases of radiation dermatitis were observed during hospitalization. Most lesions were located in the right coronary artery (61.5%), were de novo (89.3%), and nearly half were complex, with a JCTO score > 2. The mean occlusion length was 29 mm, and 33% of lesions were calcified. In-hospital death occurred in 9 patients (0.9%). Our study findings aligne with the J-CTO registry regarding the retrograde approach, which was used in 20 procedures (32.3%). Cardiac death occurred in 1.6% of cases. Additionally, a similar proportion of cases, 37 in total (59.7%), were classified as complex (very difficult).

Our study results, however, differed from the J-CTO registry in that the most common culprit artery was the LAD (51.6%), with the RCA being the second most common (37.1%). Moreover, no cases of in-hospital MACE, such as cardiac tamponade, emergent revascularization, access site surgery, or gastrointestinal bleeding, were observed.

Limitations: This study had several limitations. First, its non-randomized design may introduce selection bias, potentially impacting results. Second, the choice of guidewires and techniques was left to the operator's discretion, which could confound procedural outcome interpretations. Lastly, there were no pre-specified criteria

for terminating the procedure; as a result, fluoroscopy time, procedure duration, and contrast load were heavily influenced by each operator's decision to continue the attempt.

CONCLUSION

Most CTO lesions can be safely and successfully treated with PCI. Although, CTO treatment strategies had traditionally raised concerns about invasiveness and associated risks, these risks appear acceptable for most cases, given the actual incidence of major adverse cardiac events and high procedural success rates.

Sponsors and funding sources: There are none to be declared.

Declaration of interest statement: None to be declared.

REFERENCES

1. **Ybarra L, Cantarelli M, Lemke V *et al.* (2018)**: Percutaneous Coronary Intervention in Chronic Total Occlusion. Arq Bras Cardiol., 110: 476-83.
2. **Bryniarski L, Opolski M, Wójcik J *et al.* (2021)**: Chronic total occlusion percutaneous coronary intervention in everyday clinical practice - an expert opinion of the Association of Cardiovascular Interventions of the Polish Cardiac Society. Postepy Kardiol Interwencyjnej., 17: 6-20.
3. **Øksnes A, Skaar E, Engan B *et al.* (2023)**: Effectiveness, safety, and patient reported outcomes of a planned investment procedure in higher-risk chronic total occlusion percutaneous coronary intervention: Rationale and design of the invest-CTO study. Catheter Cardiovasc Interv., 102: 71-9.
4. **Nikolakopoulos I, Vemmou E, Karacsonyi J *et al.* (2022)**: Percutaneous coronary intervention of chronic total occlusions involving a bifurcation: Insights from the PROGRESS-CTO registry. Hellenic Journal of Cardiology, 66: 80-3.
5. **Azzalini L, Jolicoeur E, Pighi M *et al.* (2016)**: Epidemiology, Management Strategies, and Outcomes of Patients With Chronic Total Coronary Occlusion. Am J Cardiol., 118: 1128-35.
6. **Morino Y, Abe M, Morimoto T *et al.* (2011)**: Predicting successful guidewire crossing through chronic total occlusion of native coronary lesions within 30 minutes: the J-CTO (Multicenter CTO Registry in Japan) score as a difficulty grading and time assessment tool. JACC Cardiovasc Interv., 4: 213-21.
7. **Takimura H, Muramatsu T, Tsukahara R (2012)**: CT coronary angiography-guided percutaneous coronary intervention for chronic total occlusion combined with retrograde approach. J Invasive Cardiol., 24: E5-9.
8. **Rolf A, Werner G, Schuhbäck A *et al.* (2013)**: Preprocedural coronary CT angiography significantly improves success rates of PCI for chronic total occlusion. Int J Cardiovasc Imaging, 29: 1819-27.
9. **Mehran R, Claessen B, Godino C *et al.* (2011)**: Long-term outcome of percutaneous coronary intervention for chronic total occlusions. JACC Cardiovasc Interv., 4: 952-61.
10. **World Health Organization (2018)**: Global health estimates 2016: deaths by cause, age, sex, by country and by region, 2000–2016. Geneva: World Health Organization, 12: 42-7.
11. **Neumann F, Sousa-Uva M, Ahlsson A *et al.* (2019)**: 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J., 40: 87-165.
12. **Brilakis E, Grantham J, Rinfret S *et al.* (2012)**: A percutaneous treatment algorithm for crossing coronary chronic total occlusions. JACC Cardiovasc Interv., 5: 367-79.
13. **Galassi A, Tomasello S, Reifart N *et al.* (2011)**: In-hospital outcomes of percutaneous coronary intervention in patients with chronic total occlusion: insights from the ERCTO (European Registry of Chronic Total Occlusion) registry. EuroIntervention, 7: 472-9.
14. **Morino Y, Kimura T, Hayashi Y *et al.* (2010)**: In-hospital outcomes of contemporary percutaneous coronary intervention in patients with chronic total occlusion insights from the J-CTO Registry (Multicenter CTO Registry in Japan). JACC Cardiovasc Interv., 3: 143-51.