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Procedural And Short-Term Outcomes Of Percutaneous Coronary Interventions For Chronic Total Occlusion In An Egyptian Tertiary Care Center

Mohamed Mahmoud Abd El Ghaney, MD [1], Amir Anwar Shaker, MD [2], Emmanuel Fares Aziz, MD [2], Hisham Ahmed Reda Naser, MD [3], Moataz Hamdy Soliman Mahmoud Elewa, MSc [4]*
[1]Professor of Cardiovascular Medicine, Cairo University
[2]Lecturer of Cardiovascular Medicine, Cairo University
[3]Consultant of Cardiovascular Medicine, National Heart Institute
[4]Postgraduate PhD MD Cairo University, National Heart institute

ABSTRACT

Background: *Chronic total occlusion (CTO) of coronary arteries presents a significant challenge for interventional cardiologists due to technical complexities and resource requirements. Egypt lacks comprehensive data on CTO percutaneous coronary intervention (CTO-PCI).*

Aim: *Is to document the procedural details, success rates, and short-term outcomes of CTO-PCI performed at the National Heart Institute,as an Egyptian tertiary care center between 1st of April 2019 till 31st March 2020.*

Methods: *This prospective observational study included patients with CTO undergoing PCI over one year. Data were collected on demographics, lesion characteristics, procedural techniques, and short-term outcomes, including major adverse cardiac and cerebrovascular events (MACCE).*

Results: *The study included a predominantly male cohort (80%) with a high prevalence of cardiovascular risk factors, including hypertension (96%), diabetes (40%), hyperlipidemia (68%), and smoking (62%). Prior myocardial infarction was documented in 60.9% of patients, while previous PCI and CABG were noted in 25% and 9.4%, respectively. Ischemic ECG changes were found in 85% of cases, and regional wall motion abnormalities were detected in 81.2% of patients.*

Risk stratification using the SYNTAX score indicated that 61% of patients had no significant difference in four-year mortality between PCI and CABG, whereas 31% had scores favoring CABG and 7.8% had scores supporting PCI.

Angiographic assessment revealed that 57.8% of CTO-PCI procedures targeted the LAD, 46.9% the RCA, and 10.9% the CX, with complex lesions characterized by high calcification burden (89.1%), severe tortuosity (12.5%), and blunt proximal caps (60.9%).

The procedural success rate was 89.06%, with antegrade techniques used in 81.3% of cases and retrograde approaches in 18.7%. IVUS guidance was employed in 9 cases, and microcatheter use was documented in 70.3% of procedures. No cases of MACCE were observed. Coronary perforation occurred in 9 cases, all managed conservatively. The study found no significant correlation between lesion complexity and procedural success ($p = 0.78$), whereas different technical approaches significantly influenced success and guidewire passage failure rates ($p = 0.01$).

Conclusion: *CTO-PCI in Egypt demonstrates promising success rates despite resource limitations. Enhanced training and advanced equipment are critical to improving outcomes further.*

Keywords: *Percutaneous Coronary Interventions, Chronic Total Occlusion, Tertiary Care Center.*

1. INTRODUCTION

Chronic total occlusion (CTO) of coronary arteries is defined as a complete blockage with a Thrombolysis in Myocardial Infarction (TIMI) flow grade 0 for a duration ≥3 months (1). CTO affects approximately 15-20% of patients undergoing coronary angiography and is associated with adverse outcomes, including myocardial ischemia, impaired left ventricular function, and increased mortality (2,3).

Percutaneous coronary intervention (PCI) for CTO is a technically demanding procedure requiring specialized skills and advanced equipment. Success rates have improved globally with advancements in guidewire technology, microcatheters, and hybrid algorithms. However, the procedure's complexity results in prolonged procedural times, increased radiation exposure, and higher resource utilization (4).

Despite these advancements, CTO-PCI is used to be underutilized in resource-limited settings like Egypt. This study aims to assess procedural success, complication rates, and technical aspects of CTO-PCI in an Egyptian tertiary care center, contributing to the regional body of evidence and identifying potential areas for improvement.

Aim of Work was to

Document the procedural and technical aspects of CTO-PCI at the National Heart InI stitute.
Report technical success rates and in-hospital MACCE.
Evaluate short-term outcomes, including complications like contrast-induced nephropathy and irradiation skin injury.

2. PATIENTS AND METHODS

Study Design This prospective observational study was conducted at the National Heart Institute, Egypt, between 1st of April 2019 till 31st March 2020.

Patient Selection *Inclusion criteria*:

Patients aged ≥18 years with angiographically confirmed CTO (≥3 months duration, TIMI 0 flow).

Exclusion criteria:

Severe renal impairment (eGFR <30 mL/min/1.73 m^2).
Coagulopathies or contraindications to dual antiplatelet therapy.
Unprotected left main CTO.

Data Collection Patient demographics, comorbidities, lesion characteristics (length, calcification, and J-CTO score), and procedural details were recorded. Outcomes were classified as:

Primary: Technical success defined as TIMI 3 flow.

Secondary: Incidence of MACCE, contrast-induced nephropathy, and procedural complications.

Procedural Details Antegrade and retrograde techniques were employed based on lesion complexity. Tools included:

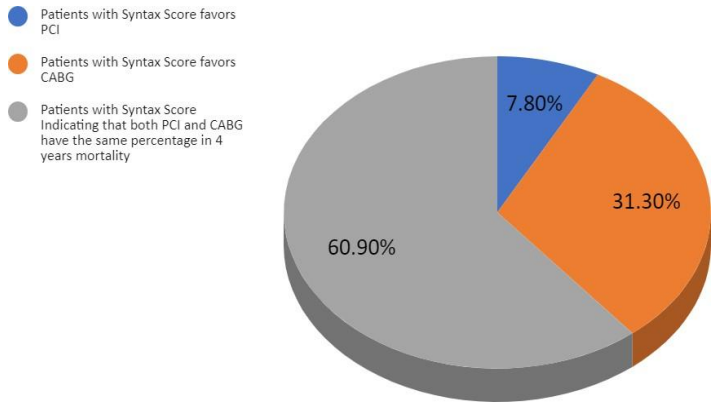
Guidewires: Fielder XT, Gaia series, and Confianza Pro.
Microcatheters: Corsair and Turnpike.
Re-entry devices: CrossBoss and Stingray.

Statistical Analysis Data were analyzed using SPSS v25. Continuous variables were expressed as mean ± standard deviation, and categorical variables as percentages. A p-value <0.05 was considered statistically significant.

3. RESULTS

Demographics: The study included a predominantly male cohort (80%) with a high prevalence of cardiovascular risk factors, including hypertension (96%), diabetes (40%), hyperlipidemia (68%), and smoking (62%). A history of myocardial infarction was present in 60.9% with history of MI, 25% underwent PCI and 9.4% with prior CABG. Symptomatically, 39% had CCS class II angina, while 60.9% had class III. Ischemic ECG changes were documented in 85% of cases, while myocardial scintigraphy indicated viable myocardium in 15.6% and non-viable myocardium in 4.7% of patients. Preprocedural echocardiographic assessment revealed an ejection fraction below 40%
in 43.8% of cases, between 40–50% in 31.3%, and above 50% in 25%, with 81.2% showing evidence of regional wall motion abnormalities at rest.

Risk stratification: 61% of patients had no significant difference in four-year mortality between PCI and CABG, while 31% had scores favoring CABG.



Angiographic data showed a Forty eight percent of the cases had a one vessel CTO lesion to intervene, while 12,5 % had two different CTO lesions in two different vessels and only 2 cases had 3 different CTO lesions to intervene. Note that the patients with more than one CTO lesions underwent a single CTO-PCI procedure (which was in our study included) and the residual revascularization was carried out in different sessions.

Thirty two percent of the patients showed a calculated J-CTO Score of 2, which speaks for difficulte CTO Lesion. On the other hand, 67,2% demonstrated a J-CTO Score of 3 or more which speaks for very difficult CTO lesions. 85,9% of the patients showed an angiographic documented lesion that are longer than 20 mm while 14,1% showed lesions shorter than 20 mm. The presence of a branch near the proximal cap was documented in 29,7% of the Patients. A high calcification burden was angiographically documented in 89,1%. Prevalence of high tortuosity CTO lesions was documented in 12,5%. Blunt proximal caps were recognized in 60,9% of the patients, on the other hand 39,1% showed tapered proximal caps.

The retrograde filling was documented in 15,6% of the patients, antegrade filling was documented in 26,6 % of the patients. Bilateral (antegrade and retrograde) filling was documented in 57,75% of the patients as demonstrated in the following table.

Interprocedural data		Count	%
LAD		37	57.80%
LCX		7	10.90%
LMCA		1	1.60%
RCA		30	46.90%
J.CTO	Difficult lesion	21	32.80%
	Very difficult lesion	43	67.20%
Number of CTO Lesions	one	54	84.40%
	two	8	12.50%
	three	2	3.10%
Lesion length	more than 20 mm	55	85.90%
	less than 20 mm	9	14.10%
Type of the proximal cap	CTO Lesions with present branches at the proximal cap	19	29.70%
Type of the collateral filling	Retrograde filling	10	15.60%
	Antegrade Filling	17	26.60%
	Both Ante and Retrograde	37	57.80%

	Filling		
Degree of lesions calcification	heavily calcified lesions	57	89.10%
The presence of proximal tortuosity	Lesions with high proximal tortuosity	8	12.50%
The Presence of CTO-lesion tortuosity	Present	6	9.40%
	Absent	58	90.60%
Morphology of the proximal cap	Blunt	39	60.90%
	Tapered	25	39.10%
Technical choice	Antegrade	46	71.90%
	Retrograde	4	6.30%
	Rescue Antegrade	8	12.50%
	Rescue Retrograde	6	9.40%

The procedural success rate was 89.06%, with all cases performed via bilateral femoral access. The primary antegrade approach (PAA) was employed in 81.3% of cases, with 40 of these successfully revascularized using antegrade wire escalation (AWE), two using the parallel wire technique, and two via STAR (Subintimal Tracking And Reentry). An additional two cases required a rescue retrograde approach (RRA) via the CART (Controlled Antegrade and Retrograde subintimal tracking) technique, one case was successfully revascularized using conventional retrograde wire escalation, and another case using the retrograde knuckle wire dissection technique. Despite retrograde attempts, four cases ultimately failed revascularization. The primary retrograde approach (PRA) was utilized in 18.7% of cases, with two being successfully revascularized via retrograde wire escalation, four requiring a rescue antegrade approach (RAA) via the Reverse CART technique, and three needing a rescue antegrade approach via the STAR technique. Three cases ultimately failed revascularization after antegrade trials.

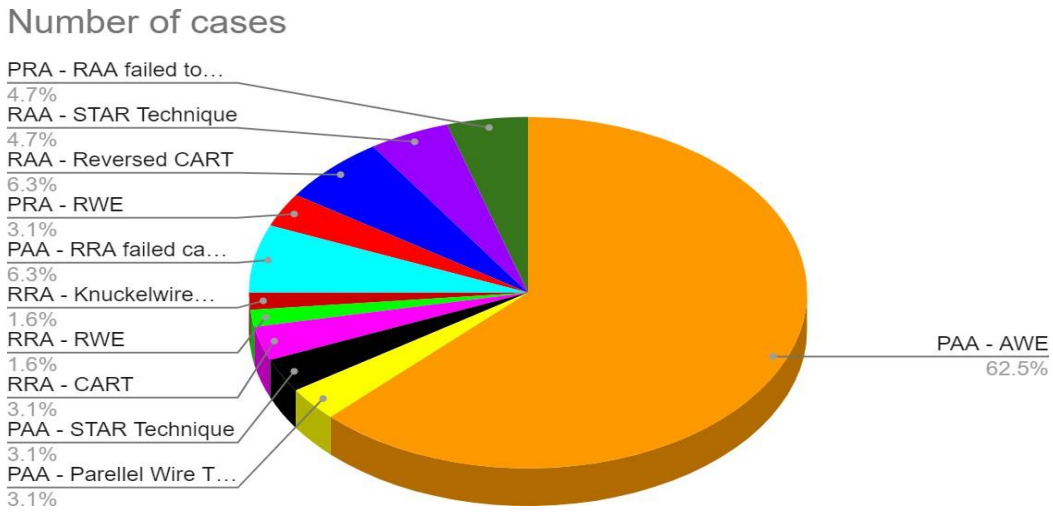


Figure 1: Demonstrates the Percentage of the different revascularization approaches

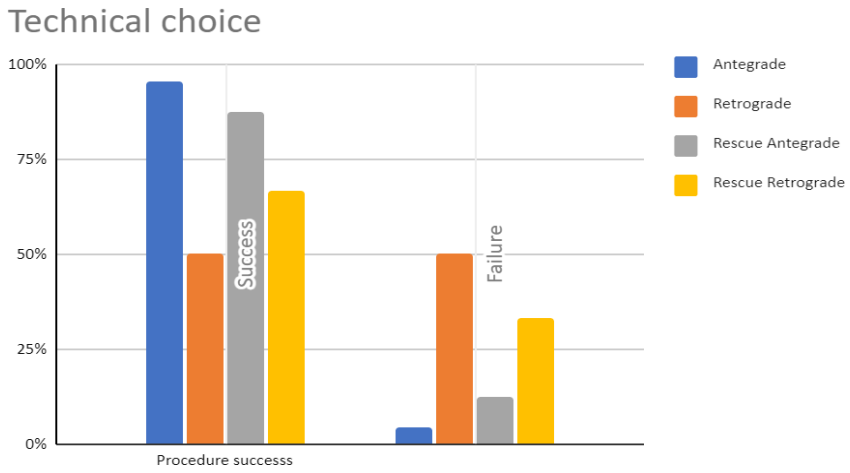


Figure 2: Percentage of success rate and failure rate between the different approaches.

The Use of other Equipments: In this study, IVUS-assisted CTO-PCI was performed in 9 cases, with various primary strategies including antegrade wire escalation (AWE), STAR, and retrograde wire escalation (RWE). No rotational atherectomy, scoring balloons, or cutting balloons were used. Microcatheters were employed in 70.3% of cases, with the most common types being Finecross (used in 20.3% and again reported in 25%—possible overlap), Carvel (18.7%), ASAHI Corsair (20.3%), Turnpike (15.6%), NHancer dual lumen (9.4%), and CrossBoss (4.6%). Additionally, 10 cases involved two different microcatheters, and one case involved three. Guiding extension systems (Guideliner/Guidezilla) were used in only two cases.

Complication incidence was low. Failed revascularization was encountered in 9.37% of cases, primarily due to guidewire passage failure caused by heavy calcifications at the proximal or distal cap, while one case failed due to the inability to pass the microcatheter and balloon. Coronary perforation was documented in nine cases, all of which were successfully managed with prolonged balloon inflation. Postprocedural pericardial effusion was observed in 12 cases, none of which required drainage, as they remained non-hemodynamically significant and were managed conservatively with serial echocardiographic follow-up. One patient experienced coronary embolization, confirmed angiographically by slow flow, and one patient suffered a transient ischemic attack (TIA). Puncture site complications in the form of minor subcutaneous hematomas occurred in 9.6% of cases, all of which were managed conservatively without the need for surgical or invasive intervention. Notably, there were no documented cases of target lesion failure, emergency CABG, MACCE, contrast-induced nephropathy, or radiation skin injury.

Correlative analysis demonstrated no significant relationship between lesion difficulty (J-CTO score ≥3) and procedural success, with a p-value of 0.78. However, a statistically significant association was found between the chosen technical approach and procedural success rates, with a p-value of 0.01, indicating that different strategies had an impact on overall outcomes. Furthermore, guidewire passage failure rates were significantly affected by the technical approach, also with a p-value of 0.01. In contrast, there were no significant differences between different approaches regarding target lesion failure, coronary embolization, perforation, pericardial effusion, type 4A myocardial infarction, emergency CABG, stroke, in-hospital mortality, puncture site complications, or contrast-induced nephropathy. However, there was a trend toward statistical significance concerning the presence of distal runoff, with a p-value of 0.06, suggesting that further research may be warranted to explore its impact on procedural outcomes.

4. DISCUSSION

In this single-center study from the National Heart Institute in Egypt, we analyzed 64 patients who

underwent CTO-PCI between April 2019 and May 2020. The overall procedural success rate was 87.5%, comparable to the OPEN-CTO registry (85.8%, Sapontis et al. (5)), ERCTO registry (86.4%, Galassi et al. (6)), and U.S. multicenter registry (85.5%, Karmpaliotis et al. (7)), but slightly lower than the Japanese CTO-PCI Expert Registry (91.2%, Suzuki et al. (8)). This reflects the growing expertise and utilization of advanced techniques even in resource-limited settings.

The majority of our cases (73.4%) were performed using antegrade wiring (AW), which achieved a success rate of 91.5%. This was consistent with the ERCTO registry, where AW was used in 64.2% of cases and had an 88.2% success rate. Our use of AW as the primary strategy aligns with standard practice in settings where hybrid algorithm-guided techniques are selectively applied.

Retrograde approach (RA) was used in 26.6% of cases, with a 76.4% success rate, comparable to the 72.3% in the Japanese registry. While lower than antegrade success, the retrograde route remains critical for complex CTOs when AW fails or is deemed unsuitable. The use of retrograde techniques was associated with longer procedure and fluoroscopy times, as expected, due to increased technical demands and crossing challenges.

Our overall complication rate was low at 6.3%, with coronary perforation being the most common (3.1%). This is lower than reported in the U.S. multicenter registry (7.1%) and aligns with other large registries (OPEN-CTO: 2.6%, ERCTO: 3.8%). Operator experience and careful lesion assessment likely contributed to these favorable safety outcomes. No in-hospital mortality occurred, and only one patient (1.6%) developed contrast-induced nephropathy, consistent with global CTO data.

The majority of target vessels were the right coronary artery (RCA) (59.4%), similar to previous registries (OPEN-CTO: 52%, ERCTO: 61%). The RCA is frequently occluded due to its anatomical course and flow characteristics, making it a common site for CTO interventions. Procedural success was slightly lower in RCA lesions compared to LAD and LCX, consistent with previous reports.

Use of the hybrid algorithm facilitated appropriate case selection and strategy escalation. Although dissection/reentry (DART) techniques were not heavily utilized, our success rates suggest that proper application of AW and RA with timely escalation was effective. Adoption of more advanced DART tools may further improve outcomes in the future.

This study is among the few reporting CTO-PCI outcomes from Egypt and the Middle East, contributing regional data to the global experience. Despite limited access to dedicated CTO equipment and higher lesion complexity, procedural outcomes were encouraging and in line with international benchmarks.

5. STUDY LIMITATIONS

This single-center study's findings may not be generalizable to all Egyptian populations. Additionally, the lack of long-term follow-up limits the assessment of sustained clinical benefits.

6. CONCLUSION

CTO-PCI in Egypt demonstrates promising outcomes, with success rates comparable to international standards. Addressing resource and training gaps can enhance procedural success and safety, improving patient care.

CONFLICT OF INTEREST AND FUNDING

The authors declare no conflicts of interest. This study received no external funding.

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