Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol.(8) Issue(12) (2023), (89-94) **online : ISSN 2356–976x**
http://bjas.bu.edu.eg

Immediate Results and Short Term Outcome after Percutaneous Coronary Interventions in Chronic Total Occlusions

Bahaa Edin H.Elsayed, Metwally H.Elemary,Mohammed A.Tabl, ALshaimaa M.Sabry, Ahmed K.Hasan
Cardiovascular Medicine Dept., National Heart institute
E-mail: bahaaedinharb@gmail.com

Abstract
Background: Percutaneous coronary intervention(PCI)in chronic total occlusion (CTO) is a fast advancing area, regarded as the final frontier of interventional cardiology.
Aim and objectives: To evaluate the immediate results & short term result after percutaneous coronary interventions in CTO.
Patients & methods: This was a dual-center prospective research conducted on 65 cases scheduled for PCI on a CTO of native coronary artery at Benha University and National Heart Institute during the period from December 2021 till the end of June 2023.
Results: Regarding Comparing crossing strategies, Procedure time (62.5 Vs 135 min, p-value =0.011), fluoroscopy time (47 Vs 85 min, p-value equals 0.030) and crossing time (22.5 Vs 45 min, p-value equals 0.003) were significantly lower with antegrade approach. However, no statistically significant variance found between antegrade and retrograde approaches concerning the presence of complications, dissection (p-value equals 0.203), perforation with (p-value equals 0.254), CIN (p-value equals 0.346), in-hospital MACE (p-value equals = 0.064), technical success (p-value equals 0.505) and procedural success (p-value =0.267).
Conclusion: PCI is a safe & effective treatment for the majority of CTO lesions. Invasiveness and possible hazards of these techniques, which have been the largest concerns of CTO therapy, may be acceptable in the majority of patients considering the real occurrences of linked significant adverse cardiac events & the operative success rates.
Key words: Immediate results and short term outcome, percutaneous coronary interventions, chronic total occlusions.

Introduction

PCI is an area of interventional cardiology that is undergoing accelerated development and is regarded as the last frontier. In recent times, their success rates have risen due to the training of specialized personnel & the development of new methods & apparatus. Despite the current scarcity of randomized & controlled investigations, the findings derived from extensive multicenter registries enable us to offer this intervention to individuals in a safe manner, in conjunction with optimized medication therapy & myocardial revascularization surgery **(1)**.

CTO are characterized as coronary obstructions that obstruct the entire lumen of a blood vessel for a duration exceeding three months and exhibit thrombolysis in myocardial infarction (TIMI 0) flow.**(2)**. A "functional CTO" refers to an occlusion in which the distal vessel remains obstructed despite minimal contrast passage **(3)**.

CTO are observed in 18-52% of coronary heart disease individuals who undergo coronary angiography, although alternative registries report an incidence ranging from sixteen percent to twenty percent **(4)**.

The aim of this investigation endeavor was to evaluate the immediate & short-term results of PCI in patients with chronic total occlusions

Patients & methods

This was a dual-center prospective research conducted on 65 cases scheduled for PCI on a CTO of native coronary artery at Benha University and National Heart Institute during the period from December 2021 till the end of June 2023.

Inclusion criteria: Patients who have CTO on angiography.
Exclusion criteria: Patients who have non-viable CTO and Patients who refuse to participate in the research.

Methods

All patients were subjected to the following:

Full history taking with special emphasis on: Personal history & Present history(Full analysis of symptoms especially chest pain (angina pectoris) defined as chest discomfort as classified by Canadian Cardiovascular Society (CCS) **(5)**.

Clinical examination

General examination with emphasis on vital signs including pulse, systolic & diastolic blood pressure, and BMI.

Investigations

Routine laboratory investigations, CBC, serum creatinine, INR, baseline cardiac troponin, virology markers, baseline twelve lead surface ECG, baseline echocardiography study & the Left ventricle systolic function.

Coronary Angiography & (PCI)

PCI was employed to address the underlying lesions in every patient. To evaluate the anatomical complexity of CAD & the long-term mortality & morbidity following PCI, the SYNTAX score was computed (6). Individuals were categorized into three groups based on the severity of their SYNTAX scores: those with low scores (0–22), those with intermediate scores (23–32), and those with high scores (≥33).In accordance with the 2018 guidelines of the European Society of Cardiology (ESC), individuals received percutaneous

treatment. Upon admission, a loading dose of clopidogrel 600 mg or Ticagrelor 180 mg and a single dose of 300 mg chewable aspirin were administered. Additionally, 70 U/kg of standard heparin was administered prior to the operation **(7)**. All PCI procedures were performed via the radial or femoral artery by qualified interventional cardiologists. Appropriate interventional apparatus was utilized to traverse the lesions. The selection of treatment methods for patients was determined by the characteristics of the lesion and coronary anatomy: direct stenting, conventional stenting, or balloon dilation exclusively. Following the intervention, 75–150 mg of aspirin daily & 75 mg of clopidogrel or ticagrelor BID were prescribed **(8)**.

The following data were collected for each patient regarding the intra-procedural details:

Lesion characteristics and J-CTO scoring, procedural characteristics(Procedure time (mins), fluoroscopy time (mins), contrast dose (ml), class of wire used, length of Stents, using of micro catheter, crossing strategies (antegrade or retrograde), procedural complications and Procedural outcomes(Technical success and procedural success.

Follow up

The cases were followed throughout the hospital stay and after 6 months from discharge for the occurrence of in-hospital major adverse cardiac events (MACE) and reassessed concerning signs & left ventricle ejection fraction improvement during the regular visits or arranged visits after telephone calls. MACE was defined as the composite of total cardiac death, myocardial infarction, coronary revascularization, stroke, & hospitalization Due to heart failure.

Results

Ages were varied from 36 years to 78 years with average age of 54.66 ± 9.95 years. The majority were males (54 patients "83.1%"). There was a high prevalence of smoking (40 patients "61.5%"), prior history of IHD (39 patients "60%"), Hypertension (35 patients "53.8%") and DM (33 patients "50.8%"). 15 patients (23.1%) had family history of premature CAD, 8 patients (12.3%) had Dyslipidemia and only 3 patients (4.6%) had Cerebrovascular Stroke. The majority of cases (39 patients "60%") presented with typical chest pain of CCS class III and 26 patients (40%) had CCS class II. Echocardiographic evaluation revealed that mean LVEF was 41.58 ± 8.40 **(Table 1)**.

During follow up of the 65 patients including who had a failed procedure, the left ventricle ejection fraction (EF %) ranged from 28% to 60%. The typical chest pain according to the CCS class of angina pectoris, was class 0 in 35 patients (53.8%) whose had no TCP with any grade of exertion, while 22 patients (33.8%) had typical chest pain with CCS class I (33.8%), 6 (9.2%) patients had typical chest pain with moderate exertion CCS class II, only two patients (3.1%) had typical chest pain with mild exertion CCS class III, and no patients was class IV whose had typical chest pain at rest (0.0%). CCS grading of angina pectoris had significantly improved after CTO-PCI at six months follow up Procedure & after follow up with (p-value= 0.002), also the left ventricle ejection fraction had significantly improved after PCI-CTO at follow up with (p-value =0.001) **(Table 2)**.

Regarding Comparing crossing strategies, Procedure time (62.5 Vs 135 min, p-value =0.011), fluoroscopy time (47 Vs 85 min, p-value=0.030) and crossing time (22.5 Vs 45 min, p-value =0.003) were significantly lower with antegrade approach. However, there was no statistically significant variance between antegrade & retrograde approaches concerning the presence of complications, dissection (p-value equals 0.203), perforation with (p-value =0.254), CIN (p-value =0.346), in-hospital MACE (p-value =0.064), technical success (p-value =0.505) and procedural success (p-value =0.267) **(Table 3)**.

Presence of dyslipidemia and prior ischemic heart disease were more prevalent in patients had procedural failure. Procedure time & fluoroscopy time were significantly lower in patients with successful procedure. Also. More patients with procedural success achieved TIMI III flow after CTO-PCI. However, procedural failure was more prevalent in patients with LCX as a diseased artery, it was not statistically significant p value above 0.05. There was a statistically highly significant relation between procedural failure and Left Main as affected artery. The technical success had a highly significant relation with the procedural success p value<0.001. In addition, the Canadian cardiovascular society (CCS) grading of angina pectoris had significantly improved after Procedural success **(Table 4)**.

Univariate analysis was done and revealed that the presence of dyslipidemia, prolonged fluoroscopy time > 61 minute and presence of complications as dissection and perforation were significant predictors of procedural failure. All significant predictors of procedure failure in the univariate analysis were entered into the multivariate model. The multivariate regression analysis outcomes revealed that there is no independent predictor of procedure failure **(Table 5)**.

Table (1): Demographic and clinical data

		Total no.=65
Gender	Female Male	11 (16.9%) 54 (83.1%)
Age	Mean±SD Range	54.66 ± 9.95 36 – 78
Risk factors	Smoking DM	40 (61.5%) 33 (50.8%)

	HTN	35 (53.8%)
	Ischemic Heart Disease	39 (60.0%)
	Cerebrovascular Stroke	3 (4.6%)
	Dyslipidemia	8 (12.3%)
	Family history of premature CAD	15 (23.1%)
LV systolic function (Ejection Fraction%)	Mean±SD	41.58 ± 8.40
	Range	٢٨ – 60
CCS class of typical chest pain TCP	Calss I	0 0 %
	Calss II	26 (40.0%)
	CalssIII	39 (60.0%)
	Class IV	0 (0.0%)

CCS: Canadian Cardiovascular Society LV: Left ventricular

Table (2): Comparison between pre-procedure and after follow up regarding CCS class of angina pectoris and left ventricle ejection fraction (EF)

		Pre-procedure	during follow up	Test value	P-value	Sig.
		No. = 65	No. = 65			
CCS grading of angina	Class 0	0 (0.0%)	35 (53.8%)	102.890*	0.002	HS
	Class I	0 (0.0%)	22 (33.8%)			
	Class II	26 (40.0%)	6 (9.2%)			
	Class III	39 (60.0%)	2 (3.1%)			
	C lass IV	0 (0.0%)	0 (0.0%)			
LV ejection fraction (EF)	Mean±SD	41.58 ± 8.40	45.94 ± 8.05	6.654•	0.001	HS
	Range	28 – 60	30 – 60			

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS) *: Chi-square test; •: Paired t-test

Table (3): Comparing crossing strategies regarding the angiographic data

		Crossing Strategies		Test value‡	P-value	Sig.
		Antegrade	Retro grade			
Procedure time (mins)	Median (IQR)	62.5 (45 – 120)	135 (70 – 180)	-2.557‡	0.011	S
Fluoroscopy time (mins)	Median (IQR)	47 (28 – 77)	85 (55 – 120)	-2.166‡	0.030	S
Radiation dose (mgrey)	Median (IQR)	3360 (2050 – 6053)	6080 (3250 – 10050)	-0.213‡	0.832	NS
Contrast dose (mL)	Median (IQR)	300 (250 – 400)	450 (380 – 500)	0.277‡	82	S
CTO crossing or attempt time (mins),	Median (IQR)	22.5 (14 – 34)	45 (34 – 60)	-3.012‡	0.003	HS
TIMI score	Median (IQR)	3 (3 – 3)	3 (3 – 3)	0.000‡	1.000	NS
TIMI I		3 (6.5%)	0 (0.0%)	3.047*	0.384	NS
TIMI II		3 (6.5%)	0 (0.0%)			
TIMI III		1 (2.2%)	1 (5.3%)			
TIMI IV		39 (84.8%)	18 (94.7%)			
In-hospital MACE		1 (2.2%)	2 (10.5%)	3.493*	0.062	NS
Dissection		12 (26.1%)	8 (42.1%)	1.620*	0.203	NS
Perforation		3 (6.5%)	0 (0.0%)	1.299*	0.254	NS
CIN		2 (4.3%)	2 (10.5%)	0.889*	0.346	NS
Technical Success	Failed	3 (6.5%)	0 (0.0%)	1.365*	0.505	NS
	Aborted for any cause	3 (6.5%)	1 (5.3%)			
	Successful	40 (87.0%)	18 (94.7%)			
Procedural success	Un successful	7 (15.2%)	1 (5.3%)	1.234*	0.267	NS
	Success	39 (84.8%)	18 (94.7%)			

*:Chi-square test; ‡: Mann Whitney test TIMI: Thrombolysis in myocardial infarction. MACE: Major adverse cardiac events CIN: Contrast induced nephropathy

Table (4): Comparing risk factors angiographic data, technical success, complications and CCS class of TCP in patients with procedural success versus procedural failure

		Procedural success		P-value	Sig.
		Failure	Success		
		No. = 8	No. = 57		
Age	Mean ± SD	59.38 ± 9.21	54.00 ± 9.95	0.154•	NS
Gender	Female	3 (37.5%)	8 (14.0%)	0.097*	NS
	Male	5 (62.5%)	49 (86.0%)		
Risk factors	Smoking	3 (37.5%)	37 (64.9%)	0.136*	NS
	Diabetic	5 (62.5%)	28 (49.1	0.479*	NS

	Hypertensive	3 (37.5%)	32 (56.1 %)	0.322*	NS
	Ischemic Heart Disease	8 (100.0%)	31 (54.4 %)	0.014*	S
	Cerebrovascular Stroke	1 (12.5%)	2 (3.5%)	0.256*	NS
	Dyslipidemia	3 (37.5%)	5 (8.8%)	0.021*	S
	Family history of premature CAD	2 (25.0%)	13 (22.8 %)	0.890*	NS
Procedure time (mins)	Median (IQR)	145 (105 – 180)	67 (45 – 120)	0.005‡	HS
Fluoroscopy time (mins)	Median (IQR)	97.5 (71 – 127.5)	50 (30 – 88)	0.013‡	S
Radiation dose(mgrey)	Median (IQR)	6225 (3825–10003.5)	3930 (2140 – 7150)	0.106‡	NS
Contrast dose (mL)	Median (IQR)	450 (325 – 675)	350 (250 – 450)	0.109‡	NS
CTO crossing or attempt time (mins),	Median (IQR)	17.5 (1.5 – 47.5)	28 (15 – 42)	0.230‡	NS
T1M1 score	Median (IQR)	1 (0 – 2.5)	3 (3 – 3)	0.000‡	HS
TIMI 0		3 (37.5%)	0 (0.0%)	0.000*	HS
TIMI I		2 (25.0%)	1 (1.8%)		
TIMI II		1 (12.5%)	1 (1.8%)		
TIMI III		2 (25.0%)	55 (96.5 %)		
SYN II	Favors CABG	0(0.0%)	5(8.8 %)	0.369*	NS
	Favors PCI	4(50.0%)	16(28.1%)		
	Both PCI and CABG have the same percentage in 4 years mortality	4(50.0%)	36(63.2%)		
Culprit arteries	LAD	3(37.5%)	34(59.6%)	0.236*	NS
	RCA	1(12.5%)	5(8.8 %)	0.733*	NS
	LCX	4(50.0%)	21(36.8%)	0.474*	NS
	LM	1(12.5%)	0(0.0 %)	0.007*	HS
CAP Morphology	Tapered	3(37.5%)	14(24.6%)	0.607*	NS
	Ambiguous	2(25.0%)	24(42.1%)		
	Blunt	3(37.5%)	19(33.3%)		
Lesion complexity	Bridging collaterals	5(62.5%)	34(59.6%)	0.878*	NS
	Occlusion length >20mm	5(62.5%)	39(68.4%)	0.737*	NS
	Within lesion bending >45	5(62.5%)	42(73.7%)	0.508*	NS
	Calcification	6(75.0%)	32(56.1%)	0.311*	NS
	Blunt stump	5(62.5%)	20(35.1%)	0.136*	NS
	Prior attempt at CTO recanalization.	2(25.0%)	15(26.3%)	0.937*	NS
(Japan CTO / J-CTO score) 5-point scoring system	Easy	0(0.0%)	1(1.8 %)	0.899*	NS
	Intermediate	1(12.5%)	10(17.5%)		
	Difficult	3(37.5%)	15(26.3%)		
	Very difiicult	4(50.0%)	31(54.4%)		
Crossing Strategies	Antegrade	7(87.5%)	39(68.4%)	0.267*	NS
	Retro grade	1(12.5%)	18(31.6%)		

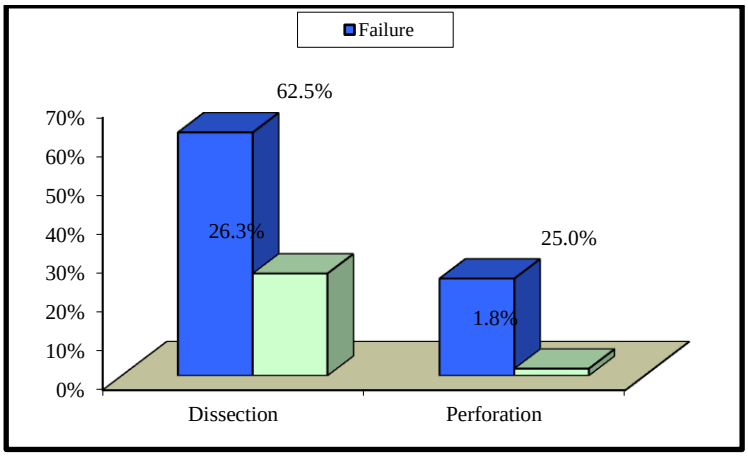

Fig. (1): Comparing complications in patients with procedural success versus procedural failure.

Table (5): Logistic regression analysis for predictors of failure

	Uni-variety				Multi-variety			
	P-value	Odds ratio (OR)	95% C.I. for OR		P-value	Odds ratio (OR)	95% C.I. for OR	
			Lower	Upper			Lower	Upper
Dyslipidemia	**0.035**	6.240	1.140	34.167	0.200	9.323	0.308	282.604
Fluoroscopy time>61	**0.020**	12.950	1.486	112.826	0.224	8.861	0.263	299.012
T1M1≤2	**0.000**	82.500	9.770	696.616	0.071	17.504	0.784	390.708
Failed technical	**0.024**	18.667	1.467	237.593	0.676	2.564	0.031	212.910
In-hospital MACE	**0.024**	7.059	1.292	38.560	0.502	2.998	0.121	74.170
Dissection	0.051	4.667	0.992	21.943	0.915	0.845	0.038	18.574
Perforation	**0.024**	18.667	1.467	237.593	0.652	2.473	0.048	127.257

Discussion

The major outcomes of the current research can be summarized as follow:

An ante-grade approach was undertaken in 46 lesions (70.7%), while a retrograde approach was utelized in 19 lesions (29.2%). procedural success rate of our research is similar to that reported in the Japanese registry and Euro registry. The in-hospital MACE and other procedural complications are low as well as comparable to non-CTO PCI. The retrograde approach is related with extended fluoroscopy, procedural time, and raised contrast load administration. Overall procedural success was achieved in 57 lesions with a success rate (87.7%). There was an improvement in LVEF and symptom during follow up. It's concordant the large registry involved 2,846 consecutive CTO-PCI individuals undertaken in Japan with a success rate (89.9%) **(9- 10)**.

Our study results were discordance with the J-CTO registry regarding the most common culprit artery was LAD (56.9%) while LCX comes in the second space (38.5%), in addition to we had low MACE (4.6%) and mortality (1.5%) after CTO PCI, also the in-hospital MACE like cardiac tamponade, emergent revascularization, access site surgery, & gastrointestinal bleeding never happened **(10)**.

An important finding of our study was that successful CTO PCI improved the function and symptoms of the left ventricle. The LVEF improved six months after successful CTO PCI, as determined by follow-up. This statistically significant objective finding validates the clinical efficacy of CTO PCI, as demonstrated in previous research **(11)**.

This was consistent with **Pillai et al.'s** descriptive follow-up investigation on CTO PCI, a single-center, non-randomized study. Antegrade parallel wire, antegrade guide wire escalation approach, & dissection/re-entry were the methods utilized. The conventional methodology in this series was antegrade. Equally elevated values of left ventricular ejection fraction (LVEF) were observed in both groups subsequent to successful CTO PCI & complete revascularization **(12)**.

In concordance with our research **Lee et al.,** involved cases that underwent 321 consecutive attempts. Antegrade and retrograde approaches were utilized on 152 & 169 patients, respectively. The retrograde group exhibited substantially longer procedure and fluoroscopy durations, as well as increased radiation exposure and contrast medium consumption, according to their findings **(13)**.

In concordance with the PROGRESS-CTO & ERCTO registries, retrograde approach was associated to longer procedural, fluoroscopy times, and increased contrast load administration **(14-15)**.

However, in our research there was no statistically significant variance among antegrade & retrograde approaches concerning the presence of complications compared with antegrade CTO PCI, in their study meta-analysis of researches published among 2000 & August 2019, they found that retrograde CTO PCI was performed in more complex lesions & was related with a higher risk for acute & long-term adverse events **(16)**.

Several prior researches revealed the efficacy of the retrograde approach, but concerns regarding procedural safety limited its wide adoption the retrograde approach has revolutionized CTO PCI by significantly increasing procedural success, even among very complex coronary chronic total occlusions (CTOs) **(17)**.

In concordance with our study, between selected US-based institutions performing CTO PCI they observed a significant reduction in total fluoroscopy time & contrast utilization paralleled with an improved procedural success rate **(18)**.

The subanalysis of the EXPLORE found that a CTO lesion length >20mm is an independent predictor of CTO PCI failure. However, in our study the univariate analysis revealed that the presence of dyslipidemia, prolonged fluoroscopy time > 61 minute and presence of complications as dissection and perforation were significant predictors of procedural failure, but the multivariate regression analysis couldn't detect an independent predictor of CTO PCI failure **(19)**.

Conclusion

PCI can be utilized to safely & effectively treat the majority of CTO lesions. When actual frequencies of significant adverse cardiac events associated with CTO treatment & procedural success rates are considered, the invasiveness & potential risks of these approaches, which have been the primary

concerns regarding CTO treatment, may be acceptable in the majority of patients.

References

[1] YBARRA, Luiz Fernando, et al. Percutaneous coronary intervention in chronic total occlusion. Arquivos brasileiros de cardiologia, 2018, 110: 476-483.

[2] CARLINO, Mauro, et al. Treatment of the chronic total occlusion: a call to action for the interventional community. Catheterization and Cardiovascular Interventions, 2015, 85.5: 771-778.

[3] JEROUDI, Omar M., et al. Prevalence and management of coronary chronic total occlusions in a tertiary Veterans Affairs hospital. Catheterization and Cardiovascular Interventions, 2014, 84.4: 637-643.

[4] AZZALINI, Lorenzo, et al. Epidemiology, management strategies, and outcomes of patients with chronic total coronary occlusion. The American journal of cardiology, 2016, 118.8: 1128-1135.

[5] CAMPEAU, Lucien. Grading of angina pectoris. Circulation, 1976, 54.3: 522-523.

[6] ZHANG, Yao-Jun, et al. Prognostic value of site SYNTAX score and rationale for combining anatomic and clinical factors in decision making: insights from the SYNTAX trial. Journal of the American College of Cardiology, 2014, 64.5: 423-432.

[7] NEUMANN, Franz-Josef, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. European heart journal, 2019, 40.2: 87-165.

[8] WRITING COMMITTEE MEMBERS, et al. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Journal of the American College of Cardiology, 2022, 79.2: e21-e129.

[9] GALASSI, Alfredo R., et al. 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: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology, 2011, 7.4: 472-479.

[10] Suzuki Y, Tsuchikane E, Katoh O, et al. Outcomes of Percutaneous Coronary Interventions for Chronic Total Occlusion Performed by Highly Experienced Japanese Specialists. J Am Coll Cardiol Intv. 2017 Nov, 10 (21) 2144–2154.

[11] NAGANUMA, Toru, et al. Impact of chronic kidney disease on outcomes after percutaneous coronary intervention for chronic total occlusions (from the Japanese multicenter registry). The American Journal of Cardiology, 2018, 121.12: 1519-1523.

[12] PILLAI, Ajith Ananthakrishna, et al. Procedural and follow-up clinical outcomes after chronic total occlusion revascularization: Data from an Indian public hospital. Indian heart journal, 2019, 71.1: 65-73.

[13] LEE, Chih-Kuo, et al. Retrograde approach is as effective and safe as antegrade approach in contemporary percutaneous coronary intervention for chronic total occlusion: a Taiwan single-center registry study. Acta Cardiologica Sinica, 2017, 33.1: 20.

[14] CHRISTOPOULOS, Georgios, et al. Development and validation of a novel scoring system for predicting technical success of chronic total occlusion percutaneous coronary interventions: the PROGRESS CTO (Prospective Global Registry for the Study of Chronic Total Occlusion Intervention) score. JACC: Cardiovascular Interventions, 2016, 9.1: 1-9.

[15] MYAT, Aung, et al. Retrograde chronic total occlusion percutaneous coronary interventions: predictors of procedural success from the ERCTO registry. Cardiovascular Interventions, 2022, 15.8: 834-842.

[16] MEGALY, Michael, et al. Outcomes with retrograde versus antegrade chronic total occlusion revascularization. Catheterization and Cardiovascular Interventions, 2020, 96.5: 1037-1043.

[17] EL SABBAGH, Abdallah, et al. Angiographic success and procedural complications in patients undergoing retrograde percutaneous coronary chronic total occlusion interventions: a weighted meta-analysis of 3482 patients from 26 studies. International journal of cardiology, 2014, 174.2: 243-248.

[18] MICHAEL, Tesfaldet T., et al. Temporal trends of fluoroscopy time and contrast utilization in coronary chronic total occlusion revascularization: insights from a multicenter United States registry. Catheterization and Cardiovascular Interventions, 2015, 85.3: 393-399.

[19] KOLK, Maarten ZH, et al. Predictors and outcomes of procedural failure of percutaneous coronary intervention of a chronic total occlusion—A subanalysis of the EXPLORE trial. Catheterization and Cardiovascular Interventions, 2021, 97.6: 1176-1183.