Zagazig University Medical Journal
www.zumj.journals.ekb.eg

DOI:10.21608/zumj.2019.13606.1255 *Cardiology*

ORIGINAL ARTICLE

PERCUTANEOUS CORONARY INTERVENTION IN CHRONIC TOTAL CORONARY OCCLUSIONS: PARAMETERS OF SUCCESS

Mahmoud Diaa El-Menshawy[1], Kamel Hassan Mohamed Ghazal[2], Ghada Ebrahim Mohamed Ebrahim[3] and Ahmed Emad El-Din Mohamed Ahmed[4*]

1 Faculty of Medicine, Zagazig University, Department of Cardiology, Sharkia Egypt
2 Faculty of Medicine, Zagazig University, Department of Cardiology, Sharkia Egypt
3 Faculty of Medicine, Zagazig University, Department of Cardiology, Sharkia Egypt
4 Kobry el kopa military medical compound, Cardiology specialized hospital, Egypt

*** Corresponding author**
Ahmed Emad El-Din Mohamed Ahmed
E.mail: omda2099@yahoo.com

Submit Date: 12-06-2019
Revise Date: 26-06-2019
Accept Date: 30-06-2019

ABSTRACT

Background: chronic total coronary occlusions (CTOs) are the most technically challenging lesion that interventional cardiologists might face, and treatment of these lesions will have great effect on future percutaneous coronary intervention (PCI) success. Despite notable advances in the procedural and medical outcomes of percutaneous revascularization, CTO remains the unresolved problem in interventional cardiology. This study aimed to detect the pre-interventional predictors for procedural success of PCI of CTO and assess improvement of Left ventricular ejection fraction after successful PCI of CTO. **Methods:** 52 Patients with CTO of more than 3 months duration having significant angina (Class III / IV) or recent acceleration of previously chronic stable angina admitted to zagazig university hospital and Kobry El-Kobba Military Hospital during period from januray 2017 till januray 2018 were included in the study. **Results:** Predictors of technical success in CTO intervention were coronary artery diameter > 3mm , short CTO length less than 20mm , tapered CTO stump, absence of calcificlesion , bending angle less than 45 degree and prescence of microchannels. While small coronary artery diameter < 3mm, CTO length more than 20mm , presence of briding collaterals and high J-CTO score were predictors of technical failure. **Conclusion:** PCI for coronary CTO should be performed for documented viable myocardium in the territory supplied by the chronicaly occluded artery. Proper evaluation of the clinical and angiographic characteristics of the patient to choose the proper plan for the recanalization. Success of PCI to CTO cause significant increase left ventricular ejection fraction.

Key words: percutaneous coronary intervention, coronary total occlusions , coronary artery bypass graft .

INTRODUCTION

Chronic total coronary occlusions (CTO) are the most technically difficult lesions that interventional cardiologists might face, and treatment of these lesions will have great effect on future percutaneous coronary intervention (PCI) success. Despite notable advances in the procedural and medical outcomes of percutaneous recanalization, CTO remains the unresolved problem in interventional cardiology**[1]**.

Coronary CTO, in spite of excellent advance in the field of interventional cardiology, remain a challenge for interventional cardiologists. CTO is defined as coronary artery occlusion with a TIMI flow score (0) estimated for more than 3 months duration. CTO is observed in 15–30% of coronary angiograms **[2]**.

Due to the low success rate of PCI for CTO in comparison to regular coronary PCI, and the greater experience needed to perform the procedures successfully, chronic occlusions are regarded as a different type of cardiac lesion . Prof Gerald Werner, CTO expert and former President of the Euro CTO

Club, recommends considering chronic total coronary occlusions target for PCI, similar to any other lesion**[3]**.

When a guide wire is able to pass the occlusion site and reach the distal lumen , acceptable results are obtained with stent implantation, as shown by several trials with angiographic primary endpoints [GISSOC , SARECCO, SICCO, SPACTO and TOSCA]. The 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention of PCI to CTO in patients with clinical indications and suitable anatomy when performed by operators with suitable expertise is (Class IIa indication, Level of Evidence B) **[4]**.

The 2014 European Society of Cardiology and European Association for CardioThoracic Surgery guidelines on myocardial revascularization recommend PCI for CTO to be considered in patients with predictable ischemia reduction in the related myocardial territory and/or angina relief (Class IIa indication , LOE B). They recommend an initial anterograde technique and consideration of a retrograde technique if antegrade one fails or a primary retrograde approach in selected patients (Class IIb indication , LOE C) **[5]**

Currently, the indication for revascularization in stable IHD are determined irrespective of whether the lesion is a CTO or not. The indication for recanalization of a coronary artery lesion, whether CTO or severe stenosis, is based on patients presentation, the effect of antianginal medications, and the risk of ischemia**[6]**.

Over the past decade, however, there has been much improvement in the available technologies for CTO PCI as well as the international spreading of advanced CTO PCI techniques and skills. Technological advancements have include the development of specific wires including soft tip one to facilitate retrograde approach success , penetration wires to facilitate passage of the proximal and distal caps as well as to facilitate dissection and reentry from the subintimal space ,dedicated microcatheters for collateral channel dilatation and dedicated reentry systems have been similarly advanced to facilitate the success of both retrograde and dissection and reentry techniques**[7]**.

METHODS

Patients

52 Patients with CTO of more than 3 months duration have significant angina (Class III / IV) or recent deterioration of previously chronic stable angina admitted to zagazig university hospital and Kobry El-Kobba Military Hospital during the period from januray 2017 till januray 2018 were included in the study.

Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion Criteria

1- CTO of more than 3 months duration.
2- positive viability test in CTO territory .
3- Significant angina {Class III / IV} or recent deterioration of previously chronic stable angina that is not explained except by the CTO.
4- Area of ischemia in the territory of the CTO vessel is more than or equal 10% of left ventricular mass.

Exclusion Criteria

1- Patients with recent myocardial infraction .
2- patients with unstable haemodynamics.
3- Presence of scar or non viable myocardium in CTO territory.
4- Uncontrolled congestive heart failure.
5- Patients with renal impairment (creatinine >1.5mg/dl).

All patients were investigated by:

1. **History taking and clinical examination** for the following data:

- Demographic data as (Age. gender).
- Risk factors (Hypertension , Diabetes Mellitus, Smoking and positive family history of ischemic heart disease).
- General and local cardiac examination for :
  1- Heart rate .
  2- Blood pressure.
  3- Body mass index.
  4- signs of cardiac decompensation (rales ,gallop ,pulmonary congestion).
  5- symptoms of Class III / IV CCS angina .

2. **12 Lead ECG** for the following data: Q waves, ST segment , T wave changes.
3. **Cardiac enzymes** were done before & every four hours after the procedure during the first 24 hours and then daily during hospital stay.
4. **Routine laboratory** investigations with special concern to:

- Serum creatinine (less than 1.5 mg/dl) .
- Lipid profile: patient is considered dyslipidaemic if LDL >70mg/dl (according to 2018 ESC guidelines).

5. **EchoDoppler Study:** for assessment of left ventricular dimensions and left ventricular ejection fraction before and three months after the procedure using Simpson's method.
6. **Myocardial perfusion scan** to assess myocardial viability in CTO territory and degree of LV ischemia .
7. **In Hospital Management**:

All patients had received:

- low-dose Aspirin (ASA) 150mg
- Unfractionated Heparin (UFH) guided by activated clotting time(ACT 300-350 second).
- Clopidogrel (600 mg as a loading dose the day before then 75 mg as a maintenance dose)
- Conventional antischemic treatment {Beta Blockers, Nitrates, ACEI & Statins}.

8. All patients were subjected to Percutaneous Coronary Intervention (PCI) for Coronary Chronic Total Occlusion with documentation of the following data:

- Number of diseased vessels.
- CTO artery.
- Length of the lesion.
- Stumpshape.
- Bridging Collaterals and its relation to stump.
- Presence of Calcification and there degree.
- Adequacy of Septal branches.
- Antegrade or Retrograde technique .
- Guidewires that had successful lesion passage.
- Balloons that could dilate the total occlusion.

9.CTO opening plan :

An antegrade approach was generally tried first

Antegrade approach :

- Antegrade wire escalation
- Antegrade dissection and reentry

If antegrade trial failed or complications developed like dissection or perforation, retrograde technique as a secondary approach was tried.

Retrograde approach :

- Kissing wire techniques
- CART technique
- Reverse CART technique
- Knucle wire technique .

10. patients were evaluated for the following points:

Success was defined as procedural success with achievement of TIMI III flow (full perfusion of the entire vessel with normal distal runoff) in CTO artery with no complications during hospital stay.

A. Any complications.

1. Angiographic complications (myocardial infarction, stroke,dissection ,perforation).
2. In-hospital complications (hematoma ,infection.....).

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Paired sample t-test of significance was used when comparing between related sample.
- Chi-square (x^2) test of significance was used in order to compare proportions between qualitative parameters.
- Binary logistic regression: was used to predict the outcome of categorical variable based on one or more predictor variables.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:
- Probability (P-value)

– *P-value ≤0.05 was considered significant.
– **P-value ≤0.001 was considered as highly significant.
– P-value >0.05 was considered insignificant.

RESULTS

Site of design: Cardiology Department, Faculty of Medicine, Zagazig University; and

Cardiology Hospital , Kobry El Koba Military medical compoud in period from january 2017 till january 2018.

Sample size: Fifty two case of chronic total coronary occlusion were included in the study calculated by Epi Info version 6 with population size 120 case per year With frequency of successful recanalization 51% , the power of test 80% and confidence level 95% .

Written consent of acceptance of sharing in the study was taken from all patients .

The study cases divided in two groups according to achievement of TIMI score grade (III) in to **technical success** and those who had TIMI score grade (zero) or(I) in to **technical failure .**

The results in our study show that the technical success percentage 86.5% (45 case) and the technical failure percentage 13.5% (7 cases) where technical success defined by achievement of TIMI III flow **(Figure 1)**.

There is no statistically significant difference between technical success and technical failure according to demographic data or risk factors **(Table 1)**.

There is statistically significant difference between technical success and technical failure according to post PCI EF% in relation to the pre PCI EF% **(Table 2 , Figure 2)**.

Technical success and failure were determined according to coronary artery diameter , CTO length , stump shape , prescence of calcification, degree of bending at occlusion site and presence of microchannels **(Table 3)** . technical success predictors were large coronary artery diameter more than 3mm , short CTO length less than 20mm , tapered CTO stump, absence of calcificlesion , bending angle less than45 degree and prescence of microchannels. While small artery diameter less than 3mm, CTO Length more than 20mm , presence of bridging collaterals , high J-CTO score (more than or equal 3) and retrograde CTO plan have predictors and of technical failure **(Table 4 , Figure 3)**.

Table 1. Comparison between technical success and failure according to risk factors.

Co-morbidities	Outcome		x2	p-value
	Technical Success *(n=45)*	**Technical Failure *(n=7)***		
HTN	34 (75.6%)	4 (57.1%)	1.044	0.307
DM	23 (51.1%)	4 (57.1%)	0.088	0.766
Smoking	25 (55.6%)	2 (28.6%)	1.767	0.184
Family History	10 (22.2%)	2 (28.6%)	0.138	0.711
Dyslipidemia	30 (66.7%)	5 (71.4%)	0.062	0.803

x^2: Chi-square test; p-value >0.05 NS

Table 2. Comparison between technical success and failure as regard pre and post ECHO result.

Echo	Outcome		t-test	p-value
	Technical Success *(n=45)*	**Technical Failure *(n=7)***		
EF%				
Pre	54.29±5.09	53.43±6.48	0.401	0.690
Post	58.47±4.83	51.71±5.22	3.406	<0.001**
LVED diameter				
Pre	6.44±6.65	5.47±0.40	0.380	0.705
Post	7.10±9.36	5.57±0.30	0.428	0.670

*t: Paired Sample t-test; p-value>0.05 NS; **p-value <0.001 HS*

Table 3. CTO vessels distribution of the study group.

CTO vessels	Total (n=52)
Vessels	
LAD	23 (44.2%)
LCX	6 (11.5%)
OM	3 (5.8%)
PL	1 (1.9%)
RCA	19 (36.5%)
Vessel diameter	
<3	10 (19.2%)
>3	42 (80.8%)
CTO Length (mm)	
<20	37 (71.2%)
>20	15 (28.8%)
Stump	
Blunt	9 (17.3%)
Tapered	43 (82.7%)
Pre Trial	
No	39 (75.0%)
Yes	13 (25.0%)
Calcification	
No	26 (50.0%)
Yes	26 (50.0%)
Bending degree	
<45	47 (90.4%)
>45	5 (9.6%)
Micro channels	
No	9 (17.3%)
Yes	43 (82.7%)
J-CTO score	
0	13 (25.0%)

1	23 (44.2%)
2	9 (17.3%)
3	7 (13.5%)
Bridging collateral	
No	43 (82.7%)
Yes	9 (17.3%)
Cntralateralinjection	
No	13 (25.0%)
Yes	39 (75.0%)
Guide Wire	
Conquest pro	5 (9.6%)
Fielder FC	5 (9.6%)
Fielder XT	4 (7.7%)
Gaia	5 (9.6%)
Miracle	5 (9.6%)
Pilot	7 (13.5%)
Progress	5 (9.6%)
PT2MS	8 (15.4%)
Runthrough	3 (5.8%)
Sion Blue	2 (3.8%)
Whisper	3 (5.8%)

Data are expressed number and percentage

Table 4. Comparison between technical success and failure according to CTO vessels.

CTO vessels	Outcome		x2	p-value
	Technical Success *(n=45)*	**Technical Failure *(n=7)***		
Vessel diameter				
<3	4 (8.9%)	6 (85.7%)	23.018	<0.001**
>3	41 (91.1%)	1 (14.3%)		
Length (mm)				
<20	36 (80.0%)	1 (14.3%)	12.745	<0.001**
>20	9 (20.0%)	6 (85.7%)		
Stump				
Blunt	5 (11.1%)	4 (57.1%)	9.011	0.011*
Tapered	40 (86.7%)	3 (42.9%)		
Pre Trial				
No	35 (77.8%)	4 (57.1%)	1.376	0.241
Yes	10 (22.2%)	3 (42.9%)		
Calcification				
No	25 (55.6%)	1 (14.3%)	4.127	0.042*
Yes	20 (44.4%)	6 (85.7%)		
Bending degree				
<45	45 (100.0%)	2 (28.6%)	35.562	<0.001**
>45	0 (0.0%)	5 (71.4%)		
Micro channels				
No	3 (6.7%)	6 (85.7%)	26.447	<0.001**
Yes	42 (93.3%)	1 (14.3%)		

J-CTO score				
0	13 (28.9%)	0 (0.0%)	1.377	0.241
1	23 (51.1%)	0 (0.0%)	4.508	0.034*
2	8 (17.8%)	1 (14.3%)	0.096	0.757
3	1 (2.2%)	6 (85.7%)	29.481	<0.001**
Bridging collateral				
No	43 (95.6%)	0 (0.0%)	38.647	<0.001**
Yes	2 (4.4%)	7 (100.0%)		
contralateral injection				
No	11 (24.4%)	2 (28.6%)	0.055	0.815
Yes	34 (75.6%)	5 (71.4%)		
Guide Wire				
Conquest pro	5 (11.1%)	0 (0.0%)	0.057	0.812
Fielder fc	4 (8.9%)	1 (14.3%)	0.057	0.812
Fielder XT	3 (6.7%)	1 (14.3%)	0.004	0.952
Gaia	2 (4.4%)	3 (42.9%)	6.396	0.011*
Miracle	4 (8.9%)	1 (14.3%)	0.057	0.812
Pilot	7 (15.6%)	0 (0.0%)	0.28	0.597
Progress	4 (8.9%)	1 (14.3%)	0.057	0.812
PT2MS	8 (17.8%)	0 (0.0%)	0.424	0.515
Runthrough	3 (6.7%)	0 (0.0%)	0.027	0.87
Sion Blue	2 (4.4%)	0 (0.0%)	0.246	0.62
Whisper	3 (6.7%)	0 (0.0%)	0.027	0.87

*x^2: Chi-square test; p-value>0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

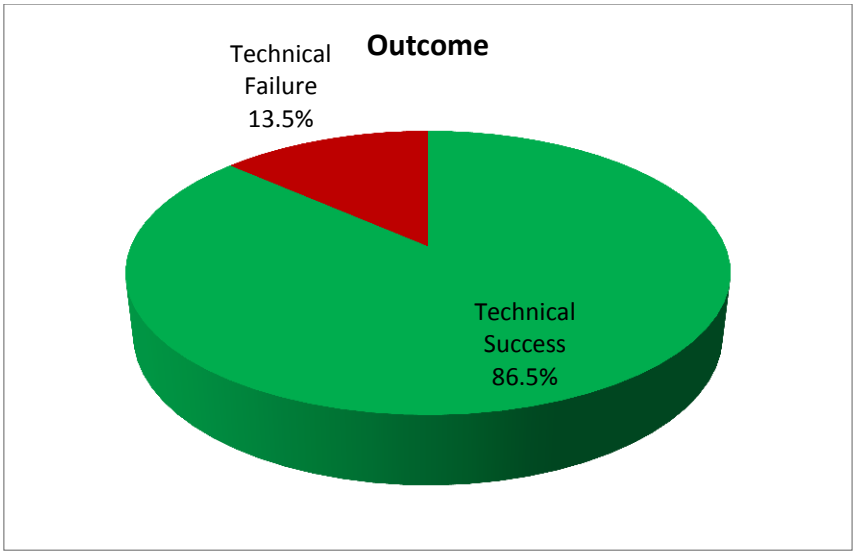

Figure 1. Pie chart outcome distribution of the study group.

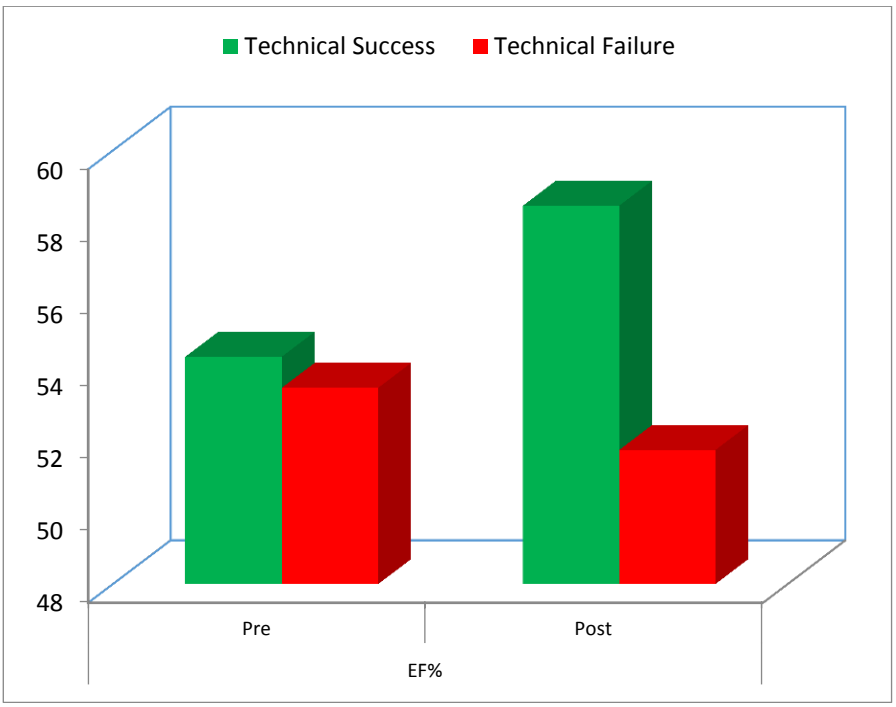

Figure 2. Bar chart between technical success and failure according to EF%

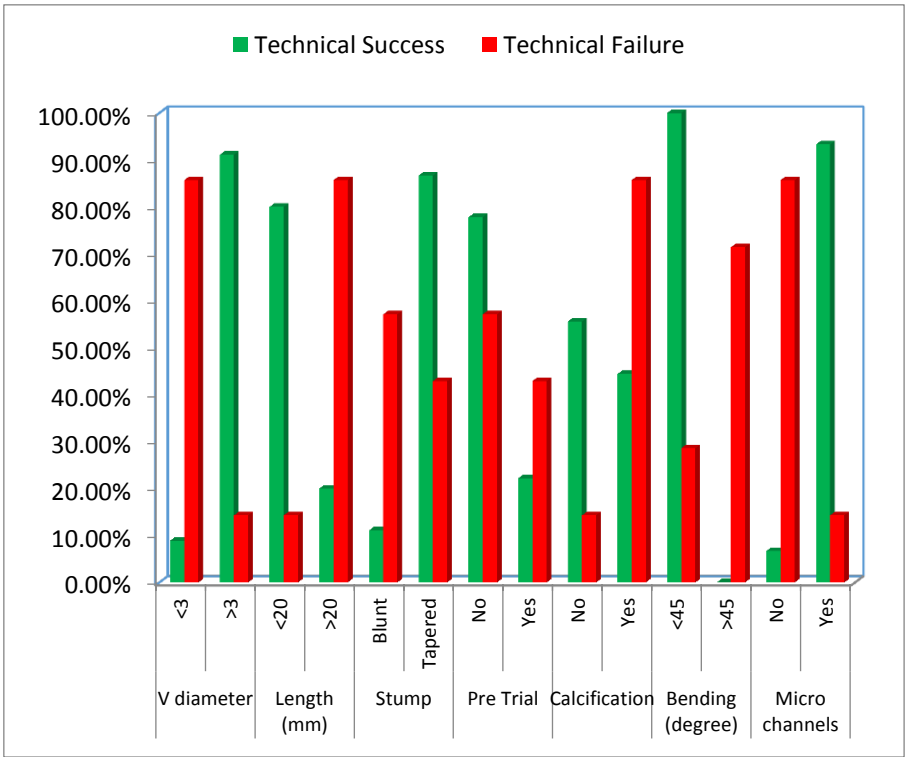

Figure 3. Bar chart between technical success and failure according to Vessel diameter,CTO length, stump, pre trial, calcification, bending degree and micro channels.the chart reveal thattechnical success more with big vessel diameter (>3mm) ,short CTO length (<20mm), tapered CTO stump, non calcificlesion,bending angle <45 degree and prescence of microchannels.

DISCUSSION

Despite notable advances in the procedural and clinical outcomes of percutaneous revascularization, CTO remains the unresolved problem in interventional cardiology**[1]**.

The documented success rate of CTO-PCI has reached > 80% due to the use of new techniques and development of dedicated devices**[8]**. Our study revealed that success rate of coronary CTO-PCI was 86.5%, that was consistent with the study published by Han et al, 2006, who reported that the overall success rate was 88.9%**[9]**. and is similar to those reported in recent large American and European CTO PCI registries (85.5% to 87.5%)**[10]**.

This is likely because of the use of novel recanalization strategies (including the retrograde approach and dissection and reentry techniques), dedicted equipment (microcatheters, guidewires, over the wire balloons and DES) and improving operator experience**[11]**.

Ahmet et al suggest that the most powerful parameters of technical failure are bridging collaterals, severe calcification and tortuosity. On the other hand, existence of microchannels is the only predictor of technical success which were matched with our study result. Moreover, they noticed that revascularization is not only an effective but also a safe option in adequately selected CTO patients, with a high success rate and low occurrence of complications**[12]**.

while several studies were planned to investigate the important factors, debate continues in regard to the effect of different clinical and angiographic factors on success and failure of PCI and long-term clinical results**[13]**. It has been reported that several angiographic factors such as absence of tapered stump , presence of bridging collaterals , and the presence of a side branch at the occlusion site are parameters of technical failure**[14]**. Severe tortuosity and moderate-to-severe calcification have also been considered to be parameters of technical failure**[15]**. Moreover, multivessel disease, lesion lengths more than 20 mm and subsequent CABG are measured to be parameters of technical failure **[16]**.

The results revealed that the different clinical risk factors had no influence on the success of coronary CTO PCI. That was consistent with Mashallah et al and Homa et al 2008 who studied the effect of clinical and coronary angiographic data of patients with CTO and showed that there was no significant correlation between the success rate of PCI and the patient's age, sex, clinical risk factors or history of recent myocardial infarction**[17]**.

The criteria supporting success by antegrade technique were: lesions with tapered end, lesions < 20mm length, lesion angulation < 45 degree and presence of bridging collaterals at CTO segment. While criteria favoring success by retrograde technique were lesion with abrupt end, lesion > 20mm length, lesion angulation > 45 degree, no side branch origin at CTO segment, difficult antegrade wiring, healthy donor artery, tapered non calcified distal cap and presence of continuous collaterals **[24]**.

On the other hand, parameters of failure of CTO PCI were absence of criteria that support antegrade and retrograde wiring, unhealthy donor vessel, blunt calcified distal cap and absence of continuous collaterals That was partially consistent with the study published by Han et al, 2006, who showed that the success rate of PCI declined with longer duration of occlusion, bridging collaterals, occluded length more than or equal 20 mm , moderate to severe calcification or tortuosity and ostial or distal site of CTO lesions. Procedural failure was caused by difficulty of guide-wire (81.0%) or balloon (19.0%) to cross the occlusion**[9]**.

However, Mashallah et al studied the effect of clinical and coronary angiographic data of patients with CTO and showed that the success rate was not affected by target vessel, location of lesion, presence of side branch at the site of occlusion and TIMI flow of artery, yet they found that the success rate of PCI was low with increase in the length of occlusion and presence of bridging collaterals**[17]**.

The results of our study support prior study by Zoran et al**.** investigated the success rate of

PCI for CTO. They detected these factors as significant predictors of PCI failure: length of CTO more than 20 mm or not measurable, Moderate to severe calcifications, Duration more than or equal 3 months and Multi-vessel disease. **[18]**.

Similarly also, Tomasello et al revealed that duration of occlusion had no influence on the procedural result. But Predictors of angiographic failure were artery diameter less than 3 mm, length of CTO >20 mm and severe calcification**[19]**.

Dong et al also showed that blunt morphology, more than or equal 45 degree of angulations of the target vessel, length of occlusion more than 20 mm were significant predictors of procedural failure**[20]**.

In our study, success rate was lower in cases with bridging collaterals through antegrade approach. That was inconsistent with the results obtained by Kinoshita et al who showed that coronary PCI can open chronic total occlusions, with or without bridging collateral channels effectively without major complications. This might be explained by the fact that bridging collaterals may be puzzled with microchannels in CTO body which facilitates CTO wiring **[21]**.

Stone et al reported that In the past, the presence of bridging collaterals was repeatedly found to be the strongest parameter of failed CTO PCI , However, with more developing experiences, success rates has no longer been inversely correlated to the presence of bridging collaterals**[22]**.

Thus, the current study results showed that success of coronary CTO PCI (by antegrade approach 34 out of 52 and by retrograde 11 out of 52) was more common in short (less than 20mm), non calcified lesions with tapered end, with less than 45 degree angulation with microchannels and without bridging collaterals. These results consistent with those of Rastegari et al who showed that predictors of an unsuccessful result of coronary CTO PCI were the presence bridging collaterals or presence of a side branch 2mm or less from the occlusion site**[23]**.

Rathore et al published that the procedure was successful by retrograde approach in (65.6%) of cases. Continuous thread-like connection, collateral tortuosity less than 90 degrees and angle with recipient vessel less than 90 degrees were significant predictors of success. Absence of continuous connection,tortious channel, angle with recipient vessel more than 90 degrees and absence of connection with recipient vessel were found to be significant predictors of procedural failure**[13]**.

In this study, IVUS was used in 20 cases. The decision of the operator to use IVUS was taken before or during the procedure. The main aims were to study cautiously the relationship of the CTO to major side branch and the effect of calcification on the success of the procedure. That was consistent with the study published by M Mohandes et al, who showed the benefit of IVUS in showing calcium in CTO segment , finding wire passage in subintimal space in part of CTO segment , wire position confirmation and more accurate vessel measurement**[24]**.

Also, Rotablator was used in 3 cases to overcome heavily calcified plaques that oppose ordinary ways of dilatation and development of interventional procedure. That was consistent with the study done by Bittl et al , who confirmed that the Rotablator is intended for plaque modification, especially in challenging, elastic or calcific lesions. The Rotablator can facilitate the procedure and increase the overall PCI success rates, especially difficult CTOs**[25]**.

Follow up of serum creatinine in the current study, was done after 24 hours of the procedure with no elevation in any patient, this is not consistent with the data registry of the Mayo clinic which revealed that the overall incidence of contrast indued nephropathy in the general population is ranging from 1.2 to 1.6%**[26]**.

Only two case had perforation of LAD with development of mild pericardial effusion which resolved spontaneously but without development of MACE, this is consistent with the results published by Ellis et al, who showed that the incidence of coronary perforation is less than 1%**[27]**.

Assessment of Cardiac enzymes was done before and every four hours after the procedure during the first 24 hours and then daily during hospital stay. We did not have any case with elevated cardiac enzymes after

the procedure. This was not consistent with the study published by Bahrmann et al who reported CK-MB elevation after recanalization of CTOs was noted in only 6% of patients with CTOs**[28]**.

Our results showed that there was significant increase in LVEF after successful CTO PCI which is in agreement with the results of Sirnes et al who observed changes in left ventricular ejection fraction after successful angioplasty of chronic coronary occlusions and showed that there was significant improvment in left ventricular ejection**[29]**.

CONCLUSION

PCI for coronary CTO should be performed for documented viable myocardium in the territory supplied by the chronicaly occluded artery. Proper evaluation of the clinical and angiographic characteristics of the patient to choose the proper plan for the recanalization starting from the guiding catheter , the approach and the instruments that will be used. Well equipped cathLab, well trained and skilled operator, assistants and cathlab team are mandatory for success of the procedure. Bigger multicenter studies, longer follow up, serial echocardiographic studies, use of CT angiography might change patient selection and contrast amount.

Conflict of Interest: Nothing to declare.
Financial Disclosures: Nothing to declare.

REFERENCES

1. **Mattichak SJ, Dixon SR, Shannon F, Boura JA, Safian RD.** Failed Percutaneous coronary intervention : a decade of experience in 21000 patients. Catheter Cardiovasc Interv 2008, 71:131-7.
2. **Sianos G**. EuroCTO Club. Recanalisation of chronic total coronary occlusions: 2012 consensus document from the EuroCTO club. EuroIntervention. 2012;8(1):139-45.
3. **Werner GS, Surber R, Ferrari M, Fritzenwanger M, Figulla HR.** The functional reserve of collaterals supplying long-term chronic total coronary occlusions in patients without prior myocardial infarction. Eur Heart J 2006; 27: 2406-2412.
4. **Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, et al .** 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. J Am Coll Cardiol 2011;58:e44-e122.
5. **Windecker S, Kolh P, Alfonso F, Collet JP, Cremer J, Falk V, et al.** 2014 ESC/EACTS Guidelines on myocardial revascularization: The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). Eur Heart J 2014;35:2541-619.
6. **Patel MR, Calhoon JH, Dehmer GJ,Grantham JA, Maddox TM, Maron DJ, et al.** ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/ STS 2017 Appropriate Use Criteria for Coronary Revascularization in Patients With Stable Ischemic Heart Disease: A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and Society of Thoracic Surgeons. J Am Coll Cardiol 2017;69:2212-41.
7. **Whitlow PL**. J Am Coll Cardiol Intv. 2012;5:393-401.
8. **Bryniarski KL, Zabojszcz M, Debski G, Marchewka J, Legutko J, Jankowski P, et al.** What Polish inter- ventional cardiologists know about indications and qualification for recanalisation of chronic total coronary artery occlusions? Kardiol Pol 2015; 73: 722-9. 20.
9. **Han YL, Wang SL, Jing QM, Li Y, Zhang J, Ma YY, et al.** Percutaneous coronary intervention for chronic total occlusion in 1263 patients: a single-center report. Chin Med J (Engl) 2006; 119: 1165-1170.
10. **Galassi AR, Sianos G, Werner GS, Escaned J, Tomasello SD, Boukhris M, et al.** Retrograde recanalization of chronic total occlusions in Europe: procedural, in-hospital, and long-term outcomes from the

multicenter ERCTO Registry. J Am Coll Cardiol. 2015;65:2388–2400.

11. **Bryniarski L, Kusak P, Surowiec S, Dudek D, Czarnecka D .** Dedicated devices and techniques – a cornerstone in recanalisation of chronic total occlusions of coronary arteries. Postep Kardiol Inter 2014; 10: 213-5. 22.
12. **Baykan AO, Gür M, Acele A, Şeker T, Quisi A, Kıvrak A, et al.** Adv Interv Cardiol 2016; 12, 1 (43): 17–24 DOI: 10.5114/pwki.2016.56945
13. **Rathore S, Matsuo H, Terashima M, Kinoshita Y, Kimura M, Tsuchikane E, et al.** Procedural and in-hospital outcomes after percutaneous coronary intervention for chronic total occlusions of coronary arteries 2002 to 2008: impact of novel guidewire techniques. JACC Cardiovasc Interv 2009; 2: 489-97. 30.
14. **Bufe A, Haltern G, Dinh W, Wolfertz J, Schleiting H, Guelker H, et al.** Recanalisation of coronary chronic total occlusions with new techniques including the ret- rograde approach via collaterals. Neth Heart J 2011; 19: 162-7. 31.
15. **Garcia-Garcia HM, Brugaletta S, van Mieghem CA, Gonzallo N, Diletti R, Gomez-Lara J, et al.** CRosser As First choice for crossing Totally occluded coronary arteries (CRAFT Registry): focus on conventional angiography and com- puted tomography angiography predictors of success. EuroInt- ervention 2011; 7: 480-6. 32.
16. **Yamamoto E, Natsuaki M, Morimoto T, Furukawa Y, Nakagawa Y, Ono K, et al.** Long-term outcomes after percutaneous coronary intervention for chronic total occlusion (from the CREDO-Kyoto registry cohort-2). Am J Cardiol 2013; 112: 767-74.
17. **Mashallah D, Homa F, Sayed M.** Success rate of PCI in patients with CTO of coronary arteries, 2008, ARYA Atherosclerosis Journal 2008, 4(3): 137-141.
18. **Zoran O, Federico P, Alessandro F, Luigi S, Corinna G, Carlo DM, et al.** Immediate results and one-year clinical outcome after percutaneous coronary interventions in chronic total occlusions.data from a multicenter, prospective, observational study (TOAST-GISE). J Am Coll Cardiol, 2003; 41:1672-1678.
19. **Tomasello SD, Galassi AR, Reifart N, Werner GS, Sianos G, Bonnier H, et al.** In-hospital outcomes of percutaneous coronary intervention in patients with chron- ic total occlusion: insights from the ERCTO (European Registry of Chronic Total Occlusion) registry. EuroIntervention 2011; 7: 472-9. 21.
20. **Dong S, Smorgick Y, Nahir M, Lotan C, Mosseri M, Nassar H, et al.** Predictors for successful angioplasty of chronic totally occluded coronary arteries. J Interv Cardiol 2005;18: 1-7.
21. **Kinoshita I, Katoh O, Nariyama J.** Coronary angioplasty of CTO with bridging collateral vessels: immediate and follow up outcome from a large single-center experience. J Am Coll Cadiol 1995; 26:409-15.
22. **Stone GW, Kandzari D, Mehran R.** Percutaneous recanalization of chronically occluded coronary arteries: a consensus document: part 1. Circulation 2005; 112:2364-72.
23. **Rastegari Y, Ghaemian A, Ghasemi M, Hendesi F.** Immediate Outcome of Coronary Angioplasty in Chronic Total Occlusions with Bridging Collateral Vessels, Iranian Heart Journal 2003; 4 (4):16-21).
24. **Mohandes M, Guarinos J, Sans J, Bardaji A .** Intravascular Ultrasound in Percutaneous Coronary Intervention for Chronic Total Occlusion 2010, Iranian Cardiovascular Research Journal Vol.4, No.3, 2010.
25. **Bittl JA, Chew DP, Topol EJ, Kong DF, Califf RM .** Meta-analysis of randomized trials of percutaneous transluminal coronary angioplasty versus atherectomy, cutting balloon atherotomy, or laser angioplasty. J Am Coll Cardiol 2004; 43: 936-942.
26. **Rihal CS, Textor SC, Grill DE, Berger PB, Ting HH, Best PJ, et al .** Incidence and prognostic importance of acute renal failure after percutaneous coronary intervention. Circulation 2002; 105: 2259-2264.
27. **Ellis SG, Ajluni S, Arnold AZ, Pompa JJ, Bittl JA, Eigler NL, et al.** Increased coronary perforation in the new device era. Incidence, classification, management, and outcome. Circulation 1994; 90: 2725-2730.
28. **Bahrmann P, Markus F, Hans R, Gerald S.** Low incident of cardiac biomarker elevation after PCI in CTO EuroIntervention: journal of EuroPCR in collaboration with the Working Group on

Interventional Cardiology of the European Society of Cardiology/2. 2006.

29. **Sirnes PA, Myreng Y, Molstad P, Bonarjee V, Golf S .** Improvement in left ventricular ejection fraction and wall motion after successful recanalization of chronic coronary occlusions. Eur Heart J 1998; 19: 273-281.

How to cite

Mohamed Ahmed, A., mohamed ebrahim, G., Mohamed ghazal, K., El-Menshawy, M. Percutaneous coronary intervention in chronic total coronary occlusions : Parameters of success. *Zagazig University Medical Journal*, 2020; (840-852): -. doi: 10.21608/zumj.2019.13606.1255