**Benha Journal of Applied Sciences (BJAS)** **print: ISSN 2356–9751**
**Vol. (7) Issue (8) (2022), (31-37)** **online: ISSN 2356–976x**
**http://bjas.journals.ekb.eg**

# Outcomes of Percutaneous Coronary Intervention in Patients with Chronic Total Occlusions and Reduced Ejection Fraction

**I.A.Mohamed[2], k.E.Elrabat[1], A.Y.Ibrahim[1] and M.M.Mandour[2]**
[1]Cardiology, Dept., Faculty of Medicine, Benha Univ., Benha, Egypt
[2]Cardiology, National Heart Institute, Cairo, Egypt
E-mail:Mandour232@yahoo.com

**Abstract**

The high incidence of chronic complete occlusion (CTO) of the coronary arteries in individuals with coronary artery disease has garnered a lot of interest (CAD). Long-term results are poorer for patients with CTO and reduced LVEF (left ventricular ejection fraction). Despite advances in other treatment modalities, percutaneous coronary intervention (PCI) continues to be the gold standard for individuals with a decreased LVEF. The purpose of this research was to analyse the influence of LV dysfunction on the results of Percutaneous coronary intervention (PCI) in patients with a lower LV ejection fraction (LVEF). Techniques Patients with CTO were recruited to the cardiac catheterization laboratory unit for elective PCI in this prospective trial. Group I (normal LVEF group) included patients with a baseline LVEF of at least 50%; group II (mid-range LVEF group) included patients with a baseline EF of 40% to 49%; and group III (reduced LVEF group) included patients with a baseline EF of 30% to 39%. There were a total of 120 patients in this trial; 40 were randomly assigned to each group. In terms of coronary intervention, there were no significant differences in procedure time (p=0.97), Syntax score (p=0.9), J-CTO score (p=0.41), wire technique (p=0.61), or wire stiffness (p=0.9), but contrast volume was significantly lower in the reduced LVEF group compared to the other groups (p=0.004). In the normal LVEF group, 87.5 percent of patients had successful PCI, in the intermediate LVEF group, 82.5 percent, and in the decreased LVEF group, 75.0 percent. There wasn't enough of a difference to warrant statistical attention. Pre-existing conditions including diabetes mellitus and the J-CTO score emerged as major contributors to the probability of periprocedural complications in the regression analysis. Our results show that CTO PCI is safe and effective even in patients with LV dysfunction. In these individuals, PCI led to better outcomes on clinical and LV echocardiographic functional measures. The incidence of major adverse cardiac and cerebrovascular events (MACCE) was similar in the three groups, therefore this improvement did not come at the price of postoperative safety.

**Keywords:** Chronic total occlusion, percutaneous coronary intervention, coronary artery disease, left ventricular ejection fraction.

## 1. Background

Since up to 52% of patients with coronary artery disease (CAD) are revealed to have chronic complete occlusion (CTO) of a coronary artery [1], this condition has received a great deal of attention. As a result, a well-thought-out strategy for CTO management is becoming increasingly important [2].

Revascularization of a coronary artery CTO is a well-established use for percutaneous coronary intervention (PCI). Still, there isn't enough of a standardised approach to choosing the best patients. In addition, PCI's efficacy in treating CTO has recently been questioned in comparison to conservative therapy [3].

Recurrent ischemia events may cause myocardial hibernation and left ventricular (LV) dysfunction, leading to clinical heart failure [4]; this is how coronary artery disease may cause heart failure. Patients with CTO and reduced LVEF (left ventricular ejection fraction) had a worse prognosis [5]. Reductions in LVEF are often treated with percutaneous coronary intervention. Revascularization may bring the heart out of hibernation [6]. Those with CAD and heart failure have more to gain from percutaneous coronary intervention, and our finding corroborates that claim. While PCI has been shown to be effective in treating individuals with poor LVEF and coronary artery CTO, there is less data available on its long-term effectiveness.

The goals of this study were to determine the success rate of CTO PCI in patients with lower LVEF and to investigate the possible influence of LV dysfunction on the success rate of Percutaneous coronary intervention (PCI) in such individuals.

## 2. Methods

The National Heart Institute of Egypt (NHEI) performed this prospective observational research from November 2019 to April 2021 at their cardiology department. Those with CTO who volunteered to have elective PCI were included in this study. Institutional review board of Egypt's Benha University gave its blessing to this research, which adhered to the principles outlined in the Helsinki declaration.

All patients had a thorough history taken, a general and cardiac-specific physical examination, a complete panel of routine laboratory tests, and a 12-lead surface ECG taken while they were resting. Patients who complained of shortness of breath or chest pain were evaluated using criteria established by the New York Heart Association (NYHA) [7] and the Canadian Cardiovascular Society (CCS) [8]. Myocardial vitality was determined using a Thallium-201 myocardial perfusion SPECT (single photon emission computed tomography) scan.

Indicated for PCI (had evidence of severe angina, and/or current worsening of chronic stable angina, with myocardial viability of more than 10% in the CTO arterial region) patients with CTO of one or more epicardial coronary arteries were included in the research.

Patients were not included if they had a scar in the CTO-related myocardium, substantial valvular, pericardial, or myocardial disease, a CTO of a distal vessel less than 2

mm in diameter, contraindications for antiplatelet medication, a history of failure CTO-PCI, or were recommended for CABG. Patients having a glomerular filtration rate of 30 ml/min/1.73 m2 or below were also not allowed to participate.

All participants provided written informed permission after an explanation of the study's purpose and methods.

Each patient had an echocardiogram performed 24 hours before PCI and again 6 months afterwards. The examination was conducted with the patient lying supine or on their left side using a Siemens Acuson S1000 Ultrasound machine (Germany) equipped with tissue Doppler imaging (TDI) capabilities and appropriate cardiac transducers. The echocardiogram was conducted by two separate renowned cardiologists. Both parties were unaware of the patient's information. The LV end-diastolic volume (LVEDV) was subtracted from the LV end-systolic volume (LVESV) to determine the LVEF [9]. Wall motion score index (WMSI) was calculated by dividing the total score by the total number of visible segments [10].

Subjects were randomly assigned to one of three groups based on their LVEF. Group I (normal LVEF group) included patients with an LVEF at baseline of at least 50%; group II (mid-range LVEF group) included patients with an LVEF at baseline of 40% to 49%; and group III (reduced LVEF group) included patients with an LVEF at baseline of 30% or less.

**Invasive Coronary Procedure**

Catheterization of the coronary arteries was done on all patients using equipment manufactured by SIEMENS and GE. Seldinger's method was used to conduct coronary angiography via both the femoral and radial arteries. Multiple projections and angles were used for both the left and right CAG, following Judkin's method. Lesion complexity in CTO was measured using the J-CTO [11] and Syntax scores [12].

CTO lesions were treated using a coronary angioplasty procedure. Operator choice was respected for guiding catheter selection, wiring method, and overall strategy for determining total procedure duration and contrast volume.

Dual antiplatelet therapy has been recommended as standard treatment for at least a year following the operation. At 1, 3, and 6 months post-procedure, patients returned for a thorough clinical evaluation and echocardiographic testing. Whenever a problem arose, patients were urged to go to the nearest emergency room.

**Study outcomes**

The study outcomes were the potential differences among the three groups in the sociodemographic and clinical data, and the effect of the LVEF status on the rate of successful intervention (the lumen diameter is <20% less than the adjacent normal coronary artery, without periprocedural major complications) [13], and the rate of major adverse cardiac and cerebrovascular events (MACCE).

**3. Statistical analysis:**

The patients' data were analyzed using the SPSS statistical software (IBM Corp., Armonk, NY, USA), version 20.0. Categorical data were expressed as frequency and percentage, and numerical data were presented as mean ± standard deviation (SD)/median and range. Chi-square, McNemar, paired sample t, and one-way ANOVA tests were used as appropriate. Regression analysis was performed to assess the potential predictors of procedural outcome. Two-tailed p-value <0.05 was statistically significant.

**4. Results**

In this study, forty patients were included in each group, with a total of 120 patients constituting the study population. The patients' ages ranged from 45 to 81, and males constituted 71%, 75%, and 82.5%, of the 3 groups, respectively. The body mass index (BMI) ranged from 24.5 to 36.5 kg/m2. Statistically insignificant differences were found among the three groups in age (p=0.93), gender (p= 0.71), and BMI (p= 0.75) (Table 1).

Patients' comorbidities are shown in table 1. Statistically significant more frequent patients with diabetes mellitus and chronic kidney disease were found in the group with reduced LVEF (p = 0.03 and 0.003, respectively). The study patients had a comparable history of smoking (p = 0.32), prior PCA (p = 0.18), and prior coronary artery bypass graft (CABG) (p = 0.66) (Table 1).

**Table (1)** Demographic data of the studied groups.

| Variable | | Group I (Normal EF) (n=40) | | Group II (mid-range EF) (n=40) | | Group III (Low EF) (n=40) | | F | P |
|---|---|---|---|---|---|---|---|---|---|
| **Age: (years)** | Mean ± SD | 61.54±6.23 | | 60.92±7.17 | | 61.14±8.45 | | 0.07 | 0.93 |
| | Range | 45 – 80 | | 46 - 81 | | 45 - 78 | | | |
| **BMI: ($Kg/m^2$)** | Mean ± SD | 27.28±2.71 | | 26.81±2.35 | | 27.03±3.14 | | 0.29 | 0.75 |
| | Range | 25 – 36.5 | | 24.5 - 36 | | 25 – 35.5 | | | NS |
| **Variable** | | **No** | **%** | **No** | **%** | **No** | **%** | $\chi^2$ | **P** |
| **Sex:** | Female | 9 | 29 | 10 | 25 | 7 | 17.5 | 0.69 | 0.71 |
| | Male | 31 | 71 | 30 | 75 | 33 | 82,5 | | |
| **DM** | | 12 | 30 | 14 | 35 | 23 | 57.5 | 7.11 | 0.03* |
| **Hypertension** | | 31 | 77.5 | 29 | 72.5 | 33 | 82.5 | 1.15 | 0.56 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Dyslipidemia** | 21 | 52.5 | 24 | 60 | 27 | 67.5 | 1.88 | 0.39 |
| **Smoking** | 24 | 60 | 25 | 62.5 | 30 | 75 | 2.30 | 0.32 |
| **CKD** | 4 | 10 | 7 | 17.5 | 20 | 50 | 11.95 | 0.003* |
| **Prior PCI** | 13 | 32.5 | 11 | 27.5 | 6 | 15 | 3.47 | 0.18 |
| **Post CABG** | 5 | 12.5 | 7 | 17.5 | 8 | 20 | 0.84 | 0.66 |

SD: Standard deviation, F: ANOVA F test, $\chi^2$: Chi square test, *: Statistically significant

Clinical assessment revealed that the cases of advanced exertional chest pain were significantly less frequent, and the cases of class 3 and 4 exertional dyspnea were significantly more frequent in the reduced LVEF group compared to the other groups (p=0.005 and 0.001, respectively) (Table 2).

**Table (2)** Canadian Cardiovascular society and New York Heart Association among the studied groups.

| **Variable** | | **Group I (Normal EF) (*n*=40)** | | **Group II (mid-range EF) (*n*=40)** | | **Group III (Low EF) (*n*=40)** | | **$\chi^2$** | **P** |
|---|---|---|---|---|---|---|---|---|---|
| | | **No** | **%** | **No** | **%** | **No** | **%** | | |
| **CCS** | **1** | 2 | 5 | 6 | 15 | 12 | 30 | | |
| | **2** | 3 | 7.5 | 9 | 22.5 | 10 | 25 | **18.32** | **0.005*** |
| | **3** | 14 | 35 | 12 | 30 | 10 | 25 | | |
| | **4** | 21 | 52.5 | 13 | 32.5 | 8 | 20 | | |
| **NYHA** | **1** | 17 | 42.5 | 12 | 30 | 4 | 10 | | |
| | **2** | 13 | 32.5 | 12 | 30 | 8 | 20 | **21.37** | **0.001*** |
| | **3** | 6 | 15 | 9 | 22.5 | 10 | 25 | | |
| | **4** | 4 | 10 | 7 | 17.5 | 18 | 45 | | |

$\chi^2$: Chi-square test. *: Statistically significant

Concerning coronary intervention procedure, there were statistically insignificant differences among the studied groups in procedure time (p = 0.97), Syntax score (p = 0.9), J-CTO score (p = 0.41), wire technique (p = 0.61), and wire stiffness (p = 0.9), but there was a significantly reduced contrast volume in the group of reduced LVEF compared to the other groups (p = 0.004) (Table 3).

**Table (3)** Angiographic characteristics and procedural data among the studied groups.

| **Variable** | | **Group I (Normal EF) (n=40)** | | **Group II (midrange EF) (n=40)** | | **Group III (Low EF) (n=40)** | | **F** | **P** |
|---|---|---|---|---|---|---|---|---|---|
| **Procedure time: (min)** | Mean ± SD | 79.81±24.13 | | 81.23±25.42 | | 80.26±23.16 | | 0.04 | 0.97 |
| | Range | 40 – 135 | | 36 - 152 | | 35 - 148 | | | |
| **Contract volume: (ml)** | Mean ± SD | 359.2±120.12 | | 338.13±111.45 | | 271.15±90.3 | | 5.9 | 0.004* |
| | Range | 145 – 575 | | 145 - 545 | | 135 - 410 | | | |
| **Syntax score:** | Mean ± SD | 23.17±3.28 | | 22.82±3.49 | | 22.91±3.71 | | 0.11 | 0.90 |
| | Range | 15 – 30 | | 16 - 29 | | 16 - 30 | | | |
| **Variable** | | **No** | **%** | **No** | **%** | **No** | **%** | **$\chi^2$** | **P** |
| **J-CTO score:** | **≥ 3** | 22 | 55 | 19 | 47.5 | 25 | 62.5 | 1.82 | 0.41 |
| | **<3** | 18 | 45 | 21 | 52.5 | 15 | 37.5 | | |
| **Wire technique:** | Antegrade | 31 | 77.5 | 29 | 72.5 | 27 | 67.5 | 1.00 | 0.61 |
| | Retrograde | 9 | 22.5 | 11 | 27.5 | 13 | 32.5 | | |
| **Wire stiffness:** | <3gm | 26 | 65 | 24 | 60 | 25 | 62.5 | 0.21 | 0.90 |
| | ≥3gm | 14 | 35 | 16 | 40 | 15 | 37.5 | | |

SD: Standard deviation, F: ANOVA F test, $\chi^2$: Chi-square test, *: Statistically significant

PCI procedural success was achieved in 87.5% of the normal LVEF group, 82.5% of the mid-range LVEF group, and 75% of the reduced LVEF group. This difference was statistically insignificant (p = 0.35).

Regression analysis revealed that diabetes mellitus and J-CTO score were the significant risk factors for periprocedural complications (Table 4).

**Table (4)** Logistic regression analysis for predictors of procedure outcome among the studied groups.

| | Univariate Logistic Regression Analysis | | |
|---|---|---|---|
| **Variable** | **OR** | **95% CI** | **P** |
| **Age** | 0.97 | 0.70-1.34 | 0.84 NS |
| **BMI** | 0.70 | 0.49-1.04 | 0.08 NS |
| **Sex** | 1.17 | 0.81-1.68 | 0.34 NS |
| **DM** | 3.92 | 1.32-9.81 | 0.03* |
| **Hypertension** | 0.79 | 0.27-2.26 | 0.65 NS |
| **Dyslipidemia** | 1.08 | 0.80-1.44 | 0.63 NS |
| **Smoking** | 0.58 | 0.18-1.85 | 0.36 NS |
| **CKD** | 1.31 | 0.97-1.77 | 0.07 NS |
| **Prior PCI** | 0.56 | 0.40-1.78 | 0.47 NS |
| **Post CABG** | 0.87 | 0.55-1.40 | 0.58 NS |
| **EF category** | 1.02 | 0.69-1.59 | 0.77 NS |
| **SYNTAX score** | 1.21 | 0.90-1.98 | 0.45 NS |
| **J-CTO score** | 16.23 | 2.13-132.87 | <0.001* |
| **Wiring technique** | 0.94 | 0.58-1.51 | 0.80 NS |
| **Wiring stiffness** | 1.33 | 0.76-2.3 | 0.32 NS |
| **Variable** | **Multivariate Logistic Regression Analysis** | | |
| | **OR** | **95% CI** | **P** |
| **DM** | 4.06 | 1.48-11.43 | 0.02* |
| **J-CTO score** | 15.32 | 2.59-114.5 | <0.001* |

OR: Odds ratio, CI: Confidence interval,*: Statistically significant

The echocardiographic assessment demonstrated that, at the 6th-month follow-up, the normal LVEF group showed no statistically significant differences in either of the echo indices, while the mid-range LVEF group demonstrated a statistically significant increase in the LVEF and a decrease in wall motion score index (WMSI), compared to the baseline data. The reduced LVEF group showed a statistically significant increase in the LVEF and a statistical decrease in WMSI (Figure 1).

In comparison to the baseline data, the 6th month follow-up showed a statistically significant decrease in the prevalence of class II angina in the normal LVEF group, while no statistically significant differences were shown in the other groups. The prevalence of class II dyspnea was significantly decreased in the mid-range and reduced LVEF groups, while no statistical significance was shown in the normal LVEF group (Table 5).

**Table (5)** Angina and dyspnea at the baseline and after 6 months in the studied groups.

| **Variable** | | **Group I (Normal EF) (*n*=40)** | | **Group II (midrange EF) (*n*=40)** | | **Group III (Low EF) (*n*=40)** | |
|---|---|---|---|---|---|---|---|
| | | **No** | **%** | **No** | **%** | **No** | **%** |
| **Angina baseline:** | **I** | 5 | 12.5 | 15 | 37.5 | 22 | 55 |
| | **II** | 35 | 87.5 | 25 | 62.5 | 18 | 45 |
| **Angina 6th month:** | **I** | 24 | 60 | 21 | 52.5 | 23 | 57.5 |
| | **II** | 16 | 40 | 19 | 47.5 | 17 | 42.5 |
| **Mc** | | **3.82** | | 2.15 | | 0.02 | |
| **P** | | **0.04*** | | 0.13 NS | | 0.98 NS | |
| **Dyspnea baseline:** | **I** | 30 | 75 | 24 | 60 | 12 | 30 |
| | **II** | 10 | 25 | 16 | 40 | 28 | 70 |
| **Dyspnea 6th month:** | **I** | 33 | 82.5 | 31 | 77.5 | 22 | 55 |
| | **II** | 7 | 17.5 | 9 | 22.5 | 18 | 45 |
| **Mc** | | 1.26 | | **4.58** | | **9.02** | |
| **P** | | 0.24 | | **0.03*** | | **<0.001**** | |

Mc: McNemar test, *: Statistically significant.

There was a comparable frequency of MACCE among the three groups (Table 6).

**Table (6)** Major Adverse Cardio-cerebrovascular Events (MACCE) among the studied groups.

| MACCE | | Group I (Normal EF) (*n*=40) | | Group II (midrange EF) (*n*=40) | | Group III (Low EF) (*n*=40) | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|---|
| | | No | % | No | % | No | % | | |
| **No** | | 35 | 87.5 | 33 | 82.5 | 29 | 72.5 | 3.01 | 0.22 |
| **Yes** | | 5 | 12.5 | 7 | 17.5 | 11 | 27.5 | | |
| **Type** | **NSTE-ACS** | 3 | 7.5 | 0 | 0 | 0 | 0 | | |
| | **Stroke** | 2 | 5 | 0 | 0 | 3 | 7.5 | | |
| | **decompensated HF** | 0 | 0 | 3 | 7.5 | 5 | 12.5 | 4.23 | 0.25 |
| | **Non-fatal MI** | 0 | 0 | 2 | 5 | 2 | 5 | | |
| | **Revascularization** | 0 | 0 | 2 | 5 | 0 | 0 | | |
| | **Malignant arrhythmia** | 0 | 0 | 0 | 0 | 1 | 2.5 | | |

$\chi^2$: Chi-square test, *: Statistically significant

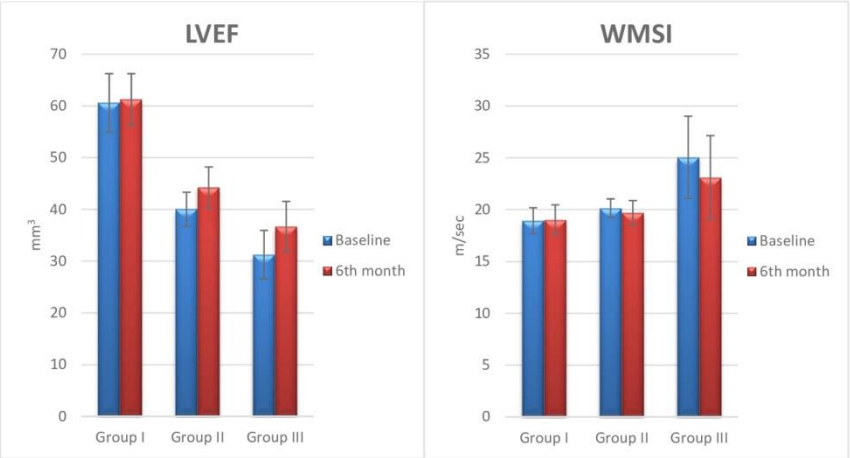


**Fig. (1)** Echocardiographic indices at baseline and 6 months postprocedural among the studied groups.

## 5. Discussion

It has been shown that ischemia symptoms ameliorate and LVEF increases after PCI for CTO [14, 15]. Because of the uncertain results and the risks associated with the treatment, it is seldom done. In addition, there is still debate on whether or not CTO-PCI is safe and effective for patients with compromised LV functions.

Average age, body mass index, and gender distribution were all similar among the three groups. That aligns with the findings of Galassi et al. (2017) [16], Simsek et al. (2022) [17], and Ito et al. (2021) [18].

This research found that the prevalence of diabetes mellitus and chronic kidney disease (CKD) was significantly higher in the group with lower LVEF, indicating that these conditions are common comorbidities and risk factors. Earlier studies have linked diabetes mellitus to an increased risk of heart failure, thus our findings are in line with them. Reducing exposure to other known cardiovascular risk factors [19,20] was shown to have no effect on this increased risk of heart failure.

CKD is recognised as a separate risk factor for cardiovascular disease. Recent research has shown that chronic kidney disease is linked to heart failure. The elevated lipid peroxidation products seen in people with CKD, which are linked to increased heart failure risks, may help to explain this [21]. However, it may be difficult to establish a causal association between nephropathy and heart failure [22] because to the well-known link between diabetes mellitus and an increased risk of cardiovascular disease and nephropathy.

In agreement with our findings, the studies of Galassi et al. (2017) [16] and Ito et al. (2021) [18] reported a significant difference in the prevalence of diabetes mellitus and CKD.

The current research found that severe dyspnea was more common in the lowered LVEF group and severe angina was less common than in the normal and mid-range LVEF groups, both of which were categorised by LVEF status. Because of the left ventricular dysfunction, this population is likely to have a greater incidence of severe dyspnea. Individuals with CTO and compromised cardiac

functions are more inclined to avoid physical activities that may cause symptoms in an effort to adjust to their health status, which may account for the reduced occurrence of angina in such patients [2]. Patients with reduced LVEF also had considerably lower angina and a higher dyspnea class, as was demonstrated in a research by Galassi et al. (2017) [16].

Time, syntactic score, J-CTO score, wire method, and wire stiffness were all similar across groups during PCI application in the present investigation, although the volume of contrast used was much smaller in the group with decreased LVEF. Our results suggest an overall equivalent PCI procedure feasibility in the research patients, despite the LVEF state. This agrees with other research showing PCI to be a viable option for patients with LV dysfunction [23, 24].

Success rates for PCI were similar among the three groups studied here. Consistent with our results, Galassi et al. (2017) [16] and Simsek et al. (2022) [17] found no statistically significant variations in CTO-PCI success rates across groups with varying LVEF levels. El Awady et al(2020) .'s research on LVEF strata also found similar rates of technical success [6].

In this research, we used a regression analysis to determine what factors were most indicative of a successful PCI procedure for the patients under review. Periprocedural problems were more likely in those with diabetes mellitus. The reported poor prognosis of individuals with diabetes mellitus following PCI [25] lends credence to this theory. Possibly contributing to these worse outcomes is medial calcification, a hallmark of diabetes mellitus-associated vasculopathy [26].

Periprocedural complications were also associated with the J-CTO score. Consistent with this, Mehta et al. (2018) found that a high J-CTO score was related to CTO-PCI failure [27].

Our research showed that individuals with mid-range and poor LVEF improved significantly in LV functional parameters as assessed by echocardiography as compared to their baseline. This is because revascularization by PCI helps the LV recover from hibernation, restores function, repairs myocardial tissue, creates collaterals, lessens unfavourable remodelling of the LV, and creates a more regular electrical pattern. Our results are consistent with those of Galassi et al. (2017), who found a substantial increase in LVEF after PCI for patients with impaired LVEF [16], and El Awady et al. (2020), who also found an increase in LVEF. Additionally, meta-analysis studies conducted by Hoebers et al. (2015) [28] and Megaly et al. (2018) [14] found that LVEF improved following PCI. The research by Cardona et al. (2016) [29] provides more evidence for this, demonstrating that patients with LVEFs below 50% were able to experience improvement.

This study adds to the growing body of evidence supporting the efficacy of percutaneous coronary intervention (PCI) by documenting a statistically significant reduction in symptom severity following PCI, specifically in the forms of dyspnea and angina, in patients with impaired LVEF and in those with preserved normal LVEF, respectively. Both Galassi et al. (2017) [16] and El Awady et al. (2020) [6] research indicated a similar trend of clinical improvement.

Finally, this investigation investigated the similar frequency of MACCE across the three groups, finding no statistically significant difference, which is consistent with previous results [6, 16, and 17]. This provides more evidence that PCI may be safely and effectively performed on patients with CTO and low LV ejection fraction.

We recognise that the sample size and duration of our research are its weaknesses. However, the prospective design and the fact that this is one of the few pieces of data about the feasibility, effectiveness, and safety of PCI in patients with CTO and varying degrees of LV function lend credence to the study.

## 6. Conclusions

CTO-PCI is possible even in patients with LVEF deterioration, as shown by our research. In such individuals, PCI was effective in the context of clinical and LV echocardiographic functional measures improvement. However, this was accomplished without increasing the risk of postoperative complications; the incidence of MACCE was similar in all three groups.

**Abbreviations Used in This Document**

Left ventricular ejection fraction (LVEF), coronary artery disease (CAD), percutaneous coronary intervention (PCI), chronic complete occlusion (CTO), the New York Heart Association (NYHA), and the Canadian Cardiovascular Society (CCS) are all terms associated with the cardiovascular system. Definitions: SPECT (single photon emission computed tomography), CAG (coronary angiography), TDI (tissue Doppler imaging), WMSI (wall motion score index), CABG (coronary artery bypass graft), MACCE (major adverse cardiac and cerebrovascular events). Body mass index (BMI) The medical term for persistent kidney failure is chronic kidney disease (CKD).

## References

[1] EL.Hannan, Y.Zhong, AK.Jacobs, Patients With Chronic Total Occlusions Undergoing Percutaneous Coronary Interventions. Circulation: Cardiovascular Interventions ,vol.9(5),pp. 003586,2016.

[2] AR.Galassi, ES.Brilakis, M.Boukhris, Appropriateness of percutaneous revascularization of coronary chronic total occlusions: an overview. Eur Heart J,vol. 14:37(35),pp.2692-700,2016.

[3] GS.Werner, V.Martin-Yuste, D.Hildick-Smith, EUROCTO trial investigators A randomized multicentre trial to compare revascularization with optimal medical therapy for the treatment of chronic total coronary occlusions. Eur Heart J,vol. 7;39(26),pp.2484-93,2018.

[4] Y.Ahmad, MC.Petrie, EM.Jolicoeur , PCI in Patients with heart failure: current evidence, impact of complete revascularization, and contemporary techniques to improve outcomes. Journal of the Society for Cardiovascular Angiography & Interventions,vol. 1(2),pp.100020,2022.

[5] M.Tajstra, Ł.Pyka, J.Gorol , Impact of Chronic Total Occlusion of the Coronary Artery on Long-Term

Prognosis in Patients With Ischemic Systolic Heart Failure: Insights From the COMMIT-HF Registry. JACC Cardiovasc Inter ,vol.12;9(17),pp.1790-7,2016.

[6] WS.El Awady, M.Samy, MM.Al-Daydamony , Periprocedural and clinical outcomes of percutaneous coronary intervention of chronic total occlusions in patients with low- and mid-range ejection fractions. Egypt Heart J,vol. 72(1),pp. 28,2020.

[7] C.Caraballo, NR.Desai, H.Mulder, Clinical Implications of the New York Heart Association Classification. J Am Heart Assoc,vol. 3;8(23),pp. 014240,2019.

[8] L.Campeau The Canadian Cardiovascular Society grading of angina pectoris revisited 30 years later. Can J Cardiol,vol. 18(4),pp.371-9,2002.

[9] EH.Yu, DM.Skyba, CE.Sloggett , Determination of left ventricular ejection fraction using intravenous contrast and a semiautomated border detection algorithm. J Am Soc Echocardiogr ,vol.16(1),pp.22-8,2003.

[10] R.Lebeau, K.Serri, MD.Lorenzo Assessment of LVEF using a new 16-segment wall motion score in echocardiography. Echo Res Pract,vol.5(2),pp.63–69,2018.

[11] HY.Fang, WC.Lee, CY.Fang Application of a snare technique in retrograde chronic total occlusion percutaneous coronary intervention - a step by step practical approach and an observational study. Medicine (Baltimore),vol.95(41),pp. 5129,2016.

[12] Y.Nagashima, R.Iijima, M.Nakamura Utility of the SYNTAX score in predicting outcomes after coronary intervention for chronic total occlusion. Herz.,vol. 40(8),pp.1090-6,2015.

[13] M.Tavakol, S.Ashraf, SJ.Brener Risks and complications of coronary angiography: a comprehensive review. Glob J Health Sci,vol.4(1),pp.65-93,2012.

[14] M.Megaly, M.Saad, P.Tajti , Meta-analysis of the impact of successful chronic total occlusion percutaneous coronary intervention on left ventricular systolic function and reverse remodeling. J Interv Cardiol ,vol,31,pp.:562–71,2018.

[15] S.George, J.Cockburn, TC.Clayton, Long-term follow-up of elective chronic total coronary occlusion angioplasty: analysis from the U.K. Central Cardiac Audit Database. J Am Coll Cardiol ,vol.64,pp.235–43,2014.

[16] AR.Galassi, M.Boukhris, A.Toma, Percutaneous Coronary Intervention of Chronic Total Occlusions in Patients With Low Left Ventricular Ejection Fraction. JACC: Cardiovascular Interventions,vol. 13:10(21),pp.2158–70,2017.

[17] B.Simsek, S.Kostantinis, J.Karacsonyi , Outcomes of chronic total occlusion percutaneous coronary intervention in patients with reduced left ventricular ejection fraction. Catheter Cardiovasc Interv,vol.99(4),pp.1059-64,2022.

[18] H.Ito, J.Masuda, T.Kurita , Effect of left ventricular ejection fraction on the prognostic impact of chronic total occlusion in a non-infarct-related artery in patients with acute myocardial infarction. Int J Cardiol Heart Vasc,vol. 26;33,pp.100738,2021.

[19] A.Rawshani, A.Rawshani, S.Franzén , Risk Factors, Mortality, and Cardiovascular Outcomes in Patients with Type 2 Diabetes. N Engl J Med1,vol.6;379(7),pp.633-44,2018.

[20] MT.Julián, N.Alonso, J.Lupón , Long-term LVEF trajectories in patients with type 2 diabetes and heart failure: diabetic cardiomyopathy may underlie functional decline. Cardiovascular Diabetology ,vol.23:19(1),pp.38,2020.

[21] KU.Eckardt, J.Coresh, O.Devuyst , Evolving importance of kidney disease: from subspecialty to global health burden. Lancet,vol. 13;382(9887),pp.158-69,2013.

[22] ZY.Fang, JB.Prins, TH.Marwick Diabetic cardiomyopathy: evidence, mechanisms, and therapeutic implications. Endocr Rev,vol. 25,pp.543–67,2004.

[23] A.Nusca, MJ.Lipinski, A.Varma , Safety of drug-eluting stents in patients with left ventricular dysfunction undergoing percutaneous coronary intervention. Am J Cardiol ,vol.15;102(6),pp.679-82,2008.

[24] E.Ammirati, V.Guida, A.Latib , Determinants of outcome in patients with chronic ischemic left ventricular dysfunction undergone percutaneous coronary interventions. BMC Cardiovasc Disord ,vol.26;15,pp.137,2015.

[25] JA.Bittl, Percutaneous Coronary Interventions in the Diabetic Patient. Circulation: Cardiovascular Interventions,vol.8(4),pp.001944,2015.

[26] MY.Wang, X.Yu, Y.Lee , Iatrogenic hyperinsulinemia in type 1 diabetes: its effect on atherogenic risk markers.J Diabetes Complications,vol. 27,pp.70–4,2013.

[27] AB.Mehta, N.Mehta, R.Chhabria , Predictors of success in percutaneous Coronary intervention for chronic total occlusion. Indian Heart J Suppl 3(Suppl 3),vol.20,pp.269-S274,2018.

[28] LP.Hoebers, BE.Claessen, J.Elias , Meta-analysis on the impact of percutaneous coronary intervention of chronic total occlusions on left ventricular function and clinical outcome. Int J Cardio ,vol.l187,pp.90-6,2015.

[29] M.Cardona, V.Martín, S.Prat-Gonzalez , Benefits of chronic total coronary occlusion percutaneous intervention in patients with heart failure and reduced ejection fraction: insights from a cardiovascular magnetic resonance study. J Cardiovasc Magn Reson,vol. 18,pp.78,2017.