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# Complete Percutaneous Coronary Revascularization: An Elegant Solution to Left Ventricular Dysfunction Caused by Severe Coronary Artery Disease

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**Complete Percutaneous Coronary Revascularization: An Elegant Solution to Left Ventricular Dysfunction Caused by Severe Coronary Artery Disease**

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**Introduction:**

Many patients with heart failure (HF) suffer from coronary artery disease (CAD) simultaneously, with estimated prevalence ranging from 50% to 65% [1]. Recent data indicate that CAD has become the most common cause of HF, surpassing hypertension and valvular heart disease [2]. Moreover, CAD substantially increases

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the risk for developing HF, whether it is with reduced or preserved ejection fraction [3]. Despite the somewhat limited evidence regarding the risk of all-cause and cardiovascular mortality, 2021 Expert Consensus Pathway for Optimization of Heart Failure Treatment has recommended coronary revascularization in appropriate patients [4]. Regardless of whether percutaneous coronary intervention (PCI) or coronary artery bypass surgery (CABG) is preferred option, patients with complex coronary occlusions are increasingly not surgical candidates and are referred for hemodynamic-supported complex percutaneous revascularization.

**Case History:**

A 64-year-old male patient with hypertension, smoking, and alcohol use was admitted to the hospital with worsening scrotal and lower extremity swelling.

**Differential diagnosis, investigations, and treatment:**

An initial cardiac evaluation revealed elevated troponin and pro-BNP levels. Echocardiogram showed severe global hypokinesis with left ventricular ejection fraction (LVEF) of 20%. Coronary angiography revealed multivessel coronary artery disease including chronic total occlusion of the right coronary artery with collaterals from the left coronary system (Figure 1). To fully characterize the territories needing revascularization, MRI viability study was obtained, cardiac magnetic resonance (CMR) showed viable myocardium at RCA, circumflex, and predominantly viable LAD, except for distal apical septal segment. (Figure 2). Due to the severity of CAD, the patient was referred for coronary artery bypass grafting (CABG), however, was deemed not a good candidate by the heart team.

**Outcome and follow-up**

After a thorough evaluation of his anatomy, the patient underwent percutaneous revascularization in two settings, first, multivessel PCI with Impella CP (Abiomed, Danver, Massachusetts) support (Figure 3, A, B) of LAD and Circumflex. Furthermore, the patient subsequently underwent chronic total occlusion (CTO) PCI to achieve complete revascularization. The CTO PCI of the right coronary artery was performed via primary retrograde approach with the placement of two drug-eluting stents (Figure 3, C, D). After complete revascularization, the patient's symptoms have improved significantly with the marked reduction in his NYHA class. Three months after, patient was NYHA Class I and his echocardiogram showed a significant recovery in LVEF to 45-50%.

**Discussion:**

Surgical revascularization has been proven favorable strategy for patients with diabetes, left main disease, and multivessel coronary artery disease. However, around 20% of these patients may not qualify for surgery due to various reasons, such as subjective decision-making by operators, inadequately accounted factors in surgical risk models (poor targets), exclusion of certain patients from clinical trials, historical preference for PCI as the primary treatment, and limited recommendations from societal guidelines [4]. The main goal of surgical approach is to ensure complete revascularization, particularly in patients who received 3 or more grafts, as this has been associated with improved survival compared to those who received <3 grafts [6]. This goal has been extrapolated to percutaneous revascularization, but its applicability to stable coronary disease remains controversial due to disparity of data. However, in patients with acute coronary syndromes with elevation of the ST segment, complete percutaneous revascularization has been shown to improve outcomes [7]. During PCI, the completeness of revascularization is crucial, as higher residual SYNTAX score has been associated with worse 5-year mortality [8].

Coronary CTO PCI is complex and requires additional training and deep understanding of different techniques. It has higher potential periprocedural complications, and limited evidence of survival benefits. However, CTO PCI is part an essential part of the corpus of complex high-risk intervention in indicated patients (CHIP), in fact it has been increasingly considered as an alternative to coronary artery bypass graft surgery. Mechanical circulatory support (MCS), specifically the Impella device, has been utilized to facilitate PCI in these patients following successful outcomes in PROTECT studies [9,10], leading to its widespread usage in catheterization laboratories.

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Hemodynamically supported revascularization is commonly performed in patients with a LVEF [?]35%, but it is not exclusive to this group. Despite advancements in procedural techniques, equipment, and the implementation of a systematic hybrid approach, CTO PCI still faces challenges due to the high-risk characteristics of many patients, particularly those with impaired left-ventricular function [11,12]. Different CTO PCI technical success rate has been reported in the literature so far. A 2021 PROGRESS-CTO Registry demonstrates a high technical success rate (85%) and a low incidence of in-hospital major adverse cardiac events (MACE) (2.1%) [13]. Data has also shown that the retrograde technique, as in our case, can increase the technical success rate, but it is associated with increased rates of complications [14,15].

The effectiveness of CTO PCI in relieving angina has been well established. Following the procedure, our patient reported significant symptomatic relief on a 3-month follow-up visit. Several studies have demonstrated improved angina symptoms following successful CTO PCI [16,17]. In comparison to patients with unsuccessful CTO PCI, the OPEN-CTO registry reported statistically significant improvement in the Seattle Angina Questionnaire Quality of Life Score and Rose Dyspnea Scale score compared with the unsuccessful procedure [18]. Similarly, the European CTO club reported improvement in dyspnea and angina after a follow-up period of 23 months [19].

Although data has significant limitations, CTO PCI does not appear to affect all-cause mortality (one-year relative risk [RR] 1.70, 95% CI 0.50-5.80 and four-year RR 1.77, 95% CI 0.19-16.06), myocardial infarction (one-year RR 1.01, 95% CI 0.43-2.36 and four-year RR 1.46, 95% CI 0.75-2.87), or cardiovascular disease mortality (one-year RR 1.14, 95% CI 0.38-3.40 and four-year RR 2.05, 95% CI 0.8-5.28) when compared to optimal medical management [20]. This finding aligns with the limited benefits of PCI revascularization in stable coronary artery disease [21], understanding that this population of not surgical candidacy has a high comorbidity burden that impacts mortality. Another consideration is that revascularization with hemodynamic support may be associated with a higher occurrence of in-hospital major adverse cardiac and cerebrovascular events (MACCE), which is likely attributed to the selective use of mechanical support in patients with higher risk profiles [22].

The data regarding LV systolic function is also not uniform. Recent REVIVED-BCIS2 trial failed to show all-cause mortality (HR 0.99, 95% CI 0.78-1.27) or LV systolic function benefits at 6 months (mean difference, -1.6 percentage points; 95% CI, -3.7 to 0.5) and at 12 months (mean difference, 0.9 percentage points; 95% CI, -1.7 to 3.4) compared with optimal guideline-directed medical therapy, regardless of viability characteristics at baseline [23], although about 30% of modalities used to assess viability were other than CMR. Contrary, RESTORE-EF observational study reported significant improvement in LVEF at 90 days from 35 +- 15% to 45 +- 14% ($p < .0001$ ) [24]. Moreover, this study revealed a substantial relative reduction of 76% in NYHA class III/IV heart failure symptoms and an impressive relative reduction of 97% in CCS angina class III/IV symptoms from the baseline measurements to the post-PCI period. The improvement in LVEF was observed exclusively in patients with LVEF below 45%, whereas the improvement in heart failure and anginal symptoms was noted across the entire spectrum of LVEF. The disparity between these two trials is likely due to differences in the study population. In the later trial, patients had higher rates of left main disease and more extensive coronary disease. Angina was also more frequent and severe in the later trial. Additionally, in the REVIVED-BCIS2 trial, two-thirds of the patients had not been hospitalized in the previous two years, and there were no cases of NSTEMI.

In conclusion, our case highlights the potential benefits of complex high-risk PCI with mechanical support and the potential benefits of CTO PCI to improve LV function.

Author contribution:

Stefan Milutinovic - Conceptualization, resources, Writing – original draft

Kamaldeep Singh - Resources, Writing – Review and Editing, Supervision

Stevan Oluic - Conceptualization, resources, Writing – original draft

Juan C. Lopez-Mattei - Visualization, Supervision, Writing – Review and Editing

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Ricardo O. Escarcega - Resources, Writing – Review and Editing, Supervision

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**Images legend:**

**Figure 1** – Left (A, B) and right (C) coronary system showing multivessel coronary artery disease including chronic total occlusion of the right coronary artery which fills with collaterals from the left coronary system, subtotally occluded proximal calcified LAD, 70-80% proximal and 70% mid left circumflex stenosis.

**Figure 2. Viability assessment with cardiac MRI:**

Panel A shows LGE acquisition in 4 Chamber plane with a transmural infarction at distal apical septal segment (see arrow).

Panel B shows LGE images in SAX plane with mid inferoseptal and mid inferior subendocardial infarction. Panel C shows

proximal apical septal segments with subendocardial infarction. These findings were consistent with viable RCA and circumflex territories and predominantly viable LAD, with non-viable distal apical septal segment.

**Figure 3** – A and B: Successful multivessel PCI with Impella support, PCI of proximal to distal circumflex with two drug-eluting stents, and successful rotational atherectomy of proximal LAD with 2 drug-eluting stents. C-D: Successful CTO PCI in retrograde fashion of the right coronary artery

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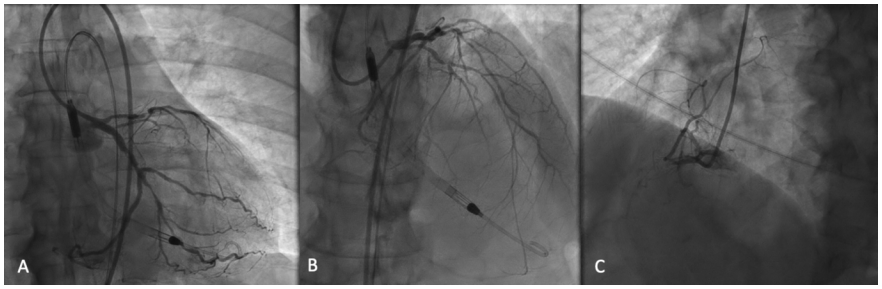


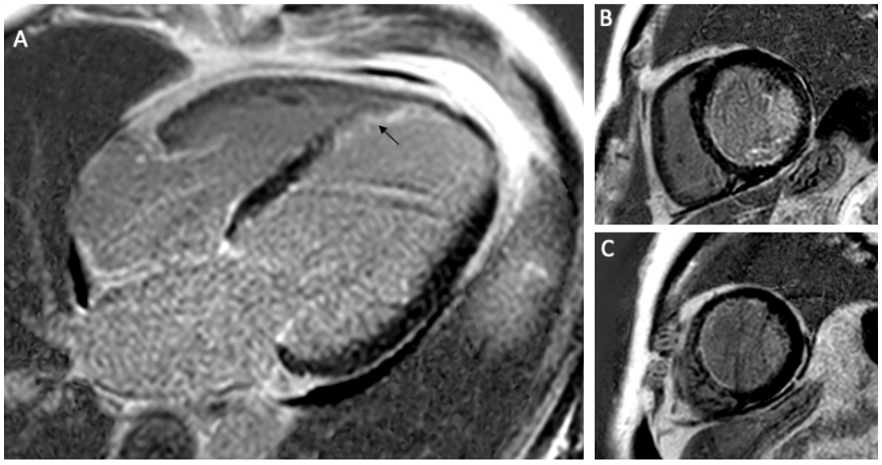

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