Published Online: 2025 December 7 **Editorial**

PCI for Chronic Total Occlusions in Individuals with Heart Failure

Arash Hashemi [1,*], Lida Ghaffari [1], Azin Alizadehasl [2,3]

[1] Erfan General Hospital, Tehran, Iran
[2] Cardio-Oncology Research Center, Iran University of Medical Sciences, Tehran, Iran
[3] Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran

[*] ***Corresponding Author:*** Erfan General Hospital, Tehran, Iran. Email: arash33h@yahoo.com

Received: 26 November, 2025; **Accepted:** 2 December, 2025

Keywords: Coronary Artery Disease, Heart Failure, Percutaneous Coronary Intervention

Coronary artery disease (CAD) remains a major global health burden and is a leading cause of heart failure and mortality. Approximately 25% of patients with CAD also have a chronic total occlusion (CTO) in a major coronary artery. The CTOs are often left untreated due to limited familiarity with treatment strategies and concerns regarding procedural risks, particularly in individuals with heart failure (1, 2).

Advances in devices and interventional techniques have significantly improved CTO revascularization success rates to over 90%, with acceptable complication profiles. Historically, patients with heart failure and coexisting CAD with CTOs were frequently considered suboptimal candidates for extensive surgical procedures such as coronary artery bypass grafting (CABG). As a result, percutaneous coronary intervention (PCI) has emerged as a less invasive alternative. However, the long-term outcomes of CTO-PCI remain insufficiently defined. While CABG is less commonly performed in heart failure patients due to operative risk, PCI offers lower procedural morbidity and may be beneficial in selected cases. Studies have demonstrated improvements in left ventricular function and exercise capacity following CTO-PCI (3). Furthermore, a study by Gong et al. identified low left ventricular ejection fraction (LVEF) and left main disease as predictors of cardiac mortality, emphasizing the potential protective role of successful CTO revascularization (4).

In summary, CAD and CTOs pose substantial risks for heart failure patients, yet evolving PCI technologies and increased operator experience offer promising potential to improve outcomes and reduce cardiac mortality.

The optimal revascularization approach in heart failure varies depending on heart failure phenotype. The STICH trial, which included patients with reduced ejection fraction (HFrEF), demonstrated that CABG improved long-term survival over 9.8 years, despite higher early mortality in the surgical group (5). Evidence regarding revascularization in heart failure with preserved ejection fraction (HFpEF) remains sparse, with most data derived from HFrEF populations. The absence of dedicated trials for HFpEF patients contributes to ongoing uncertainty. Due to perceived risks, surgeons often approach operative management in heart failure cautiously. As a result, interest in PCI techniques — including CTO intervention — has increased, offering the potential for complete revascularization (CR) with lower procedural risk.

At present, randomized trials directly comparing PCI, CABG, and optimal medical therapy specifically in heart failure patients are lacking. Several early-phase randomized clinical trials are underway to address this gap. Current evidence suggests that PCI benefits HFrEF patients, particularly when CR is achieved. The CR has been associated with improved myocardial jeopardy scores and better clinical outcomes. In selected patients supported by devices such as the Impella, outcomes may be further improved. Although these observations predominantly arise from non-randomized studies and post hoc analyses, they collectively suggest that comprehensive revascularization may benefit patients with CAD and heart failure (6).

Comparative non-randomized studies of CABG versus multivessel PCI provide additional insights but remain limited by inherent confounding factors, including selection bias. For instance, PCI is often chosen for patients with severe LV dysfunction or multivessel CAD when CABG is considered too risky. These limitations

How to Cite: Hashemi A, Ghaffari L, Alizadehasl A. PCI for Chronic Total Occlusions in Individuals with Heart Failure. Multidiscip Cardio Annal. 2025; 16 (1): e168530. https://doi.org/10.69107/mca-168530.

underscore the need for adequately powered randomized trials, especially in patients with low LVEF. Achieving successful CR — including CTO treatment — is an essential consideration in this context.

Among HFpEF patients, recent cohorts demonstrate that approximately 50% have obstructive CAD, consistent with earlier autopsy studies. However, randomized studies assessing the impact of revascularization in HFpEF are nonexistent. Whether PCI or CABG improves outcomes in HFpEF remains unknown and highlights the need for dedicated clinical trials (7).

The CR is a fundamental goal of coronary intervention and can be defined using anatomic, functional, or ischemia-guided criteria. Anatomic definitions rely on angiographic stenosis severity, while functional definitions incorporate noninvasive or invasive physiological assessment. Recent efforts have sought to standardize CR definitions across clinical practice and research. Achieving CR in heart failure patients is challenging due to the extent of CAD, comorbidities, and the presence of CTOs. Observational studies have shown higher all-cause mortality with incomplete revascularization compared with CR, reinforcing the need for randomized trials to evaluate its true impact (8).

Successful CTO-PCI plays a central role in achieving CR. Highly experienced operators now report success rates approaching 95%. While CABG is often preferred for complex multivessel disease, data from the SYNTAX trial (which excluded heart failure patients) showed comparable long-term mortality between PCI and CABG in patients who achieved CR. However, these trials were not specifically designed to evaluate CR as a primary endpoint (9).

The largest study evaluating CR, the COMPLETE trial, demonstrated significant reductions in cardiac death and myocardial infarction in STEMI patients undergoing multivessel PCI — including those with low LVEF. However, no randomized trial has evaluated the impact of revascularization in patients with obstructive CAD and HFpEF (9).

While awaiting more robust randomized data, ischemia assessment and viability imaging may provide guidance in decision-making for CAD and heart failure patients. Nevertheless, these tools should not be used in isolation to determine the timing or necessity of revascularization.

Over the past decade, coronary intervention has advanced significantly, yet heart failure patients remain underrepresented in most major trials. Innovations include potent antiplatelet agents (though bleeding risk is higher in heart failure patients), intracoronary physiology to guide PCI, ultrathin-strut drug-eluting stents, intravascular imaging for optimization, CTO recanalization protocols, specialized strategies for calcified and bifurcation lesions, and mechanical circulatory support for high-risk PCI. Many of these advances warrant further study in heart failure populations.

The CTO recanalization outcomes have substantially improved, with success rates approaching 96% in expert centers, compared with approximately 50% in the original SYNTAX trial (10). Nonetheless, the benefits of CTO-PCI in heart failure are primarily based on observational studies that may be subject to bias. The CTO-PCI carries procedural risks that may be amplified in heart failure patients. The adoption of hybrid techniques has increased success rates to 85 - 90% in specialized centers, but careful patient and lesion selection remains essential, particularly for retrograde approaches.

Despite considerable progress, the true impact of CTO-PCI on heart failure outcomes requires validation through well-designed prospective randomized trials. The SYNTAX II trial — a multicenter, single-arm study — evaluated contemporary PCI strategies to improve outcomes in three-vessel disease compared with the original SYNTAX trial, but it did not focus on HF patients (11).

Modern PCI techniques — such as hybrid iFR/FFR assessment, thin-strut platinum–chromium drug-eluting stents, intravascular ultrasound for stent optimization, contemporary bifurcation strategies, and advanced CTO recanalization — continue to evolve. However, extrapolation of data from SYNTAX II to heart failure patients must be done cautiously. High-risk PCI (CHIP) strategies show promise in severe LV dysfunction but remain highly dependent on operator expertise. Complications during PCI can have greater consequences in heart failure patients; therefore, meticulous patient selection is vital. Overall, technological advances have improved both procedural success and safety (11).

Randomized evidence comparing CABG and PCI in heart failure is still limited. The REVIVED-BCIS2 trial is evaluating the effects of PCI on heart failure hospitalization and quality of life in ischemic cardiomyopathy (12). Future trials should assess survival, quality of life, HF hospitalization, stroke, neurocognitive outcomes, and long-term prognosis across PCI, CABG, and medical therapy arms. Contemporary PCI may ultimately provide heart failure patients — particularly those with CTOs — benefits

comparable to CABG. The ongoing CTO heart failure trial aims to clarify the role of CTO-PCI in systolic heart failure.

Footnotes

Authors' Contribution: A. A., L. G., and A. H. contributed in writing and collecting articles.

Conflict of Interests Statement: A. A. is one of the associate editors of this journal.

Funding/Support: The present study received no funding/support.

References

1. Tsai TT, Stanislawski MA, Shunk KA, Armstrong EJ, Grunwald GK, Schob AH, et al. Contemporary Incidence, Management, and Long-Term Outcomes of Percutaneous Coronary Interventions for Chronic Coronary Artery Total Occlusions: Insights From the VA CART Program. *JACC Cardiovasc Interv*. 2017;**10**(9):866-75. [PubMed ID: 28473108]. https://doi.org/10.1016/j.jcin.2017.02.044.
2. Yaghoubi A, Safaie N, Azarfarin R, Alizadehasl A, Golzari SE. Evaluation of cardiovascular diseases and their risk factors in hospitalized patients in East azerbaijan province, northwest iran: a review of 18323 cases. *J Tehran Univ Heart Cent*. 2013;**8**(2):101.
3. Pasceri V, Patti G, Pelliccia F, Gaudio C, Speciale G, Mehran R, et al. Complete Revascularization During Primary Percutaneous Coronary Intervention Reduces Death and Myocardial Infarction in Patients With Multivessel Disease: Meta-Analysis and Meta-Regression of Randomized Trials. *JACC Cardiovasc Interv*. 2018;**11**(9):833-43. [PubMed ID: 29747913]. https://doi.org/10.1016/j.jcin.2018.02.028.
4. Gong X, Zhou L, Ding X, Chen H, Li H. The impact of successful chronic total occlusion percutaneous coronary intervention on long-term clinical outcomes in real world. *BMC Cardiovasc Disord*. 2021;**21**(1):182. [PubMed ID: 33858349]. [PubMed Central ID: PMC8048230]. https://doi.org/10.1186/s12872-021-01976-w.
5. Velazquez EJ, Lee KL, Jones RH, Al-Khalidi HR, Hill JA, Panza JA, et al. Coronary-Artery Bypass Surgery in Patients with Ischemic Cardiomyopathy. *N Engl J Med*. 2016;**374**(16):1511-20. [PubMed ID: 27040723]. [PubMed Central ID: PMC4938005]. https://doi.org/10.1056/NEJMoa1602001.
6. Ahmad Y, Petrie MC, Jolicoeur EM, Madhavan MV, Velazquez EJ, Moses JW, et al. PCI in Patients With Heart Failure: Current Evidence, Impact of Complete Revascularization, and Contemporary Techniques to Improve Outcomes. *J Soc Cardiovasc Angiogr Interv*. 2022;**1**(2):100020. [PubMed ID: 39132568]. [PubMed Central ID: PMC11307477]. https://doi.org/10.1016/j.jscai.2022.100020.
7. Hwang SJ, Melenovsky V, Borlaug BA. Implications of coronary artery disease in heart failure with preserved ejection fraction. *J Am Coll Cardiol*. 2014;**63**(25 Pt A):2817-27. [PubMed ID: 24768876]. https://doi.org/10.1016/j.jacc.2014.03.034.
8. Joyal D, Afilalo J, Rinfret S. Effectiveness of recanalization of chronic total occlusions: a systematic review and meta-analysis. *Am Heart J*. 2010;**160**(1):179-87. [PubMed ID: 20598990]. https://doi.org/10.1016/j.ahj.2010.04.015.
9. Mehta SR, Wood DA, Storey RF, Mehran R, Bainey KR, Nguyen H, et al. Complete Revascularization with Multivessel PCI for Myocardial Infarction. *N Engl J Med*. 2019;**381**(15):1411-21. [PubMed ID: 31475795]. https://doi.org/10.1056/NEJMoa1907775.
10. Head SJ, Davierwala PM, Serruys PW, Redwood SR, Colombo A, Mack MJ, et al. Coronary artery bypass grafting vs. percutaneous coronary intervention for patients with three-vessel disease: final five-year follow-up of the SYNTAX trial. *Eur Heart J*. 2014;**35**(40):2821-30. [PubMed ID: 24849105]. https://doi.org/10.1093/eurheartj/ehu213.
11. Modolo R, Collet C, Onuma Y, Serruys PW. SYNTAX II and SYNTAX III trials: what is the take home message for surgeons? *Ann Cardiothorac Surg*. 2018;**7**(4):470-82. [PubMed ID: 30094211]. [PubMed Central ID: PMC6082789]. https://doi.org/10.21037/acs.2018.07.02.
12. Perera D, Clayton T, Petrie MC, Greenwood JP, O'Kane PD, Evans R, et al. Percutaneous Revascularization for Ischemic Ventricular Dysfunction: Rationale and Design of the REVIVED-BCIS2 Trial: Percutaneous Coronary Intervention for Ischemic Cardiomyopathy. *JACC Heart Fail*. 2018;**6**(6):517-26. [PubMed ID: 29852933]. https://doi.org/10.1016/j.jchf.2018.01.024.