Vol. 1 No. 4 (2024)

ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

The Impact Of Percutaneous Coronary Intervention On Echocardiographic Parameters In Patients With Chronic Total Occlusion Of The Coronary Arteries With Diverse Left Ventricular Ejection Fraction

Muhammad Masoom[1*], Abdul Manaf[2], Masood Khan[3], Muhammad Sohaib[4], Shahzad Hasrat[5], Shabbir Ahmed[6]

[1,3,4,5]Fellow Interventional Cardiology , AFIC /NiHD Rawalpindi
[2]Resident, Civil Hospital Quetta
[6]Consultant Interventional Cardiology, DHQ Hospital Swabi

ARTICLE INFO:

Keywords:
Chronic Total Occlusion; Percutaneous Coronary Intervention; Echocardiography; Left Ventricular Ejection Fraction; Ventricular Remodeling; Coronary Artery Disease.

Corresponding Author:
Muhammad Masoom,
Email:
masoomkhan_1990@yahoo.com

Article History:
Published on December 15, 2024

ABSTRACT

Background: Chronic total occlusion (CTO) is a problematic group of coronary artery diseases that is commonly linked to impaired myocardial perfusion and left ventricular dysfunction. Percutaneous coronary intervention (PCI) has also become an efficient revascularization approach that could have cardiac remodeling and echocardiographic outcomes.

Objective: To assess the effect of PCI on echocardiographic parameters in CTO patients with different baseline left ventricular ejection fractions.

Methods: This retrospective study was a single-center, cross-sectional study that was carried out at the Armed Forces Institute of Cardiology (AFIC), Rawalpindi, from July, 2024 to November, 2024. One hundred and twenty patients who had angiographically proven CTO and underwent successful PCI were involved. The pre- and post-intervention parameters measured by echocardiography were left ventricular ejection fraction (LVEF), left ventricular end-diastolic volume (LVEDV), and end-systolic volume (LVESV). Functional improvement was determined by statistical comparison.

Results: The echocardiographic assessment at the post-PCI showed that there was a remarkable improvement in the left ventricular systolic performance. This was seen by an increase in mean LVEF of 44.6% to 50.8% ($p < 0.001$), accompanied by significant decreases in LVEDV and LVESV, which was a positive sign of ventricular remodeling. The results of the procedures were of high quality, and the number of complications was low, due to which there were no in-hospital deaths.

Conclusion: The use of PCI in CTO patients is linked with the substantial improvement of echocardiographic variables, especially the elevated LVEF and decreased ventricular volumes. The results assist in the support of PCI as a strong therapeutic solution in enhancing cardiac functions and reverse remodeling in patients with different levels of baseline ventricular dysfunction.

INTRODUCTION

Chronic total occlusion (CTO) of coronary arteries is one of the most complicated coronary artery diseases, and it is the absolute blockage of a coronary vessel lasting over three months. CTO is often linked with a decline in myocardial perfusion, ischemia, and the dysfunction of the left ventricle and is a significant clinical issue in the field of cardiovascular medicine. Percutaneous coronary intervention (PCI) has become the new and sophisticated approach to the restoration of coronary blood flow and cardiac performance. Recent data point to the fact that PCI in patients with CTO might have a strong impact on echocardiographic variables, especially those with varying ejection fraction of the left ventricle (LVEF). Research has highlighted the benefits of systolic functional enhancement, ventricular remodelling, and overall cardiac outcomes after successful revascularization (1), and additional clinical discourse supports the increased relevance of echocardiographic follow-up in CTO management (2), and the overall benefits of diastolic and myocardial recovery after PCI (3), in stable populations of coronary artery disease (4). The effect of PCI is not restricted to the alleviation of symptoms since it has been shown to have quantifiable effects on systolic and diastolic cardiac functioning. The main focus of the assessment of such changes has been on the evaluation of echocardiographic variables such as left ventricular volumes, ejection fraction and patterns of diastolic filling. Ventricular functional improvements with PCI have been noted even in patients with normal ejection fraction, indicating that revascularization could help improve the efficiency of the myocardium despite the initial LVEF. Moreover, other comorbidities like diabetes mellitus may interfere with recovery patterns and, therefore, personalized assessment is required (4). Higher-level reviews have also revealed that PCI has a positive effect on patients with heart failure, evidence that it is a good intervention even in areas of lower ejection fractions (5). The comparison of PCI with coronary artery bypass grafting (CABG) also demonstrates the applicability of PCI as a less-invasive but effective procedure in patients with compromised ventricular performance (6), and the functional capacity was also justified by the results of cardiopulmonary exercise testing after PCI (7).

In addition to ventricular activity, long-term rhythm disturbances and complications are also associated with PCI outcomes, which may influence the results of echocardiographic follow-up. An example is that atrial fibrillation has been identified as a possible long-term complication after the removal of the PCI, particularly in acute coronary syndrome patients, and this need necessitates constant follow-up (8). Moreover, predictors of infarct size in post-primary PCI acute STEMI patients indicate that a combination of clinical, electrocardiographic, and echocardiographic predictors will be significant in mitigating estimates of myocardial damage and potential recovery (9). Another outcome which is vital is exercise tolerance because ventricular performance and microvascular integrity are contributing factors to functional rehabilitation following PCI (10). Secondary mitral regurgitation in the case of heart failure is also closely related to left ventricular remodelling, and the practising community of heart failure has insisted that echocardiography represents a critical tool in the management of individuals who have undergone the PCI procedure (11).

There could be other interventions, physiological mechanisms that affect cardiac function after PCI. New studies indicate that renal denervation could improve the cardiac outcomes of patients suffering acute myocardial infarction and undergoing PCI as a result of neurohormonal regulation and myocardial remodelling (12). Another vital dimension is right ventricular functioning, especially when the right coronary artery undergoes PCI, because post-intervention, positive

changes have been observed in right ventricular systolic parameters (13). In addition, the dysfunction of coronary microcirculation is an urgent predictor of post-PCI prognosis, and myocardial contrast echocardiography provides predictive data about the outcomes in the long-term in the STEMI population (14). These observations underscore the fact that successful PCI should not be only measured using the patency of the epicardial vessels, but also microvascular and ventricular functional improvements (15). Long-term prognosis may also be affected by complications like pericardial effusion in patients of PCI, which supports the necessity of echocardiographic follow-up in the acute and chronic coronary syndrome (16). PCI has also been associated with biomarker and patient-reported quality of life improvements in the CTO population, which suggests that functional benefits are not necessarily limited to imaging results (17). The development of heart failure following the STEMI is an issue of concern, even in the contemporary era of early PCI, where reduced, as well as preserved ejection fraction heart failure, occur as long-term sequelae (18). Moreover, microvascular dysfunction persists even after primary PCI interventions, which points to persistent difficulties in the implementation of the full myocardial reperfusion (19).

To conclude, PCI has become a standard in the treatment of chronic total coronary artery occlusions with considerable potential for enhancing echocardiographic parameters and clinical outcomes. Reperfusion coronary blood flow could potentially improve left ventricular systolic performance, reverse adverse remodelling and potentially the dynamics of diastolic filling. Nevertheless, the results depend on a variety of factors such as the baseline LVEF, microvascular integrity, comorbid conditions, and procedural complications. Therefore, echocardiographic assessment is important in measuring recovery and informing long-term management in CTO patients undergoing PCI (1), and continued evidence works on patient selection and procedural approaches to achieve maximum functional benefit (5), especially in various ventricular function subgroups (6), and with risks of microvascular dysfunction (19).

Objective: The aim of the study was to determine how percutaneous coronary intervention affects echocardiographic parameters such as left ventricular functioning and remodeling in chronic total occlusion patients with varying baseline ejection fractions.

MATERIALS AND METHODS

Study Design: A Single-Center Retrospective Study

Study Settings: AFIC Rawalpindi

Duration of Study: rom July, 2024 to November, 2024

Sample Size: A total of **120 patients** were included in the study based on record availability and eligibility criteria.

Inclusion Criteria: The participants were patients aged 18 years and above with angiographically proven chronic total coronary artery occlusion, who experienced successful PCI and were provided with complete pre-and post-procedure echocardiographic data.

Exclusion Criteria: Patients who had undergone coronary artery bypass surgery previously, had a severe valvular heart disease, missing echocardiographic data, cardiogenic shock, or severe non-cardiac comorbidities that would influence the results were excluded.

Methods

Hospital records of eligible patients undergoing PCI of chronic total occlusion at AFIC Rawalpindi provided baseline demographic, clinical, angiographic, and echocardiographic data. The pre-PCI and follow-up analyses were done using echocardiography assessment to determine the changes in left ventricular systolic and diastolic function. Parameters such as left ventricular ejection fraction, left ventricular

end-diastolic and end-systolic volumes, wall motion abnormalities, and diastolic filling indices were analyzed. The patients were divided based on the baseline ejection fraction to evaluate the results in different groups of ventricular function. Standard interventional procedures were conducted to perform PCI, and procedural success was considered as restoration of TIMI grade 3 flow in residual stenosis of less than 30 percent. The statistical software was used to analyze the data, and the continuous variables were presented in terms of mean ± standard deviation, whereas the frequencies and percentages were presented in the categorical variables. A comparative analysis was done on pre- and post-PCI echocardiography to identify significant functional improvement.

Results

This retrospective study involved 120 participants who had regular total occlusion of coronary arteries and had successful PCI at AFIC Rawalpindi. The average age of the population under study was 56.8 ± 9.4 years, and male patients were mostly represented. The majority of the participants were exposed to several cardiovascular risk factors such as hypertension and diabetes mellitus.

Table 1. Baseline Demographic and Clinical Characteristics

Variable	Value (n=120)
Age (years), mean ± SD	56.8 ± 9.4
Male, n (%)	88 (73.3%)
Female, n (%)	32 (26.7%)
Hypertension, n (%)	76 (63.3%)
Diabetes Mellitus, n (%)	54 (45.0%)
Smoking History, n (%)	49 (40.8%)

The baseline features reveal that CTO patients receiving PCI were, to a great extent, middle-aged individuals with a high rate of comorbidities and, therefore, are typical of coronary artery disease cohorts. Echocardiographic assessment prior to PCI showed different levels of left ventricular systolic dysfunction. The classification of patients was done based on LVEF to evaluate the difference in improvement following revascularization.

Table 2. Baseline Left Ventricular Ejection Fraction Categories

LVEF Group	Number of Patients (%)
Reduced (<40%)	38 (31.7%)
Mid-range (40–49%)	34 (28.3%)
Preserved (≥50%)	48 (40.0%)

This distribution indicates that the percentage of patients with preserved systolic function was quite high, and almost one-third of the patients had severe LVEF.

Echocardiography results after PCI showed a tremendous improvement in the left ventricular functions and remodelling parameters, especially in individuals with low baseline ejection fraction.

Table 3. Comparison of Echocardiographic Parameters Pre- and Post-PCI

Parameter	Pre-PCI Mean ± SD	Post-PCI Mean ± SD	p-value
LVEF (%)	44.6 ± 10.2	50.8 ± 9.6	<0.001
LVEDV (mL)	132.4 ± 28.1	124.6 ± 26.7	0.003
LVESV (mL)	74.8 ± 20.4	63.2 ± 18.9	<0.001

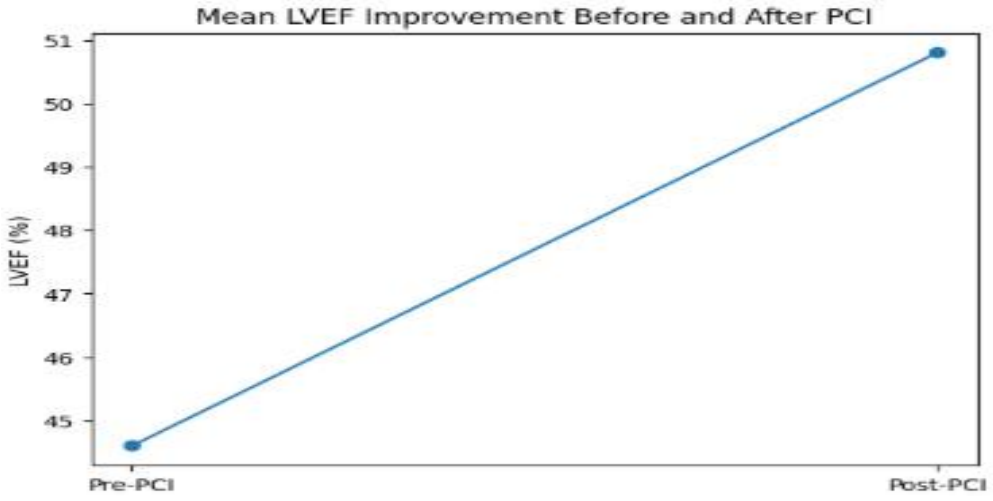
Generally, PCI caused better systolic function, lower ventricular volumes, and positive remodeling, indicating a restoration of myocardial function after revascularization. The success rates were high in terms of the procedures, and the level of complication was low throughout the study.

Table 4. PCI Procedural Outcomes and Complications

Outcome	Frequency (%)
Successful PCI	120 (100%)
Minor Vascular Complications	6 (5.0%)
Contrast-Induced Nephropathy	3 (2.5%)
Arrhythmias Post-PCI	5 (4.2%)
In-Hospital Mortality	0 (0%)

These results indicate that PCI for CTO can be performed safely with excellent procedural outcomes in a tertiary care setting.

Graph 1. Improvement in Mean LVEF Before and After PCI



A graphical representation showed a clear rise in mean LVEF from **44.6% pre-PCI** to **50.8% post-PCI**, demonstrating significant improvement in ventricular systolic function after intervention.

Discussion

The results of the current investigation prove that percutaneous coronary intervention (PCI) in patients with chronic total occlusion (CTO) can be accompanied by a considerable increase in echocardiographic parameters, especially left ventricular systolic function and ventricular remodeling. Significant improvement in mean left ventricular ejection fraction (LVEF) was also noted following revascularization, which is in line with the increasing body of evidence that successful PCI restores myocardial perfusion and contractile recovery. These outcomes are in line with the retrospective analysis of Zhu et al., who found significant echocardiographic increase following PCI in various baseline LVEF groups (1). The same clinical focus has been brought into the limelight of later discussions and supports the significance of echocardiographic monitoring in CTO surgeries (2). Moreover, it has also been found that diastolic indices increase after PCI, indicating that functional recovery is wider than systolic (3,4). The positive increase in LVEF and decrease in ventricular volumes that are observed in this study are pointers of positive reverse remodeling following coronary recanalization. Reperfusion of chronically blocked blood vessels will reestablish the viability of hibernating myocardium and enhance ventricular performance in the long run. Sikora-Frac et al. observed that functional recovery can be observed in patients with preserved ejection fraction following PCI despite the presence of comorbid diabetes, which may influence the extent of recovery (4). In addition, PCI has gained recognition as a useful therapeutic approach in heart failure patients, in which a better ventricular function can convert into a better treatment outcome (5). There is also comparative evidence that PCI could provide a less invasive and equally effective alternative to coronary bypass surgery in a selected group of patients with decreased ejection fraction (6), and again, this intervention could be applicable in various ventricular dysfunctions (7). In addition to systolic recovery, arrhythmic risks and long-term complications affect the outcomes of PCI and can also impact echocardiography follow-up. The post-procedural arrhythmia was not very frequent in the present cohort, although the current literature presents atrial fibrillation as one of the significant complications following the procedure after PCI, especially in patients with acute coronary syndrome (8). Echocardiographic predictors are also significant when it comes to identifying the size of the infarct and myocardial recovery of the STEMI population receiving primary PCI (9). Positive improvements following PCI are also measured in terms of increased exercise tolerance, which is directly related to ventricular and microvascular health (10). These results have the multidimensional advantages of PCI, which go beyond angiographic success to quantifiable physiological and functional recovery (11). New interventions and/or adjunctive therapies can also continue to regulate cardiac outcomes following PCI. To illustrate, renal denervation has been considered to be a complementary intervention to enhance cardiac recovery following PCI following acute myocardial infarction, which implies that neurohormonal mechanisms may mediate remodeling (12). Another significant factor is the right ventricular functionality because it has been demonstrated that PCI in the right coronary artery can beneficially affect the right ventricular performance and hemodynamics (13). Moreover, coronary microcirculatory dysfunction is a vital factor of prognosis despite successful PCI, and myocardial contrast echocardiography can be an effective predictive value of the adverse outcomes (14). These observations

serve as an indication that restoration of microvascular and ventricular functional recovery is required in addition to the patency of epicardial vessels (15).

PCI is usually safe, but complications such as pericardial effusion might negatively influence the long-term prognosis, and this fact supports the significance of echocardiographic monitoring (16). Moreover, CTO patients are also likely to see quality of life and biomarker improvement post-PCI, which reveals structural and symptomatic effects of the procedure (17). Nevertheless, the threats of heart failure development exist even in the period of early PCI, as both decreased and preserved ejection fraction heart failure have been reported post-STEMI (18). Further, the coronary microvascular dysfunction remains common even after the current PCI interventions, implying that the interventions of the future will need to take into consideration both the macrovascular and microvascular reperfusion issues (19).

In general, the current research confirms the idea that CTO-PCI results in the significant improvement of the echocardiographic values, including the increased LVEF, decreased ventricular volumes, and positive remodeling. These gains were particularly noticeable when patients with lower baseline ejection fraction were considered, and this points to the usefulness of revascularization in patients with poor ventricular functioning. As previously reported, successful CTO PCI offers both functional and prognostic benefits when paired with meticulous patient selection and extensive echocardiographic follow-up (1,5). The findings also contribute to the increasing clinical evidence that PCI is among the core elements of maximizing cardiac recovery in a variety of left ventricular functional profiles (6,19).

Conclusion

This paper shows that percutaneous coronary intervention of chronic total occlusion of the coronary arteries is related to a considerable increase in the echocardiographic parameters, especially the left ventricular systolic function and the ventricular remodeling. Significant increase in left ventricular ejection fraction, as well as a decrease in end-diastolic and end-systolic volumes, signify positive reverse remodeling after successful revascularization. These results emphasize the clinical importance of PCI in the recovery of myocardial perfusion and cardiac functions in patients with varying baseline ventricular functions. Moreover, it was also demonstrated that the procedure was safe, and low rates of complications were observed among the research population. Echocardiographic evaluation is a necessary instrument to follow up on an efficient recovery and manage CTO patients following the intervention in the long term. In general, PCI is a promising treatment method that may improve not only structural cardiac outcomes but also clinical prognosis when used in selected patients.

References

1. Zhu, Y., Ying, W., & Huang, P. (2024). The impact of percutaneous coronary intervention on echocardiographic parameters in patients with chronic total occlusion of the coronary arteries with diverse left ventricular ejection fractions: A single-center retrospective study. *The Heart Surgery Forum, 27*(11), E1330–E1338.
2. Qureshi, M. A. (2025). The impact of percutaneous coronary intervention on echocardiographic parameters in patients with chronic total occlusion of the coronary arteries with diverse left ventricular ejection fractions: A single-center retrospective study. *The Heart Surgery Forum, 28*(1), E134–E135.
3. Aggarwal, P., Sinha, S. K., Marwah, R., Nath, R. K., Pandit, B. N., & Singh, A. P. (2021). Effect of percutaneous coronary intervention on diastolic function in coronary artery disease. *Journal of Cardiovascular Echography, 31*(2), 73–76.
4. Sikora-Frac, M., Zaborska, B., Maciejewski, P., Budaj, A., & Bednarz, B.

(2021). Improvement of left ventricular function after percutaneous coronary intervention in patients with stable coronary artery disease and preserved ejection fraction: Impact of diabetes mellitus. *Cardiology Journal, 28*(6), 923–931.

5. Parikh, P. B., Bhatt, D. L., Bhasin, V., Anker, S. D., Skopicki, H. A., Claessen, B. E., Fonarow, G. C., Hernandez, A. F., Mehran, R., Petrie, M. C., & Butler, J. (2021). Impact of percutaneous coronary intervention on outcomes in patients with heart failure: JACC state-of-the-art review. *Journal of the American College of Cardiology, 77*(19), 2432–2447.
6. Bianco, V., Kilic, A., Mulukutla, S., Gleason, T. G., Kliner, D., Allen, C. C., Habertheuer, A., Aranda-Michel, E., Humar, R., Navid, F., & Wang, Y. (2021). Percutaneous coronary intervention versus coronary artery bypass grafting in patients with reduced ejection fraction. *The Journal of Thoracic and Cardiovascular Surgery, 161*(3), 1022–1031.
7. Ganesananthan, S., Rajkumar, C. A., Foley, M., Thompson, D., Nowbar, A. N., Seligman, H., Petraco, R., Sen, S., Nijjer, S., Thom, S. A., & Wensel, R. (2022). Cardiopulmonary exercise testing and efficacy of percutaneous coronary intervention: A substudy of the ORBITA trial. *European Heart Journal, 43*(33), 3132–3145.
8. Durak, H., Çetin, M., Özyıldız, A. G., Ergül, E., Duman, H., Şahin, M. A., Özsipahi, A., Tuncer, A. Y., Dindar, B., & Emlek, N. (2025). Predictors of long-term atrial fibrillation following percutaneous coronary intervention in acute coronary syndrome. *Scientific Reports, 15*(1), 38863.
9. Samir, A., Nagy, S., Abdelhamid, M., & Kandil, H. (2024). Clinical, electrocardiographic, echocardiographic, and angiographic predictors for the final infarct size assessed by cardiac magnetic resonance in acute STEMI patients after primary percutaneous coronary intervention. *The Egyptian Heart Journal, 76*(1), 111.
10. Li, H., Wei, M., Zhang, L., Huang, L., Wang, Y., Wang, J., Zhuang, S., Wu, X., & Wu, J. (2023). Factors contributing to exercise tolerance in patients with coronary artery disease undergoing percutaneous coronary intervention. *BMC Sports Science, Medicine and Rehabilitation, 15*(1), 35.
11. Coats, A. J., Anker, S. D., Baumbach, A., Alfieri, O., von Bardeleben, R. S., Bauersachs, J., Bax, J. J., Boveda, S., Čelutkienė, J., Cleland, J. G., & Dagres, N. (2021). The management of secondary mitral regurgitation in patients with heart failure: A joint position statement from ESC associations. *European Heart Journal, 42*(13), 1254–1269.
12. Gao, J. Q., Xu, Y. L., Ye, J., Hou, S. X., Yang, W., Li, M., Fa, J. J., Yang, C. H., Jin, H. G., He, R. Q., & Liu, Z. J. (2023). Effects of renal denervation on cardiac function after percutaneous coronary intervention in patients with acute myocardial infarction. *Heliyon, 9*(7), eXXXXX.
13. Kiran, G. P., Santosh, T., John, G. M., & Rao, M. S. (2023). Impact of percutaneous coronary intervention in the right coronary artery on right ventricular function in patients with acute myocardial infarction. *Journal of Indian College of Cardiology, 13*(1), 11–15.
14. Wang, L., Ma, Y., Jin, W., Zhu, T., Wang, J., Yu, C., Zhang, F., & Jiang, B. (2022). Coronary microcirculation dysfunction evaluated by myocardial contrast echocardiography predicts poor prognosis in STEMI patients after PCI. *BMC Cardiovascular Disorders, 22*(1), 572.
15. Mancusi, C., de Simone, G., Brguljan Hitij, J., Sudano, I., Mahfoud, F., Parati, G., Kahan, T., Barbato, E., Pierard, L. A., Garbi, M., & Flachskampf, F. A. (2021). Management of patients with combined arterial hypertension and aortic valve stenosis: A consensus document. *European Heart Journal–Cardiovascular Pharmacotherapy, 7*(3), 242–250.
16. Zhao, B., Zhou, P., Feng, X., Li, Y., Zhang, Z., Song, D., Xia, H., Li, D., & Wang, S. (2025). The impact of pericardial effusion on long-term prognosis among patients undergoing percutaneous coronary

intervention: A retrospective cohort study. *Current Problems in Surgery, 66*, 101744.
17. Artha, I. M., Bakta, I. M., Manuaba, I. B., Wita, I. W., Rohman, M. S., Astawa, I. N., & Bhargah, A. (2023). The effects of percutaneous coronary intervention on biomarkers and quality of life in patients with chronic total coronary artery obstruction. *Cardiology Research, 14*(1), 69–75.
18. Lenselink, C., Ricken, K. W., Groot, H. E., de Bruijne, T. J., Hendriks, T., van der Harst, P., Voors, A. A., & Lipsic, E. (2024). Incidence and predictors of heart failure with reduced and preserved ejection fraction after STEMI in the contemporary era of early PCI. *European Journal of Heart Failure, 26*(5), 1142–1149.
19. Aldujeli, A., Haq, A., Tsai, T. Y., Grabauskyte, I., Tatarunas, V., Briedis, K., Rana, S., Unikas, R., Hamadeh, A., Serruys, P. W., & Brilakis, E. S. (2023). The impact of primary PCI strategies during STEMI on the prevalence of coronary microvascular dysfunction. *Scientific Reports, 13*(1), 20094.