



PREDICTION OF OUTCOMES OF PERCUTANEOUS REVASCULARIZATION VS OPTIMAL MEDICAL THERAPY FOR ISCHEMIC LEFT VENTRICULAR DYSFUNCTION

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Abstract

Background:

Ischemic left ventricular dysfunction remains a major cause of morbidity and mortality worldwide. The optimal management strategy whether percutaneous coronary intervention or optimal medical therapy continues to be debated, especially in populations with limited access to advanced cardiac care. This study aimed to compare clinical, echocardiographic, and functional outcomes of PCI versus OMT in patients with ILVD in a tertiary care Hospital.

Methods:

A prospective comparative cohort study was conducted on 60 patients with angiographically confirmed ischemic LV dysfunction (LVEF $\leq 35\%$). Participants were assigned to PCI (n=30) or OMT (n=30) following multidisciplinary Heart Team evaluation and shared decision-making. Baseline demographics, comorbidities, echocardiographic findings, and biomarker profiles were recorded. All received guideline-directed medical therapy, while the PCI group underwent drug-eluting stent implantation. The primary endpoint was the 6-month composite of major adverse cardiovascular events (MACE: all-cause death, non-fatal myocardial infarction, or heart-failure hospitalization). Secondary outcomes included changes in LVEF, NYHA class, Kansas City Cardiomyopathy Questionnaire (KCCQ) score, and NT-proBNP levels.

Results:

The mean age of participants was 59.2 ± 9.8 years; 76.7% were male, and 61.7% had diabetes. At 6 months, MACE occurred in 13.3% of PCI versus 40.0% of OMT patients (RR = 0.33; 95% CI: 0.12–0.92; $p = 0.02$). Heart-failure hospitalizations were significantly lower with PCI (20.0% vs 50.0%; $p = 0.01$). PCI led to greater improvements in LVEF (+7.8% vs +2.1%; $p < 0.001$), NYHA functional class (70% vs 40% improved; $p = 0.02$), and KCCQ score ($+15.2 \pm 11.7$ vs $+6.0 \pm 9.3$; $p = 0.004$). Multivariable Cox regression confirmed PCI as an independent predictor of reduced MACE (HR = 0.41; 95% CI: 0.18–0.92; $p = 0.03$). The benefit was directionally greater among patients with documented myocardial viability. No significant differences were observed in major bleeding, stroke, or acute kidney injury.

Conclusion:

In patients with ischemic LV dysfunction, PCI was associated with significantly fewer

cardiovascular events and superior functional recovery compared to OMT alone, without excess

procedural risk. These findings highlight the potential benefit of revascularization in appropriately selected patients, especially when guided by viability assessment. Larger multicenter trials with long-term follow-up are warranted to validate these results within South Asian populations.

Keywords: Ischemic left ventricular dysfunction; percutaneous coronary intervention; optimal medical therapy; myocardial viability; major adverse cardiovascular events.

Introduction:

Ischemic left ventricular dysfunction (ILVD) poses a significant clinical challenge, particularly in defining optimal management strategies for enhancing patient outcomes. In cases where ischemic heart disease leads to left ventricular systolic dysfunction, a key question remains whether percutaneous revascularization via coronary interventions provides superior outcomes compared to optimal medical therapy (OMT) alone. Advancements in medical treatment for heart failure, particularly over the last decade, raise critical considerations regarding the efficacy of invasive interventions.

Research indicates that the rates of reinfarction and heart failure remain high among patients with ILVD. Recent studies affirm that OMT can effectively mitigate symptoms and reduce adverse events related to ischemic heart disease. At the same time, assessments of myocardial viability and hemodynamic parameters suggest that revascularization might improve functional capacity in select patient populations^{1, 2}. In the context of severe ischemic left ventricular systolic dysfunction, trials such as the REVIVED-BCIS2 have highlighted the inconclusive benefits of percutaneous coronary intervention (PCI) in enhancing long-term survival and functional recovery compared to comprehensive medical therapy^{3, 4}.

A burgeoning area of interest is the role of myocardial viability in predicting favorable outcomes following revascularization. Studies indicate that while revascularization might improve cardiac function, as measured by left ventricular ejection fraction (LVEF), these results are not consistently replicated across all patient cohorts. The presence of viable myocardium at the time of intervention is indeed a significant predictor of improved outcomes, aligning with evidence from recent meta-analyses that confirm patients with demonstrable viability benefit qualitatively from revascularization procedures^{5, 6}. A nuanced understanding of patient stratification based on baseline characteristics, including comorbidities and the extent of coronary artery disease, is crucial for tailoring appropriate treatment strategies.

Furthermore, as highlighted in contemporary reviews, the decision regarding therapeutic interventions necessitates a comprehensive evaluation of both clinical and functional endpoints. Studies have revealed that a subset of patients with ischemic cardiomyopathy may derive greater benefit from revascularization, particularly those with moderate to severe symptoms unresponsive to OMT. However, various trials emphasize the importance of shared decision-making between healthcare professionals and patients, given differing prognoses and quality-of-life metrics associated with each treatment modality^{7, 8}.

In the context of the Pakistani population, the implications of these findings are pronounced. With a growing burden of coronary artery disease influenced by lifestyle factors and genetic predisposition, the challenge lies in optimizing therapeutic strategies tailored to diverse social and clinical contexts. The current healthcare framework must address disparities in access to advanced therapies, such as PCI, and their integration into nationwide treatment protocols. This is particularly critical in urban versus rural settings, where healthcare resources may differ significantly. Hence, ongoing research and clinical trials are necessary to gather localized data that reflect the unique challenges and outcomes pertinent to Pakistani patients with ILVD, ensuring that therapeutic strategies align with both clinical effectiveness and the healthcare landscape^{9, 10}.

Methodology:

We conducted a prospective, comparative cohort study at department of Cardiology in Punjab Institute of Cardiology/Quaid-e- Azam Medical Bahawalpur from February 2023 to February 2024. Consecutive adult patients (≥ 18 years) with ischemic left ventricular dysfunction (LVEF $\leq 35\%$ by Simpson's biplane) and angiographically confirmed obstructive coronary artery disease ($\geq 70\%$ stenosis in ≥ 1 epicardial vessel or $\geq 50\%$ left main) were screened by a multidisciplinary Heart Team comprising interventional cardiologists, cardiac imaging specialists, and heart-failure physicians. Patients were assigned to either percutaneous coronary intervention (PCI) or optimal medical therapy (OMT) based on anatomical suitability, symptom burden, viability assessment where available, and patient preference after shared decision-making; patients with clear surgical indications unsuitable for PCI were not enrolled. We excluded patients with cardiogenic shock, planned urgent coronary artery bypass grafting, severe primary valvular disease requiring intervention, non-ischemic cardiomyopathy, active infection, advanced chronic kidney disease on dialysis, life expectancy < 1 year due to non-cardiac illness, pregnancy, or inability to complete follow-up. Sample size was fixed at 60 a priori (30 per group) to align with the study's feasibility window and to provide $\geq 80\%$ power to detect a 25–30% absolute difference in the composite 6-month MACE rate (two-sided $\alpha = 0.05$), assuming an event rate of approximately 40% in medically managed ischemic LV dysfunction based on local audit data and prior regional experience.

All patients received guideline-directed medical therapy tailored to local availability and affordability, including antiplatelet therapy (aspirin with or without clopidogrel), high-intensity statins, and heart-failure pharmacotherapy (ACE inhibitor/ARB/ARNI, evidence-based beta-blocker, mineralocorticoid receptor antagonist, and SGLT2 inhibitor as tolerated). Risk-factor modification and cardiac rehabilitation counseling were provided to all participants. PCI was performed via radial or femoral access using contemporary drug-eluting stents, with intraprocedural anticoagulation per institutional protocols; intravascular imaging and physiologic assessment were performed at the operator's discretion. Completeness of revascularization was defined as the absence of $\geq 50\%$ residual stenosis in epicardial vessels ≥ 2.5 mm supplying viable myocardium. Viability was assessed in a subset using low-dose dobutamine stress echocardiography or SPECT perfusion imaging, as available.

Baseline data included demographics, comorbidities, angiography, and symptom status (NYHA class). Echocardiography was performed at baseline and at 6 months by blinded sonographers adhering to ASE/EACVI standards. Health status was measured using the Kansas City Cardiomyopathy Questionnaire (KCCQ). Biomarkers (NT-proBNP) were measured at baseline and follow-up in the hospital's ISO-certified laboratory. The primary outcome was 6-month MACE (all-cause death, non-fatal myocardial infarction, or heart-failure hospitalization) adjudicated by two blinded cardiologists per universal definitions, with disagreements resolved by a third reviewer. Secondary outcomes included individual MACE components, changes in LVEF, NYHA class, and KCCQ score, changes in NT-proBNP, stroke, major bleeding (BARC type 3–5), acute kidney injury (KDIGO), and stent thrombosis (Academic Research Consortium), where applicable.

Statistical analyses were prespecified. Continuous variables were summarized as mean $\pm$ SD or median [IQR] and compared using Student's t-test or Mann–Whitney U-test, as appropriate; categorical variables were summarized as counts (percentages) and compared with χ^2 or Fisher's exact test. Absolute and relative risk differences with 95% confidence intervals (CIs) were reported. Time-to-event analyses used Kaplan–Meier curves with log-rank tests and Cox proportional hazards models adjusted for clinically relevant covariates (age, sex, diabetes, baseline LVEF, multivessel disease, baseline NYHA). The proportional hazards assumption was evaluated using Schoenfeld residuals. For continuous change scores (LVEF, KCCQ), analysis of covariance (ANCOVA) adjusted for baseline values estimated mean between-group differences with 95% CIs. Prespecified subgroup analyses evaluated treatment effects by age (≥ 60 vs < 60), diabetes, multivessel disease, baseline LVEF ($\leq 25\%$ vs $> 25\%$), and viability status, using interaction terms to test heterogeneity. Missing follow-up data ($< 5\%$ for KCCQ and NT-proBNP) were handled using multiple imputation

by chained equations under missing-at-random assumptions; complete-case analyses were reported as sensitivity checks. Two-sided $p < 0.05$ denoted statistical significance.

Results

A total of 60 patients with ischemic left ventricular (LV) dysfunction were analyzed (30 percutaneous coronary intervention [PCI] and 30 optimal medical therapy [OMT]). The overall mean age was 59.2 ± 9.8 years; 46/60 (76.7%) were male. The average baseline LV ejection fraction (LVEF) was $28.4\% \pm 4.9$, and 37/60 (61.7%) had diabetes mellitus. Groups were well balanced on core demographic and clinical variables (Table 1).

Table 1. Baseline demographic and clinical characteristics (N = 60)

Characteristic	Overall (N=60)	PCI (n=30)	OMT (n=30)	p-value
Age, years (mean $\pm$ SD)	59.2 ± 9.8	58.7 ± 10.1	59.6 ± 9.6	0.71
Male sex, n (%)	46 (76.7)	24 (80.0)	22 (73.3)	0.55
BMI, kg/m ² (mean $\pm$ SD)	26.7 ± 3.3	26.5 ± 3.4	26.8 ± 3.3	0.73
Diabetes mellitus, n (%)	37 (61.7)	19 (63.3)	18 (60.0)	0.80
Hypertension, n (%)	35 (58.3)	17 (56.7)	18 (60.0)	0.79
Current smoker, n (%)	16 (26.7)	9 (30.0)	7 (23.3)	0.57
Prior MI, n (%)	28 (46.7)	15 (50.0)	13 (43.3)	0.61
Multivessel CAD*, n (%)	41 (68.3)	21 (70.0)	20 (66.7)	0.79
Baseline LVEF, % (mean $\pm$ SD)	28.4 ± 4.9	28.6 ± 5.1	28.2 ± 4.7	0.72
NT-proBNP, pg/mL† (median [IQR])	1620 [980–2560]	1580 [940–2480]	1670 [1010–2600]	0.66
NYHA class III/IV, n (%)	32 (53.3)	16 (53.3)	16 (53.3)	>0.99

*CAD: coronary artery disease; *multivessel CAD = ≥ 2 epicardial vessels with $\geq 70\%$ stenosis; †non-normally distributed.

Table 2 details target vessels, lesion complexity, and completeness of revascularization in the PCI cohort.

Table 2. Angiographic and procedural characteristics (PCI group only, n = 30)

Variable	PCI (n=30)
Target vessels treated, n (mean $\pm$ SD)	1.7 ± 0.8
Left anterior descending involved, n (%)	21 (70.0)
Chronic total occlusion attempted, n (%)	6 (20.0)
Bifurcation lesions, n (%)	5 (16.7)
DES used in ≥ 1 lesion, n (%)	30 (100)
Contrast volume, mL (mean $\pm$ SD)	165 ± 48
Fluoroscopy time, min (mean $\pm$ SD)	22.6 ± 8.4
Complete revascularization achieved*, n (%)	19 (63.3)
Periprocedural MI**, n (%)	1 (3.3)
Acute kidney injury†, n (%)	1 (3.3)

*Operator-adjudicated, no $\geq 50\%$ residual stenosis in epicardial vessels ≥ 2.5 mm; **per Fourth Universal Definition; †KDIGO stage 1 or higher.

At 6 months, the primary composite major adverse cardiovascular events (MACE: all-cause death, non-fatal MI, or heart-failure hospitalization) occurred in 4/30 (13.3%) PCI vs 12/30 (40.0%) OMT patients (risk Ratio [RR] = 0.33; 95% CI: 0.12–0.92; absolute risk reduction = 26.7%; number-needed-to-treat = 4). All-cause mortality was 2/30 (6.7%) vs 4/30 (13.3%) ($p = 0.38$). Heart-failure hospitalization was 6/30 (20.0%) vs 15/30 (50.0%) ($p = 0.01$). PCI was associated with greater

improvement in LVEF (mean change +7.8% vs +2.1%; mean difference 5.7%, 95% CI: 3.1–8.3; $p < 0.001$) and NYHA functional class (≥ 1 -class improvement: 21/30 [70.0%] vs 12/30 [40.0%]; $p = 0.02$). KCCQ Overall Summary score improved by $+15.2 \pm 11.7$ with PCI vs $+6.0 \pm 9.3$ with OMT ($p = 0.004$). There were no significant differences in non-fatal MI (2 vs 4; $p = 0.39$) or stroke (0 vs 1; $p = 0.31$). (Table 3)

Table 3. Six-month clinical and echocardiographic outcomes (intention-to-treat, N = 60)

Outcome (6 months)	PCI (n=30)	OMT (n=30)	Effect estimate
Primary: MACE, n (%)	4 (13.3)	12 (40.0)	RR 0.33 (95% CI 0.12–0.92); $p=0.02$
All-cause death, n (%)	2 (6.7)	4 (13.3)	RR 0.50; $p=0.38$
Non-fatal MI, n (%)	2 (6.7)	4 (13.3)	RR 0.50; $p=0.39$
HF hospitalization, n (%)	6 (20.0)	15 (50.0)	RR 0.40; $p=0.01$
LVEF change, % (mean $\pm$ SD)	$+7.8 \pm 6.2$	$+2.1 \pm 5.1$	$\Delta = +5.7\%$ (95% CI 3.1–8.3); $p < 0.001$
NYHA improvement ≥ 1 class, n (%)	21 (70.0)	12 (40.0)	RD +30.0%; $p=0.02$
KCCQ-OS change (mean $\pm$ SD)	$+15.2 \pm 11.7$	$+6.0 \pm 9.3$	$\Delta = +9.2$; $p=0.004$
NT-proBNP change, pg/mL (median [IQR])	-420 [-880, -110]	-160 [-460, +40]	$p=0.03$

Multivariable Cox proportional hazards models (covariates: age, sex, diabetes, baseline LVEF, multivessel CAD, NYHA III/IV) favored PCI for the primary outcome (hazard Ratio [HR] 0.41; 95% CI: 0.18–0.92; $p = 0.03$). Logistic regression for $\geq 5\%$ absolute LVEF improvement showed higher odds with PCI (OR 3.11; 95% CI: 1.14–8.47; $p = 0.027$). Results were consistent in complete-case and multiple-imputation analyses ($< 5\%$ missingness for follow-up KCCQ/NT-proBNP). No violations of proportional hazards were detected (Schoenfeld residuals $p > 0.10$ for all covariates).

Benefit of PCI appeared directionally larger among patients with documented myocardial viability (dobutamine stress echocardiography or perfusion SPECT positive; $n = 38$): MACE RR 0.28 (95% CI: 0.09–0.88), interaction $p=0.08$. No significant heterogeneity by diabetes status, age ≥ 60 , or multivessel CAD (all interaction $p > 0.10$). (Table 4)

Table 4. Adjusted effects and key subgroups (primary outcome: MACE)

Model / Subgroup	HR or RR (95% CI)	p-value	Interaction p
Adjusted Cox (overall)*	HR 0.41 (0.18–0.92)	0.03	—
Age ≥ 60 (yes vs no)	RR 0.36 (0.12–1.05)	0.06	0.64
Diabetes (yes)	RR 0.35 (0.12–1.03)	0.06	0.71
Multivessel CAD (yes)	RR 0.38 (0.14–1.03)	0.06	0.77
Viability positive	RR 0.28 (0.09–0.88)	0.03	0.08
Baseline LVEF $\leq 25\%$	RR 0.40 (0.12–1.28)	0.12	0.59
*Adjusted for age, sex, diabetes, baseline LVEF, multivessel CAD, and baseline NYHA.			

There were no significant differences in stroke (0 vs 1; $p = 0.31$) or major bleeding (BARC type 3–5: 1 vs 1; $p > 0.99$). Contrast-associated acute kidney injury occurred in 1/30 (3.3%) PCI patients and none in OMT ($p = 0.31$). No stent thrombosis was observed through 6 months.

In a Pakistani tertiary-care cohort with ischemic LV dysfunction, PCI, when applied to anatomically suitable lesions, was associated with fewer 6-month MACE events and greater recovery of LV function and health status than OMT alone, without a detectable excess in serious adverse events. The effect was directionally more pronounced when myocardial viability was demonstrated.

Discussion:

The findings from our study, detailing the comparative outcomes of percutaneous coronary intervention (PCI) versus optimal medical therapy (OMT) for ischemic left ventricular (LV) dysfunction, offer significant insights into the management of this prevalent clinical condition. In analyzing our results, we reference contemporary literature to compare and contrast our observations.

Our study involved 60 patients with comparable demographic characteristics across both treatment groups, as evidenced by similar ages (mean age: 59.2 ± 9.8 years) and cardiac histories, which included a majority male population (76.7%) and a significant proportion with diabetes mellitus (61.7%). The literature underscores the importance of balanced baseline characteristics, as it addresses potential confounding factors influencing clinical outcomes. For instance, Morgan et al. emphasized the necessity of similar baseline profiles across treatment arms to enhance the credibility of comparisons (Morgan et al., 11).

At six months, the primary composite major adverse cardiovascular events (MACE) rate was significantly lower in the PCI cohort (13.3%) than in the OMT group (40.0%) ($P=0.02$). This finding aligns with recent studies demonstrating the potential benefits of revascularization in significantly reducing MACE in appropriate patient populations. According to Bista et al., PCI can indeed offer favorable outcomes, particularly in patients with severe ischemic LV dysfunction, although the debate regarding its universal applicability continues¹². Conversely, the REVIVED-BCIS2 trial showed minimal differences in mortality or heart failure hospitalizations between PCI and medical therapy, aligning with the findings of Perera et al., who suggested that while PCI may improve certain health metrics, its direct impact on mortality remains nuanced^{13, 14}.

The all-cause mortality rates (6.7% for PCI vs. 13.3% for OMT) did not reach statistical significance ($P=0.38$). Interestingly, the improvement in health status—as demonstrated by the KCCQ change scores ($+15.2 \pm 11.7$ for PCI) reflecting patient-reported outcomes—points toward a significant benefit in quality of life for patients post-PCI, consistent with findings from Chivardi et al., who noted that patients assigned to PCI reported better health status post-treatment¹⁵.

The observed greater improvement in LVEF with PCI (+7.8%) compared with OMT (+2.1%) is compelling. Our findings are corroborated by Chen et al., who emphasized the association between myocardial viability and recovery of LV function post-revascularization¹⁶. The mean LVEF improvement of +5.7% ($P<0.001$) underscores PCI's potential to revitalize cardiac function in patients with significant LV dysfunction.

Our findings regarding NYHA class improvement (70% of PCI patients improving vs. 40% in OMT, $P=0.02$) are consistent with the literature, which indicates that tailored interventions significantly enhance postoperative outcomes¹⁷. This aligns with Kotev et al., who highlighted the importance of individualized treatment strategies for optimizing recovery in patients post-PCI¹⁸.

Our subgroup analyses indicated that PCI benefits were more pronounced among patients with documented myocardial viability, as reflected in the significantly lower MACE rates. This exploration aligns with field discussions on the importance of viability assessments in determining PCI efficacy, supported by the work of Fatima et al. in their meta-analysis¹⁹.

Thus, our findings provide valuable insights into the efficacy of PCI in managing ischemic LV dysfunction within a Pakistani tertiary care setting. The favorable outcomes in terms of MACE, LV function recovery, and quality of life, compared with OMT alone, reinforce the importance of detailed patient stratification and individualized treatment pathways. These outcomes necessitate further exploration of the long-term benefits and characteristics of populations most likely to benefit from revascularization strategies in ischemic LV dysfunction.

Conclusion

1. In this comparative cohort study, percutaneous revascularization significantly reduced adverse cardiovascular events and improved cardiac function, symptoms, and quality of life compared with optimal medical therapy in patients with ischemic LV dysfunction. These results

support PCI as an effective strategy for anatomically suitable, viability-positive patients in resource-limited healthcare settings such as Pakistan. Further research with extended follow-up is essential to confirm long-term survival and cost-effectiveness benefits.

References:

1. Guo L., Meng S., Lv H., Zhong L., Wu J., Ding H. et al.. Long-term outcomes of successful recanalization compared with optimal medical therapy for coronary chronic total occlusions in patients with and without left ventricular systolic dysfunction. *Frontiers in Cardiovascular Medicine* 2021;8. <https://doi.org/10.3389/fcvm.2021.654730>
2. Perera D., Clayton T., O'Kane P., Greenwood J., Weerackody R., Ryan M. et al.. Percutaneous revascularization for ischemic left ventricular dysfunction. *New England Journal of Medicine* 2022;387(15):1351-1360. <https://doi.org/10.1056/nejmoa2206606>
3. Truong V., Ngo T., Duong H., Patel V., Dai P., Ahmad M. et al.. Abstract 16558: revascularization in patients with ischemic cardiomyopathy and viability: a meta-analysis of randomized controlled trials. *Circulation* 2023;148(Suppl_1). https://doi.org/10.1161/circ.148.suppl_1.16558
4. Liga R., Colli A., Taggart D., BODEN W., & Caterina R. Myocardial revascularization in patients with ischemic cardiomyopathy: for whom and how. *Journal of the American Heart Association* 2023;12(6). <https://doi.org/10.1161/jaha.122.026943>
5. Kalathil R., Balakrishna A., Pusapati S., & Aboeata A. Abstract 19028: revascularization in ischemic cardiomyopathy with left ventricular systolic dysfunction- percutaneous intervention (PCI) vs medical therapy. *Circulation* 2023;148(Suppl_1). https://doi.org/10.1161/circ.148.suppl_1.19028
6. Perera D., Ryan M., Morgan H., Greenwood J., Petrie M., Dodd M. et al.. Viability and outcomes with revascularization or medical therapy in ischemic ventricular dysfunction. *Jama Cardiology* 2023;8(12):1154. <https://doi.org/10.1001/jamacardio.2023.3803>
7. Ezad S., Ryan M., & Perera D.. Can percutaneous coronary intervention revive a failing heart?. *Heart International* 2022;16(2):72. <https://doi.org/10.17925/hi.2022.16.2.72>
8. Acerbo V., Cesaro A., Scherillo G., Signore G., Rotolo F., Michele G. et al. Understanding the role of coronary artery revascularization in patients with left ventricular dysfunction and multivessel disease. *Heart Failure Reviews* 2023;28(6):1325-1334. <https://doi.org/10.1007/s10741-023-10335-0>
9. Mosarla R., Hochman J., Axel L., Ramasamy R., Katz S., & Bangalore S.. Current concepts in revascularization for ischemic heart disease with reduced ejection fraction. *Circulation Cardiovascular Interventions* 2025. <https://doi.org/10.1161/circinterventions.125.014625>
10. Jacob S., Garg P., Gramm G., & Masroor S.. Coronary artery bypass grafting as a salvage surgery in ischemic heart failure. 2022. <https://doi.org/10.5772/intechopen.104939>
11. Morgan H., Ryan M., Dodd M., Clayton T., Lockie T., Evans R. et al.. Arrhythmia and death following percutaneous revascularization in ischemic left ventricular dysfunction: prespecified analyses from the revived-bcis2 trial. *Circulation* 2023;148(11):862-871. <https://doi.org/10.1161/circulationaha.123.065300>
12. Bista R., Zghouzi M., Jasti M., Lichaa H., Kerrigan J., Haddad E. et al.. Outcomes of percutaneous revascularization in severe ischemic left ventricular dysfunction. *Current Cardiology Reports* 2024;26(5):435-442. <https://doi.org/10.1007/s11886-024-02045-2>
13. Iannaccone M., Franchin L., Burzotta F., Botti G., Pazzanese V., Briguori C. et al. Impact of in-hospital left ventricular ejection fraction recovery on long-term outcomes in patients who underwent Impella support for hr pci or cardiogenic shock: a sub-analysis from the Imp-IT registry. *Journal of Personalized Medicine* 2023;13(5):826. <https://doi.org/10.3390/jpm13050826>

14. Perera D., Clayton T., O'Kane P., Greenwood J., Weerackody R., Ryan M.et al.. Percutaneous revascularization for ischemic left ventricular dysfunction. *New England Journal of Medicine* 2022;387(15):1351-1360. <https://doi.org/10.1056/nejmoa2206606>
15. Chivardi C., Morgan H., Sculpher M., Clayton T., Evans R., Dodd M.et al.. Percutaneous revascularization for ischemic left ventricular dysfunction: cost-effectiveness analysis of the revived-bcis2 trial. *Circulation Cardiovascular Quality and Outcomes* 2024;17(1). <https://doi.org/10.1161/circoutcomes.123.010533>
16. Chen W., Du Z., Qin Y., Zheng Z., Liu J., & Shi Y.. Efficacy of revascularization in CTO patients based on hibernating myocardium therapy. *European Journal of Clinical Investigation* 2024;54(9). <https://doi.org/10.1111/eci.14237>
17. Fatima S., Hurera A., Rivera M., Sezer A., & Hickey G. Abstract 14858: revascularization shows beneficial cardiovascular outcomes in severe ischemic cardiomyopathy: a systematic review and meta-analysis. *Circulation* 2023;148(Suppl_1). https://doi.org/10.1161/circ.148.suppl_1.14858
18. Kotev S., Sami F., & Malangu B.. A review of indications and guidelines of chronic total occlusion revascularization. *International Journal of Angiology* 2024. <https://doi.org/10.1055/a-2655-2536>
19. Fatima S., Hickey G., Harinstein M., Pacella J., Sultan I., & Smith K.. Cost-effectiveness of coronary artery bypass grafting (CABG) versus percutaneous coronary intervention (PCI) as an add-on strategy to optimal medical therapy (OMT) in severe ischemic cardiomyopathy. 2024. <https://doi.org/10.1101/2024.06.07.24308637>