VER
Vascular & Endovascular Review

# Short- and Mid-term outcomes of Coronary Artery Bypass Grafting versus Percutaneous Coronary Intervention in patients with unprotected left main coronary artery disease and impaired left ventricular ejection fraction

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https://doi.org/10.5281/zenodo.17594431

## ABSTRACT

**Background**: Acute left main (LM) coronary occlusion jeopardizes over 80% of the myocardial blood supply, which commonly hinders the left ventricular ejection fraction (LVEF), making it a life-threatening condition that demands prompt reperfusion. However, the best method for revascularization in such a condition is not settled yet.

**Objective**: We aimed to determine the safest method of revascularization for patients with significant unprotected left main coronary artery (ULMCA) occlusion and low ejection fraction by comparing the short- and midterm outcomes of surgical versus percutaneous coronary interventions (PCIs).

**Methods**: In this study, we recruited 440 patients from university hospitals in Cairo, Sohag, and other locations who underwent urgent revascularization due to angiographically evident significant occlusion of the ULMCA and a low ventricular ejection fraction (LVEF < 40%) between January 2020 and June 2024, with follow-up extending to June 2025.

**Patients were divided into 2 groups:** Group A, the coronary artery bypass grafting (CABG) group, which included 220 patients, and Group B, the PCI group, which had the same number. Our primary endpoint was to compare the incidence of the major adverse cardiac and cerebrovascular events (MACCE: all-cause mortality, myocardial infarction, stroke, and repeat revascularization) throughout the early postoperative period up to 3-year follow-up duration between the 2 groups. Propensity score matching and multivariable Cox proportional hazards models were used to adjust for baseline differences.

**Results**: Analyzing the initial (at 30 days) outcomes, the PCI cohort was associated with significantly shorter hospital stays. Rates of all-cause mortality (4.5% vs. 7.7%) and cerebrovascular stroke (2.3% vs. 2.7%) were numerically lower in the CABG group, but these differences were not statistically significant (p-value > 0.05(. At the 36 months median follow-up, MACCE was observed in 18.9% of the CABG cohort while it was noted in 29.6% of PCI patients (HR 0.68, 95% CI 0.48–0.96, p = 0.01). This disparity was primarily due to the observation that patients undergoing CABG needed less re-revascularization (6.8% compared to 16.4%, p = 0.002). Furthermore, the PCI group experienced a significantly higher overall mortality rate through the median follow-up (21.8% vs. 14.1%, p = 0.04), while the CABG group showed a greater enhancement in LVEF compared to the PCI group (+6.8 ± 4.2% vs +3.1 ± 3.7%; p = 0.001).

**Conclusion**: In patients with reduced LVEF and ULMCA disease, CABG and PCI showed comparable short-term outcomes. Less need for re-revascularization, CABG group showed significantly lower MACCE rates and higher LVEF levels up to a three-year period. In order to determine the best revascularization techniques for this high-risk population, a heart-team approach is essential.

**KEYWORDS**: LMCAD, CABG, PCI, LVEF, MACCE..

**How to Cite:** Ahmed Lamloum*1, M. Shalaby2, Mohammady Khalil Amin3, Mohsen Saber Mohammed Ahmed4, Ahmed M. Elwakeel1, Ihab Mohamed Salah Eldin Elsharkawy1, (2025) Short- and Mid-term outcomes of Coronary Artery Bypass Grafting versus Percutaneous Coronary Intervention in patients with unprotected left main coronary artery disease and impaired left ventricular ejection fraction, Vascular and Endovascular Review, Vol.8, No.5s, 243-252.

## INTRODUCTION

Unless promptly managed, acute occlusion of the left main coronary artery in the context of acute coronary syndrome without sufficient perfusing collaterals is often lethal[1]. This finding can be explained by the great territory of myocardium supplied by such a crucial artery that, on becoming acutely occluded, the heart loses up to 80% of its pumping abilities, causing severe hemodynamic instabilities, cardiogenic shock, and even pre-admission death[2,3].

With the commercial availability of drug-eluting stents, which are claimed to prolong the patency of the targeted vessel, PCI has demonstrated its ability to serve as an alternative to traditional surgical coronary artery grafting over the past decade for patients with ACS who require immediate revascularization, such as patients with ULMCA occlusion[4,5]. Furthermore, in some patient populations, numerous trials and registry data have shown short-term results that are comparable to CABG, with the benefit of less invasion and quicker recovery times[6,7].

Numerous randomized controlled trials, such as the EXCEL and NOBLE trials, indicate that PCI serves as an effective alternative to CABG for short-term outcomes. Nonetheless, surgical grafting yielded superior long-term outcomes, especially regarding re-revascularization[1,5,6]. Information is scarce regarding patients with significantly decreased LVEF, and most of these studies were done on individuals with preserved or mildly impaired LV function[8,9].

Further studies are required to determine the optimal revascularization strategy in terms of short- and mid-term outcomes because There remains a paucity of dedicated studies on patients with low LVEF and ULMCA illness.

With an emphasis on MACCE, survival, and ventricular function improvement, this study aims to assess and contrast the short- and mid-term clinical outcomes of CABG versus PCI in patients with severe ULMCA disease and decreased LVEF.

## PATIENTS AND METHODS

**Study design and population:**

This Retrospective multicenter observational cohort study with propensity-matched comparison between revascularization strategies. encompassed 440 patients necessitating urgent revascularization for acute coronary syndrome attributed to ULMCA occlusion and a diminished LVEF below 40%, as verified by coronary angiography and echocardiography conducted prior to the intervention at Cairo and Sohag University between January 2020 and June 2024, with follow-up extending to June 2025.

Patients who met our inclusion criteria were equally distributed according to the revascularization technique into 2 groups; group A (the CABG group including 220 patients) and group B (the PCI group including 220 patients).

All related demographic data, baseline preoperative echocardiographic data, and laboratory data were gathered and analyzed, with special focus on the preoperative LVEF and coronary artery lesion distribution. Postoperative early outcomes that included in-hospital MACCE, ICU, hospital stays and early mortality along with the late outcomes that included mainly the need for repeat revascularization were recorded and compared among the both groups.

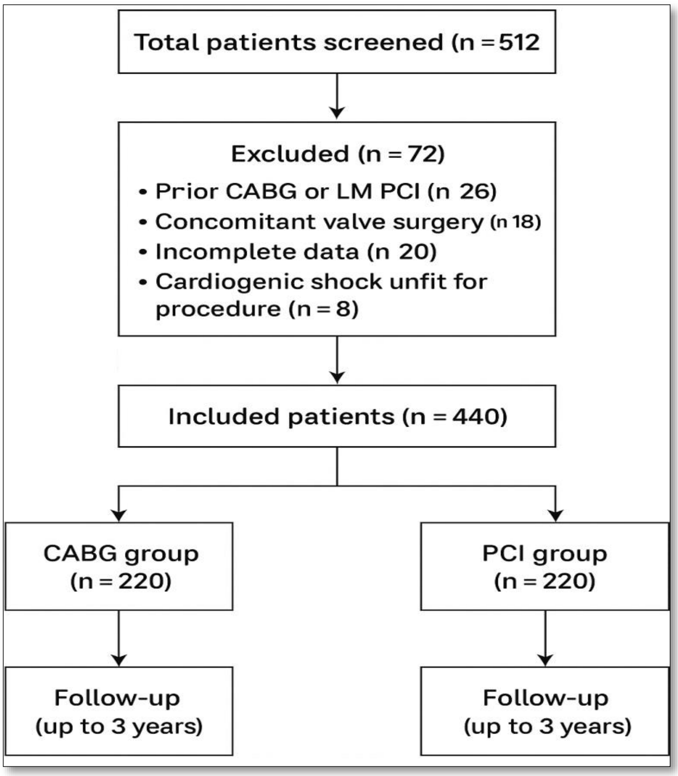


**Figure (1): Illustrating patient selection and study design.**

**Criteria for Inclusion:**

Patients with angiographically confirmed ULMCA stenosis ≥50% and reduced (LVEF < 40%) who underwent urgent revascularization by either CABG or PCI between January 2020 and June 2024, with follow-up extending to June 2025 were included. All patients had complete clinical, echocardiographic, and angiographic data available for analysis.

**Criteria for Exclusion:**
Patients with prior CABG, concomitant valvular or aortic surgery, hemodynamic instability precluding complete assessment, or incomplete medical records were excluded. Those presenting with acute mechanical complications of myocardial infarction were also excluded.

**Definitions:**
- Indications and recommendations for CABG and the other cardiac procedures were all decided following the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines[10,11].
- Left main coronary artery disease (LMCAD): ≥50% diameter stenosis of the left main coronary artery assessed by quantitative coronary angiography or intravascular imaging[1].
- Impaired LVEF: LVEF ≤40% measured by echocardiography using Simpson's biplane method[12].
- Unprotected left main disease: Absence of patent bypass grafts to the left anterior descending or left circumflex arteries[13].
- MACCE: Composite of all-cause mortality, myocardial infarction, stroke, and repeat revascularization[14,15].
- Procedural success CABG: Complete revascularization without perioperative mortality or major complications[16].
- Procedural success PCI: Successful stent deployment with <10% residual stenosis and achievement of TIMI 3 flow in all treated vessels[3].
- Perioperative mortality: Death within 30 days post-procedure or during the same hospital admission[17].

**Data gathering:**
Archived records from the involved centers were examined retrospectively for the extraction of data concerning preoperative demographic factors and comorbid conditions, surgical specifics, and postoperative results. In addition to the preoperative clinical information, the pertinent echocardiographic results, especially the LVEF, along with the coronary angiographic findings collected and evaluated.

Postoperatively, our emphasis was primarily on the MACCE, early mortality and the need for re-revascularization within the follow-up period (36 months median, IQR 24–48 months).

Moreover, data regarding the need for mechanical ventilation following the procedure, ICU stays, and overall hospital stay lengths, along with the need for pharmacological and mechanical circulatory support and wound issues, were documented.

All datasets were validated independently by two specialized statisticians, and discrepancies were settled by agreement. Missing variables (<5%) were handled using multiple imputation methods to maintain data integrity.

**Study endpoints:**
The primary endpoint of this study was the composite incidence of MACCE, which included all-cause mortality, myocardial infarction, stroke, and any repeat revascularization as recorded during the follow-up period. These outcomes were used to compare the overall efficacy and safety of the two revascularization methods in patients with unprotected LMCAD and impaired LVEF.

In the second order, we additionally analyzed the outcomes of each strategy on a three-monthly basis following the intervention, focusing on re-admission for heart failure, anginal pains, and the need for revascularization over 3 to 5 years. Moreover, data regarding early postoperative in-hospital morbidities and mortalities were gathered and analyzed to cover both short-term and mid-term procedural safety and recovery.

**Ethical approval:**
The study protocol was accepted by the ethical council of Sohag University hospitals (Approval Number: Soh-med-25-9-13PD). Each patient gave an informed written agreement for acceptance of the procedure. The study adhered to the Helsinki Declaration throughout its execution[18].

- **Measures before intervention:**

Before the intervention, a thorough examination and investigation were conducted on all patients to ensure accurate diagnosis and appropriate selection of those recruited.

The evaluations comprised electrocardiograms, echocardiograms (mainly to assess the baseline LVEF and to exclude any other cardiac problem mandating surgical intervention), and blood tests, including cardiac markers and kidney functions, culminating in an anatomical evaluation via diagnostic coronary angiography, which confirmed the existence and extent of LMCAD and directed our team towards the preferred revascularization method for each situation.

After fulfilling the inclusion criteria, the patient was enrolled in our study, and we performed an extensive data collection regarding demographic details, the existence of comorbidities, and additional risk factors
Patients with pre-interventional hemodynamic instabilities, intractable arrhythmias, or heart failure who needed mechanical circulatory and/or inotropic support were excluded from this study.

- **Procedural Measures:**

Regardless of the approach established by the multidisciplinary group in the research tertiary centers, the intervention was carried out by skilled interventional cardiologists or cardiothoracic surgeons adhering to institutional protocols. To reduce individual differences and biases from human error, we standardized the approaches for PCI or CABG by adhering to the general guidelines outlined in the following paragraphs.

For **CABG** patients, we performed a routine median sternotomy on all of our patients, using the standard cardiopulmonary techniques and either cold or warm K+ cardioplegic solution for myocardial protection. The left anterior descending artery was preferentially grafted with the left internal mammary artery (LIMA) whenever possible, and extra grafts were performed using saphenous vein or radial artery conduits. Off-pump CABG was conducted selectively in hemodynamically stable patients when it was technically suitable.

Operational data gathered and analyzed from surgical notes and anesthetic sheets included the type of surgery, operative time, cross-clamp time, total bypass time, number of grafts per CABG patient, need for blood product transfusion, need for high inotropic support, and patients transferred with packed open chest.

For **PCI** patients, drug-eluting stents were the preferred option when accessible; if not, bare metal stents were utilized as well. All cases were approached via radial or femoral arteries. Dual antiplatelet therapy was started prior to or right after PCI and continued in accordance with current guidelines.

Hemodynamic monitoring was upheld during all procedures, and mechanical circulatory support (IABP or ECMO) was applied in instances of cardiogenic shock or significant ventricular dysfunction when necessary.

- **Postoperative measures:**

After the intervention, every patient was moved to a fully equipped intensive care unit for careful monitoring of hemodynamics, cardiac electrical activity, arterial blood gases, and fluid balance, including the maintenance of fluid balance, optimal inotropic and/or mechanical support, and early commencement of appropriate blood thinners whenever feasible.

In the **CABG** group, we began early weaning of ventilatory support, extubation, and mobilization as soon as the patient exhibited acceptable motor power, hemodynamic stability, appropriate arterial blood gas (ABG) results, and satisfactory chest drain output. Beta-blockers, statins, and antiplatelet agents were routinely prescribed unless contraindicated. In the **PCI group**, dual antiplatelet therapy was continued for a year or more, along with the known secondary prevention therapy.

To evaluate the safety and effectiveness of each procedure against one another over short-term periods, data on postoperative outcomes was collected from ICU records and hospital files, which encompassed the duration of mechanical ventilation (MV), length of ICU stays, total hospital admissions, and complications related to the access of interventions.

The incidence of cardiogenic shock was meticulously documented according to globally accepted standards, and the in-hospital hazards linked to the method were assessed. Additional adverse results were observed, including arrhythmias, acute kidney injury, the requirement for mechanical support, and early postoperative death (within 30 days).

**Follow up after hospital discharge: likely 36 months median, IQR 24–48 months;**

Out-patient Follow-up visits took place at 1-, 6-, and 12-months post-discharge and then annually afterward. Every visit comprised a clinical evaluation, chest X-ray, electrocardiogram, and transthoracic echocardiography to assess LVEF. Significant adverse cardiac and cerebrovascular events (MACCE), including death, heart attack, stroke, and additional revascularization, were recorded at every follow-up stage

## STATISTICAL ANALYSIS

- **Sampling method:**

This retrospective observational multicenter study took place in three tertiary cardiac centers designed to handle cases of acute coronary syndrome. Data on patients with unprotected left main artery occlusion along with impaired LVEF who required interventional revascularization were gathered and carefully analyzed during the period between January 2020 and June 2024, with follow-up extending to June 2025.

Patients who met our previously mentioned inclusion criteria were enrolled in the study after giving both verbal and written consent following our institutional ethical committee's guidelines.

A retrospective analysis of the data from 440 patients who were enrolled in the trial was conducted in order to disclose which revascularization strategy is safer with higher efficacy in such condition.

**Data analysis:**

Software called SPSS, version 28.0, was used to analyze all of the data. The Mann-Whitney U test or independent samples t-test, as applicable, were used to compare continuous variables, which were reported as Mean ± standard deviation (SD). Fisher's exact test or chi-square test were used to compare categorical variables, which were shown as counts and percentages. To reduce baseline differences between the two groups, propensity score matching (1:1 nearest-neighbor approach without replacement, caliper 0.20) was used using a logistic regression model that included key demographic and clinical variables[19,20]. To assess event-free survival, Kaplan-Meier survival curves were produced and compared using the log-rank test[21]. A multivariable Cox proportional hazards regression was utilized to find independent determinants of MACCE[22,23]. All statistical tests were two-tailed, with a p-value < 0.05 indicating statistical significance.

## RESULTS

- **Demographic and pre-operative variables; Table 1:**

Four hundred forty patients diagnosed with angiographically confirmed ULMCA disease and diminished LVEF < 40% were recruited from January 2020 and June 2024, with follow-up extending to June 2025. They were equally split into two groups: CABG group (n = 220) and PCI group (n = 220).

Prior to matching, patients in the PCI group were somewhat older (average age 65.3 ± 8.1 vs. 63.4 ± 7.6 years, p = 0.02) and showed a greater prevalence of diabetes mellitus (60.5% vs. 52.7%, p = 0.04) as well as chronic kidney disease (14.1% vs. 8.6%, p = 0.03). In comparison, the CABG group exhibited a greater percentage of three-vessel disease (70.0% vs. 45.9%, p < 0.001) and elevated SYNTAX scores[24] (33.1 ± 7.2 vs. 28.5 ± 6.4, p < 0.001), indicating increased anatomical complexity.

No notable differences were found in sex distribution, hypertension, smoking habits, history of myocardial infarction, or initial LVEF (33.6 ± 5.9% in CABG compared to 34.1 ± 5.7% in PCI, p = 0.31).

Following propensity score matching (1:1 ratio), 190 matched pairs were achieved, showing no significant differences in baseline demographics, risk factors, or angiographic profiles (p > 0.05 for all).

**Table (1): Baseline Demographic and Clinical Characteristics of the Study Population**

| Variable | CABG (n = 220) | PCI (n = 220) | *p*-value |
|---|---|---|---|
| Age (years) | 63.4 ± 7.6 | 65.3 ± 8.1 | 0.02 |
| Male sex (%) | 77.7 | 75.9 | 0.61 |
| Diabetes mellitus (%) | 52.7 | 60.5 | 0.04 |
| Hypertension (%) | 68.6 | 70.0 | 0.74 |
| Current smoker (%) | 35.0 | 31.4 | 0.43 |
| Dyslipidemia (%) | 59.1 | 63.2 | 0.39 |
| Chronic kidney disease (%) | 8.6 | 14.1 | 0.03 |
| Previous MI (%) | 44.5 | 38.2 | 0.19 |
| LVEF (%) | 33.6 ± 5.9 | 34.1 ± 5.7 | 0.31 |
| SYNTAX score | 33.1 ± 7.2 | 28.5 ± 6.4 | <0.001 |
| Three-vessel disease (%) | 70.0 | 45.9 | <0.001 |

*MI; Myocardial infarction, LVEF; Left Ventricular Ejection Fraction, SYNTAX score; Synergy Between PCI with Taxus and Cardiac Surgery score.*

- **Procedural and peri-operative variables; Table 2:**

Table 2 demonstrated data regarding intra- and perioperative variables and disclosed that the CABG operation took a longer time than the PCI but had a higher percentage of complete revascularization (265 ± 48 min vs. 94 ± 28 min, p < 0.001 and 87.7% vs. 72.8%, p < 0.001, respectively).

Focusing on the need for perioperative mechanical support, more patients in the CABG group needed support, especially in the form of IABP (22.3% vs. 12.7%, p = 0.01), compared with the other group.

Additionally, the CABG group showed a longer need for mechanical ventilation (14.2 ± 5.8 vs. 6.3 ± 3.1 hours, p < 0.001) and ICU stay (3.8 ± 1.9 vs. 2.1 ± 1.2 days, p < 0.001). And despite the higher incidence of perioperative cerebrovascular stroke (2.7% vs. 2.3%, p = 0.81) and new-onset renal replacement therapy (4.5% vs. 3.6%, p = 0.64) among the same group, differences didn't reach a level of significance.

These findings underscored the facts that the CABG procedure prolonged the need for hospital care but gave higher revascularization of the diseased coronaries.

**Table (2): Procedural and perioperative characteristics**

| Variable | CABG (n = 220) | PCI (n = 220) | p-value |
|---|---|---|---|
| Procedural duration (min) | 265 ± 48 | 94 ± 28 | < 0.001 |
| IABP use, n (%) | 49 (22.3) | 28 (12.7) | 0.01 |
| ECMO use, n (%) | 8 (3.6) | 5 (2.3) | 0.42 |
| Complete revascularization, n (%) | 193 (87.7) | 160 (72.8) | < 0.001 |
| Contrast volume (mL) | (N/A) | 215 ± 46 | (N/A) |

| | | | |
|---|---|---|---|
| Number of stents per patient | (N/A) | 2.4 ± 0.7 | (N/A) |
| Mechanical ventilation (hours) | 14.2 ± 5.8 | 6.3 ± 3.1 | < 0.001 |
| ICU stay (days) | 3.8 ± 1.9 | 2.1 ± 1.2 | < 0.001 |
| Perioperative stroke, n (%) | 6 (2.7) | 5 (2.3) | 0.81 |
| New renal replacement therapy, n (%) | 10 (4.5) | 8 (3.6) | 0.64 |

*CABG; coronary artery bypass grafting, PCI; percutaneous coronary intervention; IABP; intra-aortic balloon pump, ECMO; extracorporeal membrane oxygenation, ICU; intensive care unit, min; minutes, mL; milliliters, n; number of patients, (N/A); Not Applicable.*

- **Early (30-day) and Mid-term Outcomes, Tables 3-4, Figure 2:**

**Early (30-day) outcomes:**

Patients in the CABG group have lower rates of all-cause mortality (4.5% vs. 7.7%), postoperative myocardial infarction (3.2% vs. 4.1%), and cerebrovascular strokes (2.3% vs. 2.7%) at 30-day follow-up compared to the PCI group, but the difference is not of clinical significance (P value > 0.05). On the contrary, the need for revascularization at the same follow-up period was significantly higher among the PCI group (6.8% vs. 1.8%, $p = 0.01$).

**Mid-term Outcomes (36 months median follow-up, IQR 24–48 months):**

As evident by significantly lower all-cause death, MACCE, and marked improvement in the cardiac function (LVEF) among the CABG group at the median follow-up (36 months (IQR 24–48 months)), the overall survival and event-free rates favored surgical revascularization.

Regarding mid-term outcomes, recorded at a median follow-up of 36 months (interquartile range 24–48 months), the incidence of the MACCE was significantly lower in the CABG group (18.9% vs. 29.6%, $p = 0.01$); that was mainly explained by the higher need for revascularization among the PCI group (13.2% vs. 5.0%, $p = 0.004$), and as demonstrated by Kaplan-Meier analysis, mid-term survival was also more favorable following CABG (85.9% vs. 78.1%, $p = 0.03$).

A significant improvement in LVEF was observed in both cohorts, more pronounced after CABG (+6.8 ± 4.2% vs. +3.1 ± 3.7%, p < 0.001), indicating superior ventricular recovery with surgical revascularization. Kaplan–Meier analysis confirmed better 3-year overall survival (85.9% vs. 78.1%, p = 0.03) and MACCE-free survival (81.1% vs. 70.4%, p = 0.01) for CABG compared with PCI.

**Table (3): Early (30-day) and mid-term outcomes**

| **Outcome** | **CABG (n = 220)** | **PCI (n =220)** | ***p*-value** |
|---|---|---|---|
| **30-day outcomes** | | | |
| All-cause mortality | 10 (4.5%) | 17 (7.7%) | 0.18 |
| Myocardial infarction | 7 (3.2%) | 9 (4.1%) | 0.64 |
| Repeat revascularization | 4 (1.8%) | 15 (6.8%) | 0.01 |
| Stroke | 5 (2.3%) | 6 (2.7%) | 0.79 |
| New-onset renal failure | 6 (2.7%) | 5 (2.3%) | 0.77 |

*MACCE = major adverse cardiac and cerebrovascular events; MI = myocardial infarction.*

**Table (4): Mid-term outcomes**

| **Outcome** | **CABG (n = 220)** | **PCI (n = 220)** | **p-value** |
|---|---|---|---|
| All-cause mortality | 31 (14.1%) | 48 (21.8%) | 0.04 |
| MACCE (composite) | 42 (18.9%) | 65 (29.6%) | 0.01 |
| Myocardial infarction | 12 (5.5%) | 17 (7.7%) | 0.32 |
| Stroke | 7 (3.2%) | 8 (3.6%) | 0.81 |
| Repeat revascularization | 11 (5.0%) | 29 (13.2%) | 0.004 |
| LVEF improvement (Δ%) | +6.8 ± 4.2 | +3.1 ± 3.7 | < 0.001 |
| 3-year survival (KM) | 85.9% | 78.1% | 0.03 |
| 3-year MACCE-free survival (KM) | 81.1% | 70.4% | 0.01 |

- **Multivariable Cox regression for predictors of MACCE, Table 5:**

Data analysis using the multivariable Cox proportional hazards regression disclosed multiple independent predictors of MACCE throughout the mid-term follow-up duration.

Incomplete revascularization was found to be the most significant risk factor for major post-intervention cardiac problems (HR 1.78, 95% CI 1.19–2.67, p = 0.005), which might be the cause, standing after the finding that PCI was an independent risk factor for more hazardous outcomes than CABG (HR 1.54, 95% CI 1.09–2.18, p = 0.01).

Besides the procedural variables, many preoperative factors were linked to the postprocedural incidence of MACCE. However, most of them, except for chronic kidney disease (HR 1.62, 95% CI 1.08–2.45, p = 0.02), displayed a non-significant role (p > 0.05).

Conversely, the higher the preoperative LVEF, the lower the incidence of MACCE. Each 1% raise in the LVEF was mirrored as a 6% decreased incidence of the worst cardiac and cerebral outcomes with a hazard ratio of 0.94 (95% confidence interval 0.91–0.98, p = 0.002).

These findings emphasize the prognostic importance of complete revascularization and preserved ventricular function, with CABG conferring a more favorable mid-term outcome compared with PCI.

**Table (5): Multivariable Cox regression for predictors of MACCE**

| Variable | Hazard Ratio (HR) | 95% CI | p-value |
|---|---|---|---|
| PCI (vs. CABG) | 1.54 | 1.09–2.18 | 0.01 |
| Incomplete revascularization | 1.78 | 1.19–2.67 | 0.005 |
| Chronic kidney disease | 1.62 | 1.08–2.45 | 0.02 |
| Age (per year) | 1.02 | 0.99–1.04 | 0.12 |
| Diabetes mellitus | 1.18 | 0.84–1.67 | 0.33 |
| Preoperative LVEF (per %) | 0.94 | 0.91–0.98 | 0.002 |

*HR = hazard ratio; CI = confidence interval; KM = Kaplan–Meier.*

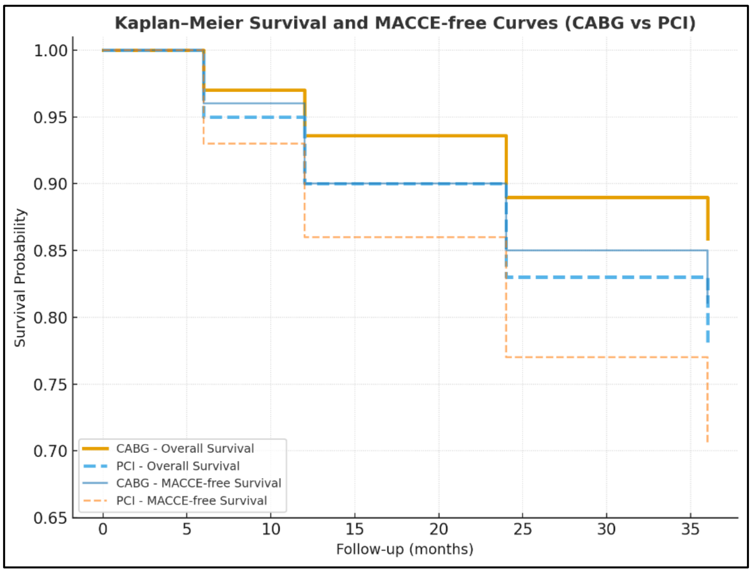


**Figure (2): Kaplan–Meier plot comparing overall survival and MACCE-free survival between CABG and PCI groups**

## DISCUSSION

Our efforts in this study were directed at highlighting the best interventional revascularization therapy for patients with ULMCA lesions and severe ischemic cardiomyopathy (LVEF < 40%) by comparing the early and mid-term outcomes of surgical CABG and transcatheter stent deployment (PCI).

We found that CABG offered higher mid-term survival and freedom from MACCE, which may be explained by the higher rates of complete revascularization and the greater improvement in myocardial activity as detected by postoperative echocardiographic studies measuring the LVEF. These findings demonstrate the prognostic value of CABG in such high-risk patients.

The primary revascularization method for ischemic heart diseases is still surgical CABG. Although percutaneous interventional therapy is becoming more and more popular as a less invasive and effective alternative to CABG, there is still disagreement about the safest and most effective revascularization method in some cases with unfavorable anatomy, insufficient collateral capillaries, limited myocardial reserve, and significant atherosclerotic burden[3,25].

Our findings that favored CABG strategy regarding less incidence of MACCE (18.9% vs. 29.6%, p = 0.01) and revascularization need (5.0% vs. 13.2%, p = 0.004) at 36 months median follow-up compared to PCI are consistent with those reported by the MAIN-COMPARE extended analysis, which showed that surgical revascularization provided lower 10-year mortality and re-revascularization rates in patients with complex or high-risk coronary disease[26].

CABG achieved these favorable outcomes among our patients by several mechanistic and procedural factors that ensured attacking all accessible culprit and non-culprit lesions with complete revascularization techniques known with far longer durability for their ability to minimize incidence of atherosclerotic plaque progression and /or rupture[27,28]. In contrast, PCI even with using drug eluting stents, still a less durable solution that commonly offer residual ischemic territories in the myocardium and residual unmanaged coronary lesions with subsequent higher rates of restenosis and need for re-revascularization[29]. This obviously mirrored in our findings, where incomplete revascularization independently predicted MACCE (HR 1.78, 95% CI 1.19–2.67, p = 0.005).

Multiple multicenter studies have corroborated our results, including the SYNTAXES trial, which tracked the participants for 10 years and indicated that patients with intricate coronary anatomy (SYNTAX score ≥ 33) experienced a significant survival advantage from CABG compared to PCI[1]. Additionally, the EXCEL and NOBLE trials demonstrated increased rates of serious adverse cardiac and cerebrovascular events, along with a greater necessity for revascularization[30,31]. Notably, the majority of these trials omitted patients with diminished LVEF. This renders real-world data, like ours, essential for addressing this evidence gap. Regardless of the revascularization method employed, following the procedure, the hibernating myocardium regained its pumping function, leading to a notable enhancement in LVEF[1] which was similarly evident in our patients. Nonetheless, a more significant enhancement post-procedure was seen after CABG in comparison to PCI (+6.8 ± 4.2% vs. +3.1 ± 3.7%, $p < 0.001$), aligning with views that theoretically indicate superior reperfusion with CABG for treating multivessel or diffusely affected coronary arteries[34]. In addition to enhancing myocardial function, CABG utilizing durable grafts, especially connecting the LIMA to the left anterior descending artery (LAD), significantly contributed to maintaining myocardial perfusion and viability[32].

The multivariable Cox regression from our study indicated that, alongside chronic renal disease, PCI and partial revascularization were standalone predictors of adverse outcomes. These elements correspond with previous studies indicating that kidney dysfunction is a major predictor of illness and death after revascularization[39]. It's noteworthy that a 6% reduction in MACCE risk was associated with each 1% increase in preoperative LVEF, highlighting the significance of ventricular function in prediction that echoes findings reported by Tsai et al.[33] as one of the most significant predictors of long-term survival after either CABG or PCI in LM disease.

Although CABG was associated with longer procedural time, extended ICU stay, and greater use of mechanical support, these early disadvantages did not translate into higher mortality or stroke rates at 30 days. This suggests that with modern perioperative management, the surgical risk is acceptable even in patients with depressed ventricular function. Similar trends were reported by Kim et al.[34] and Zhao et al.[35], where early postoperative morbidity was offset by superior long-term outcomes in the surgical arm. Clinically speaking, our results are consistent with current guidelines that indicate CABG as the preferred revascularization strategy for patients with LM disease who also have complex coronary architecture or reduced EF[10,36]. Some patients with isolated LM illness, a poor SYNTAX score, or those deemed unsuitable for surgery due to comorbidities may nevertheless benefit from PCI[37]. However, the durability of CABG outcomes and enhanced ventricular recovery support its continued dominance in this group.

This study highlights the need of tailored revascularization decisions that are based on talks within a multidisciplinary heart team and take into account surgical risk evaluations, patient comorbidities, and anatomical complexity. In the era of sophisticated mechanical circulatory support and hybrid revascularization techniques, future research should focus on prospective registries and randomized studies targeted at patients with decreased EF in order to validate and improve these findings.

## LIMITATIONS

This study's retrospective and observational design introduce potential selection bias despite prospective data collection and balanced baseline characteristics. Treatment choice was guided by multidisciplinary discretion and patient preference, which may have influenced outcomes. Unmeasured factors such as lesion complexity, completeness of revascularization, and operator experience could also have impacted results. Although follow-up was sufficient for mid-term assessment, long-term differences may remain underrepresented. Moreover, being conducted over a 36 months median follow-up, more extended follow-up are needed to confirm our findings.

## CONCLUSION

"In patients with unprotected left main coronary artery disease and reduced LVEF, CABG and PCI yielded comparable short-term outcomes. However, CABG was associated with significantly lower mid-term MACCE rates, reduced need for repeat revascularization, and greater improvement in LVEF. These findings support a heart-team–based individualized approach when selecting the optimal revascularization strategy for this high-risk population."

**Conflict of interest:** none declared

**Fund:** non-fundable

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