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*Original Article*

# Surgical revascularization in stable coronary artery disease with ventricular dysfunction: a single-center cohort study

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**Abstract:** Purpose: Stress-gated myocardial perfusion scintigraphy (MPS) is used for prognosis in stable coronary artery disease (CAD). We sought to assess coronary artery bypass grafting (CABG) outcomes in stable coronary artery disease patients who had myocardial perfusion scintigraphy and left ventricular (LV) dysfunction. Methods: Stable CAD patients who underwent CABG (2012-2019) and had stress-gated MPS were identified retrospectively. Based on the post-stress LV ejection fraction, a total of 130 patients were divided into a control group (51%) and LV dysfunction group (49%). Results: Patients with left ventricular dysfunction had significantly more mean summed stress score (22.1 ± 9 Vs. 12.5 ± 8; P ≤ 0.001) and summed resting score (14.6 ± 8 Vs. 3.7 ± 4; P ≤ 0.001) compared to the control group respectively. They also had a greater risk for developing low cardiac output syndrome after surgery (OR: 2.9, 95% CI 1.1-6.6, P=0.033). At 4.7 years, freedom from cardiac death was not statistically significant between the left ventricular dysfunction and control groups, respectively (90.2% vs. 95.6%; P=0.157). Cardiac death was not influenced by either ventricular dysfunction at the time of surgery (HR: 2.6, 95% CI 0.64-10.6, P=0.182) nor by having percent ischemic myocardium > 10% (HR: 0.86, 95% CI 0.23-3.24, P=0.826). Conclusion: Significant myocardial ischemia and ventricular dysfunction before complete surgical revascularization did not influence the risk of cardiac-related deaths on long-term follow-up. This might be related to the improved survival after CABG in patients with myocardial ischemia and left ventricular dysfunction.

**Keywords:** Coronary revascularization, imaging, prognosis

## Introduction

Cardiovascular disease (CVD) is the leading cause of early death due to non-communicable diseases worldwide. Of all of the treatable conditions, ischemic heart exerts the highest burden of disease in the developed world [1, 2]. During the last five decades, coronary artery bypass grafting (CABG) has emerged as the gold standard for treating patients with multivessel coronary disease. It remains one of the most extensively studied surgical procedures in the medical literature [3]. Besides being highly effective in relieving stable coronary artery disease (CAD) symptoms, some subgroups of patients who undergo CABG also show improved overall survival in the first ten years after revascularization compared to those who receive medical treatment alone [4].

Left ventricular (LV) dysfunction associated with ischemic cardiomyopathy due to long-standing CAD is a hallmark of patients who gain a survival benefit at ten years after undergoing CABG. In contrast, similar patients subjected to medical therapy alone do not fare as well [5]. Stress-gated myocardial perfusion scintigraphy (MPS) is used to objectively quantify functional myocardial ischemia in individuals suspected of having CAD [6]. MPS results can also be utilized as a prognosis tool to help identify those who might benefit from early revascularization versus conservative medical treatment. Hachamovitch et al. have demonstrated that early revascularization in patients with moderate to severe ischemia on MPS does give a survival advantage over optimal medical treatment [7, 8]. A few observational studies elucidated the implications of having

LV dysfunction on the predictive benefits of revascularization after stress-gated MPS [9, 10]. These studies focused on the event-free survival benefits of revascularization compared to the conservative medical management in patients suspected of having stable CAD.

Based on the previous studies, prognosis among the CAD patients is associated with LV ejection fraction, LV end-systolic volume index, and several vessels detected with stenoses angiographically [11-13]. However, clarity is needed for making decisions about revascularization in patients with ischemic cardiomyopathy. A previous study by Panza et al. [14] assessed the impact of anatomic variables on poor prognosis in ischemic cardiomyopathy. It revealed that CABG is beneficial for patients with advanced ischemic cardiomyopathy. This strengthens the case for surgical revascularization of patients with advanced CAD and worsening myocardial instability and remodeling. The present study aims to assess the impact of having LV dysfunction on the immediate and late event-free outcomes after performing CABG in patients with stable CAD who had MPS before revascularization in a retrospective observational series. We hypothesized that complete revascularization with CABG could mitigate the adverse effects of LV dysfunction in patients who present with significant functional ischemia burden. The immediate primary outcome was defined by the development of low cardiac output syndrome, and the late primary outcome was defined by freedom from cardiac death.

## Methods

### *Ethical approval*

After approval from the local institutional review board and censoring sensitive patient-specific data, individual patient consent was waived for this study (No. E-19-3849).

### *Study design*

All patients who had isolated CABG performed at our local hospital between January 2012 and June 2019 were retrospectively identified and were matched using their file number with the department of nuclear medicine's stress-gated MPS database.

### *Study sample*

A total of 1200 patients who underwent CABG were identified in the study timeframe.

### *Inclusion and exclusion criteria*

Among the 1200 identified patients, 130 patients were labeled as having stable CAD. Inclusion was done on the bases of patients who had the stress-gated MPS study done before CABG, had a gap of no more than 90 days between MPS and CABG, had LV ejection fraction > 20% on pre-operative echocardiography, and did not undergo other procedures combined with CABG. However, the patients who presented with the acute coronary syndrome (ACS) less than three months before having CABG were excluded.

### *Study procedure*

All patients had MPS performed using single-photon emission computed tomography (SPECT) in a same-day protocol with a two-time injection of the radioactive tracer methoxy-isobutyl-isonitrile labeled with technetium 99m ($^{99m}$TC-MIBI). Image acquisition was performed using a dual-head rotating gamma camera connected to a computer system [15]. Most patients in the series stress phase were pharmacologically induced using adenosine infusion (140 μg/kg/min) after stopping caffeine consumption for 24 hours. At the peak of stress, $^{99m}$TC-MIBI (8-10 millicuries) was administered. A resting examination was performed three hours later after administering a higher dose of the same tracer (24-30 millicuries). Electrocardiographic gating was used to divide the cardiac cycle into eight frames to enable quantitative assessment of LV ejection fraction and systolic function. A post-stress LV ejection fraction of ≤ 50% was used as an indicator of LV dysfunction. A computer software (Cedar-Sainai Medical Center software; QPS-Quantified Perfusion Spect, Los Angeles, CA, USA) was used for the semiquantitative evaluation of the perfusion score using the 17-segment polar map established by the American Heart Association. Normal perfusion using gender-specific normal limits was used to indicate the perfusion defect by a scale of 0-4 (0= normal, 1= mild, 2= moderate, 3= significant, and 4= no perfusion) for each of the scanned myocardial segments. The global scoring of myocardial

perfusion was expressed in the following measures: Summed Stress Score (SSS) was taken during the stress phase, Summed Rest Score (SRS) was taken during the rest phase, Summed Difference Score (SDS) was calculated by subtracting SRS from SSS, and Summed Difference percent (SD%) which is a percent fraction of the overall functional ischemia burden within the scanned myocardium (SDS/64 times 100). The ischemia burden size was considered to be significant if SD% was above 10%. All patients underwent transthoracic echocardiography before CABG surgery, and ejection fraction was determined.

All CABG procedures were done using cardiopulmonary bypass. The systemic body temperature was cooled to 32°C, and the heart was arrested using cold blood-potassium cardioplegia after applying a cross-clamp. All patients had the left internal mammary artery graft to the left anterior descending artery. A segment of the greater saphenous vein was used to graft the other targets. A minority of patients received total arterial revascularization (4%). After CABG surgery, each patient was transferred from the operating room to the cardiac intensive care unit under sedation and mechanical ventilation. Pulmonary artery catheter cardiac studies and blood gas analyses were performed on an hourly basis for the first 24-hours after surgery or longer when indicated. Completeness of revascularization was determined by successfully grafting all diseased coronary distribution territories. New Q-waves defined postoperative myocardial infarction (MI) in electrocardiography. Low cardiac output syndrome (LCOS) was defined by the use of vasopressors or mechanical devices for more than 30 minutes to maintain a systolic blood pressure greater than 90 mmHg with a cardiac index (CI) < 2.2 l/m/m$^2$. All the relevant in-hospital information was collected from a prospective local cardiac surgery registry, operative reports, and intensive care flow charts.

Crude survival was determined during the last quarter of 2019 by matching each patient's unique national identification number in the series with the national death registry. The cause of death was determined by reviewing the death certificate for those who matched in the registry. Those who did not match in the death registry were censored at the time of the inquiry. Primary cardiac death was determined if the cause of death was an acute coronary syndrome, cardiogenic shock, congestive heart failure, valvular heart disease, death during a cardiac procedure, or sudden cardiac death. Cardiac survival was determined by censoring non-cardiac causes of death.

*Data analysis*

Statistical analysis was performed using SPSS 21.0 software (SPSS Inc., Chicago, IL). Categorical data were summarized as absolute numbers and percentages. Numeric data were summarized as the mean and standard deviation (SD) or median and interquartile range. The tested variables were grouped in 2 × n tables, and the two-group comparisons were made using the Chi-square test or Fisher exact test for categorical data. Continuous variables were tested using the Student T-test or Mann-Whitney U test. The crude odds ratio with 95% confidence intervals (CIs) was estimated using univariate logistic regression, and the adjusted odds ratio (OR) with 95% CIs was estimated using multiple logistic regression analysis. Crude survival and event-free survival curves comparisons were made using the log-rank test. The results were expressed hazard ratio (HR), 95% confidence interval (95% CI), and *p* values. A two-tailed *p*-value < 0.05 was considered significant for all statistical tests.

## Results

*Cohort demographics*

Of the total 1200 isolated CABG procedures done at our local institution between 2012-2019, only 11% matched the criteria for inclusion in this series. All patients presented with stable CAD and had stress-gated MPS before CABG. The median follow-up was 4.7 years [25$^{th}$: 2.4; 75$^{th}$: 6.2]. Depending on the presence or absence of LV dysfunction on post-stress LV ejection fraction, the cohort was almost equally divided (**Table 1**). The patients with LV dysfunction presented with a significantly higher incidence of diabetes (79% vs. 52%; P=0.002) and a history of myocardial infarction (23% vs. 10%; P=0.048) in a predominantly male sample compared to controls. For the whole cohort, there was no significant discrepancy between the post-stress LV ejection fraction % as determined by post-stress MPS

**Table 1.** Demographics

| | Post-stess EF > 50% (Normal LV) | Post-stess EF ≤ 50% (Dysfunctional LV) | *P-value* |
|---|---|---|---|
| | n=69 | n=61 | |
| Age (years) | 57 (50, 65*) | 59 (54, 65*) | 0.280 |
| Male gender (%) | 60 (87%) | 49 (80%) | 0.305 |
| Diabetes | 36 (52%) | 48 (79%) | 0.002 |
| Hypertension | 55 (80%) | 52 (85%) | 0.277 |
| Hyperlipidemia | 40 (58%) | 34 (56%) | 0.468 |
| Smoking history | 61 (88%) | 51 (84%) | 0.295 |
| Family history of CAD | 10 (14%) | 13 (21%) | 0.216 |
| NYHA Class III-IV (%) | 3 (4%) | 7 (11%) | 0.188 |
| History of MI | 7 (10%) | 14 (23%) | 0.048 |
| Resting left ventricular EF % | 60 ± 6.3 | 39 ± 8.4 | < 0.001 |
| Days to revascularization | 27 (11, 47*) | 21 (7, 46*) | 0.306 |
| Left main CAD | 9 (13%) | 13 (21%) | 0.210 |
| SSS | 12.5 ± 8 | 22.1 ± 9 | < 0.001 |
| SRS | 3.7 ± 4 | 14.6 ± 8 | < 0.001 |
| SDS | 8.9 ± 8 | 7.5 ± 6 | 0.261 |
| SD% | 13.2 ± 9 | 11.0 ± 8 | 0.261 |

*The 25$^{th}$ and 75$^{th}$ centiles of the data range. NYHA: New York Heart Association class; MI: Myocardial infarction; CAD: Coronary artery disease; SSS: Summed stress score; SRS: Summed resting score; SDS: summed difference score; SD%: Summed difference percent of total myocardial perfusion.

and LV ejection fraction % measured by resting echocardiography, respectively [median 51.5% (25$^{th}$: 40%; 75$^{th}$: 59%) Vs. 50% (25$^{th}$: 40%; 75$^{th}$: 60%); P=0.284]. The mean LV ejection fraction % measured by echocardiography before CABD was 60% in the control group versus 39% in the LV dysfunction group (P ≤ 0.001). Both groups had no significant delay from the time of MPS up to undergoing CABG revascularization respectively [median 27 days (25$^{th}$: 11; 75$^{th}$: 47) vs. 21 days (25$^{th}$: 7; 75$^{th}$: 46); P=0.306]. The left main coronary disease incidence was not statistically different (13% in the controls vs. 21% in the LV dysfunction group; P=0.210).

*Pre-revascularization ischemia burden*

The LV dysfunction group had significantly more mean ischemia scores during MPS stress phase SSS (22.1 ± 9 vs. 12.5 ± 8; P ≤ 0.001) and resting phase SRS (14.6 ± 8 vs. 3.7 ± 4; P ≤ 0.001), but similar overall inducible ischemia burden SD% (11.0% vs. 13.2%; P=0.261) compared to the control group respectively. Having SD% of > 10%-as an indicator of significant ischemia burden-did not show a significant impact on the post-stress LV ejection fraction % at the time of MPS study for the entire cohort (OR: 1.37, 95% CI 0.69-2.74, P=0.368) (**Figure 1**).

*Immediate outcomes*

During the intraoperative course, the LV dysfunction groups had a significantly longer cardiopulmonary bypass time (106 ± 23 minute vs. 96 ± 17 minutes; P=0.004) and required more (≥ 2) vasopressor agents to support the circulation (23% vs. 7%; P=0.011), as compared to the controls respectively (**Table 2**). This resulted in more patients in the LV dysfunction group experiencing LCOS (25% vs. 10%; P=0.028) and increased mean peak lactic acid (10 ± 3 U/l Vs. 5.2 ± 2 U/l; P ≤ 0.001) during the ICU stay. Although not statistically significant, more patients in the LV dysfunction group required an intra-aortic balloon pump (IABP) (18% Vs. 7%; P=0.062) and had on average a lower nadir of mixed venous oxygen saturation (56 ± 7% Vs. 58 ± 6%; P=0.066) and mean CI (2.4 ± 0.6 L/kg/M$^2$ Vs. 2.6 ± 0.5 L/kg/M$^2$; P=0.092) for the first 24 hours after CABG. One patient in the LV dysfunction group died 36 days after CABG due to stroke complications. All the other patients in the series were successfully discharged home. Left ventricular dysfunction was significantly associat-

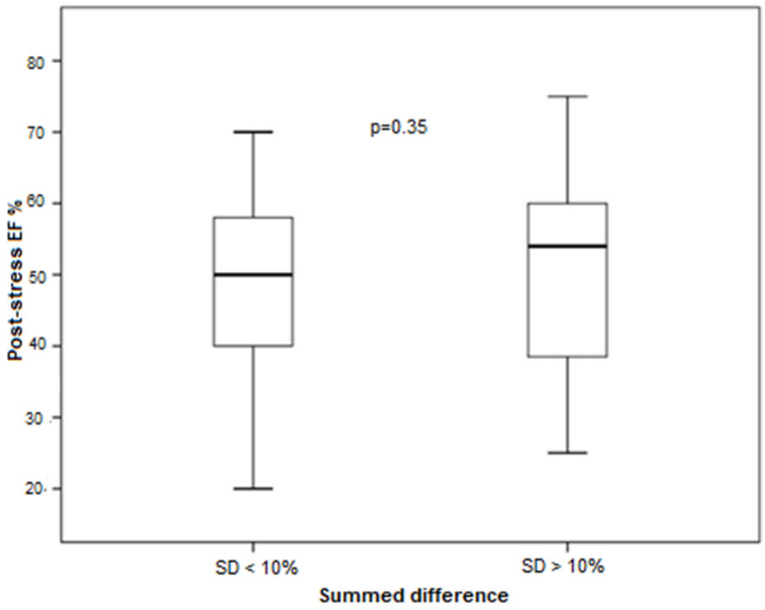


**Figure 1.** The threshold of 10% of ischemic myocardium of the total myocardial perfusion did not have an impact on the post-stress left ventricular ejection fraction during myocardial perfusion scintigraphy. SD%: Summed difference percent; EF: Ejection fraction.

ed with an increased risk of developing LCOS immediately after CABG (OR: 2.9, 95% CI 1.1-6.6, P=0.033). However, after adjusting for possible confounders: old age, sex, hypertension, hyperlipidemia, diabetes, history of MI, advanced NYHA class, and > 10% ischemic myocardium, this association became less significant (OR: 2.6, 95% CI 0.84-6.94, P=0.097) (**Figure 2**).

*Late outcomes*

At a median follow-up of 4.7 years after having the stress-gated MPS study, crude survival was worse for the LV dysfunction group than the control group, respectively, when using all-cause mortality as an endpoint (80.3% vs. 92.7%; P=0.026) (**Figure 3**). Conversely, the freedom from cardiac death was not statistically significant between the two groups, respectively (90.2% vs. 95.6%; P=0.157) (**Figure 4**). Cardiac death was not significantly influenced by either LV dysfunction at the time of CABG (HR: 2.6, 95% CI 0.64-10.6, P=0.182) nor by having percent ischemic myocardium, SD% > 10% (HR: 0.86, 95% CI 0.23-3.24, P=0.826). There was no significant interaction between having LV dysfunction and demonstrating a significant ischemia burden on MPS before CABG when adjusting for cardiac death (r=-0.058; P=0.095) as the outcome on follow-up.

## Discussion

The findings from this cohort study support the hypothesis that successful revascularization with CABG in stable CAD gives favorable outcomes in patients with ischemic cardiomyopathy when using cardiac death as an endpoint at 4.7 years median follow-up. The low yield in selecting appropriate patients for inclusion in the cohort represents an observed trend in our practice where most patients with CAD present with acute coronary syndromes. Those with stable CAD tend to be underdiagnosed or medically treated. The LV dysfunction group presented a higher spectrum of disease, which may explain the lower crude survival. They also required more circulatory support in the immediate postoperative period to mitigate the higher incidence of LCOS associated with adverse events after CABG. Despite this shortcoming, successful revascularization with CABG seems to reset the natural trajectory of cardiac death in ischemic cardiomyopathy to a good course comparable to those with preserved LV function. These findings are consistent with early landmark clinical trials where an initial CABG strategy was associated with more prolonged survival than those subjected to medical therapy alone [16]. The subgroups with more extensive CAD and higher underlying risks-including those with LV dysfunction-showed the most significant survival benefit from CABG [4]. The more contemporary extended STICH trial showed an 8% absolute mortality reduction for CABG versus guideline-based medical therapy in ischemic cardiomyopathy (EF ≤ 35%) [5]. Further comparison-in another study-of the long-term outcomes and freedom from major adverse cardiac events (MACE) between CABG and percutaneous coronary intervention (PCI) in patients with severely reduced left ventricular function (EF < 35%) demonstrated a clear

**Table 2.** Immediate revascularization outcomes

| | Post-stress EF > 50% (Normal LV) | Post-stress EF ≤ 50% (Dysfunctional LV) | *P-value* |
|---|---|---|---|
| | n=69 | n=61 | |
| Complete revascularization | 65 (94%) | 54 (86%) | 0.246 |
| Post-Op cardiac index (mean) ± SD | 2.6 ± 0.5 | 2.4 ± 0.6 | 0.092 |
| Lowest mixed venous oxygen saturation % ($SVO_2$) | 58 ± 6 | 56 ± 7 | 0.066 |
| Requirement for multiple vasopressors (%) | 5 (7%) | 14 (23%) | 0.011 |
| Peak lactic acid (U/l) ± SD | 5.2 ± 2 | 10 ± 3 | < 0.001 |
| IABP (%) | 5 (7%) | 11 (18%) | 0.062 |
| Myocardial infarction (%) | 0 (0%) | 2 (3%) | 0.218 |
| Low cardiac output syndrome (%) | 7 (10%) | 15 (25%) | 0.028 |
| New Post-Op Dialysis (%) | 0 (0%) | 0 (0%) | 0.549 |
| Atrial Fibrillation (%) | 3 (4%) | 6 (9%) | 0.304 |
| Stroke/TIA (%) | 0 (0%) | 2 (3%) | 0.218 |
| Hospital death (%) | 0 (0%) | 1 (2%) | 0.469 |

IABP: Intra-aortic balloon pump; TIA: Transient ischemic attack.

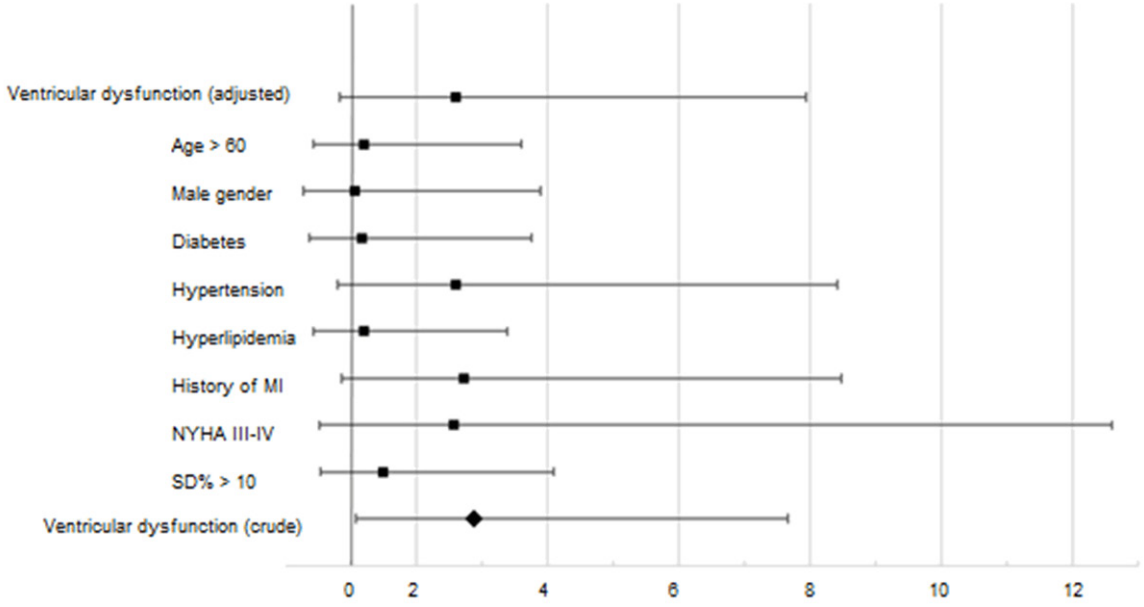


**Figure 2.** Multi-variable logistic regression for plot for left ventricular dysfunction's association with low cardiac output syndrome (LCOS) during coronary bypass surgery. NYHA: New York Heart Association class; MI: Myocardial infarction; SD%: Summed difference percent of total myocardial perfusion.

survival benefit associated with undergoing CABG across different subgroups independent of diabetes and was especially evident in those with multi-vessel disease [17]. Improved survival rates in patients with LV dysfunction post CABG can be attributed to several factors which include improvement in the LV metabolic function, improved contractility, induction of reverse LV remodeling, and the revival of hibernating myocardial cells.

Previous studies examined the merits of revascularization in different subgroups with quantifiable functional ischemia and LV dysfunction by comparing revascularization-either by CABG or PCI-against medical treatment [8-10]. The current study established a new benchmark with the two competing arms having the same revascularization procedure but at different spectrums of LV function. In a large population-based study in Sweden by Dalen et al.

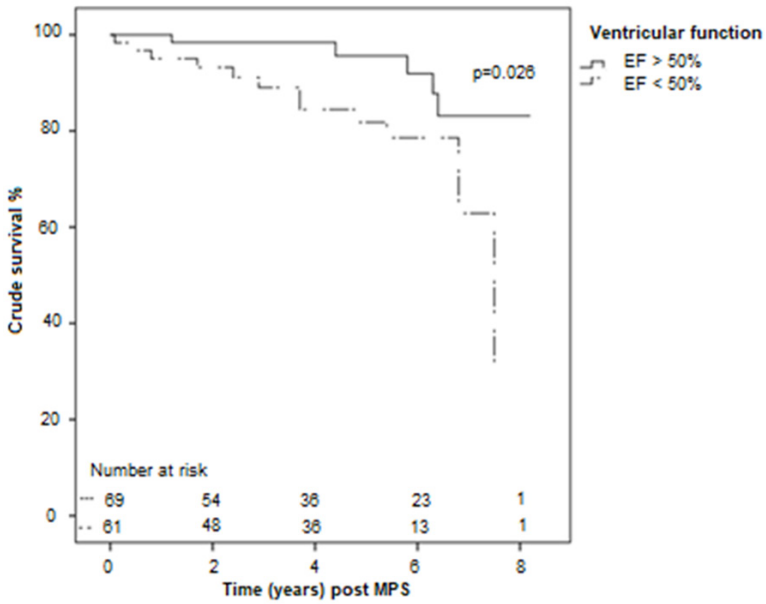


**Figure 3.** Crude survival at a median of 4.7 years of follow-up. The all-cause mortality was worse in the left ventricular dysfunction group compared with controls. EF: Ejection fraction.

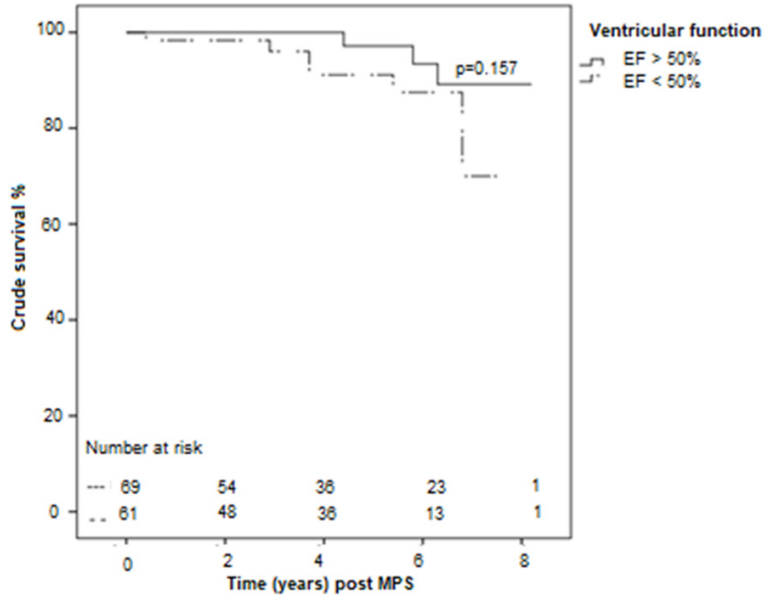


**Figure 4.** Freedom from cardiac death at a median of 4.7 years was not significantly different between left ventricular dysfunction group versus controls. EF: Ejection fraction.

looking at survival after CABG, Dalen, and colleagues found that the multivariable-adjusted hazard ratio for all-cause mortality significantly increased with the presence of heart failure but was less affected by the pre-operative LV ejection fraction, which was more associated with short-term prognostication [18]. Similarly, our study showed a significant impact of reduced ejection fraction on the immediate perioperative outcomes.

To date, the studies closest to ours were conducted using functional ischemia and LV function as prognostication tools to identify patients with stable CAD who are likely to reap the benefits of early revascularization versus conservative medical treatment. In a long-term observational series, Petretta et al. [10] demonstrated the effects of inducible functional ischemia, as determined by SD%, and post-stress LV function on the benefits of revascularization (CABG/PCI) on individuals with stable CAD during a median of 5 years. Event-free survival from cardiac death and nonfatal myocardial infarction was significantly better in the revascularization group, demonstrating significant ischemia (high SD%) and preserved LV function. Those with no evidence of ischemia on MPS did not show a survival benefit except when the LV ejection fraction was ≤ 45%. Furthermore, the optimal cutoff of the ischemia burden size for gaining the protective effect of revascularization depended on the post-stress LV function. The percent ischemic myocardium cutoff was ≥ 8.8% for preserved LV function and 4.4% for those with LV dysfunction. Accordingly, the presence of LV dysfunction was found to lower the threshold of percent ischemic myocardium to mandate revascularization to gain a survival advantage. These findings somewhat contradict a similar but an earlier study done by Hachamovitch et al. [9] where LV ejection frac-

tion was superior to percent ischemic myocardium in predicting cardiac survival at a mean follow-up 2.8 years. An interaction between percent ischemic myocardium and LV dysfunction (LV ejection fraction < 45%) was only found to give a survival benefit in the presence of significant ischemia (SD% ≥ 10%). In patients with less percent ischemic myocardium (SD% < 10%) revascularization had a worse survival when compared to conservative treatment. A key piece of information missing in both studies-including the current one-is the presence of scarred myocardium, which is unlikely to benefit from revascularization. Myocardial scan protocols other than the one applied in this study or other imaging modalities such as cardiac magnetic resonance imaging (CMRI) are better suited for differentiating scared myocardium from hibernating myocardium in ischemic cardiomyopathy. In our cohort, the exclusion of patients with acute coronary syndromes, the low number of patients with advanced NYHA class, and the stable nature of CAD all favor the presence of hibernating myocardium in LV dysfunction rather than scar tissue. Unfortunately, we have no conclusive evidence to support the presence of hibernating cells.

Early invasive revascularization has been subjected to new rounds of contemporary large-scale randomized clinical trials in the era of drug-eluting stents and guideline-based medical therapy in stable CAD. Some of these trials have failed to demonstrate the benefit of an early invasive strategy [19-21]. These studies were limited by not including many high-risk subjects, which would inherently go for immediate revisualization and thus be excluded from the randomization process. This clinical bias was recently tackled by The International Study of Comparative Health Effectiveness with Medical and Invasive Approaches (ISCHEMIA) Study [22-24]. In it, 5,179 patients from 37 countries who had stable ischemic heart disease were randomized to an invasive strategy comprised of coronary angiography followed by revascularization (PCI or CABG depending on the local heart team) plus medical therapy or just conservative medical treatment without diagnostic coronary angiography to reduce the likelihood selection bias. The study subjects had to show evidence of moderate to severe ischemia on non-invasive stress tests before randomization. At the end of 5 years (median 3.2 years) of follow-up, there was no significant difference between the two strategies in death from cardiovascular causes, MI, or hospitalization for unstable angina, heart failure, or resuscitated cardiac arrest.

On the other hand, the patients in the invasive group reported substantially fewer angina symptoms than patients in the conservative group, particularly for those who had more angina at baseline. Although this study showed that adopting an early invasive strategy was not advantageous for cardiac survival in stable CAD, it did not tease out the “high risk” group based on standardized stress-gated MPS protocols and LV function. Likely, a longer follow-up or a subgroup analysis which includes those with symptoms (35% had no angina at baseline in the ISCHEMIA trial) and LV dysfunction, would yield a survival advantage with an invasive approach. Under such assumptions, our study even becomes more relevant as all patients selected for CABG inherently had a high ischemia burden. It is also worth noting that CABG is superior to PCI when it comes to survival in high-risk multi-vessel disease. This benefit gets diluted when both interventions are lumped together, such as with the ISCHEMIA trial.

The current study is unique in shedding light on the beneficial effects of early revascularization with CABG, which may mitigate cardiac death in patients with stable CAD who demonstrate significant ischemia and LV dysfunction. Yet, its findings are limited by the retrospective observational nature of its design. The small number of patients found to have stress-gated MPS before CABG might have underpowered competing factors associated with cardiac death. The sample was predominantly male patients. There was no clear distinction between those who had scarred myocardium and those with viable myocardium for the patients with LV dysfunction, as no viability protocols were performed. There was no follow-up of LV ejection fraction post CABG. The survival follow-up was done mainly through a comprehensive administrative registry but was not verified by other direct means. Other than survival and the cause of death, the follow-up lacked any inquiries regarding the quality of life, which is becoming increasingly important and relevant in patients with ischemic heart disease.

In conclusion, the natural history of patients with stable CAD is influenced by many factors, including ischemia burden size and ventricular function. Early revascularization, particularly with CABG, seems to give a survival benefit in those with higher percent ischemic myocardium and varying degrees of LV dysfunction. Revascularization with CABG may mitigate future cardiac death in stable CAD with LV dysfunction.

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## Disclosure of conflict of interest

None.

## Abbreviations

CABG, Coronary Artery Bypass Grafting; CAD, Coronary Artery Disease; CI, Cardiac Index; CVD, Cardiovascular Disease; LCOS, Low Cardiac Output Syndrome; LV, Left Ventricular; MI, Myocardial Infarction; MPS, Myocardial Perfusion Scintigraphy; SD%, Summed Difference Percent; SDS, Summed Difference Score; SPECT, Single-Photon Emission Computed Tomography; SRS, Summed Rest Score; SSS, Summed Stress Score; CIs, confidence intervals; HR, hazard ratio.

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