Long-term outcome of surgical revascularization in patients with reduced left ventricular ejection fraction—a population-based cohort study

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Abstract

OBJECTIVES: Surgical revascularization is an established indication for patients with advanced coronary artery disease and reduced left ventricular ejection fraction (LVEF). Long-term outcomes for these patients are not well-defined. We studied the long-term outcomes of patients with ischaemic cardiomyopathy who underwent surgical revascularization in a well-defined nationwide cohort.

MATERIALS AND METHODS: A retrospective study on 2005 patients that underwent isolated coronary artery bypass grafting in Iceland between 2000 and 2016. Patients were categorized into two groups based on their preoperative LVEF, LVEF ≤35% (n = 146, median LVEF 25%) versus 9% for patients with LVEF > 35%.

Key question

Does heart failure have a significant effect on long-term outcomes after CABG surgery?

Key finding(s)

The rate of death at 5 years was 31% for patients with LVEF ≤ 35% versus 9% for patients with LVEF > 35%.

Take-home message

LVEF ≤ 35% was the strongest predictor for mortality in our cohort with a hazard ratio of 2.0.
RESULTS: Demographics were similar in both groups regarding age, gender and most cardiovascular risk factors. However, patients with LVEF ≤35% more often had diabetes, renal insufficiency, chronic obstructive pulmonary disease and a previous history of myocardial infarction. Thirty-day mortality was 4 times higher (8% vs 2%, P < 0.001) in the LVEF ≤35%-group compared to controls. Overall survival was significantly lower in the LVEF ≤35%-group compared to controls, at 1 year (87% vs. 98%, P < 0.001) and 5 years (69% vs. 91%, P < 0.001). In multivariable analysis LVEF ≤35% was linked to inferior survival with an adjusted hazard ratio of 2.0 (95%-CI 1.5 - 2.6, p<0.001).

CONCLUSIONS: A good long-term outcome after coronary artery bypass grafting can be expected for patients with reduced LVEF, however, their survival is still significantly inferior to patients with normal ventricular function.

Keywords: Surgical revascularization • Coronary artery bypass grafting • Reduced left ventricular ejection fraction • Risk factors • Long-term outcome • Survival

**ABBREVIATIONS**

| AKI | CABG | CKD | COPD | DM | eGFR | LVEF | MACCE | MI | NYHA | PCI |
|-----|------|-----|------|----|------|------|------|----|------|-----|
| Acute kidney injury | Coronary artery bypass grafting | Chronic kidney disease | Chronic obstructive pulmonary disease | Diabetes mellitus | Estimated glomerular filtration rate | Left ventricular ejection fraction | Major adverse cardiac and cerebrovascular event | Myocardial infarction | New York Heart Association | Percutaneous coronary intervention |

**INTRODUCTION**

Heart failure with reduced left ventricular ejection fraction (LVEF) as a result of coronary atherosclerosis is a major health burden, with a prevalence that is estimated to increase over the next decades [1]. Optimal treatment has not been well established and whether these patients should undergo myocardial revascularization with coronary artery bypass grafting (CABG), percutaneous coronary intervention (PCI) or receive medical therapy only is still under debate. So far, the available data comparing these treatment strategies are mostly observational [2], as many of the randomized studies on the outcome of CABG versus PCI excluded patients with severely reduced LVEF [3,4].

Despite scarce long-term data, surgical revascularization is recommended (Class 1) over medical therapy alone by current guidelines for patients with ischaemic cardiomyopathy and 3-vessel coronary disease [5]. These recommendations are mainly based on the results of the STICH trial, the largest randomized trial to date comparing CABG to medical therapy alone in patients with ischaemic heart failure [6]. The STICH trial was first published in 2011 with a 5-year follow-up but did not identify a difference in all-cause mortality between CABG versus medical therapy alone. In 2016, an extended 10-year follow-up was published and the results showed a 7% absolute reduction in overall mortality after CABG compared to medical therapy alone [7]. Furthermore, a more recent analysis of the STICH trial has confirmed a more favourable outcome in the CABG group compared with medical therapy alone for other long-term outcomes like death from cardiovascular causes and cardiovascular hospitalization [8].

With a paucity of randomized trials available, observational studies can provide important data that can help clinicians in their decision-making. We therefore decided to study the outcome of CABG procedures in patients with coronary artery disease and ischaemic heart failure with LVEF of 35% or less in a well-defined whole-nation population. Our focus was on long-term outcomes, primarily overall (all-cause) mortality but also cardiac-specific mortality along with major adverse cardiac and cerebrovascular events (MACCE). By this, our goal was to provide information on the long-term outcome of surgical revascularization in patients with reduced LVEF in a well-defined population with thorough centralized follow-up.

**MATERIALS AND METHODS**

**Ethics statement**

The study was approved by the Icelandic National Bioethics Committee and the Data Protection Commission (1/10/20, VSN-19–04). Formal consent from patients was not needed due to anonymity.

**Study design**

This was a retrospective study that spanned 16 years between 1 January 2001 and 31 December 2016. The study group consisted of consecutive patients that underwent first time, isolated CABG in Iceland, excluding all patients undergoing concomitant procedures such as valve surgery. Patients with missing information on preoperative LVEF were excluded (n = 55), leaving 2005 patients for further analysis. All operations were performed at Landspitali University Hospital, the sole cardiothoracic center that serves all of Iceland, with a current population of 380 000 inhabitants. The patients were categorized into two groups based on their preoperative LVEF; LVEF ≤35% and LVEF > 35% as controls.

**Data collection and demographics**

To identify patients, we searched a digital diagnostic and operation registry using operative codes. When all patients had been identified, clinical information was gathered retrospectively from hospital charts at Landspitali. For long-term follow-up data, we also retrospectively reviewed medical records from all other hospitals in Iceland where patients are potentially admitted with cardiovascular disease. This made it possible to obtain thorough data on long-term complications for almost all patients. Furthermore, information on CABG and PCI...
could be obtained and checked from centralized registries, with information on survival being collected from the centralized registry Statistics Iceland for all patients.

Information on preoperative LVEF was obtained from echocardiographic reports. Most often, the preoperative ultrasound was done by an experienced cardiologist with the patient in stable condition, but in some acute or semi-acute cases, the echocardiography was done in less controlled situations. If more than one preoperative echocardiograph existed for the same patient the one closest to surgery was used. In a few cases where emergency surgery was needed, there was no preoperative ultrasound on record so the intraoperative ultrasound was used to evaluate LVEF.

Preoperative demographics included gender, age, cardiovascular risk factors such as hypertension, diabetes mellitus (DM) and smoking; chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD) and a previous history of myocardial infarction (MI) and/or PCI. CKD was defined as estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m² [9]. The New York Heart Association (NYHA) functional classification [10] was used to classify heart failure symptoms and the Canadian Cardiovascular Society grading system was used to grade angina [11]. Patient symptoms were classified into stable angina, unstable angina or new MI (indication for treatment) based on presenting symptoms in the same hospital stay the surgery was performed. Euroscore II [12] was then calculated for all patients to estimate the risk for 30-day mortality. All patients had a preoperative angiogram to evaluate the severity and distribution of the coronary artery disease.

Intraoperative variables included the operative technique, the urgency of the surgery (elective versus non-elective surgery with emergency surgery being defined as surgery within 24 h from hospital admission and semi-acute surgery being in the same hospital stay), use of cardiopulmonary bypass, duration of surgery (both skin–skin time and cross-clamp time) and the number of distal anastomoses performed. Postoperative bleeding (ml) in the first 24 h after surgery was documented, as well as the rate of re-exploration for bleeding.

Data on postoperative complications within 30 days from surgery were collected. These variables were perioperative MI (defined as isolated ST-segment changes or a new left bundle branch block on electrocardiogram, along with elevation of creatine kinase MB of ≥70 µg/l); stroke, poststernotomy mediastinitis, acute kidney injury (AKI) requiring dialysis, new-onset atrial fibrillation, pneumonia and pleural effusion. Operative mortality was defined as death within 30 days of surgery.

Outcome and follow-up

The long-term endpoints collected and used in this study were MI (more than 30 days after surgery), stroke (neurological signs that persisted for more than 24 h), PCI or repeated CABG, and death. All endpoints were then combined into MACCE. The diagnostic criteria for new MI were the presence of an elevation in cardiac biomarkers, in addition to one of the following: symptoms of myocardial ischaemia, new significant changes on electrocardiogram (ST-segment changes, new left bundle branch block or development of Q-waves), new wall motion abnormalities or intracoronary thrombus detected on diagnostic imaging. Patients who had a cardiovascular event and died during the follow-up period were included in each endpoint.

Follow-up was completed for all patients on 1 June 2017 with the median follow-up being 7.6 years (range 0.1–16.4).

Statistical methods

Statistical analysis was performed with Microsoft Excel (2011) and R version 3.3.3. Categorical variables are presented as number (percentage). Continuous variables are presented as mean ± standard deviation if normally distributed, and as median [range] if not. Categorical variables were compared using the Chi-square test, except in cases where any expected count was less than 5; then Fisher’s exact test was used. Normally distributed continuous variables were compared using the t-test. Non-normally distributed continuous variables were compared using the Wilcoxon rank-sum test. The normal distribution was visually assessed using kernel density estimation. Statistical significance was set to P < 0.05 for the primary hypothesis and for other analyses that were considered exploratory. Missing data on demographic and intraoperative variables were excluded from statistical analysis. In all cases, there were fewer than 25 missing values out of all 2005 patients except for body mass index (51 patients), CKD (29 patients), smoking history (38 patients) and skin–skin time (56 patients). There was 100% follow-up and no missing data on overall mortality and other long-term endpoints except for missing data on cause of death and therefore cardiac mortality in 294 patients (13% in the LVEF ≤35% group and 15% in the LVEF >35% group). Those patients were excluded from the analysis of cardiac mortality but included in all-cause survival analysis.

Univariable logistic regression was used to compare the frequency of postoperative complications between groups. Overall, cardiac-specific and MACCE-free survival was compared between groups using the log-rank test. A Cox proportional hazards model was then used to identify predictors for mortality. Univariable models were created with variables that were plausible to affect mortality (LVEF, hypertension, age, DM, current smoking, COPD, CKD, previous PCI, NYHA class III and IV, emergency procedure, off-pump surgery, number of distal anastomoses and operation length). Statistically significant variables (P < 0.2) in the univariable analysis were then combined in a multivariable model.

Additionally, we performed a propensity score matching between the two groups, using the following variables to construct the propensity score: (age, sex, hypertension, DM, COPD, off-pump surgery, body mass index, previous PCI, current smoking and emergency operation). Those variables were used based on plausibility to affect mortality. We used the nearest neighbour method, using MatchIT in R statistics. Balance of matching was assessed by comparing standardized mean difference of cases and controls before and after. All matching variables had a standardized mean difference <0.1 following matching. The aforementioned statistical methods were used to compare the matched groups. All patients were matched but 9 patients in the study group had to be excluded due to missing data. The total number of matched patients in each group was 137.

RESULTS

Preoperative LVEF for all the 2005 patients is shown in Fig. 1. Just over 7% of the cohort had an LVEF of 35% or less (n = 146).
Baseline characteristics of the patient population can be seen in Table 1. Demographics were similar for the LVEF < 35% group and controls regarding age, gender and the proportion of patients with hypertension. However, patients in the LVEF < 35% group were more likely to have other comorbidities such as DM, renal insufficiency, COPD and a previous history of MI. Patients in the LVEF < 35% group were also more symptomatic with higher NYHA scores, and also had a higher calculated Euroscore II (4.2 vs 1.4, P < 0.001).

In the LVEF < 35% group, 93 patients (64%) presented with MI compared to 476 patients (26%) in the control group (P < 0.001).

Operative details are shown in Table 2. Almost a third of the patients in the LVEF < 35% group had elective surgery, 52% underwent a semi-acute surgery and 17% an emergency surgery. In both groups, around 80% of patients had conventional CABG where cardiopulmonary bypass was used, the rest being operated off-pump. The number of distal anastomoses was higher in the LVEF < 35% group (median 4 vs 3 for controls) and the surgeries were longer (skin–skin time 215 min vs 200 min, P < 0.001) compared to those of controls.

Overall complications were more common in the LVEF < 35% group. Table 3 shows the number of cases for each complication. The rates of perioperative MI (2% vs 4%, P = 0.2) and stroke (3% vs 1%, P = 0.06) were similar between the groups, while new-onset atrial fibrillation (43% vs 31%, P = 0.002) was more common in the LVEF < 35% group. The total chest tube output for the first 24 h after surgery was similar between groups, but re-exploration was more common in the LVEF < 35% group (11% vs 5%, P = 0.003).

Thirty-day mortality was around 4 times higher in the LVEF < 35%-group compared to controls (8% vs 2%, P < 0.001).

Figure 2 shows long-term outcomes, both for death and MACCE. Overall survival was 87% and 69% for the LVEF < 35% group at 1 and 5 years, compared to 98% and 91% for patients with LVEF > 35%. As can be seen in the figure, the lines separate most in the first few months but later on they run practically parallel. In the same groups, respectively, MACCE-free survival was 83% and 62% at 1 and 5 years compared to 94% and 82%. The rate of long-term MI was similar between groups, the rate being 2-4% at 5 years postoperatively. The need for long-term PCI was also similar between groups, being 9-11% after 10 years of follow-up. The rate of stroke at 5 years was 9% for patients with LVEF < 35% compared to 4% for controls, the difference not being statistically significant (P = 0.2).

The risk factors for overall survival are shown in Table 4. Independent predictors of long-term mortality in the multivariable model were advanced age, DM, CKD, COPD, current smoking, NYHA classification III or IV, emergency procedure and longer skin-to-skin time. Importantly, LVEF < 35% was also linked to inferior survival (adjusted hazard ratio 2.0, 95% confidence interval 1.5–2.6, P < 0.001).

Table 1: Comparison of demographic characteristics

|        | LVEF < 35% n = 146 | LVEF > 35% n = 1859 | P-value |
|--------|--------------------|---------------------|---------|
| Age (years) | 67 ± 10 | 66 ± 9 | NS (0.6) |
| Male | 126 (86) | 1531 (82) | NS (0.3) |
| Hypertension | 88 (61) | 1218 (66) | NS (0.4) |
| Diabetes mellitus | 34 (23) | 308 (17) | 0.04 |
| Chronic kidney diseasea | 33 (23) | 275 (15) | 0.02 |
| Previous myocardial infarction | 62 (43) | 429 (23) | <0.001 |
| Previous PCI | 30 (21) | 417 (22) | NS (0.7) |
| Cardiac valve diseaseb | 13 (9) | 55 (3) | <0.001 |
| History of smoking | 102 (71) | 1309 (70) | NS (0.8) |
| Current smoker | 51 (35) | 410 (22) | <0.001 |
| Chronic obstructive pulmonary disease | 18 (13) | 127 (7) | 0.02 |
| Body mass index, kg/m² | 27 ± 4 | 28 ± 5 | NS (0.00) |
| Euroscore II | 4.2 [0.7–37] | 1.4 [0.5–36] | <0.001 |
| NYHA score III or IV | 116 (80) | 1109 (60) | <0.001 |
| CCS score III/IV | 110 (75) | 1360 (73) | NS (0.6) |
| Number of diseased vessels | 121 (83) | 1497 (81) | NS (0.6) |
| Three-vessel disease | 63 (43) | 771 (41) | NS (0.8) |
| Left main stenosis | 129 (88) | 1658 (89) | NS (0.9) |
| Myocardial infarction as presenting symptom | 92 (64) | 476 (26) | <0.001 |

Mean ± SD, median [range] or number (%).

*aGFR < 60 ml/min/1.73 m².

bIn most cases mild to moderate aortic stenosis or mild to moderate mitral regurgitation, not haemodynamically significant and not requiring surgery.

CCS: Canadian Cardiovascular Society; eGFR: estimated glomerular filtration rate; NYHA: New York Heart Association; PCI: percutaneous coronary intervention; SD: standard deviation.
In the propensity-matched cohort \( (n = 137) \), the findings of both long-term complications and mortality were similar to our analysis that was performed without matching, with the outcomes being significantly inferior for patients with LVEF <35\% (5-year survival for LVEF <35\% was 69% vs 91% for controls, \( P < 0.001 \), Table 5). The difference in surgical mortality was, however, not statistically significant between groups (7% vs 4% for the LVEF <35\% group vs controls, respectively, \( P = 0.2 \)). Patient variables and standardized mean differences after matching can be seen in Supplementary Material, Table S1 and Fig. S1.

**DISCUSSION**

This whole-nation study reports long-term outcomes for patients with LVEF <35\%, in a well-defined nationwide cohort, reporting both all-cause survival and the rate of MACCE.

Compared to similar studies, the long-term outcomes on myocardial revascularization in this subgroup of patients in the present study can be regarded as generally good, albeit significantly worse for patients with lower left ventricular function, as should be expected. We observed a 30% five-year mortality after CABG for patients with LVEF <35\%, compared to 36% in the STICH trial [6] and 21–23% at 4–5 years in 2 recently published observational studies that compared CABG to PCI in patients with reduced LVEF [13, 14]. We also reported rates of MACCE that were significantly higher in the LVEF <35\% group, primarily driven by the difference in mortality observed in the groups. There was no significant difference in the rate of stroke, MI or revascularization with PCI in the two groups. That could indicate that the technical aspect of the surgery is similar between groups with similar results in revascularization.

New-onset atrial fibrillation and pneumonia were the only short-term complications that were more common with the outcomes being significantly inferior for patients with LVEF <35\% (5-year survival for LVEF <35\% was 69% vs 91% for controls, \( P < 0.001 \), Table 5). The difference in surgical mortality was, however, not statistically significant between groups (7% vs 4% for the LVEF <35\% group vs controls, respectively, \( P = 0.2 \)). Patient variables and standardized mean differences after matching can be seen in Supplementary Material, Table S1 and Fig. S1.

**Table 2:** Operative and postoperative variables

| Variable                                         | LVEF < 35\% \( n = 146 \) | LVEF > 35\% \( n = 1859 \) | P-value |
|--------------------------------------------------|---------------------------|---------------------------|---------|
| Off-pump surgery                                 | 22 (15)                   | 366 (20)                  | NS (0.2) |
| Elective surgery                                 | 46 (32)                   | 885 (48)                  | <0.001  |
| Non-elective surgery                             | 100 (68)                  | 974 (52)                  | <0.001  |
| Emergent surgery                                 | 25 (17)                   | 69 (4)                    | <0.001  |
| Semi-acute                                       | 75 (52)                   | 905 (49)                  | NS (0.5) |
| Skin–skin time, min                             | 215 [128–630]             | 200 [85–555]              | <0.001  |
| Time on CPB, min                                 | 99 [38–366]               | 85 [25–319]               | <0.001  |
| Cross-clamp time, min                           | 49 [16–191]               | 45 [10–204]               | 0.02    |
| Intraoperative inotropes                         | 109 (76)                  | 946 (51)                  | <0.001  |
| Perioperative use of IABP                        | 44 (30)                   | 56 (3)                    | <0.001  |
| Intraoperative defibrillation                    | 20 (14)                   | 269 (14)                  | NS (0.7) |
| Number of distal anastomoses                     | 4 [1–6]                   | 3 [1–6]                   | 0.02    |
| LIMA used                                        | 129 (88)                  | 1767 (95)                 | 0.001   |
| Postoperative bleeding 24 h, ml                  | 820 [115–3835]            | 760 [100–31 820]          | NS (0.08) |
| Re-exploration for bleeding                      | 16 (11)                   | 92 (5)                    | 0.003   |
| ICU days                                         | 2 [1–32]                  | 1 [0–42]                  | <0.001  |
| Total ward days                                  | 8 [0–75]                  | 7 [0–75]                  | <0.001  |

Median [range] or number (%).

CPB: cardiopulmonary bypass; IABP: intra-aortic balloon pump; ICU: intensive care unit; LIMA: left internal mammary artery.

**Table 3:** Postoperative complications

| Variable                          | LVEF <35\% \( n = 146 \) | LVEF >35\% \( n = 1859 \) | OR (95\% CI) | P-value |
|----------------------------------|---------------------------|---------------------------|--------------|---------|
| New-onset atrial fibrillation    | 63 (43)                   | 579 (31)                  | 1.7 (1.2, 2.4) | 0.003   |
| Pneumonia                        | 17 (12)                   | 107 (6)                   | 2.2 (1.2, 3.6) | 0.005   |
| Pleural effusion                 | 24 (16)                   | 220 (12)                  | 1.5 (0.9, 2.3) | NS (0.1) |
| Leg wound infection              | 16 (11)                   | 176 (9)                   | 1.2 (0.7–2.0) | NS (0.7) |
| Perioperative MI                  | 3 (2)                     | 77 (4)                    | 0.5 (0.1, 1.3) | NS (0.2) |
| Stroke                           | 4 (3)                     | 18 (1)                    | 2.9 (0.8, 7.9) | NS (0.06) |
| Poststernotomy mediastinitis     | 3 (2)                     | 14 (1)                    | 2.8 (0.6, 8.6) | NS (0.1) |
| Postoperative dialysis           | 2 (1)                     | 7 (0.5)                   | 3.7 (0.5, 15.3) | NS (0.1) |
| Thirty-day mortality             | 11 (8)                    | 28 (2)                    | 5.3 (2.5, 10.7) | <0.001  |

Number (%).

CI: confidence interval; MI: myocardial infarction; OR: odds ratio.

In the propensity-matched cohort \( (n = 137) \), the findings of both long-term complications and mortality were similar to our analysis that was performed without matching, with the outcomes being significantly inferior for patients with LVEF <35\% (5-year survival for LVEF <35\% was 69% vs 91% for controls, \( P < 0.001 \), Table 5). The difference in surgical mortality was, however, not statistically significant between groups (7% vs 4% for the LVEF <35\% group vs controls, respectively, \( P = 0.2 \)). Patient variables and standardized mean differences after matching can be seen in Supplementary Material, Table S1 and Fig. S1.

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Table 4: Cox regression analysis showing risk factors predicting for death with unadjusted and adjusted HR

|                        | Unadjusted HR | 95% CI  | P-value | Adjusted HR | 95% CI  | P-value |
|------------------------|---------------|---------|---------|-------------|---------|---------|
| LVEF \(<35\)           | 2.6           | (1.9, 3.4) | <0.001  | 2.0         | (1.5, 2.6) | <0.001  |
| Age                    | 2.2           | (2.0, 2.5) | <0.001  | 1.08        | (1.06, 1.09) | <0.001 |
| HTN                    | 1.1           | (0.9, 1.4) | NS       | 1.08        | (1.06, 1.09) | <0.001 |
| DM                     | 1.7           | (1.4, 2.2) | <0.001  | 1.9         | (1.5, 2.3)  | <0.001  |
| CKD                    | 2.8           | (2.2, 3.5) | <0.001  | 1.5         | (1.3, 2.0)  | <0.001  |
| Current smoking        | 1.2           | (1.0, 1.4) | <0.001  | 1.5         | (1.2–1.8)   | <0.001  |
| COPD                   | 2.4           | (1.8, 3.1) | <0.001  | 1.6         | (1.2, 2.2)  | <0.001  |
| Previous PCI           | 1.1           | (0.8, 1.3) | NS       | 1.1         | (0.4)     | <0.001  |
| NYHA 3 or 4            | 1.5           | (1.2, 1.8) | <0.001  | 1.3         | (1.1, 1.6)  | 0.007   |
| Emergency procedure    | 2.2           | (1.5, 3.1) | <0.001  | 1.5         | (1.0, 2.2)  | 0.03    |
| Off-pump surgery       | 0.8           | (0.7, 1.0) | 0.1      | 0.8         | (0.6–1.0)  | 0.06    |
| Distal anastomoses     | 1.0           | (0.9, 1.1) | NS       | 1.0         | (0.6)     | <0.001  |
| Operation length       | 1.003         | (1.001, 1.004) | 0.001 | 1.002       | (1.000, 1.004) | 0.006   |

CI: confidence interval; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; HR: hazard ratio; HTN: hypertension; LVEF: left ventricular ejection fraction; NYHA: New York Heart Association; PCI: percutaneous coronary intervention.
A clear strength of this study is the fact that it includes all patients who underwent CABG in a well-defined population-based cohort; the findings are therefore less affected by potential selection bias. Our database is very detailed and the survival data exact, especially with regards to mortality, where information was gained from a centralized death registry in Iceland, with a follow-up of 100%. With a median follow-up of 7.6 years and 100% follow-up for overall mortality, we now have a great insight into long-term prognosis for this subgroup of patients with LVEF <35% that has not been studied before in Iceland.

The major limitation is the retrospective design and, therefore, inevitable missing data on factors which rely on the accuracy of registration. Our postoperative long-term data are also limited to factors and events that are registered in hospital files (MACCE and death). We do not have data on postoperative medical therapy because most patients are followed up at private clinics after surgery. We therefore cannot draw any conclusions to whether patients were on optimal medical therapy. However, all patients at the cardiac surgery department at Landspitali are discharged on medications according to current guidelines. Another limitation is the possibility that ejection fraction was falsely estimated as too low in some patients that underwent acute surgery. The current study included both patients with stable and unstable angina, including those with acute MI and requiring urgent surgery. This is in contrast to the STICH trial in which patients with recent acute MI, the most common cause for left ventricular dysfunction, were excluded [6]. Acute ischaemia can cause a transient state of mechanical cardiac dysfunction which leads to temporarily reduced LVEF. This might result in misclassification to LVEF <35% for patients with acute MI. We expect this would decrease the difference in outcome between the study group and controls. A postoperative ultrasound would be helpful to evaluate plausible mis-grouped patients with temporarily reduced LVEF. However, data on postoperative ultrasound were not available, as most patients were followed up at private cardiology clinics in Iceland and the data too often missing.

In a retrospective study like ours, it is important not to make too strong conclusions, as the heterogenic cohort only includes 2005 patients. We decided to include all patients that underwent isolated CABG surgery; even those with a recent MI or severe comorbidities. Preoperatively, the patients in the LVEF <35% group were sicker, and by using a Cox regression model we tried to take this into account. Nevertheless, this is a limitation of the study. In future studies, it would, for example, be interesting to discriminate between patients with recent or chronically reduced LVEF as there is so much difference here in our cohort, with a recent MI rate of 64% vs 26% in the LVEF <35% vs controls, respectively.

CONCLUSIONS

This study shows that good long-term outcome can be obtained in CABG patients with reduced LVEF, although their survival is inferior to patients with normal ventricular function. Randomized studies are needed to evaluate the best treatment option for these patients.

SUPPLEMENTARY MATERIAL

Supplementary material is available at ICVTS online.
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The results presented in this paper have not been published previously. Part of this work was presented at the 10th joint Scandinavian conference in Cardiothoracic surgery in Copenhagen, 2018.

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Data Availability Statement

The data underlying this article will be shared on reasonable request to the corresponding author.

Author contributions

Helga B. Brynjarsdottir: Data curation; Formal analysis; Writing—original draft.
Arni Johnsen: Formal analysis; Writing—review & editing.
Alexandra A. Heimdottir: Data curation; Writing—review & editing.
Sunna Rún Heidarsson: Writing—review & editing.
Anders Jeppsson: Writing—review & editing.
Tomas Gudbjartsson: Formal analysis; Writing—review & editing.
Martin I. Sigurdsson: Formal analysis; Project administration; Supervision; Writing—review & editing.

Reviewer information

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