# The long-term benefit of a cardiac rehabilitation program after myocardial infarction in patients under the Managed Care for Acute Myocardial Infarction Survivors (MACAMIS) program in Poland: A single-center study

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## ABSTRACT

**Background:** The Managed Care for Acute Myocardial Infarction Survivors (MACAMIS) program introduced for patients after myocardial infarction (MI) consists of 4 modules including early cardiac rehabilitation (CR).

**Aims:** We compared the impact of CR on survival of patients after MI included in the MACAMIS program.

**Methods:** Patients in MACAMIS were divided into subgroups based on being qualified or not qualified for CR and on whether they completed or failed to complete CR. We evaluated one-, two-, and three-year mortality.

**Results:** Of 244 patients in MACAMIS, 174 patients were qualified for CR. They were younger, had less advanced coronary artery disease (CAD), higher ejection fraction (EF), and fewer comorbidities. Finally, 102 (58.6%) patients completed CR. These patients were younger and more likely to have STEMI; they were more often treated invasively, with no differences in comorbidity burden. The survival rates at one, two, and three years were 93.6%, 87.8%, and 65.0%, respectively. Patients who qualified for CR had a better prognosis. The mortality rates at one, two, and three years were 2.38% vs. 16.18% ($P = 0.0003$), 6.71% vs. 25.4% ($P = 0.002$), and 26.87% vs. 51.35% ($P = 0.01$), respectively. Patients who completed CR, again, had a significantly better prognosis. The mortality rate was 1% vs. 10.29% ($P = 0.009$), 4.17% vs. 17.56% ($P = 0.002$), and 23.33% vs. 40.54% ($P = 0.09$) in analyzed periods. The only independent factors related to survival were completion of CR and number of comorbidities.

**Conclusions:** Patients with MI in the MACAMIS program had better prognosis when participating in CR. After completing the MACAMIS program, increased mortality was observed in the following years. Despite the flexibility of the CR program, the proportion of patients who qualified and completed CR remained low.

**Key words:** acute coronary syndrome, acute myocardial infarction, cardiac rehabilitation, cardiovascular disease

## INTRODUCTION

Cardiovascular disease (CVD) is the main cause of morbidity and mortality worldwide [1]. It is estimated that more than 45% of the population of Poland will die as a result of CVD [2, 3]. In 2013, coronary artery disease (CAD) accounted for 23% of CVD deaths in both Europe and Poland [2]. Nevertheless, improvement in diagnostic modalities and development of modern treatment resulted in a significant decrease in early mortality. However, despite prompt access to acute cardiovascular care in

## WHAT'S NEW?

Specialized scheduled medical care after myocardial infarction may improve prognosis. The 12-month Managed Care for Acute Myocardial Infarction Survivors (MACAMIS) program is composed of several modules including scheduled visits, index medical or interventional treatment, further revascularization, cardiac rehabilitation, and electrotherapy. We documented that patients in the MACAMIS program who were referred to the cardiac rehabilitation program had a favorable prognosis in comparison to those who were not eligible (not qualified by doctors or refused to participate). Further survival benefit was gained by patients who completed the full rehabilitation program. The percentage of patients who participated in the rehabilitation program was surprisingly low despite a very flexible program schedule. The mortality rate was significantly reduced during the three years of follow-up in both groups of patients; however, there was a significant increase in mortality after the MACAMIS program ended.

acute myocardial infarction (AMI), namely percutaneous coronary interventions (PCI), the one-year mortality rate after AMI in Poland remains above 15%, which is higher than the average in European countries [4]. The outcomes for patients after acute coronary events do not depend solely on the initial in-hospital management but also on further interventions. They include optimal pharmacological therapy, reduction of known cardiovascular risk factors (obesity, hypercholesterolemia, diabetes mellitus [DM], and tobacco use), clinical and laboratory follow-up, and utilization of implantable electronic devices such as implantable cardioverter defibrillators (ICD) and cardiac resynchronization therapy with a defibrillator (CRT-D). It is, therefore, crucial to ensure that patients after their initial hospitalization are provided complex care for an extended period of time. The recent European Society of Cardiology and European Association for Cardio-Thoracic Surgery (ESC/EACTS) recommendations for cardiac care following myocardial revascularization include multimodal management, which has been shown to be essential to improve AMI patients' outcomes and increase survival [5]. Cardiac rehabilitation is clearly recommended and is as important as invasive and non-invasive medical treatments [6].

Taking into consideration benefits of reducing possible gaps in post-MI care, the Polish National Health Fund system has developed a novel, fully reimbursed program — Managed Care for Acute Myocardial Infarction Survivors (MACAMIS). The program provides one-year-long specialized care. The MACAMIS program includes scheduled ambulatory visits and consists of four modules including index hospitalization with the medical or interventional treatment of the ST-segment elevation myocardial infarction (STEMI) or the non-ST-segment elevation myocardial infarction (NSTEMI), second-stage interventional treatment when necessary, cardiac rehabilitation, and electrotherapy (implantation of ICD/CRT) [7]. Upon completion of MACAMIS patients undergo their final evaluation and are generally discharged for further care under a general physician and local cardiologist [2]. This strategy aims to improve post-discharge medical care, speed recovery and safe return to work and social life. Moreover, participation in the program helps post-MI patients improve previous lifestyle habits and modify risk factors for CVD through education and increasing awareness.

In Poland, the rehabilitation attendance rate following AMI is generally low despite broad access to this service. It has been shown that between 2009 and 2012, only 22% of patients after AMI in Poland participated in a cardiac rehabilitation program [4]. A study conducted in the Netherlands between 2003 and 2011 reported an 80% completion rate of the rehabilitation program [8]. The attendance and adherence rates to cardiac rehabilitation in 2012 in Sweden were 80% and 71%, respectively [9]. There are no data illustrating the possible source of low cardiovascular rehabilitation attendance rates in Poland, and thus we aimed to address this issue in our study.

The purpose of the study was to characterize factors influencing referral rate for a post-MI rehabilitation program and to compare outcomes for myocardial infarction survivors participating and not participating in cardiac rehabilitation under the MACAMIS program.

## METHODS

The data from a single-center registry of patients qualified for MACAMIS were analyzed. All patients were hospitalized with acute coronary syndrome (ACS) at the 2nd Department of Cardiology of Poznan University of Medical Sciences from January 2018 to the end of July 2019. All patients were treated according to the ESC recommendations either pharmacologically or via invasive interventions, mainly PCI or, much less often, with coronary artery bypass graft surgery (CABG). The patients were scheduled for follow-up in our outpatient clinic according to the MACAMIS requirements, within two weeks from the index hospitalization. The decision whether the patient would take part in an ambulatory or inpatient rehabilitation (CR) program was made by the team of an interventional cardiologist and rehabilitation specialist. The factors influencing the decision were related to general patient health (comorbidities), completed or planned staged revascularization, or the need for ICD implantation based on predischarge echocardiographic criteria. The CR consisted of physical therapy, psychological support, dietary and smoking cessation advice, and regular assessment by physicians.

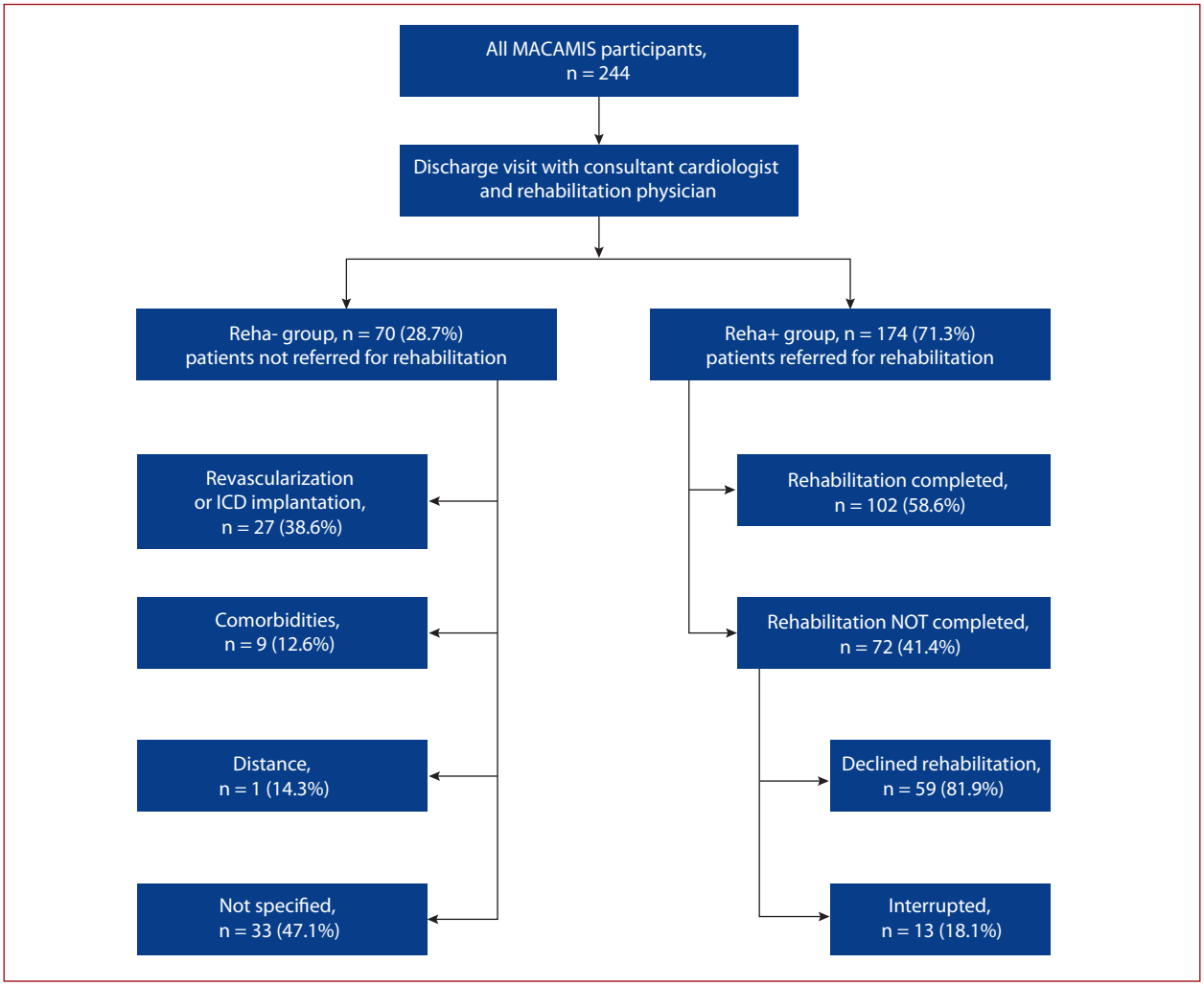


**Figure 1.** Recruitment of the patients into the Reha+ and Reha- groups with further subgroups comprised of patients who completed the recommended rehabilitation program and those who did not complete it despite referral.

Abbreviations: ICD, implantable cardioverter defibrillator; MACAMIS, Managed Care for Acute Myocardial Infarction Survivors

In the study, the patients were divided into two groups based on their eligibility for a CR program, where the "Reha+" group comprised patients who were referred for CR, and the "Reha-" group included patients who were not referred for CR for any reason. Further analyses were performed on the "Reha+" group, which was divided into patients who completed the CR ("Rehab-Completed" subgroup) and those who for any reason failed to complete the CR ("Rehab-Not-Completed" subgroup). Participant recruitment is shown in Figure 1.

Reasons for disqualification, interruption, or withdrawal from the CR were recorded. Comorbidities, several biochemical parameters, and left ventricular ejection fraction (LVEF), as well as clinical condition of the patient and their demographic data, were collected. Thereafter, one-, two-, and three-year mortality (death from any cause) was analyzed using the information obtained from Digital Affairs — Chancellery of the Prime Minister. All-cause mortality was assessed from the date of their hospital discharge after MI. Since it was a retrospective study, approval from the local ethics committee was not obligatory.

### *Statistical analysis*

Statistical analysis was performed using the Statistica data analysis software system (Dell Inc., 2016, version 13). The normality of distribution of the continuous variables was checked by the Shapiro-Wilk test. Descriptive statistics are presented as percentage for categorical variables, as mean (standard deviation [SD]) for normally distributed continuous variables, or as median (interquartile range [IQR]) for non-normally distributed continuous. The prevalence of variables was assessed by the $\chi^2$ test or the $\chi^2$ test with Yates correction as appropriate. A *P*-value <0.05 was considered significant. Differences between the two groups were determined using the Mann-Whitney test or unpaired two-tailed Student's t-test when appropriate. Kaplan-Meier survival curves were constructed to present unadjusted survival curves for each analyzed subgroup, and a log-rank test was used to compare the analyzed subgroups.

The stepwise Cox proportional hazard regression model was employed to assess the effect of clinically relevant parameters and those found to be significant in the univariate analysis.

**Table 1.** Baseline characteristics of the study population (n = 244)

| | | |
|---|---|---|
| **Diagnosis** | | |
| STEMI | 84 | 34% |
| NSTEMI | 160 | 66% |
| **Past medical history** | | |
| History of CAD | 102 | 42% |
| Previous MI | 96 | 39% |
| Previous PCI/CABG | 76 | 31% |
| HT | 168 | 69% |
| AF | 29 | 12% |
| HF | 67 | 27% |
| Stroke/TIA | 13 | 5% |
| DM | 93 | 38% |
| Dyslipidemia | 90 | 37% |
| CKD | 34 | 14% |
| **Angiographic data** | | |
| 1-vessel disease | 47 | 19% |
| 2-vessel disease | 86 | 35% |
| 3-vessel disease | 85 | 35% |
| Treatment strategy | | |
| Medical | 26 | 11% |
| Interventional | 218 | 89% |

Abbreviations: AF, atrial fibrillation; CABG, coronary artery bypass graft; CAD, coronary artery disease; CKD, chronic kidney disease; DM, diabetes mellitus; HF, heart failure; HT, hypertension; MI, myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; TIA, transient ischemic attack

## RESULTS

Two hundred forty-four patients (161 men and 83 women; mean [SD] age, 66.5 [10.5] years) were included in the MACAMIS program, and subsequently, all of them were included in our study. The clinical characteristics of the group are presented in Table 1.

There were 84 patients with STEMI (34%) and 160 patients with NSTEMI (66%). Patients with NSTEMI were significantly older than those with STEMI (mean [SD] age, 68.2 [10.8] vs. 63.4 [9.0] years; $P$ <0.001). There was no significant difference in sex distribution between ACS subgroups (male patients constituted 62% of patients with STEMI and 68% with NSTEMI). The interventional treatment (PCI or CABG) was applied in all patients with STEMI and 134 (84%) patients with NSTEMI. The majority of patients were treated with PCI, and only 4 (all in the NSTEMI subgroup) underwent emergency CABG. The median (IQR) hospitalization duration was similar in both ACS subgroups (STEMI, 7.5 [6–10] days vs. NSTEMI, 7 [5–10] days; $P$ = 0.018).

On the first scheduled visit, 174 (71.3%) patients were offered an in-hospital or an ambulatory cardiac rehabilitation program. Seventy patients (28.7%) were not considered for rehabilitation for medical reasons — further planned revascularization or ICD implantation (n = 27), significant comorbidities (n = 9), or distance to a rehabilitation center (n = 1). In 33 cases, no specific reason was recorded. Of 27 patients who were waiting for the second stage of revascularization after discharge, 4 patients died before the second procedure was performed.

In the rehabilitation-eligible group, 102 patients (58.6%) completed the recommended rehabilitation program. Of 102 patients who completed rehabilitation, 43 patients (42.2%) had in-hospital rehabilitation, 57 patients (55.9%) underwent ambulatory rehabilitation, and 2 patients (1.9%) moved from an in-hospital to an ambulatory program. Of 72 patients who failed to complete the CR program, the most frequent cause was the subjects' will to terminate CR prematurely (n = 59). Personal or family issues forced 3 patients to stop CR, and no specific reason was given in 5 cases. Also, 5 patients withdrew from CR due to comorbidities making CR difficult or impossible.

### *Comparison between the Reha+ and Reha- groups*

The majority of patients were qualified for rehabilitation (Reha+ group), with a higher proportion of patients with STEMI than NSTEMI (80% vs. 68%; $P$ = 0.031). The sex distribution was similar in the Reha+ and Reha- groups (females constituted 36.8% and 29.2%, respectively; $P$ = 0.24). A detailed comparison between the Reha+ and Reha- groups containing past medical history and selected predischarge laboratory results is presented in Table 2.

Patients in the Reha+ group had less advanced coronary artery disease and higher predischarge LVEF. Two- or three-vessel disease was present in 75% of patients in the Reha+ group and 86% in the Reha- group. Patients in the Reha+ group had a lower number of significantly narrowed or occluded arteries: median (IQR), 2 (1–3) vs. 2 (2–3), respectively; $P$ = 0.002. The Reha+ group also had lower median (IQR) initial TIMI flow (1 [0–3] vs. 3 [1–3]; $P$ <0.001) in comparison to the Reha- group.

### *Comparison between groups who completed or not completed the rehabilitation*

One hundred and two patients completed the CR program (Rehab-Completed subgroup). Patients who were not selected for the rehabilitation program were not included in the analysis to avoid referral bias related to comorbidities or incomplete revascularization. The comparison between the subgroups is presented in Table 3.

Patients in the Rehab-Completed group were more often diagnosed with STEMI (47.06% vs. 27.78%; $P$ = 0.01) and treated invasively (92.16% vs. 81.56%; $P$ = 0.02) in comparison to the Rehab-Not-Completed subgroup. There were significant differences in predischarge laboratory parameters between the two analyzed groups. NT-proBNP level in the Rehab-Completed group was remarkably lower, whereas LDL-cholesterol level was significantly higher, compared to the patients who did not finish the rehabilitation program (Table 3).

### *Mortality*

In the whole studied group, one-, two-, and three-year follow-ups were completed by 236, 227, and 104 patients, respectively. In eight patients we were not able to verify sur-

**Table 2.** Comparison of patients included or not in the rehabilitation program

| | Reha+ group (n = 174) | Reha- group (n = 70) | *P*-value |
|---|---|---|---|
| Age, year, mean (SD) | 65.05 (10.33) | 69.76 (9.96) | 0.002 |
| Females, n (%) | 64 (36.8) | 19 (27.1) | 0.24 |
| BMI, kg/m$^2$, median (IQR) | 28 (25–31) | 25 (23–29) | 0.004 |
| Predischarge EF, %, median (IQR) | 50 (44–56) | 45 (32–51) | <0.001 |
| Duration of hospitalization, days, median (IQR) | 6 (5–8) | 9 (7–12) | <0.001 |
| ACS type | | | |
| STEMI, n (%) | 68 (39.1) | 16 (22.8) | 0.03 |
| NSTEMI, n (%) | 106 (60.9) | 50 (71.4) | |
| **Past medical history** | | | |
| Previous MI, n (%) | 113 (64.9) | 34 (48.6) | 0.07 |
| Previous PCI/CABG, n (%) | 53 (30.4) | 21 (30.0) | 0.84 |
| HT, n (%) | 114 (65.5) | 52 (74.3) | 0.03 |
| DM, n (%) | 58 (33.3) | 33 (47.1) | 0.01 |
| Stroke/TIA, n (%) | 7 (4) | 6 (8.6) | 0.11 |
| AF, n (%) | 17 (9.8) | 12 (17.1) | 0.07 |
| HF, n (%) | 35 (20.1) | 30 (42.9) | <0.001 |
| CKD, n (%) | 19 (10.9) | 14 (20.0) | 0.03 |
| COPD, n (%) | 10 (5.7) | 5 (7.1) | 0.60 |
| Number of comorbidities, median (IQR) | 2 (1–3) | 3 (2–4) | <0.001 |
| **Angiographic data** | | | |
| Vessel disease, median (IQR) | 2 (1–3) | 2 (2–3) | 0.002 |
| Number of diseased vessels, n (%) | n = 151 (86.8) | n = 63 (90) | 0.09 |
| 1-vessel disease, n (%) | 38 (25.2) | 9 (14.3) | |
| 2-vessel disease, n (%) | 62 (41.1) | 24 (38.1) | |
| 3-vessel disease, n (%) | 51 (33.8) | 30 (47.6) | |
| **Invasive treatment (first procedure)** | | | |
| 1 vessel PCI, n (%) | 128 (73.6) | 46 (65.7) | 0.01 |
| 2 vessel PCI, n (%) | 21 (12.1) | 19 (27.1) | |
| Initial TIMI flow, median (IQR) | 1 (0–3) | 3 (1–3) | <0.001 |
| Final TIMI flow, median (IQR) | 3 (3–3) | 3 (3–3) | 0.36 |
| **Laboratory investigations** | | | |
| Creatinine, mg/dl, median (IQR) | 1.0 (0.8–1.2) | 1.1 (0.9–1.3) | 0.048 |
| CRP, mg/l, median (IQR) | 4.5 (1.6–9.9) | 4.9 (1.5–11.8) | 0.87 |
| NT-proBNP, pg/ml, median (IQR) | 567 (241–1483) | 1258 (478–3083) | <0.001 |
| Hemoglobin, mmol/l, median (IQR) | 8.60 (8.0–9.2) | 8.3 (7.4–9.0) | 0.048 |
| LDL cholesterol, mg/dl, median (IQR) | 96.5 (66–129) | 93 (61–136) | 0.66 |

Abbreviations: ACS, acute coronary syndrome; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; EF, ejection fraction; NT-proBNP, N-terminal pro-B-type natriuretic peptide; other — see Table 1

vival status, and they were not included in the analysis. During these periods 15, 27, and 37 patients died, respectively. The calculated survival rates were 93.6%, 87.8%, and 65.0% for the analyzed periods. The characteristics of the patients who survived and died during specific follow-up periods are presented in Tables 4 and 5.

Patients who died within 12 months post-MI were significantly older ($P$ = 0.02), more often had NSTEMI, had more comorbidities ($P$ <0.001), higher systolic blood pressure (SBP; $P$ = 0.008), lower hemoglobin ($P$ = 0.007), and higher creatinine level (p=0.008) on admission compared to survivors. There were no differences in the body mass index (BMI), number of narrowed arteries, LVEF, or type of treatment (medical or interventional) between both groups. The significance of concomitant diseases is presented in Table 4.

At three-year follow-up only age ($P$ <0.001), higher number of comorbidities ($P$ = 0.001), and higher level of creatinine ($P$ = 0.03) were related to mortality. The detailed data are presented in Table 5.

We analyzed the impact of cardiac rehabilitation in MACAMIS on mortality. The patients who were initially qualified for CR had a better chance to survive (Figure 2). The one-year mortality rate was 2.38% vs. 16.18% ($P$ <0.001), 6.71% vs. 25.4% in two years ($P$ = 0.002), and 26.87% vs. 51.35% in three years ($P$ = 0.01), respectively, for those eligible and not eligible for CR.

The second analysis was focused on the impact of completion of the CR program (n = 102) in comparison to patients who declined to participate or failed to complete CR (n = 72) (Figure 3). The mortality rate was 1% vs. 10.29% at one year ($P$ <0.01), 4.17% vs. 17.56% at two years ($P$ = 0.002), and 23.33% vs. 40.54% at three years ($P$ = 0.09).

Several clinically significant variables were included in the stepwise Cox proportional hazard regression model, namely: age, sex, type of ACS, number of significantly

**Table 3.** Comparison of patients who completed the CR program and those who did not

| | Rehab-completed n = 102 | Rehab-not-completed n = 72 | *P*-value |
|---|---|---|---|
| Age, years, mean (SD) | 63.29 (9.28) | 67.56 (11.26) | <0.001 |
| Females, n (%) | 42 (41.18) | 22 (30.56) | 0.15 |
| BMI, kg/m$^2$, median (IQR) | 27 (24–30) | 28 (25–31) | 0.47 |
| Predischarge EF, %, median (IQR) | 50 (44–58) | 48 (38–54) | 0.002 |
| EF ≤35%, n (%) | 9 (8.8) | 32 (44.4) | 0.003 |
| Duration of hospitalization, days, median (IQR) | 7 (5–8) | 8 (5-11) | 0.19 |
| ACS type<br>STEMI, n (%)<br>NSTEMI, n (%) | <br>48 (47.06)<br>54 (52.94) | <br>20 (27.78)<br>52 (72.22) | <br>0.01 |
| **Past medical history** | | | |
| Previous MI, n (%) | 75 (73.53) | 38 (52.78) | 0.005 |
| Previous CABG, n (%) | 3 (2.94) | 5 (6.94) | 0.21 |
| Previous PCI, n (%) | 21 (20.59) | 24 (33.33) | 0.06 |
| HT, n (%) | 58 (56.86) | 56 (77.78) | 0.004 |
| DM, n (%) | 32 (31.37) | 26 (36.11) | 0.51 |
| Stroke/TIA, n (%) | 3 (2.94) | 4 (5.56) | 0.39 |
| AF, n (%) | 4 (3.92) | 13 (18.06) | 0.002 |
| HF, n (%) | 19 (18.63) | 16 (22.22) | 0.56 |
| CKD, n (%) | 9 (8.82) | 10 (13.89) | 0.29 |
| COPD, n (%) | 3 (2.94) | 7 (9.72) | 0.06 |
| Number of comorbidities, median (IQR) | 2 (1–3) | 3 (1–3.5) | 0.006 |
| **Angiographic data** | | | |
| 1-vessel disease, n (%) | 25 (26.88) | 13 (22.41) | 0.29 |
| 2-vessel disease, n (%) | 41 (44.09) | 21 (36.21) | |
| 3-vessel disease, n (%) | 27 (29.03) | 24 (41.38) | |
| Non-invasive treatment, n (%) | 8 (7.84) | 14 (19.44) | 0.02 |
| **Invasive treatment (first procedure)** | | | |
| 1 vessel PCI, n (%) | 80 (78.43) | 48 (66.67) | 0.64 |
| 2 vessel PCI, n (%) | 12 (11.76) | 9 (12.50) | |
| Initial TIMI flow, median (IQR) | 1 (0–3) | 3 (0–3) | 0.003 |
| Final TIMI flow, median (IQR) | 3 (3–3) | 3 (3–3) | 0.09 |
| **Laboratory investigations** | | | |
| Hemoglobin, mmol/l, median (IQR) | 8.6 (8.0–9.2) | 8.4 (7.6–9.1) | 0.15 |
| Creatinine, mg/dl, median (IQR) | 1.0 (0.9–1.1) | 1.1 (0.8–1.2) | 0.11 |
| CRP, mg/l, median (IQR) | 4.2 (1.5–9.5) | 5.0 (1.6–11.15) | 0.29 |
| NT-proBNP, pg/ml, median (IQR) | 567 (290–1425) | 1014 (298–2549) | 0.02 |
| LDL cholesterol, mg/dl, median (IQR) | 105.5 (73–137) | 87 (61–118.5) | 0.01 |

Abbreviations: see Table 2

narrowed arteries, treatment (medical or interventional), number of arteries treated, number of comorbidities, EF, qualification for rehabilitation and completion of the rehabilitation program. The analysis revealed that every additional comorbidity present at index hospitalization (Table 1) increased the risk of all-cause death within 1st year by 2.6 (adjusted hazard ratio [HR], 2.57; 95% confidence interval [CI], 1.66–4.00; *P* <0.001), and the risk of all-cause death increased by 3.6 in those of patient who were not directed to rehabilitation (adjusted HR, 3.62; 95% CI, 1.11–11.79; *P* = 0.03). The same analysis for the second year resulted in HRs of 1.8 (adjusted HR for the second year, 1.82; 95% CI, 1.32–2.51; *P* <0.001) with every additional comorbidity, and hazard ratio of 3.2 in those of patients who were not directed to rehabilitation (adjusted HR, 3.19; 95% CI, 1.24–8.19; *P* = 0.02). In the third year of the study, the risk of all-cause death increased by 1.3 for any additional diagnosis (adjusted HR for the third year, 1.33; 1.04–1.71; *P* = 0.02) and increased by 1.1 (adjusted HR for the third year, 1.06; 1.01–1.10; *P* = 0.01) for older patients.

## DISCUSSION

Cardiac rehabilitation is an inherent part of the extensive treatment in patients following an acute coronary event. It is broadly accepted that CR should be available to all patients to improve their quality of life, avoid readmissions, and allow fast return to work and social life.

Our study compared two groups in a cohort of 244 patients following AMI qualified for the MACAMIS — one that completed CR and one that failed to complete CR. In our study, one hundred and two patients of 244 (41.8%) completed the CR program, which is a significant improvement in comparison to the average Polish CR rate of 22% reported in 2009–2012 [4]. Nevertheless, this number is still

**Table 4.** Clinical characteristics of patients at one-year follow-up (all-cause deaths vs. survivors)

| | All-cause death at 1st year (n = 15) | Survivors after 1st year (n = 221) | *P*-value |
|---|---|---|---|
| Age, years, mean (SD) | 72.4 (7.9) | 66.2 (10.5) | 0.02 |
| Female sex, n (%) | 4 (26.67) | 75 (33.94) | 0.56 |
| SBP, mm Hg, median (IQR) | 150 (130–170) | 130 (115–145) | 0.008 |
| DBP, mm Hg, median (IQR) | 84 (80–100) | 75 (70–85) | 0.06 |
| BMI, kg/m$^2$, median (IQR) | 29 (25–31) | 27 (24–30) | 0.60 |
| Predischarge EF, %, median (IQR) | 46.5 (30–50) | 50 (40–55.5) | 0.11 |
| ACS type<br>STEMI, n (%)<br>NSTEMI, n (%) | <br>0 (0)<br>15 (100) | <br>79 (35.75)<br>142 (64.25) | <br>0.003 |
| **Past medical history** | | | |
| History of CAD, n (%) | 9 (60) | 89 (40.27) | 0.14 |
| Previous CABG, n (%) | 0 (0) | 12 (5.43) | 1.00 |
| Previous PCI, n (%) | 3 (20) | 58 (26.24) | 0.93 |
| HT, n (%) | 13 (86.67) | 149 (67.42) | 0.09 |
| DM, n (%) | 11 (73.33) | 79 (35.75) | 0.004 |
| CKD, n (%) | 9 (66.67) | 25 (11.31) | <0.001 |
| Stroke/TIA, n (%) | 1 (6.67) | 11 (4.98) | 0.78 |
| AF, n (%) | 5 (33.33) | 24 (10.86) | 0.02 |
| HF, n (%) | 9 (66.67) | 58 (26.24) | 0.006 |
| COPD, n (%) | 4 (26.67) | 11 (4.98) | 0.005 |
| Number of comorbidities, median (IQR) | 4.5 (4–5) | 2 (2–3) | <0.001 |
| **Treatment strategy** | | | |
| Interventional, n (%) | 13 (92.86) | 197 (89.14) | 0.99 |
| Medical, n (%) | 1 (7.14) | 24 (10.86) | |
| **Laboratory investigations** | | | |
| Hemoglobin, mmol/l, median (IQR) | 7.1 (6.6–8.2) | 8.5 (7.9–9.2) | 0.007 |
| Creatinine, mg/dl, median (IQR) | 1.8 (1.0–2.1) | 1 (0.86–1.20) | 0.008 |
| CRP, mg/l, median (IQR) | 14.3 (3.4–34) | 4.55 (1.55–9.8) | 0.05 |

Abbreviations: DBP, diastolic blood pressure; SBP, systolic blood pressure; other — see Table 2

considered unsatisfactory, and this issue should continue to be addressed. It is worth underlining that CR under MACAMIS is fully covered by the government insurance system, hence there is no negative financial impact on the referral decision. The single most common reason for not participating or completing CR reported by the patients was the geographic location (usually a remote area), which resulted in transportation issues. It demonstrates that the number of rehabilitation wards and dedicated medical centers with out-hospital CR is probably still insufficient.

In our study, we clearly demonstrated the phenomenon of lower CR attendance among older patients with more comorbidities and poor biochemical analysis results. There seems to be a bidirectional relationship between the complexity of the patient profile and medical professionals' decision-making. Older patients with multiple health issues are probably less enthusiastic about attending CR, and at the same time referring physicians are probably discouraged by this clinical picture and are less likely to recommend CR to this particular patient population. This kind of risk-avoiding behaviour leads to continuous suboptimal and incomplete therapy in patients that possibly require it the most.

It is reported that CR has a remarkable impact on mortality and re-hospitalization rate. A large study from the Mayo Clinic, which included 2991 patients following AMI, reported significantly reduced all-cause readmission and mortality with adherence to a CR program (1.8% vs. 20.5% for CR participants and non-participants, respectively) [10]. Also, a 2016 Cochrane review reported a lower risk of recurrent hospital admissions in a group of patients attending CR [6]. The combination of pharmacotherapy (including intensive treatment of dyslipidemia involving statins, ezetimibe, or even proprotein convertase subtilisin/kexin type 9 inhibitors [PCSK-9 inhibitors] [11]) and exercise-based CR plays an important role in CVD risk factors modification (e.g. improve blood lipid profile or blood pressure) [12]. Aerobic capacity ameliorated through physical activities has also been shown to be associated with a lower prevalence of CVD risk factors and contributes to better psychological condition [13, 14]. Moreover, improvement in fitness during cardiac rehabilitation is also related to decreased mortality independent of exercise capacity measured before CR [15]. Finally, it was reported by Morrin et al. and Ernstsen et al. [16, 17] that proper CR improves the quality of life.

**Table 5.** Clinical characteristics of patients who died and survived in three-year follow-up

| | All-cause death at 3rd year (n = 37) | Survivors after 3rd year (n = 67) | *P*-value |
|---|---|---|---|
| Age, years, mean (SD) | 72.4 (9.4) | 65.3 (8.6) | <0.001 |
| Female sex, n (%) | 11 (29.35) | 23 (34.33) | 0.63 |
| SBP, mm Hg, median (IQR) | 135 (118–150) | 130 (115–150) | 0.36 |
| DBP, mm Hg, median (IQR) | 70 (70–85) | 80 (70–82.5) | 0.51 |
| BMI, kg/m$^2$, mean (SD) | 26.87 (5.06) | 27.33 (4.1) | 0.63 |
| Predischarge EF, %, median (IQR) | 45 (32–50) | 48 (40–55.5) | 0.09 |
| ACS type<br>STEMI, n (%)<br>NSTEMI, n (%) | <br>8 (21.62)<br>29 (78.38) | <br>24 (35.82)<br>43 (64.18) | <br>0.13 |
| **Past medical history** | | | |
| History of CAD, n (%) | 23 (62.16) | 26 (38.81) | 0.01 |
| Previous CABG, n (%) | 1 (2.70) | 3 (4.48) | 0.93 |
| Previous PCI, n (%) | 8 (21.62) | 17 (25.37) | 0.93 |
| HT, n (%) | 29 (78.38) | 45 (67.16) | 0.15 |
| DM, n (%) | 21 (56.76) | 20 (29.85) | 0.005 |
| CKD, n (%) | 14 (37.84) | 8 (11.94) | 0.003 |
| Stroke/TIA, n (%) | 3 (8.11) | 4 (5.97) | 0.96 |
| AF, n (%) | 9 (24.32) | 10 (14.93) | 0.32 |
| HF, n (%) | 19 (51.35) | 20 (29.85) | 0.02 |
| COPD, n (%) | 6 (16.22) | 2 (2.99) | 0.04 |
| Number of comorbidities, median (IQR) | 4 (2.5–5) | 2 (2–3) | 0.001 |
| **Treatment strategy** | | | |
| Interventional, n (%) | 32 (88.89) | 60 (89.55) | 0.82 |
| Medical, n (%) | 4 (11.11) | 7 (10.45) | |
| **Laboratory investigations** | | | |
| Hemoglobin, mmol/l, median (IQR) | 8.15 (7.15–9.2) | 8.5 (8–9.1) | 0.33 |
| Creatinine, mg/dl, median (IQR) | 1.2 (0.9–1.7) | 1 (0.8–1.2) | 0.03 |
| CRP, mg/l, median (IQR) | 6 (1.9–21.5) | 4.45 (1.55–11.8) | 0.40 |

Abbreviations: DBP, diastolic blood pressure; SBP, systolic blood pressure; other — see Table 2.

There is very recent data strongly suggesting that the MACAMIS program may be related to an improved prognosis. Jankowski et al. analyzed 10 404 participants of this Polish program and compared their outcomes with 77 335 matched non-participants — both all-cause mortality and several other end-points were all in favor of participants of this nationwide program [7]. The authors of this comprehensive outcome study specifically pointed to improved access to rehabilitation as one of the possible reasons for this desired effect of MACAMIS. Also, Kubielas et al. [18] emphasized the positive impact of systematic cardiac care and rehabilitation on prognosis in MI patients. The authors analyzed 179 972 patients admitted due to MI, of whom 24 496 (13.61%) were included in the MACAMIS program. They clearly demonstrated that participating in a comprehensive cardiac care program reduced the risk of death during the first year after acute myocardial infarction by 29% [18].

In the recent two years, due to the COVID-19 pandemic, attitudes to medical activity have changed. Telemedicine technologies can be useful tools to ensure continuity of care not only during the COVID-19 era. Teleconsultations provide epidemiological safety and increased accessibility of specialists, as well as optimal utilization of medical personnel resources [19]. Thanks to that, the MACAMIS program could be continued even when patients were diagnosed with COVID-19 and were under quarantine. The biggest impediment to telemedicine is the lack of appropriate equipment in some groups of patients, which limits the advantages of telecare (i.e. telerehabilitation in the group of elderly patients). There is no doubt that telemedicine is our future; however, there is a huge need to improve and standardize the telecare system in Poland.

The main limitation of this research is the fact that it was a single-center observational study. Local practice in post-MI care might influence the results. Since MACAMIS is a national project, multicenter research to address rehabilitation attendance issues after MI is warranted.

## CONCLUSIONS

Our analysis showed an important role of a cardiac rehabilitation program early after myocardial infarction in patients under the MACAMIS program. There was a significantly improved prognosis during the three years of follow-up in patients who had been qualified and completed rehabilitation. Even though cardiac rehabilitation was widely available and flexible at our facility, a significant number of patients were left without this possibility. Further efforts should be made to improve the qualification process and

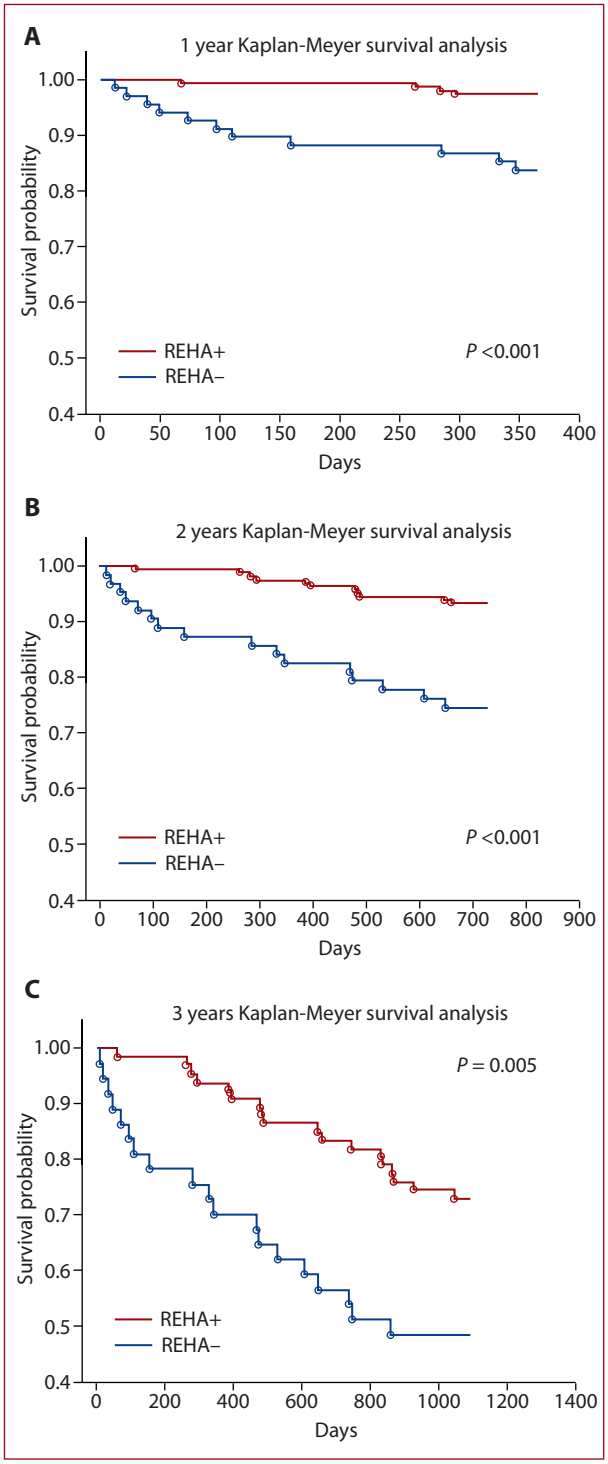


**Figure 2.** Kaplan-Meier curves displaying one-, two-, and three-year all-cause death of patients qualified (REHA+) or not qualified (REHA-) for rehabilitation in the MACAMIS program

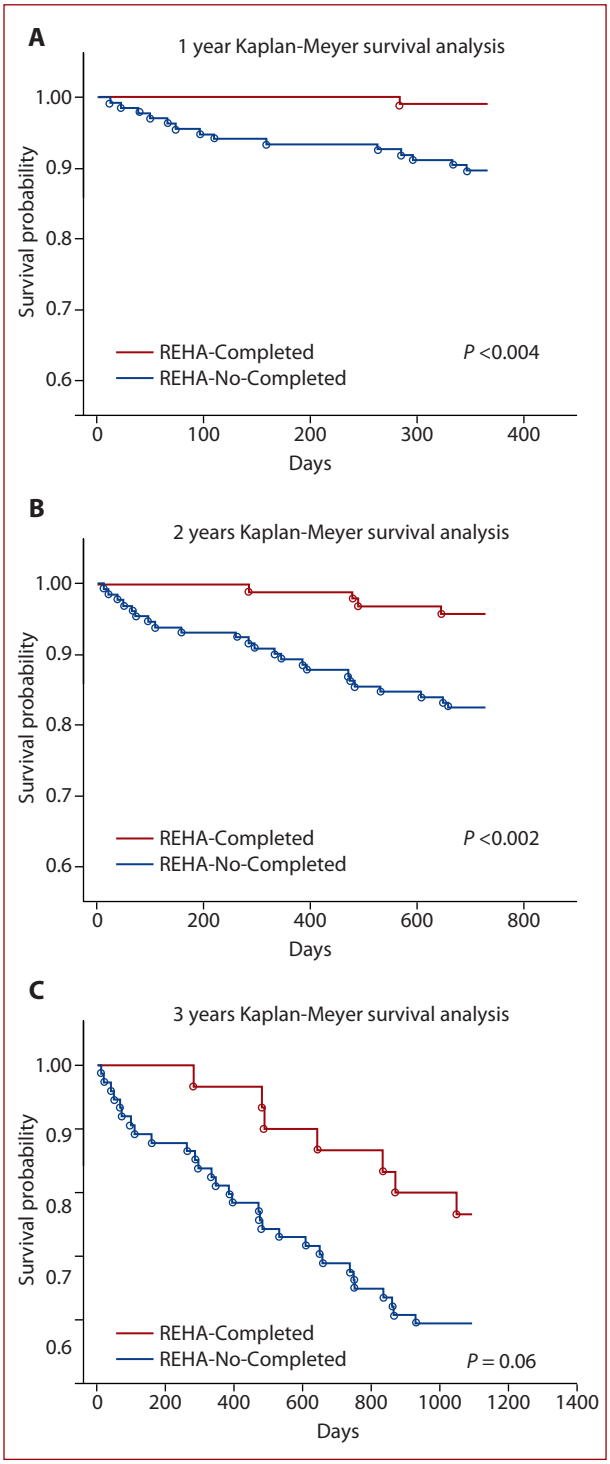


**Figure 3.** Kaplan-Meier curves displaying one-, two-, and three-year all-cause death of patients completing (REHA-Completed) and not completing (REHA-No-Completed) rehabilitation in the MACAMIS program

to encourage patient collaboration. Increased mortality after discharging from the MACAMIS program was noted and should be studied in the future.

## *Article information*

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