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# Effect of blood glucose levels on prognosis in acute myocardial infarction in patients with and without diabetes, undergoing percutaneous coronary intervention

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## Abstract

**Background:** *Diabetes mellitus (DM) is a significant factor regarding poor outcome in patients with myocardial infarction. Recently a new prognostic factor is under consideration — a baseline glucose level on admission. We sought to assess the influence of blood glucose levels on admission on prognosis of patients with acute ST-segment elevation myocardial infarction (STEMI) treated with percutaneous coronary intervention (PCI).*

**Methods and results:** *Consecutive patients treated with PCI for STEMI were analyzed. Presence or absence of DM was the first grouping criterion. The secondary criterion was the blood glucose level on admission [threshold ≥ 7.8 mmol/L (140 mg/dL)]. Hyperglycemic and non-hyperglycemic subgroups were selected within both DM and non-DM groups according to the threshold. One-year mortality of diabetics was 16.0%. There was no significant difference in 1-year mortality between hyperglycemic and non-hyperglycemic patients with DM. One-year mortality in the non-DM group was 5.6%. Patients without DM but with hyperglycemia showed a higher 1-year mortality rate than non-hyperglycemic patients (8.51% vs. 3.68%, p = 0.001). Multivariate analysis revealed that in the non-DM group blood glucose level (per 1 mmol/L) on admission was a factor affecting 1-year mortality [HR = 1.09 (1.01–1.17)].*

**Conclusions:** *Elevated blood glucose levels in STEMI affect the prognosis of patients without DM; however, it is not an independent death risk factor of patients with DM treated with PCI.* (Cardiol J 2008; 15: 422–430)

**Key words: hyperglycemia, myocardial infarction, diabetes mellitus**

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## Introduction

The incidence of diabetes mellitus (DM) in patients hospitalized with myocardial infarction ranges between 10% and 20% and is rising [1–4]. It has been proven that DM is an independent prognostic factor in patients with coronary heart disease [5]. Patients with diabetes and myocardial infarction have greater incidence of major adverse cardiovascular events (MACE) and higher in-hospital and long-term mortality [1, 2, 6, 7]. The prognostic significance of blood glucose abnormalities in patients with DM has also been suggested. It has been demonstrated that the higher the blood glucose level, the higher the short- and long-term mortality [8–10]. On the other hand, there are some reports contradicting this relationship [11, 12]. Such divergent conclusions may be due to group heterogeneity (patients with all types of acute coronary syndromes), or varying definitions of hyperglycemia cut-off values and different treatment methods (the relationship has been confirmed primarily in myocardial infarction treated with fibrinolytic therapy) [8–13]. High blood glucose levels in acute myocardial infarction may also affect the prognosis of patients without DM [12, 14–18]. The problem of analyzed group heterogeneity and differing hyperglycemia thresholds is the burden of studies analyzing the influence of glucose levels on the prognosis of patients with myocardial infarction without DM [11, 12, 14]. However, the fact, that the prognosis of patients without diagnosis of DM but with increased blood glucose in acute myocardial infarction phase is similar or even worse than patients with DM is interesting [14, 15, 19].

Considering the divergent report results on the prognostic influence of blood glucose level and heterogeneity of analyzed groups, we decided to assess this effect in a group with acute ST-segment elevation myocardial infarction (STEMI) treated with percutaneous coronary intervention (PCI).

## Methods

### Patients

We analyzed consecutive patients presenting with acute STEMI admitted to the 3rd Chair and Department of Cardiology of the Silesian Centre for Heart Diseases in Zabrze, Poland. The following patients were referred for urgent invasive diagnostics with the intention of performing PCI: with persistant (≥ 30 min) retrosternal pain, electrocardiographic features of acute myocardial infarction, i.e. ST segment elevation ≥ 0.1 mV in two or more limb leads or ST ≥ 0.2 mV in two or more pericardial leads, or acute left bundle branch block, with chest pain duration to invasive treatment below 12 hours, and who gave written consent to participate in the study. The patients after unsuccessful fibrinolytic therapy were also referred for PCI. To sum up, the patients were treated with primary and rescue PCI. Patients with pulmonary edema or cardiogenic shock were excluded from the study. All patients received 300–500 mg of oral acetylsalicylic acid, 5.000–10.000 IU of heparin and 5 mg of morphine intravenously, provided the drugs had not been given earlier. In addition, in case of additional indications the following medications were administered: nitroglycerin, beta-blocker, angiotension-converting enzyme inhibitor, antiarrhythmic drugs or atropine. The coronary angiography was performed by femoral artery puncture. The epicardial artery flow was assessed according to thrombolysis in myocardial infarction (TIMI) scoring [20]. After angiography, the patients eligible for stenting received clopidogrel 300 mg. Depending on the course and duration of the procedure, additional heparin doses were administered at the operating physician's discretion. PCI procedure with TIMI 3 flow and residual stenosis ≤ 30%, without features of dissection limiting the flow in the artery, was considered effective. After the procedure, the patients were transported to the Cardiology Care Unit. All patients received oral acetylsalicylic acid 150 mg once daily. Administration of beta-blockers, angiotension converting enzyme inhibitors and statins were recommended unless contraindications were present. All diabetic and non-diabetic patients with hyperglycemia in the acute phase of STEMI were treated with short-acting insulin given as an infusion or subcutaneous injections. Following acute myocardial infarction and at discharge, if daily demand for insulin was lower than 30 units, the treatment used before myocardial infarction was applied. If DM was diagnosed in hospital following the acute phase of myocardial infarction and daily demand for insulin was lower than 30 units, oral hypoglycemic agents or diet were used. Otherwise, intensive insulin therapy was continued. Patients received 150 mg of ticlopidine orally twice daily for 8 weeks after stenting. In the case of pain recurrence with concomitant ST segment elevation, all such patients were referred for urgent repeat coronary angiography with re-PCI if reclusion or significant infarct-related artery (IRA) stenosis were found. Data concerning clinical and angiographic characteristics, and in-hospital and 1-year prognosis were recorded on the database. Data concerning 1-year follow-up

were gathered using questionnaires, telephone calls and information gained from the National Health Fund Register, including hospitalizations, reasons for hospitalization and procedures performed. Data that were gathered using questionnaires and telephone calls were verified in the National Health Fund Register, so the final percentage of follow-up was 100%.

The study was approved by the local bioethical committee and all patients gave their informed consent.

### Blood glucose level on admission and diabetes mellitus diagnosis. Group selection

Blood glucose levels were detected using venous blood at the time the patient was admitted to the hospital and on the following days of hospitalisation, as requested by the attending physician. The presence or absence of DM was the first grouping criterion. Group 1 consisted of patients who were assumed to have diabetes, if previous diagnosis of DM (documented DM treated with insulin or oral anti-diabetic drugs or diet) or newly diagnosed DM during hospital stay was stated. The criterion of newly diagnosed DM were as follows: fasting blood glucose ≥ 7 mmol/L (126 mg/dL) stated at least twice after acute phase of myocardial infarction or blood glucose ≥ 11.1 mmol/L (200 mg/dL) stated in 2-hour glucose tolerance test done at the end of the hospitalization period. Group 2 consisted of patients without diagnosis of DM. The secondary grouping criterion was blood glucose level on admission. All patients had venous blood drawn for glucose on admission. Blood glucose level ≥ 7.8 mmol/L (140 mg/dL) was considered as hyperglycemic. According to this threshold, there were hyperglycemic and non-hyperglycemic subgroups isolated from both DM and non-DM groups.

### Endpoints

One-year mortality was selected as the primary endpoint. The relationship between blood glucose on admission and 1-year mortality was analyzed in the groups with and without DM separately. Subsequently, multivariate analysis was performed to identify independent predictors of mortality. The secondary endpoint was the percentage rate of in-hospital mortality, in-hospital and 1-year stroke, reinfarction and MACE in 1-year follow-up. MACE was defined as composite endpoint of stroke, myocardial infarction and death.

### Statistical analysis

Continuous parameters with normal distribution were presented as mean ± standard deviation (SD). The significance of mean differences was tested with a *t*-Student test. Qualitative parameters were compared with the $\chi^2$ test (with Yates correction in cases of expected size below 5). To analyze the relationship between the parameters and mortality, a Cox proportional hazard regression model was used; the results were presented as hazard ratio (HR) and 95% confidence interval (CI). Statistically significant p-levels were assumed as $< 0.05$ (two-sided). In this analysis, admission glucose concentration was used as a continuous variable. Statistical calculations and analyses were performed with Statistical PL software version 6.1 by StatSoft, Inc.

## Results

There were 1,310 consecutive patients admitted who met inclusion criteria and underwent PCI. The study group included 352 (26.9%) patients with DM and 958 (73.1%) patients without DM.

### Patients with diabetes mellitus

**Clinical particulars.** In the group with DM, blood glucose level on admission ≥ 7.8 mmol/L (140 mg/dL) was found in 289 (82.1%) patients, while blood glucose level < 7.8 mmol/L (140 mg/dL) was seen in 63 (17.9%) patients. The mean blood glucose was: 14.07 mmol/L (253.26 mg/dL) and 6.33 mmol/L (113.94 mg/dL) in hyperglycemic and non-hyperglycemic subgroups, respectively. Hyperglycemia was seen more in older patients and patients with hypertension, and the majority of the patients were female. Clinical particulars are presented in Table 1.

**Angiographic particulars.** In angiography, there was a strong trend towards higher multivessel disease prevalence in the hyperglycemic subgroup than in the non-hyperglycemic subgroup; the figures were 63.67% *vs*. 50.79%, respectively. The IRA distribution was similar in both subgroups. Likewise, the initial IRA TIMI 2–3 flow, final TIMI-3 flow, stenting and reocclusion rates did not differ significantly between the groups. Angiographic data are presented in Table 2.

**In-hospital and 1-year follow-up.** Maximum creatinine kinase concentration, hemorrhagic complications, the need of urgent coronary artery bypass grafting (CABG), left ventricular ejection fraction, stroke rate and mean time of hospitalization did not differ significantly, regardless of blood glucose on admission. In-hospital mortality in the DM group was 8.2%. Rates of stroke, myocardial reinfarction and death in 1-year follow-up were also comparable in both subgroups. One-year mortality

**Table 1.** Clinical characteristics of the analyzed groups.

| Parameters | Patients with diabetes mellitus | | | Patients without diabetes mellitus | | |
|---|---|---|---|---|---|---|
| | Blood glucose level | | p | Blood glucose level | | p |
| | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | |
| Age [years] | 58.42 ± 11.59 | 62.48 ± 9.85 | 0.01 | 55.62 ± 10.5 | 59.01 ± 10.65 | 0.000002 |
| Females [%] | 31.75 | 44.64 | 0.06 | 19.66 | 25.9 | 0.02 |
| Hypertension [%] | 60.32 | 72.66 | 0.05 | 46.21 | 51.85 | 0.088 |
| Hyperlipidemia [%] | 60.53 | 60.00 | 0.95 | 61.99 | 60.14 | 0.62 |
| Smokers [%] | 53.97 | 48.96 | 0.47 | 75.82 | 63.76 | 0.00006 |
| Prior MI [%] | 17.46 | 24.57 | 0.22 | 17.24 | 15.08 | 0.37 |
| Mean blood glucose level on admission [mmol/L] (mg/dL) | 6.33 ± 1.07 (113.94 ± ± 19.26) | 14.07 ± 4.57 (253.26 ± ± 82.26) | 0.000001 | 6.36 ± 0.96 (114.48 ± ± 17.28) | 9.91 ± 2.35 (178.38 ± ± 42.30) | 0.000001 |
| Time from onset of symptoms to PCI [h] | 6.10 ± 7.80 | 5.48 ± 4.76 | 0.54 | 4.9 ± 3.4 | 4.1 ± 2.6 | 0.00007 |
| Anterior infarction [%] | 41.27 | 43.25 | 0.77 | 39.14 | 39.42 | 0.93 |
| Fibrinolytic therapy before PCI [%] | 20.63 | 25.26 | 0.43 | 20.52 | 26.72 | 0.02 |

PCI — percutaneous coronary intervention; MI — myocardial infarction

**Table 2.** Angiographic characteristics of the analyzed groups.

| Parameters | Patients with diabetes mellitus | | | Patients without diabetes mellitus | | |
|---|---|---|---|---|---|---|
| | Blood glucose level | | p | Blood glucose level | | p |
| | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | |
| Infarction-related artery [%] | | | 0.30 | | | 0.20 |
| Right coronary artery | 39.68 | 41.87 | | 40.34 | 45.50 | |
| Circumflex coronary artery | 19.05 | 13.84 | | 17.93 | 12.96 | |
| Left anterior descending coronary artery | 39.68 | 43.94 | | 41.21 | 41.27 | |
| Left main coronary artery | 1.59 | 0.35 | | 0.52 | 0.26 | |
| Initial TIMI 2–3 flow [%] | 34.92 | 28.72 | 0.32 | 35.52 | 31.48 | 0.19 |
| Multivessel coronary disease [%] | 50.79 | 63.67 | 0.057 | 48.44 | 55.82 | 0.02 |
| TIMI 3 flow after PCI [%] | 84.13 | 90.66 | 0.12 | 92.93 | 91.27 | 0.34 |
| Stenting [%] | 65.08 | 74.39 | 0.13 | 72.24 | 74.07 | 0.52 |
| Reocclusion [%] | 7.89 | 8.50 | 0.90 | 3.86 | 6.38 | 0.12 |

PCI — percutaneous coronary intervention; TIMI — thrombolysis in myocardial infarction

of DM patients was 16.0%. The data on in-hospital and 1-year follow-up are presented in Table 3.

**Predictors of higher 1-year mortality. Multivariate analysis.** Multivariate analysis of patients with DM proved that decreased left ventricular ejection fraction and worse initial IRA flow (TIMI 0–1) were independent predictors of 1-year mortality. Moreover, there was a distinct trend suggesting a relationship between age and mortality. The blood glucose level on admission (per 1 mmol/L) was not an independent risk factor of higher 1-year mortality (HR=1.03; 95% CI 0.98–1.07; p = 0.27). The results of multivariate analysis are listed in Table 4.

## Patients without diabetes

**Clinical particulars.** In the group without DM, 378 (39.5%) patients had blood levels on admission ≥ 7.8 mmol/L (140 mg/dL), while blood glucose

**Table 3.** In-hospital and 1-year observation of analyzed groups.

| Parameters | Patients with diabetes mellitus | | | Patients without diabetes mellitus | | |
|---|---|---|---|---|---|---|
| | Blood glucose level | | p | Blood glucose level | | p |
| | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | | < 7.8 mmol/L (140 mg/dL) | ≥ 7.8 mmol/L (140 mg/dL) | |
| Maximum CK concentration [IU/L] | 1778.76 ± ± 1373.05 | 2289.52 ± ± 2081.30 | 0.14 | 1923.81 ± ± 1588.53 | 2611.11 ± ± 2178.35 | 0.000004 |
| LVEF [%] | 43.16 ± 7.77 | 43.01 ± 8.60 | 0.89 | 46.57 ± 7.3 | 44.85±7.1 | 0.0005 |
| Gastrointestinal bleeding [%] | 1.59 | 1.04 | 0.70 | 0.69 | 0.80 | 0.85 |
| Hemorrhagic complications requiring packed red blood cells [%] | 1.59 | 2.42 | 0.13 | 1.03 | 1.06 | 0.37 |
| Urgent CABG [%] | 3.17 | 5.54 | 0.44 | 5.17 | 4.76 | 0.77 |
| In-hospital stroke [%] | 0.00 | 1.73 | 0.29 | 0.86 | 2.38 | 0.16 |
| In-hospital mortality [%] | 7.94 | 8.3 | 0.92 | 0.52 | 3.44 | 0.001 |
| Mean time of hospitalization [days] | 9.33 ± 6.53 | 9.24 ± 5.06 | 0.85 | 8.33 ± 3.88 | 8.64 ± 4.84 | 0.23 |
| Stroke in 1-year follow-up [%] | 1.59 | 2.09 | 0.19 | 0.35 | 1.86 | 0.04 |
| Reinfarction in 1-year follow-up [%] | 4.76 | 5.92 | 0.44 | 5.44 | 6.38 | 0.45 |
| 1-year mortality [%] | 11.11 | 17.07 | 0.14 | 3.68 | 8.51 | 0.001 |
| MACE in 1-year follow-up [%] | 17.46 | 23.34 | 0.30 | 8.95 | 14.89 | 0.0047 |

CK — creatine kinase; LVEF — left ventricular ejection fraction; CABG — coronary artery bypass grafting; MACE — major adverse cardiovascular events

levels < 7.8 mmol/L (140 mg/dL) were determined in 580 (60.5%) patients. Mean blood glucose levels in the hyperglycemia subgroup was 9.91 mmol/L (178.38 mg/dL) and in the non-hyperglycemia subgroup, 6.36 mmol/L (114.48 mg/dL). Patients with hyperglycemia were approximately 3.5 years older, and there were more females and fewer smokers among them. The mean duration of time from onset of symptoms to PCI in the hyperglycemia subgroup was shorter (4.1 h *vs.* 4.9 h). What is more, there were more patients after ineffective fibrinolytic therapy in this subgroup. Moreover, the hyperglycemic subgroup presented a tendency to be hypertensive more often. Clinical particulars are presented in Table 1.

**Angiographic particulars.** Patients with hyperglycemia on admission had concomitant multivessel coronary heart disease more frequently, which occurred in both hyperglycemic and non-hyperglycemic subgroups (55.82% *vs.* 48.44%, respectively). However, there were no significant differences in angiographic infarction localization, initial IRA TIMI 2–3 flow, final TIMI 3 flow, and stenting and reocclusion rates in relation to blood glucose on admission. Angiographic data is presented in Table 2.

**In-hospital and 1-year follow-up.** Patients with hyperglycemia had greater myocardial infarct extent according to creatine kinase level (2611.11 IU/L *vs*. 1923.81 IU/L) and lower left ventricular ejection fraction (44.85% *vs.* 46.57%) in comparison to those without hyperglycemia. Higher levels of myocardial enzymes and lower left ventricular ejection fraction correlated with higher mortality rate. In the hyperglycemic subgroup, the in-hospital mortality rate was about 6-times higher than in the group of patients without hyperglycemia (3.44% *vs*. 0.52%). In-hospital mortality in the non-DM group was 1.7%. Moreover, patients with hyperglycemia showed a higher 1-year mortality rate compared to non-hyperglycemic (8.51% *vs*. 3.68%, respectively). One-year mortality in all patients without DM was 5.6%. Additionally, in 1-year follow-up, the hyperglycemic subgroup showed higher stroke (1.86% *vs*. 0.35%) and MACE rates (14.89% *vs*. 8.95%). The data on in-hospital and long-term follow-up are presented in Table 3.

**Predictors of higher 1-year mortality. Multivariate analysis.** Multivariate analysis revealed that in the group of patients without DM,

**Table 4.** Predictors of 1-year mortality in patients with myocardial infarction and diabetes mellitus. Multivariate analysis.

| Parameters | Hazard ratio | 95% CI | P |
|---|---|---|---|
| Initial TIMI 0–1 flow | 2.03 | 1.09–4.55 | 0.04 |
| Hypertension | 1.49 | 0.78–2.84 | 0.22 |
| Age [per 10 years] | 1.33 | 0.95–1.84 | 0.08 |
| Prior myocardial infarction | 1.28 | 0.70–2.31 | 0.40 |
| Anterior infarction | 1.12 | 0.62–2.02 | 0.68 |
| Females | 1.12 | 0.62–2.01 | 0.69 |
| Smokers | 1.06 | 0.55–2.04 | 0.84 |
| Blood glucose level [per 1 mmol/L] | 1.03 | 0.98–1.08 | 0.26 |
| Time from onset of symptoms to PCI [per 1 h] | 0.98 | 0.94–1.03 | 0.58 |
| Multivessel coronary disease | 0.93 | 0.51–1.74 | 0.84 |
| Final TIMI 3 flow | 0.85 | 0.41–1.78 | 0.67 |
| Stenting | 0.84 | 0.45–1.56 | 0.58 |
| Left ventricular ejection fraction [per 10%] | 0.47 | 0.34–0.64 | < 0.0001 |

PCI — percutaneous coronary intervention; TIMI — thrombolysis in myocardial infarction; CI — confidence interval

**Table 5.** Predictors of 1-year mortality in patients with myocardial infarction without diabetes mellitus. Multivariate analysis.

| Parameters | Hazard ratio | 95% CI | P |
|---|---|---|---|
| Age [per 10 years] | 1.74 | 1.33–2.27 | < 0.0001 |
| Multivessel coronary disease | 1.51 | 0.83–2.74 | 0.17 |
| Initial TIMI 0–1 flow | 1.41 | 0.68–2.93 | 0.34 |
| Smokers | 1.39 | 0.78–2.48 | 0.26 |
| Blood glucose level [per 1 mmol/L] | 1.09 | 1.01–1.17 | 0.04 |
| Time from onset of symptoms to PCI [per 1 h] | 1.01 | 0.96–1.05 | 0.74 |
| Females | 0.92 | 0.48–1.76 | 0.80 |
| Final TIMI 3 flow | 0.91 | 0.42–2.00 | 0.82 |
| Hypertension | 0.88 | 0.51–1.50 | 0.64 |
| Anterior infarction | 0.85 | 0.49–1.47 | 0.57 |
| Prior myocardial infarction | 0.57 | 0.27–1.19 | 0.13 |
| Stenting | 0.49 | 0.25–0.96 | 0.03 |
| Left ventricular ejection fraction [per 10%] | 0.46 | 0.34–0.64 | <0.0001 |

PCI — percutaneous coronary intervention; TIMI —thrombolysis in myocardial infarction; CI — confidence interval

blood glucose level on admission (per 1 mmol/L) was the factor affecting 1-year mortality (HR = = 1.09; 95% CI 1.01–1.17). Patients' age, stent implantation and left ventricular ejection fraction were also significant. Table 5 presents the results of multivariate analysis.

## Discussion

The mechanisms behind elevated blood glucose levels in the acute phase of myocardial infarction are not clearly identified. However, it is hypothesized that peri-infarction stress and concomitant increased adrenergic stimulation are the cause [13, 21]. Moreover, myocardial infarction may be a trigger revealing pre-existing impaired glucose tolerance or DM [22, 23]. Threshold values for hyperglycemia in acute myocardial infarction are very diversely defined in literature [8–12, 16]. Assuming the blood glucose level to be a risk factor, the assessment of a predictive value of glucose levels in the acute myocardial infarction phase is worth attention. The authors of this report defined hyperglycemia in acute myocardial infarction phase to be ≥ 7.8 mmol/L (140 mg/dL). The accepted level is convergent with other authors' reports [16, 17]. Moreover, this

cut-off point is recommended by worldwide standards for a 2-hour glucose tolerance test, a tool for carbohydrate metabolism disorder diagnosis [24–26]. Because of a possible linear relationship between blood glucose and mortality, in our multivariate analysis, admission glucose concentration was used as a continuous variable.

## Patients with diabetes mellitus

This analysis did not confirm that glucose levels during the acute phase of STEMI in patients with DM treated with PCI is connected with a higher in-hospital and 1-year mortality rate. This may be due to the similarity of initial and final IRA flow, maximum myocardial damage enzyme levels and left ventricular ejection fraction in both subgroups. These are important conclusions, since the multivariate analysis results show that the death risk in 1-year follow-up was influenced by left ventricular ejection fraction and initial infarction-related artery flow. Despite the differences of age in the subgroup with and without hyperglycemia, age was not an independent predictor of 1-year mortality in multivariate analysis adjusted for other risk factors. Results consistent with the mentioned analysis, namely the lack of a relationship between blood glucose on admission and prognosis of patients with diabetes mellitus, and myocardial infarction were presented by Foo et al. [11]. The nationwide CCP (Cooperative Cardiovascular Project) register included data of patients hospitalized due to myocardial infarction treated with fibrinolytic therapy or PCI. The analysis showed that the 30-day and 1-year mortality in patients with DM is independent on blood glucose on admission [12]. Nevertheless, there are also some reports contradicting our analysis, suggesting that prognosis of DM patients may be derived from blood glucose during the acute myocardial infarction phase. Ishihara et al. [27] presented a 2-fold higher hospital mortality rate in the subgroup of patients with DM and hyperglycemia in comparison to patients with DM without hyperglycemia. Likewise, Cao et al. [9] reported higher in-hospital mortality rate in the group of patients with DM and hyperglycemia. Multivariate analysis showed 5-fold risk of death in patients with hyperglycemia over 300 mg/dL and 2.8-fold in patients with hyperglycemia over 218 mg/dL, in comparison to patients with blood glucose level below 161 mg/dL. The meta-analysis performed by Capes et al. [8] presented higher in-hospital death risk of patients with DM and hyperglycemia in comparison to patients without hyperglycemia. It should be emphasized that the mentioned meta-analysis included patients treated with fibrinolysis or conservative therapy. Similarly, in the DIGAMI study (The Diabetes and Insulin-Glucose Infusion in Acute Myocardial Infarction), fibrinolytic therapy was used as a reperfusion method. Nonetheless, admission blood glucose level was an independent factor determining long-term mortality rate [13]. Svensson et al. [10] analyzed a group of patients with acute coronary syndromes (unstable angina — 36.75%, myocardial infarction — 63.25%) with concomitant DM and demonstrated an analogical relationship in 30-day and 2-year follow-up.

## Patients without diabetes

In this study, blood glucose levels in acute myocardial infarction in patients without DM, unlike patients with diabetes, appeared to have a significant influence on prognosis. Blood glucose levels on admission were a significant factor determining 1-year mortality. The above relationship was confirmed in other reports. In the already cited meta-analysis by Capes et al. [8], in-hospital death risk of patients without DM was about 4-times higher in patients with hyperglycemia than in those without hyperglycemia. The ICONS (Improving Cardiovascular Outcomes in Nova Scotia) registry showed significantly higher in-hospital mortality in patients without DM and hyperglycemia than in the rest of this non-DM group. In addition, multivariate analysis showed that the relative risk of death (in a group of patients without DM and with hyperglycemia *vs.* patients without DM and without hyperglycemia) was odds ratio — OR = 2.44 (1.42–4.2) [14]. The CCP registry showed that patients without DM and elevated blood glucose during acute myocardial infarction presented increased 30-day and 1-year mortality rates in relation to patients with DM [12]. Timmer et al. [17] analyzed 356 consecutive patients without DM with myocardial infarction treated with primary PCI or fibrinolysis and showed an 8-year mortality rate that differed significantly in the groups of blood glucose $< 7.8$ mmol/L, $\geq 7.8$–$11.0$ mmol/L and $\geq 11.1$ mmol/L. Additionally, they proved in multivariate analysis that blood glucose levels on admission were an independent late mortality factor. Our analysis of composite endpoint (death, reinfarction and stroke) revealed higher occurrence in the subgroup of patients without DM and with concomitant hyperglycemia. Norhammar et al. [18] reported similar results. They demonstrated that every 3 mmol/L rise in glucose levels is associated with an increased risk of death, reinfarction or congestive heart failure OR = 1.24 (1.08–1.54). In our analysis, the prognosis of patients without DM with concomitant hyperglycemia may, in part, be explained

by the following differences in group characteristics. For one, patients with hyperglycemia were generally > 60 years of age, which agreed with a multivariate analysis showing that age was an independent factor of increased mortality rate in 1-year follow up. In addition, patients without DM with hyperglycemia showed an increased rate of inefficient fibrinolysis and the presence of multivessel coronary heart disease. The patients without DM with hyperglycemia differed not only in the mentioned parameters, but also in infarction severity by the concentration of myocardial necrotic markers and left ventricular ejection fraction. The subgroup of patients with hyperglycemia had elevated myocardial necrotic markers and lower left ventricular ejection fraction. This may be relevant since ejection fraction was an independent risk factor determining 1-year mortality in multivariate analysis. Higher myocardial necrotic markers and lower left ventricular ejection fraction in patients without DM and with hyperglycemia were also reported by Timmer et al. [17]. Ishihara et al. [28], in their analysis of 529 consecutive patients with anterior wall myocardial infarction treated with PCI or fibrinolytic therapy, found that the left ventricular ejection fraction was significantly lower in the subgroup with hyperglycemia, compared to the group without hyperglycemia. Left ventricular ejection fraction recovery, measured as ΔWMS (wall motion score index), was demonstrated to be lower in patients with hyperglycemia [29]. Of note, in our study, despite the higher mortality rate of non-DM patients with hyperglycemia, this group consisted of more females, less smokers and patients with shorter pain duration than the non-hyperglycemia group.

## Limitations of the study

This study is a retrospective analysis based on the results from a single centre registry. Glycosylated hemoglobin ($HbA_{1c}$) levels in acute myocardial infarction, which would allow the assessment glucose metabolism prior to infarction and determination of its prognostic meaning, were not assessed. Due to the character of the analysis, the occurrence of diabetes that could emerge after myocardial infarction was not estimated.

## Conclusions

Elevated blood glucose levels in acute myocardial infarction affect the prognosis of patients without diabetes mellitus; however, it is not an independent risk factor of fatal outcome in patients with diabetes treated with PCI.

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