

In Patients With Acute Myocardial Infarction, the Impact of Hyperglycemia as a Risk Factor for Mortality Is Not Homogeneous Across Age-Groups

JOSÉ CARLOS NICOLAU, MD, PHD¹
 CARLOS VICENTE SERRANO JR., MD, PHD¹
 ROBERTO ROCHA GIRALDEZ, MD¹
 LUCIANO MOREIRA BARACIOLI, MD¹
 HUMBERTO GRANER MOREIRA, MD¹
 FELIPE LIMA, MD¹

MARCELO FRANKEN, MD¹
 ROBERTO KALIL, MD, PHD¹
 JOSÉ ANTONIO FRANCHINI RAMIRES, MD,
 PHD¹
 ROBERT P. GIUGLIANO, MD, SM²

OBJECTIVE—To assess the impact of hyperglycemia in different age-groups of patients with acute myocardial infarction (AMI).

RESEARCH DESIGN AND METHODS—A total of 2,027 patients with AMI were categorized into one of five age-groups: <50 years ($n = 301$), ≥ 50 and <60 ($n = 477$), ≥ 60 and <70 ($n = 545$), ≥ 70 and <80 ($n = 495$), and ≥ 80 years ($n = 209$). Hyperglycemia was defined as initial glucose ≥ 115 mg/dL.

RESULTS—The adjusted odds ratios for hyperglycemia predicting hospital mortality in groups 1–5 were, respectively, 7.57 ($P = 0.004$), 3.21 ($P = 0.046$), 3.50 ($P = 0.003$), 3.20 ($P < 0.001$), and 2.16 ($P = 0.021$). The adjusted P values for correlation between glucose level (as a continuous variable) and mortality were 0.007, <0.001, 0.043, <0.001, and 0.064. The areas under the ROC curves (AUCs) were 0.785, 0.709, 0.657, 0.648, and 0.613. The AUC in group 1 was significantly higher than those in groups 3–5.

CONCLUSIONS—The impact of hyperglycemia as a risk factor for hospital mortality in AMI is more pronounced in younger patients.

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Elevated glucose level (GL) is an independent risk factor for mortality in patients with acute myocardial infarction (AMI) (1–3), in part related to its adverse effects on microcirculation and left ventricular remodeling (4). Particularly in older people, hyperglycemia is a common complication that increases the risk of death (5). However, less is known about the impact of hyperglycemia in younger patients with AMI. Furthermore, the comparison of the impact of GL in different age-groups, particularly in very elderly adults (>80 years) versus younger adults (<50 years), has not been well studied and is the primary focus of this study.

RESEARCH DESIGN AND METHODS

Retrospective analysis of 2,027 patients (median age 64 years, 71.8% men) with AMI, hospitalized in a single tertiary center, and included prospectively in a dedicated databank.

Age-groups

Patients were divided into five age-groups: <50 years (group 1, $n = 301$), ≥ 50 and <60 years (group 2, $n = 477$), ≥ 60 and <70 years (group 3, $n = 545$), ≥ 70 and <80 years (group 4, $n = 495$), and ≥ 80 years (group 5, $n = 209$). Hyperglycemia was defined as first glucose measurement ≥ 115 mg/dL ($n = 1,025$). The time

between symptoms beginning and the glucose measurement was obtained in 1,752 patients; the median time for the population was 29 h and similar across the groups (P value = 0.642). The primary clinical outcome was in-hospital mortality.

Statistical analyses

Categorical variables are described as numbers and percentages and continuous variables as median (25th, 75th percentiles) or mean \pm SD.

For the correlation between hyperglycemia and hospital mortality, the χ^2 test was used, with the Mann-Whitney U test used for the correlation between GL (as continuous variable) and mortality. The mean GL among the groups was compared with ANOVA. Stepwise logistic regression method was applied for the comparison between hyperglycemia as a categorical variable or GL (continuous variable) with mortality (dependent variable). Two different models were developed. The first model included age, hyperglycemia (or GL), sex, ST-elevation AMI, and a history of angina, dyslipidemia, relatives with coronary artery disease, smoking, hypertension, heart failure, diabetes, stroke, coronary artery bypass surgery, percutaneous coronary intervention (PCI), and myocardial infarction. The second model included the previous variables plus primary PCI, nonprimary PCI, coronary artery bypass surgery, and fibrinolytic use during the in-hospital phase. Because there was no significant correlation between LDL or HDL and mortality, and the P interactions for these variables and hyperglycemia or GL regarding mortality were nonsignificant, neither LDL nor HDL was included in the models.

To analyze the accuracy of GLs in predicting in-hospital deaths, receiver operating characteristic (ROC) curves were constructed for each group and compared with the DeLong method. P values <0.05 were considered significant; MedCalc version 11.4.4 statistical software (MedCalc Software, Mariakerke,

From the ¹Heart Institute (InCor), University of São Paulo Medical School, São Paulo, Brazil; and the ²Thrombolysis in Myocardial Infarction (TIMI) Study Group, Brigham and Women's Hospital, Boston, Massachusetts.

Corresponding author: José Carlos Nicolau, corjnicolau@incor.usp.br.

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Belgium) was used for the ROC curve comparisons, and SPSS 16.0 (SPSS Inc., Chicago, IL) was used for the other analyses.

RESULTS—The mean GLs (in mg/dL) for groups 1–5 were, respectively, 125.8 ± 62.7 , 139.5 ± 69.4 , 143.9 ± 69.6 , 143.7 ± 69.8 , and 136.7 ± 72.1 . In comparison with group 1, the *P* values for groups 2–5 were, respectively, 0.052, 0.002, 0.003, and 0.398.

GLs were significantly higher among patients who died in hospital compared with survivors in all age-groups. Moreover, the mean difference in GL between deceased and survivors was larger in the youngest population when compared with the eldest population (65.6 ± 16.2 vs. 22.9 ± 11.1 mg/dL, $P < 0.001$). The adjusted *t* ratios (*P* values) for groups 1–5 in the first model (only baseline variables) were, respectively, 2.96 ($P = 0.003$), 4.47 ($P < 0.001$), 2.04 ($P = 0.042$), 3.48 ($P < 0.001$), and 1.85 ($P = 0.064$); for the second model (baseline variables + in-hospital interventions), the respective figures were 2.71 ($P = 0.007$), 4.47 ($P = 0.007$), 2.04 ($P = 0.042$), 3.48 ($P < 0.001$), and 1.85 ($P = 0.064$).

By univariate analyses, the odds ratios (*P* values) for in-hospital mortality in patients with hyperglycemia were the following for groups 1–5: 7.22 ($P = 0.001$), 3.17 ($P = 0.038$), 3.15 ($P = 0.003$), 3.31 ($P < 0.001$), and 2.07 ($P = 0.021$), respectively. In the first adjusted model (baseline variables), the respective group figures were 6.93 ($P = 0.004$), 3.21 ($P = 0.046$), 3.42 ($P = 0.004$), 3.20 ($P < 0.001$), and 2.25 ($P = 0.013$). In the second adjusted model (baseline + in-hospital variables), the figures were 7.57 ($P = 0.004$), 3.21 ($P = 0.046$), 3.50 ($P = 0.003$), 3.20 ($P < 0.001$), and 2.16 ($P = 0.021$), respectively.

The results of the area under the ROC curves (AUCs) are depicted in Table 1,

with best results obtained for the youngest population (AUC = 0.785) and the lowest AUC in the eldest population (AUC = 0.613).

DISCUSSION—The main finding of our study is the observation that hyperglycemia in patients with AMI is a better predictor for mortality in younger patients than in the elderly population. The increased mortality related to hyperglycemia in AMI patients has been linked to different pathophysiologic mechanisms (6–8), such as increased oxidative stress, inflammation, and activation of stress-responsive kinases. Moreover, hyperglycemia is strongly correlated with impaired coronary flow before reperfusion and has been associated with enhanced thrombin formation, platelet activation, and fibrin clot resistance to lysis. In addition, hyperglycemia has been linked to increased sensitivity to ischemia-reperfusion injury (9,10). Since the individual response to these processes (among others) varies with age, this could explain, at least in part, our results.

Another explanation for our findings (not exclusive of the previous) relates to the importance of age itself as a risk factor for mortality. Since advanced age is a strong independent risk factor for mortality in patients with AMI, hyperglycemia may have a relatively greater importance in younger populations and a weaker impact in the elderly population.

Clinical implications

There have been conflicting results regarding the clinical benefit of intensive glucose control in AMI patients (11–13). Several possible explanations for the lack of consistent benefit with intensive glucose management have been proposed, but the leading hypothesis is that it leads to a higher incidence of hypoglycemia,

which is quite deleterious in AMI patients (14). Our results add another nuance to this debate: intensive glucose control may have different effects depending on the age of the patient.

CONCLUSIONS—The value of hyperglycemia as a risk factor for in-hospital mortality in patients with AMI is not homogeneous, with a greater relative impact on mortality in the younger population. This finding may have clinical implications regarding the therapeutic approach to hyperglycemia in patients with AMI (15).

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Table 1—ROC curves according to analyzed age-groups

Age-group (years)	AUC	95% CI	<i>P</i> value
Global	0.655	0.617–0.693	<0.001
<50*	0.785	0.697–0.873	<0.001
≥50 and <60	0.709	0.551–0.867	0.004
≥60 and <70	0.657	0.576–0.738	0.002
≥70 and <80	0.648	0.585–0.710	<0.001
≥80	0.613	0.525–0.701	0.012

The AUC revealed a close relationship between age and predictive value of GLs for in-hospital mortality. The AUC for the global population was 0.655, and once again the best result was obtained for the youngest population (AUC = 0.785); in a descending way among the groups, the least predictive result was obtained for the oldest population. * $P = 0.035$ vs. aged 60–69; $P = 0.013$ vs. aged 70–79; $P = 0.007$ vs. aged >80; other comparisons statistically nonsignificant.

- statement from the American Heart Association Diabetes Committee of the Council on Nutrition, Physical Activity, and Metabolism. *Circulation* 2008;117:1610–1619
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