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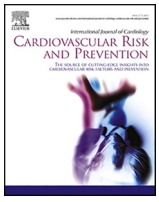

Predictive value of glucose coefficient of variation for in-hospital mortality in acute myocardial infarction patients undergoing PCI: Insights from the MIMIC-IV database

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ABSTRACT

Background: Acute myocardial infarction (AMI) carries a high short-term risk of death, even after percutaneous coronary intervention (PCI). Glucose variability (GV), measured by the glucose coefficient of variation (GluCV), is a potential risk factor for adverse outcomes. This study investigates GluCV's predictive value for in-hospital mortality in AMI patients undergoing PCI.

Method: This study involved 2325 AMI patients who were admitted to the ICU and underwent PCI from the MIMIC-IV database. Patients were categorized into quartiles based on GluCV: <0.13, 0.13–0.20, 0.20–0.29, and ≥0.29. Multivariable logistic regression and Restricted cubic spline (RCS) analysis were employed to analyze the relationship between GluCV and in-hospital mortality. Mediation analysis was used to evaluate the role of GluCV in the relationship between disease complexity and severity.

Results: Among the 2325 patients, 203 (8.7 %) died during hospitalization. Higher GluCV was associated with increased in-hospital mortality. Adjusted odds ratios for mortality were 1.35 (95 % CI: 0.71–2.55), 1.91 (95 % CI: 1.04–3.51), and 3.32 (95 % CI: 1.83–6.02) for the second, third, and fourth groups, respectively. RCS analysis indicated a linear relationship between Log GluCV and mortality risk, with each 1 SD increase in Log GluCV associated with a 1.70-fold increase in mortality. Subgroup analysis showed a stronger relationship between GluCV and mortality in patients younger than 70. Mediation analysis indicated that GluCV partially mediates the effect of comorbidities on organ dysfunction.

Conclusions: GluCV is an important predictor of in-hospital mortality in AMI patients undergoing PCI. Managing GV to minimize fluctuations may improve patient prognosis.

1. Background

Acute myocardial infarction (AMI) is characterized by myocardial necrosis due to acute and sustained ischemia and hypoxia of the coronary arteries. Even after percutaneous coronary intervention (PCI), patients remain at a significant risk of short-term mortality, particularly those with multiple comorbidities [1–3]. Previous studies have identified factors such as the duration of diabetes and blood glucose levels at admission as independent risk factors for adverse short- and long-term outcomes in AMI patients. However, these studies have limitations. Some have focused exclusively on diabetic patients, neglecting the impact of glucose levels on non-diabetic individuals [4], while others have considered blood glucose levels only at admission, without accounting for fluctuations throughout hospitalization [5,6].

Glucose variability (GV), which refers to the fluctuations in blood glucose levels over time, including the frequency and amplitude of hyperglycemia and hypoglycemia [7,8], has emerged as an important predictor of outcomes in critically ill patients. Among the various metrics used to assess GV, the Mean Amplitude of Glycemic Excursions (MAGE) is recognized as a reliable indicator of poor outcomes in

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hospitalized patients [9,10]. Despite its precision, MAGE's complex calculation process and the need for frequent glucose measurements limit its practicality for routine clinical use.

In contrast, the glucose coefficient of variation (GluCV) provides a simpler and more accessible alternative for evaluating GV and is unaffected by the mean glucose. Numerous studies have demonstrated that GluCV effectively predicts in-hospital mortality in various patient populations [11–18]. However, some studies on GluCV have not limited their focus to specific diseases, resulting in significant heterogeneity among patient populations. Consequently, their conclusions may have limited applicability to specific clinical scenarios [11,19].

To address these gaps, this study aims to investigate the predictive value of GluCV for in-hospital all-cause mortality in AMI patients undergoing PCI. As GluCV is an indicator of GV, this study seeks to provide new evidence for using GV as a prognostic marker in AMI patients.

2. Method

2.1. Database source

This study was designed based on the Medical Information Mart for Intensive Care IV (MIMIC-IV, version 2.2), a large, single-center, freely accessible database containing data from 180,734 hospitalized patients, including 66,239 ICU admissions for 50,920 patients at Beth Israel Deaconess Medical Center between 2008 and 2019 [20,21]. Data extraction was conducted by an approved researcher (Zixuan Zhang) with certification of No.13038605. To protect patient privacy, all personal identifiers were de-identified. Our study involved the analysis of a third-party anonymized public database with IRB approval; therefore, our IRB approval is considered exempt.

2.2. Selection of study population

This study included AMI patients admitted to the ICU for the first time and undergoing PCI. AMI was defined based on the International Classification of Diseases (ICD), which includes ICD-9 and ICD-10 diagnosis codes, encompassing both ST-elevated myocardial infarction (STEMI) and non-ST-elevated myocardial infarction (NSTEMI). Patients with an ICU stay of less than 1 day or more than 30 days and those who did not undergo PCI were excluded. Additionally, patients with fewer than three glucose measurements were excluded to ensure the calculation of GluCV.

2.3. Data extraction and definitions

Data were extracted and collected using PostgreSQL (version 16.0) from the MIMIC-IV database. All glucose measurements during the ICU stay were extracted to calculate GluCV. GluCV is defined as the standard deviation (SD) of all repeated glucose measurements divided by the mean glucose level, expressed as a percentage: GluCV = (SD/Mean) × 100 % [22,23]. Additionally, data on patients' demographics (age, sex, height, weight), vital signs (heart rate, respiratory rate, systolic blood pressure), and laboratory tests (hemoglobin, white blood cells, platelets, bicarbonate, creatinine, sodium) were extracted. Comorbidity information was obtained using ICD-9 or ICD-10 diagnosis codes, and details of the PCI procedure, including the number of stents and treated vessels, were retrieved using ICD-9-CM and ICD-10-PCS codes. The use of extracorporeal membrane oxygenation (ECMO), intra-aortic balloon pump (IABP), vasoactive drugs (dobutamine, dopamine, epinephrine, norepinephrine, phenylephrine, milrinone, vasopressin), and β-blockers were also recorded. Patients were categorized into four groups (G1, G2, G3, G4) based on the interquartile range (IQR) of GluCV, with G1 serving as the reference group.

2.4. Outcomes

The primary outcome was in-hospital all-cause mortality, determined by the recorded date of death and discharge date in the MIMIC IV database.

2.5. Statistical analyses

Categorical variables were presented as numbers and percentages (%), and differences were examined using the chi-square test. Continuous variables were expressed as mean ± SD or median and IQR, and they were compared using either analysis of variance (ANOVA) or the Wilcoxon rank-sum test. Crude and adjusted logistic regression models were used to determine the association between GluCV and outcomes, providing odds ratios (ORs) and 95 % confidence intervals (CIs). Covariates included age, sex, body mass index (BMI), ST-segment status, congestive heart failure (CHF), cerebrovascular disease (CVD), chronic kidney disease (CKD), chronic pulmonary disease (CPD), peripheral vascular disease (PVD), diabetes mellitus (DM), atrial fibrillation (AF) during hospitalization, systolic blood pressure, SpO2, hemoglobin, white blood cell count, platelet count, sodium, potassium, creatinine, troponin T, CK-MB, number of treated vessels, vasoactive drugs, IABP, and CRRT usage. Subgroup analyses were performed based on age, sex, CHF, CVD, CKD, PVD, CPD, DM, AF, and ST-segment status using adjusted models. Four-knot (P25, P50, P75, P95) restricted cubic spline (RCS) plots were used to explore potential non-linear relationships between GluCV levels and mortality risk. Log-transformed GluCV (Log GluCV) was analyzed as a continuous variable due to its non-normal distribution. Mediation analysis was conducted to explore direct and indirect relationships between disease complexity, symptom severity, and GluCV. The Charlson Comorbidity Index (CCI) represented disease complexity, and the Sequential Organ Failure Assessment (SOFA) score represented symptom severity. The non-parametric bootstrap method, repeated 1000 times, was used to calculate the average causal mediation effect (ACME), average direct effect (ADE), and total effect. All statistical analyses were performed using R software (version 4.4.0). A p-value <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics

This study includes 2325 patients admitted to the ICU for the first time due to AMI and undergoing PCI. The patient selection process is illustrated in Fig. 1. Among the 2325 AMI patients, 1816 (78.1 %) were diagnosed with STEMI, and 509 (21.9 %) with NSTEMI. The median age of the patients was 69 years, with 1513 (65.1 %) being male. CHF was present in 1129 patients (48.6 %), CVD in 260 patients (11.2 %), CKD in 567 patients (24.4 %), and DM in 897 patients (38.6 %). During hospitalization, 589 patients (25.3 %) experienced AF, and 895 patients (38.5 %) had sinus bradycardia (SB). No patients experienced ventricular fibrillation or atrioventricular block during their hospital stay. Patients were divided into four groups based on the IQR of their GluCV: <0.13 (n = 581), 0.13–0.20 (n = 596), 0.20–0.29 (n = 550), and ≥ 0.29 (n = 598). Table 1 summarizes the demographic and clinical characteristics of the study population across these groups. 203 (8.7 %) patients died during hospitalization, the comparison between deceased and surviving patients is shown in Supplemental Table 1.

3.2. The association between GluCV and in-hospital death

Logistic regression analysis indicated a significant association between GluCV and all-cause mortality in patients (Fig. 2). In the crude model, compared to the reference group (G1), the OR for the remaining three groups were 1.83 (95 % CI: 1.02–3.29), 3.55 (95 % CI: 2.06–6.11), and 5.98 (95 % CI: 3.56–10.03). After adjusting for demographic

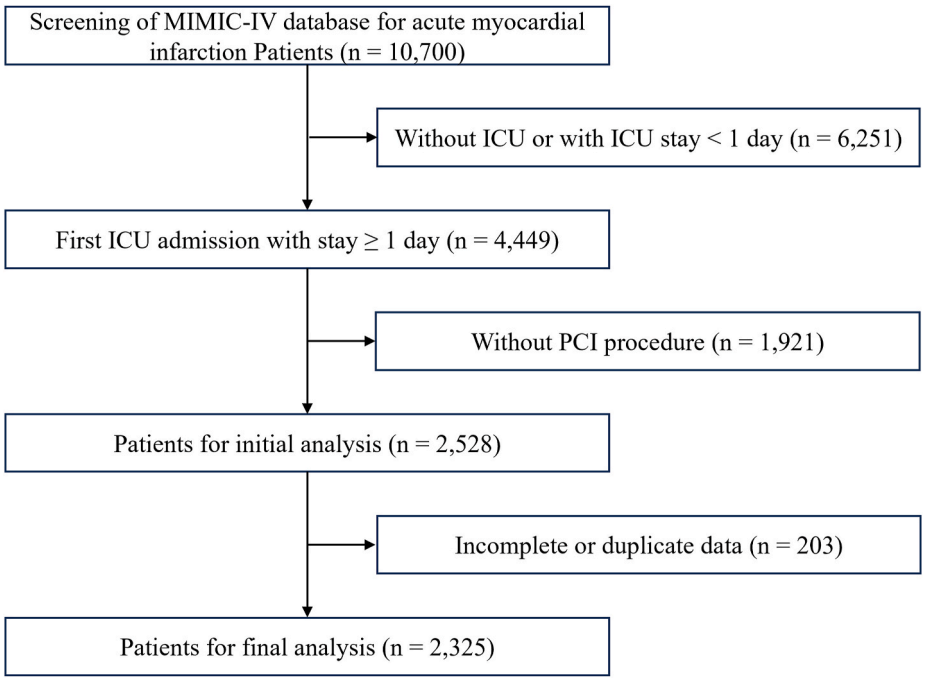

Fig. 1. Flow chart of the inclusion of the study population.

parameters, medical history, laboratory tests, and interventions, the OR were 1.35 (95 % CI: 0.71–2.55), 1.91 (95 % CI: 1.04–3.51), and 3.32 (95 % CI: 1.83–6.02) for the remaining groups, respectively, showing an increasing risk of in-hospital death with higher GluCV.

3.3. Restricted cubic spline

To further explore the potential non-linear relationship between continuous GluCV and in-hospital all-cause mortality, we performed RCS analysis (Fig. 3A and B). The results showed that the *P-non-linear* in the crude and adjusted models were 0.191 and 0.147, respectively, indicating a linear relationship between GluCV and in-hospital death risk. In the adjusted model, we observed an inflection point at Log GluCV = −2.27. Data were divided into two groups based on this inflection point: Log GluCV < −2.27 and Log GluCV ≥ −2.27. Segmented regression was performed for each group, as shown in Table 2. For Log GluCV ≥ −2.27, each 1 SD increase in Log GluCV was associated with a 1.70-fold increase in the risk of in-hospital death (OR 1.70, 95 % CI: 1.47–1.97).

3.4. Subgroup analysis

As shown in Table 3, subgroup analyses were conducted to validate the stability of the study results. No significant interactions were found in subgroups based on sex, CHF, CVD, CKD, PVD, CPD, DM, AF during hospitalization, or ST-segment elevation. However, the association between GluCV and in-hospital all-cause mortality was more pronounced in patients younger than 70 years compared to those aged 70 years and older (P for interaction = 0.034).

3.5. Mediation analysis

Mediation analysis was performed to evaluate the role of GluCV in the relationship between disease complexity and symptom severity. According to Table 4, the ACME of CCI on SOFA through GluCV was 0.016 (95 % CI: 0.004, 0.027, P = 0.004), the ADE of CCI on SOFA was 0.076 (95 % CI: 0.024, 0.125, P = 0.002), and the total effect was 0.092 (95 % CI: 0.041, 0.142, P < 0.001). The proportion of the total effect mediated by GluCV was 17.5 % (95 % CI: 0.044, 0.439, P = 0.004).

4. Discussion

This study analyzed data from 2325 AMI patients undergoing PCI in the MIMIC-IV database, revealing a significant association between GluCV and in-hospital all-cause mortality. Specifically, in the adjusted model, compared to patients in the G1 group, the mortality risk increased by 1.35, 1.91, and 3.32 times in the G2, G3, and G4 groups, respectively, with statistically significant results in the G3 and G4 groups. Further analysis of the adjusted RCS curve showed a positive linear relationship between Log GluCV and in-hospital mortality risk beyond the inflection point. These findings suggest that among the AMI patients undergoing PCI in this study, greater GluGV is associated with higher in-hospital mortality, especially when GluCV exceeds 0.2.

Subgroup analysis indicated that the relationship between GluCV and in-hospital mortality risk was more significant in patients younger than 70 years. Previous studies have shown that age is significantly related to systemic chronic inflammation (SCI) [24]. Older patients often have low-grade and persistent SCI, and many suffer from multiple chronic diseases, which can affect blood glucose levels and thus weaken the impact of glucose fluctuations on mortality risk. Conversely, younger patients have better regulatory abilities for acute diseases and exhibit more pronounced physiological changes in response to various stressors [25,26]. They also have lower disease complexity, making the association between glucose fluctuations and outcomes more significant. However, the predictive value of GluCV is not limited to younger or less complex patients. In patients with more complex comorbidities, GluCV still plays a meaningful role. Our mediation analysis demonstrated that GluCV explained approximately 17.5 % of the total effect between CCI and SOFA scores. Given the multifactorial nature of these conditions, glucose fluctuations alone cannot accurately predict mortality risk and should be analyzed in conjunction with patients' medical history and other clinical factors [27,28]. However, in critical care settings, patient outcomes are often influenced by a variety of physiological processes, and every controllable factor can play a crucial role in reversing or mitigating the progression of organ dysfunction and, ultimately, improving survival outcomes. In severe cases, where treatment options

Table 1
Baseline characteristics grouped according to GluCV levels.

Variables	Total	Groups [1–4] divided by GluCV				p value
		G1 (<0.13)	G2 (0.13–0.20)	G3 (0.20–0.29)	G4 (≥0.29)	
Sample, %	2325 (100.0)	581 (25.0)	596 (26.6)	550 (23.7)	598 (25.7)	
Age, years	69.0 [60.0,78.0]	66.00 [57.0,76.0]	68.00 [60.0,78.0]	72.00 [64.0,79.8]	69.00 [60.0,77.0]	<0.001
Male, %	1513 (65.1)	401 (69.0)	413 (69.3)	344 (62.5)	355 (59.4)	<0.001
BMI, kg/m2	29.0 [25.6,33.1]	29.0 [25.6,33.1]	28.7 [25.6,32.5]	28.86 [25.7,32.8]	29.22 [25.9,33.3]	0.321
Emergency admission, %	2001 (86.1)	500 (86.1)	501 (84.1)	472 (85.8)	528 (88.3)	0.209
STEMI, %	1816 (78.1)	487 (83.8)	459 (77.0)	415 (75.5)	455 (76.1)	0.001
CHF, %	1129 (48.6)	199 (34.3)	241 (40.4)	308 (56.0)	381 (63.7)	<0.001
CVD, %	260 (11.2)	39 (6.7)	60 (10.1)	73 (13.3)	88 (14.7)	<0.001
CKD, %	567 (24.4)	78 (13.4)	105 (17.6)	159 (28.9)	225 (37.6)	<0.001
CPD, %	536 (23.1)	90 (15.5)	130 (21.8)	157 (28.5)	159 (26.6)	<0.001
PVD, %	367 (15.8)	61 (10.5)	83 (13.9)	102 (18.5)	121 (20.2)	<0.001
DM, %	897 (38.6)	111 (19.1)	156 (26.2)	243 (44.2)	387 (64.7)	<0.001
AF, %	589 (25.3)	79 (13.6)	140 (23.5)	186 (33.8)	184 (30.8)	<0.001
SB, %	895 (38.5)	218 (37.5)	220 (36.9)	216 (39.3)	241 (40.3)	0.609
HR, bpm	81.0 [72.0,93.0]	80.0 [70.0,88.0]	81.0 [71.0,93.0]	81.0 [71.3,93.0]	83.0 [74.0,96.0]	<0.001
RR, bpm	17.0 [14.0,21.0]	17.0 [14.0,20.0]	17.0 [14.0,21.0]	18.0 [15.0,22.0]	18.0 [14.0,22.0]	0.007
SBP, mmHg	120.0 [105.0,135.0]	121.0 [109.0,138.0]	119.0 [106.0,132.0]	119.0 [103.0,133.8]	119.5 [103.0,134.8]	0.022
TEMP, °C	36.3 [35.7,37.1]	36.3 [35.70,37.0]	36.3 [35.7,37.1]	36.4 [35.7,37.2]	36.2 [35.7,37.0]	0.217
SpO_2, %	98.0 [95.0,100.0]	98.0 [96.0,100.0]	98.0 [96.0,100.0]	98.0 [95.0,100.0]	98.0 [95.0,100.0]	0.746
Hb, K/uL	11.5 [9.8,13.2]	12.3 [10.7,13.6]	11.8 [10.0,13.4]	11.1 [9.4,12.8]	10.9 [9.2,12.5]	<0.001
WBC, K/uL	11.2 [8.6,14.6]	10.1 [8.1,12.7]	11.3 [8.7,14.5]	11.6 [8.9,15.5]	12.1 [9.1,16.4]	<0.001
PLT, K/uL	203.0 [158.0,255.0]	207.0 [165.0,252.0]	195.0 [156.8245.3]	203.0 [159.0,253.8]	211.0 [152.3271.0]	0.076
Bc, mmol/L	23.0 [21.0,25.0]	24.0 [22.0,26.0]	23.0 [21.0,25.0]	23.0 [20.0,25.0]	22.0 [19.3,25.0]	<0.001
Creatinine, mg/dL	1.0 [0.8,1.4]	0.9 [0.7,1.1]	0.9 [0.8,1.2]	1.0 [0.8,1.4]	1.2 [0.9,1.8]	<0.001
Sodium, mmol/L	138.0 [136.0,140.0]	138.0 [136.0,140.0]	138.0 [136.0,140.0]	138.0 [135.0,140.0]	137.0 [134.0,140.0]	<0.001
Potassium, mmol/L	4.2 [3.9,4.6]	4.1 [3.9,4.4]	4.2 [3.9,4.5]	4.2 [3.9,4.6]	4.3 [3.9,4.8]	<0.001
Inr	1.2 [1.1,1.4]	1.2 [1.1,1.3]	1.2 [1.1,1.4]	1.2 [1.1,1.4]	1.3 [1.1,1.5]	<0.001
Troponin T, ng/mL	0.8 [0.2,2.8]	1.7 [0.3,3.7]	0.7 [0.2,2.7]	0.8 [0.2,2.3]	0.8 [0.2,2.4]	0.001
CK-MB, ng/mL	23.0 [7.0,94.0]	35.0 [10.0,118.0]	24.0 [6.0,96.0]	18.5 [7.0,73.5]	18.0 [6.0,81.8]	<0.001
Vasoactive agent, %	959 (41.2)	130 (22.4)	253 (42.4)	268 (48.7)	308 (51.5)	<0.001
β-blocker, %	2175 (93.5)	553 (95.2)	569 (95.5)	516 (93.8)	537 (89.8)	<0.001
ECMO, %	18 (0.8)	0 (0.0)	0 (0.0)	6 (1.1)	12 (2.0)	<0.001
IABP, %	181 (7.8)	23 (4.0)	43 (7.2)	49 (8.9)	66 (11.0)	<0.001
CRRT, %	95 (4.1)	5 (0.9)	17 (2.9)	27 (4.9)	46 (7.7)	<0.001
Stents, %						
No	1098 (47.2)	199 (34.3)	300 (50.3)	278 (50.5)	321 (53.7)	<0.001
1 stent	840 (36.1)	257 (44.2)	212 (35.6)	184 (33.5)	187 (31.3)	
2 or more stents	387 (16.6)	125 (21.5)	84 (14.1)	88 (16.0)	90 (15.1)	
Treated arteries, %						
No	984 (42.3)	166 (28.6)	286 (48.0)	249 (45.3)	283 (47.3)	<0.001
1 artery	1092 (47.0)	360 (62.0)	249 (41.8)	238 (43.3)	245 (41.0)	
2 arteries	205 (8.8)	46 (7.9)	50 (8.4)	48 (8.7)	61 (10.2)	
3 or more arteries	44 (1.9)	9 (1.5)	11 (1.8)	15 (2.7)	9 (1.5)	

GluCV: Glucose coefficient of variation; STEMI: ST-Elevated Myocardial Infarction; BMI: Body mass index; CHF: Congestive heart failure; CVD: Cerebrovascular disease; CKD: Chronic kidney disease; CPD: Chronic pulmonary disease; PVD: Peripheral vascular disease; DM: Diabetes mellitus; AF: Atrial fibrillation; SB: sinus bradycardia; HR: Heart rate; RR: Respiratory rate; SBP: systolic blood pressure; TEMP: temperature; SpO_2: peripheral capillary oxygen saturation; Hb: hemoglobin; WBC: white blood cells; PLT: platelets; Bc: bicarbonate; INR: international normalized ratio; Troponin T: cardiac troponin T; CK-MB: creatine kinase-MB; ECMO: extracorporeal membrane oxygenation; IABP: intra-aortic balloon pump; CRRT: continuous renal replacement therapy.

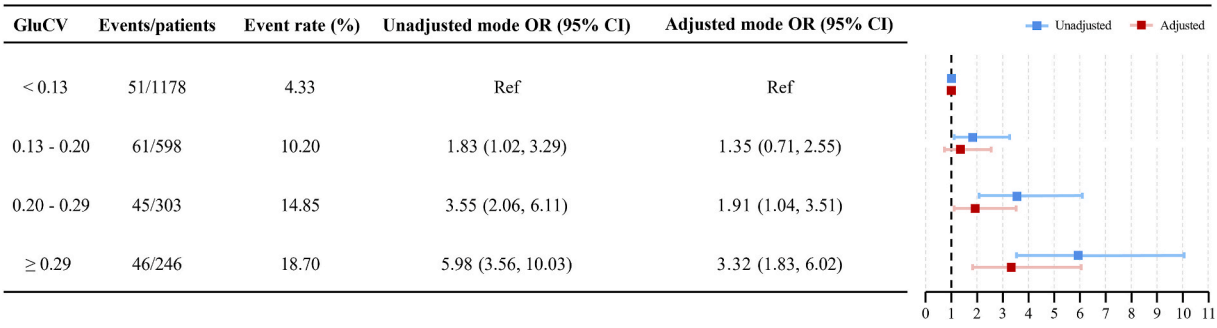

Fig. 2. The association between GluCV and in-hospital death. OR = Odds Ratio, CI = Confidence Interval, Ref = Reference.

are often limited, controlling GluCV could potentially tip the balance toward a better prognosis.

Previous studies have shown that frequent glucose fluctuations can increase the production of reactive oxygen species (ROS) and mitochondrial dysfunction, activating various oxidative stress pathways, leading to endothelial dysfunction and inflammatory responses, exacerbating vascular and myocardial cell damage, and even affecting autonomic function, thereby increasing the risk of arrhythmias [29–31].

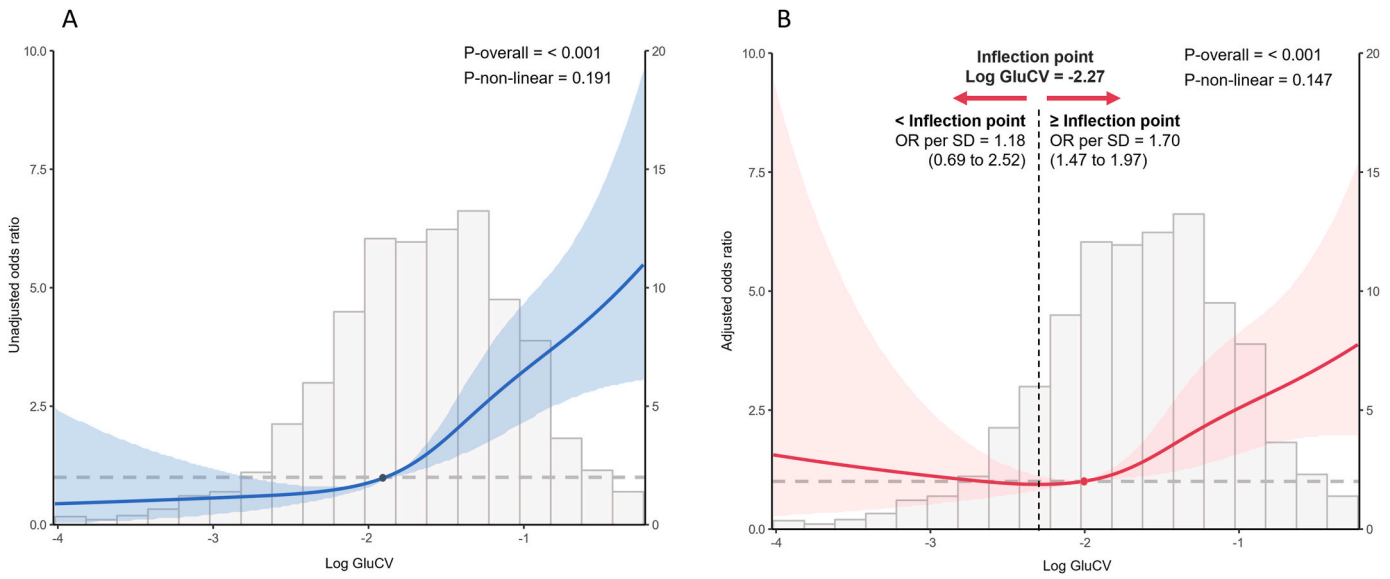

Fig. 3. Restricted cubic spline plots for the association of GluCV with in-hospital death. (A) unadjusted model; (B) adjusted model. Log GluCV = log glucose coefficient of variation; OR = Odds Ratio; SD = standard deviation.

Table 2
Effect of standardized Log GluCV level on in-hospital death: adjusted odds ratios from segmented logistic regression analysis.

Characteristic	OR per SD	95 % CI	p-value
Log GluCV (<−2.27)	1.18	0.69, 2.52	0.61
Log GluCV (≥−2.27)	1.70	1.47, 1.97	<0.001

OR = Odds Ratio; SD = standard deviation; CI = Confidence Interval.

AMI patients typically have pre-existing vascular dysfunction and myocardial damage, and oxidative stress caused by glucose fluctuations can worsen their condition. For diabetic patients, the duration of diabetes closely reflects the burden of vascular complications, which in turn is associated with in-hospital clinical outcomes in AMI patients [32–34]. Studies have also indicated that high GV correlates more significantly with various complications than chronic hyperglycemia, and high GV in AMI and cardiac surgery patients is associated with severe

Table 3
Subgroup analysis for the association between GluCV and in-hospital death.

Subgroups	Groups [1–4] divided by GluCV				P for interaction
	G1 (<0.13)	G2 (0.13–0.20)	G3 (0.20–0.29)	G4 (≥0.29)	
Age, years					0.034
≥70 (n = 1134)	Ref	0.92 (0.43–1.98)	1.57 (0.78–3.16)	2.12 (1.04–4.35)	
<70 (n = 1191)	Ref	2.65 (0.67–10.4)	2.82 (0.69–11.6)	7.42 (1.99–27.7)	
Gender					0.290
Female (n = 812)	Ref	0.62 (0.23–1.68)	1.4 (0.58–3.4)	2.29 (0.97–5.39)	
Male (n = 1513)	Ref	2.13 (0.87–5.24)	2.37 (0.98–5.73)	4.48 (1.87–10.73)	
CHF					0.178
Yes (n = 1129)	Ref	1.02 (0.44–2.37)	1.52 (0.71–3.25)	2.16 (1.02–4.57)	
No (n = 1196)	Ref	1.82 (0.63–5.22)	2.12 (0.72–6.22)	5.24 (1.89–14.55)	
CVD					0.868
Yes (n = 260)	Ref	3.91 (0.43–35.32)	2.76 (0.3–25.39)	4.13 (0.51–33.66)	
No (n = 2065)	Ref	1.29 (0.65–2.56)	1.84 (0.95–3.55)	3.29 (1.73–6.23)	
CKD					0.297
Yes (n = 567)	Ref	0.61 (0.18–2.09)	1.28 (0.43–3.77)	2.71 (0.9–8.16)	
No (n = 1758)	Ref	2.08 (0.89–4.82)	2.55 (1.1–5.9)	4.01 (1.78–9)	
PVD					0.928
Yes (n = 367)	Ref	0.69 (0.16–2.88)	1.33 (0.38–4.69)	3.08 (0.88–10.72)	
No (n = 1958)	Ref	1.47 (0.7–3.09)	2.04 (0.99–4.19)	3.22 (1.59–6.51)	
CPD					0.606
Yes (n = 536)	Ref	0.72 (0.18–2.96)	1.08 (0.29–4.07)	2.8 (0.77–10.19)	
No (n = 1789)	Ref	1.51 (0.73–3.12)	1.92 (0.95–3.88)	2.98 (1.49–5.95)	
DM					0.101
Yes (n = 897)	Ref	1.26 (0.38–4.17)	0.81 (0.26–2.53)	2.16 (0.76–6.16)	
No (n = 1428)	Ref	1.29 (0.6–2.78)	2.61 (1.24–5.46)	3.77 (1.79–7.94)	
AF					0.779
Yes (n = 589)	Ref	0.95 (0.29–3.09)	1.73 (0.59–5.06)	3.25 (1.1–9.6)	
No (n = 1736)	Ref	1.69 (0.77–3.7)	2.04 (0.93–4.46)	3.5 (1.66–7.36)	
STEMI					0.550
Yes (n = 1816)	Ref	1.26 (0.63–2.5)	1.53 (0.79–2.99)	2.74 (1.44–5.22)	
No (n = 509)	Ref	1.52 (0.2–11.42)	4.52 (0.69–29.64)	7.55 (1.09–52.12)	

GluCV: Glucose coefficient of variation; CHF: Congestive heart failure; CVD: Cardiovascular disease; CKD: Chronic kidney disease; CPD: Chronic pulmonary disease; PVD: Peripheral vascular disease; DM: Diabetes mellitus; AF: Atrial fibrillation; STEMI: ST-elevated myocardial infarction.

Table 4
Mediating effect and proportions of GluCV between CCI and SOFA.

Effect	Estimate	95 % CI	P-value
ACME	0.016	0.004, 0.027	0.004
ADE	0.076	0.024, 0.125	0.002
Total Effect	0.092	0.041, 0.142	<0.001
Mediation proportions	0.175	0.044, 0.439	0.004

GluCV: Glucose coefficient of variation; CCI: Charlson comorbidity index; SOFA: Sequential organ failure assessment; ACME: Average causal mediation effect; ADE: Average direct effect; CI: Confidence interval.

cardiovascular adverse events and in-hospital mortality [14]. Our study found that GluCV is correlated with in-hospital mortality risk in non-diabetic patients, consistent with previous findings [2,35–37].

The results of this study have significant practical implications. Managing GV may be more crucial than merely controlling average glucose levels in cardiovascular disease patients. Continuous glucose monitoring (CGM) can provide multidimensional assessments of GV levels, helping predict in-hospital mortality risk [38]. Personalized treatment strategies based on glucose management may become an important direction for future cardiovascular disease research.

4.1. Limits

Despite the significant association between GluCV and in-hospital mortality risk in AMI patients undergoing PCI, this study has several limitations. First, as a retrospective analysis, it has inherent selection and information biases. Second, the study is based on data from a single center, which may limit the generalizability of the results to a broader population. Moreover, important variables such as detailed PCI procedural information (e.g., TIMI flow, culprit vessels), lifestyle behaviors, and socioeconomic status were not available in the MIMIC-IV database, which restricted our ability to fully evaluate the impact of these factors on patient outcomes. Future research should consider multicenter, large-scale prospective studies with more comprehensive data collection, combined with advanced big data analytics and machine learning approaches [39], to develop and validate predictive models that incorporate a wide range of risk factors, including GluCV. Additionally, exploring the mechanisms of controlling glucose fluctuations and their application in different populations will help further optimize treatment strategies for hospitalized patients, providing more precise medical care.

5. Conclusion

In summary, this study indicates that GluCV is a significant predictor of in-hospital mortality risk in AMI patients undergoing PCI, regardless of diabetes status. Clinically, managing GV is crucial for improving patient prognosis. Future research should continue to explore and validate these findings, thereby promoting the development of clinical practice and enhancing patient survival and quality of life.

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CRediT authorship contribution statement

Zixuan Zhang: Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **Mengmeng Ji:** Writing – review & editing, Validation, Data curation. **Qingqing Zhao:** Investigation, Formal analysis. **Luying Jiang:** Writing – review & editing, Investigation, Data curation. **Shilang Fan:** Investigation, Formal analysis. **Houjuan Zuo:** Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcrp.2024.200347.

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