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MANAGEMENT OF HYPERGLYCEMIA IN THE EMERGENCY DEPARTMENT AND ITS IMPACT ON MORTALITY AND ADVERSE OUTCOMES

MANEJO DE LA HIPERGLICEMIA EN EL SERVICIO DE EMERGENCIA Y SU IMPACTO EN MORTALIDAD Y DESENLACES DESFAVORABLES

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ABSTRACT

Introduction: Glycemic control in emergency settings is essential for predicting patient outcomes. **Objective:** To determine whether glycemic control impacts mortality and clinical outcomes in Peru. **Methods:** An observational, analytical, retrospective cohort study was conducted in three national hospitals in Metropolitan Lima between August and December 2022. A total of 730 patients aged over 18 years with hyperglycemia (serum glucose >180 mg/dL), with or without a history of diabetes mellitus (DM), were included. Clinical, demographic, and biochemical variables were assessed. Glycemic control was defined as blood glucose ≤180 mg/dL within 24 hours of treatment. The composite outcome included mortality, need for mechanical ventilation, and hemodialysis due to acute kidney injury (AKI). Poisson regression with robust variance was used for multivariate analysis. The study was approved by ethics committees, and data confidentiality was respected. **Results:** Glycemic control was achieved in 45.2% of patients at 24 hours, which was associated with a lower rate of prolonged hospital stay (51.8% vs. 60.5%; aRR: 0.86; 95% CI: 0.74–0.99; p=0.031). No significant association was found with other outcomes: mechanical ventilation (RR: 1.53; 95% CI: 0.90–2.59; p=0.115), AKI requiring hemodialysis (RR: 0.88; 95% CI: 0.44–1.78; p=0.727), mortality (RR: 1.13; 95% CI: 0.55–2.31; p=0.735), or the composite outcome (RR: 1.07; 95% CI: 0.74–1.55; p=0.724). Similar results were found in the sub-analysis of patients with DM. **Conclusion:** Early glycemic control reduces the duration of hospital stay but does not impact other clinical outcomes, suggesting the need for a comprehensive and personalized approach.

Keywords: Glycemic control; Hyperglycemia; Length of stay; Mortality; Emergencies. (Source: MESH-NLM)

RESUMEN

Introducción: El control glucémico en emergencias es importante para el pronóstico del paciente. **Objetivos:** Determinar si el control glucémico impactó en la mortalidad y desenlaces clínicos en Perú. **Métodos:** Se realizó un estudio observacional, analítico, de cohorte retrospectiva en tres hospitales nacionales de Lima Metropolitana, entre agosto y diciembre de 2022. Se incluyeron 730 pacientes mayores de 18 años con hiperglicemia (glucosa sérica >180 mg/dL), con o sin antecedente de diabetes mellitus (DM). Se evaluaron variables clínicas, demográficas y bioquímicas, y se definió control glicémico como glucemia ≤180 mg/dL a las 24 horas de tratamiento. El desenlace combinado incluyó mortalidad, necesidad de ventilación mecánica y hemodiálisis por enfermedad renal aguda (ERA). Se utilizó regresión de Poisson con varianza robusta para análisis multivariado. El estudio fue aprobado por comités de ética y se respetó la confidencialidad de los datos. **Resultados:** El 45,2 % logró control glicémico a las 24 horas, lo que se asoció con menor estancia hospitalaria prolongada (51,8 % vs. 60,5 %; RRa: 0,86; IC95 %: 0,74–0,99; p=0,031). No hubo asociación significativa con otros desenlaces: ventilación mecánica (RR: 1,53; IC95 %: 0,90–2,59; p=0,115), ERA con hemodiálisis (RR: 0,88; IC95 %: 0,44–1,78; p=0,727), mortalidad (RR: 1,13; IC95 %: 0,55–2,31; p=0,735) y desenlace combinado (RR: 1,07; IC95 %: 0,74–1,55; p=0,724). Resultados similares se hallaron en el subanálisis de pacientes con DM. **Conclusión:** El control glicémico temprano reduce la estancia hospitalaria, pero no impacta en otros eventos clínicos, sugiriendo la necesidad de un abordaje integral y personalizado.

Palabras claves: Control glucémico; Hiperglucemia; Mortalidad; Tiempo de internación; Urgencias médicas. (Fuente: DeCS- BIREME)

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INTRODUCTION

Hyperglycemia is a public health problem with significant implications for the progression of hospitalized patients. It has been identified as a poor prognosis factor in various medical conditions, including cardiovascular diseases, severe infections, and systemic inflammatory states [1]. At the regional level, Latin America has a high burden of metabolic diseases, which increases the prevalence of hyperglycemia in emergency services[2,3].

Hyperglycemia is not only associated with worse outcomes in severe infections but also with a higher risk of cardiovascular events. It has been shown that elevated glucose levels negatively impact coagulation and hemostasis, promoting a prothrombotic state that increases mortality in various pathologies [4]. In patients with decompensated heart failure, a "U-shaped" relationship between hyperglycemia and mortality has been identified, with both excessively high and low blood glucose levels increasing the risk of death and rehospitalization [5]. Similarly, in patients with acute myocardial infarction, hyperglycemia upon hospital admission has been established as an independent predictor of mortality both in the short and long term[6]. Furthermore, in population-based studies, it has been shown that the relationship between hyperglycemia and cardiovascular mortality in patients with diabetes or prediabetes follows an "L-shaped" pattern, indicating that even mild increases in glucose can negatively impact survival[7].

The management of hyperglycemia in emergency services varies considerably and remains a challenge. The American Diabetes Association guidelines [8] recommend an individualized approach based on continuous glucose monitoring and the use of insulin when necessary, prioritizing insulin analogs to reduce the risk of hypoglycemia. However, studies have shown that in hospitals, insulin is often used inappropriately on a sliding scale, which can increase the risk of hypoglycemia and metabolic imbalance [9]. In this context, it is important to consider the impact of hyperglycemia in vulnerable populations, such as older adults with diabetes, in whom high prevalence of frailty has been found, which in turn is associated with worse cognitive and emotional function, increasing vulnerability to unfavorable outcomes [10]. Despite the existing evidence on the association between hyperglycemia and poor prognosis in various clinical conditions, there is still limited information in the Latin American context about management strategies in emergency services and their impact on mortality and complications. Therefore, the aim of this study is to determine the management of hyperglycemia in the emergency department and its relationship with glycemic control, as well as the impact of glycemic control on mortality and unfavorable outcomes in three national hospitals in Peru during the period from August to December 2022.

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METHODS

Design and study area

A retrospective cohort analytical observational study was conducted. The study area included three national referral hospitals located in Metropolitan Lima: Hospital Nacional Hipólito Unanue, Hospital Nacional Dos de Mayo (both under the Ministry of Health), and Hospital Edgardo Rebagliati Martins, which is part of the social security system (EsSalud). Data collection spanned the period from August to December 2022.

Population and sample

The study population consisted of patients over 18 years old who were admitted to the emergency medicine service for hyperglycemia in the mentioned hospitals. A non-probabilistic convenience sampling method was employed. Inclusion criteria were: admission for hyperglycemia to the emergency department, serum glucose greater than 180 mg/dL, with or without a history of diabetes mellitus (DM), and a minimum stay of 24 hours in the emergency service. Patients with incomplete clinical records or missing information about the insulin regimen and clinical outcomes were excluded.

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Variables and instruments

Dependent variables included: need for mechanical ventilation, acute kidney injury (AKI) requiring hemodialysis, death, and a combined outcome, which included the occurrence of at least one of these three events, defined 24 hours after admission to avoid bias from early clinical decisions or progression. Prolonged hospital stay was analyzed separately and was not part of the combined outcome. Additionally, cases of decompensated chronic kidney disease (CKD) were excluded from the hemodialysis outcome. The main independent variable was glycemic control at 24 hours after the initiation of insulin treatment, defined as a glucose level ≤180 mg/dL, according to international recommendations[8,11] for hospitalized patients. Data collected included sociodemographic factors (age, sex, marital status, type of insulin regimen), medical history (diabetes mellitus, hypertension, neoplasms, diabetic foot, infections, cerebrovascular events), and reasons for admission associated with or not related to hyperglycemia (such as diabetic ketoacidosis, hyperosmolar or mixed states). Vital signs upon admission (blood pressure, heart rate, respiratory rate, temperature) and biomarkers (initial glucose and at 24 hours, hemoglobin, leukocytes, neutrophils, lymphocytes, platelets, C-reactive protein, and arterial gases) were also recorded.

Hypoxemia was defined by a $SatO_2/FiO_2$ ratio less than 315. Anemia was considered if hemoglobin was below 12 g/dL in females or 13 g/dL in males. Platelets were categorized as thrombocytopenia ($<150\times10^3$/µL), normal ($150–400\times10^3$/µL), and thrombocytosis ($>450\times10^3$/µL). Leukocytes were classified as leukopenia ($<4\times10^3$/µL), normal ($4–11\times10^3$/µL), and leukocytosis ($>11\times10^3$/µL); neutrophils as neutropenia ($<1.5\times10^3$/µL), normal ($1.5–7.7\times10^3$/µL), and neutrophilia ($>7.7\times10^3$/µL); and lymphocytes as lymphopenia ($<1\times10^3$/µL), normal ($1–4.8\times10^3$/µL), and lymphocytosis ($>4.8\times10^3$/µL). The acid-base status was defined based on pH, HCO_3, and pCO_2 as metabolic or respiratory acidosis or alkalosis, or normal status.

Procedures

Clinical and demographic data were extracted from both electronic and physical medical records of the patients, using a pre-prepared data collection form. The medical progress notes, medical orders, laboratory results, and hospitalization reports were reviewed to obtain complete and accurate information on each case.

Statistical analysis

The data were entered into a database in Microsoft Excel and then analyzed using the statistical software STATA version 16. For descriptive analysis, central tendency and dispersion measures were used for quantitative variables, and absolute and relative frequencies for categorical variables. In the bivariate analysis, the Student's T-test was applied for comparing means of numerical variables, and the Chi-square test for comparing proportions in categorical variables.

Multivariate analysis was conducted using a Poisson regression model with robust variances, including the variables that showed significant association in the bivariate analysis, as well as the primary independent variable of interest, which was the achievement of glycemic control at 24 hours. To avoid collinearity, variables with clinical overlap or shared origins from the same pathophysiological process (e.g., diabetic foot and diabetes) were excluded. For hematological parameters from the leukocyte count (total leukocytes, neutrophils, and lymphocytes), if both leukocytes and neutrophils or leukocytes and lymphocytes showed significant association with the outcome, neutrophils or lymphocytes were prioritized, excluding leukocytes due to their high correlation with these cell subtypes. A p-value of <0.05 was considered statistically significant, and the crude (RR) and adjusted (aRR) relative risks with their respective 95% confidence intervals were estimated.

Ethical considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and was approved by the ethics committees of the three participating hospitals. The confidentiality and anonymity of the patients were ensured, maintaining their privacy and the integrity of their personal data throughout the study.

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RESULTS

Table 1 shows that the median age of the patients was 60.0 years (interquartile range (IQR): 50.0-70.0), and 52.8% were male. The majority had a history of diabetes mellitus (85.1%), and nearly one-third had hypertension (32.6%). Regarding outcomes, 56.6% had a prolonged hospital stay, and 41.0% required admission to critical care units. The median duration of hospital stay was 12.0 days (IQR: 8.0-17.0), and the mortality rate reached 4.0%.

Table 1. General characteristics of patients admitted for hyperglycemia to the emergency department in three Peruvian hospitals.

Clinical and demographic characteristics	Total N=730
Age	60.0 (50.0-70.0)
Sex	
Male	385 (52.8%)
Female	344 (47.2%)
Occupation	
Housewife	218 (29.9%)
Merchant	127 (17.4%)
Retired	90 (12.3%)
None	23 (3.2%)
Other	271 (37.1%)
Marital status	
Single	221 (30.3%)
Married	399 (54.7%)
Divorced	41 (5.6%)
Widowed	69 (9.5%)
Medical history	
Diabetes mellitus	621 (85.1%)
HTN	238 (32.6%)
Cirrhosis	16 (2.2%)
Chronic Pulmonary Disease	15 (2.1%)
Neoplasms	156 (21.4%)
Other	117 (16.0%)
Unfavorable outcomes	
Prolonged stay	
No	317 (43.4%)
Yes	413 (56.6%)

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Table 1. Continuation

Hospital stay (days)	12.0 (8.0-17.0)
Mortality	
Alive	701 (96.0%)
Deceased	29 (4.0%)
Admission to critical units	
No	431 (59.0%)
Yes	299 (41.0%)
Need for mechanical ventilation	
No	678 (92.9%)
Yes	52 (7.1%)
AKI with need for hemodialysis	
No	694 (95.1%)
Yes	36 (4.9%)

AKI: Acute Kidney Injury. HTN: Hypertension

The most frequent reasons for admission are detailed in Table 2, where it is observed that hyperglycemic crises accounted for 30.4% of the cases, followed by diabetic foot (20.8%), urinary tract infection (20.5%), and skin and soft tissue infection (16.0%).

Other relevant diagnoses included pneumonia (13.8%) and cerebrovascular disorder (8.1%), while less frequent causes were acute coronary syndrome (1.4%) and hypertension in the context of urgency or emergency (1.0%).

Table 2. Reasons for admission of patients with hyperglycemia treated in the emergency department of three Peruvian hospitals.

Reason for Admission	Total, n (%)
Hyperglycemic crises*	222 (30.4)
Diabetic foot	152 (20.8)
Urinary tract infection	150 (20.5)
Skin and soft tissue infection	117 (16.0)
Pneumonia	101 (13.8)
Cerebrovascular disorder	59 (8.1)
Others	59 (8.1)
Acute respiratory failure	26 (3.6)
Abdominal sepsis/acute gastroenteritis	21 (2.9)
Decompensated chronic kidney disease	21 (2.9)
Encephalopathy/sensory disturbance	19 (2.6)
Acute coronary syndrome / acute myocardial infarction	10 (1.4)

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Table 2. Continuation

Abdominal pain syndrome	9 (1.2)
Hypertension (emergency/urgency)	7 (1.0)
Liver failure	2 (0.3)

* Hyperglycemic crises include diabetic ketoacidosis (n=182), hyperosmolar state (n=13), and mixed state (n=27).

Of the total patients who received a fixed-dose regimen (n = 253), 53.0% achieved glycemic control, while 47.0% did not achieve it. In contrast, among patients managed with a sliding-scale regimen (n = 477), only 41.1% achieved glycemic control within 24 hours, while 58.9% did not reach this goal. This difference was statistically significant (p=0.002). In Table 3, factors associated with prolonged hospital stay were identified in the adjusted analysis, including the presence of neoplasms (aRR: 0.69; 95% CI: 0.56-0.85), hypoxemia (aRR: 1.29; 95% CI: 1.07-1.56), neutrophilia (aRR: 1.27; 95% CI: 1.08-1.49), metabolic alkalosis (aRR: 1.30; 95% CI: 1.09-1.55), respiratory acidosis (aRR: 1.35; 95% CI: 1.06-1.72), and C-reactive protein levels (aRR: 0.55; 95% CI: 0.46-0.67).

Table 3. Risk factors for prolonged hospital stay in patients with hyperglycemia treated in the emergency department of three Peruvian hospitals.

	Without prolonged stay (n=317)	With prolonged stay (n=413)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Age	60.0 (51.0-70.0)	60.0 (50.0-69.0)	0.910	1.00 (0.99–1.00)	0.688	-	-
Sex			0.950				
Male	167 (43.4%)	218 (56.6%)		Ref.	Ref.	-	-
Female	150 (43.6%)	194 (56.4%)		1.00 (0.88–1.13)	0.951	-	-
Marital status			0.880				
Single	97 (43.9%)	124 (56.1%)		Ref.	Ref.	-	-
Married	174 (43.6%)	225 (56.4%)		1.00 (0.87-1.16)	0.946	-	-
Divorced	19 (46.3%)	22 (53.7%)		0.96 (0.70–1.30)	0.776	-	-
Widowed	27 (39.1%)	42 (60.9%)		1.08 (0.87–1.36)	0.473	-	-
Diabetes mellitus			0.120				
No	40 (36.7%)	69 (63.3%)		Ref.	Ref.	-	-
Yes	277 (44.6%)	344 (55.4%)		0.88 (0.75–1.03)	0.101	-	-
HTN			0.310				
No	220 (44.7%)	272 (55.3%)		Ref.	Ref.	-	-
Yes	97 (40.8%)	141 (59.2%)		1.07 (0.94–1.22)	0.305	-	-
Neoplasms			<0.001				
No	229 (39.9%)	345 (60.1%)		Ref.	Ref.	-	-
Yes	88 (56.4%)	68 (43.6%)		0.73 (0.60–0.88)	0.001	0.69 (0.56-0.85)	<0.001
Hyperglycemic crises			0.950				
No	221 (43.5%)	287 (56.5%)		Ref.	Ref.	-	-
Yes	96 (43.2%)	126 (56.8%)		1.00 (0.88-1.15)	0.948	-	-

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Table 3. Continuation

	Without prolonged stay (n=317)	With prolonged stay (n=413)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Diabetic foot			0,270				
No	257 (44.5%)	321 (55.5%)		Ref.	Ref.	-	-
Yes	60 (39.5%)	92 (60.5%)		1.09 (0.94-1.26)	0.254	-	-
Urinary tract infection			0,870				
No	251 (43.3%)	329 (56.7%)		Ref.	Ref.	-	-
Yes	66 (44.0%)	84 (56.0%)		0.99 (0.84-1.16)	0.874	-	-
Skin and soft tissue infection			0,660				
No	264 (43.1%)	349 (56.9%)		Ref.	Ref.	-	-
Yes	53 (45.3%)	64 (54.7%)		0.96 (0.80-1.15)	0.661	-	-
Pneumonia			0,140				
No	280 (44.5%)	349 (55.5%)		Ref.	Ref.	-	-
Yes	37 (36.6%)	64 (63.4%)		1.14 (0.97-1.35)	0.113	-	-
Cerebrovascular disorder			0,660				
No	293 (43.7%)	378 (56.3%)		Ref.	Ref.	-	-
Yes	24 (40.7%)	35 (59.3%)		1.05 (0.84-1.31)	0.648	-	-
First glucose level	294.0 (217.0-416.0)	296.4 (226.1-409.5)	0,440	1.00 (1.00-1.00)	0.430	-	-
Delta glucose at 24 hours	-112.5 (-226.0--47.0)	-127.2 (-234.0--69.0)	0,068	1.00 (1.00-1.00)	0.200	-	-
Systolic BP	120.0 (100.0-135.0)	120.0 (100.0-130.0)	0,720	1.00 (1.00-1.00)	0.705	-	-
Diastolic BP	70.0 (60.0-80.0)	70.0 (60.0-80.0)	0,330	1.00 (1.00-1.00)	0.285	-	-
Heart rate	89.0 (78.0-102.0)	88.5 (78.0-102.0)	0,930	1.00(1.00-1.00)	0.633	-	-
Respiratory rate	20.0 (18.0-22.0)	20.0 (18.0-22.0)	0,930	1.00 (0.99-1.01)	0.799	-	-
Temperature	37.0 (36.2-37.0)	37.0 (36.0-37.0)	0,160	1.00 (0.97-1.03)	0.794	-	-
Hypoxemia			0,002				
No	290 (44.8%)	357 (55.2%)		Ref.	Ref.	-	-
Yes	15 (24.2%)	47 (75.8%)		1.37 (1.17-1.61)	<0.001	1.29 (1.07-1.56)	<0.007
SaFi Index (SaO_2/FiO_2)	415.2 (342.9-485.7)	400.0 (325.8-495.2)	0,280	1.00 (1.00-1.00)	0.840	-	-
Anemia			0,850				
No	148 (43.8%)	190 (56.2%)		Ref.	Ref.	-	-
Yes	169 (43.1%)	223 (56.9%)		1.01 (0.89-1.15)	0.855	-	-
Platelets			0,500				
Thrombocytopenia	19 (42.2%)	26 (57.8%)		1.00 (0.77-1.29)	0.977	-	-
Normal	223 (42.0%)	308 (58.0%)		Ref.	Ref.	-	-
Thrombocytosis Leukocytes	52 (48.1%)	56 (51.9%)		0.89 (0.74-1.09)	0.262	-	-

Table 3. Continuation

	Without prolonged stay (n=317)	With prolonged stay (n=413)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Leukopenia	2 (28.6%)	5 (71.4%)		1.35 (0.84-2.20)	0.217	-	-
Normal	137 (47.2%)	153 (52.8%)		0.74 (0.46-1.20)	0.217	-	-
Leukocytosis	178 (41.1%)	255 (58.9%)		1.12 (0.98-1.28)	0.109	-	-
Neutrophils			0.097				
Neutropenia	5 (41.7%)	7 (58.3%)		1.15 (0.70-1.88)	0.586	1.35 (0.85-2.14)	0.211
Normal	116 (49.2%)	120 (50.8%)		Ref.	Ref.	-	-
Neutrophilia	196 (40.7%)	286 (59.3%)		1.17 (1.01-1.35)	0.038	1.27 (1.08-1.49)	0.004
Lymphocytes			0.063				
Lymphopenia	92 (50.8%)	89 (49.2%)		0.84 (0.71-0.99)	0.033	0.91 (0.76-1.09)	0.292
Normal	213 (41.2%)	304 (58.8%)		Ref.	Ref.	-	-
Lymphocytosis	12 (37.5%)	20 (62.5%)		1.06 (0.80-1.40)	0.667	0.98 (0.71-1.36)	0.900
Metabolic status according to ABG			0.004				
Metabolic acidosis	76 (42.9%)	101 (57.1%)		1.15 (0.96-1.36)	0.121	1.01 (0.84-1.21)	0.945
Metabolic alkalosis	48 (33.1%)	97 (66.9%)		1.34 (1.14-1.58)	<0.001	1.30 (1.09-1.55)	0.004
Respiratory acidosis	8 (28.6%)	20 (71.4%)		1.43 (1.10-1.86)	0.007	1.35 (1.06-1.72)	0.016
Respiratory alkalosis	33 (49.3%)	34 (50.7%)		1.02 (0.78-1.32)	0.892	1.09 (0.83-1.43)	0.520
Normal	149 (50.2%)	148 (49.8%)		Ref.	Ref.	-	-
C-Reactive protein	9.5 (1.3-47.3)	10.3 (2.0-24.0)	0.340	1.00 (1.00-1.00)	0.001	0.55 (0.46-0.67)	<0.000

* Chi-square test (categorical independent variable) or Mann-Whitney U test (numerical independent variable).
RR: Relative Risk. aRR: Adjusted Relative Risk. HTN: Hypertension. BP: Blood Pressure. ABG: Arterial Blood Gas analysis.

In Table 4, it can be observed that, in the adjusted analysis, the factors associated with a higher risk of presenting the combined outcome were the presence of neoplasms (aRR: 1.71; 95% CI: 1.10-2.67), pneumonia (aRR: 1.84; 95% CI: 1.14-2.97), cerebrovascular disorder (aRR: 1.63; 95% CI: 1.05-2.51), elevated temperature (aRR: 1.34; 95% CI: 1.07-1.66), hypoxemia (aRR: 2.66; 95% CI: 1.80-3.93), thrombocytopenia (aRR: 2.21; 95% CI: 1.32-3.69), neutrophilia (aRR: 1.65; 95% CI: 1.07-2.55), lymphopenia (aRR: 0.61; 95% CI: 0.39-0.94), metabolic acidosis (aRR: 1.87; 95% CI: 1.17-2.99), and respiratory acidosis (aRR: 3.12; 95% CI: 1.95-4.97).

Table 4. Risk factors for combined outcome in patients with hyperglycemia admitted to the emergency department of three Peruvian hospitals.

	Without Combined Outcome (n=634)	With Combined Outcome (n=96)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Age	60.0 (50.0-70.0)	62.5 (51.0-70.5)	0.380	1.00 (0.99-1.02)	0.373	-	-
Sex			0.710				
Male	336 (87.3%)	49 (12.7%)		Ref.	Ref.	-	-
Female	297 (86.3%)	47 (13.7%)		1.07 (0.74-1.56)	0.709	-	-
Marital status			0.510				
Single	196 (88.7%)	25 (11.3%)		Ref.	Ref.	-	-
Married	344 (86.2%)	55 (13.8%)		1.22 (0.78-1.90)	0.382	-	-
Divorced	37 (90.2%)	4 (9.8%)		0.86 (0.32-2.35)	0.772	-	-
Widowed	57 (82.6%)	12 (17.4%)		1.54 (0.82-2.90)	0.183	-	-
Diabetes mellitus			0.018				
No	87 (79.8%)	22 (20.2%)		Ref.	Ref.	-	-
Yes	547 (88.1%)	74 (11.9%)		0.59 (0.38-0.91)	0.016	1.11 (0.77-1.59)	0.583
HTN			0.220				
No	422 (85.8%)	70 (14.2%)		Ref.	Ref.	-	-
Yes	212 (89.1%)	26 (10.9%)		0.77 (0.50-1.17)	0.211	-	-
Neoplasms			0.005				
No	509 (88.7%)	65 (11.3%)		Ref.	Ref.	-	-
Yes	125 (80.1%)	31 (19.9%)		1.75 (1.19-2.59)	0.005	1.71 (1.10-2.67)	0.017
Hyperglycemic crisis			0.087				
No	434 (85.4%)	74 (14.6%)		Ref.	Ref.	-	-
Yes	200 (90.1%)	22 (9.9%)		0.68 (0.43-1.07)	0.093	-	-
Diabetic foot							
No	492 (85.1%)	86 (14.9%)		Ref.	Ref.	-	-
Yes	142 (93.4%)	10 (6.6%)		0.44 (0.24-0.83)	0.011	-	-
Urinary tract infection			0.018				
No	495 (85.3%)	85 (14.7%)		Ref.	Ref.	-	-
Yes	139 (92.7%)	11 (7.3%)		0.50 (0.27-0.91)	0.024	0.71 (0.41-1.22)	0.215
Skin and soft tissue infection			<0.001				
No	521 (85.0%)	92 (15.0%)		Ref.	Ref.	-	-
Yes	113 (96.6%)	4 (3.4%)		0.23 (0.09-0.61)	0.003	0.33 (0.11-1.03)	0.056
Pneumonia			<0.001				
No	563 (89.5%)	66 (10.5%)		Ref.	Ref.	-	-
Yes	71 (70.3%)	30 (29.7%)		2.83 (1.94-4.12)	<0.001	1.84 (1.14-2.97)	0.013

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Tabla 4. Continuation

	Without Combined Outcome (n=634)	With Combined Outcome (n=96)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Cerebrovascular disorder							
No	590 (87.9%)	81 (12.1%)		Ref.	Ref.	-	-
Yes	44 (74.6%)	15 (25.4%)		2.10 (1.30-3.41)	0.002	1.63 (1.05-2.51)	0.028
First glucose	297.0 (223.0-416.0)	273.0 (218.5-372.7)	0.260	1.00 (1.00-1.00)	0.668	-	-
Delta glucose at 24 hours	-123.0 (-234.0--57.6)	-112.0 (-216.7--67.6)	0.900	1.00 (1.00-1.00)	0.977	-	-
Systolic BP	120.0 (100.0-134.0)	110.0 (90.0-129.0)	0.011	1.00 (0.99-1.00)	0.328	-	-
Diastolic BP	70.0 (60.0-80.0)	65.0 (57.5-80.0)	0.039	0.99 (0.98-1.00)	0.322	-	-
Heart rate	89.0 (78.0-102.0)	89.0 (78.0-103.0)	0.680	1.00 (0.99-1.01)	0.738	-	-
Respiratory rate	20.0 (18.0-22.0)	20.0 (18.0-27.0)	0.003	1.04 (1.01-1.06)	0.004	1.00 (0.97-1.04)	0.803
Temperature	37.0 (36.0-37.0)	37.0 (36.7-37.5)	<0.001	1.42 (1.18-1.70)	<0.001	1.34 (1.07-1.66)	0.009
Hipoxemia			<0.001				
No	585 (90.4%)	62 (9.6%)		Ref.	Ref.	-	-
Yes	29 (46.8%)	33 (53.2%)		5.55 (3.98-7.75)	<0.001	2.66 (1.80-3.93)	<0.001
SaFi Index (SaO_2/FiO_2)	414.3 (351.0-495.2)	370.0 (202.8-466.7)	<0.001	1.00 (1.00-1.00)	0.492		
Anemia			0.100				
No	301 (89.1%)	37 (10.9%)		Ref.	Ref.	-	-
Yes	333 (84.9%)	59 (15.1%)		1.37 (0.94-2.01)	0.105	-	-
Platelets			0.029				
Thrombocytopenia	33 (73.3%)	12 (26.7%)		2.02 (1.19-3.44)	0.009	2.21 (1.32-3.69)	0.002
Normal	461 (86.8%)	70 (13.2%)		Ref.	Ref.	-	-
Thrombocytosis	96 (88.9%)	12 (11.1%)		0.84 (0.47-1.50)	0.561	1.11 (0.63-1.93)	0.722
Leukocytes			0.076				
Leukopenia	6 (85.7%)	1 (14.3%)		1.48 (0.23-9.41)	0.678	-	-
Normal	262 (90.3%)	28 (9.7%)		Ref.	Ref.	-	-
Leukocytosis	366 (84.5%)	67 (15.5%)		1.08 (0.17-6.75)	0.932	-	-
Neutrophils			0.049				
Neutropenia	11 (91.7%)	1 (8.3%)		0.94 (0.14-6.40)	0.947	0.83 (0.18-3.89)	0.809
Normal	215 (91.1%)	21 (8.9%)		Ref.	Ref.	-	-
Neutrophilia	408 (84.6%)	74 (15.4%)		1.73 (1.09-2.73)	0.020	1.65 (1.07-2.55)	0.023
Lymphocytes			0.120				
Lymphopenia	157 (86.7%)	24 (13.3%)		1.07 (0.69-1.66)	0.758	0.61 (0.39-0.94)	0.026
Normal	453 (87.6%)	64 (12.4%)		Ref.	Ref.	-	-
Lymphocytosis	24 (75.0%)	8 (25.0%)		2.02 (1.06-3.84)	0.032	0.83 (0.48-1.46)	0.527

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Table 4. Continuation

	Without Combined Outcome (n=634)	With Combined Outcome (n=96)	p-value*	RR (95% CI)	p-value	aRR (95% CI)	p-value
Metabolic status according to ABG							
Metabolic acidosis	144 (81.4%)	33 (18.6%)		1.85 (1.17-2.92)	0.009	1.87 (1.17-2.99)	0.009
Metabolic alkalosis	136 (93.8%)	9 (6.2%)		0.61 (0.30-1.26)	0.184	1.18 (0.56-2.49)	0.656
Respiratory acidosis	13 (46.4%)	15 (53.6%)		5.30 (3.27-8.61)	<0.001	3.12 (1.95-4.97)	<0.001
Respiratory alkalosis	60 (89.6%)	7 (10.4%)		1.03 (0.47-2.25)	0.932	0.67 (0.28-1.63)	0.376
Normal	267 (89.9%)	30 (10.1%)		Ref.	Ref.	-	-
C-Reactive protein	10.5 (1.9-28.7)	6.1 (1.0-21.1)	0.053	1.00 (0.99-1.00)	0.073	-	-

* Chi-square test (categorical independent variable) or Mann Whitney U test (numerical independent variable).
RR: Relative risk. aRR: adjusted relative risk. HTN: hypertension. BP: blood pressure. ABG: Arterial Blood Gases analysis.

As shown in Table 5, patients who achieved the glycemic control target had a lower risk of prolonged hospital stay compared to those who did not achieve it, with a significant association observed in the adjusted analysis (aRR: 0.86; 95% CI: 0.74-0.99). No significant associations were found between glycemic control achievement and other clinical outcomes evaluated. In the sub-analysis of only patients with DM, similar results were found as in the full cohort: glycemic control was associated with a shorter prolonged hospital stay, with a RR of 0.77 (95% CI: 0.67-0.90) and an aRR of 0.79 (95% CI: 0.68-0.93), adjusted for history of neoplasms, lymphocyte count, metabolic state, and hypoxemia.

Table 5. Association between achieving glycemic control and clinical outcomes in patients with hyperglycemia admitted to the emergency department of three Peruvian hospitals.

Outcome, n (%)	Did not achieve goal (n=400)	Achieved goal (n=330)	Total (n=730)	RR (95% CI)	p-value	RRa (IC95%)	p-value
Prolonged stay	242 (60,5)	171 (51,8)	413 (56,6)	0,86 (0,75–0,98)	0,020	0,86 (0,74-0,99)	0,031
Mechanical ventilation	23 (5,8)	29 (8,8)	52 (7,1)	1,53 (0,90–2,59)	0,115	-	-
*AKI with hemodialysis	18 (4,6)	13 (3,9)	31 (4,4)	0,88 (0,44–1,78)	0,727	-	-
Death	15 (3,8)	14 (4,2)	29 (4,0)	1,13 (0,55–2,31)	0,735	-	-
Combined outcome	51 (12,8)	45 (13,6)	96 (13,2)	1,07 (0,74–1,55)	0,724	-	-

RR: Relative Risk. aRR: Adjusted Relative Risk. AKI: Acute Kidney Injury. DM: Diabetes Mellitus.

DISCUSSION

Several studies in surgical settings have shown that adequate glycemic control during the perioperative period is associated with better clinical outcomes, including shorter hospital stays. For example, the study by Kurtoglu et al.[12] demonstrated that implementing a glycemic control protocol in patients undergoing major abdominal surgery not only reduced the rate of hyperglycemia but also decreased the time required to reach glycemic values within the target range, which is associated with faster recovery and, presumably, shorter hospitalization. Similarly, in the meta-analysis by Eckert et al.[13], although no statistical significance was reached in the reduction of ICU stay days, a

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enteral formulas for glycemic control, suggesting a possible indirect benefit through greater metabolic stability. These findings support those observed in the present study, where early achievement of glycemic control seems to have had a positive impact on reducing prolonged stays. Clinically, these results underline the relevance of establishing early intervention protocols in the emergency department to normalize blood glucose from the moment of admission, aiming to optimize hospital care efficiency and reduce costs associated with unnecessary prolonged hospitalization.

The finding of a reduction in prolonged hospital stays after achieving early glycemic control is also supported by studies conducted in intensive care and other clinical settings. Becker et al. [14], in a retrospective study in a high-complexity medical ICU, demonstrated that patients with acceptable glycemic control (<180 mg/dL) had a lower probability of experiencing hospital and ICU stays longer than predicted, even after adjusting for severity variables. Similarly, Rady et al. [15] identified that persistently elevated blood glucose was associated with longer mechanical ventilation duration and prolonged stays, particularly in non-diabetic patients, which suggests that sustained metabolic dysfunction may reflect a more intense inflammatory response or greater disease severity. In a different setting, Mozazfia et al. [16] also found that a greater admission glycemic gap (AGG) was related to worse outcomes in neurocritical patients, implying that stress hyperglycemia not corrected early may prolong clinical evolution. The AGG is defined as the difference between the plasma glucose upon admission and the patient's estimated average chronic glucose value, usually calculated from glycated hemoglobin. This indicator helps distinguish acute hyperglycemia from the chronic component and has been proposed as a more precise marker of the metabolic impact of acute stress. Together, these findings suggest that timely glycemic control, beyond its effect on metabolic parameters, could indirectly modulate the progression of acute disease, thereby reducing the duration of hospital stays. Therefore, this study reinforces the need to implement early intervention strategies, even outside critical care units, as the benefits observed in ICUs may be extrapolated, with the advantage of applying them in the earlier stages of care.

Despite the observed benefit in reducing prolonged hospital stays, this study did not find a decrease in mortality, the need for mechanical ventilation, or emergency hemodialysis upon achieving glycemic control in the first 24 hours. This result contrasts with certain studies in surgical settings, where glycemic control has shown associations with a reduction in major complications. For instance, Yang et al.[17] reported that patients with HbA1c ≥6.0% and postoperative blood glucose >200 mg/dL had a fourfold higher risk of postoperative complications following emergency surgery, suggesting that persistent hyperglycemia may be linked to adverse outcomes. However, it is important to note that the strategies and timelines for achieving glycemic control were not detailed in that study, limiting the comparability with the early approach adopted in our work.

Additionally, Taylor et al.[18], through the SUGAR initiative, significantly improved postoperative glycemic control but failed to reduce the incidence of infections or other complications, which coincides with the lack of impact on major clinical events observed in our investigation. Together, these results indicate that glycemic control alone, even if achieved early, may not be sufficient to modify severe clinical outcomes if it is not accompanied by a comprehensive strategy that includes other pathophysiological and contextual determinants. Therefore, although early control is valuable, it should not be overestimated as the sole prognostic measure in acute settings. In intensive care settings, the relationship between glycemic control and major clinical outcomes has been widely debated, and the findings of the present study in which early glycemic control did not reduce mortality, mechanical ventilation, or hemodialysis admission align with

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multiple pieces of evidence that question the direct clinical benefit of strict glycemic control in critically ill patients. The meta-analysis by Eckert et al.[13], for example, showed that although specialized formulas for glycemic control in critically ill patients reduced blood glucose levels and insulin requirements, there was no significant impact on mortality, mechanical ventilation duration, or ICU stay days. Similarly, the multicenter trial conducted by Agus et al.[19] in critically ill children found no differences in mortality, ventilation, or ICU-free days between strict glycemic control (80–110 mg/dL) and moderate control (150–180 mg/dL), but there was an increase in severe hypoglycemia in the intensive intervention group, questioning the risk-benefit profile of aggressive intervention. Likewise, studies by Rady et al. and Becker et al. [14,15] suggest that while there is an association between hyperglycemia and mortality, this relationship is modulated by multiple individual factors such as the underlying diagnosis, inflammatory response, use of steroids or catecholamines, and the presence or absence of pre-existing diabetes.

These findings reinforce the idea that early glycemic control in itself is not a sufficient isolated tool to modify life prognosis or avoid advanced life support, and its impact may be dependent on the patient's risk profile, the etiology of the acute illness, and the pathophysiological moment at which intervention occurs. Therefore, in the emergency setting, where clinical heterogeneity is considerable, interventions must be personalized. The results of the present study also echo investigations conducted in other clinical settings, where the impact of glycemic control on mortality and other adverse outcomes has been variable and, in many cases, limited. For example, in patients with acute cerebrovascular disease, both the meta-analysis by Wu et al. [20] and the SHINE study analysis[21] found no significant benefits from intensive glycemic control on mortality, functionality at 90 days, or event recurrence, although there was an increased risk of severe hypoglycemia.

Similarly, in hospitalized COVID-19 patients, Klonoff et al.[22] reported that sustained hyperglycemia on days 2 or 3 was associated with higher mortality only in non-critical patients, while in the ICU, this relationship was not significant after the second day, suggesting a narrow time window for glycemic control to impact prognosis. In neurocritical patients, Mozazfia et al. [16] found that a higher AGG was associated with higher mortality, indicating that beyond the absolute value of glucose, the magnitude of the acute glycemic imbalance relative to prior chronic control may be more relevant. Additionally, studies such as those by Li and Yuan [23] in severe coronary disease, and the meta-analysis by Crabtree et al. [24] in older and frail adults, highlight that the intensity of glycemic control must be carefully individualized, as excessively strict control may be harmful in certain groups. In light of this evidence, the results of the present study reinforce the notion that early glycemic control is an intervention with relevant logistical and metabolic potential such as in reducing hospital stay but it should not be assumed as a universally effective strategy for preventing major events in all clinical contexts.

Therefore, it is recommended to direct emergency glycemic management toward early but safe control, avoiding extremes, and considering other pathophysiological and prognostic variables that may modulate the expected clinical benefit in each patient.

This study has limitations inherent to its retrospective design, such as dependence on incomplete or heterogeneous clinical records between hospitals, which could have introduced information bias. The use of non-probabilistic convenience sampling limits the generalizability of the findings to other populations. Furthermore, some potentially influential clinical variables, such as baseline functional status or degree of dehydration, were not considered. Finally, although multivariate models were applied, residual confounding factors that were not controlled for cannot be ruled out.

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CONCLUSION

The findings of this study suggest that achieving glycemic control within the first 24 hours of admission to the emergency department is associated with a reduction in prolonged hospital stays, representing a relevant clinical and logistical benefit in the care of patients with acute hyperglycemia. However, this early control did not demonstrate a significant impact on mortality or the occurrence of critical outcomes such as the need for mechanical ventilation or emergency hemodialysis. These results indicate that while timely glycemic control may contribute to a more favorable and efficient progression, its effect on major clinical outcomes appears to be conditioned by multiple factors, so it is recommended to implement it as part of a comprehensive and personalized approach to the management of acute patients.

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ORIGINAL ARTICLE

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