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Original Scientific Paper

GLUCOSE AND SODIUM LEVELS AS DISEASE OUTCOME PREDICTORS IN CRITICALLY ILL PATIENTS

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SUMMARY – The main aim of this study was to examine the association of glucose and sodium level with diagnosis and disease outcome of critically ill patients. Glucose and sodium concentrations of 283 patients admitted in critical condition to the Intensive Care Unit of the Department of Internal Medicine in a period from November 1, 2015 to February 28, 2017 were reviewed. The most common diagnoses in critically ill patients were acute kidney injury (26.1%) and sepsis (including septic shock, 22.3%). Significantly lower glucose concentration was observed in patients with acute kidney injury (p=0.02), whereas patients in sepsis and septic shock had a significantly higher sodium concentration (p=0.04). Higher glucose level was related to higher mortality rate (p=0.001). On the other hand, sodium level was not significantly associated with survival. Higher mortality, as well as higher glucose concentration were more common in patients older than 65 years (p<0.001). Study results showed significantly lower glucose concentrations in patients with acute kidney injury, whereas in patients older than 65, glucose concentration was significantly higher. Patients in sepsis and septic shock had significantly higher sodium concentrations. Higher concentration of glucose was connected with higher mortality in the elderly, whereas sodium concentration did not show connection with mortality.

Key words: *Critical illness; Glucose; Intensive care unit; Sodium*

Introduction

Patients admitted to the intensive care unit (ICU) are a heterogeneous population which differs in admission diagnoses and comorbidities. The most common indications for admission to the ICU are hemodynamic instability, respiratory failure, and sepsis. About 50% of patients admitted to the ICU have a fatal outcome, of which 80% die within 15 days of admission[1]. Mortality of patients in the ICU depends on the patient general condition, age, length of stay, immobility, comorbidities, the need to use mechanical ventilation and vasopressor drugs, etc.[2]. Electrolyte disturbances and insulin use have been shown to be associated with increased mortality of patients in the ICU, indicating the importance of monitoring glucose and sodium levels in these patients[3].

Glucose is the most important source of energy for human metabolism. Impaired glucose levels, whether hyperglycemia or hypoglycemia, have been associated

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with poor outcomes of patients in the ICU[4,5]. These patients have stress hyperglycemia, which is defined as a transient increase in glucose concentration in response to an acute condition, i.e., disease. In most cases, these patients do not have diabetes. However, stress hyperglycemia can also occur in patients with diabetes in whom glucose concentrations are mostly higher than 13.9 mmol/L. According to the American Diabetes Association, in patients without diabetes, stress hyperglycemia is defined as a glucose concentration higher than 7.8 mmol/L in the presence of acute disease. Glycosylated hemoglobin (HbA1c) levels help distinguish patients with stress hyperglycemia (HbA1c <6.5%) from those with undiagnosed diabetes (HbA1c >6.5%)[6].

Stress hyperglycemia and insulin resistance are mechanisms preserved through evolution that enable survival in periods of great stress for the body. In ischemic conditions such as sepsis, glucose passes from the bloodstream through the interstitial space into the cell due to concentration gradient. Elevated blood glucose levels in stress hyperglycemia facilitate the transfer of glucose down the concentration gradient and thus allow adequate cell nutrition while avoiding hyperosmolarity of extracellular fluid. Furthermore, acute hyperglycemia may protect the cell by promoting pathways that inhibit apoptosis and promote angiogenesis[4].

Hormones that oppose insulin action (catecholamines, glucagon, growth hormone and cortisol), adipokines and inflammatory cytokines are involved in the pathophysiology of stress hyperglycemia. They lead to excessive glucose production in the liver and insulin resistance. Glucose is a proinflammatory mediator which can lead to a vicious circle in which hyperglycemia leads to even more severe hyperglycemia[7]. To avoid these consequences of severe stress hyperglycemia, glucose monitoring and treatment of hyperglycemia is intensified. However, strict control of glucose levels has been shown to often lead to moderate and severe hypoglycemia associated with higher mortality in critically ill patients. Hypoglycemia leads to reduced glucose availability to glucose-dependent cells and tissues such as the brain and macrophages. Hypoglycemia may also occur as a consequence of the underlying disease and thus may serve as a marker for identification of diseases that lead to increased mortality in the ICU[5].

Sodium is the main extracellular cation. Disorders of sodium concentration are one of the most common electrolyte disturbances in the ICU. About one-third of patients are admitted to the ICU with sodium disorders and another third of patients will develop the disorder during hospitalization[8,9].

According to previous research, hyponatremia is present in 15%-30% of patients admitted to the ICU, most often with slightly reduced sodium levels. The mortality of patients with hyponatremia is up to three times higher than that of patients with normal sodium concentration. All degrees of hyponatremia are associated with increased mortality in critically ill patients[10,11]. Factors influencing the occurrence of hyponatremia are old age, renal failure, adrenal and thyroid insufficiency, diuretic use, chronic heart failure, and central nervous system diseases[8]. Hyponatremia leads to a decrease in the extracellular fluid osmolarity leading to intracellular edema which is particularly dangerous in the brain. If hyponatremia is corrected too quickly, a sudden increase in extracellular fluid osmolarity will lead to dehydration of brain cells and consequent demyelination[12]. Disruption of sodium concentration alone may not lead to higher mortality in these patients but may serve as a marker of the severity of the underlying disease, especially if sodium levels are extremely low[13].

On admission to the ICU, hypernatremia is present in 2% to 6% of patients, while between 6% and 26% of patients will develop hypernatremia during their hospital stay. Hypernatremia is associated with increased patient mortality regardless of its severity. Studies have shown that mild hypernatremia is associated with twice the mortality and severe with three times the mortality compared with patients with normal sodium levels[14]. Hypernatremia can occur due to fever (sepsis and pneumonia), uncontrolled diabetes, osmotic diarrhea, and excessive use of furosemide with inadequate water intake. Hypernatremia leads to insulin resistance, prevents hepatic breakdown of lactate, reduces left ventricular contractility, and leads to neurological consequences[8,9].

The aim of this study was to examine the effect of different glucose and sodium concentrations on patient outcome in the ICU.

Patients and Methods

The research was organized as a cross-sectional study with historical data. It was approved by the Ethics Committee of the Faculty of Medicine Osijek, Josip Juraj Strossmayer University in Osijek. Data

were collected by searching medical records of the Department of Internal Medicine, Osijek University Hospital Center. All patients admitted to the ICU of the Department of Internal Medicine, Osijek University Hospital Center in the period from November 1, 2015 to February 28, 2017 were included in the study. The research included 283 patients of both genders.

On searching the documentation, patient age, gender, diagnosis at admission, and disease outcome were recorded. Of laboratory findings, data on the concentrations of glucose and sodium at patient admission to the ICU were monitored. According to the outcome of the disease, patients were divided into two groups, i.e., transfer and death. Patients were divided into groups according to glucose and sodium concentrations into those who had low, normal and high values. Glucose values were further divided into categories as follows: mild (4.0-4.3 mmol/L), moderate (2.0-3.9 mmol/L) and severe (<2.0 mmol/L) hypoglycemia, normal values 4.4-6.4 mmol/L; and mild (6.5-10.0 mmol/L), moderate (10.1-15.0 mmol/L), severe (15.1-25.0 mmol/L) and extreme (>25.0 mmol/L) hyperglycemia. Sodium values were further divided into categories as follows: mild (130-134 mmol/L), moderate (125-129 mmol/L) and severe (<125 mmol/L) hyponatremia, normal values 135-145 mmol/L; and mild (146-155 mmol/L), moderate (156-160 mmol/L) and severe (>160 mmol/L) hypernatremia. Data on glucose concentration at admission were available for 282 patients.

Statistical analysis

Categorical data were expressed as absolute and relative frequencies. Numerical data were described by the median and interquartile range. The normality of distribution of numerical variables was examined by the Shapiro-Wilk test. Differences in category variables were examined with the χ^2-test and, if necessary, with Fisher exact test. For testing differences between numerical data, the Mann Whitney U test was used[15]. All p values were two-tailed. The significance level was set to Alpha=0.05. MedCalc Statistical Software version 14.12.0 (MedCalc Software bvba, Ostend, Belgium; 2014) was used on statistical analysis.

Results

The research included 283 patients, of which 144 (50.9%) were men and 139 (49.1%) were women. Their median age was 73 years (interquartile range, 63 to 80 years) ranging from 19 to 93 years. The most

Table 1. Basic characteristics of patients admitted to the Intensive Care Unit

		n (%)
Gender	Male	144 (50.9)
	Female	139 (49.1)
Age	<65 years	89 (31.4)
	≥65 years	194 (68.6)
Diagnosis	Acute kidney injury	74 (26.1)
	Sepsis, septic shock	63 (23.3)
	Coronary artery disease	28 (9.9)
	Heart failure	24 (8.5)
	Pneumonia	20 (7.1)
	Drug intoxication	20 (7.1)
Glucose*	Low	19 (6.7)
	Normal	59 (20.9)
	High	204 (72.3)
Sodium	Low	76 (26.9)
	Normal	166 (58.7)
	High	41 (14.5)
Outcome	Transfer	108 (38.2)
	Death	175 (61.8)
Total		283 (100)

*Data available on 282 patients

Table 2. Glucose and sodium levels in relation to diagnosis at admission to the Intensive Care Unit

	n (%)			p
	Low	Normal	High	
Acute kidney injury				
Glucose	7 (9.5)	8 (10.8)	59 (79.7)	**0.02***
Sodium	13 (17.6)	44 (59.5)	17 (23)	0.53*
Sepsis, septic shock				
Glucose	4 (6.3)	17 (27)	42 (66.7)	0.38*
Sodium	7 (11.1)	31 (49.2)	25 (39.7)	**0.04***
Coronary artery disease				
Glucose	0	6 (21.4)	22 (78.6)	0.42†
Sodium	6 (21.4)	17 (60.7)	5 (17.9)	0.35*
Heart failure				
Glucose	0	3 (13)	20 (87)	0.28†
Sodium	2 (8.3)	18 (75)	4 (16.7)	0.27†
Pneumonia				
Glucose	2 (10)	3 (15)	15 (75)	0.18†
Sodium	1 (5)	16 (80)	3 (15)	0.72†
Drug intoxication				
Glucose	2 (10)	6 (30)	12 (60)	0.32†
Sodium	2 (10)	12 (60)	6 (30)	0.85†

*χ^2-test; †Fisher exact test

Table 3. Glucose and sodium levels in relation to age of patients admitted to the Intensive Care Unit

	n (%)			p*
	Low	Normal	High	
Glucose				
<65 years	7 (8)	33 (38)	48 (55)	**<0.001**
≥65 years	12 (6.2)	26 (13.4)	156 (80.4)	
Sodium				
<65 years	9 (10.1)	51 (57.3)	29 (32.6)	0.2
≥65 years	32 (16.5)	115 (59.3)	47 (24.2)	

*χ^2-test

common diagnoses on admission were acute kidney injury (n=74, 26%) and sepsis (including septic shock, n=63, 22.3%). The largest number of patients had elevated glucose values (n=204, 72.3%), whereas sodium values were mostly normal (n=166, 58.7%). Fatal outcome was reported in 175 (61.8%) patients (Table 1).

Patients with acute kidney injury were significantly more likely to have elevated glucose values (p=0.02, χ^2-test). Sodium values were significantly higher in subjects with sepsis and septic shock (p=0.04, χ^2-test). No significant differences in glucose and sodium concentrations were found compared to other diagnoses (Table 2).

Glucose concentrations differed significantly between the two age groups observed. The largest number of patients older than 65 had elevated glucose values (80.4%; p<0.001, χ^2-test). In this age group, 13.4% of patients had normal glucose values, in contrast to the age group younger than 65, where 38% of patients had normal glucose values. No significant differences in sodium concentration were found according to age. In both age groups, the majority of patients had normal sodium values (Table 3).

Table 4. Glucose levels in relation to outcome of patients admitted to the Intensive Care Unit

Glucose (mmol/L)	n (%)			p*
	Transfer	Death	Total	
Severe hypoglycemia (<2.0)	2 (40)	3 (60)	5 (1.8)	**0.001**
Moderate hypoglycemia (2.0-3.9)	1 (14.3)	6 (85.7)	7 (2.5)	
Mild hypoglycemia (4.0-4.3)	4 (57.1)	3 (42.9)	7 (2.5)	
Euglycemia (4.4-6.4)	36 (61)	23 (39)	59 (20.9)	
Mild hyperglycemia (6.5-10.0)	33 (38.8)	52 (61.2)	85 (30.1)	
Moderate hyperglycemia (10.1-15.0)	15 (26.8)	41 (73.2)	56 (19.9)	
Severe hyperglycemia (15.1-25.0)	11 (22.9)	37 (77.1)	48 (17)	
Extreme hyperglycemia (>25.0)	5 (33.3)	10 (66.7)	15 (5.3)	
Total	107 (37.9)	175 (62.1)	282 (100)	

*Fisher exact test

Table 5. Sodium levels in relation to outcome of patients admitted to the Intensive Care Unit

Sodium (mmol/L)	n (%)			p*
	Transfer	Death	Total	
Severe hyponatremia (<125)	5 (55.6)	4 (44.4)	9 (3.2)	0.12
Moderate hyponatremia (125-129)	5 (22.7)	17 (77.3)	22 (7.8)	
Mild hyponatremia (130-135)	15 (33.3)	30 (66.7)	45 (15.9)	
Eunatremia (136-145)	73 (44)	93 (56)	166 (58.7)	
Mild hypernatremia (146-155)	9 (25)	27 (75)	36 (12.7)	
Moderate hypernatremia (156-160)	0	1 (100)	1 (0.4)	
Severe hypernatremia (>160)	1 (25)	3 (75)	4 (1.4)	
Total	108 (38.2)	175 (61.8)	283 (100)	

*Fisher exact test

Table 6. Outcome in relation to gender and age of patients admitted to the Intensive Care Unit

		n (%)			p*
		Transfer	Death	Total	
Gender	Male	61 (42.4)	83 (57.6)	144 (50.9)	0.14
	Female	47 (33.8)	92 (66.2)	139 (49.1)	
Age	<65 years	50 (56.2)	39 (43.8)	89 (31.4)	**<0.001**
	≥65 years	58 (29.9)	136 (70.1)	194 (68.6)	
Total		108 (38.2)	175 (61.8)	283 (100)	

*Fisher exact test

Significant difference in glucose concentration was observed according to treatment outcome (p=0.001, Fisher exact test). Patients who had normal glucose values were more likely to have a positive treatment outcome, i.e., they were transferred from the ICU. On the other hand, patients with elevated glucose levels and those with moderately and significantly reduced values were more likely to have fatal outcome (Table 4). The median glucose value was 7.3 mmol/L (interquartile range 5.7-11.8 mmol/L) in patients who were transferred and 10.6 mmol/L (interquartile range 7.1-15.4 mmol/L) in patients who died, yielding a significant difference (p<0.001, Mann Whitney U test).

No significant difference in sodium concentration was observed according to patient outcome (p=0.12, Fisher exact test). The greatest difference was observed in patients with moderately low (125-129 mmol/L) and slightly elevated (146-155 mmol/L) sodium levels. These patients were more likely to have fatal outcome (Table 5). The median sodium concentration was 138 mmol/L (interquartile range 135-141 mmol/L) in patients who were transferred and 137 mmol/L (interquartile range 133-142 mmol/L) in patients who died, which did not make a significant difference (p=0.79, Mann Whitney U test).

There were no significant differences between men and women in relation to survival (p=0.14, Fisher exact test). Older age was significantly associated with fatal outcome (p<0.001, Fisher exact test). Death was reported in 70.1% of patients over 65 years of age and in 43.8% of patients under 65 years of age (Table 6).

Discussion

Glucose and sodium disorders are extremely common in patients admitted to the ICU. Due to their important roles in maintaining homeostasis of the body, it is necessary to examine their impact on survival. These disorders are often asymptomatic and great attention should be paid to their early detection and initiation of treatment in order to improve the outcomes of critically ill patients. The study was conducted on 283 patients admitted to the ICU over a period of 16 months. Glucose and sodium concentrations were recorded on admission and their impact on survival of these patients was examined, i.e., whether these patients were transferred from the ICU or had a fatal outcome. Glucose values significantly affected survival. On the other hand, sodium values did not show significant association with survival of critically ill patients.

All degrees of hyperglycemia were significantly associated with poorer outcome. It is known that glucose stimulates the production of proinflammatory mediators and thus stimulates the inflammatory process. Acute hyperglycemia causes vasoconstriction and consequent hypoperfusion of organs by reduced nitric oxide synthesis in the endothelium. Furthermore, hyperglycemia increases the risk of infection, causes glucotoxicity in immune cells, promotes lymphocyte apoptosis, reduces neutrophil activity, and by glycosylation of immunoglobulins and complement reduces their activity[6]. Blood glucose levels above 10.0 mmol/L exceed the renal glucose threshold and lead to osmotic diuresis causing hypovolemia[4]. All these factors contribute to higher mortality of critically ill patients and explain the result obtained in our study. Zhang *et al.* investigated the impact of hyperglycemia on the outcome of 7895 critically ill patients. The group of patients with a glucose concentration higher than 11.1 mmol/L had higher 30-day and 90-day mortality and had a longer stay in the ICU compared to normoglycemic patients, which is in line with our results[16].

In our study, 6.7% of patients had low glucose levels on admission to the ICU. These patients had higher mortality compared with patients who had normal glucose values. Patients with hypoglycemia are older, have diabetes, need mechanical ventilation, stay longer in the ICU and have higher mortality, which is in line with the results of our study[17]. Increased mortality is due to a number of side effects of hypoglycemia, e.g., dysfunction of the autonomic nervous system, release of inflammatory mediators and cytokines, leukocyte activation, QT prolongation (and consequent predisposition to fatal arrhythmias), and impaired brain function. Complications (renal, cardiac, hepatic, and bacteremia) are more common in patients with hypoglycemia during their stay in the ICU[18]. The NICE-SUGAR study on 6026 critically ill patients also showed a negative effect of hypoglycemia on outcome[5].

Numerous studies have shown that hyponatremia is an independent predictive factor for mortality in critically ill patients. In a study by Funk *et al*., hyponatremia was present in 17.7% of patients admitted to the ICU, which is slightly less than in our study (26.9%). In their study, there were more neurological patients who may have had concomitant syndrome of inappropriate antidiuretic hormone secretion causing hyponatremia. All degrees of hyponatremia were associated with increased mortality, which is not consistent with the results of our study[10]. In our study, patients with severe hyponatremia were more likely to be transferred from the ICU. Chawla *et al.* examined the potential reasons for better survival of patients with severe hyponatremia compared to patients with mild and moderate hyponatremia. They believe that patients with moderate hyponatremia are more likely to have more severe underlying disease and/or comorbidities and thus higher mortality. On the other hand, patients with severe hyponatremia were more likely to be admitted to the ICU primarily due to severe disorder in sodium concentration rather than due to severe under-

lying disease. This is supported by the fact that patients with severe hyponatremia who survived were more likely to have drug-induced hyponatremia (thiazide diuretics and selective serotonin reuptake inhibitors) and had no severe comorbidities[13]. It is not entirely clear why decreased sodium values are associated with higher mortality. Hoorn and Zietse propose three scenarios, as follows: 1) hyponatremia is the direct cause of death; 2) the severity of the underlying disease is the cause of death and hyponatremia, which does not contribute to mortality but is a marker of the severity of the underlying disease; and 3) hyponatremia leads to organ dysfunction and thus indirectly leads to death[19]. In our study, no significant association was found between hyponatremia and mortality. A possible explanation is the small number of subjects and inclusion of only those patients who had hyponatremia at admission. For the same reason, no significant results were obtained on the association of hypernatremia and higher mortality. All degrees of hypernatremia were associated with poorer outcome, which is consistent with other studies. Hypernatremia leads to organ dysfunction by affecting metabolism, central nervous system, cardiovascular system and muscles (may cause rhabdomyolysis)[14,20]. Darmon *et al*. studied the effect of sodium disturbance on admission on the mortality of 11,125 patients. Hypernatremia was present in 17.6% of patients, which is in line with the results of our study (15%). All degrees of hypernatremia were associated with increased mortality[9].

The most common diagnoses of patients admitted to the ICU were acute kidney injury, sepsis and septic shock, coronary artery disease, heart failure, pneumonia, and drug intoxication. Patients with acute kidney injury were significantly more likely to have elevated glucose levels.

Acute kidney injury is a clinical syndrome that develops within a few hours to 7 days and is characterized by sharp decrease in renal function. It is defined as an increase in creatinine level ≥0.3 mg/dL within 48 hours or increase in creatinine level 1.5 times higher than normal within 7 days or urine volume <0.5 mL/kg/h over 6 hours. The incidence of this condition in the ICU ranges from 20% to 40%, which is in line with the results of our study (26.1%). Mortality of patients with acute renal failure is about 50%[21]. The association between hyperglycemia and acute kidney injury has been investigated in a number of studies. Gordillo *et al*. showed that with each increase of 0.55 mmol/L (10.0 mg/dL) in the maximum glucose measurement, the risk of developing acute kidney injury increases by 12%. Hyperglycemia leads to tissue damage due to increased formation of free oxygen radicals in mitochondria. The proximal tubule is particularly sensitive to free oxygen radicals. In hyperglycemic rabbits, higher creatinine levels, decreased renal cortex perfusion and severe morphological damage to the kidneys were observed[22,23]. Important risk factors for the development of acute kidney injury are old age and accompanying comorbidities, especially hypertension and diabetes. In recent years, the average age of patients admitted to the ICU has increased. It is estimated that in the United States, every second bed in the ICU is occupied by a patient older than 65. In our study, 68.6% of patients were older than 65, reflecting a higher proportion of elderly population in Croatia than in the United States. In the elderly, the kidney is more susceptible to prerenal failure due to changes in the tone of renal blood vessels in which vasoconstriction predominates. Fluid loss (vomiting, diarrhea, diuretics), decreased cardiac output, and drugs with negative effect on renal perfusion (nonsteroidal anti-inflammatory drugs and angiotensin-converting enzyme inhibitors) also contribute to decreased renal plasma flow. In our study, it was found that patients older than 65 were more likely to have elevated glucose levels (80.4% had elevated glucose levels), which by the above mentioned mechanisms participate in the development of acute kidney injury. Comorbidities such as hypertension and diabetes are more common in people over 65 years and are a risk factor for acute kidney injury and death in these patients[21]. This explains the significant association between acute kidney injury and elevated glucose levels, as well as the significantly higher mortality in patients over 65 years of age recorded in our study.

Disorders of glucose and sodium concentrations have consequences for the whole body. In the case of critically ill patients treated in the ICU who have impaired homeostasis and need numerous medications and invasive life support techniques, the accompanying impairment of glucose and sodium concentrations further impairs their body's ability to defend itself and leads to increased mortality in these patients. In order to improve the outcome of these patients, attention and effort should be focused on their early recognition and appropriate treatment.

A disadvantage of this research is that glucose and sodium concentrations were not monitored during the

stay in the ICU but only at admission. Furthermore, patients were not followed-up after transfer from the ICU. Our study was of a cross-sectional nature and prospective studies are needed to conduct further research on this topic.

Conclusion

The most common diagnoses in patients admitted to the ICU were acute kidney injury, sepsis and septic shock, coronary artery disease, heart failure, pneumonia, and drug intoxication. Acute kidney injury was associated with lower glucose levels while sepsis and septic shock were associated with higher sodium levels. Elevated glucose levels, as well as older age (≥65 years) increased mortality in critically ill patients. Sodium concentration did not have a significant impact on survival in critically ill patients.

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Sažetak

RAZINE GLUKOZE I NATRIJA KAO PREDSKAZATELJI ISHODA BOLESTI KOD KRITIČNIH BOLESNIKA

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Glavni cilj ovog istraživanja bio je ispitati povezanost koncentracije glukoze i natrija s dijagnozom i ishodom bolesti kod bolesnika u kritičnom stanju. Pregledane su koncentracije glukoze i natrija kod 283 bolesnika primljenih u kritičnom stanju u Jedinicu intenzivnog liječenja Klinike za unutarnje bolesti u razdoblju od 1. studenoga 2015. do 28. veljače 2017. godine. Najčešće dijagnoze bolesnika u kritičnom stanju bile su akutno zatajenje bubrega (26,1%) i sepsa (uključujući septički šok, 22,3%). Značajno niža koncentracija glukoze zabilježena je u bolesnika s akutnim zatajenjem bubrega (p=0,02), dok su bolesnici u sepsi i septičkom šoku imali značajno višu koncentraciju natrija (p=0,04). Povišena koncentracija glukoze bila je povezana s povećanom smrtnošću (p=0,001). S druge strane, koncentracija natrija nije bila značajno povezana s preživljenjem. Viša smrtnost kao i viša koncentracija glukoze bili su češći u bolesnika starijih od 65 godina (p<0,001). U prikazanom istraživanju utvrđene su značajno niže koncentracije glukoze kod bolesnika s akutnim zatajenjem bubrega, dok su u bolesnika starijih od 65 godina bile značajno više koncentracije glukoze. Kod bolesnika u sepsi i septičkom šoku uočene su značajno više koncentracije natrija. Povišena koncentracija glukoze bila je povezana s višom smrtnošću u starijih osoba, dok koncentracija natrija nije bila povezana s preživljavanjem.

Ključne riječi: *Glukoza; Jedinica intenzivnog liječenja; Kritično stanje; Natrij*