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Research Article

The Evaluation of Different Sodium Concentrations in Children with Diabetic Ketoacidosis

Ebtessam Mohammed Mahmoud Silema*, Shymaa El-Sayed Ali Mohamed, Lamyaa Hussain Abdulrahman Seliem and Nehad Refhat Mostafa Sallam

Pediatrics department, Shebin Elkom Teaching Hospital, Shebin Elkom, Menoufia, Egypt

***Corresponding Author:** Ebtessam Mohammed Mahmoud Silema, Pediatrics department, Shebin Elkom Teaching Hospital, Shebin Elkom, Menoufia, Egypt.

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Abstract

Background: Diabetic ketoacidosis is the leading cause of morbidity and mortality in children with type 1 diabetes. DKA also can occur in children with type 2diabetes. DKA may occur in type 2 diabetes under conditions of extreme stress such as serious infection, trauma, cardiovascular or other emergencies, and, less often, as a presenting manifestation of type 2diabetes, a disorder called ketosis-prone diabetes mellitus.

Objective: This study was to evaluate of different sodium concentrations in children with Diabetic ketoacidosis.

Methods: This study was conducted on 60 children admitted to the PICU, Shebeen El-kom Teaching Hospital, with DKA including patients during August 2022 till April 2024. A written informed consent was obtained from the parents of all patients of the study. The study was approved by the Ethics Committee of Faculty of Medicine, Shebeen El-kom Teaching Hospital.

Results: in the current study, there were no significant differences between the four readings, changes and rate of change after 12th hr. between the studied groups. On comparison inside each group: Group I, there were no significant differences between the four readings in group I regarding corrected Na+ level.

Conclusion: There was a significant decrease (RBG) or increase (blood pH, blood bicarbonate, serum K+, corrected Na+) throughout the study period inside each of groups I and II. There is need for further research on large scale patients in multicenter studies to investigate the ideal fluid concentrations used in the treatment of DKA and their effects-side effects.

***Keywords**: Children; Concentrations; Diabetic Ketoacidosis; Na+; Rehydration*

Introduction

Diabetes mellitus (DM) is a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The abnormalities in carbohydrate, fat, and protein metabolism that are found in diabetes are due to deficient action of insulin on target tissues [1].

Diabetic ketoacidosis is the leading cause of morbidity and mortality in children with type 1 diabetes. DKA also can occur in children with type 2diabetes. DKA may occur in type 2 diabetes under conditions of extreme stress such as serious infection, trauma, cardiovascular or other emergencies, and, less often, as a presenting manifestation of type 2diabetes, a disorder called ketosis-prone diabetes mellitus [2]. In addition, DKA and its complications are the most common cause of hospitalization, mortality, and morbidity in children with established type 1 diabetes [3].

The serum sodium concentration is affected by hyperglycemia. The magnitude of this effect is determined by two major factors. Hyperglycemia will raise the plasma osmolality, resulting in osmotic water movement out of the cells which lowers the serum sodium by dilution. Physiologic calculations suggest that the serum sodium should be lowered by 1.6 mEq/L for every 100 mg/dL (5.55 mmol/L) elevation in serum glucose [4]. This study was to evaluate of different sodium concentrations in children with Diabetic ketoacidosis.

Patients and Methods

This prospective study was conducted on 60 children aged from 10 months to 15 years, 27 males and 33 females, admitted to the PICU, Shebeen El-kom Teaching Hospital, with DKA including patients. The duration of the research was 21 months from August 2022 till April 2024. A written informed consent was obtained from the parents of all patients in the study. The study was approved by the Ethics Committee of Shebeen El-kom Teaching Hospital.

All patients included in this study were subjected to the following

- **Complete history taking:** A questionnaire was planned to fulfill the following data: Demographic data: name, age, sex, socio-economic status, Age of onset of diabetes (disease duration). History of previous admission due to DKA and Family history of diabetes.
- **Vital data:** Heart rate, respiratory rate: type of breathing, blood pressure and temperature.
- **Neurological examination:** Conscious level according to Glasgow coma scale
- **Laboratory investigations:** Random blood sugar by SD Codefree blood glucose Meter. (Yeogtong.dong, Yeongtong- gu, Suwon-si Kyonggi.do, Korea.) Acetone in urine by dip steak. Serum Na+and K+. (Caretium Medical Instrument Co. Limited Beishan industrial part 7th floor Building Shenzhen, China).

Statistical analysis

Results were tabulated and statistically analyzed using standard computer program using MICROSOFT EXCEL 2017 and SPSS V.25 program for MICROSOFT WINDOWS 10. The description of data was in the form of mean (±) SD for quantitively data, and frequency and proportion for qualitative data, The mean is the sum of all observations by the number of observations. While the standard deviation is a measure of the degree of scatter of individual varieties around their mean, non-normally distributed numerical data were presented as median (IQR). Chi-squared ($\chi 2$), Standard student-t test (t), Mann-Whitney test (z). P value <0.05 was considered statistically significant.

Results

In the current study, there was no significant difference found between studied groups regarding sex, age and LOS (Table 1).

	Group I (n = 30)		Group II (n = 30)		Test of sig. (p)
	No.	%	No.	%	
Sex					
Male	13	43.3	16	53.3	X^2= 0.601 (0.438)
Female	17	56.7	14	46.7	
Age (years)					
Range	0.83 - 14.0		0.92 - 13.0		t = 0.995 (0.324)
Mean ± SD	9.13 ± 3.88		8.20 ± 3.34		
Length of stay (LOS) (days)					
Range	2.0 - 6.0		2.0 - 6.0		Z a= 1.914 (0.056)
Mean ± SD	2.63 ± 1.03		2.97 ± 0.93		
Median	2.0		3.0		

Table 1: *Comparison between two studied groups according to demographic data.*

Group I: patients received an IV solution with Na+ concentration of 75mEq/L.

Group II: patients received an IV solution with Na++concentration of 100 mEq/L.

Also, there were no significant differences between the four readings, changes and rate of change after 12th hr. between the studied groups. On comparison inside each group: Group I, there were no significant differences between the four readings in group I regarding corrected Na+ level and Group II, there were no significant differences between the four readings in group II regarding corrected Na+ level (Table 2). Additionally, there were no significant differences between the four readings, changes and rate of change after 12th hr. between the studied groups.

Correct Na	Group I (n = 30)	Group II (n = 30)	Test of sig. (p)	P_1	P_2
1st hr.					
Range	138.0 - 154.0	140.0 - 155.0	t = 0.903 (0.370)		
Mean ± SD	144.67 ± 4.40	145.63 ± 3.87			
4th hr.					
Range	139.0 - 150.0	139.0 - 152.0	t = 1.161 (0.251)	0.273	0.068
Mean ± SD	143.47 ± 3.03	144.40 ± 3.20			
8th hr.					
Range	141.0 - 148.0	140.0 - 157.0	t = 0.359 (0.721)	1.000	0.191
Mean ± SD	144.23 ± 1.96	144.50 ± 3.57			
12th hr.					
Range	140.0 - 149.0	141.0 - 147.0	t = 0.337 (0.737)	1.000	0.051
Mean ± SD	143.60 ± 2.27	143.77 ± 1.48			
Rate of change after 12th hr.					
Range	-6.04 - 5.80	-6.45 - 2.84	Z = 0.688 (0.492)		
Mean ± SD	-0.65 ± 3.45	-1.22 ± 2.42			
Median	-0.68	-1.04			
Change after 12th hr.					
Range	-9.0 - 8.0	-10.0 - 4.0	Z = 0.675 (0.500)		
Mean ± SD	-1.07 ± 5.0	-1.87 ± 3.62			
Median	-1.0	-1.50			

Table 2: *Comparison of Corrected Na+ (mEq/L) between the studied groups.*

On comparison inside each group: Group I, there was a significant increase in the 4th, 8th and 12th hours in comparison to the 1st hour in group I regarding K+ level and Group II, there was a significant increase in the 4th, 8th and 12th hours in comparison to the 1st hour in group II regarding K+ level (Figure 1).

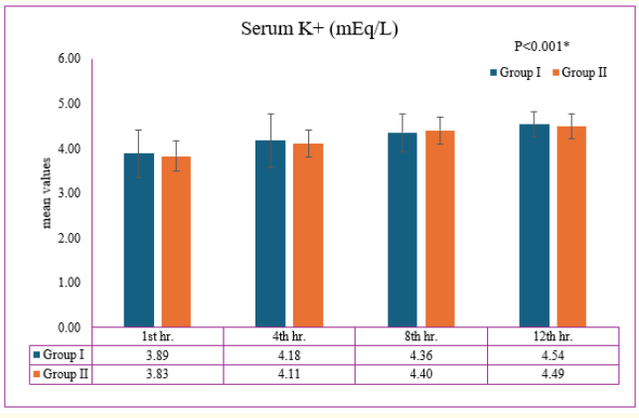

Figure 1: *Comparison of serum K+ (mEq/L) between the studied groups.*

Discussion

The optimal treatment for pediatric DKA has been a topic of debate for decades. Multiple working groups and consensus conferences have been convened to develop guidelines for pediatric DKA treatment. Intravenous fluid regimens for rehydration of children with DKA have been the main topic of controversy [5].

At the center of controversy surrounding DKA treatment in children are physicians' concerns about possibly causing or exacerbating DKA-related cerebral edema or injury with inappropriate intravenous rehydration. Clinically overt and potentially life-threatening cerebral edema occur in about 0.5-1% of DKA episodes, making this entity difficult to study [3,6].

Cerebral edema typically occurs 4-12 hours after treatment is activated but can be present before treatment has begun or may develop at any time during treatment for DKA. Symptoms and signs of cerebral edema are variable and include onset of headache, gradual decrease or deterioration in level of consciousness, inappropriate slowing of the pulse rate, and an increase in blood pressure [6]. The cause or causes of cerebral edema remain unknown. The use of hypotonic fluids during resuscitation has been suggested as a cause, as have reductions in plasma Na+ concentration and rapid changes in plasma osmolality [6,7].

There are other potential risk factors at diagnosis or during treatment that may be associated with increased risk for developing cerebral edema including, greater hypocapnia at presentation of DKA, more severe acidosis at presentation, bicarbonate treatment for correction of acidosis and greater volumes of fluid given in the first 4 hours. Increased serum urea nitrogen at presentation of DKA is associated with increased risk of cerebral edema and this association may reflect greater dehydration in these patients [8].

In the present study, there was no significant difference found between studied groups regarding sex, age and LOS. In the present study, regarding RBG changes there were no significant differences in between the hourly readings, changes and rate of change after 12^{th} hours between the studied groups. However, there was a significant decrease in RBG in the 2^{nd}, 3^{rd}, 4^{th},5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th}, 11^{th}, 12^{th} hours in comparison to the 1^{st} hour in groups I and II. This was in accordance with Savaş-Erdeve., *et al.* [9]. who compared between two groups; the first group: patients received an IV solution with a Na+ concentration of 75mEq/L, the second group: patients received a solution with a Na+ concentration of 100 mEq/L and reported that the change in blood glucose levels did not differ significantly between the groups.

In the present study, there were no significant differences between the four readings, changes and rate of change after 12^{th} hours between the studied groups regarding serum corrected serum sodium levels. Ironically, regarding serum Na+ level, there was a significant increase in the 4^{th}, 8^{th} and 12^{th} hours in comparison to the 1^{st} hour in groups I and II, but on performing corrected serum Na+ level there was a non-significant difference in the 4^{th}, 8^{th} and 12^{th} hours in comparison to the 1^{st} hour in groups I and II. This was in accordance with Savaş-Erdeve., *et al.* [9]. who reported that the course of plasma Na+ at follow-up showed no difference between patients in the two Groups. Additionally, Toledo., *et al*., [10]. reported in their study that the course of plasma Na+ at follow up was not found to show any differences between patients receiving rehydration solutions containing 75mEq/L and 100mEq/L of Na+. Likewise, hypernatremia was not observed in the patients receiving an isotonic solution. Moreover, Rother., *et al*. [11] stated that there is still insufficient evidence correlating the Na+ concentration in the rehydration solutions with the plasma sodium levels during treatment. Montañana., *et al*. [12] had reported that the use of hypotonic fluids increases the risk of hyponatremia when compared with isotonic fluids at 24 hours following infusion interval and that the use of isotonic fluids did not increase the incidence of adverse events compared with hypotonic fluids.

Conclusion

- There was a significant decrease (RBG) or increase (blood pH, blood bicarbonate, serum K+, serum Na+ not for corrected Na+) throughout the study period inside each of groups I and II.
- There is need for further research on large scale patients in multicenter studies to investigate the ideal fluid concentrations used in the treatment of DKA and their effects-side effects.

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