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Original Article:
Half Saline or Normal Saline Maintenance Intravenous Fluid Therapy in Children

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ABSTRACT

Background and Aim: Electrolyte disorders in hospitalized children have several causes. One of the most important and common causes is using inappropriate maintenance intravenous fluids. This study aimed to investigate the effect and type of maintenance of intravenous fluids on the incidence of electrolyte disturbance in hospitalized children.

Methods: This research is a prospective cohort study. Non-surgical hospitalized children were divided into two groups based on the type of intravenous fluid received (normal saline [0.9% NaCl] or half saline [0.45% NaCl]). After matching two groups in terms of age and gender, the incidence of electrolyte disturbances (sodium and potassium) was evaluated in the two groups on the second and third days of the study.

Results: A total of 163 patients were included in this study. About 55.5% of the children were boys, and 44.5% were girls. The Mean±SD age of the children was 48.42±36.35 months, and their mean weight was 19.49±10.88 kg. Also, 50.6% of patients were in the half saline group and 49.4% in the normal saline group. Initially, serum sodium and potassium levels were normal in both groups. On the second and third days of the study, the incidence of serum sodium and potassium disorders was higher in patients who received half saline fluid, but this higher incidence was not statistically significant (P>0.05).

Conclusion: There is no significant difference between normal saline and half saline in terms of electrolyte disturbance if the patient's clinical condition is judged correctly and an appropriate volume of fluids is prescribed.

Keywords: Solutions, Fluid therapy, Child, Electrolytes, Sodium, Potassium

Introduction

Intravenous (IV) fluid is used to meet the basic needs of water, electrolytes, and calories in children with acute illnesses who cannot receive it orally. For this purpose, most maintenance IV fluids contain a combination of water, sodium, potassium, chlorine, and dextrose [1].

Adding dextrose to IV fluids to provide needed calories increases the fluid osmolarity. Still, dextrose passes rapidly through the cell membrane and is metabolized, so it has little effect on the tonicity of the prescribed

fluid. In other words, the tonicity of the prescribed fluid depends on sodium concentration [2].

Sodium is the most abundant extracellular fluid electrolyte with a concentration of 135-145 mEq/L and the most important determinant of extracellular fluid osmolarity and tonicity. Plasma sodium disorders (hypernatremia and hyponatremia) are the most common electrolyte disorders in hospitalized children. Electrolyte disturbances, especially sodium and potassium disorders, have several causes; one of the most important and common causes is inappropriate IV fluids therapy [3-5].

Because the body's daily requirement is 3 mEq/kg sodium and 2 mEq/kg potassium, fluids containing 30 mEq/L sodium and 20 mEq/L potassium have traditionally been used in pediatric fluid therapy since the 1950s based on the Holliday-Segar method. According to this method, in infants and children < 10 kg, the best choice is D5 in 1/4 N/S plus 20 mEq/L KCl, and for children ≥ 10 kg, the best choice is D5 in 1/2 NS plus 20 mEq/L KCl [6-9].

New reports have shown that hospitalized children are prone to the syndrome of inappropriate antidiuretic hormone secretion, hyponatremia, and its complications such as cerebral edema, encephalopathy, and even death. Thus, the use of isotonic fluid (normal saline or 0.9% NaCl) has recently been increased to reduce the risk of hyponatremia and its complications [10-16]. Normal saline contains 150 mEq/L of sodium and chlorine. This amount is more than the body's physiological need and puts a child in danger of hyperchloremic metabolic acidosis, edema, hypertension, and hypernatremia. So there are some debates in its routine use [2, 17, 18].

Different opinions about which type of fluid (normal saline or half saline) is more suitable for children have confused pediatricians. Therefore, considering the importance of intravenous fluid therapy in hospitalized children, this study was designed to investigate the effect of two types of fluids prescribed in children (normal saline versus half salt) on the incidence of electrolyte disturbances, especially sodium and potassium.

Materials and Methods

This research is a prospective cohort study, conducted at Besat Hospital in Sanandaj City, Iran, in 2019-20. This study was approved by the Ethics Committee of Kurdistan University of Medical Sciences, Iran (IR.MUK.REC.1397/289). The informed consent was obtained from the parents of the patients.

According to previous studies, with a 95% confidence and 90% test power, the number of 37 was calculated for each group using the sample size formula. To increase the accuracy of the study, we tried to recruit between 50 and 100 patients in each group.

Sampling was random until the sample size was completed and included all children aged 2-12 years admitted to the Pediatric Ward.

Patients were divided into two groups based on the type of intravenous fluid received. The choice of prescribed fluids was based on the clinical judgment of the treating physician. The first group received normal saline (5%D in 0.9% NaCl +20 mEq/L KCl) and the second group received half saline (5%D in 0.45% NaCl +20 mEq/L KCl).

The inclusion criteria were children 2-12 years old weighing more than 10 kg who were NPO (Non Per Oral) on the first day of hospitalization. They should not have any underlying disease affecting plasma sodium and potassium levels, such as acute kidney injury, hepatic disease, hormonal and metabolic disorders, watery diarrhea, surgical disorders, cardiac disease, malignancy, or severe burns. The patients must have needed fluid therapy for at least 48 hours without electrolyte disturbance at the beginning of hospital admission. The maximum amount of daily fluid therapy in the maintenance level was based on the patient's weight.

To reduce confounding factors, patients with the following conditions were excluded from the study: discharge of the patient before 48 hours, fluid therapy before admission to the hospital, severe dehydration and the need for bolus fluid therapy at the beginning of hospitalization, and using Oral Rehydration Solution (ORS) on the second day.

Blood samples were taken for initial tests, including Complete Blood Count (CBC), Blood Urea Nitrogen (BUN), Creatinine (Cr), Na, K, Venous Blood Gas (VBG), urine analysis, and renal ultrasound at the time of admission. Patients were included in the study based on the inclusion and exclusion criteria. Sodium and potassium were measured and re-recorded on the second and third study days. The collected data were statistically analyzed after completing the sample size.

The hospitalized patients were all NPO (Non Per Oral) on the first day, and the fluid therapy was based on weight and maintenance level. The decision to choose the type of fluid at the beginning of treatment was based on the clinical judgment of the treating physician. The

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Table 1. Mean and standard deviation of quantitative variables of children studied

Quantitative Variables	Mean±SD	Min	Max
Age (mo)	48.42±36.35	24	144
Weight (kg)	19.49±10.88	10	50
Primary serum potassium (mEq/L)	4.02±0.24	3.5	4.4
Primary serum sodium (mEq/L)	137.32±5.08	135	145
Blood urea nitrogen (mg/dL)	10.97±4.13	4	23
Creatinine (mg/dL)	0.56±0.095	0.4	1
Hemoglobin (g/dL)	11.16±3.64	9.7	16.6
Platelet (count/µL)	334589.93±82980.75	160000	464000
White blood count (count /µL)	8554.48±6896.04	3250	18500
Urine specific gravity	1017±8	1005	1028
pH	7.38±0.15	7.35	7.5
HCO_3 (mEq/L)	18.48±10.98	15.3	30

amount of fluid was reduced to 50%-80% of the maintenance dose based on the patient's tolerance and the physician's opinion with the start of oral feeding and regular diet on the second day, and no patients were given ORS. Sodium and potassium were measured daily according to the needs of patients in the hospital, along with other tests. So no additional invasive action was imposed on the patient. Children who developed severe electrolyte disturbances during treatment that required specific treatment were excluded from the study.

Table 2. Incidence of electrolyte disturbance (sodium-potassium) on the second and third days

Serum Electrolytes		No. (%)		P
		Normal Saline (Group 1)	Half Normal Saline (Group 2)	
Serum sodium levels on the second day	Hyponatremia	6(7.4)	16(19.3)	0.11
	Normal	74(91.4)	66(79.5)	
	Hypernatremia	1(1.2)	1(1.2)	
Serum sodium levels on the third day	Hyponatremia	6(7.4)	13(15.67)	0.29
	Normal	73(90.1)	69(84.1)	
	Hypernatremia	2(2.5)	1(1.2)	
Serum potassium levels on the second day	Hypokalemia	1(1.2)	3(3.6)	0.57
	Normal	(56(69.1	54(65.1)	
	Hyperkalemia	24(29.6)	26(31.3)	
Serum potassium levels on the third day	Hypokalemia	1(1.2)	3(3.6)	0.41
	Normal	60(74.1)	67(80.7)	
	Hyperkalemia	20(24.7)	13(15.6)	

Demographic information of location, age, sex, weight, initial diagnosis, and other data was recorded in a designed questionnaire.

Statistical analysis

First, the data were revised then the collected data were descriptively analyzed in SPSS version 21 to determine the frequencies, means, and standard deviations. The Chi-square and independent t test were used to compare quantitative and qualitative variables, respectively. The significance level was set at less than 0.05.

Results

A total of 164 patients aged 2-12 years were studied; 91 patients (55.5%) were boys, and 73 patients (44.5%) were girls. The Mean±SD age of the children was 48.42±36.35 months, and their Mean±SD weight was 19.49±10.88 kg. At the beginning of treatment, their mean±SD serum sodium and potassium were 137.32±5.08 and 4±0.24 mEq/L, respectively. Other variables affecting the serum level of electrolytes were normal (Table 1).

Their most prevalent diseases were pneumonia with 24.4%, febrile seizure with 13.4%, pyelonephritis with 9.1%, and acute asthma attack with 7.3%.

Patients were divided into 2 groups based on the type of fluid therapy.

In the first group (receiving normal saline [5% D in 0.9% NaCl plus 20 mEq/L KCl]), 81 patients (49.4%) were included, of whom 35 were girls and 46 were boys, and their mean±SD age was 49.14±37.42 months. In the second group (receiving half saline [5% D in 0.45% NaCl plus 20 mEq/L KCl], 83 patients (50.6%) were included, of whom 38 were girls, and 45 were boys, and their mean±SD age was 47.72±35.49 months. The two groups were homogeneous regarding age (P=0.8) and sex (P=0.75).

The normal serum sodium level is 135-145 mEq/L. A sodium level less than 135 mEq/L is considered hyponatremia and more than 145 mEq/L hypernatremia in this study.

On the second day, the results of serum sodium level measurement showed that in the first group, 7.4% had hyponatremia, 1.2% had hypernatremia, and 91.4% were normal. On the third day, the results of sodium level measurement showed that in the first group, 7.4% had hyponatremia, 2.5% had hypernatremia, and 90.1% were normal (Table 2). On the second day, the results of serum sodium level measurement showed that in the second group, 19.3% had hyponatremia, 1.2% had hypernatremia, and 79.5% were normal. On the third day, the results of serum sodium level measurement showed that in the second group, 15.67% had hyponatremia, 1.2% had hypernatremia, and 84.1% were normal. The incidence of sodium disorders on the second and third days was higher in the group receiving half saline than normal saline. Still, this higher incidence was not statistically significant (P>0.05) (Table 2).

Since potassium is an essential electrolyte in the body, we also studied changes in serum potassium levels in this study. The normal serum potassium level is 3.5-4.5 mEq/L, a potassium level less than 3.5 mEq/L is considered hypokalaemia, and higher than 4.5 mEq/L is considered hyperkalemia in this study. Accordingly, the results of serum potassium levels measurement on the second day showed that in the first group, 1.2% had hypokalemia, 29.6% had hyperkalemia, and 69.1% were normal. The results of serum potassium levels measurement on the third day showed that in the first group,1.2% had hypokalemia, 24.7% had hyperkalemia, and 74.1% were normal. On the second day, the results of serum potassium levels measurement showed that in the second group, 3.6% had hypokalemia, 31.3% had hyperkalemia, and 65.1% were normal. On the third day, the results of serum potassium levels measurement showed that in the second group, 3.6% had hypokalemia, 15.6% had hyperkalemia, and 80.7% were normal. Potassium disorders were also higher in the group receiving half saline compared to the group receiving normal saline, but this higher value was not statistically significant (P>0.05) (Table 2).

Discussion

Total Body Water (TBW) in a full-term infant is equivalent to 75% birth weight. During the first year, TBW gradually decreases and reaches 60% of body weight in one year. Since sodium is the main cation of extracellular fluid and the main determinant of extracellular fluid osmolarity and potassium is the main cation of intracellular fluid, accurate control of these electrolytes is very important. Since one of the most common causes of electrolyte disturbances in children is the administration of intravenous fluids, the volume, and type of intravenous fluid have always been a major challenge in pediatrics and are often experimental and based on clinical judgment [1, 2, 5, 19].

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In our study, 163 children aged 2-12 years with a Mean±SD age of 48.42±36.35 months were studied in two groups receiving normal saline and half saline. Patients did not receive anything per oral on the first day, but the volume of venous fluid decreased with the onset of oral feeding and with respect to oral tolerance on the second day.

In 1956, Holliday and Segar suggested that sodium in maintenance fluids should equal the amount of sodium in breast milk at about 30 mmol/L. Accordingly, fluid therapy is performed in children with hypotonic fluid for a long time [2, 6, 7].

Water and sodium homeostasis and regulation of serum osmolality are one of the main functions of the kidneys, which are regulated by the Antidiuretic Hormone (ADH). Stressful conditions such as respiratory and central nervous system infections, trauma, surgery, and anesthesia can increase ADH secretion. Consequently, administration of hypotonic fluid containing large amounts of free water can lead to difficulty in excreting free water and causes iatrogenic hyponatremia in critically ill children [20, 21].

McNab et al. conducted a study on children who needed fluid therapy for 6 hours or more at the Royal Children's Hospital (Melbourne, Australia) in 2015. They investigated the effect of two types of fluid containing sodium 140 mmol/L versus 77 mmol/L sodium. In this study, those who received normal saline experienced less hyponatremia (P=0.002) [22].

Moghtaderi et al. compared the effect of isotonic and hypotonic fluids on the incidence of hyponatremia in children within 6 hours after surgery. They showed that the incidence of hyponatremia in patients receiving hypotonic fluids is high (P=0.002) [12].

In a meta-analysis study, Wang et al. evaluated isotonic fluids versus hypotonic fluids in hospitalized children. According to the results, the risk of hyponatremia in patients who received hypotonic solution was significantly higher than those who received isotonic fluids (P=0.004) [13].

Our study results showed that the overall incidence of sodium disorder was 8.6% in patients of the first group (normal saline) and 20.5% in the second group (half saline) on the second day. Sodium disorder rates on the third day were 9.9% and 16.87% in patients in the first group (normal saline) and in the second group (half saline), respectively. These results are somewhat consistent with other studies' results. However, the overall incidence of electrolyte disturbance in the second group (half saline) was higher than that in the first group (normal saline). Still, there was no significant difference between the two groups, which could be due to differences in the volume and duration of fluid therapy. Another reason for this difference may be that surgical patients were not included in our study.

Given that free water retention and hyponatremia are due to ADH secretion, some researchers believe that using less volume of maintenance fluid to prevent iatrogenic hyponatremia is of equal value and even better than isotonic fluids [23-25].

A study by Neville showed that hyponatremia does not occur in cases where fluid intake is limited [20]. Another study by Kannan found that patients who received about 75% of maintenance fluid were less likely to develop hyponatremia [26].

This finding indicates that in addition to the type of fluid prescribed, fluid volume is essential in developing electrolyte disturbance.

These studies demonstrate the importance of fluid volume in developing electrolyte disturbances.

In our study, the patients were NPO only for the first 24 hours, and the volume of fluid therapy was 50% to 80% maintenance in the second 24 hours. No severe electrolyte disturbance occurred, and there was no significant difference between normal saline and half saline in terms of electrolyte disturbance. This finding indicates that in children with normal renal function, the kidneys can handle the water and electrolyte status. In addition to the type of fluid prescribed, fluid volume is also essential in developing electrolyte disturbance.

Also, the overall rate of potassium disorder was 30.8% in patients of the first group (normal saline) and 34.9% in the second group (half saline) on the second day. On the third day, potassium disorder rates were 25.9% and 19.3% in the first group (normal saline) and in the second group (half saline), respectively. Although the overall incidence of electrolyte disturbance in the second group (half saline) was higher than the first group (normal saline), this difference was not statistically significant (P>0.05).

Conclusion

Based on the study findings, if the patient's clinical condition is judged correctly and a suitable fluid volume

is prescribed, there is not much difference between normal saline and half saline fluids in terms of electrolyte disturbance.

The choice of volume and fluid type should be based on the patient's clinical condition, and there is no fixed method for all patients.

The most important limitation of our study was the study samples who were patients admitted to the pediatric ward. They did not have very severe illnesses. If such a study is performed on critically ill patients admitted to the intensive care unit with more people and longer follow-up periods, different results may be obtained.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Kurdistan University of Medical Sciences, Iran (Code: IR.MUK.REC.1397/289).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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