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Rehydration: Comparison of Isotonic and Hypotonic Saline with Dextrose in Children

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Introduction: Early rehydration with bolus fluid can be life saving. We compared isotonic saline with a hypotonic fluid which was composed of saline 0.9%, dextrose, and bicarbonate in our clinical setting.
Materials and Methods: 71 children entered to this study, 41 cases received isotonic saline and the remaining 30 cases received hypotonic fluid which was composed of 750 cc saline 0.9%, 28 cc bicarbonate 7.5%, and 222cc dextrose 5% for resuscitation fluid challenge at a dose of 20ml/kg over 20 minutes that could be repeated up to 3 times as needed. Serum sodium (Na), potassium (K), blood sugar (BS) and bicarbonate (HCo3) were measured before initiating rehydration and after 3 hours. T independent test was used to compare the values between the two groups and T paired test in each group in SPSS 16. The level of significance was set at 0.05.
Results: Serum Na, K, BS, and HCo3 were 134±5, 3.8 ±0.6, 90±16, and 11.6±3.6 before and 135±4, 3.7±0.5, 73±13, and 15±3 three hours after rehydration in the isotonic group, respectively.
In the isotonic rehydrated group, BS drop and HCo3 rise significantly ($p<0.001$). Serum Na, K, BS, and HCo3 were 134±6, 3.6±0.6, 91±15, and 10.1±1.9 before and 136±3, 3.6±0.4, 94±10, and 15±2 three hours after rehydration in the hypotonic saline group, respectively. Serum sodium increased 2meq/dl ($p<0.04$) and bicarbonate increased 4.9 meq/l ($P< 0.001$).
Conclusions: The hypotonic serum containing 115meq/l of sodium chloride combined with 25meq/l of sodium bicarbonate and dextrose 1.1% is not associated with a decrease in BS or hyponatremia. It also increases serum HCo3 prominently.

Keywords: Hypotonic Solutions; Isotonic Solutions; Dehydration; Child.

Running Title: Comparison of Isotonic and Hypotonic Saline with Dextrose

Introduction

Gastroenteritis results in 6-20 million deaths in pediatric group annually worldwide. Children with gastroenteritis may lose 10-20% of their volume within first hours [1]. The mortality of gastroenteritis in developed countries has increased [2]. It may be more ominous news for developing countries that lack effective management, especially for children. Administration of isotonic saline (0.9% sodium chloride) containing 154 meq/l of sodium is an acceptable management for parenteral rehydration. On the other hand, hypotonic saline has been used in critically ill children without causing hyponatremia in some studies. Nevil et al found isotonic serum was superior to hypotonic fluid in children with dehydration [3].

There are debates about the best fluid for children and recent publications have suggested that hyponatremia may develop in children with gastroenteritis treated with intravenous hypotonic saline [3-4]. However, this theory is rejected by another study which used hypotonic fluid containing saline 0.3% and glucose 5% although they excluded pre shock patients from the study [5].

In this study, we used a hypotonic fluid containing dextrose 1.1% and 140meq/l of sodium including 25meq/l of sodium bicarbonate and 115 meq/l of sodium chloride. We evaluated this solution which contained both dextrose and sodium bicarbonate in catabolic ill children.

Materials and Methods

After obtaining the approval of the ethics committee of our centers and informed consent from the participants, this cross sectional study was performed on patients with moderate to severe dehydration who needed intravenous fluid rehydration with sodium bicarbonate under 16meq/l. Patients were divided into two groups: the first group received normal saline (Na=154 meq/l) and the second group received hypotonic serum which contained 750cc normal saline, 222cc dextrose 5%, and 28 cc sodium bicarbonate, resulting in a solution containing 137 meq/l of sodium. This fluid was administered at a dose of 20ml/kg during 20 minutes which could be repeated for up to 3 times (up to 60ml/kg) as needed. Laboratory tests included blood sugar, serum bicarbonate, sodium, potassium, blood urea nitrogen, and creatinine at the time of admission and after four hours as the target point of comparison. Thirty-five cases entered each group. Patients with severe shock or cardiopulmonary resuscitation, serum bicarbonate under 5 meq/l, and preexisting diseases like renal failure, congestive heart failure, liver disease or diabetes were excluded from the study. Hyponatremia and hypernatremia were defined as serum sodium less than 135 and more than 155meq/dl, respectively. Statistical method: Quantitative measures were expressed as mean ± standard deviation, maximum and minimum comparison of quantitative measures between the two groups was performed using T independent test, and changes of the measures before and after therapy were evaluated with paired T test. Chi square test was used for qualitative evaluation of the measures. All analyses were performed with SPSS 20. P value less than 0.05 was considered significant.

Results

Seventy-one children entered the study. The mean age of the participants in the isotonic (group 1) and hypotonic (group 2) groups was 25.5±25.6 and 29.3±23.9 months, respectively. Blood sugar, BUN, Cr, Na, and K were measured in both groups and their changes after 3 hours were compared. The mean blood sugar was 90±16 mg/dl in group 1 and 91±15 mg/dl in group 2, and the mean serum bicarbonate was 11.6±3.6 and 10.1±1.9 mg/dl in group 1 and 2, respectively. All the study cases had gastroenteritis and were classified based of their serum sodium levels: serum sodium was between 135-145 meq/l in 58 out of 71 subjects, more than 145 meq/l in 8 out of 71 participants, and lower than 135 meq/l in the remaining 5 cases.

The mean serum sodium was 134±5 in group 1 and 134±6 meq/l in group 2.

The mean serum potassium was 3.8 ±0.6 in group 1 and 3.6±0.6 meq/l in group 2. The mean BUN was 25±9 and 31±11mg/dl in group 1and 2, and the mean creatinine was 0.8 ±0.3 and 1±0.26 mg/dl in group 1 and 2, respectively.

After 3 hours, these tests were repeated and evaluated between the two groups and in each group. Table 1 shows plasma sodium, potassium, sugar, and bicarbonate before and after rehydration in both groups.

In group 1 After 3 hours there are not any difference between the values of serum sodium , serum potassium , and serum bicarbonate between two groups while blood sugar decreased significantly in children who received isotonic saline (Table 1) .Comparison of changes in both group indicated that in the isotonic saline group, blood sugar decreased after 3 hours of rehydration significantly ($p< 0.001$) while this decrement did not occur in patients who received hypotonic serum containing saline, dextrose, and bicarbonate ($p< 0.4$).

Blood base increased in both isotonic and hypotonic groups significantly ($p< 0.001$).

The serum sodium did not change after serum therapy in the isotonic group ($p< 0.6$) but increased 2meq/l in the hypotonic group ($p< 0.04$). Serum potassium did not change in isotonic ($p< 0.09$) and hypotonic ($p< 0.8$) groups from admission to 3 hours after fluid therapy.

Table 1. Changes of serum sodium, potassium, base, and blood sugar in two types of serum therapy

	Isotonic			Hypotonic		
	First	p value	3 hours later	First	p value	3 hours later
Na meq/l	134±5	P< 0.6	135±4	134±6	P< 0.041	136±3
K meq/l	3.8 ±0.6	P< 0.09	3.7±0.5	3.6±0.6	P< 0.8	3.6±0.4
BS g/dl	90±16	P< 0.0001	73±13	91±15	P< 0.48	94±10
Base meq/l	11.6±3.6	P< 0.0001	15±3	10.1±1.9	P < 0.0001	15±2

Discussion

Gastroenteritis is one of the most common pediatric disorders in emergency rooms. The standard approach to intravenous fluid therapy for these children is administration of a serum containing sodium chloride (NaCl) 0.9% in bolus followed by a hypotonic solution ranging from 0.2-0.45% NaCl to replace the remaining deficit and supply daily maintenance fluid, which are the key elements of successful management in addition to treating the underlying disease [6,7]. Acute gastroenteritis may lead to metabolic acidosis, electrolyte disturbances, and carbohydrate intolerance [8]. The main step in the management of gastroenteritis is fluid replacement in hypovolemic cases while 9.2% of the gastroenteritis cases suffer from hypoglycemia that is more associated with prolonged vomiting and results in starvation [9]. Hypoglycemia is sometimes a problem related to other diseases like metabolic syndromes which may mimic gastroenteritis in practice [10, 11]. In one study, the amount of administered intravenous dextrose to children with acute gastroenteritis was important to achieve clinical efficacy [12] while in another study, early administration of intravenous dextrose could help to terminate vomiting and ongoing outpatient managements [13]. Hyponatremia is another relatively common problem which may occur during rehydration therapy in 18.5% of the patients admitted with isonatremic dehydration in the context of gastroenteritis. It is known as hospital acquired hyponatremia which obligates the researchers to revise fluid management in dehydration of children. Hyponatremia may occur due to of the hypotonic effects of AVP excess in special conditions following volume depletion or some stimuli such as nausea and vomiting. In this situation saline 0.9% would be superior to hypotonic fluids as a volume expander [6]. A number of studies suggest that the rate of the fluid infusion is more important than the type of the fluid to prevent hyponatremia [14]. The safety of large bolus doses of isotonic saline is evident because it does not cause hyponatremia [15]. Comparison of hypotonic and isotonic fluid in critically ill children in post operation shows that hypotonic saline does not increase the occurrence of hyponatremia in comparison to isotonic saline [16]. According to our study, the hypotonic serum containing 28ml NaHCo3, 222 ml dextrose 5%, and 722 ml isotonic saline prescribed as bolus doses of 20ml/kg that may be repeated as needed until recovery of hemodynamic parameters and isotonic saline 0.9% showed similar changes in the serum sodium concentration. This increment was 2 meq/dl in average for hypotonic saline and 1 meq/dl in isotonic saline after 3 hours of observation. In fact, our findings showed that the fluid type was not per se enough to induce dysnatremia [14,16]. Another factor that we evaluated was the changes of blood sugar in patients who received isotonic and hypotonic fluid. The results showed that in the hypotonic group, blood sugar was stable after 3 hours while in the isotonic saline group, serum blood sugar decreased 20 mg/dl after 3 hours which was significant. Other studies have also reported the association of hypoglycemia and gastroenteritis [9-11]. According to our study, hypoglycemia should be part of our intervention in the first visit and early management of hemodynamic instability regardless of blood sugar and catabolic state of children. Serum bicarbonate did not change after 3 hours in the isotonic 0.9% saline and hypotonic saline with 2.5 meq/100ml bicarbonate and dextrose. The increment of base

in the hypotonic saline group after 3 hours of recovery time of rehydration was higher than isotonic saline (4.9 vs. 3.4 meq/l) although the difference was not significant.In fact, this finding supports the studies that combined dextrose 5% and isotonic saline to produce lower levels of serum ketones as compared to isotonic saline in dehydration due to gastroenteritis [17]. In fact, our hypotonic solution had a lower sodium level (137 meq/dl) in comparison with the normal saline solution (154 meq/dl); however, the sodium content of our solution was very similar to the sodium content of the Ringer's solution and its efficacy in early rehydration therapy was comparable to the isotonic normal saline solution [18]. In spite of these beneficial changes with the use of hypotonic saline containing dextrose, bicarbonate, and isotonic saline, there was no difference in serum potassium between the two groups of isotonic and hypotonic solutions.

Conclusions

A mildly hypotonic solution containing dextrose and bicarbonate is not associated with serum sodium or blood sugar decrease. It is a safe fluid and increases serum bicarbonate insignificantly in dehydrated children more than isotonic saline.

Conflict of Interest

None declared

Financial Support

None declared

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