ORAL REHYDRATION THERAPY IN 140 INFANTS SUFFERING FROM HYPERNATREMIC DIARRHEAL DEHYDRATION

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Abstract - 140 hypernatermic dehydrated infants aged 2-24 months, were hospitalized during a 21 month period. They were treated with oral electrolyte solutions A and B in which the concentration of sodium and potassium was equal (50 mmol/L sodium and 30 mmol/L potassium) but the sodium bicarbonate content differed. The serum sodium concentration returned to normal 48 hours after treatment. Seven cases became hypernatermic and in two cases hyponatermia became symptomatic on admission, 8 cases were hypokalemia, that were corrected 12 hours after treatment. Convulsions occurred in 18 patients (12.8%). Serum bicabonate concentrations, 12 and 48 hours after treatment were not significantly different in those who revived solution A and B (containing 30 mmol/L and 40 mmol/L, respectively). Oral rehydration solution consumed in 72 cases was incorrectly prepared in 29 cases (40.27%). No mortality was recorded. Mean increase in weight was 4.5%, 48 hours after admission and duration of hospitalization was 5.6 days.

Hydration, hypernatermia, hypokalemia, hyponatermia, acidosis and improvement in general condition all occurred in a period of 48 hours.

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INTRODUCTION

Oral rehydration therapies have been used successfully in treating dehydrated patients for many years and its advantages have been frequently mentioned (1,2).

The purpose of this study is to assess the effects of oral rehydration therapy in hypernatermic dehydration of different severities in a period of time shorter than 48-72 hours that is the accepted period for the restoration of the deficit, in intravenous therapy of hypernatermic dehydrated patients.

We also evaluated the modifications of serum electrolytes concentrations especially the modifications of serum sodium concentrations during the oral rehydration therapy.

MATERALS AND METHODS

The study population consisted of 140 infants aged 2 to 24 months, who were hospitalized in Bahrami Children's Hospital, affiliated to Tehran University of Medical Sciences during 21 months from July 1989 to March 1991. They were admitted because they suffered from diarrhea, vomiting, mild and moderate to severe dehydration.

Table 1. Clinical assessment of severity of dehydration (2)

Signs and Symptoms	Mild Dehydration	Moderate Dehydration	Severe Dehydration
Body Weight loss (%)	3-5	6-9	10 or more
General appearance and condition	Thirsty; alert; restless	Thirsty; restless or lethargic but irritable to touch	Drowsy; limp, cold, sweaty, cyanotic extremities, may be comatose
Rapid pulse	Normal rate and strength	Rapid and weak	Rapid, feeble sometimes impalpable
Respiration	Normal	Deep, may be rapid	Deep and rapid
Anterior fontanel	Normal	Sunken	Very sunken
Systolic blood pressure	Normal immediately	Normal or low	Pinch retracts very slowly
Eyes	Normal	Sunken	Grossly sunken
Tears	Present	Absent to reduced	Absent
Mucous membranes	Moist	Dry	Very dry
Urine flow	Normal	Reduced amount and dark	Anuric/ severe oliguria
Capillary refill	Normal	+2 sec	> 3 sec
Estimated fluid deficit (ml/kg)	30-50	60-90	100 or more

All infants were initially examined by the hospital house officers. Patients, biographical data, medical history and physical examinations were performed and the severities of dehydration were assessed according to table 1.

Two or more signs of dehydration in each category were considered in the assessment of each class of dehydration.

The composition of the two different solutions used in the treatment of hypernatermic infants are demonstrated in table 2.

Table 2. Composition of electrolytes in solutions (mmol/L)

Solution	Sodium	Potassium	Bicarbonate	Chloride	Dextrose	Osmolarity (mosmol/L)
A*	50	30	30	50	110	270
B**	50	30	40	40	110	270

* Made by adding the following to 1000 ml of tap water: sodium chloride 1.17g; potassium chloride 2.3 g; sodium bicarbonate 2.5 g; and anhydrous dextrose 20 g.

** Made by adding the following to 1000 ml of tap water: sodium chloride 0.6g; potassium chloride; 2.3 g; sodium bicarbonate 3.34g; and anhydrous dextrose 20g.

The volume of fluid administered to patients during the period of deficit therapy, consisted of 20 ml/kg/hr till the resolution of signs of dehydration. During this period of time, physical examination was repeated at frequent intervals.

Afterwards, the fluid volume administered was calculated on the basis of 100ml/kg/24hr as maintenance therapy. Ongoing losses were estimated up to 50ml/kg/24hr in the most severe cases.

Laboratory studies performed on admission included venous blood sampling for serum concentrations of sodium, potassium and bicarbonate. Laboratory studies were repeated 12 and 48 hours after treatment. In all samples) sodium and potassium were measured by flame photometry.

Fourty eight hours after admission, most infants were fed with breast milk or dried milk (formula) at about 10 to 20 Kcal/kg/24hr. This amount was gradually increased to 100 Kcal/kg/24hr within the next few days; thereafter the amount of oral solution was decreased as necessary.

Table 3. Historical and clinical findings

Features	Values
	(Mean±SD)
Number of patients	140
Age (months)	7.1±3.37
Male to female ratio	77.63
Duration of diarrhea before admission (days)	2.87 ± 2.43
Frequency of diarrhea in the day bofore admission	9.71 ± 3.79
Duration of vomiting before admission (days)	2.23 ± 1.41
Frequency of vomiting in the day bofore admission	5.37 ± 1.64
Severity of dehydration n(%)	121 (100%)
Severe dehydration	43 (35.5%)
Moderate dehydration	71 (58.7%)
Mild dehydration	7 (5.8%)
Rectal temperature (C) on admission	38.58 ± 3.46
Rectal temperature (C) 12 hr after admission	37.44 ± 3.51
Rectal temperature (C) on discharge	37.17 ± 0.41
Weight on admission (kg)	6.56 ± 1.02
Weight 12 hr after admission	6.79 ± 1.14
Weight 48 hr after admission	6.86 ±1.68
Duration of hospitalization (days)	5.6 ± 2.99

RESULTS

The clinical findings and the results of serum electrolytes (sodium, potassium, bicarbonate) are shown in table 3 and table 4.

Hyponatremia (Na^+ < 130 mmol/L) occurred in seven of our patients, two cases of hyponatermia (Na^+ 128 and Na^+ 124 mmol/L) appeared twelve hours after treatment and in 5 cases 48 hours after treatment. In these 5 cases serum sodium concentrations were between 120-129 mmol/L.

Table 4. Concentration of serum electrolytes in plasma (mmol/L) in 140 Dehydrated hypernatermic patients (Sodium> 150 mmol/L).

	Number of patients	Mean ± SD (mmol/L)
Sodium on admission	140	160.48 ± 8.84
		P < 0.001
12 hours later	138	14.78 ± 10.25
		P< 0.001
48 hours later	129	142.31 ± 7.47
Potassium		
on admission	124	4.63 ± 0.31
		P< 0.001
12 hour later	113	4.94 ± 0.98
48 hours later	103	4.95 ± 0.95 N.S.
Bicarbonate		
On admission	47	10.64 ± 4.36
12 hours later	39	14.78 ± 4.24
		P< 0.001
48 hours later	36	18.74 ± 3.84

Table 5. Concentration of serum electrolytes in hypernatermic patients with convulsions

Convulsions	Number of patients	Mean ± SD (mmol/L)
Convulsions after admission		
Sodium		
On admission	18	170.2 ± 10.45
12 hours later	18	156.8 ± 15.6
48 hours later	17	148.76 ± 9.9
Convulsions Prior to admission		
Sodium		
On admission	5	157.4 ± 5.17
12 hours later	4	151 ± 11.69
48 hours later	4	143.25 ± 18.57

Hypokalemia (K^+ < 3.5 mmol/L) occurred in 8 patients on admission, serum potassium concentrations were between 2.8-3.4 mmol/L and only one patient became hypokalemic 12 hours after the beginning of treatment (serum K^+ 3.3 mmol/L).

Hyperkalemia (K^+ > 6 mmol/L) was reported in 10 cases on admission, in 19 cases 12 hours later and in 14 cases 48 hours after the begining of treatment. Convulsion occurred in 18 patients after treatment and in 5 cases it occurred prior to admission. The results of serum sodium concentrations in these two groups are shown in table 5. Serum calcium and glucose measured in 14 and 10 cases respectively were normal in the first group (n=18).

CT scans were performed in 5 of these 18 cases, in 3 cases, the CT scan was normal and in 2 cases the CT scan showed diffuse cerebral hemorrhage.

ORS was consumed in 72 cases (28 g and 7 g packets) as mentioned by the parents of our patients and in 29 cases (40.27%) the preparation of ORS solutions had been incorrect.

The serum sodium concentrations in this two groups of patients who convulsed, are indicated in table 5 and the effects of electrolytes solutions on serum sodium bicarbonate concentrations, in table 6.

Table 6. Serum sodium bicarbonate concentrations in hypernatermic patients consuming electrolytes solution A and B.

Electrolyte solutions	Number of patients	Mean ± SD (mmol/L)
Electrolyte solution A		
On admission	28	10.95 ± 3.83
		P<0.001
12 hr later	28	14.82 ± 4.3
		P<0.001
48 hr later	23	18.85 ± 4.13
Electrolyte solution B		
On admission	19	10.2 ± 5.12
		0.01<P<0.05
12 hr later	11	14.68 ± 4.31
		0.01<P<0.05
48 hr later	13	18.55 ± 3.44

DISCUSSION

Oral rehydration therapy has been widely and successfully used for many years in treating dehydrated patients (1,2,3,4,5).

The purpose of this study was the evaluation of the effects of oral electrolyte solutions in 140 hypernatermic patients of different severities and also to assess the changes of serum electrolytes particularly the serum sodium concentrations in a period of time shorter than 48 hours, the accepted interval for the correction of hypernatermic dehydrations (6).

The electrolyte solution A was used for 39 patients and the electrolyte solution B in 101 cases. The compostion of these two electrolyte solutions are shown in table 2.

The concentrations of sodium and potassium in these two solutions are equal, both solutions containing 50 mmol/L Na^+ and 30 mmol/L K^+. To improve the correction of serum bicarbonate and to avoid hyperchloremia, the amount of bicarbonate was increased in solution B. The concentration of chloride was consequently decreased. The effects of these two solutions, on the serum sodium and potassium concentrations for this reason are considered together.

The fall of serum sodium was 11.7 mmol/L 12 may have hours after admission and 18.17 mmol/L 48 hours after hospitalization. The mean serum sodium concentration returned towards normal level 12 hours after treatment (Table 4). This fall in serum sodium concentration in 12 hours is twice more than the amount of 10 mmol/L/24 hr; the accepted drop in the serum concentration per day in intravenous therapy (6). The serum sodium concentrations (mean ± SD) returned to normal 48 hours after treatment.

Two of the seven hyponatermic cases became symptomatic, they manifested a generalized seizure, The serum sodium concentrations was 120 and 124 in these two cases. We believe that the rate of fluid administration should be slowed down in order to prevent these hyponatermia.

Eight cases of hypokalemia on admission were corrected twelve hours following admission. Total body potassium decrease and the serum potassium concentrations may be low, normal or increased in diarrhea, dehydration and associated metabolic acidosis. The correction of hypokalemia 12 hours after treatment is the reason for the adequacy of the amount of potassium in these two solutions. All hyperkalemic cases were due to red cell hemolysis and liberation of intracellular potassium. Our patients didn't manifest any clinical or cardiological signs of hyperkalemia.

Convulsions occurred in 18 patients during treatment, in this group of patients the mean value of serum sodium concentration on admission was 9.72 mmol/L higher than the mean serum sodium concentration of the whole group (n=140) on admission. The fall of the mean serum sodium concentraion in these 18 patients was 13.4 mmol/L 12 hours after treatment. The rapid fall of the mean value explains the frequency of convulsions that occurred during the treatment of hypernatermic dehydration (6), however, 12.8% of our patients convulsed during treatment; this is approximately half that of the percentage reported previosly in a study on intravenous therapy of hypernatremic infants in Iran (4).

Serum glucose or serum calcium concentrations may fall during the treatment of hypernatermic diarrheal dehydration (6). Serum calcium and serum glucose, measured in respectively 14 and 10 infants, with seizures, were normal after treatment.

CT scans were carried out in 5 of 18 patients who convulsed after admission. The CT scans were normal in 3 cases, and in 2, the CT scans showed diffuse cerebral hemorrhage.

High sodium intake, due to incorrect preparation of ORS was observed in 29 out of 72 cases (40.27%); this played an important role in the genesis of hypernatermia. Incorrect preparations of the ORS solution increase the sodium concentration even up to 360 mmol/L. The kidneys' ability to conserve water is much less than the ability to excrete water and this limitation in water conservation easily leads to an increase in serum sodium concentration. The formulation of the oral rehydration salts, offered to the public should consider a safety margin for these erroneous preparations.

Convulsion in 5 patients happened prior to admission and in 4 cases of these patients incorrectly prepared ORS was consumed (28 g dissolved in 1 or 2 glasses of water). The rapid rise in serum sodium concentration may explain the convulsions in these 5 infants (Table 5). The rise and decline of hypernatermic dehydration in Egyptian children from 49% in 1984 (19% with severe hypernatermia) to 10% in 1989 coincided with increasing use of ORS and then increasing ability of mothers to mix solutions correctly (7-9).

Finally the effects of sodium bicarbonate content of the electrolyte in solution A and B were compared (table 6). Twelve and forty - eight hours after the consumption of the above solutions, no statistically significant differences were noticed. The mean value of sodium bicarbonate concentration (14.78 mmol/L) 12 hours after treatment reached a level high enough to allow the kidneys to correct very easily this mild acidosis. The mean values of serum sodium bicarbonate 48 hours after treatment approached normal values. (Table 4).

Corrections of dehydration, hypernatremia, hypokalemia, acidosis and improvement in general condition all were achieved in a period of 48 hours or less (12 hours).

Reports of hypernatermic diarrheal dehydration treated with oral rehydration solutions in 12 hours are published in the literature (9) and further evaluation of this sort of treatment is encouraged (9). Solutions containing a sodium concentration around 60 mmol/L are considered safe, and effective in treating hypernatermic diarrhea dehydration (10). However recent results in the literature have been conflicting and the search for the optimal solution continues (11,12). Convulsions occurred less frequently in comparison to the rate of convulsions in reported dehydrated hypernatremic infants treated intravenously. No mortality was recorded. 5 patients treated intravenously after admission were excluded (3.4%). During the study period (21 months), 715 dehydrated infants with

gastroenteritis were admitted, and 20.2% of these patients suffered from hypernatermic diarrhea dehydraion. The mean increase in weight (4.5%) and the mean duration of hospitalization 5.6 days are indicated the table 3.

In conclusion, the present data support the efficacy, practicability and relative safety of these two electrolyte solutions (Na^+ 50 mmol/L, K^+ 30 mmol/L) in the treatment of infants with hypernatremic diarrheal dehydration, in a period of time shorter than 48 hours.

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