RICE-POWDER SALT SOLUTION IN THE TREATMENT OF ACUTE DIARRHEA IN YOUNG CHILDREN

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Abstract. Dehydration is the most common cause of death in diarrheal patients. Early oral rehydration therapy (ORT) can prevent or reverse dehydration from diarrhea in almost all cases. Shortages of oral rehydration salt (ORS) packets in certain areas remain a major problem of the Diarrheal Diseases Control Program of Thailand. To find an effective solution that can be prepared locally, a randomized trial of oral rehydration solutions was conducted. A rice-powder salt solution containing rice-power 30 g/l and salt 3.5 g/l (RPSS) was evaluated in a group (n = 23) of infants and young children aged between 4 months and 5 years with mild or moderate dehydration from acute watery diarrhea, and the results were compared with those who received WHO recommended glucose electrolyte solution (WHO-ORS) (n = 21), and glycine supplemented WHO-ORS (G-ORS) (n = 20). The efficacies of WHO ORS and G-ORS were found to be similar. The RPSS was found to be more effective than WHO-ORS and G-ORS as shown by a significantly lower stool frequency, lower rate of stool output, a significantly shorter duration of diarrhea, and a smaller intake of rehydration fluid. Promotion of the effective rice-salt solution could increase early implementation of ORT in many rural communities.

INTRODUCTION

The glucose-based electrolyte oral rehydration solution recommended by the World Health Organization (WHO-ORS) has been widely used for treatment of diarrheal episodes. The use is based on the finding that the movement of sugars across the mucosal membrane of small intestinal epithelial cells is coupled to the movement of sodium (Schultz, 1977). The formulation has, however, no effect on the volume, frequency, and duration of diarrhea (Sack *et al,* 1978). Two clinical trials on patients with acute diarrhea reported that glycine supplemented WHO-ORS solution (G-ORS) caused a significant reduction in stool volume and duration of diarrhea (Nalin *et al,* 1970; Patra *et al,* 1984). However, in two other clinical trials of children with acute diarrhea, no therapeutic advantage was observed for the G-ORS (Vesikari and Isolaurl, 1986; Santosham *et al,* 1986).

The Diarrheal Diseases Control Program of Thailand has used WHO-ORS since 1980. However, shortages of the ORS packets in certain areas in the country remain one of the major problems of the Program (Uthen Charanasri, Ministry of Public Health, personal communication). An effective solution prepared locally would, therefore, make management of diarrhea more available everywhere. A pilot study carried out in this Faculty (Siddiqui, 1985) allowed us to conclude that rice-powder salt solution (RPSS) could be used as an oral rehydration solution in treatment of acute watery diarrhea in young children. In the present study we describe a randomized trial of a rice-powder salt solution containing rice powder 30 g/l and salt 3.5 g/l (RPSS), glycine supplemented WHO-ORS (G-ORS), and WHO-ORS in the treatment of acute watery diarrhea in young children with mild and moderate dehydration.

MATERIALS AND METHODS

Seventy-six children aged 4 months to 5 years (mean, 12 months) who had acute watery diarrhea of less than 7 days duration with signs of mild or moderate dehydration, admitted to the Chon Buri Regional Hospital, central Thailand were recruited

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into the study. To avoid the risks of a new therapy, children with severe dehydration were not studied. The study was approved by the National Ethical Committee. Written informed consent was obtained from all of the parents. A thorough clinical examination was made for each child. The child was then randomly assigned to one of the three treatment groups. Twelve patients were excluded because withdrawal of parental consent. Twenty-three, 21, and 20 patients who received RPSS, G-ORS, and WHO-ORS, respectively, completed the study. Blood samples for hematocrit, serum specific gravity, and electrolytes (sodium and potassium) determinations were drawn on admission, and every morning thereafter until cessation of diarrhea. In addition the hematocrit and serum specific gravity were also measured 8 hours after commencement of treatment. Complete blood count, blood urea nitrogen, and creatinine were performed on admission.

Fecal samples obtained from all patients on hospital arrival were processed at the Chon Buri Hospital's laboratory for Enteropathogenic *Escherichia coli, Shigella, Salmonella,* and vibrios by the standard methods.

The volume of fluids intake was measured from pre-marked containers after treatment 4 and 8 hours initially and every 8 hours thereafter. Stool output was weighted from pre-weighed disposal absorbent pads which were changed according to the patient's stool frequency. To prevent spillage of urine to the absorbent pads, disposable urine collectors were used to obtain urine samples. Vomiting frequencies and volumes were also recorded. Body weight was measured on admission, 24 and 48 hours, and daily until diarrhea ceased.

The RPSS was prepared from separately pre-bagged rice powder, (22.5 g) and salt (2.6 g). These would approximately be 3 tablespoonfuls of rice powder and 3/4 teaspoonfuls of salt. A fresh preparation was made by adding 1 packet of rice powder to a small amount of water and boiled for 10 minutes while stirring once in a while to make a uniform solution, and water was added up to 750 ml. The solution was then cooled, the salt was dissolved. The electrolyte contents of RPSS measured by flame photometer showed sodium 63.4 ± 4 mmol/l, and chloride 62.4 ± 4 mmol/l. *In vivo* hydrolysis by intraluminal enzymes converts 80-86% of rice to glucose, amino acids and oligopeptides (Molla *et al,* 1982). Therefore 30 g/l of rice powder would liberate approximately 24 g (133 mmol/l) glucose in the intestinal lumen. The fluid was discarded four hours after preparation if not consumed.

WHO-ORS was prepared by mixing 1 packet of ORS (Thai Government Pharmaceutical Organization) with 750 of cool boiled water. The contents of WHO-ORS were glucose 111 mmol/l, sodium 90 mmol/l, chloride 80 mmol/l, potassium 20 mmol/l and bicarbonate 30 mmol/l. G-ORS was prepared by mixing a pre-bagged glycine (Merck) 6.2 g and a packet of the ORS in 750 ml of cool boiled water. This amount of glycine when reconstituted will give rise to approximately 111 mmol/l. The WHO-ORS and G-ORS were discarded 24 hours after preparation if not consumed. The fluids were prepared in the final volume of 750 ml, corresponding to the volume of commonly used bottle containers in Thailand.

The oral fluid was administered mainly by the mothers or by attendants, the amount given followed the WHO guidelines. All the patients were allowed plain water as needed. Breast feeding was continued for breast-fed patients. Diluted milk was offered to the bottle-fed patients, and hospital diet (eg rice, fish, egg, etc) was offered to the older children as soon as the initial dehydration was corrected (WHO, 1984). Based on the clinical judgement antibiotics were not used in all the patients.

RESULTS

The 64 patients studied, 82% were infants, 12% aged between 13-23 months, other 6% aged 24-56 months. The mean age, body weight, duration of diarrhea before admission, history of vomiting, and dehydration status on admission of the three groups were comparable. Most of the patients (80-83%) presented with moderate dehydration with mean diarrhea durations of 29, 24, and 30 hours respectively. Approximately 85% of them had vomiting (Table 1). Enteropathogens were not detected in all the patients' rectal swab specimens. All patients could be rehydrated orally within the first four hours and were successfully treated. The RPSS was accepted well by all the patients and their parents.

Table 1

Comparison of various characteristics of diarrheal patients treated with rice-powder salt solution (RPSS), glycine supplemented WHO-ORS (G-ORS), and WHO-ORS.

Variable	RPSS (n = 23)	G-ORS (n = 21)	WHO-ORS (n = 20)
Mean age (month) ± SD	12.7 ± 3.3	12.5 ± 3.3	11.6 ± 4.4
Male/female	16/7	15/6	12/8
Mean body weight on admission (kg) ± SD	8.7 ± 0.8	8.6 ± 0.8	8.5 ± 0.8
Duration of diarrhea before admission (hour) ± SD	28.6 ± 6.3	24.3 ± 3.1	29.7 ± 5.1
History of vomiting			
% of patients	83	86	85
Duration (hour) ± SD	28.1 ± 6.8	12.9 ± 2.7	25.7 ± 5.7
Dehydration status			
Mild (%)	17	19	20
Moderate (%)	83	81	80

Table 2 shows the effects of therapy analyzed 24 and 48 hours after treatment. The stool frequency, stool output, and amount of rehydration fluids consumed in G-ORS- and WHO-ORS-treated patients at 24 hours as well as at 48 hours were more or less similar. During the 16 to 24 hours, the stool frequency, stool output and fluid consumed in the RPSS group began to decrease. In the second 24 hours, it was observed that the stool frequency in the RPSS group was significantly less than those in the G-ORS and WHO-ORS groups ($p < 0.05$, < 0.05). The mean stool output and required rehydration solution in the RPSS group were approximately 60% of those in the G-ORS- and WHO-ORS-treated groups. However, the differences were not statistically significant. There was no vomiting in the RPSS group after 16 hours of treatment, and the vomiting frequency in the first 24 hours of the three groups showed no significant differences. Each patient's revovery was judged by passage of formed or semisolid stools. Fifty-four % of the patients recovered within 48 hours after treatment, 20% recovered within 72 hours, the others in 96 hours. The mean duration of diarrhea after admission in the RPSS group (45 hours) was significantly less than those of the G-ORS and WHO-ORS groups (64 and 63 hours, respectively) ($p < 0.05$, < 0.05). Compared with the body weight on admission, the average percent gain in body weight after 24 hours of treatment of patients in the three groups was approximately 7%.

Complete blood count, blood urea nitrogen, and creatinine values on admission were normal. On admission, in the RPSS group, nine patients had hyponatremia, and three patients had hypernatremia. Twenty-four hours after treatment all had normal serum sodium levels except one whose level had no change, remaining at 130 mmol/l. Three RPSS-treated patients had serum potassium levels lower than three mmol/l on admission, the levels were within normal values 24 hours later. All of them were asymptomatic. Serum specific gravity, hematocrit, and average serum levels of sodium and potassium of the RPSS group were within normal values on recovery (Table 3).

DISCUSSION

Oral rehydration therapy is a simple and effective form of treatment that can be used at home by family members. In almost all cases, except the most severe cases of diarrhea, dehydration can be prevented or reversed if ORT is started early. This

Table 2

Effect on 24- and 48-hour treatment (mean ± SE) with rice-powder salt solution (RPSS), glycine supplemented WHO-ORS (G-ORS) and WHO-ORS in diarrheal children.

Variable	RPSS (n = 23)	G-ORS (n = 21)	WHO-ORS (n = 20)
Stool output (g)			
1st 24 hours	476 ± 62	713 ± 160	616 ± 140
2nd 24 hours	289 ± 43	575 ± 146	679 ± 122
Total (g/48 h)	765 ± 52	1,278 ± 153	1,295 ± 139
Stool frequency			
1st 24 hours	5.8 ± 0.2	9.3 ± 1.0	7.5 ± 0.6
2nd 24 hours	3.0 ± 0.3	6.8 ± 1.5	6.7 ± 1.6
Total (number/48h)*	8.8 ± 1.2	16.1 ± 3.2	14.2 ± 4.2
Rehydration solution intake (ml)			
1st 4 hours	248 ± 55	245 ± 59	366 ± 66
1st 24 hours	714 ± 113	959 ± 263	970 ± 255
2nd 24 hours	295 ± 106	726 ± 118	687 ± 190
Total (ml/48h)	1,009 ± 137	1,685 ± 360	1,657 ± 386
Vomiting frequency			
1st 24 hours	0.77 ± 0.5	1.23 ± 0.2	1.45 ± 0.2
% gain in body weight 1st 24 hours	6.7 ± 2.8	7.0 ± 3.9	7.5 ± 4.0
Duration of diarrhea after admission (hour)*	45 ± 4	64 ± 4	63 ± 11

Figures in parenthesis are the number of patients studied.
* = Statistically significant ($p < 0.05$).

study has shown that the rice-powder salt solution containing 30 g/l rice and salt 3.5 g/l was effective in correcting dehydration and maintaining hydration in diarrhea in young children, and more effective than the WHO-ORS as shown by an appreciably lower rate of stool output, a shorter duration of diarrhea, and a smaller intake of rehydration fluid.

Other studies have shown that rice-based electrolyte solution containing various amounts of rice, ie 30, 50, and 80 g/l were more effective than WHO-ORS in treatment of acute diarrhea in children and adults (Molla *et al,* 1982; Patra *et al,* 1982; Molla *et al,* 1985). These show the wide margin of safety of rice concentrations. However, we observed that solutions containing rice powder greater than 30 g/l were too sticky for young infants. This may lead to inadequate volume of fluid intake for rehydration.

Rice is cheap, easily obtained in many developing countries where diarrhea is common. In humans, starch is rapidly hydrolyzed by salivary and pancreatic amylases to glucose, maltose, maltotriose, and branched dextrins (Auricchio *et al,* 1967). The oligosaccharides are further hydrolyzed to glucose by the maltase of the brush border of the enterocytes (Eggermont, 1969). The RPSS can be used in young infants because most of the active disaccharidases are fully developed since birth (Auricchio, 1965). The efficiency of the specific intestinal enzymes in hydrolyzing rice powder remains at a satisfactory level in diarrhea caused by *Vibrio cholerae, Escherichia coli,* rotavirus, and *Shigella* (Molla *et al,* 1981). Intraluminal digestion of rice

Table 3

Biochemical values (mean ± SE) during the study period.

Variable	RPSS (n = 23)	G-ORS (n = 21)	WHO-ORS (n = 20)
Serum specific gravity			
Admission (0 hours)	1.042 ± 0.001	1.044 ± 0.009	1.044 ± 0.003
8 hours	1.040 ± 0.002	1.040 ± 0.001	1.039 ± 0.001
Recovery	1.036 ± 0.001	1.037 ± 0.010	1.036 ± 0.003
Hematocrit (%)			
Admission (0 hours)	35.6 ± 1.4	35.2 ± 0.8	37.5 ± 1.0
8 hours	32.9 ± 0.9	33.2 ± 0.7	33.6 ± 1.0
Recovery	32.0 ± 1.0	33.2 ± 1.3	32.9 ± 1.0
Serum sodium (mmol/l)			
Admission	135.5 ± 2.5	131.2 ± 2.6	132.0 ± 2.4
Recovery	135.0 ± 1.4	132.6 ± 10.2	140.8 ± 2.2
Serum potassium (mmol/l)			
Admission	3.8 ± 0.2	4.3 ± 0.3	4.5 ± 0.2
Recovery	3.8 ± 0.2	4.6 ± 0.2	5.0 ± 0.2

powder liberates glucose slowly without causing an osmolar load, hence it is possible to give a relatively high quantity of rice powder without losing its effectiveness. The rice-powder salt solution is, therefore, very useful in field application where exact measurements are not possible. In addition, rice also contains seven to 10% of protein (Houston and Kohler, 1970), this made RPSS a more nutritious solution.

Despite having a lower sodium concentration than the WHO-ORS, RPSS was effectively used in patients with hypo- and hyper-natremia. Several factors may play role, ie our patients had only mild and moderate dehydration, and milk, plain water, and food were allowed *ad libitum*. Moreover, a normal functioning kidney would be able to handle acid-base and electrolyte disequilibrium once the extracellular fluid volume deficit has been adequately corrected.

The finding in this study that G-ORS was not clinically superior to the WHO-ORS solution, in that neither stool output nor duration of diarrhea was reduced by the solution, is similar to observations in other WHO-supported studies (The Study Group on Improved ORS, 1991). The G-ORS does not deserve further study.

Most rotavirus diarrhea cases are children under one year of age, and frequently accompany by vomiting (Leksomboon *et al*, 1981). In this study, 82% of patients were infants, a majority of them (85%) had vomiting, no enteric pathogens were isolated from routine bacterial cultures of stool samples, and they recovered without using antibiotics. The evidence suggests that rotavirus may be the major etiologic agent. However, the failure to find pathogens may be due to a number of factors, including the unavailability of facilities to look for pathogens such as Enterotoxigenic *Escherichia coli, Campylobacter jejuni, Aeromonas hydrophila,* and *Plesiomonas shigelloides.*

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