RICE GRUEL IN MANAGEMENT OF INFANTILE DIARRHOEA

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SYNOPSIS

Arising from the increasing prevalence of cow milk allergy in infants in Singapore as a result of the fall in breast feeding, rice water was utilised in treating these babies with gradual increase in solids being offered. The success in the use of rice gruel suggested to us its use in infantile diarrhoea in Singapore. It was found that rice gruel is more effective than the World Health Organisation oralyte solution which was then in current use. Rice gruel has replaced WHO oralyte solution in the Department of Paediatrics, National University of Singapore. The mechanisms whereby rice water is superior to other oralyte solutions are discussed.

INTRODUCTION

The existence of a severe form of cow milk allergy encountered among Singaporean babies was first pointed out in 1965 (1). It had also been pointed out that the status of breast feeding in Singapore mothers had drastically changed from 1950 to 1960 (2). For example, among the lower socio-economic group mothers, 90% initiated breast feeding in 1950, 85% were still breast feeding at 1 month and 77% at 3 months. In 1960, the corresponding figures had fallen to 70%, 65% and 42%. The falls were even more drastic among the higher socio-economic groups so that in 1960, only 16% of the mothers were breast feeding their babies by

3 months. Our observations of severe cow milk allergy observed in 1965 are the direct consequence of this fall in breast feeding among the Chinese mothers in Singapore. This fall continued so that by 1970, only 4% of the higher socio-economic group were breast feeding by 3 months and only 5% of the lower socio-economic group were breastfeeding their babies by 3 months.

The babies with severe cow milk allergy were either fed on cow milk from birth or were fed breast milk for a short period before changing to cow milk. The onset of severe diarrhoea was early and occurred in the first two weeks in those fed cow milk from birth and later in those who were initially breast fed. All the latter infants were well when they were first breast fed. As a result of the severe diarrhoea, these infants were brought to hospital in a severe state of dehydration and malnutrition. They were all rehydrated intravenously and tolerated to some extent oral glucose feeds. However, the moment cow milk was introduced even in dilute concentration, the diarrhoea re-started. Once initiated, the diarrhoea took a long time to stop after I/V re-hydration. In a small group of such babies, severe anaphylactic shock ensued on re-introduction of cow milk and death occurred within half an hour. At autopsy, the gut was denuded of epithelium and the lumen filled with fluid exuded from the blood vessels. These cases reached almost epidemic proportions at one time. The mortality rate was almost 100%.

To try and save some of these infants a simple form of parenteral hyperalimentation was introduced (3). The mortality rate was reduced to 30% but the extreme high cost of the procedure at that time and the high rate of septicaemia made us look for other management strategies. With the assistance of the Singapore Breastfeeding Mothers Group, 2 milk banks were established. Breast milk overcame the problems of malignant diarrhoea in babies with cow milk allergy but the number of breast milk donors was small, which was understandable due to the drastic fall in breastfeeding. Secondly, there were insufficient voluntary workers to collect the breast milk and deliver it to the milk banks for storage. We realised that breast milk banks would not be the final answer, and we were experimenting with solids to feed these babies with allergy to cow milk and we started with rice porridge or rice water. This is standard fare for the Chinese who add more water in cooking the rice so that the rice is not the usual solid glutinous preparation but a liquid rice preparation or congee. The soft rice grains float in the starchy supernatant. This rice water can be made more concentrated by adding more congee to the liquid. We fed this rice carbohydrate liquid to these babies with cow milk allergy and found that in many instances the diarrhoea improved. Gradually, protein and fat were added in the form of boiled fish and chicken, until the baby began to put on weight.

The effectiveness of rice water in cow milk allergy has been assessed in a series of 19 cases (4), 63% of whom were Chinese, 32% Malay and 5% others. The behaviour of these 19 babies with cow milk allergy is depicted in (Table 1).

7 babies who were given rice water were challenged with cow milk. The results are shown in (Table 2).

The efficacy of rice water in stopping the diarrhoea in cow milk allergy suggested to us that it may be useful in treating babies with diarrhoea from other causes.

TABLE 1

SYMPTOMS	NO.	%
Symptoms subside after elimination of cow milk	19/19	100
Symptoms recur when given oral dextrose saline	5/17	29
Symptoms recur when given soy milk	8/10	80
Symptoms subside or do not recur when given rice water	10/10	100
Symptoms subside or do not recur when on breast milk	19/19	100
Symptoms recur within 48 hours after challenge with cow milk	9/12	75

TABLE 2

Symptoms recurred within 48 hours after challenge with cow milk	7/7
Improved when given rice water again	7/7

PRESENT MORBIDITY AND MORTALITY IN SINGAPORE DUE TO DIARRHOEA:

Although diarrhoea causes 5 million deaths of children under the age of 5 years annually in the developing countries (i.e. about 10 deaths in every minute) (5), the state of infantile diarrhoea in Singapore is totally different as shown in (Table 3) showing that death from diarrhoea is now rare.

The degree of dehydration seen in cases of diarrhoea admitted to the Department of Paediatrics, National University of Singapore, is compared between cases admitted in 1968 (3) and now (Table 4).

Table 3 and 4 highlight the fact that infantile diarrhoea in Singapore generally is not as severe as seen in the developing countries, and this situation must be realised when the results utilising rice water in the treatment is compared with other oralyte solutions.

TABLE 3
AGE-SPECIFIC MORTALITY RATE/1000 FROM DIARRHOEAL (0-14 YEARS)

YEAR	MORTALITY RATE
1962	0.395
1963	0.273
1964	0.181
1965	0.158
1966	0.188
1967	0.164
1968	0.129
1969	0.126
1970	0.120
1971	0.098
1972	0.088
1973	0.102
1974	0.056
1975	0.027
1976	0.035
1977	0.026

TABLE 4

	1968		1981	
	NO.	%	NO.	%
Mild dehydration (<5%)	11	52.3	96	76.2
Moderate dehydration (5-10%)	5	23.8	28	22.2
Severe dehydration (<10%)	5	23.8	2	2.6

MATERIALS AND METHODS

Consecutive cases of gastroenteritis admitted to the Department of Paediatrics from October 1980 to May 1981, i.e. over a period of 8 months were studied. There were altogether 130 cases. Serum electrolytes were obtained from each patient on admission to the ward in order to study the biochemical state. All patients were artificially fed and all cases of malignant diarrhoea due to cow milk allergy were excluded.

The serum sodium, chloride, urea, potassium and bicarbonate status were studied. All patients recovered; there were no deaths and no untoward sequalae.

There were 84 males and 46 females with a male preponderance. There were 99 Chinese, 16 Malay and 15 Indians reflecting approximately the ethnic distribution of babies in Singapore.

The age groups of the patients are seen in (Table 5).

The high incidence in those aged 1-2 months is not surprising considering that breast feeding is uncommon in Singapore.

The state of hydration on admission is shown in Table 4 (right hand column). As can be seen, compared to 12 years before, severe cases are less common now and this accounts for the fall in mortality rate (Table 1). Yet, it should be realised that all the babies were ill enough to be admitted, i.e. each of them showed a certain degree of dehydration.

(Table 6) shows how long the patients had been ill before admission, i.e. the number of days they had been having diarrhoea before admission.

As can be seen dehydration can set in rapidly within 1 or 2 days of diarrhoea.

Dehydration due to diarrhoea has been usually classified as isotonic, hypertonic or hypotonic. The serum sodium is usually considered to be a good indication of the type of dehydration. Hypernatraemic dehydration is one when the serum sodium is 150 mEq/L or more, and hyponatraemic dehydration occurs when serum sodium is 130 mEq/L or less and isotonic dehydration when serum sodium is between 131-149 mEq/L. (Table 7) compares the numbers and percentages of patients with the 3 types of dehydration in 1968 and now.

It is thus seen that hypernatraemic dehydration is extremely uncommon and that ¾ or more are isotonic. There was one case of hypertonic dehydration in the 1968 series (5%) but none in the present series.

If hypokalaemia is defined as 3.5 mEq/L or less, then in the present series of 123 patients where the serum potassium was measured, there were 10 patients with hypokalaemia, giving an incidence of 8.1%.

The serum bicarbonate was measured as an indicator of the degree of metabolic acidosis. This was done in 120 cases, and in every one of them, the serum bicarbonate was lower than normal, the mean and standard deviation being 16.24 mEq/L ± 3.85.

Blood urea was measured in 123 patients and if 40 mg/dl and over is taken as a high value, then there were 16 cases, giving the incidence of 13%. The mean value was 23.82 mg/dl with a standard deviation of 12.07 mg/dl.

In 21 cases, calcium and magnesium were estimated. In none of the cases was a serum calcium of 9 mg/dl or less found. However, there were 3 cases where the serum magnesium was less than 1 mg/dl. The mean ± S.D. for calcium was 9.9 ± 0.41 mg/dl and the mean ± S.D. for magnesium was 1.21 ± 0.7 mg/dl.

Alternate cases of infantile gastroenteritis in the 1981 series above were put on rice water (RW) or the

TABLE 5

AGE (months)	1	2	3	4	5	6	6-12	12-24	TOTAL
NO.	14	10	6	7	5	7	31	50	130

TABLE 6

NO. DAYS DIARRHOEA	1	2	3	4	5	>5
NO. PATIENTS	25	31	21	13	9	27

TABLE 7

TYPE OF DEHYDRATION	1968 SERIES (N = 21) NO.	%	PRESENT SERIES (N = 125) NO.	%
HYPOTONIC (SERUM Na = 130 mEq/L or less)	5	23.8	20	16.3
ISOTONIC (SERUM Na = 131-149 mEq/L)	15	71.4	105	83.7
HYPERTONIC (SERUM Na = 150 mEq/L or more)	1	4.8	0	0

standard World Health Organisation (WHO) oralyte solution (WOS), which were the only initial oral fluid used for IGE. It was the purpose to compare the effect of oral RW to WOS.

On admission, each patient's hydration status was assessed, i.e.< 5%, 5-10% or >10% dehydration. Serum electrolytes were taken before any treatment was started. Milk was totally withdrawn for 24 hours, or longer, as the situation demanded. Those who needed intravenous fluid hydration were dripped accordingly for 24 hours usually and then the oral fluids (RS or WOS) given depending on the protocol. The I/V fluid given was 3.75% glucose in 0.23% saline. When oral fluid was started, this was given for 24 hours as RW or WOS. On day 2, ¼ strength powdered milk was given; on day 3, ½ strength; on day 4, ¾ strength and on day 5, full strength. In the WOS group, the diluted milk feeds were made up with water while those on RW had the milk made up with rice water as the diluent fluid.

On day 3, the serum electrolytes were again estimated. For each baby, the number of stools passed were noted daily.

Altogether there were 63 patients on WOS and 67 on RW. All recovered fully and there were no deaths nor any sequalae from the episode of gastroenteritis.

RESULTS

The comparability of the 2 groups was assessed in terms of the age groups, sex, race, number of days of diarrhoea before admission, degree of dehydration and the electrolytes prior to treatment.

The ages in the 2 groups are depicted in (Table 8).

The male and female incidence is seen in (Table 9).

The ethnic group distribution is shown in (Table 10).

(Table 11) depicts the number of days of diarrhoea prior to admission to hospital.

Severity of dehydration in the two groups is shown in (Table 12).

(Table 13) shows the values for sodium (Na), chloride (Cl), urea, potassium (K) and bicarbonate (HCO_3) on admission before treatment.

It is thus seen that there was no statistical differences between the serum Na, Cl, urea, K and HCO_3 in the two groups.

In conclusion, the randomisation of the two groups revealed no statistical significance with regard to age, sex, ethnicity, days of diarrhoea before admission, the serum electrolytes, serum urea and dehydration. Hence, the two groups were comparable.

After each group had been treated with WOS or RW, the serum electrolytes were repeated on day 3, to see if there were any differences in the results. In each group the values were placed in two different subgroups, i.e. those who had been given an I/V drip and those without I/V drip. Table 14 depicts the values for the two groups, the alphabetical code being just a convenient label to identify the particular value for statistical comparison.

The only statistical significance were between C and H ($p<0.01$), i.e. in the WOS group the serum urea was lower in those with I/V drip; between N and S ($p = 0.002$), i.e. in the RW group. The serum potassium was lower in those given I/V drip; between C and M ($p <0.01$), i.e. in those without I/V drip, the blood urea on day 3 in the RW group was lower than those in the WOS group.

There was no statistical significance in the following groups:

A — F	K — P	A — K	F — P	J — T
B — G	L — Q	B — L	C — Q	
D — I	M — R	D — N	H — R	
E — J	O — T	E — O	I — S	

The fall in blood urea in the WOS group after I/V fluids may reflect the correction of whatever dehydration there was initially. The fall in serum potassium in the RW group after I/V drip is not surprising as with rehydration and improvement in renal function, more potassium is excreted. The difference in the blood urea on the 3rd day between the WOS and the RW group without I/V drip is difficult to explain, it being slightly higher in the WOS group since the protein intake for both had been the same, unless it is concluded that rehydration was faster and more effective in the RW group because of better absorption.

Finally, the effect on the frequency of stools is compared. (Table 15) demonstrates the percentage of patients passing 0, 1, 2, 3, 4, 5 or 5 stools per day on days 1, 2, 3 and 4 in the 2 groups.

It is obvious from Table 15 that babies on rice water pass less stools/day compared to those on WOS.

TABLE 8

AGE (months)	1	2	3	4	5	6	6-12	12-24	TOTAL
WOS Group (no.)	5	4	1	1	1	5	17	29	63
RW Group (no.)	9	6	5	6	4	2	14	21	67

There is no statistical difference in the two groups ($p > 0.05$).

TABLE 9

SEX	MALE	FEMALE	TOTAL
WOS Group (no.)	39	24	63
RW Group (no.)	45	22	67

There is no statistical difference in the two groups ($p > 0.05$)

TABLE 10

ETHNIC GROUP	CHINESE	MALAY	INDIAN	TOTAL
WOS Group (no.)	49	9	5	63
RW Group (no.)	50	7	10	67

There is no statistical difference in the two groups ($p > 0.05$)

TABLE 11

DAYS DIARRHOEA	1	2	3	4	5	>5	TOTAL
WOS Group (no.)	15	15	10	7	3	13	63
RW Group (no.)	10	16	11	6	6	14	63

There is no statistical difference in the two groups ($p > 0.05$)

TABLE 12

DEGREE OF DEHYDRATION	5%	5-10%	10%	TOTAL
WOS Group (no.)	50	13	0	63
RW Group (no.)	46	15	2	63

There is no statistical difference in the two groups ($p > 0.05$)

TABLE 13

UREA/ELECTROLYTES (mean ± S.D.)	SODIUM mmol/l	CHLORIDE mmol/l	UREA mg/dl	POTASSIUM mmol/l	BICARBONATE mmol/l
WOS Group	134.44 ± 4.81	101.78 ± 14.3	24.59 ± 11.1	4.41 ± 0.75	16.46 ± 3.99
No. patients	59	59	59	59	57
RW Group	133.78 ± 3.85	101.19 ± 4.83	23.06 ± 13.05	4.52 ± 0.79	16.03 ± 3.71
No. patients	64	64	64	64	63
p value	> 0.05 (NS)	> 0.05 (NS)	> 0.05 (NS)	> 0.05 (NS)	> 0.05 (NS)

S.D. = STANDARD DEVIATION
N.S. = NOT SIGNIFICANT

TABLE 14

	WITHOUT I/V DRIP					WITH I/V DRIP				
ELECTROLYTES	Sodium mmol/L	Chloride mmol/L	Urea mg/dl	Potassium mmol/L	Bicarbonate mmol/L	Sodium mmol/L	Chloride mmol/L	Urea mg/dl	Potassium mmol/L	Bicarbona mmol/L
Patients on oral Electrolyte solution										
Mean	137.25	104.67	21.58	4.68	19.92	137.14	107.26	12.61	4.26	19.89
S.D.*	± 4.14	± 4.54	± 10.11	± 0.7	± 3.96	± 4.45	± 4.41	± 8.53	± 0.68	± 3.8
N+	12	12	12	12	12	28	28	28	28	28
Code	A	B	C	D	E	F	G	H	I	J
Patients on rice water										
Mean	135.27	103.05	14.36	4.85	19.32	135.42	105.09	15.3	3.99	18.66
S.D.*	± 3.49	± 3.64	± 4.36	± 0.699	± 3.6	± 4.09	± 4.06	± 6.55	± 0.74	± 4.04
N+	22	22	22	22	22	32	32	32	32	32
Code	K	L	M	N	O	P	Q	R	S	T

*S.D. = STANDARD DEVIATION
+N = NO. PATIENTS

TABLE 15
SHOWING PERCENTAGE OF PATIENTS IN EACH GROUP PASSING 0, 1, 2, 3, 4, 5 OR MORE STOOLS PER DAY ON DIFFERENT DAYS

NO. STOOLS/DAY	0	1	2	3	4	5 OR >
DAY 1						
ORAL ELECTROLYTE SOLUTION	9.23	16.92	15.38	20.0	16.92	21.57
RICE WATER	33.33	28.79	13.64	13.64	4.55	6.06
p VALUE	< 0.001	NS	NS	NS	< 0.05	< 0.01
DAY 2						
ORAL ELECTROLYTE SOLUTION	13.33	13.33	13.33	13.33	13.33	33.33
RICE WATER	26.15	29.23	23.08	12.31	4.62	4.62
p VALUE	NS	< 0.05	NS	NS	NS	< 0.0001
DAY 3						
ORAL ELECTROLYTE SOLUTION	10.17	16.95	11.86	22.03	11.86	27.12
RICE WATER	35.38	30.77	13.85	13.85	4.62	1.54
p VALUE	< 0.001	NS	NS	NS	NS	< 0.0001
DAY 4						
ORAL ELECTROLYTE SOLUTION	10.42	16.67	16.67	16.67	20.83	18.75
RICE WATER	47.37	22.81	12.28	12.28	5.26	0
p VALUE	< 0.0001	NS	NS	NS	< 0.05	< 0.0001

DISCUSSION

The most important finding from this controlled trial with WOS and RW in the management of IGE is the effectiveness of RW in reducing the frequency of stools and hence faster rehydration compared to WOS. There were no differences in the two groups with regard to age, sex, ethnic group, number of days of diarrhoea before admission, degree of dehydration, initial serum sodium, chloride, urea, potassium and bicarbonate. Hence, the two groups were eminently comparable. Yet, RW was as effective or even more effective than WOS in controlling the diarrhoea when used in the manner described above.

However, certain points must be noted. This claim is made in the Singapore context, in cases where the degree of dehydration is usually not great, e.g. 79.4% of the WOS group had less than 5% dehydration and 73.0% of the RW group was in this category. Yet, these were admitted to hospital because of failure of treatment outside hospital. They were considered to be necessary to be warded. There were 13 cases with 5-10% dehydration out of 63 in the WOS group and 15 out of 63 in the RW group with none in the 10% dehydration group in WOS treated group and two in the RW-treated group. It is therefore concluded that in Singapore, the majority of cases of IGE can be dealt with effectively by the use of RW only for 24 hours, and then graduated milk feeds mixed with rice water on subsequent days. In the hospital, WOS can be dispensed in packets and the parents make it up with boiled water when they return home. The disadvantages of WOS is the cost and the labour of making up the packets and once made up, it may not remain sterile unless it is kept in the refrigerator, if the family has one. RW is sterile as it is boiled during preparation of cooked rice. It is free and freely available in the home. There is no opportunity for 'wrong' mixing which can occur with WOS because the salt in the packets is a precise weighed amount and when added to one litre of water produces precise concentrations of Na, Cl, K and HCO_3. Addition of two packets to 1 litre of water or adding one packet to less than one litre of water will produce hypernatremia, and instances of this have occurred because some parents felt that more is better.

It is important to realise that although the amount of Na, K and Cl in RW is extremely low, its use for 24 hours and resumption of diluted milk on day 2 onwards, managed to produce extracellular fluid solute content similar to those babies fed on WOS which contains more electrolytes than rice water (Table 14). There are several possibilities for this surprising finding. Firstly, RW is absorbed better than WOS as evidenced by the diminished number of stools (Table 15). We have evidence that in many patients after onset of diarrhoea, glucose is poorly absorbed. This may be due to derangement of the glucose carrier status in the small intestinal epithelia. The usual hypothesis put forward for the use of WOS is that as glucose is absorbed, sodium is "carried in" with it. Obviously, if glucose is not absorbed because of involvement of the glucose carrier system, the solutes in WOS will be wasted and this may account for the greater number of stools in those babies given WOS. (Figure 1) shows that in babies with diarrhoea, a glucose-saline oral solution and a rice water preparation were given to the babies, and the blood glucose was estimated every ½ hour for 2 hours. It is seen that the blood glucose after rice water is no less than after dextrose-saline. The amount of starch in rice-water was analysed and found to contain, on the average, a value of 5.7 g starch per 100 ml of rice water. Another doubt about the use of rice water is the absence of bicarbonate while WOS contains 2.5 g sodium bicarbonate in 1 litre and this gives 30 mmol of HCO_3 per litre. However, in infantile diarrhoea, the metabolic acidosis is usually of the normal anionic gap variety. However, the incorporation of bicarbonate in oralyte solution was based on work in adults with cholera and it was also assumed that it is needed in infants with diarrhoea. However, the faecal content of bicarbonate in children suffering from rotavirus and E. coli diarrhoea was only 6 and 18 mmol/litre respectively (7). Furthermore, a recent trial using oralyte solution without bicarbonate has shown no difference in correction of the metabolic acidosis in 2 groups of children with diarrhoea, one being given oralytes with bicarbonate and the other given oralytes without bicarbonate. We have found that there is some sodium and potassium in rice water.

Secondly the osmolality of WOS is high compared to RW because the number of molecular particles in the latter are much less. The mean osmolality of RW was 8.9 ± 3.4 and that of WOS was 317.5 ± 77.2, the latter being about 36 times higher than in rice water (8). The differences in osmolality between RW and WOS at different dilution is shown in (Figure 2). It has also been found that feeding infants with formulae of different osmolalities will affect the osmolalities of gastric and duodenal contents (9), viz a higher osmolar feed will cause a higher osmolality of gastric and duodenal contents. The workers advise that hyperosmolar feeds may be dangerous for preterm infants. We have also confirmed this and added to this knowledge by estimating the osmolality of ileal contents in babies with ileostomies when fed rice water and infant formulae (10, 11). This is reflected in (Table 16).

Hence, there is a lowered osmolality and volume in ileal fluid when fed rice water, and this holds the key to the success of RW in the treatment of infant diarrhoea.

Thirdly, the main molecular particles in RW is starch, a polysaccharide, and it may be possible that polysaccharides of this type are dealt with and absorbed by the intestinal epithelia much better com-

TABLE 16
EFFECTS OF RW AND MILK ON OSMOLALITY AND VOLUME OF ILEAL FLUID

FEEDS	ILEAL FLUID OSMOLALITY (mosmol/kg)	ILEAL FLUID VOLUME (ml/day)
MILK	601 ± 125 (n = 30)	130 ± 95 (n = 25)
RICE WATER	362 ± 63 (n = 2)	36 ± 24 (n = 2)

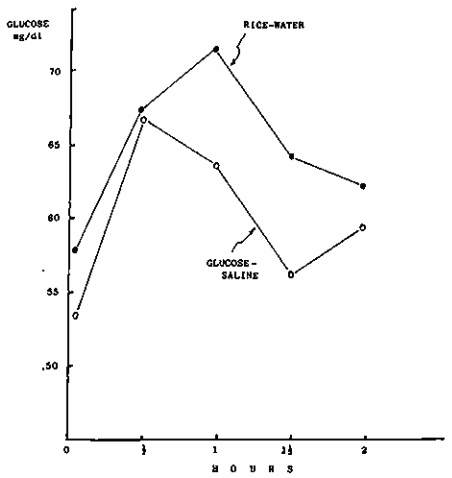

FIGURE 1: Babies with diarrhoea given oral rice water and oral dextrose-saline. The mean values of blood glucose for rice water were not lower than the values in the babies given dextrose saline: babies given rice-water (n = 7) and babies given oral dextrose-saline (n = 4). This shows that babies with diarrhoea can digest starch.

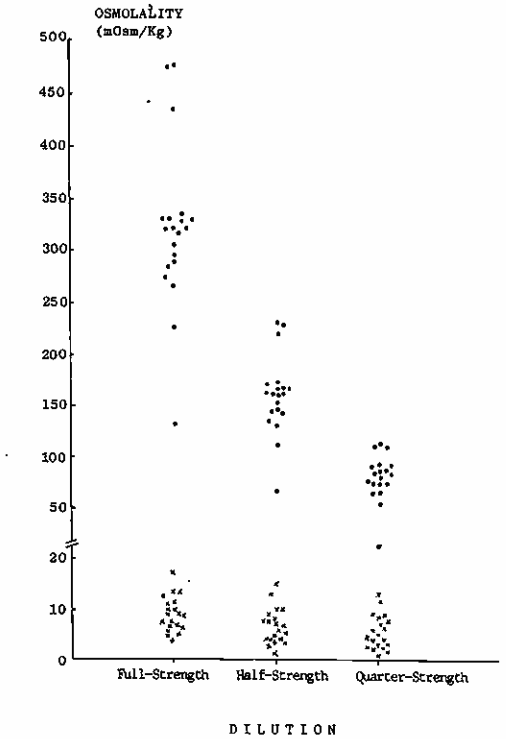

FIGURE 2: Osmolality of rice-water (x) and of WHO oralyte solution (•) at various dilutions.

pared to glucose. Observations on the above are being made and already there is some evidence for the three reasons cited above.

It is therefore concluded that, in the Singapore context, RW can be effectively used in the treatment of IGE. We are now working on adapting the rice water by addition of salt so that it can also be used for the most severe forms of IGE which are equivalent to those due to cholera, so that this treatment may be used for the more severe forms of diarrhoea seen in other countries in Southeast Asia and elsewhere.

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