

## Effectiveness of forced rehydration and early re-feeding in the treatment of acute diarrhoea in a tropical area

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**Background.** The administration of oral re-hydration solution (ORS) via continuous infusion through a nasogastric (NG) tube and early re-feeding facilitates delivery in hospitalised children and the return back home.

**Methods.** Design: the observation was made during a one-year stage in the Camillian Medical Centre (CMC) of Ouagadougou in Burkina Faso. 4,131 infants and children under 5 years old, affected by acute diarrhoea and severe dehydration (loss of weight >10%) were studied. Those children having difficulties for oral re-hydration were hydrated by continuous infusion through naso-gastric (NG) tube; the NG tube was put in by the nurses and connected to a 500 ml bottle, in which a mixture of glucose and electrolytes was dissolved according to the formula (glucose 20 g + NaCl 3.5 g + NaHCO<sub>3</sub> 2.5 g KCl 1.5 g in 1 litre of water). The infusion rate was 20-30 drops/minute. No sedative or anti-emetic drug was given, unless in the presence of uncontrolled vomiting. At the end of infusion, flour of millet (60%), soy bean (20%), peanut butter (10%), sugar (10%) and salt (1%) was administered and continued at home or in the nearby areas available for the night.

**Results.** After 4-5 hrs of infusion 3,717 children (90%) showed a significant gain of weight, although the weight prior to the acute event preceding hospitalisation was never reached during their stay at the CMC. Only 413 children

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(10%) required a longer period of forced infusion: at the end of the day, however, they were fed with this flour.

**Conclusions.** A simple strategy, based on a NG infusion plus an oral administration of flour has proven safe and effective in encompassing those difficulties encountered in the treatment and prevention of dehydration in developing countries where the therapy, in children affected by diarrhoea, still represents a major daily occupation.

Key words: Rehydration solutions - Refeeding, diarrhoea - Diarrhoea therapy - Tropical medicine.

Diarrheal diseases have contributed significantly to the morbidity and mortality of children throughout the world. It is estimated that in developing nations more than 5 million people, the majority of whom are infants and children, die each year as a consequence of diarrhoea. In developed countries the problem is less drastic, but still remarkable. By the age of 5 years 6.5% of children with diarrhoea in the USA require hospitalisation and the mortality rate among those hospitalised reaches 1/500 infants.<sup>1</sup>

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Fig. 1.—Room where the forced re-hydration with NG tube took place (10-15 or more children a day).  
*Aspetto della sala dove si svolgeva la idratazione forzata per via naso gastrica (10-15 o più bambini al giorno).*

Whilst much of the morbidity, mortality and medical costs incurring in the management of diarrhoea diseases is hardly controlled, dehydration which follows diarrhoea can be easily prevented by oral re-hydration.<sup>2</sup> WHO and UNICEF have recommended a single formulation of oral re-hydration solution (ORS) based on a single carbohydrate and three electrolytes. This product has proven safe and highly effective in the treatment and prevention of dehydration from diarrhoea of all aetiologies and in all age groups on a world-wide basis.<sup>3</sup> Only 25% of those who should benefit from ORS, however, actually receive this therapy due to the known difficulties in oral assumption of liquids during the acute phase of diarrhoea.<sup>4</sup> Intravenous infusion of glucose and electrolyte solutions, on the other hand, could well represent the optimum of re-hydration, but there are several difficulties in the preparation and maintenance of peripheral veins.

This article provides a brief report on a simple strategy, based on a nasogastric (NG) infusion plus an oral administration of flour of millet, soy bean and peanut butter formula, which has proven effective in encompassing those difficulties encountered in the treatment and prevention of dehydration in developing countries where the therapy, in children affected by diarrhea, still represents a major daily occupation.

### Materials and methods

#### *Patient selection*

The observation was made during a one-year (1998-1999) stage in the Camillian Medical Centre (CMC) of Ouagadougou in Burkina Faso.

In this centre the paediatric unit enrolls two Camillian sisters, two black nurses and an



Fig. 2.—Aspect of re-hydration, note the position of NG tube and the relationship between mother-infant. *Particolare delle modalità di idratazione, notare la posizione del sondino nasogastrico bloccato sulla narice e il decubito del binomio madre-bambino.*

European volunteer, medical doctors, who stay at CMC for a short (2 to 6 months) or long (1 year) period.

We studied infants and children under 5 years old affected by acute diarrhoea and severe dehydration (>10%). 100-150 children every day were admitted to the CMC. Cases with diarrhoea diseases represent 16.2% of all patients (58,129) seen over a year (4,131 with dehydration, 5,304 without dehydration, total: 9,435/year 1998). The remainder are mostly pulmonary or parasitic diseases, with malaria representing 13.5% of all the consultations.

#### *Baseline evaluation*

The diagnosis of diarrhoea was based on the number of liquid evacuations (>8), with or without blood, and on loss of weight (>10%). The duration and frequency of diarrhoea were obtained from interview of the patient's parents by the admitting physician.

At the time of enrolment into the study, all patients were also examined by the admitting physician to assess the degree of dehydration by clinical criteria (weight loss, skin fold analysis). Based on clinical findings, the loss of weight was correlated with the duration of diarrhoea and the distance from the CMC. In all the children examined with diarrhea a stool examination was carried out, at the CMC laboratories, in order to look for parasites (vegetative forms or cysts, warm eggs).

#### *Treatment protocol*

Those children having severe dehydration and loss of weight (> 10%) were hydrated by continuous infusion through NG tube; the NG tube was put in by the nurses and connected to a 500 ml bottle, in which was dissolved a mixture of glucose and electrolytes according to the OMS formula (glucose 20 g + NaCl 3.5 g + NaHCO<sub>3</sub> 2.5 g KCl 1.5 g in 1 litre of water, which correspond to glucose

110 mMol/L, Na 31.35 mEq/L, K 10.49 mEq/L, Cl 45.3 mEq/L, HCO<sub>3</sub> 21.64 mEq/L). The infusion rate was 20-30 drops/minute. The volume of liquid infusion was 50-100 ml/kg/day for the first 10 kg of weight and 25-50 ml/kg/day for the remaining weight. No sedative or anti-emetic drug was given, unless in the presence of uncontrolled vomiting. The infusion was set up in a communicating room with the patient's mother's continuous assistance (Figs. 1 and 2). At the end of infusion, flour of millet (60 g), soy bean (20 g) and peanut butter (10 g), sugar (9-9.5%) and salt (0.5-1%) according the formula suggested by Association Burkinabè des Unites MISOLA was administered and continued at home or in the nearby areas available for the night and in children who continued to have diarrhoea the NG infusion was continued alternatively to nutrition with flour in the volume of 100 ml/kg. According to the results of stool examination an anti-parasitic or antibiotic treatment was prescribed at the end of infusion.

**Results**

Of over 4,131 observed children only 413 (10%) showed a lesser dehydration, while 3,717 children (90%) had a considerable loss of weight (>10%). All of them received NG infusion. 3,710 children showed a significant gain in weight (ranging between 5.7-10%, median 8%), although the weight prior to the acute event preceding daily hospitalisation was never reached during their stay at the CMC (Table I). The hydration condition was also evaluated though by clinical criteria. The number of stool emissions dramatically reduced after 6 hrs re-hydration. The same was observed for vomiting which disappeared with re-hydration. The time of infusion was about 5-6 hours. Only 413 children (10%) required a longer period of forced infusion, since their weight loss was higher than 15%. The weight gain was more dramatic (median 10%, range 7-13%) in those 194 children (4.7%) negative for parasites and leukocytes in the stool examination. After 6 hours of NG infusion through the same way they were fed with the formula of flour

TABLE I.—Clinical course of 3717 children with significant loss of weight before and after NG dehydration. *Decorso clinico in 3717 bambini con significativa perdita di peso prima e dopo NG idratazione.*

Characteristics	Before	After
Degree of dehydration (%)	>10	<5
Stool frequency (no/day)	8±1	2±1
Duration of diarrhea prior and after admission (days)	2±0.5	0.5±0.1
Frequency of vomiting prior to admission (no/day)	2±1	—
Duration of vomiting prior to admission (days)	2±0.5	—
Duration of rehydration (h)	6±1.5	—
Formula volume (ml/kg/day) refeeding	100±10	—
Duration of hospitalization (days)	1±0.5	—

of millet, soy bean and peanut in the nearby areas until the end of the day or outside for the night if their home was much distant from the CMC. No children needed intravenous rehydration and 330 children (8%), who resulted at the stool examination affected by parasites (*G. lamblia*, *trichomonas*, *endoamoeba*) received treatment at home with metronidazole (30-40 mg/kg/day) for seven days, while 826 children (20%) who showed leukocytes in the stool only cotrimoxazole (35 mg/kg/day) for seven days. 2,975 children who were negative for parasites and leukocytes in the stools had a diarrhoea of viral origin. All children after NG rehydration at CMC were fed at home for a short period with flour and then continued their usual diet when they reached the village.

**Discussion and conclusions**

The first information of a forced rehydration with NG infusion dates back to 1985 and in this report 530 children with life-threatening dehydration were given physiological NaCl-solution (15 ml/kg b. w.) intravenously and subsequently 2 to 4 courses with glucose electrolyte solution administered as a continuous drip-infusion via a NG tube until the patient shed urine. 42 moderately dehydrated children were treated by one or several NG only and therapy was then continued at home. Only 4 children in the group with se-

TABLE II.—ORS in the market and their composition compared with the ideal formula recommended for European children by ESPGAN.

*Soluzioni reidratanti orali in commercio e loro composizione paragonata con la soluzione ideale per i bambini europei come raccomandato dall'ESPGAN.*

Commercial Name	Glucose mmol/l	Na mEq/l	K mEq/l	Cl mEq/L	HCO <sub>3</sub> mEq/L	Other anion	Osmol.	Glu/Na
Reidrax	183	23	8.6	21	0	11	245	7.9
Pedialyte	250	30	20	30	0	28	247	8.2
Dicodral liquido	110	30	20	40	10	0	210	8.2
Dicodral 60	90	60	20	37	0	14.3	221.3	1.5
Dicodral forte	110	90	20	80	30	0	330	1.2
Alhydrate	80 g/l (1)	60	20	60	0	18	300	—
Amidral	47 g/l (2)	60	20	60	20	0	167	—
Oralamid	62.2 g/l (3)	60	20	52	0	12	224	—
Sodioral	88	60	20	30	0	50	215	1.5
Reidral	75	60	20	60	0	30	225	1.2
Equidral	(4)	60	20.44	28.66	0	18	220	—
Idravita	60	60	20	50	0	10	230	—
GES 60	110	60	20	50	30	0	270	—
ESPGAN	74-111	60	20	25-60	10	0	200-250	1.2-1.8
Our formula	110	31.35	10.49	45.3	21.64	0	240	3.7

1) Mixture of saccharose and maltodextrine; 2) Starch of rise; 3) Mixture of glucose, starch of mais, and vegetables; 4) Glucooligosaccaride (Biocecolians).

vere dehydration died. Gremse<sup>6</sup> compared intravenous and NG rehydration in children, who failed attempts at oral re-hydration (OR). Following rehydration, infants received soy formula and a maintenance oral electrolyte solution to replace ongoing stool losses, as directed by the attending physician. Rehydration was successful in 91.6%, with lesser duration and cost of hospitalisation. Recently Ahmed *et al.*<sup>7</sup> utilizing a standardized protocol that included slow rehydration with an emphasis on oral rehydration also with NG infusion (1997) against non-protocol conventional treatment (1996) have shown that standardized protocol resulted in fewer episodes of hypoglycemia, less need for intravenous fluids, and a 47% reduction in mortality.

The ideal solution for re-hydration according to ESPGAN must contain Na 60 mEq/L, K 20 mEq/L, glucose 90 mMol/L, HCO<sub>3</sub> 10 mEq/L. The glucose/Na ratio must be lower than 1.4 and osmolarity lower than 240 (Table II).

The solution we used has less content of Na (30 mEq/L) and more glucose (110 mEq/L) and recalls the composition of liquid Dicodral. The lower Na content has been preferred because in the country the *V. cholera* disease is sporadic and consequently

the loss of Na with the stools is relatively moderate.

Early feeding after 6 hours infusion is in accordance with the present prescription of an early introduction of carbohydrates or a mixture of cereals in the treatment of diarrhoea.<sup>8</sup> In fact, the use of cereal-derived ORS and cereal-based feeding appears to diminish the severity of illness in studies conducted in developed countries.<sup>9</sup> Controlled trials of cereal-derived ORS or cereal-based feeding performed in the United States, showed that children with acute watery diarrhoea, who received standard glucose-based ORS with soy-based, lactose-free infant formula after the first 2 days continued to have more diarrhoea than children who received rice syrup solid containing ORS in alternation with rice-based, lactose-free infant formula (median duration of diarrhoea 3 *vs* 2 days,  $p = 0.04$ ). Moreover, significant differences were found for all outcome measures in the rice ORS group compared with the hypotonic glucose ORS group, showing that the former is significantly more effective in reducing the course of diarrhoea and the time taken to return to normal drinking and eating habits.<sup>10</sup> Rautanen *et al.*<sup>11</sup> showed that a hypotonic ORS (osmolality 224 mmol/l, Na 60 mmol/l), compared with

an isotonic high glucose ORS (osmolality 304 mmol/l, sodium 60 mmol/l) in children with acute diarrhoea was more effective in patients with rotavirus positive than with rotavirus negative diarrhoea in terms of stool output and mean consumption of ORS for maintenance hydration, suggesting the advisability of reducing the intake of glucose with preference for cereal derived ORS. Moreover, since transitory lactase deficiency is frequent during rotavirus positive diarrhoea, the introduction of milk must be delayed. In fact, the flour used by us does not contain lactose, but only carbohydrate derived from millet. Some clinical trials using complex carbohydrate as substrate in ORSs instead of glucose have shown a number of important clinical benefits in acute diarrhoea.<sup>12-13</sup> Foremost among these are reduced stool volumes, shorter duration of diarrhoea illness, and lower ORS intake. This clinical advantage may be explained by: <sup>1</sup> increased substrate availability, <sup>2</sup> a "kinetic advantage" for glucose absorption by glucose polymer, <sup>3</sup> differential handling of glucose monomer and polymer by the small intestine, <sup>4</sup> low osmolality, <sup>5</sup> a separate effect of peptides and amino acids on solute-linked sodium absorption, <sup>6</sup> an anti-secretory moiety in rice, and <sup>7</sup> enhanced mucosal repair and regeneration. We suggest that among the possible mechanisms proposed the hypotonicity plays the key role in the enhanced clinical efficacy of complex carbohydrate ORSs. If confirmed, this concept could guide future development of glucose and/or complex carbohydrate-based ORSs. However not with standing the recommended treatment for acute diarrhoea including ORS and rapid re-feeding is increasingly recommended, a study conducted in Finland <sup>14</sup> has demonstrated that OR had been attempted in 67% of the children managed at the outpatient department and in 65% of those admitted. The total energy intake was medially two-thirds of that recommended for the age group, suggesting that today if OR has become accepted in the management of acute diarrhoea, the rapid realimentation is not yet equally accepted. The same conclusion is reached by the results of a written questionnaire distributed at two pediatrics

annual meetings in Israel:<sup>15</sup> most pediatricians (83%) used ORS for treatment of dehydration in acute diarrhoea, but 60% of pediatricians believed that full-strength feeds are inappropriate in the presence of diarrhoea, and 67% of them do not recommend full-strength formulas. In addition, 37% of the pediatricians stop feeding temporarily in the presence of diarrhoea, in contrast to the AAP guidelines.<sup>16</sup> Moreover, there were no differences in knowledge and management practices among pediatricians graduating in Israel, Europe, or the United States, and no differences among pediatricians working in an ambulatory setting or in a hospital. These findings suggest that steps for implementing the guidelines are needed in Israel and most probably worldwide.<sup>17-18</sup>

A diarrhoea that begins acutely but lasts longer than two weeks may have other causes and it is defined as persistent since it does not respond to simple rehydration.<sup>19</sup> Factors that increase the risk of acute diarrhoea becoming persistent in developing countries, include antecedent malnutrition, micronutrient deficiency particularly for zinc and vitamin A, transient impairment in cell mediated immunity, infection with enteroinvasive *Escherichia coli* and *cryptosporidium*, sequential infection with different pathogens and lack of exclusive breast feeding during the initial four months of life. In the developing countries persistent diarrhea was 45% of total diarrhea deaths. The role of antimicrobial agents and individual micronutrients in persistent diarrhoea reduces case fatality in hospital settings to about 2-3%.<sup>20</sup> In these children diets providing modest amounts of milk mixed with cereals are well tolerated and those who fail on such diets providing carbohydrate as a mixture of cereals and glucose or sucrose hasten recovery. To day children who do not respond positively to NG rehydration and after early feeding do not gain their original weight, need other laboratory examinations to exclude proteic malnutrition or HIV infection. In the Burkina Faso these children have a short life despite medical attention.<sup>21</sup>

In conclusion rehydration therapy is the key treatment in the management of acute

watery diarrhoea, whereas antibiotics play a vital role in the management of acute invasive diarrhoea. Rehydration may be done either by the oral or intravenous routes with Ringer's lactate depending upon the degree of dehydration. Forced NG rehydration with salt solution of WHO formula may represent a safe alternative for OR therapy in developing countries and also worldwide. Antibiotic therapy is beneficial for cholera and shigellosis only, while antiparasitic agents are indicated only if *Endamoeba*, *Trichomonas* or *G. Lamblia* are present. Antidiarrhoeals are of no benefit for the treatment of acute diarrhoea. Appropriate feeding during diarrhoea is recommended with beneficial outcome. HIV screening is necessary in the presence of persistent diarrhea which does not respond to early rehydration and re-feeding with appropriate cereal mixture based on flower of millet, protein of soy bean and peanut butter.

### References

- Glass RI, Lew JF, Gangarosa RE, Le Baron CW, Ho MS. Estimates of morbidity and mortality rates for diarrheal diseases in American children. *J Pediatr* 1991;118:527-33.
- Parkes G. Treating diarrhoea. Rehydration should have been emphasised. *BMJ* 1997;315:1378.
- Mahalanabis D. Current status of oral rehydration as a strategy for the control of diarrhoeal diseases. *Indian J Med Res* 1996;104:115-24.
- Programme for Control of Diarrhea Disease: Sixth Programme Report 1986-1987. Geneva, World Health Organization, 1988; 26-27 (publication # WHO/CDD 88.28).
- Rosegger H, Sixl W. Oral rehydration by NG tube using continuously sterilized water in infants with diarrhea in South Sudan. *Pediatr Padol* 1985;20:363-8.
- Gremse DA. Effectiveness of NG rehydration in hospitalized children with acute diarrhea. *J Pediatr Gastroenterol Nutr* 1995;21:145-8.
- Ahmed T, Ali M, Ullah MM, Choudhury IA, Haque ME, Salam MA *et al*. Mortality in severely malnourished children with diarrhoea and use of a standardised management protocol. *Lancet* 1999;353:1919-22.
- Duggan C, Nurko S. Feeding the gut: the scientific basis for continued enteral nutrition during acute diarrhea. *J Pediatr* 1997;13:801-8.
- Sandhu BK. Early re-feeding in the management of acute diarrhea. *Acta Paediatr* 1995;84:1986.
- Wall CR, Swanson CE, Cleghorn GJ. A controlled trial comparing the efficacy of rice-based and hypotonic glucose oral rehydration solutions in infants and young children with gastroenteritis. *J Gastroenterol Hepatol* 1997;12:24-8.
- Rautanen T, Kurki S, Vesikari T. Randomised double blind study of hypotonic oral rehydration solution in diarrhoea. *Arch Dis Child* 1997;76:272-4.
- Thillainayagam AV, Hunt JB, Farthing MJ. Enhancing clinical efficacy of oral rehydration therapy: is low osmolality the key? *Gastroenterology* 1998;114:197-210.
- Goepf JG, Katz S, Cuervo E, Reid R, Moran JR, Santosham M. Comparison of two regimens of feeding and oral electrolyte solutions in infants with diarrhea. *J Pediatr Gastroenterol Nutr* 1997;24:374-9.
- Kaila M, Onnela T, Isolauri E. Treatment of acute diarrhoea in practice. *Acta Paediatr* 1997;86:1340-4.
- Shamir R, Zahavi I, Abramowich T, Poraz I, Tal D, Pollak S *et al*. Management of acute gastroenteritis in children in Israel. *Pediatrics* 1998;101:892-4.
- Practice parameter: the management of acute gastroenteritis in young children. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. *Pediatrics* 1996;97:424-35.
- Sandhu BK, Isolauri E, Walker-Smith JA, Banchini G, Van Caille-Bertrand M, Dias JA *et al*. A multi center study on behalf of the European Society of Pediatric Gastroenterology and Nutrition Working Group on Acute Diarrhoea. Early feeding in childhood gastroenteritis. *J Pediatr Gastroenterol Nutr* 1997;24:522-7.
- Walzer-Smith JA, Sandhu BK, Isolauri E, Banchini G, Van Caille-Bertrand M, Dias JA *et al*. Guidelines prepared by the ESPGAN Working Group on Acute Diarrhoea. Recommendations for feeding in childhood gastroenteritis. European Society of Pediatric Gastroenterology and Nutrition. *J Pediatr Gastroenterol Nutr* 1997;24:619-20.
- Bhan MK, Bhandari N, Bhatnagar S, Bahl R. Epidemiology & management of persistent diarrhoea in children of developing countries. *Indian J Med Res* 1996;104:103-11.
- Bhattacharya SK. Management of acute diarrhoea. *Indian J Med Res* 1996;104:96-102.
- Simpore J, Pignatelli S, Sanou PT, Ilboudo D, Barlati S, Musumeci S. Prevalence of HIV, MST and their relationship to children's malnutrition in Ouagadougou. In Press, 2000.

## Efficacia della idratazione forzata e della precoce realimentazione nel trattamento della diarrea acuta in area tropicale

Le malattie diarroiche hanno contribuito in maniera determinante all'incremento della mortalità e morbilità dei bambini nel mondo. Si stima che nei paesi in via di sviluppo più di 5 milioni di persone,

la maggior parte dei quali sono bambini, muoiono ogni anno come conseguenza della diarrea. Nei paesi sviluppati il problema è meno rilevante: dall'età di 5 anni il 6,5 % dei bambini con diarrea negli USA