Oral rehydration therapy and early refeeding in the management of childhood gastroenteritis

Canadian Paediatric Society

Français en page 535

Acute gastroenteritis continues to be associated with substantial morbidity in developed countries and has a significant mortality in developing countries (1). The average child younger than five years of age experiences 2.2 diarrheal episodes per year in industrialized countries (2), and this rate in developing countries is significantly higher. Treatment from resulting dehydration accounts for an estimated 220,000 hospitalizations per year in the United States (3), with comparable rates in Canada. Worldwide, acute gastroenteritis accounts for 1.5 to 2.5 million deaths annually (4,5). Prolonged diarrhea and malnutrition are primary causes of morbidity and mortality in Canadian native populations.

Oral rehydration therapy (ORT), using a simple, inexpensive glucose and electrolyte solution promoted by the World Health Organization (WHO), has saved the lives of millions of children with gastroenteritis. The development of an oral rehydration solution (ORS) has been regarded as one of the most important medical advances of the 20th century (6). In spite of the efficacy and remarkable success of ORT, it has not been used extensively in developed countries. This reluctance could be based on a lack of familiarity with ORT techniques, fear of induction of iatrogenic hypernatremia, or entrenched patterns of practice (5,7). Compared with intravenous hydration, ORT has been shown to be safe, practical, inexpensive, highly effective and technologically appropriate for developing and developed countries (8). In an effort to encourage the use of ORT, a simple approach is outlined.

THE SCIENTIFIC BASIS OF ORT

The scientific basis for the use of an ORS is the cotransport of glucose and sodium across the intestinal membrane. The sodium-potassium-ATP pump on the basolateral membrane of the enterocyte provides the gradient that drives the process. The cotransport system is relatively intact in infective diarrhea due to viruses or enteropathogenic bacteria, whether invasive or enterotoxigenic (4,9). Glucose enhances sodium and, secondarily, water absorption. The optimal glucose to sodium ratio to ensure maximal sodium absorption is 1:1 (10).

CONTROVERSY IN ORS COMPOSITION

Although the success of glucose-electrolyte-based ORT is beyond doubt, controversy exists about the ideal composition of the ORS, especially with respect to the sodium and glucose concentrations and, thus, osmolality. The standard WHO-recommended ORS contains 90 mmol/L of sodium, 20 mmol/L of potassium, 80 mmol/L of chloride, 30 mmol/L of bicarbonate and 111 mmol/L of glucose, with an osmolarity of 311 mOsm/L. Hypernatremia after the use of such an ORS in patients with noncholera diarrhea has occasionally been reported (11). In a large, multicentre, paediatric study, treatment with reduced-osmolarity ORS was associated with a 33% reduction in the need for unscheduled intravenous therapy when compared with the standard ORS (10). Hahn et al (9) performed a meta-analysis on 15 randomized controlled trials and found that reduced-osmolarity ORS is associated with fewer unscheduled intravenous therapy sessions, lower stool volume and less vomiting when compared with the standard WHO-recommended ORS. Based on these research findings (Level A evidence) (see Appendix), WHO recommends a revised formulation of reduced osmolarity (245 mOsm/L) ORS containing 75 mmol/L of sodium, 20 mmol/L of potassium, 65 mmol/L of chloride, 10 mmol/L of citrate and 75 mmol/L of glucose (Table 1) (12). The European Society of Paediatric Gastroenterology and Nutrition recommends an ORS containing 60 mmol/L of sodium for children in developed countries (13). They also recommend that the osmolarity of the ORS be between 200 mOsm/L and 250 mOsm/L. The American Academy of Pediatrics suggests that an ORS containing 45 mmol/L to 50 mmol/L of sodium can be used both as maintenance and rehydration solutions in otherwise healthy children who are mildly or moderately dehydrated (14). The compositions of ORSs used in Canada are presented in Table 1, and have been found to be safe.

The substitution of short-chain glucose polymers (starch) from rice and other cereals helps to reduce the osmolarity while providing a favourable ratio of glucose to sodium. This may also add additional calories without increasing the osmotic load. Rice on hydrolysis yields glucose, amino acids (such as glycine and lysine) and oligopeptides. A meta-analysis of 13 clinical trials concluded that the benefit of a rice-based ORS is sufficiently great to warrant its use in patients with cholera (15). The benefit is considerably smaller for children with noncholera diarrhea (15). An updated meta-analysis of 22 clinical trials concluded that a rice-based ORS is effective in reducing stool output in patients with cholera but does not reduce the stool output in children with noncholera diarrhea

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TABLE 1
Compositions of World Health Organization oral rehydration solutions (ORS) and ORS used in Canada

Product	Carbohydrate (g/L)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Base (mmol/L)	Osmolarity (mOsm/L)
WHO (standard formula)	20	90	20	80	30	311
WHO (revised formula)	13.5	75	20	65	10	245
Pedialyte (Abbott Laboratories, USA)	25	45	20	35	30	250
Gastrolyte (Aventis Pharma, USA)	17.8	60	20	60	10	240
Enfalyte (Mead Johnson Nutritionals, USA)	32 (rice syrup solids)	50	25	45	11	200
Cera (Cera Products, USA)	40 (rice digest) 10 (sucrose)	50	20	40	30	220

TABLE 2
Clinical assessment of degree of dehydration*

Mild (under 5%)	Moderate (5% to 10%)	Severe (over 10%)
Slightly decreased urine output	Decreased urine output	Markedly decreased or absent urine output
Slightly increased thirst	Moderately increased thirst	Greatly increased thirst
Slightly dry mucous membrane	Dry mucous membrane	Very dry mucous membrane
Slightly elevated heart rate	Elevated heart rate	Greatly elevated heart rate
	Decreased skin turgor	Decreased skin turgor
	Sunken eyes	Very sunken eyes
	Sunken anterior fontanelle	Very sunken anterior fontanelle
		Lethargy
		Cold extremities
		Hypotension
		Coma

**Some of these signs may not be present*

(16). The use of a rice-based ORS is safe and is associated with a significantly lower risk of requiring unscheduled intravenous therapy (level A evidence) (17).

The addition of substrates, such as glycine, alanine and glutamine, to enhance sodium cotransport has been investigated; however, none of these preparations have been shown to be superior to traditional ORS (4,18). Zinc-fortified ORS, on the other hand, can reduce the duration and severity of diarrhea (level A evidence) (4,19). Based on data from developing countries, the WHO and United Nations International Children's Fund recommend daily 20 mg zinc supplements for 10 to 14 days for children with acute diarrhea (10 mg per day for infants younger than six months of age) (20). Because of the effectiveness of traditional ORS and the increased cost of zinc-fortified ORS, zinc-fortified ORS are not routinely recommended.

IMPLEMENTATION OF ORT

Clinical assessment of the degree of dehydration is shown in Table 2. Although loss in body weight is a useful indicator of dehydration, it should always be corroborated by changes in clinical signs, because weight measurement is susceptible to many potential errors (eg, when different scales are used or the technique of measurement is not standardized) (21). Also, weight may change significantly depending on whether the child has recently eaten, voided or defecated (21). Fluid therapy should include the following elements: rehydration, replacement of ongoing losses, and maintenance. The physician should determine the duration of the illness, the number of episodes of vomiting or diarrhea, and the apparent volume of fluid intake and output. An algorithm helpful in the management of acute gastroenteritis in children is shown in Figure 1. If the child refuses ORS, then flavoured ORS or ORS popsicles, which may be more acceptable to some children, may be tried (13,22,23).

Rehydration in children with hypernatremic dehydration should be planned so that fluid and electrolyte balance is normalized slowly over 48 h to 72 h to avoid cerebral edema. The amount of maintenance fluid given to children with hypernatremic dehydration should be reduced by 25% because hypernatremic patients have a higher antidiuretic hormone level.

Almost all children with vomiting respond to ORT (14,21). The key is to give small amounts of ORS at frequent intervals, and the volume should be gradually increased until the child can drink as desired (21). Using a

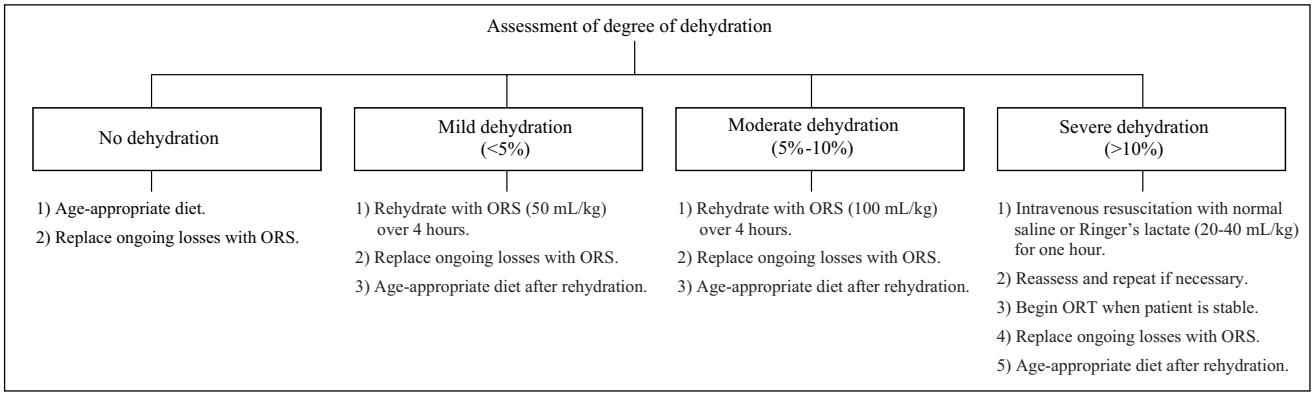

Figure 1) *Algorithm for managing acute gastroenteritis in children. ORS Oral rehydration solution; ORT Oral rehydration therapy*

spoon or dropper for very small infants can significantly increase the retention of ORS. In a child who refuses to drink, squirting the ORS into the mouth with a syringe may help. In the very small number of children who refuse to drink by any of these measures, nasogastric gavage should be considered before intravenous hydration.

Oral rehydration powders are more convenient to store, less expensive, and have a longer shelf-life than ORSs, but these powders must be mixed precisely to avoid changes in glucose and electrolyte concentrations (21). Inaccurate measurement of the volume of water for dilution can result in an erroneous concentration of electrolytes. The potential for error is even greater if the chemicals for the ORS are not prepackaged (21). For this reason, we recommend a premixed ORS as opposed to a powdered or homemade one.

Fluids containing nonphysiological concentrations of glucose and electrolytes, such as carbonated drinks and sweetened fruit juices, are discouraged because these drinks have a high carbohydrate content, very low electrolyte content and high osmolarity (24). Administration of such hyperosmolar solutions may produce osmotic diarrhea if given in sufficiently large quantities. Parents should be specifically instructed not to offer plain water to children with acute gastroenteritis because the intake of water alone may lead to hyponatremia and hypoglycemia (21).

EFFECTIVENESS OF ORT

ORT is as effective as, if not better than, intravenous fluid therapy for rehydration of moderately dehydrated children, and this has been confirmed by two recent meta-analyses (level A evidence) (25,26). Fonseca et al (26) performed a meta-analysis on 16 randomized controlled trials conducted in 11 countries involving 1545 children. The investigators concluded that ORT is as effective, if not better than, intravenous rehydration. ORT is associated with significantly fewer major adverse events and a shorter hospital stay compared with intravenous therapy, and is successful in most children. The meta-analysis performed by Bellemare et al (25) on 14 randomized controlled trials yielded a similar result. Compared with intravenous therapy, ORT is less traumatic to the child, cheaper, easier to administer, and can be administered in a variety of settings, including the home (26). As such, ORT should be the treatment of choice in children with mild or moderate dehydration (27).

LIMITATIONS OF ORT

Although ORT is successful in over 95% of cases, there are certain contraindications to the use of ORT. These include protracted vomiting despite small, frequent feeding, severe dehydration with a shock-like state, impaired consciousness, paralytic ileus and monosaccharide malabsorption (4,8,14). Children whose ongoing stool losses exceed 10 mL per kilogram of body weight per hour should not be denied ORT because the majority of the children will respond to ORT (4).

EARLY REFEEDING

Early refeeding has both clinical and nutritional benefits (level A evidence) (28,29). Early refeeding has been shown to induce digestive enzymes, improve absorption of nutrients, enhance enterocyte regeneration, promote recovery of disaccharidases, reduce the duration of diarrhea, maintain growth and improve nutritional outcomes (4,21,28,29). For infants who are breastfed, breastfeeding should be continued throughout, even during the initial rehydration phases (4). It is not necessary to dilute formula or to give lactose-free formula in refeeding nonbreastfed infants (4,28). Children without dehydration should continue to be fed an age-appropriate diet. Children with dehydration should be fed an age-appropriate diet as soon as they have been rehydrated (4,14).

RECOMMENDATIONS

- Rehydration and maintenance of adequate fluid and electrolyte balance is the key to the management of a child with acute gastroenteritis. ORT should be the treatment of choice in children with mild or moderate dehydration.
- ORS should be given at frequent intervals, gradually increased in volume until the child can drink as desired.
- Children without dehydration should continue to be fed an age-appropriate diet. Children with dehydration

should be fed an age-appropriate diet as soon as they have been rehydrated.

- When evaluating dehydration, loss in body weight should always be corroborated by clinical signs, because errors in weight measurement are common.
- Fluid therapy should include the following elements: rehydration, replacement of ongoing losses, and maintenance.
- Premixed ORS, rather than powdered or homemade ones, should be used. ORS powders are more convenient to store, less expensive, and have a longer shelf life than ORS fluids, but they must be mixed precisely to avoid changes in glucose and electrolyte concentrations.
- Carbonated drinks and sweetened fruit juices are discouraged because of their high carbohydrate content, very low electrolyte content and high osmolarity.
- Parents should be specifically instructed not to offer plain water to children with acute gastroenteritis to avoid hyponatremia and hypoglycemia.
- Contraindications to ORT include protracted vomiting despite small, frequent feeding, severe dehydration with shock-like state, impaired consciousness, paralytic ileus and monosaccharide malabsorption.

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APPENDIX
Levels of evidence and strength of recommendations*

Level of evidence	Description
I	Evidence obtained from at least one properly randomized controlled trial.
II-1	Evidence obtained from well-designed controlled trial without randomization.
II-2	Evidence obtained from well-designed cohort or case-controlled analytical studies, preferably from more than one centre or research group.
II-3	Evidence obtained from comparisons between times and places, with or without the intervention. Dramatic results in uncontrolled experiments could also be included in this category.
III	Opinions of respected authorities, based on clinical experience, descriptive studies or reports of expert committees.
Grade	**Description**
A	There is good evidence to recommend the clinical preventive action.
B	There is fair evidence to recommend the clinical preventive action.
C	The existing evidence is conflicting and does not allow a recommendation to be made for or against use of the clinical preventive action; however, other factors may influence decision-making.
D	There is fair evidence to recommend against the clinical preventive action.
E	There is good evidence to recommend against the clinical preventive action.
I	There is insufficient evidence to make a recommendation; however, other factors may influence decision-making.

**Data from reference 30*

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