

# PRACTICAL SUMMARIES IN ACUTE CARE

*A Focused Topical Review of the Literature for the Acute Care Practitioner*

## Oral Rehydration Therapy for Children with Gastroenteritis-associated Dehydration

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### Introduction

ACUTE GASTROENTERITIS IN CHILDREN is not a benign condition. Worldwide, millions of young children continue to die from this treatable condition every year. Fortunately, in developed countries like the United States, deaths are uncommon, but a substantial proportion of pediatric acute care visits and hospitalizations are directly related to the dehydration caused by this condition. The associated healthcare costs are significant.<sup>1</sup>

Oral rehydration therapy (ORT) is a tested, proven, and effective management strategy for acute pediatric gastroenteritis. The World Health Organization has espoused its use in developing countries since the 1970s. Since the 1990s, the American Academy of Pediatrics has promoted ORT as the preferred treatment of fluid

and electrolyte losses caused by diarrhea in children with mild to moderate dehydration.<sup>2</sup> In spite of this, ORT has failed to be widely adopted by pediatricians, family physicians, and acute care practitioners in this country.

The objectives of this review are:

- To demonstrate the safety and effectiveness of ORT in children with mild to moderate dehydration associated with acute gastroenteritis;
- To describe new, noninvasive technologies that can be used to estimate the volume deficit and acidosis status of dehydrated children;
- To suggest an effective antiemetic therapeutic option when vomiting persists; and
- To offer parental teaching tools that will allow early at-home management of dehydration in children.

### ORT vs. IV Rehydration in Children with Mild to Moderate Dehydration from Gastroenteritis

**Source:** Hartling L, Bellemare S, Wiebe N, et al. Oral versus intravenous rehydration for treating dehydration due to gastroenteritis in children. *Cochrane Database of Systematic Reviews* 2006;3:CD004390.

HARTLING AND COLLEAGUES reviewed 17 trials that compared ORT with intravenous therapy (IVT) in children with dehydration from acute gastroenteritis. One thousand fifteen (1,015) children received ORT and 796 were managed with IVT. Several of the studies used nasogastric tube rehydration as the initial rescue method if the child failed ORT.

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Their analysis demonstrated no significant difference between the two groups for the major outcomes of weight gain, hyo- or hypernatremia, duration of diarrhea, or total fluid intake at six hours and 24 hours. The ORT group had shorter hospital stays (1.2 fewer days [95% CI 0.02 to 2.38 days]). Phlebitis was an adverse outcome associated with

IVT, and paralytic ileus was associated with ORT. Perhaps the most meaningful observation was that, on average, only a single child out of 25 failed ORT and required IVT (95% CI 14 to 100).

### Commentary

This systematic review nicely summates the best evidence available on the topic of ORT. The authors' conclusions are irrefutable: IVT can no longer be supported as the initial therapeutic intervention when rehydrating the child with mild to moderate dehydration.

In developing countries, where medical supplies and advanced technologies are not readily available, ORT is commonly used to manage dehydrated children. It is estimated that tens of thousands of lives are saved annually because of this practice. Here in the United States, clinicians are more accustomed to initiating immediate IVT when patients require treatment for hypovolemia. One reason seems to be the perception that IVT is more expeditious and potentially shortens ED length of stay; this perception is inaccurate and is addressed in the following article.

charge in children with mild to moderate dehydration who were managed with intravenous rehydration therapy. The clinical setting was a children's hospital staffed by board certified/eligible pediatric emergency physicians. Five hundred forty-nine (549) children were enrolled, with a mean treatment time of 5.4 hours (+/- 2.4 hours). Treatment times exceeded four hours regardless of time of day, day of the week, season of the year, or age of the child.

Atherly-John and her colleagues demonstrated similar findings when they compared ORT to IVT in their ED setting. Mean treatment times were 3.75 hours for the 18 ORT patients and six hours for the 16 IVT patients. In addition, they reported that less staff time was required in the ORT group (36 minutes vs. 65 minutes). Seventy-seven percent (77%) of parents in the ORT group, as compared to 38% in the IVT group, reported that they were highly satisfied with all aspects of the ED visit.

### Commentary

The American Academy of Pediatrics recommends that a four-hour trial of oral rehydration be administered to children with mild to moderate dehydration, since ORT is successful in the vast majority of patients.<sup>2</sup> These studies refute the general impression that IV rehydration is the more expedient way to achieve target rehydration goals. The impact on patient throughput in today's busy EDs is likely to be adverse whenever a treatment plan routinely requires more time than an alternative and equally effective plan. In addition, it is evident that increased staff time, combined with use of IV materials, has significant healthcare cost implications.

One other issue, not specifically addressed by the authors, is worthy

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of comment; the likelihood of medical error arguably increases whenever IV access exists — another advantage of ORT.

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## Is ORT a Standard of Care for Children in Pediatric EDs in the United States?

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**Source:** Bender BJ, Ozuah PO, Crain EF. Oral rehydration therapy: Is anyone drinking? *Pediatric Emergency Care* 2007;23:624-626.

**B**ENDER AND HER COLLEAGUES conducted a national survey of all physicians in the American Academy of Pediatrics (AAP) Section on Emergency Medicine. The purpose of the survey was three-fold: 1) to determine the percentage of respondents who were applying the AAP's ORT practice parameter that was promulgated in 1996 ("ORT is the preferred treatment of fluid and electrolyte losses caused by diarrhea in children with mild to moderate dehydration."); 2) to examine the attitudes of pediatric emergency physicians when presented with recently published data about oral rehydration therapy; and 3) to assess whether the number of years in practice was associated with reported practice.

Seven hundred fifty-six (756) physicians received the survey; 445 (59%) responded. Recent medical school graduates used ORT 95% of the time for children with mild dehydration, but only 55% of the time for moderate dehydration. For older physicians these rates were 86% and 33%. Older physicians, when compared to their younger colleagues, were less likely to agree with new data that supported ORT as the preferred initial approach in children with moderate dehydration

(74% vs. 90%) and were less inclined to incorporate ORT into their practice (75% vs. 90%).

### Commentary

This study exemplifies a commonly observed phenomenon: Often, it takes years for changing recommendations in medical care to be adopted by a majority of practicing clinicians. It is reasonable to assume that this cohort of pediatric emergency physicians are aware of the science relating to ORT effectiveness. It is probably also reasonable to assume that other groups of physicians who manage dehydrated children, e.g. those practicing general emergency medicine and those staffing free-standing acute care facilities, may not appreciate the value of ORT in the moderately dehydrated child. The fact that a quarter of older and more experienced pediatric emergency physicians responding to this survey were unwilling to incorporate this knowledge into their practice is both surprising and concerning. This is unfortunate, given the overall value that ORT can bring to both the clinical and the home environments.

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## Is There a Noninvasive Way to Measure Dehydration-associated Hypovolemia in Children with Acute Gastroenteritis?

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**Source:** Chen L, Kim Y, Santucci KA. Use of ultrasound measurement of the inferior vena cava diameter as an objective tool in the assessment of children with clinical dehydration. *Acad Emerg Med* 2007;14:841-845.

**T**HIS PROSPECTIVE OBSERVATIONAL study was conducted in an urban pediatric ED. Children with

clinical evidence of dehydration, the majority of whom had acute gastroenteritis as the cause, and a matched set of normal control subjects underwent bedside ultrasound measurements of their inferior vena cava (IVC) and aorta (A). The IVC/A ratio was then calculated.

The mean IVC/A ratio was significantly lower in the dehydrated cohort: 0.75 vs. 1.01, with a mean difference of 0.26 (95% CI 0.18 to 0.35). In those patients who required IV therapy, the IVC/A ratio increased during treatment from 0.75 to 1.09, with a mean difference of 0.35 (95% CI 0.29 to 0.39).

### Commentary

A number of severity scales have been developed over the years that use easily obtainable historical and physical exam findings to classify pediatric dehydration into three broad categories: mild, moderate, and severe. Attempts have been made to simplify these scales in order to make them more user-friendly to the clinician.<sup>3,4</sup> Furthermore, the accuracy of some time-honored findings, such as skin turgor measurement, has been questioned.<sup>5</sup>

The availability of focused bedside ultrasonography in acute care settings, including EDs, is now commonplace. Readily performed measurements of IVC diameter and collapsibility, cardiac activity and urinary bladder volume can provide an immediate assessment of overall volume status in adults. This study by Chen and colleagues suggests that this technology can also be applied to the pediatric population to assess volume status. The strengths of bedside ultrasonography are its immediate availability, its noninvasiveness, and its ability to measure response to therapy over time.

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## Can Dehydration-associated Acidosis in Children with Acute Gastroenteritis Be Measured Noninvasively?

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**Source:** Nagler J, Wright RO, Krauss B. End-tidal carbon dioxide as a measure of acidosis among children with gastroenteritis. *Pediatrics* 2006;118:260-267.

THE AUTHORS OF THIS STUDY POSTULATED that children with significant dehydration would develop compensatory respiratory alkalosis in response to any significant degree of metabolic acidosis. Their study question asked simply: If clinically dehydrated children are typically volume contracted and, therefore, metabolically acidotic, wouldn't they naturally compensate with respiratory alkalosis? If so, end-tidal carbon dioxide concentrations (ETCO<sub>2</sub>), measured non-invasively, might be able to be correlated with the severity of dehydration.

A convenience sample of 130 children with vomiting and diarrhea were enrolled. Their end tidal carbon dioxide concentrations were correlated with their serum bicarbonate concentrations. A strong correlation was found. If the ETCO<sub>2</sub> was > 34 mmHg, the HCO<sub>3</sub> was always > 15 mmol/L. An ETCO<sub>2</sub> < 31mm Hg effectively predicted significant dehydration, defined as a HCO<sub>3</sub> ≤ 15 mmol/L (ROC 0.95 and LR 20.4). In addition, children who returned for an unanticipated, but related, visit had lower ETCO<sub>2</sub> levels than those who did not return.

### Commentary

Most children who present with gastroenteritis-associated dehydration do not require laboratory test-

ing. However, those with more severe degrees of dehydration and those who fail initial rehydration therapy routinely do have testing performed, with specific attention focused on HCO<sub>3</sub> concentrations. This study demonstrates that ETCO<sub>2</sub> technology, if available to the clinician, can provide a non-invasive way to measure the degree of acidosis. This information could be used to more effectively triage patients at the time of initial health-care contact, guide decision making re: need for laboratory testing, and monitor the effectiveness of therapy.

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## What Anti-emetic Agent Is Effective and Safe in Children When Vomiting Prevents ORT?

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**Sources:** Ramsook C, Sahagun-Carreon I, Kozinetz CA, et al. A randomized clinical trial comparing oral ondansetron with placebo in children with vomiting from acute gastroenteritis. *Ann Emerg Med* 2002;39:397-403; Freedman SB, Adler M, Seshadri R, et al. Oral ondansetron for gastroenteritis in a pediatric emergency department. *New England Journal of Medicine* 2006;354(16):1698-705; Roslund G, Hepps TS, McQuillen KK. The role of oral ondansetron in children with vomiting as a result of acute gastritis/ gastroenteritis who failed oral rehydration therapy: A randomized, controlled trial. *Ann Emerg Med* 2008;52:22-29; DeCamp LR, Byerley JS, Doshi N, et al. Use of antiemetic agents in acute gastroenteritis: a systematic review and meta-analysis. *Arch Pediat and Adoles Med* 2008;162:858-865.

VARIOUS ANTI-EMETIC DRUGS have been used to control vomiting in children, although most have not been studied in the pediatric population. Therapeutic effec-

tiveness of these agents has been inconsistent and the side-effect profile can be significant, with drowsiness and akathisia being the most common adverse events reported. Ondansetron, a selective serotonin inhibitor which specifically antagonizes 5-HT<sub>3</sub> receptors, possesses anti-emetic activity and is commonly used with emetogenic chemotherapy.

Freedman and his colleagues conducted a prospective, double-blind, placebo-controlled trial comparing ondansetron to placebo in children 6 months through 10 years of age who presented to the ED with symptoms consistent with acute gastroenteritis and were determined to have mild to moderate dehydration. Children were excluded if they weighed less than 8 kg, were severely dehydrated, had underlying diseases that could affect the assessment of hydration (e.g. renal failure) or had previous abdominal surgery.

The dose of ondansetron was weight-based: 2 mg for children weighing 8 to 15 kg; 4 mg for those weighing 15 to 30 kg; and 8 mg for those weighing more than 30 kg. Both the ondansetron and placebo tablets were rapidly dissolving and retained on the tongue for 5 seconds prior to being swallowed. If the child vomited within 15 minutes after receiving the tablet, a second dose was administered.

An oral electrolyte solution was initiated 15 minutes after tablet administration. 30 mL was offered to the child every 5 minutes. The oral rehydration period was limited to one hour to mimic routine clinical practice. The need for intravenous hydration and ultimate disposition were determined by the treating physician. The primary outcome was the proportion of children who vomited while receiving oral rehydration therapy. Secondary out-

comes included the number of vomiting episodes, and the rates of rescue intravenous rehydration and hospital admission. There were 107 children in each group.

Fifteen (15) children in the ondansetron group and 37 in the placebo group vomited while receiving ORT (15% vs. 35%,  $P < 0.001$ ; relative risk 0.40 [95% CI 0.26 to 0.61]). The mean number of vomiting episodes was also significantly lower in the ondansetron group (0.18 vs. 0.65,  $P < 0.001$ ; relative risk 0.30 [95% CI 0.18 to 0.50]).

Fifteen (15) children in the ondansetron group (14%) and 33 in the placebo group (31%) received IV rehydration while in the ED ( $P = 0.003$ ). Hospital admission rates were similar in both groups (4% overall). ED stays were shorter in the ondansetron group.

The only adverse event that could be ascribed to ondansetron was an increase in the episodes of diarrhea while undergoing oral rehydration (1.4 vs. 0.5,  $P < 0.001$ ). There were no episodes of akathisia or excessive drowsiness witnessed in the ED. Follow-up, which was completed in 96% of the children, revealed no additional adverse events occurring after discharge from the ED.

The other source references demonstrate similar effectiveness of ondansetron in children who initially fail ORT with significant reductions in the number of patients requiring intravenous rescue or hospital admission.

### Commentary

Traditional anti-emetic agents used in children to control vomiting have included promethazine, prochlorperazine and metaclopramide. The effectiveness of these medications has been ques-

tioned and the side effect profiles are not insignificant.

These source references demonstrate that a single dose of oral ondansetron administered in the ED can significantly reduce vomiting in children with acute gastroenteritis, resulting in fewer children requiring rescue IV rehydration. The usual dose of ondansetron in children is weight-based at 0.15mg/kg. However, an easy way to dispense it for both ED and out-patient management utilizes the 4 mg oral dissolving tablet: one-half tab for children 8–15 kg, 1 tab for children 15–30 kg, and 2 tabs for children who weigh more than 30 kg. An added benefit appears to be ondansetron's safety and benign side effect profile.

The cost of ondansetron is greater than that of more traditional agents. However, this is more than offset by cost avoidance associated with less IV therapy (e.g. materials, nursing time).

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## Can Patients' Parents Simply and Cheaply Produce Their Own Safe and Effective ORT Solution?

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**Source:** <http://rehydrate.org/solutions/homemade.htm>.

**T**HIS READILY ACCESSIBLE AND free Web site, which links to the Rehydration Project, provides clear and easy to follow instructions on how to produce an acceptable ORT.

The simplest solution can be made by adding 1 teaspoon of table salt and 8 teaspoons of sugar to a liter of water (boiled as appropriate). A slightly more complex, but also more physiologic, solution adds one-half teaspoon sodi-

um bicarbonate and one-third teaspoon salt substitute (potassium) to the above formula.

Obviously, parental competency and understanding are essential. A critical issue to address is ensuring that the parent responsible for making the solution understands the difference between a teaspoon and a tablespoon. Parents should also be instructed to advance their child to a normal diet as soon as possible.

The following treatment plans can be easily shared with parents and are likely to be successful:

*For mild dehydration (3%–5%):*

Replace 50 mL (or 10 teaspoons) per kg at a rate of 5–10 mL (or 1–2 teaspoons) every 1–2 minutes. If vomiting persists, decrease the rate to every 5–10 minutes. Replace each subsequent diarrheal stool with 4–8 ounces of ORT.

*For moderate dehydration (6%–9%):*

Replace 100 mL (or 20 teaspoons) per kg at a rate of 5–10 mL (or 1–2 teaspoons) every minute. If vomiting persists, decrease the rate to every five minutes. Replace each subsequent diarrheal stool with 4–8 ounces of ORT.

It is critical that families have been medically evaluated, or understand when medical evaluation is indicated.

### Commentary

Many of the over-the-counter beverages that parents commonly turn to when attempting to rehydrate children are the worst possible choices, given their unfavorable glucose concentration. Examples include soft drinks, apple juice, and Gatorade™. As glucose concentrations exceed approximately 100 mM per liter, sodium and water absorption from the gut lumen becomes impaired and diarrhea can be exacerbated. Commercially available solutions specifi-

cally produced for domestic ORT therapy are relatively effective but can cost more than some families are able to afford. Providing parents with the information contained on this Web site offers the opportunity for a rich learning moment and teaches a skill that has lasting value.

## **Gradual Re-feeding vs. Immediate Normal Feeding in Children with Acute Gastroenteritis**

**Source:** Grunenberg N. Is gradual introduction of feeding better than immediate normal feeding in children with gastroenteritis? *Arch Dis Child* 2003;88:455-457.

**T**HIS SYSTEMATIC REVIEW EVALUATED 145 articles relevant to this question and found 12 to be of sufficient quality to include in the final analysis. More than 1,300 patients were included. Overall, there was no difference in the time to resolution of symptoms or symptom control between the two dietary approaches.

### **Commentary**

This information should allow the clinician to spend more time emphasizing the best way for parents to provide ORT and less time describing how to gradually reintroduce a normal diet over time. A regular diet of well-tolerated foods can be immediately offered to the child once vomiting has been controlled. This also applies to breast milk in the child who is being breast-fed. It is probably wise to advise against typically poorly tolerated fatty foods and products that have high concentrations of simple sugars (e.g., soft drinks, popsicles, gelatin

desserts). There is also little evidence that restricting lactose-containing foods is beneficial.

## **Summary**

Given the frequency of pediatric acute care visits in the United States related to vomiting and diarrhea, it is apparent that parents continue to have great concern that these symptoms place their child in jeopardy. A time-proven therapy that is effective, inexpensive, non-invasive, and easily utilized in children with mild to moderate disease exists: oral rehydration therapy.

Clearly the child with severe dehydration requires immediate attention; vascular access is essential and aggressive IV administration of isotonic fluid is required. Fortunately, this case scenario represents the minority of children with acute gastroenteritis-associated dehydration.

For the vast majority of children with mild to moderate dehydration, ORT will be effective. In fact, it is estimated that only 1 in 25 children will fail ORT when it is appropriately delivered. However, this has to date been an under-appreciated and under-utilized approach in our collective clinical practice. Increased awareness of the following principles will likely result in increased comfort with and adoption of ORT:

- ORT should be the initial therapeutic approach of choice in children with mild to moderate dehydration, as long as contraindications do not exist (e.g., the possibility of bowel obstruction or significant risk for aspiration).
- The degree of dehydration may be estimated by performing bedside ultrasonographic measurements: IVA/A diameter ratios, inferior vena cava collapsibility, uri-

nary bladder volume, and cardiac contractility.

- Appropriately constituted ORT solutions are required. Commercially available products specifically produced for ORT are reasonable choices. Effective and inexpensive solutions can easily be produced by responsible and informed care providers. Commonly chosen solutions, such as fruit juices, soft drinks, and sport drinks, have unacceptably high sugar concentrations and can actually prolong the duration of diarrhea.

- A specific treatment plan for feedings should be deliberately followed and can be easily described. Parents should be encouraged to feed through episodes of vomiting during the early stages of ORT.

- Most children will not require laboratory testing. An innovative non-invasive procedure is worthy of consideration if available to the treating clinician. An end tidal carbon dioxide level of greater than 34 mmHg accurately predicts a bicarbonate concentration of greater than 15 mmol/L, while an ETCO<sub>2</sub> of less than 31 mmHg accurately predicts a bicarbonate concentration of equal to or less than 15 mmol/L. The ETCO<sub>2</sub> can also be monitored to determine the effectiveness of ORT. Success of ORT can also be monitored clinically or by following the ultrasonographic measurements described previously.

- For children who continue to vomit, ondansetron appears to be an effective and well-tolerated antiemetic. An easy way to dispense it for both ED and outpatient management utilizes the 4 mg oral dissolving tablet: one-half tab for children 8–15 kg, 1 tab for children 15–30 kg, and 2 tabs for children who weigh more than 30 kg.

- The child's usual diet can be immediately reinstated once

vomiting has resolved. This includes the infant who is breast feeding. Eliminating lactose does not appear to be beneficial in most instances.

- Responsible and motivated parents should be provided with useful resources to access in the event of future episodes of acute gastroenteritis in their children. Internet sites, such as the Rehydration Project, may be helpful.

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## CME QUESTIONS

6. In the ED, IV rehydration results in shorter hospital stays and requires less staff time than oral rehydration.
- True
  - False
7. The failure rate of oral rehydration therapy in children with mild to moderate dehydration is:
- 1 in 10
  - 1 in 15
  - 1 in 20
  - 1 in 25
8. For the dehydrated child who continues to vomit through ORT, the most effective and best tolerated anti-emetic medication is:
- promethazine
  - prochlorperazine
  - ondansetron
  - metoclopramide
9. The immediate return to a normal diet, including breast feeding, in children with acute gastroenteritis will prolong vomiting and diarrhea.
- True
  - False
10. A correctly measured end tidal CO<sub>2</sub> of 35 mmHg in a dehydrated child accurately predicts a HCO<sub>3</sub><sup>-</sup> >15 mmol/L.
- True
  - False

Answers: 6, b; 7, d; 8, c; 9, b; 10, a

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