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Pediatric Emergency Medicine Practice Acute Gastroenteritis — An Update

You are nearing the end of a busy shift when a nurse comes up to you and says that there is a family with 3 kids in the next room who are all complaining of nausea, vomiting, and diarrhea. As you enter the room, you note an 8-month-old who is being held in her mom's arms and her 2 older siblings, ages 5 and 7, none of whom appear toxic. Before you begin, the mom interrupts and states that she has just seen her children's pediatrician and that her doctor sent her to the ED for blood-work and IV fluid rehydration. You briefly contemplate telling the mom that you are the emergency medicine doctor and you will make the decisions in the ED, but you decide that it would be better to first gain her trust by performing an appropriate history and physical examination and then discussing treatment options regarding rehydration.

Gastroenteritis refers to inflammation of the lining of both the stomach and small intestines. The majority of cases are infectious with viral organisms predominating; however, bacterial and parasitic infections can be a specific concern in the appropriate patient. Non-infectious gastrointestinal inflammation may follow certain ingestions (eg, toxic mushroom ingestion, gluten in patients with celiac disease, dairy in lactose sensitive patients), medications (eg, chemotherapeutic agents, non-steroidal anti-inflammatory medications, certain antibiotics), chemical toxins (eg, anticholinergic toxins, heavy metals, plant substances), and malignancy and can be seen in other conditions such as Crohn's disease and ischemic bowel disease.

July 2010
Volume 7, Number 7

Authors

Amandeep Singh, MD
Department of Emergency Medicine, Highland General Hospital, Oakland, CA; Assistant Clinical Professor of Medicine, Department of Emergency Medicine, UC San Francisco, San Francisco, CA

Michelle Fleurat, MD
Resident Physician, Department of Emergency Medicine, Alameda County Medical Center - Highland General Hospital, Oakland, CA

Peer Reviewers

Kenneth T. Kwon, MD, FAAP, FACEP
Director of Pediatric Emergency Medicine, Associate Clinical Professor, University of California, Irvine Medical Center, Orange, CA; Director, Pediatric Emergency Services, Mission Hospital/ Children's Hospital of Orange County at Mission, Mission Viejo, CA

Paula Whiteman, MD, FACEP, FAAP
Attending Physician, Ruth and Harry Roman Emergency Department, Cedars-Sinai Medical Center, Los Angeles, CA; Director of Pediatric Emergency Services, Providence Tarzana Medical Center, Tarzana, CA

CME Objectives

Upon completion of this article, you should be able to:

1. Cite the most common etiologies for pediatric diarrheal illness in the emergency department.
2. Identify historical and examination findings that predict the degree of pediatric dehydration.
3. Describe the rationale for the use of oral rehydration therapy in mild and moderately dehydrated children.
4. Describe the risks and benefits for medication use in the treatment of acute gastroenteritis.

Date of original release: July 1, 2010
Date of most recent review: June10, 2010
Termination date: July 1, 2013
Medium: Print and Online
Method of participation: Print or online answer form and evaluation
Prior to beginning this activity, see "Physician CME Information" on page 23.

Accreditation: EB Medicine is accredited by the ACCME to provide continuing medical education for physicians. **Faculty Disclosure:** Dr. Singh, Dr. Fleurat, Dr. Kwon, Dr. Whiteman, and their related parties report no significant financial interest or other relationship with the manufacturer(s) of any commercial product(s) discussed in this educational presentation. **Commercial Support:** This issue of *Pediatric Emergency Medicine Practice* did not receive any commercial support.

Although some acute gastroenteritis syndromes consist predominately of either vomiting or diarrhea, most have an element of both, with additional symptoms being variably present such as anorexia, abdominal pain, and fever. Clinicians should be wary of diagnosing children who present with isolated diarrhea or vomiting as having "viral gastroenteritis" until a thorough evaluation of other causes has been completed. A variety of serious conditions such as appendicitis, bacterial enteritis, diabetic ketoacidosis, pyelonephritis, pneumonia, intussusception, and toxic ingestions can present with symptoms identical to gastroenteritis. A thorough clinical examination, selective application of laboratory testing and diagnostic imaging, and documentation of suitable return precautions will prevent misdiagnoses and unexpected outcomes in these patients.

Epidemiology

Worldwide infectious gastrointestinal illness and dehydration are leading causes of morbidity and mortality, accounting for an estimated 1.5 billion diarrheal episodes per year and 1.5 to 2.5 million deaths annually in patients < 5 years of age.[1-3] In developed countries, where dehydration is less likely to cause mortality, gastroenteritis is a significant cause of morbidity. Annually, acute gastroenteritis (AGE) is responsible for 3.7 million physician visits, 135,000 to 220,000 pediatric admissions (9%-13% of total hospitalizations for children < 5 years of age), and 150 to 300 deaths among children < 5 years of age in the US.[4-6] Societal costs are significant, with approximately $1 billion per year in total costs attributed to rotaviral infection alone.[7-9]

Pediatric death due to diarrheal illness is related to severe volume depletion and its associated complications. Advancements in the recognition and treatment of dehydration have largely prevented pediatric deaths in the US; however, diarrheal illnesses still claim a significant number of children < 5 years of age annually (1 per 915 to 935 hospitalizations).[4-6] Risk factors for death from diarrheal illness include age < 1 year, low-birth weight (< 2500 gm); African-American ethnicity, Hispanic-American ethnicity, or American-Indian ethnicity; and illness during the winter months. Additionally, maternal factors such as age < 20 years, failure to complete high school, delay in obtaining prenatal care, and unmarried status are associated with pediatric death from diarrheal illness.[4,5,10-14]

Risk Factors For Gastroenteritis

Infants and toddlers are at particular risk for gastroenteritis and dehydration due to a relative lack of resistance against gastrointestinal pathogens. This lack of protection stems from an immature gastrointestinal immune system and an absence of prior exposure to infectious pathogens[15-20] as well as risk-taking behavior (ie, poor hand/foot hygiene combined with exploring objects, including hands and feet, through taste) in children < 2 years of age. Additionally, diarrheal illnesses are seen more frequently in immunocompromised patients, children who are on gastric acid inhibitors (ie, histamine-2 receptor antagonists and proton pump inhibitors),[21] and in children who have not received rotavirus vaccination.[22]

The transition time from breast milk to formula or cow's milk places children at risk for gastroenteritis. Breastfeeding is thought to confer some degree of protection against gastrointestinal pathogens through the transmission of maternal antibodies, hormones that stimulate gastrointestinal development, anti-inflammatory proteins, and white blood cells.[23] Several trials have shown breastfeeding to reduce the frequency and severity of gastroenteritis in children < 2 years of age. In a prospective cohort study of 674 pairs of mothers and infants, babies who were breast-fed for 13 weeks or more had significantly fewer episodes of gastroenteritis compared to formula-fed infants (2.9% vs 15.7%, $P < 0.001$; adjusted odds ratio [OR] of 0.09, with a 95% confidence interval [CI], 0.02-0.37).[24] Dewey et al reported that babies who were breast-fed had about half the episodes of diarrheal illness compared to formula-fed infants during the first year of life (0.16 vs 0.33 episodes per 100 days at risk, $P < 0.05$). The

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Evidence-Based Practice Recommendations For The Treatment of Pediatric Gastroenteritis — visit www.ebmedicine.net/ppr7 average duration of illness was 3 days in breast-fed infants compared to 6.5 days in formula-fed infants.[25] In both studies, these observations remained consistent after adjustment for several potential confounders (eg, socioeconomic status, use of day care, smoking, etc.).

Risk Factors For Dehydration

Children < 2 years of age are prone to dehydration for several physiologic reasons. Infants and toddlers have a relatively large body surface area (compared to body volume), which contributes to fluid loss through skin evaporation. In addition, children have a higher baseline metabolic rate compared to adults and thus have higher baseline insensible losses compared to adults. When pediatric patients develop fever or dehydration, they often compensate by further increasing their heart rate and respiratory rate, both of which increase these fluid losses. Finally, pre-verbal children depend upon their parent or caregiver for fluid intake. This may be problematic if caregivers are not sensitive to the fluid needs of the newborn.

Breast-fed infants are also less likely to become significantly dehydrated or require hospitalization when battling a gastrointestinal infection when compared to non-breast-fed infants. This protection wanes once the decision is made to convert from breast milk to formula or cow's milk. Fuchs et al reported that formula- or cow's milk-fed infants had a 6-fold higher risk of dehydration compared to children fed with breast milk. Compared with those still breastfeeding, children who stopped breastfeeding in the previous 2 months were 8 times more likely to develop dehydration from an acute diarrheal illness.[26] The severity and duration of dehydration ultimately affects decisions regarding pediatric hospitalization. A population-based survey in the United Kingdom found the risk of hospitalization for diarrhea was significantly reduced in breast-fed infants to infants who never breast-fed (adjusted OR 0.37; 95% CI, 0.18-0.78).[27]

Relevant Practice Guidelines

There have been a half-dozen guidelines released by various organizations that have made recommendations for the evaluation and management of patients with acute gastroenteritis. **(See Table 1.)** Unfortunately, specific knowledge of these guidelines is rather poor, and physicians rarely employ all aspects of "best evidence" practices in patient care.[33-36] A survey of US pediatricians found that while 34% of respondents were familiar with the American Academy of Pediatrics guidelines regarding gastroenteritis, less than 10% reported use of these guidelines.[37] Physicians that do not use clinical guidelines often site practicing "cookbook medicine" and not allowing for clinical judgment as the reasons why organized guidelines are not followed.[37]

Critical Appraisal Of The Literature

A PubMed literature review was conducted for all published articles from 1966 to May 2010 relevant to the evaluation of pediatric gastroenteritis and the assessment of dehydration using the term *gastroenteritis* combined with the terms *assessment*, *clinical signs*, *symptoms*, and *treatment*. The search was then repeated using the term *dehydration* with the same additional search terms. Articles were limited to pediatric patients (ages 0-18 years) and articles written in English. The references of review articles including practice guidelines and selected clinical trials were reviewed for additional relevant articles. When available, the literature reported herein pertains to the evaluation and management of gastroenteritis in developed countries.

The existing literature on pediatric gastroenteritis is limited in several areas.

Etiology

There are no studies that have performed a comprehensive evaluation of stool samples in all patients presenting with AGE to the ED. This is not surprising since the ED population is somewhat heterogeneous and includes

Table 1: Relevant Practice Guidelines

Publication Year	Organization	Title
1996	American Academy of Pediatrics	The management of acute gastroenteritis in young children[28]
2001	European Society of Paediatric Gastroenterology, Hepatology, and Nutrition – Working Group on Acute Diarrhea	Practical guidelines for the management of gastroenteritis in children[29]
2003	Center for Disease Control and Prevention	Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy[1]
2006	Agency for Healthcare Research and Quality	Evidence-based clinical care guideline for acute gastroenteritis in children aged 2 months through 5 years[30]
2009	National Institute for Health and Clinical Excellence (UK Guidelines)	Diarrhea and vomiting caused by gastroenteritis: diagnosis, assessment and management in children younger than 5 years[31]
2009	American College of Emergency Physicians – Pediatric Emergency Medicine Committee	The management of children with gastroenteritis and dehydration in the Emergency Department[32]

children with minor diarrheal illness for whom stool testing is not justified as well as children with moderate and severe symptoms that require observation and potential hospital admission. The increased use of immunoassays and other microbiological techniques to isolate suspected pathogens is likely to advance our understanding of this disease process.[38,39]

Clinical Evaluation

Subtracting the current weight from the pre-illness weight and then dividing this number by the pre-illness weight establishes the gold-standard measurement for acute dehydration. Since the pre-illness weight is rarely known, most studies use a post-hydration weight as a substitute for this value. However, post-hydration weights may not accurately reflect the pre-illness weight and are known to vary throughout the day based on fluid/solid intake as well as bowel and bladder habits.

Clinical scales assessing dehydration are equally problematic and have been shown to both overestimate dehydration in some cases and underestimate it in others. Some newer simplified clinical scales use acidosis as their clinical outcome. Acidosis is not a reliable surrogate for dehydration and is of unclear value in the assessment of these patients.

Laboratory Evaluation

Studies that have looked at the value of blood-work and urine testing for the assessment of pediatric dehydration have yielded conflicting results, with most concluding that routine laboratory testing is not helpful or is marginally helpful for the majority of children with AGE and/or dehydration. Despite findings of specific laboratory abnormalities in some studies, no specific laboratory test or combination of laboratory tests have been shown to be predictive of dehydration severity in place of accurate clinical acumen.

More recent studies have tried to determine the frequency and significance of a "clinically significant laboratory abnormality." This term is problematic since what is "clinically significant" may vary between medical providers. Furthermore, outpatient management and self-correction of these abnormalities through return of oral fluid and normal food intake is rarely discussed or examined.

Outcome

The outcome variables in many pediatric dehydration articles are inconsistent. Although the majority of studies evaluating the value of the clinical examination and laboratory markers use ≥ 5% dehydration (using the post-hydration weight standard) as their primary outcome, other studies report degree of acidosis, need for intravenous fluid hydration, or need for hospital admission as primary outcomes. Ultimately, these last 2 variables are more clinically relevant than the ability to estimate the level of dehydration.

Etiology

Viruses are the most frequently implicated pathogens causing pediatric AGE in the US. Rotavirus, norovirus, astrovirus, enteric adenovirus, and sapovirus have been recognized as the most common agents responsible for viral diarrhea in pediatric patients in both outpatient, emergency department (ED), and inpatient settings.[40-48] Bacterial infection of the gastrointestinal tract is seen in 7% to 10% of ED patients with acute diarrheal illness and is most commonly due to *Escherichia coli*, Campylobacter species, Salmonella species, Shigella species, and *Yersinia enterocolitica*.[41,42,44,47,49,50] *Clostridium difficile* infection is a major cause of nosocomial enterocolitis that generally occurs after exposure to antibiotics, healthcare facilities, or infected individuals. Parasitic etiologies to AGE are uncommon in immunocompetent patients that have not come into contact with contaminated food, water, or other infected individuals. The most common parasitic organisms responsible for AGE are *cryptosporidium*, *giardia*, and *entamoeba* histolytica.[41,42,44] While certain clinical clues can help suggest the possible microbial etiology of AGE, stool testing is the only reliable way to obtain a definitive etiology.

Rotavirus

Rotavirus is the leading recognized cause of diarrhea-related illness and death among infants and young children.[51-53] In the US, before the introduction of a rotavirus vaccine in 2006, this virus was estimated to cause 2.1 to 3.2 million episodes of diarrhea; 400,000 to 600,000 outpatient visits; 160,000 emergency department visits; 50,000 to 70,000 hospitalizations; and 20 to 60 deaths each year among children < 5 years of age.[54-60] In US children < 3 years of age, rotavirus is believed to send 1 out of every 11 children to the ED or outpatient clinic and result in the hospitalization of 1 out of every 150 children.[61]

Rotavirus tends to infect younger children, usually between 6 months and 2 years of age. It predominately has a winter-spring seasonality, with case activity beginning in the western US during December to January, extending across the country and, ending in the Northeast region during May to June. These peaks in rotavirus activity correspond to peaks in gastroenteritis-related visits to the ED.[62] Rotavirus infection is less common during the summer months (July-September).

Several studies have tried to distinguish the clinical features of gastroenteritis related to rotavirus infection from other viral gastroenteritis.[57,61,63-66] When taken together, these studies show that individually and together, the symptoms of vomiting, diarrhea, and fever seem to be more common and severe in children with AGE due to rotavirus infection. In a population-based surveillance study involving 516 children < 3 years of age (181 inpatients, 201 ED patients, 134 outpatients) in 3 US counties, children with

AGE due to rotavirus were more likely to present with vomiting (95% vs 79%, $P < 0.001$), diarrhea (92% vs 84%, $P < 0.001$), and fever (79% vs 65%, $P < 0.001$) compared to non-rotavirus-related AGE. The presence of all 3 symptoms was found in 70% of children with AGE due to rotavirus compared to 42% with non-rotavirus-related AGE ($P < 0.001$).[61] Rotavirus-positive-related AGE has also been associated with higher rates of dehydration and need for IV fluids.[57,63,64]

Rotavirus diarrhea has been noted to have a distinctive odor, leading experienced practitioners to believe that they can diagnose rotavirus infection by olfactory inspection alone. In a study out of the United Kingdom, a group of 7 experienced pediatric infectious disease nurses were asked to classify 68 stool samples by smell alone from infants < 18 months old who were admitted to the hospital with acute diarrhea. Olfactory inspection of stool for the diagnosis of rotavirus was found to have a positive likelihood ratio of 3.2 (95% CI, 1.2-8.4) and a negative likelihood ratio of 0.7 (95% CI, 0.5-0.9).[65]

Following the introduction of the pentavalent rotavirus vaccine, there has been a delayed onset and diminished magnitude of rotavirus activity in the US.[68-69] Preliminary sentinel laboratory surveillance data from the Centers for Disease Control and Prevention have noted a 64% drop amongst rotavirus-positive tests in the first year following vaccine release.[69] The Advisory Committee on Immunization Practices recommends routine vaccination of US infants with 3 doses of this rotavirus vaccine administered orally at 2, 4, and 6 months of age. The first dose should be administered between 6 and 12 weeks of age. Subsequent doses should be administered at 4 to 10 week intervals, and all 3 doses should be administered by age 32 weeks.

Norovirus

Norovirus is the 2nd most common case of severe childhood gastroenteritis, accounting for approximately 12% of severe gastroenteritis cases among children < 5 years of age.[70,71] Noroviruses have recently become implicated as the leading cause of AGE epidemics in the US. Over 95% of previously unidentified outbreaks of nonbacterial AGE have now been attributed to norovirus infection by polymerase chain reaction analysis.[72] Outbreaks can involve people of all ages and occur in a variety of settings (eg, long-term care facilities, hospital wards, day-care centers, cruise ships, restaurants, and catered events).[73] In the US, norovirus is estimated to account for > 235,000 clinic visits, 91,000 ED visits, and 23,000 hospitalizations among children < 5 years of age.[70]

Norovirus is a self-limited gastrointestinal infection that lasts 2 to 3 days. Patients often present with vomiting followed by abdominal cramping, fever, and watery diarrhea. Other constitutional symptoms such as headache, chills, and myalgias are variably present.[71] Compared to rotavirus infection, norovirus infection is associated with less intense diarrhea and is less likely to present with a fever.[74,75] Norovirus-positive-related AGE is less likely to produce clinically-significant dehydration (7% vs 22%, $P < 0.05$ for ≥ 5% dehydration) and is less likely to result in the need for intravenous fluid replacement (41% vs 64%, $P < 0.05$), compared to rotavirus-positive-related AGE.[76] Like rotavirus, norovirus has been associated with benign infantile seizures.[77,78]

Bacterial And Parasitic Gastroenteritis

Several studies have examined the ability to distinguish bacterial or parasitic etiologies from viral gastroenteritis on the basis of initial clinical presentation.[44,47,49,50] In a prospective cohort study involving 1626 patients with acute diarrhea who presented to a pediatric ED, multivariate regression analysis demonstrated that fever (OR 2.3; 95% CI, 1.3-4.2), passing of ≥ 10 stools in the previous 24 hours (OR 4.5; 95% CI, 2.7-7.4) and travel outside of the US in the previous 30 days (OR 3.7; 95% CI, 1.7-8.0) were associated with the identification of a bacterial or parasitic pathogen on stool testing.[44] Finkelstein et al reported similar findings in a group of 1035 infants < 1 year of age with diarrhea. In this study, a parental report of blood in the stool, fever (T > 38ºC [100°F]), and passing of ≥ 10 stools in the previous 24 hours were associated with bacterial isolation on stool testing (OR 4.5; 95% CI, 2.8-7.3 for fever, unable to calculate OR for other variables).[50] A combination of blood in the stool and temperature > 38ºC (100°F) or passing of ≥ 10 stools in the previous 24 hours was associated with significant positive likelihood ratios (LR) to alter management (LR 13.5; 95% CI, 6.4-28.4 and LR 11.8; 95% CI, 4.8-29.2, respectively).[50] Abdominal tenderness was associated with bacterial infection in 2 studies (Klein et al reported a relative risk [RR] of 3.8; 95% CI, 2.4-5.7 and Denno et al reported an OR of 7.1; 95% CI,1.8-27.1). A strong seasonal variation in pathogen recovery has also been noted, with bacterial organisms more likely to be cultured in the months from May to October and viral organisms more likely to be found during the late fall, winter, and early spring months.[44,47,50]

Interestingly, the presence of vomiting (OR 0.4; 95% CI, 0.2-0.6) and the duration of diarrhea > 10 days (OR 0.3; 95% CI, 0.1-0.9) were negatively associated with the identification of a bacterial or parasitic pathogen on stool testing.[44] In a cohort of 50 patients < 3 years of age seen in pediatric outpatient clinics, persistent diarrhea (ie, diarrhea > 14 days) was seen only in patients with bacteria- and parasite-culture negative stool.[48]

Pathophysiology

This section illustrates the pathophysiology behind rotavirus infection to illustrate how viruses typically infect the gastrointestinal system and produce the stereotypical symptoms of vomiting and diarrhea.

Rotaviruses are icosahedral double-stranded RNA viruses that infect the mature absorptive villous epithelium of the upper two-thirds of the small intestine.[79] Following viral replication, virons are released into intestinal lumen and undergo further replication in the distal areas of the small intestine. Nausea and vomiting occur as responses to excess serotonin, which is released following the viral invasion of enterochromaffin cells located in the epithelial lining of the gastrointestinal lumen. Stimulation of central nervous system serotonin receptors results in activation of the chemoreceptor trigger zone and vomiting center.

The manifestation of diarrhea occurs as virons infect and destroy gastrointestinal enterocyte cells. Enterocyte cell lysis changes the shape of intestinal villi causing them to atrophy and fuse, thereby reducing the surface area for electrolyte and carbohydrate absorption. This in turn leads to an osmotic gradient of fluid into the intestinal lumen. Computed tomographic imaging of patients with gastroenteritis demonstrates abnormal bowel wall thickening (> 3 mm), mucosal enhancement, and fluid-filled bowel loops in the small intestine, with no radiographic findings in the stomach, appendix, or colon.[80] The normal villous architecture is restored within 7 to 10 days.

Differential Diagnosis

Diseases That Can Masquerade As Gastroenteritis

- **Appendicitis –** Symptoms include vomiting that follows abdominal pain, small amounts of watery diarrhea (compared to the voluminous amounts produced as a consequence of gastroenteritis), and mild or absent fever.
- **Bacterial Enteritis –** Symptoms include diarrhea and history suggesting recent consumption of contaminated food, with or without fever. Recent travel suggests Traveler's Diarrhea. Recent antibiotics suggest *Clostridium difficile* infection.
- **Pyelonephritis Or Pneumonia –** In children, typical extra-intestinal infections can produce diarrhea. In these patients, the location of the infection should be obvious after selective laboratory testing.
- **Intussusception –** Symptoms include intermittent colicky pain followed by periods of rest or improvement. Diarrhea is a late sign and is often bloody.
- **Malrotation With Volvulus –** Severe abdominal pain or bilious vomiting in a previously healthy infant should prompt consideration for this diagnosis.
- **Toxic Ingestion –** Ingestions of mushrooms, heavy metals, and cholinergic drugs will produce a clinical picture similar to AGE. Ask about accidental toxic ingestions.
- **Malabsorption Disorder –** Patients with celiac disease and lactose intolerance exhibit symptoms that include diarrhea, gas, bloating, and stomach pains that seem to be triggered by certain foods.
- **Diabetic Ketoacidosis –** This condition commonly presents with dehydration and thirst, along with some abdominal pain and nausea and vomiting. Diarrhea is an atypical feature, but in patients with concomitant polyuria and polydipsia, a glucose-point-of-care test is recommended.

Prehospital Care

Prehospital care for the pediatric patient with acute gastroenteritis should focus on assessing the level of dehydration and initiation of fluid replacement to correct significant dehydration. Although contemporary pediatric dehydration scales are believed to give a more accurate reflection of the level of dehydration, these scales are far too complex to be of use in the prehospital setting. The most useful individual signs for predicting ≥ 5% dehydration in children are abnormal capillary refill time, abnormal skin turgor, and abnormal respiratory pattern.[81] These signs should be taught to paramedics and assessed in children who are believed to be hypovolemic.

Children with dehydration are at risk for hypoglycemia, the symptoms of which may go unrecognized by medical providers or may be mistakenly ascribed to dehydration. Two recent reports have noted that hypoglycemia is seen in about 10% of children with gastroenteritis who present to the ED.[82,83] A paramedic point-of-care glucose check is therefore reasonable to obtain in any patient with symptoms of neuroglycopenia, any critically ill patient with acute diarrheal illness, or in any patient requiring intravenous fluid rehydration. Rapid glucose determination will also facilitate the diagnosis of diabetic ketoacidosis. A retrospective study involving 54 children with unrecognized new-onset type I diabetes mellitus noted that 9 out of 54 (16.7%) were diagnosed with gastroenteritis by the initial medical providers.[84]

Mandati and Bachur recently derived a decision rule to predict acidosis (serum bicarbonate ≤ 16 mmol/L or end-tidal CO_2 ≤ 31 mm Hg), a surrogate for dehydration, among 130 children < 7 years of age with a chief complaint of vomiting, diarrhea, or dehydration.[85] High-risk patients (ie, either < 2 years of age or ≥ 2 years of age with dry mucous membranes and > 2 days of illness) were at significant risk for acidosis (OR 8.5; 95% CI, 2.4-3.0). The authors of this rule advocate for its use in assisting triage decisions in the ED; however, these variables are relatively easy to obtain and may assist prehospital providers in determining the degree of illness in pediatric patients at risk for dehydration.

ED Evaluation

The decision to take a child to the ED is a complex process for parents. This decision involves expectations developed from the community and societal-level as well as family-level expectations, child factors, and access to care.[86] A survey of parents who brought their child to the ED for gastroenteritis reported that parents believed their children were "very sick." Interestingly, physician caregivers, blinded to these results, believed the children they cared for were "not very sick."[87]

History

The clinical history in a child who presents to the ED with gastroenteritis should assess the onset, frequency, quantity, and character (eg, blood, bile, mucous) of the diarrhea and/or vomiting. Additional important historical features include the duration of illness and the presence or absence of abdominal pain and fever. A report of fluid intake (including type of fluid ingested), urine output, and mental status will provide helpful information regarding the hydration status of the patient. If available, the most recent weight of the child should be recorded and compared to the present weight. The past medical history should identify underlying chronic medical conditions, history of recent infections (especially those treated with antibiotics), rotavirus vaccine status, and current medication use.

The predictive value of the parental history in determining the degree of dehydration has been examined in 4 prospective studies involving a total of 550 children.[85,88-90] The most comprehensive of these trials involved a 132 parent-child pairs that presented to an ED with a chief complaint that included the terms *vomiting*, *diarrhea*, or *decreased intake of fluids*.[89] Parents were asked to complete a computer-based interview that covered 9 historical items related to pediatric dehydration (eg, decreased oral intake, decreased urine output, and history of vomiting or diarrhea in past 12 hours). Parent-reported data demonstrated higher sensitivity (range 73%-100%) than specificity (range 0%-49%) for the outcome of ≥ 5% dehydration. None of these variables were individually able to significantly alter pre-test probability to predict ≥ 5% dehydration (ie, all had LR < 2).[89] Parental history was equally poor at predicting acidosis (serum bicarbonate ≤ 16 mmol/L or end-tidal CO_2 ≤ 31 mm Hg) and the more clinically relevant outcomes of need for intravenous fluids and hospital admission.[85,89] Conversely, 2 reports found parental report of a normal urine output to decrease the likelihood of ≥ 5% dehydration (Porter et al[89] reported a LR of 0.16; 95% CI, 0.01-2.53 and Gorelick et al[90] reported a LR of 0.27; 95% CI, 0.14-0.51).

Physical Examination

During the physical examination, the general condition and mental status of the patient should be noted. A review of the heart rate, blood pressure, quality of pulses, depth and rate of breathing, temperature, and room air oxygen saturation should all be noted. The examination should begin with the child across the room in a position of comfort (eg, the parents' arms or in their lap). Overall appearance, activity, and responsiveness of the child to stimulation should be observed. Next, a head-to-toe physical examination focusing on the signs of dehydration and a general assessment of abdominal pathology should be completed. For the assessment of dehydration specifically, the appearance of the eyes (including the degree to which they are sunken), the presence or absence of tears, and the hydration status of the lips and mouth should be evaluated. Skin turgor should be examined by pinching a small skin fold on the lateral abdominal wall at the level of the umbilicus using the thumb and index finger. The fold should be promptly released and the time it takes to return to normal form measured.[81] Finally, capillary refill should be assessed in the child's fingertip, with the arm at the level of the heart, in a warm ambient temperature. Pressure should be gradually increased on the palmar surface of the distal fingertip, then released immediately after the capillary bed blanches. The time elapsed until restoration of normal color should be estimated.[81] Several published guidelines on the assessment and treatment of gastroenteritis use a combination of a dozen or so clinical findings to develop a clinical dehydration table. **(See Table 2 on page 8.)**

The precision and accuracy of the physical examination findings associated with dehydration were assessed in a well-done systematic review.[81] A total of 13 studies used the post-hydration weight standard to determine the degree of dehydration. In general, the interobserver reliability of the signs of dehydration was poor to moderate. **(See Table 3 on page 9.)**

The 3 most useful signs in determining ≥ 5% dehydration are prolonged capillary refill (pooled LR 4.1; 95% CI, 1.7-9.8), abnormal skin turgor (pooled LR 2.5; 95% CI, 1.5-4.2), and abnormal respiratory pattern (pooled LR 2.0; 95% CI, 1.5-2.7).[81] Absence of tears had a pooled LR of 2.3 (95% CI, 0.9-5.8), but the potential of this sign is limited by a wide 95% CI that crosses 1.0. The presence of cool extremities or a weak pulse may also be helpful in determining the degree of dehydration; however, the limited number of studies that evaluated these findings limits pooling of this data. Unfortunately, the findings of poor overall appearance, increased heart rate, sunken fontanelle, sunken eyes, or dry mucous membranes have limited value as individual features in detecting ≥ 5% dehydration.[81]

Clinical Prediction Rules

A limitation of the previously mentioned findings is that the assessment of dehydration is not based on individual historical and physical examination features; rather, clinicians combine multiple historical and examination elements to estimate the degree of dehydration. Vega and Avner asked a group of pediatric physicians to record a clinical estimate of the degree of dehydration in 97 dehydrated children (85% due to AGE) who were judged to require intravenous (IV) fluid hydration (using a 9-item clinical scale for dehydration with items similar to those found in **Table 3** as the basis for their estimate.)[91] Children were classified based on which category of dehydration (ie, mild, moderate, or severe) had the majority of clinical findings. Using this scale, "moderate" dehydration had a LR of 2.1 (95% CI, 0.9-4.8) for the prediction of ≥ 5% dehydration. "Severe" dehydration had a LR of 4.3 (95% CI, 2.4-7.8) for the prediction of ≥ 10% dehydration.[81,91]

Several studies have developed clinical prediction rules that combine a number of clinical features to aid in determining hydration status.[90,92,93] Although derived from separate populations, these rules share several common variables including the presence of dry mucous membranes,[90,92,93] general appearance of infant/child,[90,93] decreased/absent tears,[90,93] and sunken eyes on examination.[92,93] Additionally, capillary refill time > 2 seconds,[90] abnormal skin turgor,[92] and abnormal mental status[92] were shown in these trials to predict dehydration. These rules demonstrate that the greater the number of these variables present, the more likely the child is to be ≥ 5% dehydrated using the post-hydration weight standard. The fact that there is significant overlap to the variables in these studies lends credibility to their validity; however, their most serious shortcoming is that they have yet to be validated in external settings. Additionally, the clinical applicability in the determination of the outcome of ≥ 5% dehydration is a matter of debate. Furthermore, none of these publications conform to the standards for the development of prediction rules in emergency medicine.[94]

Friedman et al derived a clinical prediction rule for dehydration in 137 children < 3 years of age with AGE.[93] Four variables (dry mucous membranes, general appearance, sunken eyes on examination, and decreased tears), each assigned 0, 1, or 2 points based on clinical examination, were found to be predictive of dehydration. In a validation study involving 205 children < 5 years of age with AGE, clinical outcomes were found to correlate with the categories of "no dehydration" (total score 0 points), "some dehydration" (total score 1 to 4 points), and "moderate/severe dehydration" (total score 5 to 8 points).[95] The ED length of stay in the 3 groups were (mean +/- standard deviation [SD]): no dehydration, 245 +/- 181 minutes; some dehydration, 397 +/- 302 minutes; moderate/severe dehydration, 501 +/- 389 minutes. The need for intravenous fluids in the 3 groups was no dehydration, 15%; some dehydration, 49%; moderate/severe dehydration, 80%.[95]

Diagnostic Studies

Tests For Dehydration

The utility of laboratory testing in estimating hydration status has been evaluated in multiple studies, with researchers testing about a dozen or so variables to aid in this task. In general, these studies conclude that no single laboratory value has adequate discriminatory power to distinguish clinically-significant dehydration and that the role of these tests is therefore limited.[28,32,81,96,97]

Table 2: Clinical Assessment Of Dehydration

Variable	Mild, 3%-5%	Moderate, 6%-9%	Severe, ≥ 10%
Urine output	Normal to decreased	Decreased	Minimal
Thirst	Slightly increased; might refuse liquids	Moderately increased	Drinks poorly; unable to drink
Mental status	Normal	Normal, fatigued or restless, irritable	Apathetic, lethargic, unconsciousness
Heart rate	Normal	Increased	Increased*
Quality of pulses	Normal	Normal to decreased	Weak, thready
Blood pressure	Normal	Normal	Normal to reduced
Breathing	Normal	Normal; fast	Deep
Fontanelle	Normal	Sunken	Sunken
Eyes	Normal	Slightly sunken	Deeply sunken
Tears	Present	Decreased	Absent
Mucous membranes	Moist	Dry	Parched
Extremities	Warm	Cool	Cold, mottle, cyanotic
Capillary refill	Normal	Prolonged	Prolonged; poor
Skin turgor	Normal	Recoil in < 2 sec	Recoil in > 2 sec

* Bradycardia may appear in severe cases

Acidosis (serum bicarbonate – variably defined, but generally < 16 mEq/L) has been shown to predict ≥ 5% dehydration,[91,98-101] need for significant fluid resuscitation,[102] and hospitalization in one earlier study.[103] However, more recent studies have not shown a correlation between serum bicarbonate and hospital admission[82,85] or between serum bicarbonate and unscheduled return visits.[82] Related variables, such as venous pH,[88,104] serum anion gap,[104] and base deficit,[88,101] have all shown variable usefulness in their ability to predict ≥ 5% dehydration. Similar to the findings of studies that evaluated the clinical examination, the bedside value of determining ≥ 5% dehydration is questionable (ie, published clinical guidelines recommend an initial trial of oral fluids in patients with < 10%, not < 5%, dehydration).

Blood urea nitrogen (BUN) and BUN/creatinine levels have been proposed as markers for dehydration.[88,98,100,101,104,105] A recent pooled analysis of these trials noted that LRs ranged from 1.4 to 2.9 using BUN various cutoff values ranging from 18 mg/dL to 40 mg/dL.[81] Similarly, a BUN/creatinine ratio of 40 had a LR of 2.1 (95% CI 0.5-8.9) to predict ≥ 5% dehydration.[81,104]

Urine specific gravity and the presence of urine ketones are commonly used to assess for dehydration. Of the 3 studies that we could find related to the use of these indices in the setting of pediatric dehydration from AGE, none of the 3 reported a significant correlation between these variables and ≥ 5% dehydration.[100,104,106]

Tests For Rotavirus And Bacterial Enteritis

Rotavirus latex agglutination and antibody immunoassay tests have been on the market for over 25 years. These assays can be used to confirm the diagnosis of rotavirus, thereby limiting additional stool testing in pediatric patients. The current generation of tests has sensitivities ranging from 70% to 90% and specificities of 90% to 100%.[107]

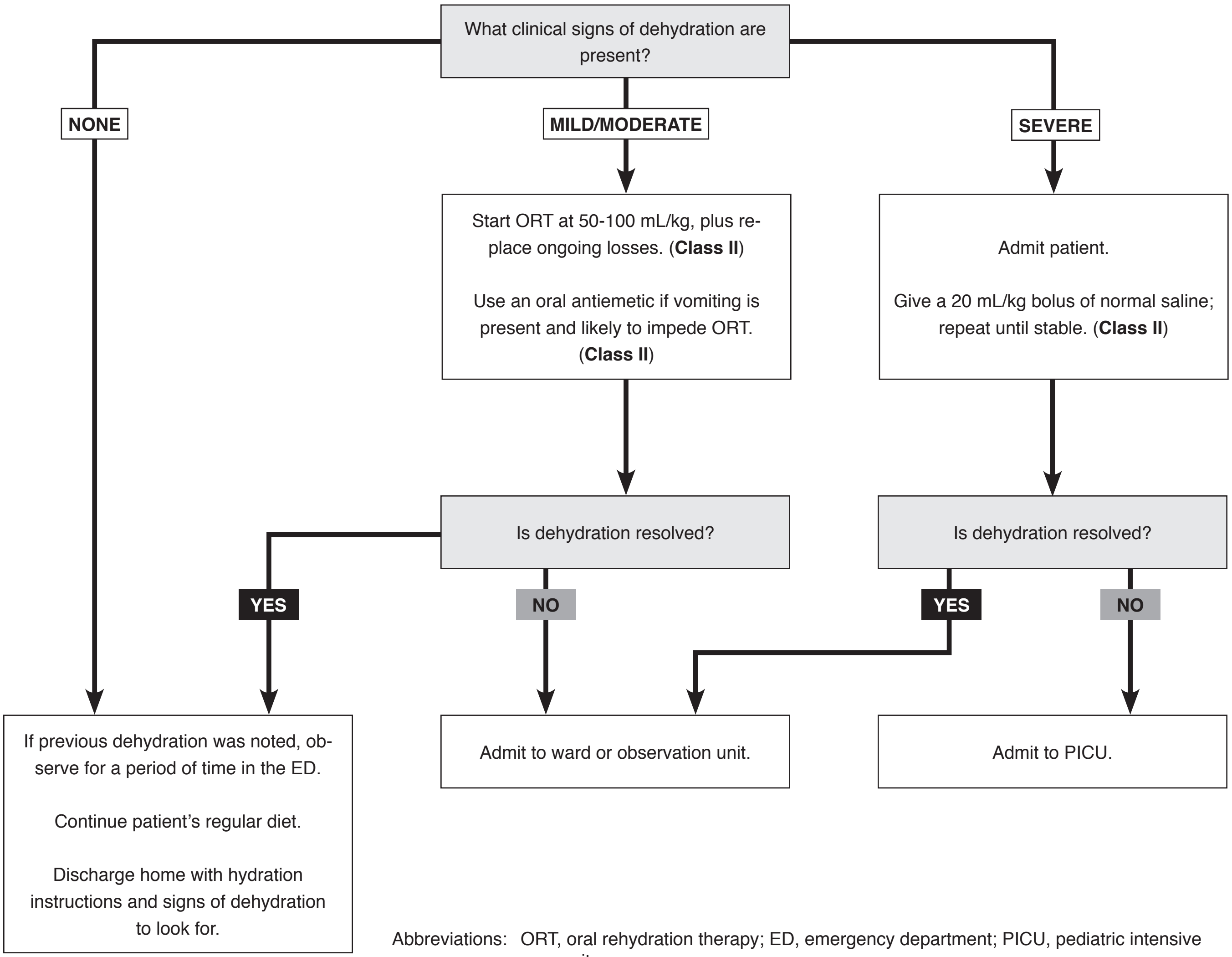
The presence of fecal leukocytes has traditionally been associated with the presumption of a bacterial or parasitic origin to diarrhea. In a systematic review and meta-analysis of the literature from 1970 to 1994, Huicho et al determined the accuracy of several fecal-based tests, including stool white blood cells counts, for predicting the results of stool cultures. Using a receiver operating characteristic curve, a peak sensitivity of 70% for the test was noted at a specificity of just 50%. Using a cutoff to maximize specificity (90%) resulted in a sensitivity of only 40%.[108] The test was noted to depend heavily on the time it took for the specimen to be examined after it had been retrieved and also on the experience of the operator. Increasing time results in increasing cell lysis and decreased sensitivity.[109]

C-reactive protein (CRP) has recently been used to distinguish viral gastroenteritis from bacterial enteritis. Marcus et al studied a bedside CRP test in 44 pediatric patients who presented to the ED with AGE of less than 48 hours duration. Using a cutoff value of 95 mg/L, CRP had a sensitivity of 87% and a specificity of 92%

Table 3: Summary Test Characteristics For Clinical Findings To Detect 5% Dehydration[81]

Finding	Number of Studies, Number of Patients	Range of k Values	LR Summary, Value (95% CI) or Range	
			Present	Absent
Poor overall appearance	3 studies, 398 patients	0.18-0.61	1.9 (1.0-3.8)	0.5 (0.3-0.6)
Increased heart rate	3 studies, 462 patients	Not Reported	1.3 (0.8-2.0)	0.8 (0.6-1.1)
Weak pulse	2 studies, 360 patients	0.15 to 0.50	3.1, 7.2	0.7, 1.0
Abnormal respiratory pattern	4 studies, 581 patients	-0.04 to 0.40	2.0 (1.5-2.7)	0.8 (0.6-0.9)
Sunken fontanelle	3 studies, 308 patients	0.10 to 0.27	0.9 (0.6-1.3)	1.1 (0.8-1.5)
Sunken eyes	4 studies, 533 patients	0.06 to 0.59	1.7 (1.1-2.6)	0.5 (0.4-0.6)
Absent tears	3 studies, 398 patients	0.12 to 0.75	2.3 (0.9-5.8)	0.5 (0.3-1.1)
Dry mucous membrane	4 studies, 533 patients	0.28 to 0.59	1.7 (1.1-2.6)	0.4 (0.2-0.8)
Cool extremity	2 studies, 206 patients	0.23 to 0.66	1.5, 18.8	0.9, 1.0
Prolonged capillary refill	4 studies, 478 patients	0.01 to 0.65	4.1 (1.7-9.8)	0.6 (0.4-0.9)
Abnormal skin turgor	5 studies, 602 patients	0.36 to 0.55	2.5 (1.5-4.2)	0.7 (0.6-0.8)

Clinical Pathway: Management Of Dehydration In Pediatric Gastroenteritis



Abbreviations: ORT, oral rehydration therapy; ED, emergency department; PICU, pediatric intensive care unit

Class Of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA.* 1992;268(16):2289-2295.

for predicting culture-confirmed bacterial enteritis.[110] Before we accept the results of this industry-sponsored trial that used a post-hoc cutoff value to maximize the performance characteristics of this test, further studies are required, especially those that compare the use of CRP to clinical judgment and those that report a change in patient management based on test results.

Additional Laboratory Abnormalities

A host of other laboratory abnormalities, such as hyponatremia and hypernatremia,[82] hypokaleamia,[82] hypoglycemia,[82,83] hyperamylasemia,[111] and elevated antidiuretic hormone levels, have been reported with AGE.[112] A study of 182 children with dehydration noted hypoglycemia (glucose < 60 mg/dL) in 18 patients (10%), hypokalemia (K < 3.5 mmol/L) in 11 patients (6%), and hypernatremia (Na > 150 mmol/L) in 6 patients (3%).[82] Reid et al reported a hypoglycemia rate of 9% in a retrospective analysis of 196 children < 5 years of age with AGE.[83] When the authors of the retrospective analysis tried to analyze predictors of hypoglycemia in children with AGE, they found 3 variables on multivariate analysis: female gender (OR 2.6; 95% CI, 1.3-5.0), signs of neuroglycopenia (OR 3.5; 95% CI, 1.4-8.6), and number of vomiting episodes greater than or equal to the number of diarrhea episodes (OR 2.1; 95% CI, 1.0-4.4).[113]

Other Considerations

Several other studies have reported interesting findings with respect to laboratory testing in children with AGE. Hampers et al reported that providing physicians with price information next to laboratory orders resulted in significantly decreasing testing done in the ED, without sacrificing patient care.[114] This same group also reported nearly equivalent clinical outcomes between physicians that order few tests for children with gastroenteritis compared to physicians that order more tests.[115] Finally, this group also confirmed that children seen in a ED compared to a "fast-track" type area[116] and children of families with significant language-barriers[117] have longer ED stays and additional diagnostic testing performed.

Treatment

Oral Rehydration Therapy

Worldwide, the use of oral rehydration therapy (ORT) has resulted in significant improvement in pediatric mortality from dehydration over the last 30 years. In developed countries, ORT is used much less often in favor of faster and less labor-intensive IV fluid replacement. Only 15% of emergency physicians stated in a recent study that they would choose ORT in children with moderate dehydration.[118] The current practice guidelines for gastroenteritis recommended by the Centers for Disease Control and Prevention and endorsed by the American Academy of Pediatrics recommend that treatment should include 2 phases, rehydration and maintenance. For mild to moderate dehydration, administer 50 to 100 mL/kg of oral rehydration solution (ORS) over 2 to 4 hours to replace the fluid deficit with additional ORS to replace ongoing losses. Use a teaspoon or dropper or nasogastric tube if necessary. In cases of severe dehydration, immediate IV rehydration with normal saline or Lactated Ringer's Solution should be administered at 20 mL/kg until vital signs and mental status return to normal. With frail or malnourished infants, 10 mL/kg should be administered as they may be unable to increase cardiac output in response to rehydration, and rehydration status should be reassessed frequently. For a more detailed look at rehydration, see the January 2010 *Pediatric Emergency Medicine Practice* issue "An Evidence-Based Review Of Dehydration In The Pediatric Patient."

Antiemetics

Traditionally, antiemetic agents have not been used in pediatric patients out of concern for adverse events. One study assessing antiemetic use among emergency medicine, pediatric emergency medicine, and pediatric providers in 2002 indicated that promethazine was the most commonly used antiemetic, and adverse reactions were reported most often with prochlorperazine.[119] The most commonly reported side effects of prochlorperazine included dystonia/dyskinesia, akathisia, hyperreflexia, and impaired consciousness. Promethazine lacks antidopaminergic actions and thus antipsychotic effects. Its major side effect is CNS depression, possibly due to antihistamine properties. Use of these antiemetics is controversial because of these adverse effects, particularly extrapyramidal side effects and sedation that may interfere with ORT. Dimenhydrinate is a combination of diphenhydramine and theophylline in an attempt to decrease the drowsiness caused by diphenhydramine. It is used more often in Canada and Germany than in the US, and while it has been shown to reduce vomiting episodes, it did not improve oral rehydration or clinical outcome.[120]

Ondansetron is a selective serotonin 5-HT3 receptor-blocking agent that previously was indicated for post-chemotherapy and post-surgical nausea and vomiting and has a very good side effect profile. One meta-analysis of 11 articles by Ross Decamp et al published in 2008 reviewed antiemetics in the pediatric population, and the ondansetron studies were the most recently published and achieved the highest quality ratings. Overall, ondansetron compared to placebo reduced hospital admissions (number needed to treat [NNT] 14), reduced the need for intravenous fluid administration (NNT 5), and resulted in cessation of vomiting while in the emergency department.[121] Indication for intravenous fluid administration varied by study but included persistent emesis, refusal to drink, and persistent dehydration. There was no significant difference in return to care. Freedman et al showed that weight-based, one-time dosing of oral dissolving tablets (ODT) was effective in allowing ORT in a cohort of children from 6 months to 10 years.[122] Oral dissolving tablets are a noninvasive, cost effective way to facilitate ORT in children. Several studies have noted that the benefit of nausea control comes at the expense of prolonging diarrheal episodes during the 48-hour period following administration of the drug.[123] Most studies were done in children > 6 months of age, and use in young infants should be done with caution as the safety and efficacy has not been confirmed.

Antibiotics

The question of antibiotic use is more relevant when discussing infectious diarrhea and less with acute gastroenteritis. Because the clinical picture between these two entities can be difficult to distinguish, this article briefly discusses the treatment of infectious diarrhea. Cases that may require antimicrobial therapy are those that have increased potential to develop complications such as sepsis or disseminated intravascular coagulation. This population includes those with HIV, those undergoing chemotherapy, diabetics, neonates and young infants, organ transplants, or those with articular or valve prosthesis. The World Health Organization currently recommends empiric antimicrobial therapy in the setting of febrile acute bloody diarrhea in young children.[124] The use of antibiotics in acute diarrhea has been shown to be a risk factor for developing persistent symptoms.

Antidiarrheals

There are 3 major classes of antidiarrheal agents. Mechanisms of action include decreasing gut motility, antisecretory, adsorbent, and probiotics. Loper-

Risk Management Pitfalls To Avoid In Pediatric Gastroenteritis

1. **"That kid you sent home last night with acute gastroenteritis is back. The surgeon who just saw him thinks that he has acute appendicitis."**
   Early appendicitis and gastroenteritis can be difficult to distinguish on clinical grounds alone. In fact, 10% to 33% of young children with appendicitis will present with a symptom complex that includes diarrhea. The history of pain that migrated to the right lower quadrant or the presence of right lower quadrant tenderness on examination should heighten your suspicion for appendicitis, whereas frequent bouts of copious diarrhea should lower your suspicion for appendicitis. Regardless, observation and good discharge instructions are key.

2. **"How would I know their child would end up in the pediatric intensive care unit, I thought his symptoms would get better in a day or two."**
   For any child who is dehydrated, your discharge conversation and instructions should specifically highlight the symptoms and signs of worsening dehydration **(See Sample Discharge Instructions on page 14)**. In general, discharge instructions need to be written in simple language and should be location-, time-, and action-specific. For example, "Return to the ED immediately if your child continues to vomit and is unable to keep any fluids down" is preferred to "Return if worsening."

3. **"I examined that child when he first came to the ED. After some oral fluids, the nurse said he looked OK, so I sent him home."**
   Yeah, but that same nurse forgot to tell you that she saw him vomit everything up and that his repeat vital signs were unchanged before he left. Three steps will reduce the risk of missing an alternative diagnosis leading to an unexpected return visit to the ED. First, document serial abdominal examinations and response to hydration strategy. Second, read the nursing notes and talk to the nurse caring for the patient to make sure you have not missed any important information or events that took place while the patient was in the ED. Third, talk to the family and document location-, time-, and action-specific return precautions.

4. **"The nurses had a hard time getting an IV on that kid so I just told them to forget it and let the parents feed him small sips."**
   Failure to place an IV in a pediatric patient can be due to nursing inexperience but can also be due to severe dehydration in children. Your best IV starter has just 3 attempts before you should go to an intraosseous line or nasogastric tube for rehydration in the severely dehydrated child.

5. **"I had no idea that the family of the infant that I sent home lived 40 minutes away and did not have a car to return for a repeat evaluation today."**
   Consider extended ED observation or hospital

amide is an opiate receptor agonist whose side effects include lethargy, paralytic ileus, toxic megacolon, central nervous system (CNS) depression, coma, and even death. It can also prolong transit time and subsequently bacterial infection. Antisecretory drugs include bismuth subsalicylate and racecadotril (acetorphan). Bismuth subsalicylate can produce salicylate toxicity. A recent study comparing racecadotril, an inhibitor of intestinal encephalinases that decreases the secretion of water and electrolytes, to placebo found no difference in number of stools and time to resolution of symptoms.[125] Previous studies of racecadotril used in moderate to severe diarrhea in hospitalized children have shown improvement in symptoms. Adsorbents include smectite, a natural hydrated alumino-magnesium silicate that binds to digestive mucus and is used in several countries outside of the US. A meta-analysis of smectite showed a moderate reduction in the duration of diarrhea.[126]

Special Circumstances

Antibiotic-associated diarrhea (AAD) is unexplained diarrhea occurring between 2 hours and 2 months after starting antibiotics. The prevalence of AAD in the pediatric population is around 11% . A recent review by Alam et al found that risk factors include children younger than 2 years and type of antibiotic.[127] The risk seems to be higher with antibiotics that act on anaerobes, such as amoxicillin, the combination of amoxicillin/clavulanate, cephalosporins, and clindamycin.[128] Antibiotic-associated diarrhea is associated with altered intestinal microflora, mucosal integrity, vitamin and mineral metabolism, and crampy abdominal pain. Erythromycin accelerates the rate of gastric emptying; amoxicillin/clavunate stimulates small bowel motility. The majority of patients improve with discontinuation of the antibiotics. A recent meta-analysis concluded that probiotics prevent AAD in 1 out of 7 children taking antibiotics.[129]

Risk Management Pitfalls To Avoid In Pediatric Gastroenteritis

admission for any infant < 1 year of age with gastroenteritis, especially if the family has limited access to healthcare.

6. **"Our QA committee just asked me to justify why I sent home a child with compensated shock. I don't even know what compensated shock is."**
   Compensated shock is a condition where a child displays all the signs of poor peripheral perfusion but is maintaining an adequate central blood pressure. For example, a severely dehydrated child with cool extremities and no urine output who is tachycardic and tachypneic but is able to maintain a minimal blood pressure is likely to be in a state of compensated shock. Children presenting with signs and symptoms consistent with severe dehydration should be admitted to the hospital or a short-stay unit for further observation.

7. **"I ended up admitting that kid you signed out to me who developed abdominal pain and diarrhea after starting his antibiotics for a skin infection. Did you consider that he may have *C difficile* colitis?"**
   Any child with diarrhea following recent antibiotic use should be evaluated for *C difficile* infection. Although mild infection may be self-limited, the presence of fever, leukocytosis, or abdominal tenderness can indicate significant colitis requiring antibiotic treatment with metronidazole or vancomycin.

8. **"That kid we just sent home with gastroenteritis is back. His parents now say that he just had a bloody bowel movement."**
   Bloody diarrhea is unusual for viral gastroenteritis and is more commonly associated with bacterial enteritis. In the absence of fever, consider intussusception, hemolytic uremic syndrome, inflammatory bowel disease, and pseudomembranous colitis. Once these diagnoses have been eliminated, the diagnosis of intestinal enteritis can be entertained.

9. **"Doc, I just roomed a little 2-month-old with bilious vomiting in the next room. Do you want me to get anything started on him?"**
   Yes. Bilious emesis is always worrisome in an infant and should be considered a surgical emergency until proven otherwise. The top consideration in this child is intestinal malrotation.

10. **"The family you asked to come back today is doing fine. They say their daughter is doing much better today."**
    Recommend 24-hour follow-up, either in the ED or in a pediatrician's office, for any child that you are worried about. This is especially true for patients who present with abdominal pain and vomiting only. Although the ultimate diagnosis may be gastroenteritis, the lack of diarrhea should be considered an atypical finding and should be further explored while in the ED.

Sample Discharge Instructions

1. **What is gastroenteritis?**
   Gastroenteritis is an illness that can cause vomiting and diarrhea and may lead to dehydration in your child. Gastroenteritis is most often caused by a virus infection and typically gets better in a couple of days without any medication. Infrequently, early appendicitis can be misdiagnosed as gastroenteritis. For this reason, if you feel like your child is not improving in 6 to 8 hours, please return to the ED for repeat evaluation.

2. **What is dehydration?**
   Dehydration is the "drying out" of the body that occurs when a child loses more fluids (through vomiting, diarrhea, and fever) than he or she is able to drink. This can happen very quickly in infants and small children as these children have less "extra" fluid to lose. If your child is diagnosed with gastroenteritis, it is important to recognize and prevent dehydration.

3. **How do I prevent dehydration in my child?**
   The best way to prevent dehydration in infants is to try to feed your baby (using breast milk or formula) more often. If your child is older, make sure that he or she is drinking enough liquids to replace the fluids that are lost through diarrhea and vomiting. If your child is nauseated (feels like throwing up), use small sips of a commercially prepared oral rehydration solution every few minutes. Drinks that are high in sugar (such as juices or soft-drinks) might make the diarrhea worse and should be avoided.

   There has been much confusion and folklore about optimal foods for children with gastroenteritis. Children who are not dehydrated should continue to eat a regular diet, and infants who are breastfeeding should continue to do so unless you are told otherwise by your pediatrician. Most children with diarrhea tolerate full-strength cow's milk products. It is not necessary to dilute or avoid milk products. Recommended foods include a combination of complex carbohydrates (rice, wheat, potatoes, bread), lean meats, yogurt, fruits, and vegetables. High fat foods are more difficult to digest and should be avoided. It is not necessary to restrict a child's diet to clear liquids or the BRAT diet (bananas, rice, applesauce, toast) as these diets are poor in nutritional content.

4. **How do I know if my child is getting dehydrated?**
   You should consider dehydration if your child had vomiting or diarrhea and has any of the following of these signs:
   - feeling dizzy when sitting or standing up
   - dry lips and mouth
   - urinating less frequently (< 1 wet diaper every 6 hours), especially if the urine looks dark and has a strong smell
   - little or no tears while crying
   - not paying attention to toys or television or being difficult to wake up

5. **How do I treat dehydration at home?**
   If your child has mild symptoms, you can care for your child at home with help from your doctor. Start by giving your child 1 to 2 teaspoons of an oral rehydration solution every 1 to 2 minutes. This adds up to over 1 cup an hour. If your child does well, you can slowly give bigger sips a little less often - every 5 minutes or so. When your child is no longer dehydrated and is not nauseated or vomiting, begin giving regular foods and drinks again.

6. **When should I call my doctor or return to the ED?**
   The following is a list of signs and symptoms that are worrisome and require immediate medical attention:
   - bloody diarrhea
   - if an infant refuses to drink anything for more than 3 to 4 hours
   - signs of dehydration
   - abdominal pain that comes and goes or is severe
   - Any fever >102°F (39°C) or a fever >101°F (38.4°C) that persists for more than 3 days
   - behavioral changes, including lethargy or decreased responsiveness

Clostridium difficile infection (CDI) is uncommon in children, but according to recent studies the incidence of community-acquired CDI in the pediatric population is increasing. *Clostridium difficile* infection is responsible for somewhere between 5% to 20% of AAD and almost all cases of colitis. Sensitive predictors are severe diarrhea, the presence of blood or mucus, fecal leukocytes > 5/HPF, and the presence of Gram-positive bacilli with oval subterminal spores. Pseudomembranous colitis usually presents with abdominal cramps, fever, leukocytosis, fecal leukocytes, hypoalbuminemia, colonic thickening on CT, and punctate yellow plaques seen on endoscopic examination. Most of these cases are *C difficile* positive. Either metronidazole or vancomycin orally for 10 days is the drug of choice.

Controversies/Cutting Edge

End-Tidal CO_2 To Measure Acidosis

End-tidal CO_2 values have recently been shown to correlate accurately with serum HCO_3 levels among children with vomiting and diarrhea. In a prospective study involving 130 children with gastroenteritis, children were connected to a noninvasive portable handheld end-tidal capnographer with an oral/nasal cannula.[130] After a 60 second stabilization period, the most frequently displayed $ETCO_2$ value over the next 30- to 60-seconds was recorded. An $ETCO_2 \leq 31$ mm Hg correlated well in detecting serum $HCO_3 \leq 15$ mmol/L (LR 20.4). An $ETCO_2$ value ≥ 34 mm Hg was unlikely to be associated with serum $HCO_3 \leq 15$ mmol/L (LR 0.04).[130] A correlation between $ETCO_2$ and serum HCO_3 has been demonstrated in 2 additional studies on pediatric gastroenteritis and in studies of metabolic acidosis.[85,131]

Time-Elapsed Digital Photography To Measure Capillary Refill Time

High-speed digital photography can be used to assess capillary refill time. Investigators from Canada took a high-quality digital picture of a child's finger-

Cost-Effective Strategies

- Minimize routine blood- and urine-testing in children with non-severe gastroenteritis. Laboratory values rarely change disposition decisions and only occasionally lead to electrolyte management. The most frequent abnormal laboratory test that requires a change in therapy is glucose, a laboratory test that can be checked by doing a point-of-care test. The complete blood count is not helpful in the setting of gastroenteritis. The presence of a leukocytosis may be due to a more serious underlying infection or may be due to stress form vomiting. Electrolyte values, serum bicarbonate, and serum BUN, or BUN/Cr ratio all have limited value in the assessment of dehydration. Similarly, urine studies do not need to confirm the diagnosis of dehydration. Laboratory testing should be reserved for infants < 1 year of age, those with severe dehydration, and patients with an altered mental status at baseline and should be considered in patients with atypical features.
- Eliminate radiographic testing in patients with gastroenteritis. Radiographs are of no use in patients with typical signs and symptoms of gastroenteritis. These can only be helpful if another diagnosis (eg, bowel obstruction) is being entertained.
- Order stool studies selectively. In general, stool studies are expensive, time-consuming, and low yield. Consider obtaining stool cultures in patients with epidemiological risk factors supporting the diagnosis of bacterial enteritis, with temperature > 38.5°C (101.3°F), and in whom empiric antibiotics will be prescribed. It is also reasonable to send cultures on patients with significant white blood cells or red blood cells on stool microscopy. Testing for ova and parasites should be done in immunocompromised patients and in patients that have had recent international travel.
- Oral rehydration is preferred to IV rehydration in most patients able to tolerate oral intake. Hydration with oral fluids has several advantages including cost and patient satisfaction, and it buys you a period of observation in the ED, during which time the parents of the patient are directly observing that their child is able to tolerate oral fluids.
- Oral ondansetron has been shown to be effective in treating nausea in patients with acute gastroenteritis. In the ED setting, ondansetron has been found to be safe and effective at decreasing vomiting and the need for admission. Although some pediatric emergency medicine specialists prefer to only give 1 dose of ondansetron in the ED, others prefer to send patients home with a small prescription for additional tablets in case the symptoms return.
- Implement an evidence-based practice guideline regarding laboratory testing, need for IV hydration, and the use of antiemetic agents in the ED. Implementation of a multidisciplinary evidence-based pathway will likely reduce the need for hospital admissions, laboratory testing, and rehydration using IV fluids. In studies out of Australia and Cincinnati, the implementation of evidence-based guidelines for gastroenteritis resulted in a significant drop in hospital admissions.

tip, applied pressure to the fingertip for 5 seconds, and then used high-speed digital photography and computer software to determine how long it took for the finger to return to its baseline color. In a prospective study of 83 children with gastroenteritis, digitally measured capillary refill time performed better than conventional capillary refill and overall clinical assessment in determining dehydration. Digital capillary refill time had an overall sensitivity of 100% (95% CI, 75%-100%) and specificity of 91% (95% CI, 82%-97%) in determining ≥ 5% dehydration.[132]

Ultrasound Of The Inferior Vena Cava To Assess Dehydration

Bedside ultrasound measurement of the inferior vena cava (IVC) and aorta (Ao) has been shown to be useful in objectively assessing children with dehydration.[133-136] In a prospective case-control study involving a total of 72 pediatric patients, 36 children with clinical evidence of dehydration (56% due to gastroenteritis) requiring IV fluid resuscitation were matched with 36 age-, gender-, and weight-matched controls.[134] Compared to controls, the dehydrated children had a significantly lower IVC/Ao ratio (mean 0.75 vs 1.01, mean difference 0.26 [95% CI, 0.18-0.35, $P < 0.001$]). These 36 cases were also self-matched after receiving IV hydration with 25 to 50 mL/kg of normal saline (median amount of 20 mL/kg). Compared to post-hydration measurements, the pre-hydration cases had a significantly lower IVC/Ao ratio (mean of 0.75 vs 1.09, mean difference 0.34 [95% CI, 0.29-0.34, $P < 0.001$]). Using a post-hoc cutoff ratio of 0.72, the test had a sensitivity of 39% and a specificity of 100%. With a cutoff ratio of 1.0, the test has a sensitivity of 97% and a specificity of 58%.[134] In a separate study involving a total of 75 pediatric patients, the finding of complete IVC collapse during inspiration was 25% sensitive and 100% specific for dehydration.[135]

Dextrose-Containing Fluids For Rehydration

The addition of dextrose to rehydration solutions stimulates insulin release while inhibiting glucagon release. These actions stop lipolysis and the production of ketone bodies, and thereby decrease nausea and vomiting. Furthermore, utilization of the sodium-glucose cotransport mechanism across the intestinal villi is also thought to enhance rehydration. These observations have led some researchers to believe that early administration of dextrose to patients receiving IV fluid hydration will help terminate vomiting and decrease outpatient treatment failures. A recent retrospective case-control study involving 168 children who received IV fluid in the ED for the treatment of dehydration secondary to acute gastroenteritis reported that the addition of dextrose to rehydration solutions was associated with a decrease in 72-hour return visit for hospital admission.[137]

Disposition

The vast majority of children with acute gastroenteritis can be managed as outpatients. **(See Sample Discharge Instructions on page 14.)** Hospital admission should be considered in children at high-risk for morbidity (eg, children < 1 year old, very-low birth weight children), children with significant medical comorbidities (especially those affecting the ability to relate thirst and dehydration), children with electrolyte abnormalities that require IV repletion, and children with severe dehydration. Acidosis has been found to correlate with hospital admission in some, but not all studies.

Short stay hospitalization (ie, < 23 hours) or observation units provide adequate time for rehydration for the majority of patients with acute gastroenteritis who need to be admitted for dehydration. A retrospective review of 208 hospitalized patients with dehydration secondary to acute gastroenteritis noted that the time from hospital admission to adequate rehydration (defined as a drop in urine-specific gravity to 1.010 or less) was < 12 hours in 165 out of 208 (79%) patients and < 24 hours in 197 out of 208 (95%) patients.[138]

Observation units have been credited with improving patient satisfaction, lowering patient charges, and having consistently demonstrated quality of care comparable to inpatient units. Optimal use of an observation unit is predicated on selecting a population of patients that will likely improve in < 24 hours. As a quality improvement measure, unplanned inpatient admissions are often reviewed to determine the appropriateness of admission to the observation unit. Mallory et al evaluated the appropriateness of admission of 82 pediatric patients with dehydration secondary to gastroenteritis who were initially admitted to a pediatric observation unit but then had an unplanned inpatient admission. He compared the historical, physical examination, and laboratory characteristics of these patients with 348 pediatric patients admitted with the same diagnosis to the pediatric observation unit who were successfully discharged before 24 hours. No significant differences were found between the 2 groups with respect to these variables.[139]

Summary

Acute gastroenteritis is a common illness that can result in significant dehydration in infants and young children. Luckily, most cases are mild and require little more than an adequate clinical examination and oral rehydration. Intravenous fluids are rarely needed and should be reserved for children who present with severe dehydration. Following resolution of the illness, a normal low-fat diet should be resumed.

Case Conclusion

After talking to the mom, you realized that the pediatrician never evaluated the patients and only told the mom by telephone that her kids may need IV hydration. You convinced mom to let you try ODT ondansetron followed by oral hydration therapy. Since none of the kids appeared that ill, you decided not to do any additional testing.

Practice Recommendations

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References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available.

1. King CK, Glass R, Bresee JS, et al. Centers for Disease Control and Prevention. Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy. *MMWR Recomm Rep.* 2003;52;1-16. (**Practice guideline**)
2. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year. *Lancet.* 2003;361:2226-2234.
3. Lopez AD, Begg S, Bos E. Demographic and epidemiological characteristics of major regions, 1990-2001. In Lopez AD, Mathers CD, Ezzati M, eds. Global burden of disease and risk factors. 1st ed. Washington, DC: The World Bank and Oxford University Press; 2006:17-44.
4. Glass RI, Lew JF, Gangarosa RE, et al. Estimates of the morbidity and mortality rates for diarrheal disease in American children. *J Pediatr.* 1991;118:S27-S33. (**Review**)
5. Fischer TK, Vibound C, Parashar U, et al. Hospitalizations and deaths from diarrhea and rotavirus among children <5 years of age in the United States, 1993-2003. *J Infect Dis.* 2007;195:1117-1125. (**Review**)
6. Maleck MA, Curtis AT, Holman RC, et al. Diarrhea- and rotavirus-associated hospitalizations among children less than 5 years of age: United States, 1997 and 2000. *Pediatr.* 2006117:1887-1892. (**Review**)
7. Tucker AW, Haddix AC, Bresee JS, et al. Cost-effectiveness analysis of a rotavirus immunization program for the United States. *JAMA.* 1998;279:1371-1376.
8. Widdowson MA, Meltzer MI, Zhang X, et al. Cost-effectiveness and potential impact of rotavirus vaccination in the United States. *Pediatr.* 2007;119:684-697.
9. Lee BP, Azimi PH, Staat MA, et al. Nonmedical costs associated with rotavirus disease requiring hospitalization. *Pediatr Infect Dis J.* 2005;24:984-988.
10. Kilgore PE, Holman RC, Clarke MJ, et al. Trends of diarrheal disease-associated mortality in US children, 1968 through 1991. *JAMA.* 1995:274:1143-1148. (**Epidemiologic data**)
11. Ho MS, Glass RI, Pinsky PF, et al. Diarrheal deaths in American children. Are they preventable? *JAMA.* 1988;260:3281-3285. (**Review**)
12. Gibson JJ, Alexander GR. Correlates of infant death from infectious diarrhea in the southeastern United States. *South Med J.* 1985;78:26-30. (**Epidemiologic data**)
13. Bern C, Lew J, McFeeley P, et al. Diarrheal deaths in children living in New Mexico: toward a strategy of preventive interventions. *J Pediatr.* 1993;122:920-922. (**Retrospective analysis**)
14. Parashar UD, Kilgore PE, Holman RC, et al. Diarrheal mortality in US infants. Influence of birth weight on risk factors for death. *Arch Pediatr Adolesc Med.* 1998;152:47-51. (**Retrospective analysis**)
15. Velázquez FR, Matson DO, Calva JJ, et al. Rotavirus infections in infants as protection against subsequent infections. *N Engl J Med.* 1996;335:1022-1028. (**Observational cohort study; 200 patients**)
16. Fischer TK, Valentiner-Branth P, Steinsland H, et al. Protective immunity after natural rotavirus infection: a community cohort study of newborn children in Guinea-Bissau, west Africa. *J Infect Dis.* 2002;186:593-597. (**Observational cohort study; 200 infants followed for up to 2 years**)
17. Reves RR, Hossain MM, Midthun K, et al. An observational study of naturally acquired immunity to rotaviral diarrhea in a cohort of 363 Egyptian children. Calculation of risk for second episodes using age-specific person-years of observation. *Am J Epidemiol.* 1989;130:981-988. (**Observational cohort; 363 infants follow for 2 years**)
18. Bernstein DI, Sander DS, Smith VE, et al. Protection from rotavirus reinfection: 2-year prospective study. *J Infect Dis.* 1991;164:277-283. (**Observational cohort; 163 infants followed over 2 years**)
19. Bhan MK, Lew JF, Sazawal S, et al. Protection conferred by neonatal rotavirus infection against subsequent rotavirus diarrhea. *J Infect Dis.* 1993;168:282-287. (**Observational cohort; 204 infants**)
20. Velaquez FR. Protective effects of natural rotavirus infection. *Pediatr Infect Dis J.* 2009;28 Suppl:S54-S56.
21. Canani RB, Cirillo P, Roggero P, et al. Therapy with gastric acid inhibitors increases the risk of acute gastroenteritis and community-acquired pneumonia in children. *Pediatr.* 2006;117:e817-820. (**Case-control study; 186 subjects**)
22. Marshall GS. Rotavirus disease and prevention through vaccination. *Pediatr Infect Dis J.* 2009;28:355-362.
23. Golding J, Emmett PM, Rogers IS. Gastroenteritis, diarrhoea and breast feeding. *Early Hum Dev.* 1997;49 Suppl:S83-S103. (**Review**)
24. Howie PW, Forsyth JS, Ogston SA, et al. Protective effect of breast feeding against infection. *BMJ.* 1990;300:11-16.
25. Dewey KG, Heinig J, Nommsen-Rivers LA. Differences in morbidity between breast-fed and formula-fed infants. *J Pediatr.* 1995;126:696-702.
26. Fuchs SC, Victora CG, Martines J. Case-control study of risk of dehydrating diarrhea in infants in vulnerable period after full weaning. *BMJ.* 1996;313:391-394.
27. Quigley MA, Kelly YJ, Sacker A. Breastfeeding and hospitalization for diarrheal and respiratory infection in the United Kingdom Millennium Cohort Study. *Pediatr.* 2007;119:e837-e842.
28. Practice parameter: the management of acute gastroenteritis in young children. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute

Gastroenteritis. *Pediatr.* 1996;97:424-435. (**Practice guideline**)
29. Sandhu BK; European Society of Paediatric Gastroenterology, Hepatology, and Nutrition Working Group on Acute Diarrhea. Practical guidelines for the management of gastroenteritis in children. *J Pediatr Gastroenterol Nutr.* 2001;33:S36-S39. (**Review/guideline**)
30. Cincinnati Children's Hospital Medical Center. Evidence-based clinical care guidelines for acute gastroenteritis in children aged 2 months through 5 years: Cincinnati Children's Medical Center; 2006 May 15. http://www.guideline.gov/summary/summary.aspx?doc_id=9529&nbr=5079&ss=15. (**Practice guideline**)
31. National Institute for Health and Clinical Excellence. Diarrhoea and vomiting caused by gastroenteritis: diagnosis, assessment and management in children younger than 5 years. National Collaborating Centre for Women's and Children's Health 2009 Apr. 174 http://guidance.nice.org.uk/CG84. (**Practice guideline**)
32. Colletti JE, Brown KM, Sharieff GQ, et al. ACEP Pediatric Emergency Medicine Committee. The management of children with gastroenteritis and dehydration in the emergency department. *J Emerg Med.* 2010;38:686-698. (**Practice guideline**)
33. Bezerra JA, Stathos TH, Duncan B, et al. Treatment of infants with acute diarrhea: What's recommended and what's practiced. *Pedaitr.* 1992;90:1-4.
34. Reis EC, Goepp JG, Katz S, et al. Barriers to use of oral rehydration therapy. *Pediatr.* 1994;93:708-711.
35. Szajewska H, Hoekstra JH, Sandhu B. Management of acute gastroenteritis in Europe and the impact of the new recommendations: A multicenter study. *J Pediatr Gastroenterol Nutr.* 2000;30:522-527.
36. Hoekstra JH; European Society of Paediatric Gastroenterology, Hepatology, and Nutrition Working Group on Acute Diarrhea. Acute gastroenteritis in industrialized countries: compliance with guidelines for treatment. *J Pediatr Gastroenterol Nutr.* 2001;33:S31-S35. (**Review/guideline**)
37. Flores G, Lee M, Bauchner H, et al. Pediatricians' attitudes, beliefs, and practices regarding clinical practice guidelines: a national survey. *Pediatr.* 2000;105:496-501. (**Survey; 627 respondents**)
38. Marcos LA, DuPont HL. Advances in defining etiology and new therapeutic approaches in acute diarrhea. *J Infect.* 2007;55:385-393.
39. Wilhelmi I, Roman E, Sanchez-Fauquier A. Viruses causing gastroenteritis. *Clin Microbiol Infect.* 2003;9:247-262. (**Review**)
40. Brandt CD, Kim HW, Rodriguez WJ, et al. Pediatric viral gastroenteritis during eight years of study. *J Clin Microbiol.* 1983;18:71-78. (**Epidemiologic data**)
41. Uhnoo I, Wadell G, Svensson L, et al. Aetiology and epidemiology of acute gastroenteritis in Swedish children. *J Infect.* 1986;73-89.
42. Caeiro JP, Mathewson JJ, Smith MA, Jiang ZD, Kaplan MA, DuPont HL. Etiology of outpatient nondysenteric diarrhea: A multicenter study in the United States. *Pediatr Infect Dis J.* 1999;18:94-97.
43. Waters V, Ford-Jones EL, Petric M, et al. Etiology of community-acquired pediatric viral diarrhea: A prospective longitudinal study in hospitals, emergency departments, pediatric practices and child care centers during the winter rotavirus outbreak, 1997 to 1998. *Pediatr Infect Dis J.* 2000;19:843-848.
44. Klein EJ, Boster DR, Stapp JR, et al. Diarrhea etiology in a Children's Hospital Emergency Department: A prospective cohort study. *Clin Infect Dis.* 2006;43:807-813
45. Lyman WH, Walsh JF, Kotch JB, Weber DJ, Gunn E, Vinje J. Prospective study of etiologic agents of acute gastroenteritis outbreaks in child care centers. *J Pediatr.* 2009;154:253-257.
46. Vernacchio L, Vezina RM, Mitchell AA, et al. Diarrhea in American infants and young children in the community setting – incidence, clinical presentation, and microbiology. *Pediatr Infect Dis J.* 2006;25:2-7. (**Review**)
47. Denno DM, Stapp JR, Boster DR, et al. Etiology of diarrhea in pediatric outpatient settings. *Pediatr Infect Dis J.* 2005;24:142-148.
48. Vernacchio L, Vezina RM, Mitchell AA, et al. Characteristics of persistent diarrhea in a community-based cohort of young US children. *J Pediatr Gastroenterol Nutr.* 2006;43:52-58. (**Prospective; 50 patients**)
49. DeWitt TG, Humphrey KF, McCarthy P. Clinical predictors of acute bacterial diarrhea in young children. *Pediatr.* 1985;76:551-556.
50. Finkelstein JA, Schwartz JS, Torrey S, et al. Common clinical features as predictors of bacterial diarrhea in infants. *Am J Emerg Med.* 1989;7:469-473. (**Prospective; 1035 infants**)
51. De Zoysa I, Feachem RG. Interventions for the control of diarrhoeal disease among young children: rotavirus and cholera immunization. *Bull World Health Organ.* 1985;63:569–583. (**Review**)
52. Parashar UD, Hummelman EG, Bresee JS, et al. Global illness and deaths caused by rotavirus disease in children. *Emerg Infect Dis.* 2003 May. Available from: URL: http://www.cdc.gov/ncidod/EID/vol9no5/02-0562.htm (**Meta-analysis**)
53. Parashar UD, Burton A, Lanata C, et al. Global mortality associated with rotavirus disease among children in 2004. *J Infect Dis.* 2009;200 Suppl 1:S9-S15. (**Review**)
54. Jin S, Kilgore P, Holman RC, Clarke MJ, Gangarosa EJ, Glass RI. Trends in hospitalizations for diarrhea in the United States children from 1979 through 1992: estimates of the morbidity associated with rotavirus. *Pediatr Infect Dis J.* 1996:15:397-404. (**Review**)
55. Glass RI, Kilgore PE, Holman RC, et al. The epidemiology of rotavirus diarrhea in the United States: surveillance and estimates of disease burden. *J Infect Dis.* 1996;174 suppl 1:S5-11. (**Epidemiologic data**)
56. Parashar UD, Holman RC, Clarke MJ, et al. Hospitalizations associated with rotavirus diarrhea in the United States, 1993 through 1995: Surveillance based on the new ICD-9-CM rotavirus-specific diagnostic code. *J Infect Dis.* 1998;177:13-17.
57. Yee EL, Staat MA, Azimi P, et al. Burden of rotavirus disease among children visiting pediatric emergency departments in Cincinnati, Ohio, and Oakland, California, in 1999-2000. *Pediatr.* 2008;122:971-977. (**Review**)
58. Malek MA, Curns AT, Holman RC, et al. Diarrhea- and rotavirus-associated hospitalizations among children less than 5 years of age: United States, 1997 and 2000. *Pediatr.* 2006;117:1887-1892. (**Review**)
59. Fischer TK, Viboud C, Parashar U, et al. Hospitalizations and deaths from diarrhea and rotavirus among children <5 years of age in the United States, 1993-2003. *J Infect Dis.* 2007;195:1117-1125. (**Review**)
60. Charles MD, Holman RC, Curns AT, et al. Hospitalizations associated with rotavirus gastroenteritis in the United States, 1993-2002. *Pediatr Infect Dis J.* 2006;25:489-493. (**Retrospective analysis**)
61. Payne DC, Staat MA, Edwards KM, et al. Active, population-based surveillance for severe rotavirus gastroenteritis in children in the United States. *Pediatr.* 2008;122:1235-1243. (**Prospective; 739 patients**)
62. Rodriguez VA, Silverman ME, Cochrane DG, et al. Biosurveillance of ED visits for gastroenteritis. *Am J Emerg Med.* 2007;25:535-539. (**Epidemiologic data**)
63. Rodriguez WJ, Kim HW, Arrobio JO, et al. Clinical features of acute gastroenteritis associated with human reovirus-like agent in infants and young children. *J Pediatr.* 1977;91:188-193. (**Review**)
64. Uhnoo I, Olding-Stenkvist E, Kreuger A. Clinical features or acute gastroenteritis associated with rotavirus, enteric adenoviruses, and bacteria. *Arch Dis Child.* 1986;61:731-738.
65. Staat MA, Azimi PH, Berke T, et al. Clinical presentation of rotavirus infection among hospitalized children. *Pediatr Infect Dis J.* 2002;21:221-227. (**Prospective; 68 patients**)
66. Coffin SE, Elser J, Marchant C, et al. Impact of acute rota-

virus gastroenteritis on pediatric outpatient practices in the United States. *Pediatr Infect Dis J.* 2006;25:584-589. (**Prospective multicenter; 303 patients**)
67. Poulton J, Tarlow MJ. Diagnosis of rotavirus gastroenteritis by smell. *Arch Dis Child.* 1987:62:851-852. (**Prospective; 68 specimens**)
68. Staat MA, Fairbrother G, Edwards KM, et. al. Delayed onset and diminished magnitude of rotavirus activity - United States, November 2007 - May 2008. *MMWR.* 2008;57:697-700. (**Epidemiologic data**)
69. Panozzo CA, Tate JE, Payne DC, et al. Reduction in rotavirus after vaccine introduction - United States 2000-2009. *MMWR.* 2009;58:1146-1149. (**Epidemiologic data**)
70. Patel MM, Widdowson MA, Glass RI, et al. Systemic literature review of role of norovirus in sporadic gastroenteritis. *Emerg Infect Dis.* 2008;14:1224-1231. (**Review**)
71. Glass RI, Parashar UD, Estes MK. Norovirus gastroenteritis. *N Engl J Med.* 2009;361:1776-1785. (**Review**)
72. Frankhauser RL, Noel JS, Monroe SS, et al. Molecular epidemiology of "Norwalk-like viruses" in outbreaks of gastroenteritis in the United States. *J Infect Dis.* 1998;178:1571-1578.
73. Jenkins P, Green S, Davis JP, et al. Norovirus activity – United States, 2006-2007. *MMWR.* 2007;56:842-846.
74. Narkeviciute I, Tamusauskaite. Peculiarities of norovirus and rotavirus infections in hospitalized young children. *J Pediatr Gastroenterol Nut.* 2008;46:289-292. (**Retrospective; 140 patients**)
75. Wu TC, Liu HH, Chen YJ, et al. Comparison of clinical features of childhood norovirus and rotavirus gastroenteritis in Taiwan. *J Chin Med Assoc.* 2008;71:566-570. (**Prospective; 201 patients**)
76. Junquera CG, de Baranda CS, Mialdea OG, et al. Prevalence and clinical characteristics of norovirus gastroenteritis among hospitalized children in Spain. *Pediatr Infect Dis J.* 2009;28:604-607. (**Prospective, 352 patients**)
77. Chen SY, Tsai CN, Lai MW, et al. Norovirus infection as a cause of diarrhea-associated benign infantile seizures. *Clin Infect Dis.* 2009;48:849-855. (**Prospective observational; 353 patients**)
78. Narchi H. Benign afebrile cluster convulsions with gastroenteritis: An observational study. *BMC Pediatr.* 2004;4:2. (**Prospective observational; 14 patients**)
79. Haffejee IE. The pathophysiology, clinical features and management of rotavirus diarrhoea. *Q J Med.* 1991;288:289-299. (**Review**)
80. Tajiri H, Kiyohara Y, Tanaka T, et al. Abnormal computed tomography findings among children with viral gastroenteritis and symptoms mimicking acute appendicitis. *Pediatr Emerg Care.* 2008;24:601-604. (**Retrospective; 302 patients**)
81. Steiner MJ, DeWalt DA, Byerley JS. Is this child dehydrated? *JAMA.* 2004;291:2746-2754. (**Review**)
82. Wathen JE, MacKenzie T, Bothner JP. Usefulness of the serum electrolyte panel in the management of pediatric dehydration treated with intravenously administered fluids. *Pediatr.* 2004;114:1227-1234. (**Prospective; 182 patients**)
83. Reid SR, Losek JD. Hypoglycemia complicating dehydration in children with acute gastroenteritis. *J Emerg Med.* 2005;29:141-145. (**Retrospective; 196 patients**)
84. Pawlowicz M, Birkholz D, Niedzwiecki M, et al.Difficulties or mistakes in diagnosing type 1 diabetes mellitus? The consequences of delayed diagnosis. *Pediatr Endocrinol Diabetes Metab.* 2008;14:7-12. (**Retrospective anaylsis; 335 patients**)
85. Madati PJ, Bachur R. Development of an emergency department triage tool to predict acidosis among children with gastroenteritis. *Pediatr Emerg Care.* 2008;24:822-8830. (**Prospective; 103 patients**)
86. Graham JM, Fitzpatrick EA, Black KJ. "My child can't keep anything down!" Interviewing parents who bring their preschoolers to the emergency department for diarrhea, vomiting, and dehydration. *Pediatr Emerg Care.* 2010;26:251-256.
87. Freedman SB, Deiratany S, Goldman RD, et al. Development of a caregiver gastroenteritis knowledge questionnaire. *Ambul Pediatr.* 2002;8:261-265.
88. Mackenzie A, Barnes G, Shann F. Clinical signs of dehydration in children. *Lancet.* 1989;334:605-607.
89. Porter SC, Fleisher GR, Kohane IS,et al. The value of parental report for diagnosis and management of dehydration in the emergency department. *Ann Emerg Med.* 2003;41:196-205. (**Prospective observational; 132 patients**)
90. Gorelick MH, Shaw KN, Murphy KO. Validity and reliability of clinical signs in the diagnosis of dehydration in children. *Pediatr.* 1997;99:E6. (**Prospective cohort; 186 patients**)
91. Vega RM, Avner JR. A prospective study of the usefulness of clinical and laboratory parameters for predicting percentage dehydration in children. *Pediatr Emerg Care.* 1997;13:179-182. (**Prospective; 97 children**)
92. Duggan C, Refat M, Hashem M, et al. How valid are the clinical signs of dehydration in infants? *J Pediatr Gastroenterol Nutr.* 1996;22:56-61. (**Prospective cohort; 135 patients**)
93. Freidman JN, Goldman RD, Srivastava R, et al. Development of a clinical dehydration scale for use in children between 1 and 36 months of age. *J Pediatr.* 2004;145:201-207. (**Prospective cohort; 137 patients**)
94. Steill IG, Wells GA. Methodologic standards for the development of clinical decision rules in emergency medicine. *Ann Emerg Med.* 1999;33:437-447.
95. Goldman RD, Friedman JN, Parkin PC. Validation of the clinical dehydration scale for children with acute gastroenteritis. *Pediatr.* 2008;122:545-549. (**Prospective observational; 205 patients**)
96. Liebelt EL. Clinical and laboratory evaluation and management of children with vomiting, diarrhea, and dehydration. *Curr Opin Pediatr.* 1998;10:461-469.
97. DeWalt DA. Dehydration in infants and young children. *Ann Emerg Med.* 2009;53:395-397.
98. Bonadio WA, Hennes HH, Machi J, et al. Efficacy of measuring BUN in assessing children with dehydration due to gastroenteritis. *Ann Emerg Med.* 1989;18:81-83. (**Prospective case study; 50 patients**)
99. Narchi H. Serum bicarbonate and dehydration severity in gastroenteritis. *Arch Dis Child.* 1998;78:70-71. (**Letter**)
100. Yilmaz K, Karaboculglu M, Citak A, et al. Evaluation of laboratory tests in dehydrated children with acute gastroenteritis. *J Paediatr Child Health.* 2002;38:226-228. (**Retrospective; 168 patients**)
101. Shaoul R, Okev N, Tamir A, et al. Value of laboratory studies in assessment and dehydration in children. *Ann Clin Biochem.* 2004;41:192-196. (**Retrospective; 300 patients**)
102. Poole SR. Criteria for measurement of dehydration. *Ann Emerg Med.* 1990;19:730-731.
103. Reid SR, Bonadio WA. Outpatient rapid intravenous rehydration to correct dehydration and resolve vomiting in children with acute gastroenteritis. *Ann Emerg Med.* 1996;28:318-323. (**Prospective cohort; 58 patients**)
104. Teach SJ, Yates EW, Feld LG. Laboratory predictors of fluid deficit in acutely dehydrated children. *Clin Pediatr.* 1997;36:395-400. (**Prospective cohort; 40 patients**)
105. Amin SS, Jusniar B, Suharjono. Blood urea nitrogen in gastroenteritis with dehydration. *Pediatr Indones.* 1980;20:77-80. (**36 patients**)
106. Steiner MJ, Nager AL, Wang VJ. Urine specific gravity and other urinary indices – Inaccurate tests for dehydration. *Pediatr Emerg Care.* 2007;23:298-303. (**Prospective cohort; 79 patients**)
107. Dennehy PH, Gauntlett DR, Tente WE. Comparison of nine commercial immunoasays for the detection of rotavirus in fecal specimends. *J Clin Microbiol.* 1988;26:1630-1634.
108. Huicho L, Campos M, Rivera J, et al. Fecal screening tests in the approach to acute infectious diarrhea: A scientific overview. *Pediatr Infect Dis J.* 1996;15:486-494.
109. Herbert M. Medical Myth: Measuring white blood cells in the stools is useful in the management of acute diarrhea. *West J Med.* 2000;172:414.

110. Marcus N, Mor M, Amir L, et al. The quick-read c-reactive protein test for the prediction of bacterial gastroenteritis in the pediatric emergency department. *Pediatr Emerg Care.* 2007;23:634-637.
111. Ben-Horin S, Farel Z, Mouallem M. Gastroenteritis-associated hyperamylasemia – Prevalence and clinical significance. *Arch Intern Med.* 2002;162:689-692.
112. Neville KA, Verge CF, O'Meara MW, et al. High antiduuretic hormone levels and hyponatremia in children with gastroenteritis. *Pediatr.* 2005;116:1401-1407.
113. Reid S, McQuillan S, Losek J. Hypoglycemia complicating dehydration due to acute gastroenteritis. *Clin Pediatr.* 2003;42:641-646.
114. Hampers LC, Cha S, Gutglass DJ, et al. The effect of price ordering information on test ordering behavior and patient outcomes in a pediatric emergency department. *Pediatr.* 1999;103:877-882. (**Prospective, nonblind, controlled**)
115. Powell EC, Hampers LC. Physician variation in test ordering in the management of gastroenteritis in children. *Arch Pediatr Adolesc Med.* 2003;1157:978-983. (**Prospective observational; 15 providers**)
116. Hampers LC, Cha S, Gutglass DJ, et al.Fast track and the pediatric emergency department: Resource utilization and patient outcomes. *Acad Emerg Med.* 1999;6:1153-1159
117. Hampers LC, Cha S, Gutglass DJ, et al. Language barriers and resource utilization in a pediatric emergency department. *Pediatr.* 1999;103:1253-1256. (**Prospective cohort; 2467 patients**)
118. Ozuah PO, Avner JR, Stein RE. Oral rehydration, emergency physicians, and practice parameters: a national survery. *Pediatrics.* 2002; 109(2):259-261. (**National survey; 176 respondents**)
119. Kwon, K, Rudkin, S, Langdorf ML. Antiemetic Use in Pediatric Gastroenteritis: A National Survey of Emergency Physicians, Pediatricians, and Pediatric Emergency Physicians. *Clin Ped.* 2002:641-652. (**Cross-sectional National survey; 593 respondents**)
120. Uhlig U. Dimenhydrinate in children with infectious gastroenteritis: A prospective, RCT. *Pediatrics.* 2009; 124:e622-632. (**Randomized control trial; 243 patients**)
121. Ross Decamp R, Byerley J, Doshi N, et al. Use of antiemetic agents in acute gastroenteritis. *Arch Pediatr Adolesc Med.* Vol 162 (No 9). Sep 2008 (**Systematic Review and meta-analysis; 11 articles met inclusion criteria**)
122. Freedman SB, Adler M, Seshadri R, et al. Oral ondansetron for gastroenteritis in a pediatric emergency department. *N Engl J Med.* 2006;354:1698-1705. (**Prospective**)
123. Roslund G, Hepps, TS, McQuillen KK. The role of oral ondansetron in children with vomiting as a result of acute gastritis/gastroenteritis who have failed oral rehydration therapy: A randomized controlled trial. *Ann Emerg Med.* 2008: 52:22-29. (**Prospective; 106 patients**)
124. World Health Organization. The management of bloody diarrhoea in young children. WHO, Geneva, Switzerland, 1994 (WHO/CDD/94.49) (**Policy/guideline**)
125. Santos M. Use of racecadotril as outpatient treatment for acute gastroenteritis: a prospective, randomized, parallel study. *J Pediatr.* 2009; 155: 62-67. (**Prospective, randomized; 189 patients**)
126. Szajewska H, Dziechciarz P, Mrukowicz J. Meta-analysis: smectite in the treatment of acute infectious diarrhea in children. *Aliment Pharmacol Ther.* 2006;23:217-227. (**Meta-analysis; 9 randomized controlled trials**)
127. Alam S, Mushtaw M. Antibiotic associated diarrhea in children. *Indian Pediatrics.* 2009; 46: 491-496. (**Review**)
128. Wistrom J, Norrby SR, Myhre EB, et al. Frequency of antibiotic associated diarrhoea in 2462 antibiotic-treated hospitalized patients: a prospective study. *J Antimicrob Chemother.* 2001; 47: 43-50. (**Prospective; 2462 patients**)
129. Szajewska H, Ruszczynski M, Radzikowski A. Probiotics in the prevention of antibiotic-associated diarrhea: a meta-analysis of randomized controlled trials. *J Pediatr.* 2006; 149: 367-372 (**Meta-anaylsis; 6 randomized control trials**)
130. Solana Garcia MJ, Lopez Lopez R, Gutierrez J, et al. Use of capnography in acute gastroenteritis. *An Pediatr.* (Barc). 2008;68:342-345.
131. Nagler J, Wright RO, Krauss B. End-tidal carbon dioxide as a measure of acidosis among children with gastroenteritis. *Pediatr.* 2006;118:260-267. (**Prospective; 146 patients**)
132. Shavit I, Brant R, Nijssen-Jordan C, et al. A novel imaging technique to measure capillary-refill time: improving diagnostic accuracy for dehydration in young children with gastroenteritis. *Pediatr.* 2006;118:2402-2408. (**Prospective; 83 patients**)
133. Kosiak W, Swieton D, Piskunowicz M. Sonographic inferior vena cava/aorta diameter index, a new approach to the body fluid status assessment in children and young adults in emergency ultrasound - preliminary study. *Am J Emerg Med.* 2008;26:320-325.
134. 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. (**Prospective observational; 36 pairs with matched controls**)
135. Ayvazan S, Dickman E, Likourezos A, et al. Ultrasound of the inferior vena cava can assess volume status in pediatric patients. *Ann Emerg Med* 2009;54:S102.
136. Levine AC, Shah S, Noble VE, Epino H. Ultrasound assessment of dehydration in children with gastroenteritis. *Ann Emerg Med.* 2009;54:S91.
137. Levy JA, Bachur RG. Intravenous dextrose during outpatient rehydration in pediatric gastroenteritis. *Acad Emerg Med.* 2007;14:324-331. (**Case control study; 56 cases and 112 controls**)
138. McConnochie KM, Conners GP, Lu E, Wilson C. How commonly are children hospitalized for dehydration eligible for care in alternative settings? *Arch Pediatr Adolesc Med.* 1999;153:1233-1241. (**Retrospective; 208 patients**)
139. Mallory MD, Kadish H, Zebrak M, et al. Use of a pediatric observation unit for treatment of children with dehydration caused by gastroenteritis. *Pediatr Emerg Care.* 2006;22:1-6. (**Retrospective cohort with nested case-control; 430 patients**)

CME Questions

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1. **What are the 2 most common viruses that cause gastroenteritis?**
   a. Rotavirus and adenovirus
   b. Rotavirus and norovirus
   c. Sapovirus and astrovirus
   d. Norovirus and adenovirus

2. **A recent study showed which triad to be present in a higher percentage of rotavirus children versus those without rotavirus?**
   a. Vomiting, diarrhea, and fever
   b. Vomiting, diarrhea, and abdominal pain

c. Vomiting, diarrhea, and dysuria
d. Vomiting, bloody diarrhea, and abdominal pain

3. **What is the proposed cause of nausea and vomiting in gastroenteritis?**
   a. Gastric cell damage
   b. Destruction of gastrointestinal enterocyte cells
   c. Serotonin activation of the vomiting center
   d. There is no proposed mechanism

4. **What are the 3 most useful individual signs for predicting ≥ 5% dehydration in children?**
   a. Abnormal capillary refill time, sunken eyes, and sunken fontanelle
   b. Abnormal capillary refill time, abnormal skin turgor, and abnormal respiratory pattern
   c. Dry mucous membranes, absent tears, and abnormal skin turgor
   d. Increased heart rate, abnormal respiratory pattern, and hypotension

5. **What elements are included in the clinical dehydration score?**
   a. Dry mucous membranes, weak pulse, and abnormal respiratory pattern
   b. General appearance, mucous membranes, and tears
   c. General appearance, eyes, mucous membranes, and tears
   d. Prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern

6. **How should abnormal skin turgor be tested?**
   a. Pinch the cheek just lateral to the mouth
   b. Pinch the skin on the dorsum of the hand
   c. Pinch a small skin fool on the lateral abdominal way at the level of the umbilicus
   d. Pinch the skin just superior to the antecubital fossa

7. **Which of these children is most likely to be dehydrated?**
   a. A child with no history of diarrhea per the parent
   b. A child previously seen by their pediatrician during the same illness
   c. A child presenting for the first time during a particular illness
   d. A child with post-tussive emesis

8. **What is the best way to examine the abdomen of an infant or young child?**
   a. It is best to surprise them
   b. At the end of the physical examination
   c. When the child is calm, possibly sitting on the parents lap or sleeping
   d. Have the parents do it and give you a detailed description

9. **What is the mechanism of action of ondansetron?**
   a. Selective serotonin 5-HT3 receptor-blocking agent
   b. Opiate receptor agonist
   c. Decreased gut motility
   d. H1 antagonist

10. **Which ORS is recommended by the WHO?**
    a. Osmolarity < 270 mOsm/L in which the glucose and sodium content were each reduced to 75 mmol/L to give a total osmolarity of 245 mOsm/L
    b. Osmolarity 310
    c. Polymer-based ORS
    d. Diluted fruit juices or sports drinks

11. **How much of an initial PO bolus should be given to a moderately dehydrated child?**
    a. The amount of ORS should be based on what the child asks to drink
    b. Administer 50-100 mL of ORS/kg over 2-4 hours to replace the fluid deficit
    c. Administer 100-200 mL of ORS/kg over 12 hours to replace the fluid deficit
    d. Administer 20 mL of ORS/kg in the first hour, then ad lib

12. **In which patient population does the WHO recommend antimicrobial therapy?**
    a. Setting of febrile acute bloody diarrhea in young children
    b. All children with watery diarrhea
    c. Children under the age of 2 years
    d. If the parents ask for antibiotics

13. **Which antibiotics have a higher incidence of antibiotic associated diarrhea?**
    a. Gentamycin and vancomycin
    b. Levofloxacin and gentamycin
    c. Amoxicillin, amoxicillin/clavulanate, cephalosporins, and clindamycin
    d. All antibiotics have the same incidence in the pediatric population

14. **Which risk factors should alert the emergency medicine clinician that a child with cancer may be at higher risk for typhlitis?**
    a. Fever, vomiting, diarrhea
    b. History of chemotherapy in the last 2 weeks, mucositis, stem cell transplantation
    c. Sibling with similar symptoms
    d. Radiation therapy with chemotherapy in the last year

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5550 Triangle Parkway, Suite 150
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Pediatric Emergency Medicine Practice Acute Gastroenteritis — An Update

Singh A, Fleurat M. July 2010; Volume 7, Number 7

Gastroenteritis refers to inflammation of the lining of both the stomach and small intestines. The majority of cases are infectious, with viral organisms predominating; however, bacterial and parasitic infections can be a specific concern in the appropriate patient. This article will help the reader to cite the most common etiologies for pediatric diarrheal illness in the emergency department, identify historical and examination findings that predict the degree of pediatric dehydration, describe the rationale for the use of oral rehydration therapy in mild and moderately dehydrated children, and describe the risks and benefits for medication use in the treatment of acute gastroenteritis. For a more detailed and systematic look at acute gastroenteritis in the pediatric patient, see the full text article at www.ebmedicine.net.

Key Points	Comments
The 3 most useful signs in determining ≥ 5% dehydration are prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern.[81]	Prehospital care for the pediatric patient with acute gastroenteritis should focus on assessing the level of dehydration and initiation of fluid replacement to correct significant dehydration. Although contemporary pediatric dehydration scales are believed to give a more accurate reflection of the level of dehydration, these scales are far too complex to be of use in the prehospital setting. Prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern should be taught to paramedics and assessed in children who are believed to be hypovolemic.
Most children are not significantly dehydrated and do not require routine laboratory testing or IV hydration.	The utility of laboratory testing in estimating hydration status has been evaluated in multiple studies, with researchers testing about a dozen or so variables to aid in this task. In general, these studies conclude that no single laboratory value has adequate discriminatory power to distinguish clinically-significant dehydration and that the role of these tests is therefore limited.[28,32,81,96,97]
Oral rehydration solutions are cost-effective ways to treat mild to moderate dehydration.	For mild to moderate dehydration, administer 50 to 100 mL/kg of oral rehydration solution (ORS) over 2 to 4 hours to replace the fluid deficit, with additional ORS to replace ongoing losses. Use a teaspoon or dropper or nasogastric tube if necessary. In cases of severe dehydration, immediate IV rehydration with normal saline or Lactated Ringer's Solution should be administered at 20 mL/kg until vital signs and mental status return to normal. With frail or malnourished infants, 10 mL/kg should be administered as they may be unable to increase cardiac output in response to rehydration, and rehydration status should be reassessed frequently.
Serotonin-receptor blockers (eg ondansetron) can be used in the emergency department to alleviate nausea and vomiting, improve oral hydration, and cut-down on hospital admissions.	Ondansetron is a selective serotonin 5-HT3 receptor-blocking agent that previously was indicated for post-chemotherapy and post-surgical nausea and vomiting and has a very good side effect profile. One meta-analysis of 11 articles by Decamp et al published in 2008 reviewed antiemetics in the pediatric population, and the ondansetron studies were the most recently published and achieved the highest quality ratings. Overall, ondansetron compared to placebo reduced hospital admissions (number needed to treat [NNT] 14), reduced the need for intravenous fluid administration (NNT 5), and resulted in cessation of vomiting while in the emergency department.[121]
Following rehydration, an age-appropriate, unrestricted diet should begin as soon as possible. Partial dilution of formula, restriction of lactose, and use of the BRAT diet are not necessary.	There has been much confusion and folklore about optimal foods for children with gastroenteritis. Children who are not dehydrated should continue to eat a regular diet, and infants who are breastfeeding should continue to do so unless you are told otherwise by your pediatrician. Most children with diarrhea tolerate full-strength cow's milk products. It is not necessary to dilute or avoid milk products. Recommended foods include a combination of complex carbohydrates (rice, wheat, potatoes, bread), lean meats, yogurt, fruits, and vegetables. High fat foods are more difficult to digest and should be avoided. It is not necessary to restrict a child's diet to clear liquids or the BRAT diet (bananas, rice, applesauce, toast) as these diets are poor in nutritional content.

See reverse side for reference citations.

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REFERENCES

These references are excerpted from the original manuscript. For additional references and information on this topic, see the full text article at ebmedicine.net.

28. Practice parameter: the management of acute gastroenteritis in young children. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. *Pediatr*. 1996;97:424-435. **(Practice guideline)**
32. Colletti JE, Brown KM, Sharieff GQ, et al. ACEP Pediatric Emergency Medicine Committee. The management of children with gastroenteritis and dehydration in the emergency department. *J Emerg Med.* 2010;38:686-698. **(Practice guideline)**
81. Steiner MJ, DeWalt DA, Byerley JS. Is this child dehydrated? *JAMA.* 2004;291:2746-2754. **(Review)**
96. Liebelt EL. Clinical and laboratory evaluation and management of children with vomiting, diarrhea, and dehydration. *Curr Opin Pediatr.* 1998;10:461-469.
97. DeWalt DA. Dehydration in infants and young children. *Ann Emerg Med.* 2009;53:395-397.
121. Decamp LR, Byerley J, Doshi N, et al. Use of antiemetic agents in acute gastroenteritis. *Arch Pediatr Adolesc Med.* Vol 162 (No 9). Sep 2008 **(Systematic Review and meta-analysis; 11 articles met inclusion criteria)**

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