EB MEDICINE

PEDIATRIC EMERGENCY MEDICINE PRACTICE

AN EVIDENCE-BASED APPROACH TO PEDIATRIC EMERGENCY MEDICINE ▲ EBMEDICINE.NET

Acute Gastroenteritis: Evidence-Based Management of Pediatric Patients

February 2018
Volume 15, Number 2

Abstract

Although most cases of acute gastroenteritis require minimal medical intervention, severe dehydration and hypoglycemia may develop in cases of prolonged vomiting and diarrhea. The mainstay of treatment for mild-to-moderately dehydrated patients with acute gastroenteritis should be oral rehydration solution. Antiemetics allow for improved tolerance of oral rehydration solution, and, when used appropriately, can decrease the need for intravenous fluids and hospitalization. This issue reviews the common etiologies of acute gastroenteritis, discusses more-severe conditions that should be considered in the differential diagnosis, and provides evidence-based recommendations for management of acute gastroenteritis in patients with mild-to-moderate dehydration, severe dehydration, and hypoglycemia.

Author

KeriAnne Brady, MD, FAAP
Director of Pediatric Emergency Medicine Education, Attending Physician, Department of Emergency Medicine, New York-Presbyterian/Queens; Instructor of Emergency Medicine in Clinical Pediatrics, Weill Cornell Medical College, New York, NY

Peer Reviewers

Landon A. Jones, MD
Medical Director, Makenna David Pediatric Emergency Center, University of Kentucky, Department of Emergency Medicine, Assistant Professor, Emergency Medicine and Pediatrics, Lexington, KY

Alexander Toledo, DO, PharmD, FAAEM, FAAP
Chief, Section of Pediatric Emergency Medicine, Arizona Children's Center, Maricopa Medical Center, Clinical Assistant Professor of Child Health and Emergency Medicine, University of Arizona College of Medicine, Phoenix Campus, Phoenix, AZ

Prior to beginning this activity, see "Physician CME Information" on the back page.

Editors-in-Chief

Ilene Claudius, MD
Associate Professor, Department of Emergency Medicine and Pediatrics, USC Keck School of Medicine, Los Angeles, CA

Tim Horeczko, MD, MSCR, FACEP, FAAP
Associate Professor of Clinical Emergency Medicine, David Geffen School of Medicine, UCLA ; Core Faculty and Senior Physician, Los Angeles County-Harbor-UCLA Medical Center, Torrance, CA

Editorial Board

Jeffrey R. Avner, MD, FAAP
Chairman, Department of Pediatrics, Professor of Clinical Pediatrics, Maimonides Children's Hospital of Brooklyn, Brooklyn, NY

Steven Bin, MD
Associate Clinical Professor, UCSF School of Medicine; Medical Director, Pediatric Emergency Medicine, UCSF Benioff Children's Hospital, San Francisco, CA

Richard M. Cantor, MD, FAAP, FACEP
Professor of Emergency Medicine and Pediatrics; Director, Pediatric Emergency Department; Medical Director, Central New York Poison Control Center, Golisano Children's Hospital, Syracuse, NY

Steven Choi, MD, FAAP
Assistant Vice President, Montefiore Health System; Director, Montefiore Network Performance Improvement; Executive Director, Montefiore Institute for Performance Improvement; Associate Professor of Pediatrics, Albert Einstein College of Medicine, Bronx, NY

Ari Cohen, MD, FAAP
Chief of Pediatric Emergency Medicine, Massachusetts General Hospital; Instructor in Pediatrics, Harvard Medical School, Boston, MA

Jay D. Fisher, MD, FAAP
Clinical Professor of Pediatric and Emergency Medicine, University of Nevada, Las Vegas School of Medicine, Las Vegas, NV

Marianne Gausche-Hill, MD, FACEP, FAAP, FAEMS
Medical Director, Los Angeles County EMS Agency; Professor of Clinical Emergency Medicine and Pediatrics, David Geffen School of Medicine at UCLA; EMS Fellowship Director, Harbor-UCLA Medical Center, Department of Emergency Medicine, Los Angeles, CA

Michael J. Gerardi, MD, FAAP, FACEP, President
Associate Professor of Emergency Medicine, Icahn School of Medicine at Mount Sinai; Director, Pediatric Emergency Medicine, Goryeb Children's Hospital, Morristown Medical Center, Morristown, NJ

Sandip Godambe, MD, PhD
Chief Quality and Patient Safety Officer, Professor of Pediatrics and Emergency Medicine, Attending Physician, Children's Hospital of the King's Daughters Health System, Norfolk, VA

Ran D. Goldman, MD
Professor, Department of Pediatrics, University of British Columbia; Research Director, Pediatric Emergency Medicine, BC Children's Hospital, Vancouver, BC, Canada

Joseph Habboushe, MD, MBA
Assistant Professor of Emergency Medicine, NYU/Langone and Bellevue Medical Centers, New York, NY; CEO, MD Aware LLC

Alson S. Inaba, MD, FAAP
Pediatric Emergency Medicine Specialist, Kapiolani Medical Center for Women & Children; Associate Professor of Pediatrics, University of Hawaii John A. Burns School of Medicine, Honolulu, HI

Madeline Matar Joseph, MD, FACEP, FAAP
Professor of Emergency Medicine and Pediatrics, Chief and Medical Director, Pediatric Emergency Medicine Division, University of Florida College of Medicine-Jacksonville, Jacksonville, FL

Stephanie Kennebeck, MD
Associate Professor, University of Cincinnati Department of Pediatrics, Cincinnati, OH

Anupam Kharbanda, MD, MS
Chief, Critical Care Services Children's Hospitals and Clinics of Minnesota, Minneapolis, MN

Tommy Y. Kim, MD, FAAP, FACEP
Associate Professor of Pediatric Emergency Medicine, University of California Riverside School of Medicine, Riverside Community Hospital, Department of Emergency Medicine, Riverside, CA

Melissa Langhan, MD, MHS
Associate Professor of Pediatrics and Emergency Medicine; Fellowship Director, Director of Education, Pediatric Emergency Medicine, Yale University School of Medicine, New Haven, CT

Robert Luten, MD
Professor, Pediatrics and Emergency Medicine, University of Florida, Jacksonville, FL

Garth Meckler, MD, MSHS
Associate Professor of Pediatrics, University of British Columbia; Division Head, Pediatric Emergency Medicine, BC Children's Hospital, Vancouver, BC, Canada

Joshua Nagler, MD, MHPEd
Assistant Professor of Pediatrics and Emergency Medicine, Harvard Medical School; Fellowship Director, Division of Emergency Medicine, Boston Children's Hospital, Boston, MA

James Naprawa, MD
Attending Physician, Emergency Department USCF Benioff Children's Hospital, Oakland, CA

Joshua Rocker, MD
Associate Chief and Medical Director, Division of Pediatric Emergency Medicine, Assistant Professor of Pediatrics and Emergency Medicine, Cohen Children's Medical Center of New York, Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, New Hyde Park, NY

Steven Rogers, MD
Associate Professor, University of Connecticut School of Medicine, Attending Emergency Medicine Physician, Connecticut Children's Medical Center, Hartford, CT

Christopher Strother, MD
Assistant Professor, Emergency Medicine, Pediatrics, and Medical Education; Director, Undergraduate and Emergency Department Simulation; Icahn School of Medicine at Mount Sinai, New York, NY

Adam E. Vella, MD, FAAP
Associate Professor of Emergency Medicine, Pediatrics, and Medical Education, Director Of Pediatric Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

David M. Walker, MD, FACEP, FAAP
Director, Pediatric Emergency Medicine; Associate Director, Department of Emergency Medicine, New York-Presbyterian/Queens, Flushing, NY

Vincent J. Wang, MD, MHA
Professor of Pediatrics, Keck School of Medicine of the University of Southern California; Associate Division Head, Division of Emergency Medicine, Children's Hospital Los Angeles, Los Angeles, CA

International Editor

Lara Zibners, MD, FAAP, FACEP
Honorary Consultant, Paediatric Emergency Medicine, St. Mary's Hospital Imperial College Trust, London, UK; Nonclinical Instructor of Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, NY

Pharmacology Editor

Aimee Mishler, PharmD, BCPS
Emergency Medicine Pharmacist, Maricopa Medical Center, Phoenix, AZ

CME Editor

Deborah R. Liu, MD
Associate Professor of Pediatrics, Keck School of Medicine of USC; Division of Emergency Medicine, Children's Hospital Los Angeles, Los Angeles, CA

Case Presentations

An 18-month-old girl who is up-to-date on her immunizations and has no prior medical history presents with vomiting and diarrhea for the last 3 days. She initially had multiple episodes of nonbloody, nonbilious emesis that stopped yesterday. On the second day, watery, voluminous diarrhea started. Her parents estimate she has had approximately 20 episodes of diarrhea since yesterday; they cannot quantify urine output because she has had so many episodes of diarrhea. The girl does not have a fever or other symptoms. On examination, she is lying on the stretcher with her eyes closed. The girl weighs 12 kg, and her vital signs are: rectal temperature, 37.6°C (99.7°F); heart rate, 165 beats/min; blood pressure, 90/65 mm Hg; respiratory rate, 22 breaths/min; oxygen saturation, 100% on room air. Although she is crying during the examination, the girl produces no tears. Her lips are dry and her eyes appear sunken. Her abdomen is soft, with no tenderness elicited on palpation. Her capillary refill is 2 seconds. She has watery, yellow-colored stool in her diaper. Should you give this child a dose of ondansetron and attempt oral hydration or does she need intravenous hydration? Do you need to send the stool for culture? Do any laboratory studies need to be performed?

A 2-year-old boy with no past medical history is brought to the ED by his parents. His mother states that his illness started with vomiting, approximately 4 episodes, that has now resolved. He has had 10 episodes of watery, nonbloody stools in the last 2 days. He is drinking well and has appropriate urine output. The boy attends daycare, and several other children at the daycare center have the same symptoms. On examination, he is playing with his toy cars while sitting on the stretcher. His vital signs are within normal limits. He has moist oral mucosa and normal cardiac and lung examinations. His abdomen is soft, with no tenderness elicited. You diagnose him with acute gastroenteritis and inform his parents that they should continue with aggressive oral hydration. The parents ask you whether there is any medication you could prescribe that might stop his diarrhea. They also want to know if there are specific foods he should avoid. As you consider the parents' questions, you think about whether you should prescribe an antidiarrheal agent for this child? Should you recommend that the parents prescribe the traditional BRAT (bananas, rice, applesauce, toast) diet for the next few days? Are probiotics appropriate in this clinical scenario?

Selected Abbreviations

AGE	Acute gastroenteritis
D2.5NS	Dextrose 2.5% in normal saline
D5NS	Dextrose 5% in normal saline
ESPGHAN	European Society for Pediatric Gastroenterology, Hepatology and Nutrition
NG	Nasogastric
NS	Normal saline (0.9% sodium chloride)
ORS	Oral rehydration solution

Introduction

Nausea, vomiting, and diarrhea are some of the most common presenting complaints of pediatric patients presenting to the emergency department (ED); and these symptoms may be associated with abdominal pain. The most common discharge diagnosis for children who present with these symptoms is acute gastroenteritis (AGE). AGE is defined as inflammation of the stomach and intestines, typically resulting from viral infection or bacterial toxins. Both vomiting AND diarrhea must be present for the diagnosis of AGE. Most cases of AGE are due to viral pathogens and are usually mild and self-limited, with no need for major medical intervention. Bacterial and parasitic infections are less common, but should be considered in the appropriate clinical context. Antibiotic-associated diarrhea and *Clostridium difficile* colitis are also possible etiologies of AGE symptoms.

This issue of *Pediatric Emergency Medicine Practice* discusses various etiologies of AGE, details how to determine the level of a patient's dehydration, and reviews practice guidelines and high-quality studies that can inform the emergency clinician of the most recent and proven treatments for AGE.

Critical Appraisal of the Literature

A literature search was performed in PubMed using the search terms *gastroenteritis, colitis, cows' milk protein allergy,* and *allergic colitis.* Filters included the English language and ages birth to 18 years. No date limits were imposed. Several thousand articles were found, which were screened by title and then abstract. The Cochrane Database of Systematic Reviews and policy statements by the American Academy of Pediatrics (AAP) were also searched. One hundred-seventy articles were reviewed in full, and 119 were ultimately selected for inclusion.

There are many randomized controlled trials related to pediatric AGE. The most common topics include the use of antiemetics, the ideal intravenous (IV) fluid for resuscitation, and the utility of probiotics. While many of these studies come to similar conclusions about the utility of various treatments, several involve relatively few subjects. The most recent practice guidelines published by the AAP are over 20 years old,[1] but more recent studies exist. The studies by Roslund et al and Ramsook et al are robust randomized trials of oral ondansetron use in AGE.[2,3] Articles evaluating probiotic use were also reviewed, such as Dinleyici et al[4] and Van Niel et al,[5] that evaluate *Saccharomyces and Lactobacillus* therapy for diarrhea, respectively. There is also a recent guideline for the treatment of AGE in children that was developed and published in 2014 by the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Pediatric

Copyright © 2018 EB Medicine. All rights reserved.

Reprints: www.ebmedicine.net/pempissues

Infectious Diseases.[6] These recommendations were also endorsed by the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition.

Etiology and Pathophysiology

Etiology

AGE is one of the most common diagnoses in the pediatric population. It can affect patients of all ages, but tends to be more severe in younger patients. Diarrheal illnesses kill hundreds of thousands of children each year; this occurs largely in overburdened healthcare systems in the developing world, where children already suffering from malnutrition can succumb to dehydration.[7,8] In the United States and other developed countries, there are far fewer deaths secondary to AGE; however, there are still significant costs, including medical care and time lost from work and school.[9]

Viral Pathogens

Worldwide, viral pathogens are the most common cause of AGE, accounting for up to 80% of cases.[10] Rotavirus is a leading cause of AGE in the developing world, causing dehydration, hospitalization, and death.[11] Since the recent introduction of the rotavirus vaccine in the developed world, the burden of rotavirus has decreased significantly, with dramatic reductions in healthcare and societal costs.[12-15] Other viruses, such as norovirus, remain prominent in the United States and throughout the world.[9,16,17]

Bacterial Pathogens

Bacterial causes of AGE are less common than viral etiologies, but their course tends to be more severe. Pathogens such as *Salmonella* spp, *Shigella* spp, *Campylobacter* spp, and *Escherichia coli* are found worldwide. *E coli* and *Shigella* spp are the most common bacterial pathogens in developing countries; *Campylobacter* spp are the most common in the developed world.[7,10] Bacterial AGE is more commonly seen in areas of compromised sanitation, but can be seen in any environment.

Some bacterial infections require treatment with antibiotics to hasten recovery and decrease bacterial shedding. The preferred antibiotic varies, based on bacterial type and resistance patterns. Some bacterial causes of colitis (ie, *E coli* O157:H7) can cause hemolytic uremic syndrome due to bacterial lysis and may be exacerbated by antibiotic administration. For these reasons, antibiotics should not be started in most cases of suspected bacterial AGE until the species has been identified via cultures or polymerase chain reaction (PCR)-based diagnostic studies. Exceptions are made for children who are very ill and hemodynamically unstable in spite of hydration; antibiotics should be started empirically in these cases.

Antibiotics

Antibiotics have revolutionized medicine since their introduction over 75 years ago; however, they are not without consequences. Over the last 2 to 3 decades, the importance of the naturally derived gut biome that each person develops over time has begun to be appreciated, and its importance in the functions of digestion and the immune system have been recognized. Each course of antibiotics alters this biome and can lead to a myriad of gastrointestinal symptoms, including abdominal pain, bloating, nausea, vomiting, and diarrhea.

A potentially serious complication of antibiotic use is *C difficile* colitis, which may cause severe abdominal pain, voluminous diarrhea, dehydration, and blood loss. The emergency clinician should inquire about current and/or recent antibiotic use in all patients who present with vomiting and diarrhea, and consider this diagnosis when historically appropriate.[18] Because the rate of asymptomatic carriage is quite high in children aged < 12 months, testing for *C difficile* toxin is not recommended in this age group.[19]

Pathophysiology

The etiologies of AGE cause disease via a common-end pathway. Infection, gut biome alteration, and even the host's own immune system cause inflammation of the lining of the stomach and intestines, which can lead to abdominal pain, nausea, vomiting, diarrhea, and hematochezia.

Differential Diagnosis

Inflammatory Bowel Disease

Many patients with IBD who present to the ED will already carry their diagnosis and will be experiencing an acute flare of the disease. The diagnosis of IBD requires endoscopy and biopsies; it will not be diagnosed in the ED. For more information on managing pediatric IBD, see the July 2014 issue of *Pediatric Emergency Medicine Practice*, "Pediatric Inflammatory Bowel Disease in the Emergency Department: Managing Flares and Long-Term Complications," available at: www.ebmedicine.net/pedIBD.

Allergic Colitis

Allergic colitis in infants due to cows' milk allergy will often present first to the ED. Worried parents will bring in an infant (usually aged < 3 months), with concerns for vomiting, poor oral intake, and/or diarrhea and bloody stools. These children are usually very well-appearing with a reassuring physical examination. There is no definitive test that can be performed in the ED for allergies to protein in cows' milk; however, parents whose children are allergic to cows' milk can usually be reassured and given instructions for elimination of the likely offending

 Copyright © 2018 EB Medicine. All rights reserved.

protein.[20-22] In food-protein-induced enterocolitis, a more dramatic presentation may occur, with multiple episodes of forceful emesis, pallor, and floppiness, as well as diarrhea.[21,23] These patients will typically appear ill and require resuscitation in the ED, including blood work, imaging, and IV fluids, due to the extent of vomiting and the child's ill appearance on presentation.[21]

Other Diagnoses

Consider a broad differential when first evaluating children with vomiting and diarrhea. There are many other diagnoses that can present with nausea/vomiting and diarrhea. **(See Table 1.)** Diagnoses such as appendicitis, intussusception, volvulus, hepatitis, pancreatitis, and gallbladder disease do not usually cause diarrhea, but they can all present with this symptom. Gastrointestinal issues are the most commonly encountered mimics of AGE, but urological, gynecological, and other organ systems occasionally merit consideration. Many of these disease processes have a much more severe course, with a higher risk of morbidity and mortality.

Prehospital Care

Prehospital care of the patient with vomiting and diarrhea should involve initial stabilization. Emergency medical services providers should recognize abnormal vital signs, especially tachycardia and hypotension. Patients with signs of severe dehydration should have IV fluids started (20 mL/kg of 0.9% sodium chloride [normal saline (NS)] or lactated Ringer's solution) if an IV line can be easily inserted. For children in hypovolemic shock from dehydration, an intraosseous (IO) line should be placed for fluid administration. In patients with severe dehydration or abnormal mental status, point-of-care glucose testing should be performed, and dextrose should be administered in patients with hypoglycemia.

Table 1. Differential Diagnosis of Conditions That Cause Vomiting and/or Diarrhea

Gastrointestinal
- Ingested foreign body
- Food protein allergy (esophagitis/colitis)
- Acute gastroenteritis
- Appendicitis
- Choledocholithiasis/cholecystitis/cholelithiasis
- Gastritis
- Hepatitis
- Pancreatitis
- Inflammatory bowel disease
- Irritable bowel syndrome
- Small-bowel obstruction
- Constipation
- Pyloric stenosis
- Intussusception
- Intestinal malrotation/volvulus
- Hirschsprung disease
- Cyclic vomiting
- Incarcerated hernia

Urologic/Gynecologic
- Pelvic inflammatory disease
- Testicular torsion/epididymitis
- Prostatitis
- Ovarian cyst/torsion
- Pregnancy
- Ectopic pregnancy
- Urolithiasis
- Urinary tract infection/pyelonephritis

Other
- Group A streptococcal pharyngitis
- Pneumonia
- Diabetic ketoacidosis
- Myocarditis/heart failure
- Henoch-Schönlein purpura
- Anaphylaxis
- Asthma
- Tumor
- Meningitis
- Elevated intracranial pressure

Emergency Department Evaluation

Patients with signs of shock should be evaluated rapidly and treated upon arrival, recognizing that children in compensated shock may only demonstrate tachycardia with a normal blood pressure. Severely dehydrated patients with tachycardia and hypotension should have IV or IO access established immediately, and isotonic fluids should be started. In ill-appearing children or children with sleepiness or altered mental status, point-of-care glucose testing should be performed at the bedside and dextrose provided for those who are hypoglycemic. (See the "Treatment" section, page 9.) Children have diminished glycogen stores compared to adults and are more susceptible to developing associated hypoglycemia.

History

The history should focus on the duration of time the patient has had symptoms, and should clarify whether both vomiting and diarrhea are present, with a discussion of the number of episodes for each. Many patients present for medical attention very early in the course of AGE, with concerns of more serious pathology; however, diarrhea may not have yet started. Vomiting that has continued for more than 24 to 48 hours without diarrhea is not AGE, and, while it may represent merely gastritis, a broad differential of intracranial, endocrine, gastrointestinal, genitourinary, and other pathology should be considered. Inquire as to the color of both the emesis and stool, as bilious or bloody emesis and bloody stools are a cause for concern for etiologies other than AGE. The presence of hematemesis, bilious emesis, or hematochezia may necessitate further testing. If abdominal pain is present, ask the patient or parent to describe the location and quality of the pain. The presence or absence of fever can be important, as well as a history of recent travel and sick contacts with similar symptoms. Quantity of urine output should be questioned, though in diapered children, frequent watery stools may make quantification of urine output difficult. Since viral AGE is highly contagious, inquiry should be made regarding possible ill contacts. Finally, the names of medications taken currently and in the last month should be noted.

Copyright © 2018 EB Medicine. All rights reserved.

Physical Examination

As always, the physical examination should begin with a review of the vital signs. Look for fever, tachycardia, and hypotension, which is usually a late finding. Tachypnea may be a sign of respiratory compensation for metabolic acidosis secondary to dehydration and starvation ketoacidosis. Capillary refill should be evaluated, as children often manifest delayed capillary refill (> 2 seconds) before hypotension. Children with minimal dehydration (< 3% loss of body weight) will have a normal physical examination. Children with mild-to-moderate dehydration (3%-9% loss of body weight) may have slightly sunken eyes, decreased tears, dry mouth, and slightly increased heart rate. Children with severe dehydration (> 9% loss of body weight) will likely be lethargic and tachycardic, with no tears, very dry mouth, and prolonged capillary refill.[24]

The abdominal examination should locate any tenderness to palpation, making note if there is no tenderness, diffuse tenderness, or focal tenderness (eg, epigastric, right upper quadrant, or right lower quadrant). AGE tends to cause mild and diffuse abdominal pain; however, sometimes it causes no pain at all. Patients with focal tenderness should be considered to have another diagnosis, such as pancreatitis with epigastric/periumbilical tenderness, cholecystitis or hepatitis with right upper-quadrant tenderness, or appendicitis with right lower-quadrant tenderness.

Skin and eye examinations are also important. Jaundice is not expected in AGE and should raise the possibility of liver, pancreas, or gallbladder disease. A genitourinary examination should be performed in all patients with abdominal pain to evaluate for a testicular/ovarian pathology. Consider a pelvic examination in all sexually active females to evaluate for gynecological mimics of AGE.

Determining the Degree of Dehydration

In theory, the degree of dehydration can help guide management and interventions. Ideally, the degree of dehydration is determined by comparing a child's current weight with the pre-illness weight. Parents very rarely know this information, so physical signs such as tear production, mucous membrane appearance, skin turgor, capillary refill, activity level, etc, are more clinically useful. There are many different dehydration scores available, such as the World Health Organization (WHO) scale for dehydration, the Clinical Dehydration Scale (CDS), and the Gorelick scale for dehydration. The WHO scale for dehydration is a 4-point scale that evaluates the patient's general condition, eyes, thirst, and the feel of the patient's skin.[25] The CDS is also a 4-point scale; it includes rating the patient's general appearance, eyes, mucous membranes, and degree of tears.[26,27] The Gorelick scale can be used in either a 4-point format or a 10-point format, with the first 4 characteristics being those in the 4-point scale.[28, 29] **(See Table 2.)** A meta-analysis of these scales showed that no single scoring system is best.[30] A more recent study comparing the CDS, Gorelick, and WHO scales found that the CDS was very limited in its ability to diagnose dehydration, and neither the Gorelick nor the WHO scale was highly accurate.[31] In general, these scoring systems can identify children with severe dehydration, but often miss children with mild dehydration and fail to adequately differentiate between children with mild and moderate dehydration.[32] Since the recommended treatment for mild and moderate dehydration is the same—oral rehydration solution (ORS) only—and most clinicians can recognize severe dehydration, the use of these complex scoring systems (some have 12 different clinical findings) are perhaps not routinely needed.[24]

Table 2. The 4- and 10-Point Gorelick Scale for Dehydration for Children Aged 1 Month to 5 Years

Characteristic	No or Minimal Dehydration	Moderate to Severe Dehydration
*General appearance**	*Alert*	*Restless, lethargic, unconscious*
*Capillary refill**	*Normal*	*Prolonged or minimal*
*Tears**	*Present*	*Absent*
*Mucous membranes**	*Moist*	*Dry; very dry*
Eyes	Normal	Sunken; deeply sunken
Breathing	Present	Deep; deep and rapid
Quality of pulses	Normal	Thready, weak, or impalpable
Skin elasticity	Instant recoil	Slow recoil; recoil > 2 sec
Heart rate	Normal	Tachycardia
Urine output	Normal	Reduced; not passed in many hours

* These items alone comprise the 4-point scale.

Severity of dehydration is determined by the number of clinical signs present.

Scoring for the 4-point scale (italics): presence of ≥ 2 clinical signs indicates ≥ 5% BWΔ; presence of ≥ 3 clinical signs indicates ≥ 10% BWΔ.

Scoring for the 10-point scale (all signs/symptoms): presence of ≥ 3 clinical signs indicates ≥ 5% BWΔ; presence of ≥ 7 clinical signs indicates ≥ 10% BWΔ

Abbreviation: BWΔ, body-weight change.

Used under Creative Commons Attribution 4.0 International (CC BY 4.0). https://creativecommons.org/licenses/by/4.0/

Adapted from: Kimberly Pringle, Sachita P Shah, Irenee Umulisa, et al. Comparing the accuracy of the three popular clinical dehydration scales in children with diarrhea. *Int J Emerg Med.* 2011;4:58. http://intjem.springeropen.com/articles/10.1186/1865-1380-4-58 Licensee Springer 2011.

 Copyright © 2018 EB Medicine. All rights reserved.

In clinical practice, urine specific gravity, urine ketones, serum bicarbonate, and blood urea nitrogen (BUN) are the most commonly used values to determine the level of dehydration. However, there is little consensus among researchers regarding the utility of these laboratory tests for identifying the level of dehydration. In a 2007 study, neither urine ketones nor urine specific gravity were found to correlate with the initial level of dehydration on presentation to the ED.[33] Shaoul et al evaluated BUN as a measure of dehydration and found it to be 95% specific for dehydration status.[34] However, Bonadio et al reported that BUN levels are not an accurate measure of dehydration.[35] Serum bicarbonate has been investigated in multiple studies as well. Narchi concluded that it should not be used alone to assess for severity of dehydration.[36] Vega and Avner reported that a serum bicarbonate level < 17 mEq/L had a sensitivity of 77% for detecting moderate dehydration and a sensitivity of 94% for detecting severe dehydration. Combining a clinical dehydration scale with serum bicarbonate level resulted in 100% sensitivity in detecting severe dehydration.[37]

Diagnostic Studies

Laboratory Studies

In cases of clear-cut AGE with mild-to-moderate dehydration, there is almost no indication for laboratory testing.[38] If there is no reason to place an IV catheter, there is no reason to collect blood for laboratory studies. Oral rehydration is the mainstay of treatment in these cases. Neither the ESPGHAN nor the AAP recommend measurement of serum electrolytes in children with mild or moderate dehydration who will be treated with ORS.[1,6]

For children with signs of severe dehydration, a set of electrolytes with BUN and creatinine should be obtained, as well as point-of-care blood glucose testing. Laboratory studies should be obtained in all neonates with any level of dehydration and in patients with an altered mental status not explained by their suspected level of dehydration. Children for whom oral rehydration has failed and subsequently receive IV fluids should probably have a set of electrolytes with BUN and creatinine sent.[1] C-reactive protein has not been shown to differentiate viral versus bacterial causes of AGE and is not recommended in obvious cases of AGE.[39] For cases in which the diagnosis is uncertain, tests such as a hepatic panel, lipase/amylase, complete blood cell count, urine or serum human chorionic gonadotropin, C-reactive protein, and sedimentation rate may be obtained, along with a basic metabolic panel.

Stool Studies

Stool cultures and other stool studies are not required in most cases of uncomplicated AGE. In children with prolonged (> 3 or 4 days) or bloody diarrhea, toxic-appearing children, and children who have recently traveled abroad, stool cultures may be appropriate.[40] In children aged > 1 year with frequent, watery stools and recent antibiotic use, consider sending stool for a *C difficile* toxin assay; the diarrhea of *C difficile* colitis is rarely bloody.[41,42] Avoid testing the stool of children aged < 1 year for *C difficile*, as these children can be asymptomatic carriers and a positive result is very difficult to interpret.[42]

Stool ova and parasite examinations are typically low-yield tests; however, in children with an appropriate travel history or concern for *Giardia* (recent camping or fresh water exposure), stool should be sent to the laboratory for ova and parasite testing.[43] Toxocariasis and cysticercosis are 2 worm infections that can occur in children living in poverty in the United States.[44] Consider sending stool for ova and parasite testing in children without a concerning travel history if diarrheal symptoms have been prolonged with negative prior stool cultures and/or there is evidence of weight loss or failure to gain weight.

Fecal calprotectin acts as an inflammatory marker in the stool. Gastroenterologists will sometimes request this test when evaluating for IBD or allergic colitis. Two studies have evaluated fecal calprotectin as a marker to aid in differentiating viral from bacterial AGE. In both studies, children with bacterial infections had significantly higher levels of fecal calprotectin in the stool than children with viral infections and controls.[45,46] In many EDs, fecal calprotectin can take days for results. In general, fecal calprotectin is not a test that will affect the acute management of vomiting and diarrhea in the ED; however, it may be helpful in the outpatient workup of other illnesses, and can be sent in consultation with pediatric gastroenterology.

Imaging Studies

No imaging is required in the workup of uncomplicated AGE. One case report series examined the use of ultrasound to evaluate colonic wall thickness in patients with *C difficile* colitis; however, this study involved only adults, and its application to children is unknown.[47] While information from this study could be potentially useful in equivocal cases, most cases are more readily identified with a positive *C difficile* toxin test.

If the patient's diagnosis is uncertain, imaging can be useful. Ultrasound can diagnose intussusception, appendicitis, cholecystitis, ectopic pregnancy, pyloric stenosis, and testicular or ovarian pathologies. Computed tomography and magnetic resonance imaging may identify appendicitis, IBD, or bowel obstruction. An upper gastrointestinal series can demonstrate intestinal malrotation and volvulus.

Copyright © 2018 EB Medicine. All rights reserved.

Treatment

Antiemetics

Very high doses of 5-hydroxytryptamine 3 (5-HT3) receptor antagonists, such as ondansetron (Zofran®) had been used for vomiting in oncology settings for many years before they started being used the ED. Prior to the introduction of 5-HT3 antagonists to pediatric emergency medicine, most children who presented to the ED with vomiting continued to vomit. Medications such as promethazine and metoclopramide were used occasionally, but were associated with such unpleasant side effects (eg, sedation, drowsiness, extrapyramidal reactions, and severe respiratory depression) that it was deemed safer not to use them, especially in children aged < 2 years.[48-50] The United States Food and Drug Administration (FDA) states that promethazine is contraindicated in children aged < 2 years and should be used cautiously in children aged ≥ 2 years, due to the risk for respiratory depression and apnea.[51] According to the 2014 guidelines for the management of AGE developed by the ESPGHAN, metoclopramide is not recommended in children with nausea and vomiting that is due to AGE.[6]

Ondansetron has become the most commonly used 5-HT3 antagonist in United States EDs, though several others are used in other settings. Ondansetron selectively binds 5-HT3 both peripherally on the vagal nerve terminals and centrally in the chemoreceptor trigger zone. Numerous studies over the last decade have shown that ondansetron is safe and effective for AGE treatment in the ED. Vomiting children who are given ondansetron prior to an oral challenge are less likely to fail oral rehydration, require IV hydration, and be admitted to the hospital.[2,40,48,50,52] Children treated with ondansetron also leave the ED sooner than those who are not given ondansetron prior to oral challenge.[53,54] IV ondansetron should be administered to children who require IV fluids. Two studies of children receiving IV fluids for AGE after failed oral challenge showed a higher rate of complete resolution of vomiting and a lower admission rate in the IV ondansetron group versus the placebo group.[55,56]

Dosages and Administration Routes for Ondansetron

Ondansetron can be given via oral, IV, or intramuscular (IM) routes (IM approved in children aged ≥ 12 years). In children with mild-to-moderate dehydration due to AGE with continued nausea and vomiting, strongly consider giving a single oral weight-based dose approximately 15 to 30 minutes prior to attempting oral rehydration. Most studies recommend the following oral pediatric dosing guidelines for ondansetron: children weighing < 15 kg: 2 mg; children weighing 15 kg to 30 kg: 4 mg; children weighing ≥ 30 kg: 8 mg.[57,58]

Ondansetron has been shown to be safe in children aged as young as 1 month, but many emergency clinicians have a lower age limit from 4 to 12 months. Oral disintegrating tablets are probably the best tolerated; the oral solution may precipitate vomiting. Some hospitals will not allow oral disintegrating tablets to be cut in half; in these situations, or if the oral disintegrating tablets or oral solution are not available or tolerated, the IV preparation can be given orally.[59] For children with severe dehydration in whom IV hydration will be started immediately, IV ondansetron can be given (0.15 mg/kg, max 8 mg).

Side Effects of Ondansetron

Ondansetron does have potential side effects that must be considered. Cardiac dysrhythmias are the most serious complication. The FDA has issued a safety communication for the potential of QT prolongation with ondansetron. Patients with personal or family history of prolonged QT should probably not be given ondansetron without an electrocardiogram prior to administration. Children with significant electrolyte disturbances may also be at increased risk of arrhythmias. In a postmarketing analysis, there were no identified reports of arrhythmia after a single dose of oral ondansetron; therefore, routine electrocardiogram prior to administration of ondansetron for AGE is not recommended, even for multiple doses.[60] In the FDA-mandated study of ondansetron-associated QT prolongation that was conducted by GlaxoSmithKline, only a 32 mg single IV dose of ondansetron was found to cause a significant increase in QT interval; this dose is no longer recommended. The FDA recommends a single IV dose no higher than 16 mg and an oral dose no higher than 24 mg.[61] These doses are used for nausea and vomiting associated with chemotherapy and are much higher than the doses routinely used for patients with AGE in the ED setting (maximum dose, 8 mg oral or IV).

Some studies have shown an increased number of diarrheal episodes in children who receive ondansetron.[3] However, in at least 2 studies, this amounted to only 1 more episode of diarrhea, which is not clinically significant.[2,62]

A concern of some emergency clinicians is the fear of masking a more serious alternative diagnosis. While this is always possible, a large retrospective review published in 2010 did not find that the use of ondansetron in suspected AGE led to an increased risk of masking a more serious illness.[63]

Interestingly, ondansetron may not alter the treatment of AGE as much as once thought. Despite the fact that multiple studies have shown that administration of ondansetron leads to better ORS tolerance, less need for IV hydration, and decreased need for admission, in actual practice, IV hydra-

 Copyright © 2018 EB Medicine. All rights reserved.

tion rates are unchanged in many EDs. Freedman et al examined IV hydration rates in EDs across the United States over a 9-year period, from a time of low oral ondansetron use (median of 0.11% of patient visits) to high use (median of 42.2% of patient visits). Admission rates were no different and IV hydration rates went from 18.7% to 17.8%, from low use to high use, respectively. Only 13.5% of children who received IV hydration were given oral ondansetron.[64] These findings suggest that ondansetron is not being used in the patients who might benefit the most. In a retrospective case-control study from Ireland, children with mild-to-moderate dehydration with presumptive AGE were started on ORS in the waiting room, with parents given explicit instructions on how to administer it. If the child failed to tolerate the ORS, they were given a single oral dose of ondansetron and ORS was restarted 30 minutes later. Over a 6-week period, a 19% decrease in IV fluid administration was noted.[58]

Oral Rehydration

Once antiemetic medication has been administered (or in cases where vomiting has spontaneously ceased), the next step in management is the initiation of oral rehydration. Patients with mild-to-moderate dehydration should begin oral rehydration with an appropriately formulated ORS (Pedialyte®, Enfalyte®, or generic formulations of these solutions).[65-67] Use of ORS leads to decreased length of hospitalization for patients with AGE and is equivalent to IV hydration with respect to weight gain and duration of diarrhea.[49] In one meta-analysis of ORS versus IV hydration, it was determined that for every 25 children treated with ORS, 1 treatment would fail and require IV hydration.[68]

ORS is not used as often as it should be in developed countries.[69] This is especially true in the United States.[70] Emergency clinicians need to present ORS as the best way to rehydrate children.[66] In the developed world, it is not recommended for parents to mix their own rehydration solution because mistakes can easily be made, and commercially prepared ORSs are readily available.[71] Other liquids, such as water, juices, sports drinks, soups, etc, are not traditionally recommended for mild-to-moderate dehydration because they do not contain the ideal ratio of sugars and salts to promote intestinal absorption, and they may serve as an osmotic diuretic. However, in a recent study from Canada, children with minimal dehydration due to AGE were randomized to receive either dilute apple juice followed by whatever fluid they preferred at home or apple-flavored ORS followed by ORS at home. The children in the diluted apple juice group had less treatment failure and less IV fluid administration than the ORS group.[72]

Rehydration should begin slowly, with the child initially consuming only a few milliliters (5 mL to 10 mL) every 5 minutes for the first 30 minutes. Once a child is tolerating that amount over a half-hour, then the amount consumed can be increased by 5-mL increments over the next 30 minutes or so. Depending on the degree of dehydration, 50 to 100 mL/kg of ORS should be given over 3 to 4 hours to correct dehydration.[24,73] Most dehydrated children will not refuse ORS; consider this when caring for a child who will not drink the ORS offered to them.[65,74] After they are rehydrated, children can continue taking ORS at maintenance or they can resume taking regular fluids and foods.

Children who tolerate fluids in the ED and are discharged home must continue to drink, and parents must be aware of the need to replace fluid losses from continued vomiting and diarrhea. A rough calculation of the amount of ORS needed to replace emesis and diarrhea is 10 mL/kg for each episode of emesis or diarrhea.[75]

Nasogastric and Intravenous Hydration

Some children will continue to vomit even after administration of antiemetics or will refuse to take adequate liquids by mouth due to fear of vomiting, disability, or stubbornness. In some countries, children with mild-to-moderate dehydration will have a nasogastric (NG) tube placed and rehydration solution will be given via this route. In the United States and many other countries, an NG tube is considered the option of last resort for rehydration due to AGE; children who fail oral rehydration after antiemetics typically have an IV catheter placed and IV fluids are administered. This is despite the fact that rehydration via NG tube is associated with fewer complications and shorter ED and inpatient hospital stays.[40] In a study comparing NG hydration to IV hydration, there were only 2 failed attempts at NG tube insertion, but there were at least 27 failed attempts at IV catheter insertion.[76]

The reluctance to place an NG tube for administration of ORS comes from both emergency clinicians and parents. Emergency clinicians can be trained to better utilize NG hydration. In a study conducted in a tertiary children's hospital in South Wales, UK, researchers were able to dramatically decrease the rate of IV hydration while increasing NG hydration. This was achieved by implementing a program for nurses and physicians that utilized written materials and teaching sessions over a 1-month period. The rate of IV hydration for hospitalized patients went from 15% to 4% and the rate of NG hydration from 0% to 15%.[77] This study did not address the resistance that parents may have for NG hydration. A study in Israel surveyed parents presenting with their child to a pediatric ED with concerns for dehydration, and found almost all preferred IV hydration over NG.[78] The placement

Copyright © 2018 EB Medicine. All rights reserved.

of NG tubes in children is perceived by healthcare providers to be more painful and traumatic than IV catheters.[40] No studies could be found that evaluate discomfort and distress in children during and after NG tube placement either alone or compared to IV catheter insertion.

Intravenous Fluid Resuscitation

For children presenting to the ED with AGE and severe dehydration, rapid resuscitation with IV fluids is paramount. When the IV catheter is placed, blood work should be obtained to evaluate electrolytes and renal function. In addition, a rapid bedside glucose test should be obtained, as hypoglycemia often complicates severe dehydration. One study demonstrated that the duration of vomiting seems to be an important risk factor for hypoglycemia in children aged < 5 years; those with hypoglycemia had a mean of 2.6 days of vomiting compared to 1.6 days in the nonhypoglycemic group.[79] In children with severe dehydration, most emergency clinicians would start with a 20 mL/kg NS bolus of fluids (or lactated Ringer's solution). In children with stable blood pressure and normal capillary refill, infusion over 30 to 60 minutes is appropriate. In severely dehydrated patients who are very ill/toxic-appearing, the IV fluid bolus should be administered over 10 to 15 minutes, if possible. This rapid bolus may be administered via the push-pull method, with a 3-way stopcock, or via the detach-reattach method.

Dextrose-Containing Fluids

There has been some recent discussion about using dextrose-containing fluids in initial resuscitation. In children with severe dehydration and hypoglycemia, it may be helpful to give a 20 mL/kg bolus of 5% dextrose in NS (D5NS). However, in children with normal glucose levels, the benefits are unclear. A recent study from Spain used 2.5% glucose in NS (D2.5NS) at a rate of 20 mL/kg/hr for 2 hours in children with mild-to-moderate dehydration. The authors of that study found that 83% of subjects were successfully hydrated (tolerated oral fluids and discharged home within 6 hours). However, this study did not compare children with a "standard" rehydration group, so superiority cannot be determined.[80] Another study compared children receiving an initial 20 mL/kg IV bolus of D5NS to children given 20 mL/kg of NS. Children who received the dextrose-containing fluids had a greater reduction in their serum ketone levels at 1 and 2 hours; however, there was no difference in hospitalization rates.[81] These results were confirmed in a 2017 study from Spain, in which children given 20 mL/kg D2.5NS per hour for 2 hours had similar hospitalization and return rates as children given 20 mL/kg NS per hour for 2 hours.[82] While the addition of dextrose to the resuscitation fluid may or may not be clinically significant, it does appear to be safe for a single bolus.

For children who receive IV hydration, there does appear to be a benefit to receiving dextrose-containing solution after the initial bolus resuscitation period. In one study, children who received D5NS after an initial NS bolus were 3.9 times less likely to have a return visit to the ED with subsequent admission than children given no IV dextrose; the more dextrose they received, the lower the rate of return. Both of these findings were statistically significant.[83]

Rapid Versus Standard Rehydration

Another question that has come up with regard to IV hydration is rapid versus standard rehydration. Freedman et al examined a rapid rehydration protocol versus standard rehydration (60 mL/kg/hr vs 20 mL/kg/hr of NS) and found no difference regarding time to rehydration or prolonged treatment time. However, there was a significant difference in median time to discharge, with the rapid group staying longer in the ED (6.3 vs 5.0 hours).[84] A 2016 systematic review evaluated 3 studies comparing standard versus rapid IV hydration protocols and determined that there was no superiority of rapid (60 mL/kg/hr) compared to standard (20 mL/kg/hr) IV hydration.[85]

Antidiarrheal Agents

While antiemetics have been effective in decreasing vomiting, an equally effective and safe antidiarrheal agent has yet to be developed. In much of the developing world, it is the persistence of diarrhea that contributes the most to dehydration in AGE. This is less common in industrialized nations, most likely due to the better baseline nutritional status of children in these countries. However, even in the developed world, there is a desire to find a better antidiarrheal medication, as time missed from school and work is extremely costly.

Loperamide

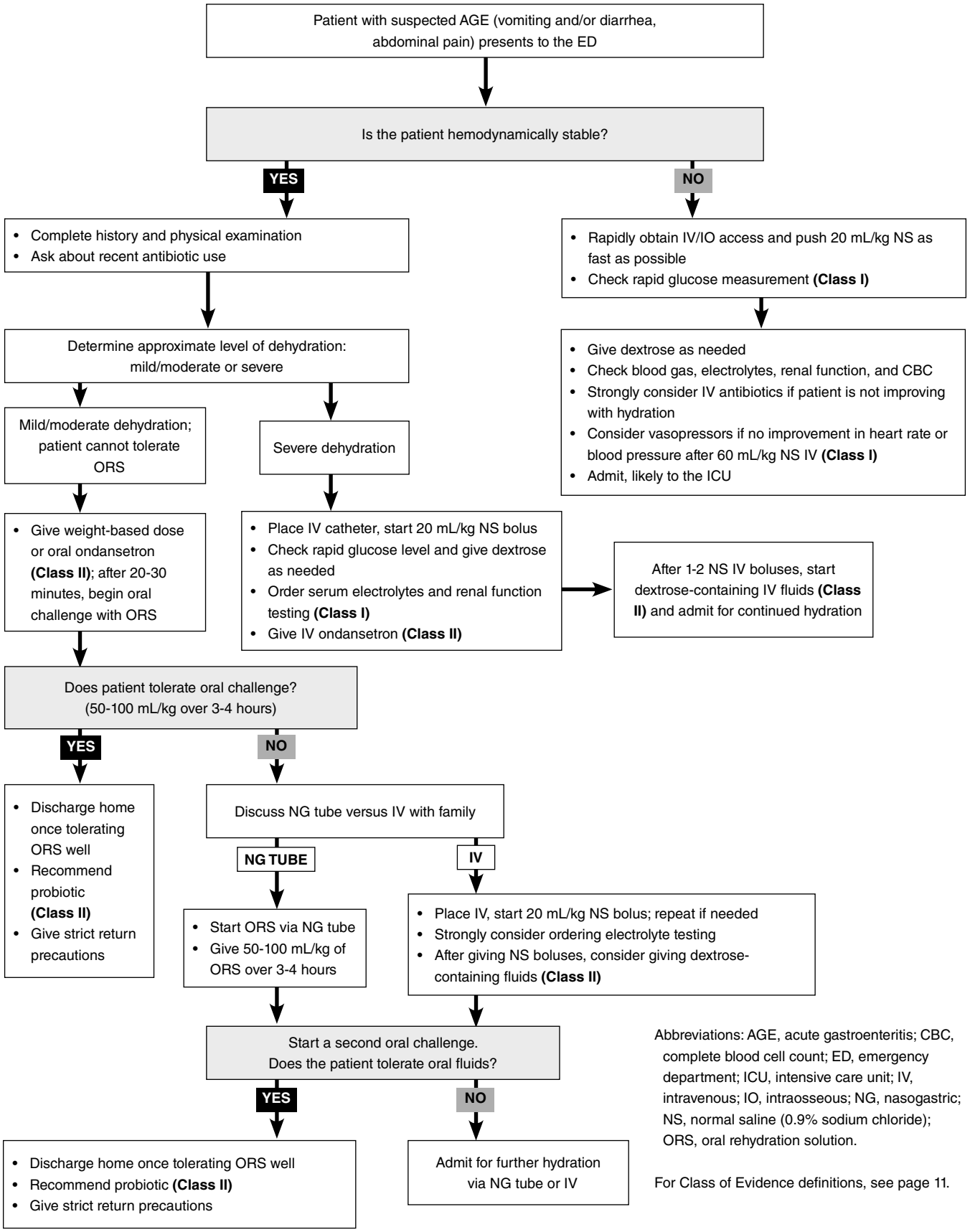
Loperamide (Imodium®) is available without prescription in the United States. It is an opioid receptor agonist with predominant effects in the intestines, acting as both an antisecretory and antimotility agent. It cannot be used in children aged < 2 years because it causes drowsiness and ileus; it is strongly discouraged in children of all ages, due to reports of death secondary to paralytic ileus.[49] There are also reported cases of abuse.[86,87]

Bismuth Subsalicylate

The salicylate portion of bismuth subsalicylate (PeptoBismol®) acts as an antisecretory agent. It also has antimicrobial effects through direct action on the bacterial cell wall. Several studies have shown decreased duration of diarrhea when

 Copyright © 2018 EB Medicine. All rights reserved.

Clinical Pathway for Management of Pediatric Patients With Suspected Acute Gastroenteritis



Abbreviations: AGE, acute gastroenteritis; CBC, complete blood cell count; ED, emergency department; ICU, intensive care unit; IV, intravenous; IO, intraosseous; NG, nasogastric; NS, normal saline (0.9% sodium chloride); ORS, oral rehydration solution.

For Class of Evidence definitions, see page 11.

Copyright © 2018 EB Medicine. All rights reserved.

bismuth subsalicylate is used. However, it must be administered every 4 hours, and there is concern about salicylate toxicity if it is used incorrectly; therefore, it is not recommended for use in children as an antidiarrheal agent.[49]

Probiotics

Probiotics are nonpathogenic organisms that work by regulating the gut biome and help to lessen inflammatory pathways.[88] Prebiotics are food products that promote the growth and activity of bacteria that reside in the gut.[89] Synbiotics are a combination of probiotics and prebiotics. Probiotics help decrease stool volume and frequency in AGE, as well as other conditions. Numerous studies and meta-analyses have shown that *Lactobacillus rhamnosus* GG and *Saccharomyces boulardii* can reduce the length of diarrheal symptoms in children, with very few side effects;[40,49,90-96] they may also reduce stool volume.[5] Probiotics are probably most effective if started early.[73,89]

Probiotics seem to have the greatest impact on diarrhea due to viral causes, especially rotavirus, and have only minimal benefit in bacterial AGE.[97,98] A large outpatient study in Italy found that children given *L rhamnosus* GG orally twice daily had a significantly shorter duration of diarrhea (median 78.5 hours) compared to those given only ORS (median 115.5 hours).[99] In a large study from Turkey, *S boulardii* shortened the course of diarrhea by approximately 24 hours in hospital, ED, and outpatient settings. Hospitalized children receiving the probiotic had a 36-hour shorter mean length of stay.[4] A large, multicenter trial is currently underway in several Canadian pediatric EDs that will provide further data on the effects of probiotics on diarrheal illnesses in outpatient children in the developed world.[100] In one study, children given ORS with *L rhamnosus* GG were compared to children given ORS alone. The children who received the solution with probiotics had a shorter duration of diarrhea and were discharged from the hospital earlier than children who were given ORS alone.[101]

There are many other probiotics or combination products available for purchase from drug and health-food stores. However, for many of these products, there is either no or limited research into their safety and efficacy against diarrhea.[102-105] This is a very active area of investigation, with new studies being published regularly. A study from Vandenplas et al compared 111 children with AGE treated with a synbiotic (containing *L rhamnosus* GG as well as other probiotics) to placebo. The synbiotic group had fewer follow-up physician visits and prescription medications ordered for their illness, leading to 25% lower healthcare costs, as well as a 24-hour shorter duration of diarrhea.[106] Even before diarrhea has started, *L rhamnosus* GG or *S boulardii* can be recommended upon discharge from the ED.

Zinc

Zinc supplementation should be strongly considered when treating diarrhea in children residing in developing countries; supplementation significantly reduces diarrhea duration in children with underlying zinc deficiency.[6]

Special Populations

Most young infants who present to the ED with the chief complaint of vomiting will end up with a relatively benign diagnosis. However, patients aged < 12 months should always be approached with a very broad differential. The most serious diagnosis to consider is intestinal malrotation and volvulus. Most children with malrotation will present within the first year of life, with about half diagnosed within the first month. Emergency clinicians should inquire about the color of the emesis; bilious emesis should make malrotation and volvulus the presumed diagnosis until proven otherwise. Infants with formula- or milk-colored emesis may have benign reflux, intussusception, protein allergy (cows' milk or other), urinary tract infection (espe-

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
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- 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

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Copyright © 2018 EB Medicine. 1-800-249-5770. No part of this publication may be reproduced in any format without written consent of EB Medicine.

 Copyright © 2018 EB Medicine. All rights reserved.

cially if fever is present), or pyloric stenosis (forceful vomiting, progressively worsening emesis, very hungry infant after vomiting).[107] AGE could still be the ultimate diagnosis in this age group, but other entities should be considered. Because AGE requires the presence of both vomiting and diarrhea for diagnosis, these more-severe conditions deserve particular attention in the patient who is vomiting without diarrhea.

Patients with prior abdominal surgeries who present with vomiting require extra consideration and evaluation. These children are at risk for intestinal obstruction due to adhesions, and this possibility should be addressed. Inquire about bowel movements, abdominal pain, and abdominal distension. A single dose of an antiemetic can be given prior to an oral challenge, but if vomiting continues, further investigation should follow. Finally, if these children are discharged home with a prescription for an antiemetic, strict return precautions must be given to patients and their caregivers.

Finally, children with chronic medical problems (eg, diabetes, heart disease, renal disease, and cystic fibrosis) warrant a more thorough evaluation when they present with symptoms of AGE. Children with diabetes need at least a finger-stick glucose test and urinalysis to evaluate for diabetic ketoacidosis. Children with cardiac and renal disease are more sensitive to dehydration and will often need measurement of electrolytes and administration of IV fluids much earlier in their course of AGE than a child without cardiac or renal disease. Patients with cystic fibrosis are also more sensitive to dehydration due to AGE; these children are also at risk for pancreatitis due to their exocrine dysfunction and *C difficile* colitis due to chronic antibiotic administration.

Controversies and Cutting Edge

Despite the advances in medicine and hygiene in the last 100 years, AGE continues to cause much morbidity and mortality. Physicians and scientists are continuously looking for new medications and treatment regimens that might help reduce this burden. Some of these new ideas have proven to be more useful in the developing world, while others may have a great impact worldwide.

Racecadotril

Racecadotril is an antidiarrheal drug that has been shown in a few studies to reduce the duration and frequency of diarrhea in infants and children. It is an enkephalinase inhibitor and results in decreased secretion of water and electrolytes into the intestines. Its efficacy may be slightly less than loperamide, but it is much better tolerated and has been demonstrated to be safe in children as young as 2 months old. Early studies had shown a decrease in the median duration of diarrhea, with decreased stool output at 48 hours in the racecadotril group. These studies were funded by the developers of the drug, however, and had many withdrawn subjects from the treatment group that were not included in the data analysis.[49] A recent meta-analysis of studies that examined the effectiveness of racecadotril in decreasing diarrhea found that it was well-tolerated and resulted in decreased duration of symptoms, as well as less stool frequency and volume. However, the included studies were of poor quality and subject to bias.[108] This medication is available in Europe, South America, and parts of Asia, but is not approved by the United States FDA at this time.

Gelatin Tannate

Gelatin tannate has sparked interest as a possible antidiarrheal treatment in AGE. It is a tannic acid suspension in a gelatin solution that can alter the gut microbiome, decrease intestinal wall permeability, and reduce inflammation. In a prospective, single-blinded, randomized study from Italy, children who drank ORS with added gelatin tannate had significantly fewer bowel movements at 72 hours and 31 hours shorter duration of diarrhea compared to those given plain ORS.[109] In this study, the only adverse effect reported was nausea approximately 20 minutes after taking the gelatin tannate. It is unclear whether gelatin tannate by itself would have the same effect. A group in Poland has proposed a study of gelatin tannate alone in children aged < 5 years with AGE, which will possibly address this question as well as determine the safety of gelatin tannate in children.[110] Gelatin tannate is currently not commercially available it the United States.

Prebiotics

An interesting study out of Nicaragua evaluated the efficacy of a new polyphenol-based prebiotic, Aliva™, for the treatment of diarrhea. In this double-blinded prospective study, a single dose of either Aliva™ or placebo was given to patients aged ≥ 2 years who presented to an outpatient clinic with symptoms consistent with AGE. Patients in the Aliva™ group had significantly less time to last unformed stools (median time, 1 hr 50 min versus 67 hr 50 min), with less abdominal pain and gas and bloating symptoms compared to the placebo group. However, the accuracy of these results is questionable. It is unclear whether the company that makes Aliva™ funded this study; there is no discussion of the baseline characteristics of the 2 groups; and there have been no follow-up or confirmatory studies of the same product. Also, they did not include patients who were vomiting, which would exclude a large proportion of patients suffering from AGE.[111]

Copyright © 2018 EB Medicine. All rights reserved.

N-acetylcysteine

There is one case report examining the administration of N-acetylcysteine (NAC) for treatment of rotavirus AGE. Three children with rotavirus-proven AGE were given NAC after their first day of diarrhea and were compared to 2 children who were given standard therapy (all 5 children had not received the rotavirus vaccine). The 3 who were given NAC had decreased diarrheal output compared to the other 2 and had resolution of symptoms in 2 days.[112] It is unclear whether this treatment would work on AGE due to other infectious agents. This was not a randomized trial, and further studies are needed. However, this treatment has the potential to be useful in the developing world where rotavirus is still quite common and resources are scarce.

Disposition

A majority of patients seen in the ED who are diagnosed with AGE will be discharged home. For children with severe dehydration and those who are unable to tolerate oral hydration, admission for continued IV or NG hydration is necessary. The parents/caregivers of children who are discharged will need explicit discharge instructions with anticipatory guidance. Parents/caregivers must understand that they will need to continue to replace fluid losses due to vomiting and diarrhea, as well as provide maintenance hydration.

Children who are breast-fed should continue to breast-feed during their illness, and there should be no recommendations to eliminate specific foods from a child's diet upon discharge home.[65,113] The traditional BRAT diet does not lead to decreased stool output and can lead to further weight loss.[114] Studies have demonstrated that children fed their regular diet have shorter hospitalizations, decreased duration of symptoms, and return to their pre-illness weight sooner than children who are diet-restricted.[73,115] The intestinal lining needs the nutrients found in a regular, well-balanced diet in order to regenerate damaged cells.[116] A lactose-free diet should be considered only in cases when a child's diarrheal output increases dramatically after consuming milk-based products.[73] Children should return to the ED if they are not able to tolerate any oral fluids, have significantly decreased urine output (< 3 urine outputs in a 24-hour period), or have significantly decreased activity level or changes in mentation.

Antiemetics, such as ondansetron, do not need to be prescribed on discharge. Most children with AGE will recover completely with only ORS at home. While the use of ondansetron has not resulted in the masking of more serious illness,[63] there is minimal literature on discharge prescription for pediatric AGE.

Prolonged diarrhea keeps children out of school and daycare and parents out of work. Probiotics should be recommended for children being discharged from the ED with AGE, even if diarrhea has not yet started. Either oral *L rhamnosus* GG (at least 10^{10} colony-forming units daily) or *S boulardii* (250 mg twice daily) should be prescribed or recommended to be taken until symptoms have resolved.

Antibiotics should be prescribed only for children with proven *C difficile* colitis or cases where a bacterial pathogen (non–*E coli* O157:H7) is identified and diarrheal symptoms are persistent. First-line treatment for *C difficile* colitis in children is to discontinue any antimicrobials the child is on.[41,117] If the child is no longer on the antibiotic and/or symptoms are moderate, metronidazole (30 mg/kg/day oral, divided into 4 doses; max 2 g daily) should be started. For children with severe symptoms or with a second recurrence, oral vancomycin (40 mg/kg/day, divided into 4 doses; max 2 g daily) is appropriate. Children in the latter category will likely require hospital admission.[19] If stool cultures/studies were sent during an ED visit for AGE, antibiotics may be started for positive results at the time of discharge (if rapid PCR is available) or after discharge, depending on the pathogen identified and the patient's continued symptoms. Some causes of bacterial AGE should not be treated with antibiotics secondary to hemolytic uremic syndrome, and others require only treatment in the very ill child.[118,119] **(See Table 3, page 14.)** Consultation with a pediatric infectious disease specialist may be needed.

Most children seen in the ED for AGE should be advised to follow up with their primary care doctor. Since the overwhelming majority of cases are viral in nature and self-limited, further workup will not be needed. Children who have prolonged symptoms or symptoms such as weight loss or failure to gain weight should be seen by a pediatric gastroenterologist. Children with mild cases of *C difficile* colitis and most cases of infant allergic colitis can also be managed by a general pediatrician. More complex cases of these entities will likely require specialist follow-up.

Summary

AGE in children is most commonly due to viral infections. Viral AGE tends to have a mild and self-limited course that requires only oral hydration with an appropriately formulated ORS. An antiemetic, such as ondansetron, is safe and effective and can aid in oral rehydration by treating persistent nausea and vomiting. Even children with moderate dehydration can usually be rehydrated adequately with ORS given by mouth or NG tube. Some children with AGE may develop severe dehydration and require IV hydration and admission to the hospital. Children with suspected severe dehydration should

 Copyright © 2018 EB Medicine. All rights reserved.

have a rapid glucose measurement, as hypoglycemia often accompanies dehydration due to AGE. For children who require IV fluids, NS at 20 mL/kg is fully supported by the literature. Laboratory studies including blood work and stool studies are not needed in most cases of AGE, but should be considered in certain circumstances. Protein allergies should be in the differential diagnosis in young infants presenting with vomiting and diarrhea. *C difficile* colitis should be considered in children aged > 12 months who have a recent history of antibiotic use. The oral probiotics *L rhamnosus* GG and *S boulardii* have been shown to decrease the duration and frequency of diarrhea in children and should be recommended for children with AGE who are discharged from the ED.

Time- and Cost-Effective Strategies

- To address nausea/vomiting due to presumed AGE, give a dose of an antiemetic (eg, ondansetron) early to children who present to the ED with these symptoms. Most of these children will have only mild-to-moderate dehydration and should be rehydrated with ORS only. IV ondansetron should be given to patients who require IV fluids, as these patients are then more likely to tolerate oral fluids and may be discharged home.
- ORS should be the first fluids offered to children with mild-to-moderate dehydration secondary to AGE. IV fluids are indicated only in severe dehydration or in children who are unable to take ORS enterally.
- Laboratory studies are generally not indicated in mild-to-moderate dehydration due to AGE. In

Table 3. Antibiotic Therapy for Bacterial Gastroenteritis

Pathogen	Indication for Antibiotic Therapy	Drug of Choice[a]	Alternative Agents
Shigella spp	Proven or suspected shigellosis	Oral: azithromycin (12 mg/kg on day 1, followed by 6 mg/kg for 4 days); Parenteral, IV, IM: ceftriaxone (50 mg/kg for 2-5 days)[b]	Cefixime (8 mg/kg/day); ciprofloxacin[c] PO (20-30 mg/kg/day). For a known susceptible strain: TMP/SMX[b] (8 mg/kg/day of TMP) or ampicillin (100 mg/kg/day) or nalidixic acid (55 mg/kg/day)
Salmonella spp (non–typhoidal)	Antibiotic therapy is indicated only in high-risk children[d] to reduce the risk of bacteremia and extraintestinal focal infections	Ceftriaxone (50-100 mg/kg/day)	Azithromycin (10 mg/kg/day); ciprofloxacin[c] PO (20-30 mg/kg/day); for a known susceptible strain, TMP/SMX[d] (8 mg/kg/day of TMP)
Campylobacter spp	Antibiotic therapy is recommended mainly for the dysenteric *Campylobacter* gastroenteritis and is most efficacious when started within 3 days after onset of the disease	Azithromycin (10 mg/kg/day for 3 days, or a single dose of 30 mg/kg)	Doxycycline (> 8 years) or ciprofloxacin (> 17 years), when susceptible
Shiga toxin-producing *Escherichia coli*	Antibiotic therapy is not recommended	—	—
Enterotoxigenic *Escherichia coli*	Antibiotic therapy is recommended, mainly for traveler's diarrhea	Azithromycin (10 mg/kg/day for 3 days)	Cefixime (8 mg/kg/day for 5 days); TMP/SMX[d] (8 mg/kg/day of TMP); ciprofloxacin[d] PO (20-30 mg/kg/day); rifaximin (> 12 years, 600 mg/day, for 3 days)
Vibrio cholerae	Antibiotic therapy is recommended for confirmed or suspected case by travel history	Azithromycin (10 mg/kg/day for 3 days, or a single 20 mg/kg dose)	Doxycycline (> 8 years), ciprofloxacin (> 17 years), or TMP/SMX[d] (when susceptible)
Clostridium difficile	Antibiotic therapy is recommended for moderate and severe cases	Metronidazole (30 mg/kg/day for 10 days)	Vancomycin PO (40 mg/kg/day)

PO = per os.

[a]Depends on local antibiotic susceptibility profile, which should be monitored.

[b]TMP/SMX, trimethoprim–sulfamethoxazole.

[c]Ciprofloxacin is usually not recommended in the pediatric age group, but it can be used in children < 17 years when an alternative is not feasible.

[d]Please view article for more details on treatment regimens including medication doses and alternative medications.

Reprinted from: Alfredo Guarino, Shai Ashkenazi, Dominique Gendrel, et al, European Society for Pediatric Gastroenterology, Hepatology, and Nutrition/European Society for Pediatric Infectious Diseases Evidence-Based Guidelines for the Management of Acute Gastroenteritis in Children in Europe: Update 2014, *Journal of Pediatric Gastroenterology and Nutrition*, Volume 59, Issue 1, page 132-152, http://journals.lww.com/jpgn/fulltext/2014/07000/European_Society_for_Pediatric_Gastroenterology,.26.aspx.

Abbreviations: IM, intramuscular; IV, intravenous.

Copyright © 2018 EB Medicine. All rights reserved.

Risk Management Pitfalls in Management of Pediatric Patients With Gastroenteritis

1. **"She vomited 10 times over the last 24 hours, with 5 episodes of diarrhea. Even though she didn't appear dehydrated on examination, her mother was very worried, so I sent a set of electrolytes and a stool culture."**
   In children with mild or short-term gastroenteritis, electrolytes and stool cultures are of little clinical value. Electrolytes will rarely affect the management of children with mild-to-moderate dehydration. Viral infections are the most common cause of AGE, so stool cultures are not needed.

2. **"Even though her parents said she hadn't urinated in 18 hours, I didn't think she could be severely dehydrated because she was drinking fluids right in front of me, without vomiting."**
   Even when the vomiting in AGE stops, children can still lose significant volume through diarrhea. Observe skin turgor, weight loss, capillary refill, decreased urine output, tear production, and other signs of dehydration.

3. **"I didn't find out that the patient had hypoglycemia until the electrolyte panel came back."**
   If you are starting IV hydration in a child that you suspect has severe dehydration, point-of-care glucose testing should be performed rather than waiting for the formal metabolic panel. Young children have low glucose reserves and can easily develop hypoglycemia when they are dehydrated. Hypoglycemia should be treated promptly.

4. **"ORS tastes bad, so I gave my moderately dehydrated patient soda for his oral challenge after giving him a dose of ondansetron."**
   Sugary drinks do not have the correct formulation of electrolytes to allow for optimal absorption of water and electrolytes and may cause worsening diarrhea. These fluids are appropriate in children with either no or minimal dehydration due to AGE. One recent study suggests that dilute apple juice is another option for rehydration in children who are not dehydrated or those with minimal dehydration.[72]

5. **"The child was slightly tachycardic but had no other signs of dehydration on examination and had only been sick for a few hours. It was late at night and the child was sleeping, so we gave IV fluids immediately."**
   Almost all children with mild-to-moderate dehydration due to AGE can rehydrate via the enteral route. IV placement is painful, IV fluids are more expensive, and the complication rate is higher than from enteral rehydration.

6. **"I prescribed azithromycin for my patient who had diarrhea for the last 4 days because I was afraid she might have a bacterial infection."**
   In all well-appearing children and most ill children, antibiotics should not be started until there is confirmation of a bacterial pathogen in the stool. Most cases of AGE are caused by viruses, and in many cases of bacterial AGE, antibiotics are not needed or may prolong or worsen symptoms. Initiating antibiotics unnecessarily may harm the patient.

7. **"I told the mother to stop breast-feeding her son for a couple of days and to give lots of rice and bananas to bulk up his stools."**
   Breast-feeding should continue during episodes of AGE. There is no evidence to support the idea that a BRAT diet leads to quicker resolution of diarrhea compared to a regular diet.

8. **"I sent a stool sample for culture since it was bloody, but I didn't think about *C difficile* as a possibility. I didn't know about the recent history of 2 different courses of antibiotics for otitis media in the last month."**
   In children aged > 12 months, it is always good to ask about recent antibiotic use. *C difficile* colitis may resolve on its own, but it often requires treatment with oral antibiotics.

9. **"She had been vomiting for the last 3 days. I just assumed that she had the AGE that everyone else was coming in with lately. It turns out she had acute pancreatitis."**
   Most cases of vomiting alone will be early AGE; however, there are many other serious entities that will also cause vomiting. Prolonged vomiting without diarrhea is concerning. Look carefully for signs and symptoms that might suggest other diagnoses, such as severe abdominal pain, jaundice, polyuria/polydipsia, bilious emesis, abdominal distension, etc.

10. **"My patient came back 2 days later with severe dehydration. She looked great when I discharged her. I thought the parents would know what to bring her back for."**
    Don't assume that parents know or recognize signs of dehydration. Counsel them that if vomiting and diarrhea continue, they must be able to replace the fluid losses as well as give maintenance fluids. If they cannot, they should return for further medical care.

 Copyright © 2018 EB Medicine. All rights reserved.

children with concerns for severe dehydration, a rapid bedside glucose measurement should be performed, as hypoglycemia is relatively common in these patients and should be corrected quickly.

- Probiotics should be prescribed or recommended for children with AGE early in the course of their illness. This can help decrease the duration of their diarrhea by approximately 24 hours and may decrease the need of further interventions and medications.

Case Conclusions

Given her history and physical examination, you decided that the 18-month-old girl very likely had severe dehydration. Based on her tachycardia, dry lips, sunken eyes, and lack of tears, you decided to start her on IV fluids. You placed an IV and started a 20 mL/kg bolus of NS. You sent a blood sample for electrolytes, BUN, and creatinine. At the same time, you obtained a rapid glucose test, which revealed a value of 55 mg/dL. You gave the girl a 5 mL/kg bolus of 10% dextrose. After 1 IV NS bolus, the girl's heart rate decreased to 150 beats/min. You started a second 20 mL/kg IV bolus of NS. The girl continued to have episodes of watery diarrhea in the ED. You ordered a repeat point-of-care rapid glucose test. The results showed her glucose level was 122 mg/dL. After the second IV NS bolus, her heart rate decreased to 135 beats/min and the girl finally produced urine. Her bicarbonate level came back at 13 mEq/L. You decided to admit her for further IV hydration due to her level of dehydration on presentation, her refusal to take any fluids by mouth, and the continued diarrhea. You decided not to send stool cultures, as there was no fever, no blood in the stool, no recent travel, and no sick contacts. The girl was started on D5NS at 1.5 times maintenance and was transferred to the pediatric inpatient floor.

The 2-year-old boy was well-appearing, with no signs of dehydration on examination. The numerous sick contacts at daycare made the diagnosis of viral AGE most likely. You informed the boy's parents that antidiarrheal agents, such as loperamide, are not recommended in this age group. You told them that although the BRAT diet had been previously recommended by providers as the best diet for patients with diarrhea, studies have shown that an early return to an age-appropriate diet leads to quicker resolution of symptoms of AGE. You advised his parents to have their child return to his regular diet. You also remembered that many recent studies have shown that the duration of diarrheal illnesses can be reduced if certain probiotics are started early. You recommended that the parents start their son on a probiotic containing Lactobacillus rhamnosus *GG and continue it until the diarrhea resolved. The boy was discharged home with strict return precautions, including a description of concerning signs of dehydration.*

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 is included in bold type following the references, where available. The most informative references cited in this paper, as determined by the author, are noted by an asterisk (*) next to the number of the reference.

1. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. Practice parameter: the management of acute gastroenteritis in young children. *Pediatrics.* 1996;97(3):424-435. **(Practice guidelines)**
2.* 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(1):22-29. **(Prospective study; 106 subjects)**
3.* Ramsook C, Sahagun-Carreon I, Kozinetz CA, et al. A randomized clinical trial comparing oral ondansetron with placebo in children with vomiting from acute gastroenteritis. *Ann Emerg Med.* 2002;39(4):397-403. **(Prospective study; 145 subjects)**
4. Dinleyici EC, Kara A, Dalgic N, et al. *Saccharomyces boulardii* CNCM I-745 reduces the duration of diarrhoea, length of emergency care and hospital stay in children with acute diarrhoea. *Benef Microbes.* 2015;6(4):415-421. **(Prospective study; 363 subjects)**
5. Van Niel CW, Feudtner C, Garrison MM, et al. *Lactobacillus* therapy for acute infectious diarrhea in children: a meta-analysis. *Pediatrics.* 2002;109(4):678-684. **(Meta-analysis; 9 studies)**
6.* Guarino A, Ashkenazi S, Gendrel D, et al. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition/European Society for Pediatric Infectious Diseases evidence-based guidelines for the management of acute gastroenteritis in children in Europe: update 2014. *J Pediatr Gastroenterol Nutr.* 2014;59(1):132-152. **(Guideline)**
7. O'Ryan M, Lucero Y, O'Ryan-Soriano MA, et al. An update on management of severe acute infectious gastroenteritis in children. *Expert Rev Anti Infect Ther.* 2010;8(6):671-682. **(Review)**
8. Liu L, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet.* 2012;379(9832):2151-2161. **(Epidemiological study)**
9. Schnadower D, Finkelstein Y, Freedman SB. Ondansetron and probiotics in the management of pediatric acute gastroenteritis in developed countries. *Curr Opin Gastroenterol.* 2015;31(1):1-6. **(Review)**
10. Bonadio WA. Acute infectious enteritis in children. Emergency department diagnosis and management. *Emerg Med Clin North Am.* 1995;13(2):457-472. **(Review)**
11. Elliott EJ. Acute gastroenteritis in children. *BMJ.* 2007;334(7583):35-40. **(Review)**
12. Szajewska H, Dziechciarz P. Gastrointestinal infections in the

Copyright © 2018 EB Medicine. All rights reserved.

pediatric population. *Curr Opin Gastroenterol.* 2010;26(1):36-44. **(Review)**

13. Dalby-Payne JR, Elliott EJ. Gastroenteritis in children. *BMJ Clin Evid.* 2011;2011. **(Systematic review)**
14. Davey HM, Muscatello DJ, Wood JG, et al. Impact of high coverage of monovalent human rotavirus vaccine on emergency department presentations for rotavirus gastroenteritis. *Vaccine.* 2015;33(14):1726-1730. **(Time-series analysis)**
15. Atchison CJ, Stowe J, Andrews N, et al. Rapid declines in age group-specific rotavirus infection and acute gastroenteritis among vaccinated and unvaccinated individuals within 1 year of rotavirus vaccine introduction in England and Wales. *J Infect Dis.* 2016;213(2):243-249. **(Review)**
16. Wikswo ME, Kambhampati A, Shioda K, et al. Outbreaks of acute gastroenteritis transmitted by person-to-person contact, environmental contamination, and unknown modes of transmission--United States, 2009-2013. *MMWR Surveill Summ.* 2015;64(12):1-16. **(Surveillance summary)**
17. Payne DC, Vinjé J, Szilagyi PG, et al. Norovirus and medically attended gastroenteritis in U.S. children. *N Engl J Med.* 2013;368(12):1121-1130. **(Surveillance study)**
18. Deshpande ND, Shivakumar S, Bawa KS, et al. Pseudomembranous colitis. *Indian Pediatr.* 1993;30(3):372-374. **(Case report)**
19. Schutze GE, Willoughby RE, Committee on Infectious Diseases, et al. *Clostridium difficile* infection in infants and children. *Pediatrics.* 2013;131(1):196-200. **(Policy statement)**
20. Kaya A, Toyran M, Civelek E, et al. Characteristics and prognosis of allergic proctocolitis in infants. *J Pediatr Gastroenterol Nutr.* 2015;61(1):69-73. **(Observational study; 60 subjects)**
21. Nowak-Wegrzyn A. Food protein-induced enterocolitis syndrome and allergic proctocolitis. *Allergy Asthma Proc.* 2015;36(3):172-184. **(Review)**
22. Boyle JT. Gastrointestinal bleeding in infants and children. *Pediatr Rev.* 2008;29(2):39-52. **(Review)**
23. Heine RG. Gastrointestinal food allergies. *Chem Immunol Allergy.* 2015;101:171-180. **(Review)**
24.* Colletti JE, Brown KM, Sharieff GQ, et al. The management of children with gastroenteritis and dehydration in the emergency department. *J Emerg Med.* 2010;38(5):686-698. **(Review)**
25. World Health Organization. The treatment of diarrhoea. A manual for physicians and other senior health workers. Available at: apps.who.int/iris/bitstream/10665/43209/1/9241593180.pdf. Accessed January 15, 2018. **(Government report)**
26. Friedman 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(2):201-207. **(Prospective cohort study; 137 subjects)**
27. Goldman RD, Friedman JN, Parkin PC. Validation of the clinical dehydration scale for children with acute gastroenteritis. *Pediatrics.* 2008;122(3):545-549. **(Prospective observational study; 205 subjects)**
28. Gorelick MH, Shaw KN, Murphy KO. Validity and reliability of clinical signs in the diagnosis of dehydration in children. *Pediatrics.* 1997;99(5):E6. **(Prospective cohort study; 186 subjects)**
29. Pringle K, Shah SP, Umulisa I, et al. Comparing the accuracy of the three popular clinical dehydration scales in children with diarrhea. *Int J Emerg Med.* 2011;4:58. **(Prospective study; 49 subjects)**
30. Freedman SB, Vandermeer B, Milne A, et al. Diagnosing clinically significant dehydration in children with acute gastroenteritis using noninvasive methods: a meta-analysis. *J Pediatr.* 2015;166(4):908-916. **(Meta-analysis; 9 studies, 1039 subjects)**
31. Falszewska A, Dziechciarz P, Szajewska H. Diagnostic accuracy of clinical dehydration scales in children. *Eur J Pediatr.* 2017. **(Prospective observational study; 128 subjects)**
32. Falszewska A, Dziechciarz P, Szajewska H. The diagnostic accuracy of Clinical Dehydration Scale in identifying dehydration in children with acute gastroenteritis: a systematic review. *Clin Pediatr (Phila).* 2014;53(12):1181-1188. **(Review)**
33. Steiner MJ, Nager AL, Wang VJ. Urine specific gravity and other urinary indices: inaccurate tests for dehydration. *Pediatr Emerg Care.* 2007;23(5):298-303. **(Prospective cohort study; 79 subjects)**
34. Shaoul R, Okev N, Tamir A, et al. Value of laboratory studies in assessment of dehydration in children. *Ann Clin Biochem.* 2004;41(Pt 3):192-196. **(Retrospective review; 300 subjects)**
35. 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(7):755-757. **(Prospective study; 50 subjects)**
36. Narchi H. Serum bicarbonate and dehydration severity in gastroenteritis. *Arch Dis Child.* 1998;78(1):70-71. **(Prospective study; 106 subjects)**
37. Vega RM, Avner JR. A prospective study of the usefulness of clinical and laboratory parameters for predicting percentage of dehydration in children. *Pediatr Emerg Care.* 1997;13(3):179-182. **(Prospective study; 97 subjects)**
38. Churgay CA, Aftab Z. Gastroenteritis in children: part 1. Diagnosis. *Am Fam Physician.* 2012;85(11):1059-1062. **(Review)**
39. Meloni GF, Tomasi PA, Spanu P, et al. C-reactive protein levels for diagnosis of *Salmonella* gastroenteritis. *Pediatr Infect Dis J.* 1999;18(5):471-473. **(Confirmatory study; 248 subjects)**
40. Bruzzese E, Lo Vecchio A, Guarino A. Hospital management of children with acute gastroenteritis. *Curr Opin Gastroenterol.* 2013;29(1):23-30. **(Review)**
41. Pothoulakis H, Triadafilopoulos G, LaMont JT. Antibiotic-associated colitis. *Compr Ther.* 1985;11(12):68-73. **(Review)**
42. Brook I. Pseudomembranous colitis in children. *J Gastroenterol Hepatol.* 2005;20(2):182-186. **(Review)**
43. Kucik CJ, Martin GL, Sortor BV. Common intestinal parasites. *Am Fam Physician.* 2004;69(5):1161-1168. **(Review)**
44. Weatherhead JE, Hotez PJ. Worm infections in children. *Pediatr Rev.* 2015;36(8):341-352. **(Review)**
45. Sýkora J, Siala K, Huml M, et al. Evaluation of faecal calprotectin as a valuable non-invasive marker in distinguishing gut pathogens in young children with acute gastroenteritis. *Acta Paediatr.* 2010;99(9):1389-1395. **(Prospective analysis; 107 subjects)**
46. Duman M, Gencpinar P, Biçmen M, et al. Fecal calprotectin: can be used to distinguish between bacterial and viral gastroenteritis in children? *Am J Emerg Med.* 2015;33(10):1436-1439. **(Prospective study; 84 subjects)**
47. Razzaq R, Sukumar SA. Ultrasound diagnosis of clinically undetected *Clostridium difficile* toxin colitis. *Clin Radiol.* 2006;61(5):446-452. **(Case reports)**
48. Leung AK, Robson WL. Acute gastroenteritis in children: role of anti-emetic medication for gastroenteritis-related vomiting. *Paediatr Drugs.* 2007;9(3):175-184. **(Review)**
49.* Freedman SB. Acute infectious pediatric gastroenteritis: beyond oral rehydration therapy. *Expert Opin Pharmacother.* 2007;8(11):1651-1665. **(Review)**
50. Levine DA. Antiemetics for acute gastroenteritis in children. *Curr Opin Pediatr.* 2009;21(3):294-298. **(Review)**
51. Starke PR, Weaver J, Chowdhury BA. Boxed warning added to promethazine labeling for pediatric use. *N Engl J Med.* 2005;352(25):2653. **(Correspondence)**
52. Das JK, Kumar R, Salam RA, et al. The effect of antiemetics in childhood gastroenteritis. *BMC Public Health.* 2013;13

 Copyright © 2018 EB Medicine. All rights reserved.

Suppl 3:S9. **(Meta-analysis; 7 studies)**

53. Marchetti F, Bonati M, Maestro A, et al. Oral ondansetron versus domperidone for acute gastroenteritis in pediatric emergency departments: multicenter double blind randomized controlled trial. *PLoS One.* 2016;11(11):e0165441. **(Prospective study; 356 subjects)**
54. Freedman SB, Tung C, Cho D, et al. Time-series analysis of ondansetron use in pediatric gastroenteritis. *J Pediatr Gastroenterol Nutr.* 2012;54(3):381-386. **(Retrospective cohort study; 3508 patient visits)**
55. Reeves JJ, Shannon MW, Fleisher GR. Ondansetron decreases vomiting associated with acute gastroenteritis: a randomized, controlled trial. *Pediatrics.* 2002;109(4):e62. **(Prospective study; 107 subjects)**
56. Stork CM, Brown KM, Reilly TH, et al. Emergency department treatment of viral gastritis using intravenous ondansetron or dexamethasone in children. *Acad Emerg Med.* 2006;13(10):1027-1033. **(Prospective study; 166 subjects)**
57. Freedman SB, Powell EC, Nava-Ocampo AA, et al. Ondansetron dosing in pediatric gastroenteritis: a prospective cohort, dose-response study. *Paediatr Drugs.* 2010;12(6):405-410. **(Prospective observation study; 105 subjects)**
58. Mullarkey C, Crowley E, Martin C. The addition of ondansetron to a oral rehydration protocol for children with acute gastroenteritis. *Ir Med J.* 2013;106(9):266-268. **(Retrospective study; 449 subjects)**
59. Ibrahim K, Al Ansari K. Flavored intravenous ondansetron administered orally for the treatment of persistent vomiting in children. *J Trop Pediatr.* 2016;62(4):288-292. **(Prospective study)**
60. Freedman SB, Uleryk E, Rumantir M, et al. Ondansetron and the risk of cardiac arrhythmias: a systematic review and postmarketing analysis. *Ann Emerg Med.* 2014;64(1):19-25. **(Review)**
61. United States Food & Drug Administration. FDA drug safety communication: new information regarding QT prolongation with ondansetron (Zofran). Available at: www.fda.gov/Drugs/DrugSafety/ucm310190.htm. Accessed January 15, 2018. **(Government report)**
62. Fedorowicz Z, Jagannath VA, Carter B. Antiemetics for reducing vomiting related to acute gastroenteritis in children and adolescents. *Cochrane Database Syst Rev.* 2011(9):CD005506. **(Systematic review; 7 studies, 1020 subjects)**
63. Sturm JJ, Hirsh DA, Schweickert A, et al. Ondansetron use in the pediatric emergency department and effects on hospitalization and return rates: are we masking alternative diagnoses? *Ann Emerg Med.* 2010;55(5):415-422. **(Retrospective review; 34,117 subjects)**
64. Freedman SB, Hall M, Shah SS, et al. Impact of increasing ondansetron use on clinical outcomes in children with gastroenteritis. *JAMA Pediatr.* 2014;168(4):321-329. **(Retrospective observational analysis; 804,000 patient visits)**
65. Lifschitz CH. Treatment of acute diarrhea in children. *Curr Opin Pediatr.* 1997;9(5):498-501. **(Review)**
66. Hoekstra JH, European Society of Paediatric Gastroenterology, Hepatology and Nutrition Working Group on Acute Diarrhoea. Acute gastroenteritis in industrialized countries: compliance with guidelines for treatment. *J Pediatr Gastroenterol Nutr.* 2001;33 Suppl 2:S31-S35. **(Review)**
67. Freedman SB, Ali S, Oleszczuk M, et al. Treatment of acute gastroenteritis in children: an overview of systematic reviews of interventions commonly used in developed countries. *Evid Based Child Health.* 2013;8(4):1123-1137. **(Review)**
68. Bellemare S, Hartling L, Wiebe N, et al. Oral rehydration versus intravenous therapy for treating dehydration due to gastroenteritis in children: a meta-analysis of randomised controlled trials. *BMC Med.* 2004;2:11. **(Meta-analysis; 14 studies)**
69. Yiu WL, Smith AL, Catto-Smith AG. Nasogastric rehydration in acute gastroenteritis. *J Paediatr Child Health.* 2003;39(2):159-161. **(Retrospective review; 166 subjects)**
70. Freedman SB, Sivabalasundaram V, Bohn V, et al. The treatment of pediatric gastroenteritis: a comparative analysis of pediatric emergency physicians' practice patterns. *Acad Emerg Med.* 2011;18(1):38-45. **(Survey; 235 responders)**
71. Dale J. Oral rehydration solutions in the management of acute gastroenteritis among children. *J Pediatr Health Care.* 2004;18(4):211-212. **(Review)**
72. Freedman SB, Willan AR, Boutis K, et al. Effect of dilute apple juice and preferred fluids vs electrolyte maintenance solution on treatment failure among children with mild gastroenteritis: a randomized clinical trial. *JAMA.* 2016;315(18):1966-1974. **(Prospective noninferiority study; 647 subjects)**
73. Granado-Villar D, Cunill-De Sautu B, Granados A. Acute gastroenteritis. *Pediatr Rev.* 2012;33(11):487-494. **(Review)**
74.* Guarino A, Albano F, Guandalini S, et al. Oral rehydration: toward a real solution. *J Pediatr Gastroenterol Nutr.* 2001;33 Suppl 2:S2-S12. **(Review)**
75. Churgay CA, Aftab Z. Gastroenteritis in children: part II. Prevention and management. *Am Fam Physician.* 2012;85(11):1066-1070. **(Review)**
76. Nager AL, Wang VJ. Comparison of nasogastric and intravenous methods of rehydration in pediatric patients with acute dehydration. *Pediatrics*. 2002;109(4):566-572. **(Prospective study; 96 subjects)**
77. Fox J, Richards S, Jenkins HR, et al. Management of gastroenteritis over 10 years: changing culture and maintaining the change. *Arch Dis Child.* 2012;97(5):415-417. **(Retrospective audit)**
78. Nir V, Nadir E, Schechter Y, et al. Parents' attitudes toward oral rehydration therapy in children with mild-to-moderate dehydration. *ScientificWorldJournal.* 2013;2013:828157. **(Survey; 100 responders)**
79. Reid SR, Losek JD. Hypoglycemia complicating dehydration in children with acute gastroenteritis. *J Emerg Med.* 2005;29(2):141-145. **(Retrospective prevalence study; 196 subjects)**
80. Janet S, Molina JC, Marañón R, et al. Effects of rapid intravenous rehydration in children with mild-to-moderate dehydration. *Pediatr Emerg Care.* 2015;31(8):564-567. **(Prospective observation study; 83 subjects)**
81. Levy JA, Bachur RG, Monuteaux MC, et al. Intravenous dextrose for children with gastroenteritis and dehydration: a double-blind randomized controlled trial. *Ann Emerg Med.* 2013;61(3):281-288. **(Prospective double-blind study; 188 subjects)**
82. Sendarrubias M, Carrón M, Molina JC, et al. Clinical impact of rapid intravenous rehydration with dextrose serum in children with acute gastroenteritis. *Pediatr Emerg Care.* 2017. DOI: 10.1097/PEC.0000000000001064 **(Prospective randomized study; 145 subjects)**
83. Levy JA, Bachur RG. Intravenous dextrose during outpatient rehydration in pediatric gastroenteritis. *Acad Emerg Med.* 2007;14(4):324-330. **(Retrospective case control study; 168 subjects)**
84. Freedman SB, Parkin PC, Willan AR, et al. Rapid versus standard intravenous rehydration in paediatric gastroenteritis: pragmatic blinded randomised clinical trial. *BMJ.* 2011;343:d6976. **(Prospective study; 126 subjects)**
85. Toaimah FH, Mohammad HM. Rapid intravenous rehydration therapy in children with acute gastroenteritis: a

systematic review. *Pediatr Emerg Care.* 2016;32(2):131-135. **(Systematic review; 3 studies, 464 subjects)**

86. Borron SW, Watts SH, Tull J, et al. Intentional misuse and abuse of loperamide: a new look at a drug with "low abuse potential." *J Emerg Med.* 2017;53(1):73-84. **(Review)**
87. MacDonald R, Heiner J, Villarreal J, et al. Loperamide dependence and abuse. *BMJ Case Rep.* 2015 May 2;2015. DOI: 10.1136/bcr-2015-209705 **(Case report and review)**
88. Magrone T, Jirillo E. The interplay between the gut immune system and microbiota in health and disease: nutraceutical intervention for restoring intestinal homeostasis. *Curr Pharm Des.* 2013;19(7):1329-1342. **(Review)**
89. Vandenplas Y, De Greef E, Hauser B, et al. Probiotics and prebiotics in pediatric diarrheal disorders. *Expert Opin Pharmacother.* 2013;14(4):397-409. **(Review)**
90. Guarino A, Guandalini S, Lo Vecchio A. Probiotics for prevention and treatment of diarrhea. *J Clin Gastroenterol.* 2015;49 Suppl 1:S37-S45. **(Review)**
91. Allen SJ, Martinez EG, Gregorio GV, et al. Probiotics for treating acute infectious diarrhoea. *Cochrane Database Syst Rev.* 2010(11):CD003048. **(Meta-analysis; 56 studies)**
92. Vandenplas Y. Probiotics and prebiotics in infectious gastroenteritis. *Best Pract Res Clin Gastroenterol.* 2016;30(1):49-53. **(Review)**
93. Feizizadeh S, Salehi-Abargouei A, Akbari V. Efficacy and safety of *Saccharomyces boulardii* for acute diarrhea. *Pediatrics.* 2014;134(1):e176-e191. **(Meta-analysis; 22 studies)**
94. Szajewska H, Skórka A, Ruszczyński M, et al. Meta-analysis: *Lactobacillus* GG for treating acute gastroenteritis in children--updated analysis of randomised controlled trials. *Aliment Pharmacol Ther.* 2013;38(5):467-476. **(Meta-analysis; 2963 subjects)**
95. Cruchet S, Furnes R, Maruy A, et al. The use of probiotics in pediatric gastroenterology: a review of the literature and recommendations by Latin-American experts. *Paediatr Drugs.* 2015;17(3):199-216. **(Review)**
96. Barnes D, Yeh AM. Bugs and guts: practical applications of probiotics for gastrointestinal disorders in children. *Nutr Clin Pract.* 2015;30(6):747-759. **(Review)**
97. Caffarelli C, Cardinale F, Povesi-Dascola C, et al. Use of probiotics in pediatric infectious diseases. *Expert Rev Anti Infect Ther.* 2015;13(12):1517-1535. **(Review)**
98. Thomas DW, Greer FR, Committee on Nutrition; Section on Gastroenterology, Hepatology, and Nutrition. Probiotics and prebiotics in pediatrics. *Pediatrics.* 2010;126(6):1217-1231. **(Review)**
99. Canani RB, Cirillo P, Terrin G, et al. Probiotics for treatment of acute diarrhoea in children: randomised clinical trial of five different preparations. *BMJ.* 2007;335(7615):340. **(Prospective study; 571 subjects)**
100. Freedman SB, Williamson-Urquhart S, Schuh S, et al. Impact of emergency department probiotic treatment of pediatric gastroenteritis: study protocol for the PROGUT (Probiotic Regimen for Outpatient Gastroenteritis Utility of Treatment) randomized controlled trial. *Trials.* 2014;15:170. **(Study currently ongoing, prospective; 886 subjects planned)**
101. Guandalini S, Pensabene L, Zikri MA, et al. *Lactobacillus* GG administered in oral rehydration solution to children with acute diarrhea: a multicenter European trial. *J Pediatr Gastroenterol Nutr.* 2000;30(1):54-60. **(Prospective study; 287 subjects)**
102. Szajewska H, Ruszczycski M, Kolaček S. Meta-analysis shows limited evidence for using *Lactobacillus acidophilus* LB to treat acute gastroenteritis in children. *Acta Paediatr.* 2014;103(3):249-255. **(Meta-analysis; 304 subjects)**
103. Pieścik-Lech M, Urbańska M, Szajewska H. *Lactobacillus* GG (LGG) and smectite versus LGG alone for acute gastroenteritis: a double-blind, randomized controlled trial. *Eur J Pediatr.* 2013;172(2):247-253. **(Prospective study; 88 subjects)**
104. İşlek A, Sayar E, Yılmaz A, et al. The role of *Bifidobacterium lactis* B94 plus inulin in the treatment of acute infectious diarrhea in children. *Turk J Gastroenterol.* 2014;25(6):628-633. **(Prospective study; 156 subjects)**
105. Pieścik-Lech M, Shamir R, Guarino A, et al. Review article: the management of acute gastroenteritis in children. *Aliment Pharmacol Ther.* 2013;37(3):289-303. **(Review)**
106. Vandenplas Y, De Hert S, group Ps. Cost/benefit of synbiotics in acute infectious gastroenteritis: spend to save. *Benef Microbes.* 2012;3(3):189-194. **(Prospective study; 111 subjects)**
107. Parashette KR, Croffie J. Vomiting. *Pediatr Rev.* 2013;34(7):307-319. **(Review)**
108. Gordon M, Akobeng A. Racecadotril for acute diarrhoea in children: systematic review and meta-analyses. *Arch Dis Child.* 2016;101(3):234-240. **(Meta-analysis; 7 studies, 1591 subjects)**
109. Mennini M, Tolone C, Frassanito A, et al. Gelatin tannate for acute childhood gastroenteritis: a randomized, single-blind controlled trial. *Paediatr Drugs.* 2017;19(2):131-137. **(Prospective study; 60 subjects)**
110. Michałek D, Kołodziej M, Konarska Z, et al. Efficacy and safety of gelatine tannate for the treatment of acute gastroenteritis in children: protocol of a randomised controlled trial. *BMJ Open.* 2016;6(2):e010530. **(Proposed prospective study; 158 subjects)**
111. Noguera T, Wotring R, Melville CR, et al. Resolution of acute gastroenteritis symptoms in children and adults treated with a novel polyphenol-based prebiotic. *World J Gastroenterol.* 2014;20(34):12301-12307. **(Prospective study; 300 subjects)**
112. Guerrero CA, Torres DP, García LL, et al. N-acetylcysteine treatment of rotavirus-associated diarrhea in children. *Pharmacotherapy.* 2014;34(11):e333-e340. **(Case report)**
113. Sandhu BK, European Society of Paediatric Gastroenterology Hepatology Nutrition (ESPGHAN) Working Group on Acute Diarrhoea. Rationale for early feeding in childhood gastroenteritis. *J Pediatr Gastroenterol Nutr.* 2001;33 Suppl 2:S13-S16. **(Review)**
114. Guarino A, Winter H, Sandhu B, et al. Acute gastroenteritis disease: report of the FISPGHAN Working Group. *J Pediatr Gastroenterol Nutr.* 2012;55(5):621-626. **(Policy statement)**
115. Dugdale A, Lovell S, Gibbs V, et al. Refeeding after acute gastroenteritis: a controlled study. *Arch Dis Child.* 1982;57(1):76-78. **(Prospective study; 59 subjects)**
116. Brandt KG, Castro Antunes MM, Silva GA. Acute diarrhea: evidence-based management. *J Pediatr (Rio J).* 2015;91(6 Suppl 1):S36-S43. **(Review)**
117. McFarland LV, Ozen M, Dinleyici EC, et al. Comparison of pediatric and adult antibiotic-associated diarrhea and *Clostridium difficile* infections. *World J Gastroenterol.* 2016;22(11):3078-3104. **(Review)**
118. Phavichitr N, Catto-Smith A. Acute gastroenteritis in children: what role for antibacterials? *Paediatr Drugs.* 2003;5(5):279-290. **(Review)**
119. Pickering LK. Antibiotic therapy of colitis. *Pediatr Infect Dis J.* 2001;20(4):465-466. **(Review)**

 Copyright © 2018 EB Medicine. All rights reserved.

CME Questions

Current subscribers receive CME credit absolutely free by completing the following test. Each issue includes *4 AMA PRA Category 1 Credits™*, 4 ACEP Category I credits, 4 AAP Prescribed credits, or 4 AOA Category 2-A or 2-B credits. Online testing is available for current and archived issues. To receive your free CME credits for this issue, scan the QR code below with your smartphone or visit www.ebmedicine.net/P0218.

1. What is the most common cause of bacterial AGE in children who live in the United States?
a. *Campylobacter jejuni*
b. *Shigella sonnei*
c. *Escherichia coli* O157:H7
d. *Yersinia enterocolitica*

2. You are seeing an 18-month-old boy who has had vomiting and diarrhea for the last 36 hours. His parents state he has had approximately 10 episodes of vomiting and 10 episodes of watery diarrhea. They cannot quantify his urine output. He is drinking very little and appears very tired. His weight today is 11 kg. His parents state that at a well-child visit last week his weight was 12.5 kg. What is his dehydration level?
a. He is not dehydrated
b. Mild dehydration (3%-5% dehydration)
c. Moderate dehydration (6%-9% dehydration)
d. Severe dehydration (> 9% dehydration)

3. You are seeing a 5-year-old boy with 2 days of vomiting and diarrhea. His parents say that he has not been able to keep down any fluids in the last 24 hours. Based on his physical examination, you determined that he has severe dehydration. In addition to placing an IV and giving a rapid bolus of 0.9% sodium chloride (normal saline, NS), what laboratory test should be performed immediately?
a. Rapid glucose measurement
b. Urinalysis
c. C-reactive protein
d. Stool culture

4. A 2-year-old girl is brought in by her parents with the chief complaint of vomiting for the last 4 hours, with a total of 6 episodes. They state that she has no other symptoms. Her physical examination is normal. The girl vomited right before you came into the examination room. What should be your first step in the management of this patient?
a. Give a weight-based dose of oral ondansetron and then wait 20 to 30 minutes before starting an oral challenge.
b. Immediately start an IV and give a 20 mL/kg NS bolus.
c. Immediately start an oral challenge with orange juice.
d. Discharge the patient home with instructions to let the child sleep and try oral rehydration in the morning.

5. What is the best oral fluid to give a child with mild-to-moderate dehydration due to viral AGE?
a. A smoothie
b. Commercially prepared oral rehydration solution (ORS)
c. Water
d. Ginger ale

6. A 2-year-old child with mild dehydration due to suspected viral AGE continues to vomit after a dose of oral ondansetron. According to evidence-based studies, what is the next most appropriate step in her care if IV access appears difficult?
a. Give a dose of oral metoclopramide.
b. Check a rapid glucose level.
c. Place an nasogastric tube and start rehydration with ORS via this route.
d. Place an IO catheter and start maintenance fluids.

7. What is the preferred IV solution to give a hemodynamically stable child with severe dehydration due to AGE?
a. 30 mL/kg 5% dextrose in NS given over 1 hour
b. 20 mL/kg NS given over 1 hour or less
c. 60 mL/kg NS given over 1 hour
d. 20 mL/kg 5% dextrose in NS given over 1 hour

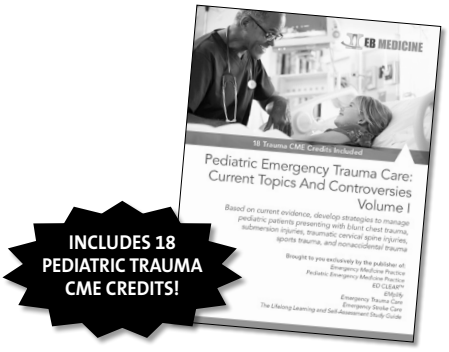
Copyright © 2018 EB Medicine. All rights reserved.

8. **You are discharging a 4-year-old boy who came to the ED with complaints of vomiting and diarrhea. He is well-hydrated on examination and has tolerated ORS after a dose of ondansetron. The family asks if you could prescribe something for his diarrhea. You have recently read that probiotics may help shorten the course of diarrhea in viral AGE. Which probiotic should you recommend/prescribe?**
   a. *Bifidobacterium lactis*
   b. *Streptococcus thermophiles*
   c. *Lactobacillus rhamnosus* GG
   d. *Bacillus coagulans*

9. **What diet recommendations should you make to the parents of a child you are discharging from the ED with the diagnosis of AGE?**
   a. Stop breast-feeding until the diarrhea has stopped.
   b. No solids should be given until vomiting has stopped for 24 hours.
   c. Give a BRAT diet until diarrhea has resolved.
   d. Provide a regular, age-appropriate diet.

10. **What is the first-line treatment for** *Clostridium difficile* **colitis in a 5-year-old child with no prior history of** *C difficile* **infection? She has had 3 days of watery diarrhea (about 4 times per day) and is currently on day 7/10 of clindamycin for an abscess on her right thigh. Her parents say she has been drinking well with normal urine output.**
   a. Start oral metronidazole 30 mg/kg/day divided 4 times per day.
   b. Start oral vancomycin 40 mg/kg/day divided 4 times per day.
   c. Discontinue the clindamycin.
   d. Continue clindamycin and add the probiotic *S boulardii*.

The Definitive Guide to Pediatric Trauma has Arrived



Stay up-to-date with current guidelines and best practices for your pediatric trauma patients. ***Pediatric Emergency Trauma Care: Current Topics and Controversies, Volume II*** provides updates on 5 critical topics, along with treatment recommendations to help you determine the critical actions required when caring for these patients.

Visit www.ebmedicine.net/NKBXF to get instant access to this must-have resource

EB MEDICINE

Ace Your ABEM Exams With Our 2015-2018 LLSA Study Guides!

Get full article reprints, plus a handy summary, an in-depth discussion of key points, and 35 CME credits!

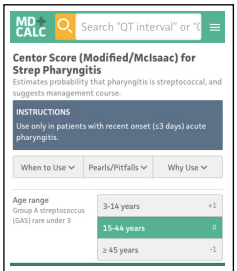
Visit www.ebmedicine.net/NKLXT or call 1-800-249-5770 to order!

EB MEDICINE

 Copyright © 2018 EB Medicine. All rights reserved.

Here's a sample of
Calculated Decisions
Developed in partnership
with MDCalc

Calculated Decisions
POWERED BY MDCALC
Clinical Decision Support for *Pediatric Emergency Medicine Practice* Subscribers



Click the thumbnail above to access the calculator.

Centor Score (Modified/McIsaac) for Strep Pharyngitis

Introduction: The Centor Score estimates the probability that pharyngitis is streptococcal and suggests the management course.

Points & Pearls

- The Centor Score correlates directly with the risk of a throat culture that is positive for group A *Streptococcus* (GAS).
- The most recently updated guideline from the Infectious Diseases Society of America for diagnosis and management of GAS pharyngitis no longer recommends empiric treatment. The new recommendation is to test patients who are at higher risk for GAS pharyngitis, but give antibiotics only when a patient's rapid antigen detection test or throat culture is positive for GAS (Shulman et al 2012).
- The modified criteria designated by McIsaac et al (2004) include an age component, along with tonsillar swelling. GAS is incredibly rare in patients aged < 3 years, and is also less common in older adults, so the age component can help clinicians risk stratify patients.
- Most cases of pharyngitis are viral in origin. Given the rare incidence of acute rheumatic fever, along with the questionable benefits of early antibiotics to prevent sequelae like peritonsillar abscess, antibiotics are now prescribed much less often. Steroids (such as dexamethasone) and NSAIDs (nonsteroidal anti-inflammatory drugs) often provide similar pain relief and resolution of symptoms to antibiotics.

CALCULATOR REVIEW AUTHORS

Graham Walker, MD
Department of Emergency Medicine
Kaiser Permanente San Francisco, San Francisco, CA

Rachel Kwon, MD
MDCalc

Why to Use

Most pharyngitis is viral and does not respond to antibiotic treatment. The Centor Score attempts to predict which patients will have culture-confirmed GAS infections of the pharynx, to help determine which patients to test in the first place.

The newer FeverPAIN Score is similar, but the Centor Score has the advantage of distinguishing adolescents and young adults from preadolescents, which is important because streptococcal carrier rates for preadolescents are higher than for adolescents and young adults, and older patients exhibit more severe symptoms and develop suppurative complications more frequently (Mitchell et all 2011).

When to Use

- For use in children with pharyngitis, primarily; the risk of GAS decreases significantly with age into adulthood.
- Use only in patients with recent onset (≤ 3 days) of acute pharyngitis.

Next Steps

Steroids and NSAIDs improve symptoms; antibiotics are often indicated in GAS pharyngitis, but do not prevent its suppurative complications, such as peritonsillar abscess.

Critical Actions

It is still important to carefully consider patients with symptom duration longer than 3 days, even though the Centor Score does not apply. While symptoms are not compatible with a diagnosis of acute pharyngitis, these patients require evaluation for suppurative complications (eg, peritonsillar abscess or Lemierre syndrome), or viral infections in adult patients (eg, infectious mononucleosis or acute HIV) (Centor 2017).

Evidence Appraisal

The goal of the original study by Centor et al was to develop criteria to diagnose GAS infection in adult patients presenting to the emergency department with a sore throat (Centor et al 1981). The original model designated 4 criteria: tonsillar exudates; swollen, tender anterior cervical nodes; absence of cough; and history of fever. Patients exhibiting all 4 variables had a 56% probability of having a group A beta strep-positive culture; the probability was 32% in patients with 3 variables, 15% in patients with 2 variables, 6.5% in patients with 1 variable, and 2.5% in patients with none of the variables.

The Centor Score was later modified to include age (McIsaac et al 1998) and was validated (McIsaac et al 2004) for use in both children and adults presenting with a sore throat. McIsaac et al (1998) determined that using the Centor Score would reduce the number of unnecessary initial antibiotic prescriptions by 48%, without increasing throat culture use.

The Centor Score and its modifications were derived in relatively small samples (n = 286 and n = 521, respectively). In order to more precisely classify the risk of GAS infection, Fine et al (2012) performed a national-scale validation of the score on a geographically diverse population of > 140,000 patients presenting in a clinical setting. The study was carried out over the course of more than a year, mitigating any impact of seasonality of GAS incidence on the results. This analysis provided more precise interpretations of risk for each category of the Centor Score and still fell within the 95% confidence interval of the original study by Centor et al (1981), which had a much smaller sample size.

In their comparison of the Centor Score with other identification and treatment strategies, McIsaac et al (2004) found that use of the score resulted in fewer overall tests (throat cultures and rapid antigen detection tests) per person, but more throat cultures (96.1% of adults) than other strategies. As a result, the Centor Score represented a compromise, requiring the least diagnostic testing, providing 100% sensitivity and greater than 90% specificity in both children and adults, and producing significant reductions in unnecessary use of antibiotics, compared with other strategies.

Harris et al (2016) encouraged the use of the Centor Score primarily to identify patients with a low probability of GAS pharyngitis who do not warrant further testing, citing the low positive predictive value of the criteria.

Calculator Creator

Robert M. Centor, MD
Click here to read more about Dr. Centor.

References

Original/Primary References

- Centor RM, Witherspoon JM, Dalton HP, et al. The diagnosis of strep throat in adults in the emergency room. *Med Decis Making*. 1981;1(3):239-246.
- McIsaac WJ, White D, Tannenbaum D, et al. A clinical score to reduce unnecessary antibiotic use in patients with sore throat. *CMAJ*. 1998;158(1):75-83.

Validation References

- Fine AM, Nizet V, Mandl KD. Large-scale validation of the Centor and McIsaac scores to predict group A streptococcal pharyngitis. *Arch Intern Med*. 2012;172(11):847-852.
- McIsaac WJ, Kellner JD, Aufricht P, et al. Empirical validation of guidelines for the management of pharyngitis in children and adults. *JAMA*. 2004;291(13):1587-1595.

Other References

- Shulman ST, Bisno AL, Clegg HW, et al. Executive summary: clinical practice guideline for the diagnosis and management of group A streptococcal pharyngitis: 2012 update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2012;55(10):1279-1282.
- Harris AM, Hicks LA, Qaseem A, et al. Appropriate antibiotic use for acute respiratory tract infection in adults: advice for high-value care from the American College of Physicians and the Centers for Disease Control and Prevention. *Ann Intern Med*. 2016;164(6):425-434.
- Mitchell MS, Sorrentino A, Centor RM. Adolescent pharyngitis: a review of bacterial causes. *Clin Pediatr (Phila)*. 2011;50(12):1091-1095.
- Centor R. Centor's corner: FeverPAIN versus Centor Score. *Paging MDCalc [blog]*. Available at: http://paging.mdcalc.com/2017/08/18/centors-corner-feverpain-versus-centor-score/. Accessed November 16, 2017.

Copyright © MDCalc • Reprinted with permission.

Related Calculator

- Click here to access the FeverPAIN Score for Strep Pharyngitis.

Are you making the most of your *Pediatric Emergency Medicine Practice* subscriber benefits?

Look for your monthly content, all available on the 1st of each month!

- Issue in print and online
- ***Points & Pearls*** executive summary
- ***Calculated Decisions***
- Easy online CME testing

Go online to www.ebmedicine.net/topics to see what's new!

 Copyright © 2017 EB Medicine. All rights reserved.

Journals with Multi-Media Training

Emergency Medicine Practice, published 12 times per year in a multi-media format, provides diagnosis techniques and treatment recommendations that can be applied immediately and reliably to your practice. Written by practicing, experienced ED physicians, *Emergency Medicine Practice* can boost your clinical confidence, refresh your memory of the fundamentals, and keep you abreast of the most relevant updates in emergency medicine.

An annual subscription now includes print issues, full online access to archived issues, CME, and so much more! You also receive our exclusive ***Points & Pearls*** supplement (a 2-page digest of each issue), the companion podcast (***EMplify***), and our new ***Calculated Decisions*** supplement (including links to MDCalc's risk scores and calculators you can use in real time!).

Price: $349 (group rates available) **CME:** 48 credits **Format:** Print, Online, & More

Pediatric Emergency Medicine Practice is the leading evidence-based resource that gives you concise, applicable information on the management of pediatric patients. Whether you work in a pediatric ED or a general ED, knowledge of appropriate diagnosis and management of pediatric emergencies is critical to delivering optimal patient care.

An annual subscription now includes print issues, full online access to archived issues, CME, and so much more! You also receive our exclusive ***Points & Pearls*** supplement (a 2-page digest of each issue), the companion podcast (***EMplify Pediatrics***—*coming soon*), and our new ***Calculated Decisions*** supplement (including links to MDCalc's risk scores and calculators you can use in real time!).

Price: $319 (group rates available) **CME:** 48 credits **Format:** Print, Online, & More

To order: call 1.800.249.5770 or visit www.ebmedicine.net

This edition of *Calculated Decisions*, powered by MDCalc, is published as a supplement to *Pediatric Emergency Medicine Practice* as an exclusive benefit to subscribers. *Calculated Decisions* is the result of a collaboration between EB Medicine, publisher of *Pediatric Emergency Medicine Practice*, and MD Aware, developer of MDCalc. Both companies are dedicated to providing evidence-based clinical decision-making support for emergency medicine clinicians.

Contact EB Medicine:
Phone: 1-800-249-5770
or 678-366-7933
Fax: 770-500-1316
Address:
5550 Triangle Parkway, Suite 150
Norcross, GA 30092

Contact MD Aware:
MDCalc
Phone: 646-543-8380
Address:
902 Broadway, 6th Floor
New York, NY 10010

Pediatric Emergency Medicine Practice (ISSN Print: 1549-9650, ISSN Online: 1549-9669, ACID-FREE) is published monthly (12 times per year) by EB Medicine (5550 Triangle Parkway, Suite 150, Norcross, GA 30092).

Opinions expressed are not necessarily those of this publication. Mention of products or services does not constitute endorsement. This publication is intended as a general guide and is intended to supplement, rather than substitute, professional judgment. It covers a highly technical and complex subject and should not be used for making specific medical decisions. The materials contained herein are not intended to establish policy, procedure, or standard of care. Copyright © 2017 EB Medicine. All rights reserved. No part of this publication may be reproduced in any format without written consent of EB Medicine. This publication is intended for the use of the individual subscriber only and may not be copied in whole or part or redistributed in any way without the publisher's prior written permission.

PEDIATRIC EMERGENCY MEDICINE PRACTICE
AN EVIDENCE-BASED APPROACH TO PEDIATRIC EMERGENCY MEDICINE ▲ EBMEDICINE.NET

Welcome Aboard!

EB Medicine is proud to welcome Tim Horeczko, MD, MSCR, FACEP, FAAP, as the Co-Editor-in-Chief of ***Pediatric Emergency Medicine Practice***.

Dr. Horeczko brings years of experience and a wealth of knowledge. His desire to improve pediatric emergency care aligns perfectly with the mission of our publication.

Dr. Horeczko is a practicing emergency physician at Los Angeles County-Harbor-UCLA Medical Center in Torrance, CA and an Associate Professor of Clinical Emergency Medicine at the David Geffen School of Medicine at UCLA.

As Editors-in-Chief, Ilene Claudius, MD and Dr. Horeczko, will work together to ensure ***Pediatric Emergency Medicine Practice*** provides high-quality, evidence-based management recommendations, so that emergency clinicians can provide the best care for their patients.

Physician CME Information

Date of Original Release: February 1, 2018. Date of most recent review: January 15, 2017. Termination date: February 1, 2021.

Accreditation: EB Medicine is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. This activity has been planned and implemented in accordance with the accreditation requirements and policies of the ACCME.

Credit Designation: EB Medicine designates this enduring material for a maximum of *4 AMA PRA Category 1 Credits™*. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

ACEP Accreditation: *Pediatric Emergency Medicine Practice* is also approved by the American College of Emergency Physicians for 48 hours of ACEP Category I credit per annual subscription.

AAP Accreditation: This continuing medical education activity has been reviewed by the American Academy of Pediatrics and is acceptable for a maximum of 48 AAP credits per year. These credits can be applied toward the AAP CME/CPD Award available to Fellows and Candidate Fellows of the American Academy of Pediatrics.

AOA Accreditation: *Pediatric Emergency Medicine Practice* is eligible for up to 48 American Osteopathic Association Category 2-A or 2-B credit hours per year.

Needs Assessment: The need for this educational activity was determined by a survey of medical staff, including the editorial board of this publication; review of morbidity and mortality data from the CDC, AHA, NCHS, and ACEP; and evaluation of prior activities for emergency physicians.

Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

CME Objectives: Upon completion of this article you should be able to: (1) Determine the laboratory studies that are and are not needed for acute gastroenteritis; (2) describe the ideal treatment strategy for mild-to-moderate dehydration due to gastroenteritis; (3) explain how antiemetics can decrease healthcare costs; and (4) describe which probiotics are most effective in reducing diarrheal symptoms associated with acute gastroenteritis.

Discussion of Investigational Information: As part of the journal, faculty may be presenting investigational information about pharmaceutical products that is outside Food and Drug Administration approved labeling. Information presented as part of this activity is intended solely as continuing medical education and is not intended to promote off-label use of any pharmaceutical product.

Faculty Disclosure: It is the policy of EB Medicine to ensure objectivity, balance, independence, transparency, and scientific rigor in all CME-sponsored educational activities. All faculty participating in the planning or implementation of a sponsored activity are expected to disclose to the audience any relevant financial relationships and to assist in resolving any conflict of interest that may arise from the relationship. Presenters must also make a meaningful disclosure to the audience of their discussions of unlabeled or unapproved drugs or devices. In compliance with all ACCME Essentials, Standards, and Guidelines, all faculty for this CME activity were asked to complete a full disclosure statement. The information received is as follows: **Dr. Brady, Dr. Jones, Dr. Toledo, Dr. Claudius, Dr. Horeczko, Dr. Mishler, 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. Dr. Jagoda made the following disclosures: Consultant, Daiichi Sankyo Inc; Consultant, Pfizer Inc; Consultant, Banyan Biomarkers Inc; Consulting fees, EB Medicine.**

Commercial Support: This issue of *Pediatric Emergency Medicine Practice* did not receive any commercial support.

Earning Credit: Two Convenient Methods: (1) Go online to www.ebmedicine.net/CME and click on the title of this article. (2) Mail or fax the CME Answer And Evaluation Form with your June and December issues to *Pediatric Emergency Medicine Practice.*

Hardware/Software Requirements: You will need a Macintosh or PC with internet capabilities to access the website.

Additional Policies: For additional policies, including our statement of conflict of interest, source of funding, statement of informed consent, and statement of human and animal rights, visit http://www.ebmedicine.net/policies.

CEO: Stephanie Williford **Finance & HR Manager:** Robin Wilkinson **Publisher:** Suzanne Verity **Director of Editorial Quality:** Dorothy Whisenhunt, MS
Senior Content Editor & CME Director: Erica Scott **Content Editor:** Cheryl Belton, PhD, ELS **Editorial Content Coordinator:** Angie Wallace
Office Manager: Kiana Collier **Account Manager:** Dana Stenzel
Online Marketing Manager: Marcus Snow **Marketing Manager:** Anna Motuz, MBA **Database Administrator:** Jose Porras

Direct all inquiries to:
EB Medicine
Phone: 1-800-249-5770 or 678-366-7933
Fax: 1-770-500-1316
5550 Triangle Parkway, Suite 150
Norcross, GA 30092
E-mail: **ebm@ebmedicine.net**
Website: **ebmedicine.net**
To write a letter to the editor, please email:
iclaudiusmd@ebmedicine.net

Subscription Information
Full annual subscription: $319 (includes 12 monthly evidence-based print issues; 48 *AMA PRA Category 1 Credits™*, 48 ACEP Category I credits, 48 AAP Prescribed credits, and 48 AOA Category 2A or 2B CME credits; and full online access to searchable archives and additional CME). Call 1-800- 249-5770 or go to www.ebmedicine.net/subscribe to subscribe.
Individual issues: $39 (includes 4 CME credits). Call 1-800-249-5770 or go to www.ebmedicine.net/PEMPissues to order.
Group subscriptions at heavily discounted rates are also available.
Contact groups@ebmedicine.net for more information.

Pediatric Emergency Medicine Practice (ISSN Print: 1549-9650, ISSN Online: 1549-9669, ACID-FREE) is published monthly (12 times per year) by EB Medicine. 5550 Triangle Parkway, Suite 150, Norcross, GA 30092. Opinions expressed are not necessarily those of this publication. Mention of products or services does not constitute endorsement. This publication is intended as a general guide and is intended to supplement, rather than substitute, professional judgment. It covers a highly technical and complex subject and should not be used for making specific medical decisions. The materials contained herein are not intended to establish policy, procedure, or standard of care. Pediatric Emergency Medicine Practice is a trademark of EB Medicine. *Copyright © 2018 EB Medicine All rights reserved. No part of this publication may be reproduced in any format without written consent of EB Medicine. This publication is intended for the use of the individual subscriber only, and may not be copied in whole or in part or redistributed in any way without the publisher's prior written permission – including reproduction for educational purposes or for internal distribution within a hospital, library, group practice, or other entity.*