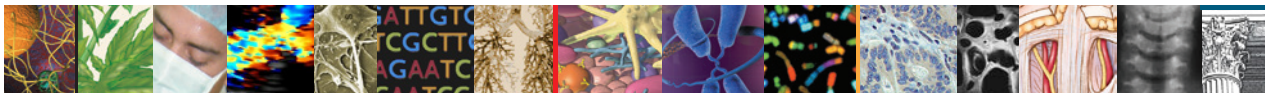

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Perspective

Facing the Shortage of IV Fluids — A Hospital-Based Oral Rehydration Strategy

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Puerto Rico produces 44% of the intravenous (IV) fluid bags used in the United States.[1] On September 20, 2017, Hurricane Maria struck the island, causing a humanitarian crisis and widespread devastation that escalated a critical shortage of IV fluids throughout the United States. Initially, small-volume bags — 50- and 100-ml bags used to dilute medications — became scarce. Today, the larger 500- and 1000-ml IV-fluid bags are also in short supply. U.S. hospitals are scrambling to develop strategies for rationing IV fluids to ensure availability for the patients who need them most.

Hurricane Maria is only the latest challenge to the U.S. IV-fluid supply. Since 2014, U.S. hospitals have faced varying degrees of IV-fluid shortages, whose causes were multifactorial. IV-fluid production is complex and highly regulated in order to ensure quality and safety, which makes it expensive for hospitals and compounding pharmacies to produce their own. Most of the IV fluid used in the United States is produced by only three manufacturers, so availability is vulnerable to even small fluctuations in supply. In addition, hospitals buy IV fluids through large group-purchasing organizations representing hundreds of hospitals so that they can negotiate with manufacturers for lower prices or better access to scarce resources. Some observers argue that these organizations' market power keeps prices so low that they create a disincentive for manufacturers to increase production or for small producers to enter the market.[2]

Given these supply-side constraints, the U.S. IV-fluid supply will be vulnerable for the foreseeable future. It is therefore critical for U.S. hospitals to develop both short- and long-term alternatives to IV-fluid use.

Emergency departments (EDs) are substantial consumers of IV fluids in the United States. The 59-bed ED at Brigham and Women's Hospital treats more than 62,000 adult patients each year and, in the 5 months from September 2017 through January 2018, used 8519 liters of IV fluids — nearly 30% of the hospital's total consumption. As the current IV-fluid shortage worsened, the team in the Division of International Emergency Medicine and Humanitarian Programs of the Department of Emergency Medicine was asked to develop an oral

Brigham and Women's Hospital Oral Rehydration Protocol

Use for patients with mild dehydration — in general, patients with the following conditions:
- Acute gastroenteritis
- Pregnancy-related hyperemesis
- Mild viral upper respiratory infection or pharyngitis

Exclusion Criteria:
- Moderate or severe dehydration
- Inability to receive oral intake for another reason

Protocol Steps:
1. Order oral rehydration fluids in the electronic health record (EHR); add antiemetic, pain control, or both if needed. Consider benzocaine or menthol lozenges in addition to acetaminophen or ibuprofen for pharyngitis. If there is significant nausea or pain, wait 20 min after medications to begin drinking (can start immediately otherwise).
2. The EHR order will direct the nurse to bring the patient two 500-ml pitchers of desired drink (flavored oral electrolyte solution or dilute sports drink or juice).
   - Provide patient with straw as well as 30-ml medicine cup.
   - Instruct patient to drink two large sips or 30 ml every 3–5 min. Use timers on cell phones or ask family to assist.
   - Explain target hydration goals (see below) and provide a tracking sheet. Draw lines on pitcher for target volumes (e.g., "250 ml left"). Patient or family member should complete the tracking sheet.
   - Return to reencourage oral intake as needed.
3. Troubleshooting:
   - If oral intake is insufficient, determine why and give additional antiemetic, pain control, or both as needed.
   - If taste is a problem and dehydration mild (or not due to gastroenteritis), consider alternative liquid options, such as half-strength sports drink, dilute juice, or ginger ale.
4. For pregnancy-related hyperemesis, oral intake can often help. Encourage patients to try to eat a few crackers if possible.

Target Hydration Goals*:
Target times are given for the amount of liquid remaining at 2 sips or 30 ml every 3 min (or every 5 min)
- 1000 ml remaining: 0 min (0 min)
- 750 ml remaining: 25 min (40 min)
- 500 ml remaining: 50 min (1 hr 20 min)
- 250 ml remaining: 1 hr 15 min (2 hr)
- 0 ml remaining: 1 hr 40 min (2 hr 40 min)

* Patients with vomiting should be encouraged to maintain a slower rate of intake until they tolerate the fluid well. Patients without vomiting can drink faster, as tolerated. After an intake of 250 ml has been successfully completed without vomiting, and if nausea is well controlled, intake can increase to four sips or 60 ml every 3–5 min.

rehydration protocol for ED patients with mild dehydration. The protocol outlined in the box has since been adopted hospital-wide.

Oral rehydration therapy has been studied for nearly 60 years. It has been shown to reduce mortality from diarrheal illnesses by 93%[3] and to reduce the case fatality rate of cholera from 30% to 1%.[4] It is less expensive than IV-fluid therapy, and its use results in fewer admissions and shorter lengths of stay.[5] A 2006 meta-analysis showed that oral rehydration was equivalent to the administration of IV fluid for the management of dehydration due to gastroenteritis in children.[5] Data on use in adults have revealed similar efficacy, although in smaller studies. Oral rehydration therapy has been widely adopted in low- and middle-income countries where IV fluids are expensive and resources limited. Conversely, despite this evidence, oral rehydration has not been widely used in adults in high-income countries, probably owing to the widespread availability and ease of use of IV fluids.

Our protocol is based on research[3-5] and protocols for oral rehydration in low-resource settings and in the United States and on our experience as emergency physicians with more than 50 combined years of work in health care delivery in low- and middle-income countries around the world.

Patients who meet the criteria for deployment of our protocol are adults with mild dehydration from conditions such as pharyngitis, gastroenteritis, pregnancy-related vomiting, and upper respiratory tract infection. Patients with severe dehydration or who are unable to take liquids by mouth for other reasons (e.g., small bowel obstruction) are excluded; these patients constitute the minority of our ED patients who traditionally receive IV fluid. The hospital also created a new order in our electronic medical record and order-entry system, called Oral Rehydration Fluids, that streamlines the process.

Under our protocol, we aim to have patients take 500 to 1000 ml of oral fluids while in the ED, since patients who drink this volume successfully can most likely continue oral rehydration at home. Providers are encouraged to offer analgesics, antipyretics, and antiemetics as needed to improve the tolerance of oral hydration. Patients may start drinking immediately if they are able, or they may wait 20 minutes for symptom improvement after administration of these comfort medications. Patients are offered their choice of drinks, including artifi-

cially flavored oral electrolyte solution, water, dilute juice, or dilute sports drinks. If electrolyte disturbances are suspected on the basis of the clinical presentation, the oral electrolyte solution is preferred. Using powdered formulations of sports drinks reduces the storage space needed. The variety of fluid options reduces reliance on a single brand-name product. As with IV strategies, clinical judgment must be used when choosing oral hydration in patients with coexisting conditions such as renal disease, diabetes, or heart failure.

Each patient is provided a straw, a 30-ml medicine cup, and 1000 ml of the patient's preferred fluid. Patients are instructed to drink 30 ml (two large sips) every 3 to 5 minutes and may ask family members or use a cellphone to time the sips. Providers explain the drinking goals (see box) and draw lines on the pitchers to delineate target volumes (e.g., "250 ml left").

The patient or a family member completes a tracking sheet to monitor total intake. Patient and family participation is key to success. Encouragement is offered regularly. Patients with insufficient oral intake are reevaluated and given additional antiemetics and pain control as needed. If the patient doesn't like the taste of the chosen drink, another drink is tried. The patient may increase the pace after tolerating the first 250 ml. Patients who vomit should wait 20 minutes before starting to drink again.

To ensure implementation of our protocol, providers were sent an email message by hospital leadership detailing the IV-fluid shortage and the oral rehydration protocol. ED nursing leaders trained nurses and ED technicians and posted flyers throughout the ED. We also provided additional training and reminders about the oral rehydration protocol to our faculty and residents.

We are now studying the impact of our protocol on IV-fluid use. According to our preliminary data, IV-fluid use by volume decreased by just over 30% in the first week after the oral hydration protocol was distributed throughout the hospital. In the 3 weeks after protocol implementation, the fraction of ED patients with IV-fluid orders decreased by 15%.

There are potential limitations to our protocol. Oral rehydration can take longer than IV hydration and requires more effort from the patient. However, it also causes less pain because there is no IV catheter insertion, and our protocol's emphasis on structured time goals and drinking small amounts can encourage patients to stay hydrated in a manner that they can continue at home. Although oral rehydration can be effective in moderate to severe dehydration, with the use of a nasogastric tube if needed, currently our protocol targets mild dehydration only. It could be expanded to include more severe cases if the IV-fluid shortage worsened.

We share this protocol as a replicable model for other U.S. hospitals looking for strategies during the IV-fluid shortage. Experience in low-resource settings worldwide has proven the efficacy of oral rehydration therapy, and vulnerabilities of the U.S. IV-fluid supply chain are expected to continue. We believe that widespread use of oral rehydration protocols would therefore be a rational practice change and a mainstream model for use in the United States even after the current IV-fluid shortage crisis ends.

Disclosure forms provided by the authors are available at NEJM.org.

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