Improving intravenous fluid therapy in children with gastroenteritis

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Abstract Gastroenteritis is one of the most common medical conditions seen by pediatricians. The standard approach to intravenous fluid therapy for these children has been to administer a 0.9% sodium chloride (NaCl) bolus followed by a hypotonic solution ranging from 0.2–0.45% NaCl to replace the remaining deficit plus maintenance. We have questioned the safety of this approach as there have been reports of death or permanent neurologic impairment from hyponatremic encephalopathy. Hanna and Saberi (Pediatr Nephrol. doi:10.1007/s00467-009-1428-y) found the incidence of hospital-acquired hyponatremia (sodium<135 mEq/L) to be 18.5% for patients presenting with isotonic dehydration from gastroenteritis. This confirms that the current approach of using hypotonic fluids results in a high incidence of hyponatremia. Hypotonic fluids are not appropriate for rehydration in patients with gastroenteritis as it is a state of arginine vasopressin (AVP) excess due to both hemodynamic stimuli from volume depletion and non-hemodynamic stimuli such as nausea and vomiting. Free water will be retained until the volume deficit is corrected and the hemodynamic stimulus for AVP production abates. A safer and more effective approach is the administration of 0.9% NaCl in a continuous infusion following bolus therapy. 0.9% NaCl not only serves as prophylaxis against hyponatremia, but it is superior to

hypotonic fluids as an extracellular volume expander and corrects the volume deficit more rapidly.

Keywords Encephalopathy · Fluid therapy · Gastroenteritis · Hyponatremia · Hyponatremia · Sodium

Gastroenteritis is one of the most common medical conditions seen by pediatricians, accounting for over 150,000 hospitalizations per year or approximately 10% of all hospital admissions in children <5 years of age in the USA [1]. The standard approach to intravenous fluid therapy for these children has been to administer a 20–40 ml/kg bolus of 0.9% sodium chloride (NaCl) followed by a hypotonic solution with a sodium concentration ranging from 0.2–0.45% NaCl to replace the remaining deficit plus maintenance if unable to tolerate an oral rehydration solution [2]. We have questioned the safety of using a hypotonic fluid in this approach [3, 4], as there have been reports of death or permanent neurologic impairment from hospital-acquired hyponatremic encephalopathy [5–7]. It is now well established that hypotonic maintenance fluids result in hospital-acquired hyponatremia in children [8–10]. This has been best demonstrated in the post-operative setting where the incidence of hospital-acquired hyponatremia (sodium<135 mEq/L) is 20–30% [11–15]. Surprisingly, there have been no studies to evaluate the safety of the deficit-plus-maintenance-fluid approach in hospitalized children with gastroenteritis.

In this issue of *Pediatric Nephrology*, Hanna and Saberi evaluated the incidence of hyponatremia (sodium<135 mEq/L) in children treated with deficit-plus-maintenance-fluid therapy for gastroenteritis [16]. They found the incidence of hospital-acquired hyponatremia to be 18.5% for patients presenting with isotonic dehydration, with an average fall

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in serum sodium of almost 6 mEq/L in approximately 13 h in those that developed hyponatremia. The average fall in serum sodium for all patients studied was 1.7 mEq/L. No patients developed hyponatremic encephalopathy. The results of this study confirm that the current approach of using hypotonic fluids following bolus fluid therapy in children with gastroenteritis results in a high incidence of hyponatremia.

The majority of patients with gastroenteritis have isotonic dehydration. In these patients, the volume deficit is primarily extracellular. In the deficit-plus-maintenance approach, part of the extracellular volume deficit is replaced with a fluid bolus, with the remainder being replaced over 24 h along with the maintenance fluids. The problem with this approach is that when the composition of the maintenance fluid used to calculate the final fluid composition is a hypotonic solution with a sodium concentration of 30 mEq/L, as originally proposed by Holliday and Segar [17], the final sodium composition of the intravenous fluids will always be hypotonic. Hypotonic maintenance fluids are not appropriate for patients with increased arginine vasopressin (AVP) as this will predictably result in hyponatremia due to free water retention [18]. Gastroenteritis is a known state of AVP excess [19] due to both hemodynamic stimuli for AVP production from volume depletion and non-hemodynamic stimuli, such as nausea and vomiting. Free water will be retained following the initial fluid bolus until the volume deficit is fully corrected and the hemodynamic stimulus for AVP production abates. A safer and more effective approach in the management of children with gastroenteritis would be to administer a continuous infusion with a sodium concentration of 0.9% NaCl following bolus therapy. 0.9% would not only serve as prophylaxis against hyponatremia, but it is superior to hypotonic fluids as an extracellular volume expander and would correct the volume deficit faster. 0.9% NaCl could be discontinued in favor of a hypotonic solution once the patient is deemed to be volume replete, as evidenced by good peripheral perfusion and urine output, and intravenous fluid could be stopped altogether when oral fluids are taken well.

0.9% would seem to be the best choice to correct volume depletion and prevent the development of dysnatremia in patients with gastroenteritis, but it is not without risk. Hypernatremia can develop in patients with gastroenteritis treated with 0.9% NaCl from either large gastrointestinal free water losses or increased insensible water losses from high fever. These high-risk patients should be closely monitored, and measures to prevent hypernatremia should be taken. 0.9% NaCl should only be used until the patient is assessed to be volume replete, at which point hypotonic fluids could be used. Electrolytes should be monitored at least daily in these high-risk patients, and isotonic fluid

should be discontinued if the patient is hypernatremic (sodium > 144 mEq/L).

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