What tonicity of intravenous maintenance fluids should I prescribe to postoperative patients?

You are consulted to co-manage a 6-year-old girl being admitted for an elective complex orthopedic procedure who is expected to be hospitalized for 72 hours. In addition to managing any problems related to her mild persistent asthma, you are asked to prescribe postoperative intravenous fluids. During rounds, your medical student confidently recommends D5 with 0.2% normal saline to run at 60 cc/hour in this 20-kg child based on the Holliday-Segar method, which she is very proud to have mastered. Mastery of simple math aside, is the student correct to choose this fluid?

Intravenous maintenance fluids (IVF) are 1 of the most familiar tools in the pediatric hospitalist’s tool box, and often our first experience in the hospital was learning to compute maintenance IVF. In the “old” days, after any deficit was replaced, 0.2% normal saline (NS) was prescribed for maintenance as calculated by Holliday and Segar 55 years ago.¹ Over time, the recognition of nonosmotic stimuli for antidiuretic hormone (ADH) production and iatrogenic hyponatremia, occasionally accompanied by severe neurologic morbidity and death, has put into question the use of hypotonic maintenance fluids.²,³ Although many hospitalists abandoned the routine use of 0.2% NS, they were unprepared to make the brobdingnagian leap to isotonic saline, fearing hypernatremia, hypertension, edema, and hyperchloremic metabolic acidosis. During the fray, many took the intellectually uncomfortable compromise position, prescribing 0.45% NS for maintenance, or perhaps the wiser move, abandoning maintenance IVF altogether in favor of intermittent boluses of isotonic fluids, providing the added benefit of decreasing painful intravenous infiltrates.

In the November issue of Pediatrics, Choong et al⁴ addressed this question, at least as it relates to the postoperative patient, with the largest prospective trial on the subject. Their objective was to evaluate the risk of hyponatremia after administration of an isotonic (0.9% NS) compared with a hypotonic (0.45% NS) parenteral maintenance solution (PMS) for 48 hours to postoperative pediatric patients. They conducted a blinded, randomized controlled trial on euvolemic patients 6 months to 16 years of age admitted for elective surgery, with an expected stay of >24 hours and no predisposing condition for sodium abnormalities. The research pharmacist prepared masked solutions of 0.45% NS and 0.9% NS combined with 5% dextrose. Potassium chloride was added according to the treating physician’s request. Levels of plasma sodium and urine sodium, as well as potassium, were measured every 12 hours and plasma ADH levels every 24 hours, but none of these results were made available to the treating physician. A safety officer...
reviewed the masked sodium levels, and if they fell outside of predefined thresholds, the treating physician was referred to clinical pathways for hyponatremia or hypernatremia management, without disclosing the actual sodium level or unblinding the PMS. If electrolyte abnormalities persisted, the treating physician could change to an open-label PMS, without unblinding the study solution.

The primary outcome was hyponatremia, defined as plasma sodium <135 mmol/L. Secondary outcomes were: (1) severe hyponatremia (plasma sodium <130 mmol/L) or symptomatic hyponatremia; (2) hypernatremia (plasma sodium >145 mmol/L); (3) plasma ADH levels; (4) adverse events attributable to PMS and/or sodium derangements occurring within 48 hours after the intervention, including generalized edema and new-onset hypertension; and (5) proportion of patients who changed to open-label PMS during the study period.

Between March 2008 and December 2009, a total of 728 consecutive children were screened and 258 were enrolled. One hundred twenty-eight children were screened and 258 were enrolled. Between March 2008 and December 2009, a total of 728 consecutive children were screened and 258 were enrolled. Four hundred twenty-eight children were randomized to receive isotonic PMS and 130 to receive hypotonic PMS. Baseline characteristics were similar between the 2 groups, as were pre-intervention intakes of sodium, fluid volume, and electrolyte-free water. Treating physicians ordered baseline plasma sodium levels for only 6% of patients. Primary outcome data were unavailable for 40 patients, mostly secondary to sampling difficulties. Patients receiving hypotonic PMS were diagnosed with hyponatremia significantly more often than those receiving isotonic PMS (40.8% vs 22.7%; relative risk: 1.82 [95% confidence interval: 1.21–2.74]; \( P = .004 \)) and trended toward more diagnoses of severe hyponatremia (6.2% vs 0.8%; relative risk: 7.21 [95% confidence interval: 0.93–55.83]; \( P = .059 \)).

No significant differences were found in any of the secondary outcome measures other than more patients in the hypotonic PMS group changing to open-label isotonic PMS (9.2% vs 2.3%; \( P = .036 \)), with hyponatremia being the most common reason for the change (5.4% vs 0.8%; \( P = .033 \)).

This study has some limitations to consider when interpreting the data: a very high incidence of hyponatremia, few baseline sodium measurements, uncontrolled and undocumented intra-operative fluids, and other sources of free water (oral fluids) not accounted for in the study. In an accompanying editorial, Moritz and Ayus briefly summarize the 20 studies that followed their landmark paper in 2003, all supporting the supposition that hypotonic fluids cause hyponatremia and isotonic fluids prevent it. They even state that by today’s standards, the US Food and Drug Administration would not approve hypotonic fluids for routine use. First, do no harm. Hyponatremia is the most common electrolyte abnormality in children and most often occurs when they are receiving hypotonic intravenous fluids, with occasionally devastating consequences. Routinely using isotonic maintenance fluids will sharply curtail the incidence of hyponatremia and probably eliminate hospital-acquired hyponatremic encephalopathy.

Unlike Holliday and Segar’s\(^1\) healthy patients, our patient will be postoperative and at high risk of having elevated ADH levels. The use of 0.2% (or 0.45%) 0.9% NS is a habit-based intervention, whereas NS is emerging as an evidence-based one. Therefore, preternatural math skills aside, I will gently persuade my medical student to order isotonic maintenance fluids for this patient.

**REFERENCES**

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