

Avoiding hypotonic solutions in paediatrics: Keeping our patients safe



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A previously healthy, fully immunized, 14 kg four-year-old girl presented to the local emergency department with a seven-day history of upper respiratory tract symptoms and 24 h of fever, irritability and decreased oral intake. Her temperature on presentation was 38.9°C, heart rate 120 beats/min, respiratory rate 25 breaths/min, and blood pressure 90/60 mmHg. She was alert but irritable on physical examination, mildly volume-depleted and had evidence of meningismus. Her electrolytes were normal, notably a serum sodium concentration of 138 mmol/L, and there was pleocytosis of the cerebrospinal fluid.

The patient was admitted with a working diagnosis of bacterial meningitis, given a 20 mL/kg normal saline bolus and commenced on intravenous (IV) vancomycin and ceftriaxone. She was started on maintenance IV fluids, consisting of dextrose 3.3% in NaCl 0.3% (‘2/3 – 1/3’) with KCl 20 mmol/L at 50 mL/h. She was also permitted to drink oral fluids as tolerated.

Twenty-four hours later, the child’s irritability improved; however, she was noted to have headache and nausea. She was assessed by the paediatrician who reassured the family that these symptoms were consistent with meningitis. Her urine output was noted to be adequate, though it was not specifically quantified. Electrolytes were not repeated.

That evening (36 h following admission), the patient was noted to be increasingly lethargic and subsequently had a generalized seizure. She was managed with IV lorazepam, followed by a phenobarbital load of 20 mg/kg. Stat electrolytes requested at the onset of the seizure revealed hyponatremia ($[Na^+]$: 122 mmol/L). Hypertonic saline (3% NaCl) was administered, and arrangements were made for transfer to a tertiary care centre.

En route she suffered a respiratory arrest, requiring intubation and ventilation. The child progressed to cardiac arrest, with unsuccessful resuscitation. In addition to evidence of meningitis (pathology and cultures were positive for *Neisseria meningitidis*, serotype B), the autopsy revealed severe cerebral edema with secondary brainstem herniation believed to be caused by the acute hyponatremia.

Note: For privacy reasons, elements from published cases were used to construct this vignette (1,2).

LEARNING POINTS

- Paediatric hyponatremia cases have been reported in the literature, the majority of which documented the use of hypotonic IV fluids (1). Though severe cases are infrequent, their devastating outcomes have prompted the emergence of recent research and evidence for safe IV fluid practices in children.
- Acute hyponatremia is defined as a fall in serum sodium concentration from normal to <135 mmol/L within 48 h of presentation, with severe hyponatremia indicating a serum sodium concentration <130 mmol/L or accompanied by symptoms (3).

TABLE 1
Commonly used intravenous solutions

Intravenous solution	Na (mmol/L)	K (mmol/L)	Cl (mmol/L)	% EFW
Very hypotonic 0.2% NaCl in D5W	34	0	34	78
0.3% NaCl in D5W (‘2/3-1/3’)	51	0	51	67
Hypotonic 0.45% NaCl in D5W	77	0	77	50
Near-isotonic Lactated Ringers	139	4	109	16
Isotonic 0.9% NaCl in D5W	154	0	154	0

Adapted from: *Guidelines for prescribing maintenance intravenous fluids in children*. McMaster Children’s Hospital, 2008. EFW Electrolyte free water

- Its development is attributable to antidiuretic hormone (ADH) secretion, which prevents free water excretion and intake of electrolyte-free water (EFW) in the form of both IV and oral hypotonic solutions (4).
- Any hospitalized child can be at risk for hyponatremia in the presence of multiple nonosmotic stimuli for ADH, such as pain, nausea, infections (eg, gastroenteritis, bronchiolitis, pneumonia, meningitis), malignancies, anesthesia and several medications (5-8).
- IV fluid boluses in mild to moderate dehydration should be used with caution; they may lead to excretion of hypertonic urine with secondary generation of EFW by the kidney, contributing to a decrease in serum sodium (9).
- Acute hyponatremia results in intracellular swelling, manifesting as cerebral edema (6). Children are at particular risk of neurological sequelae due to their higher brain-to-skull size ratio (6).
- Symptoms of hyponatremia may be nonspecific, such as headache, nausea, vomiting, and muscle cramps (5), and may progress to lethargy, seizures and respiratory arrest. Death results from brainstem herniation (10).
- To date, isotonic solutions have been demonstrated to be safer than hypotonic solutions as an initial empirical maintenance fluid choice (outside of the NICU setting), with the addition of glucose and potassium as appropriate (Table 1) (3,11-14). To enhance patient safety, some institutions have removed very hypotonic solutions from their ward stock or require subspecialty approval for their use.
- Maintenance IV fluids should be individualized, based on the child’s fluid status, electrolytes, oral intake and individual risk factors for ADH secretion (15). In the vast majority of cases, hypotonic fluids should be avoided for hospitalized children.
- As with all drugs, maintenance fluids should be re-evaluated on a daily basis, or more frequently as clinically indicated (15).

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- Based on consensus opinion, it is recommended that patients receiving IV fluids at more than 50% of their maintenance rate should have their serum electrolytes monitored daily, or more frequently as clinically indicated (15).
- A CPSP study is currently underway to determine the incidence of and explore risk factors for Canadian cases of symptomatic hyponatremia related to IV fluid administration.

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