Hospital-wide Patient Care
Clinical Practice Guideline

Fluid and Electrolyte Administration in Children

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1.0 Introduction

Sodium is the major cation of the extracellular fluid (ECF) compartment and together with chloride anion constitutes the major effective osmolality of that space. Potassium and phosphate are the major intracellular ions and the two compartments are separated by a semi-permeable membrane which allows free flow of water between the intracellular fluid (ICF) and the ECF with no osmolar gradient between them. Serum osmolarity is tightly regulated by osmoreceptors in the hypothalamus. Any minor increase in osmolality is sensed by these receptors and causes the release of antidiuretic hormone (ADH) and the excretion of a concentrated urine. Lowering of serum osmolality normally inhibits the release of ADH and the excretion of a dilute urine. Salt and water homeostasis is frequently abnormal in hospitalized patients and hyponatraemia (Plasma Sodium (PNa) <135 mmol/l) is the most commonly occurring electrolyte abnormality, which, except in rare circumstances (e.g. hyperglycaemia or hypertriglyceridemia), indicates a low serum osmolality and an expanded ICF compartment.

Acute hyponatraemia, defined as a fall in serum sodium to < 130 mmol/L within 48 hours, which can result in acute cerebral oedema and brain stem herniation, has frequently been associated with the administration of intravenous (IV) hypotonic fluids in children, particularly in the perioperative period. These patients retain water due to the failure of the normal physiological response, which would be the inhibition of ADH secretion and excretion of a dilute urine. Non-physiological stimuli for ADH secretion include pain, vomiting, anxiety, narcotics, anesthetic agents and positive pressure ventilation. Isotonic fluids, which contain no electrolyte free water, will reduce this risk but not eliminate it. Studies have shown that intraoperative volume expansion with isotonic fluids results in the excretion of a hypertonic urine and the risk of hyponatraemia, a process referred to as desalination. The use of hypotonic saline in the post operative period increases the risk of developing acute hyponatraemia.

2.0 Definitions

Definition	Serum [Na+] mmol/L
Normal/reference range	135 - 145
Hyponatraemia	< 135
Acute Hyponatraemia	Reduction in PNa to <130 mmol/L in 48 hrs
Moderate Hypernatraemia	150 - 169
Severe Hypernatraemia	> 169

3.0 Clinical Practice Recommendations

The purpose of this clinical practice guideline is to facilitate appropriate screening, prescription and monitoring of IV fluids and electrolyte administration in patients admitted to SickKids or treated in the Emergency Department. The target users of this guideline are physicians, nurses and paramedics.

This guideline should be followed when prescribing IV maintenance fluids, defined as those estimated to replace normal physiologic urine output and insensible losses, in children not receiving enteral fluid or those with reduced oral intake. Recommendations on the type of solution to be used for fluid bolus therapy are also included. IV fluids prescribed to replace losses from the GI tract and other ECF compartments should be of the same electrolyte composition as the fluid that is being lost. This guideline **does not apply to** patients in the neonatal intensive care unit.

Indications: Intravenous fluids are prescribed in paediatric patients for the following indications:
(a) *maintenance fluid therapy* to replace estimated normal physiologic urine output and insensible losses in patients with reduced or no oral intake;
(b) *bolus fluid therapy* to expand the circulating volume in children with hypovolaemia or shock; or
(c) *fluid therapy to replace abnormal losses* from the GI tract and other body cavities.

3.1 General Principles

3.1.1 Any hospitalized child requiring IV fluids should be considered at risk of non-physiological (inappropriate) ADH secretion. Groups particularly at risk identified in published case series include children undergoing surgery and those with acute medical illnesses including meningitis, encephalitis, bronchiolitis and pneumonia. In the absence of a need to correct a fluid deficit in these patients, IV fluids should be administered at the rate of 60-70% of the usual calculation for normal maintenance requirements and in the form of isotonic saline or Ringer's Lactate. The type of fluid chosen should be based on the guidelines below. (Grade C)

3.1.2 Oral fluid intake must be included in estimation of fluid requirements. Most oral fluids are very hy potonic. (i.e. low sodium concentration) Both the volume and the concentration of sodium in IV and oral fluids are important contributors to development of hyponatraemia. (Grade C)

3.1.3 Proprietary enteral fluid preparations and TPN solutions are low in sodium (<40 mmol/L) and may be a substantial source of electrolyte free water. Patients on long term TPN and who are not acutely ill are not at increased risk for the development of acute hyponatraemia. (Grade C)

3.1.4 Infants and young children have limited glycogen stores and saline solutions with added dextrose are required to prevent hypoglycaemia and ketosis. (Grade C)

3.1.5 Children with cardiac failure, renal failure and hepatic failure with ascites have chronically low PNa values because of water retention and/or abnormalities of the renin/angiotensin mechanism. These patients have chronic hyponatraemia and are not at risk for the development of cerebral oedema. (Grade C)

3.2 Assessment

3.2.1 Before starting IV fluids, baseline serum electrolytes (Na, K, glucose, urea, creatinine) should be measured.[2] Patients undergoing day surgery where the IV is discontinued at the end of the case do not need their electolytes measured. (Grade C)

3.3 Prescription of IV fluid therapy

3.3.1 ***2/3 & 1/3*** **(0.3 NaCl with 3.3% dextrose) is no longer available in the hospital .** *0.2% NaCl* with dextrose and 5 or 10% dextrose in water all contain substantial amounts of electrolyte free water

and ***must not be used as maintenance IV fluids .***[1-3] Patients with a demonstratable free water deficit may require the administration of these types of hypotonic solutions. The use of these fluids is restricted to the CCU, NICU, and Nephrology services. Consultation should be obtained from Nephrology if these solutions are being considered. (Grade B)

3.3.2 IV fluid boluses should only be used in children with significant ECF contraction or impending shock and only in the form of isotonic saline (*0.9% NaCl or Ringers Lactate*). The injudicious use of IV bolus therapy will transiently over expand the ECF compartment and result in an increase in the renal sodium excretion. (Grade C)

3.3.3 IV fluid therapy to replace losses from the GI tract should only be in the form of isotonic saline (*0.9% NaCl or Ringers Lactate*).[4] Solutions with added dextrose may be required based on patient age and the blood glucose level. (Grade B)

3.3.4 Until serum electrolyte values are known, when starting IV maintenance fluids, *0.9% NaCl or Ringers Lactate* are recommended.[1, 3] Solutions with added dextrose may be required based on patient age and the blood glucose level. This solution should be adjusted when serum electrolyte results become available. (Grade C)

3.3.5 If serum sodium is less than 138 mmol/L, *0.9% NaCl,*[5] or *Ringers Lactate* should be prescribed. Solutions with added dextrose may be required based on patient age and the blood glucose level. (Grade C)

3.3.6 If serum sodium is between 138 -144 mmol/L, IV fluids should contain a sodium concentration of 77-154 mmol/L such as *0.45% NaCl,*[2] *0.9% NaCl*, or *Ringers Lactate*. Solutions with added dextrose may be required based on patient age and the blood glucose level. (Grade C)

3.3.7 If serum sodium is between 145 - 154 mmol/L, the IV fluid sodium concentration should approximate one half normal saline (*0.45% NaCl).*[5] Solutions with added dextrose may be required based on patient age and the blood glucose level. Patients with raised intracranial pressure may require the increases in PNa to hypernatraemic levels to treat cerebral oedema. (Grade C)

3.3.8 Patients with hypernatraemia (PNa > 154 mmol/L) have either a water loss (dehydration) or salt gain (the use of IV solutions with a high sodium concentration). Infants and young children with severe hypernatraemia due to dehydration (free water loss) are at risk for the development of cerebral oedema with rapid rehydration when hypotonic saline is used. The deficit should be replaced slowly, initially with isotonic saline. (Consult Nephrology) Patients with hypernatraemia due to salt gain may receive hypotonic fluids such as *0.2% NaCl* (eg. 0.2% NaCl with dextrose). (Refer to recommendation 3.3.1). (Grade C)

3.3.9 Perioperative fluids should only be in the form of isotonic *(0.9% NaCl or Ringers Lactate*). Solutions with added dextrose may be required based on patient age and the blood glucose level. In the absence of the need to continue with IV fluids for the replacement of ongoing losses the IV should be discontinued or reduced to minimum and patients encourage to take enteral fluids.[6] (Grade B)

3.3.10 Although the data on acute hyponatraemia come from case reports and cases series the limited number of published prospective studies suggest that the use of isotonic saline is less likely to result in hyponatraemia and does not result in hypernatraemia.[4,6,7] (Grade B)

3.4 Monitoring

3.4.1 Patients receiving >50% of maintenance fluids by the IV route should have at least daily measurements of serum electrolytes and glucose. (Grade C)

3.4.2 All children receiving IV fluids have an accurate daily intake and output record kept and, when feasible, daily weight measurement. (Grade C)

3.5 Diagnosis and treatment of acute symptomatic hyponatraemia

3.5.1 Acute symptomatic hyponatraemia is a medical emergency and requires rapid and aggressive treatment to prevent the downward spiral of seizures, apneoa and brain stem coning. The common features of the onset of cerebral oedema due to hyponatraemia are lethargy, diminished level of consciousness, headache and vomiting. Most cases have been reported in children where the PNa level has fallen from normal levels to <125 mmol/L within 48 hours but can occur at higher levels. Acute hyponatraemia should be suspected where there is the new onset of seizures in patients receiving hypotonic IV fluids.[8] (Grade C)

3.5.2 Discontinue the IV fluid being administered and give 2 - 3 mL/kg of 3% NaCl or 1 g/kg mannitol rapidly. (Grade C)

3.5.3 Notify the critical care unit. (Grade C)

3.5.4 Measure the serum electrolytes and correct the PNa to above 130 mmol/L acutely using either 2 - 3 mL/kg of 3% saline (repeat if necessary) or 1 g/kg mannitol, administered rapidly. (Grade C)

3.5.5 Change IV maintenance fluid to isotonic at minimal levels. (Grade C)

3.6 Assessment & prescribing recommendations summary

Assessment: Lab Tests	
Condition	**Lab Tests to be ordered**
Prior to IV fluid administration	• Serum electrolytes (Na, K, glucose, urea, creatinine) • Timing: At the time of the decision to administer
ALL patients receiving maintenance IV fluids at 50% calculated maintenance levels or replacement IV fluids for ongoing losses	• Daily serum electrolytes (Na, K) • Daily intake and output • Daily weight measurement

Prescription of IV Fluids		
Condition	**Recommendations for IV Fluids prescription**	**Na mmol/L**
IV Bolus (use for severe ECF Contraction /impending Shock)	• 0.9% NaCl with or without dextrose* or	154
	• Ringers Lactate with or without dextrose*	130
Perioperative	• 0.9% NaCl with or without dextrose* or	154
	• Ringers Lactate with or without dextrose*	130
Unknown serum [Na+]	• 0.9% NaCl with or without dextrose* or	154
	• Ringers Lactate with or without dextrose* (contains 4 mmol/L potassium)	130
Serum [Na+] < 138 mmol/L	• 0.9% NaCl with or without dextrose* or	154
	• Ringers Lactate with or without dextrose*	130
Serum [Na+] = 138 – 144 mmol/L	IV fluids should contain a sodium concentration of 77-154 mmol/L such as:	
	• 0.45% NaCl with or without dextrose* or	77
	• 0.9% NaCl with or without dextrose* or	154

	• Ringers Lactate with or without dextrose*	130
Serum [Na+] = 145 - 154 mmol/L	• For maintenance IV fluid, sodium concentration should approximate one half normal saline, such as:	
	• 0.45% NaCl with or without dextrose	77
Serum [Na+] >155 mmol/L**	• 0.2% NaCl with dextrose for salt gain or isotonic saline for free water loss (See below for details)	34
Solutions with added dextrose may be required based on patient age and the blood glucose level . KCl to be added to IV solutions depending on plasma level . ***** Patients with severe hypernatraemia due to dehydration (free water loss) are at risk for cerebral oedema with rapid rehydration using hypotonic saline . A nephrology consult is required. Patients with hypernatraemia due to salt gain should receive hypotonic fluids .***		

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4.0 Implementation of CPG

- Factors or processes that will assist with implementation
  - Reorganize the 2-bin carts in the hospital: Take off what we do not want used (i.e. 0.2% NS with dextrose) but maintain this in CCU, NICU services and as required by area for medication administration.

- Organizational changes that may be required to apply the recommendations
  - Review KidCare order sets, remove 2/3 - 1/3 and restrict 0.2% NaCl with dextrose, D5W, D10W

- Key review criteria/indicators for monitoring and audit purposes
  - Audit to see the percentage of patients who are having their electrolytes measured
  - Audit to see how many times solutions with 0.2% NaCl with dextrose, D5W, D10W are prescribed and % valid cases

5.0 Related Documents

National Patient Safety Agency (UK) Patient Safety Alert: Reducing the risk of Hyponatraemia when administering IV infusions to children . Issued March 28, 2007

6.0 Statement of Evidence

A literature search was completed using Medline (1966-2007), Embase (1980 - 2006), the Cochrane Library, personal files and reference lists, using key words: fluid therapy, hypotonic saline, and hyponatraemia. A systematic review and details of the literature search have been published previously.[1] The CPG development group met on several occasions to discuss the literature and to draft recommendations.

Table 1 serves as a guideline to the hierarchy of evidence available; with meta-analysis considered to be the highest level of evidence and expert opinion considered to be the lowest level of evidence that can be used to support each recommendation in this CPG.

Table 1. Grades of Recommendation	
A	At least one randomized controlled trial , systematic review , or meta-analysis.
B	At least one cohort comparison , case study or other experiment study .
C	Expert opinion , experience of a consensus panel .

7.0 References

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8.0 Guideline Group and Reviewers

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Reviewers were selected to reflect different backgrounds and perspectives. Their comments and suggestions were considered and the document amended accordingly.

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Change Level