Guideline

Treatment of Severe Hyponatraemia in Children

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Applicable to	Children's Health Queensland clinical staff				
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Purpose

Hyponatraemia is the most common electrolyte abnormality encountered in children. Severe hyponatraemia (sodium < 120 mmol/L) is associated with increased mortality and morbidity and can lead to a wide spectrum of clinical symptoms. It is most common in children with pre-existing morbidities or be part of critical illness that may delay presentation. The management therefore may start in a variety of areas and specialisms and so a guideline is required to align treatment to current internationally recommended safe standards

Related documents

Procedures, Guidelines, Protocols

- Diabetic Ketoacidosis: Emergency Management in Children. CHQ-GDL-00706. http://qheps.health.qld.gov.au/childrenshealth/resources/guidelines/gdl-00706.pdf

Guideline

Mild or moderate hyponatraemia is very common in paediatric practice and can usually be reduced by avoiding intravenous (i.v.) hypotonic electrolyte solutions. It may also result from water replacement of GI losses or sole water intake with pain and illness before arrival in hospital. **However, this guideline will deal with the potentially life- threatening situation of severe hyponatraemia (<120 mmol/L)** where central demyelination as a consequence of over-rapid correction of sodium levels is a risk.

**In the case of a child with moderate hyponatraemia (sodium of 120-125mmol/l) this protocol may be used to achieve a sodium level at the lower-end of the normal range after 36 hours but it is unlikely they will have CNS symptoms related to the sodium level or require strong sodium infusions.*

**The presence of hyponatraemia of any degree is not normal and should prompt investigation to determine a cause and repeat testing to ensure moderate or severe hyponatraemia is not developing.*

Paediatric Causes of Severe Hyponatraemia (Appendix 2):-

1) Loss of Sodium

- Effective circulating volume depletion secondary to
  a. Gastrointestinal losses
  b. Renal losses: salt-wasting nephropathy, diuretics
  c. Skin loss from sweat, burns
  d. Salt wasting (cerebral or cardiac)
  e. Hypoaldosteronism often with adrenal crisis and hyperkalaemia
  f. Oedematous states ("Third spacing"): heart failure, cirrhosis, nephrotic syndrome, hypoalbuminaemia.
- **In all of the above if the volume depletion is sufficient to cause shock there may be activation of ADH secretion from carotid baroreceptor stimulation that by-passes the hypothalamic osmoreceptors further worsening the hyponatraemia. Treatment of shock therefore turns off ADH and the resulting diuresis causes sodium to rise rapidly.**

2) Dilution

- Non-hypovolemic states of antidiuretic hormone (ADH) excess – includes DDAVP overdose and Syndrome of inappropriate secretion of antidiuretic hormone (SIADH) also called non-osmotic ADH secretion;
- water intoxication;
- hypotonic (inappropriate) i.v. fluids –common cause of moderate/mild hyponatraemia.

See Appendix 2 for establishing a cause for hyponatraemia and suggested investigations.

3) Artefactual

- Laboratory or sampling error -e.g. sampling above an infusion or from a contaminated line. An unexpected result should prompt a re-check ideally on a different machine and from a different site.
- Hyperglycaemia; mannitol treatment – both will have high serum osmolality (compared to 1 & 2 above where there is hypoosmolality). See Appendix 1.
- Severe hypertriglycerideaemia with visible lipaemia (blood gas analyser sodium not affected by lipaemia).

Symptoms of Severe Hyponatraemia

Early symptoms are non-specific and include headache, nausea and vomiting, lethargy, weakness, confusion, altered consciousness, agitation and irritability. Seizures may be the first symptom. As hyponatraemia worsens there may be coma with a high risk for cerebral herniation (decorticate/decerebrate posturing), apnoea and cardiac arrhythmias.
Severe hyponatraemia more commonly occurs in the context or pre-existing chronic morbidity that may delay recognition of symptoms or in acutely unwell patients receiving critical care (such as head injury or burns).

It appears that ACUTE severe hyponatraemia (e.g. from documented excess water intake) does NOT carry the same risk of cerebral demyelination. It can safely be corrected with strong saline infusions without a limit on the rate of rise of sodium. HOWEVER if there is any doubt that the hyponatraemia could have been present for more than 48h proceed as below.

Treatment of Severe Chronic Hyponatraemia

ALERT Symptomatic confirmed severe hyponatraemia <120 mmol/L

- **Treat shock, if present with 0.9% Saline. Then pause and reassess - this may by itself cause a rise in serum sodium as diuresis occurs. Monitor urine output.**
- **Prompt i.v. infusion of 2mL/kg 3% NaCl (hypertonic saline) over 20 min.**
- **Check the serum sodium concentration after 20 min and repeat an infusion of 2ml/kg 3% hypertonic saline for the next 20 min if the sodium has not increased by 5mmol/L.**

- **Repeat twice or until a target of 5 mmol/L increase in serum sodium concentration is achieved.**
- **Aim for no more than 10 mmol/L rise in sodium in first 24h and 18 mmol in first 48h.**
- **Manage patients on PICU. Strongly consider arterial line or large bore venous line for hourly blood Na measurement**
- **Consult the paediatric endocrinology team for advice on treating adrenal crisis or the use of antidiuretic hormone if re-lowering of sodium is required for over-rapid correction.**

If no improvement in symptoms:-

- Continue an i.v. infusion of 3% hypertonic saline or equivalent aiming for an additional 1 mmol/L per h increase in serum sodium concentration.
- Stop the infusion of 3% hypertonic saline or equivalent when the symptoms improve, the serum sodium concentration increases 10 mmol/L in total or the serum sodium concentration reaches 130 mmol/l, whichever occurs first.
- Consider other causes of the CNS symptoms rather than hyponatraemia
- Check the serum sodium concentration hourly to 2 hourly as long as an i.v. infusion of 3% hypertonic saline or equivalent is continued, and until a sodium level of 130mmol/L is reached.

When symptomatic improvement occurs:-

- Stop the infusion of hypertonic saline.
- Keep the i.v. line open by infusing the smallest feasible volume of 0.9% saline until cause-specific treatment is started.
- Start a cause-specific treatment if available, aiming at least to stabilise sodium concentration.

- Limit the increase in serum sodium concentration to a total of 10 mmol/L during the first 24 h and an additional 8 mmol/L during every 24 h thereafter until the serum sodium concentration reaches 130 mmol/l.
- Once the sodium is 130 mmol/L check the serum sodium concentration 4-6 hourly then twice daily afterwards until the serum sodium concentration has stabilised.

Risk factors for developing cerebral demyelination (central pontine myelinosis) **in treated hyponatraemic patients**

- Severe chronic hyponatraemia: Na ≤115 mmol/L
- Development of hypernatraemia on treatment
- Increase in serum sodium exceeding 25 mmol/L in 48 hours
- Hypoxaemia
- Severe liver disease
- Thiazide diuretics
- Severe Burns
- Malnutrition
- Hypokalaemia
- Renal failure

Re-lowering of sodium in those at risk of cerebral demyelination.
*** This approach has been verified in animal studies but not human trials.*

If overcorrection occurs, re-lowering of the serum sodium can be achieved by administering desmopressin in combination with repeated 3 mL/kg infusions of 5% dextrose in water administered over 1 hour — measuring the serum sodium before repeating until the sodium has been returned to a level below the limit for the patient (e.g. 8-10 mmol/L in any 24 hour period or 18 mmol/l in any 48 hour period).
High dose dexamethasone 6 hourly for 48 hours *may* help prevent brain injury in the situation of excessive sodium rise (*again from animal studies*).
An arterial line or large bore venous line that can be sampled is mandatory for such cases.

Treatment of the syndrome of non-osmotic ADH secretion (also called SIADH).

It is important to recognise the syndrome of antidiuretic hormone excess as the treatment differs significantly from other causes of hyponatraemia. In SIADH the effective serum osmolality is <275 mOsm with a paired Urine osmolality >100 mOsm. There are no signs of hypovolaemia, adrenal, thyroid, pituitary or renal insufficiency and no recent use of diuretic agents. Normal (0.9%) saline infusion will not raise the serum sodium and the treatment of hyponatraemia is through fluid restriction. The use of lithium, tetracyclines and vasopressin receptor antagonists is *not* currently recommended. Severe SIADH can lead to very low Na levels (<120 mmol) but remains a diagnosis of exclusion. Severe Hyponatraemia due to SIADH should be treated with 3% saline as described above.

Signs and symptoms of cerebral demyelination.

Initially there is an improvement of CNS signs of hyponatraemia followed 2-7 days later by dysarthria, spastic quadriplegia, pseudobulbar palsy, ataxia and the "locked-in" syndrome of consciousness with total muscle paralysis (sometimes with preserved vertical eye movements.

Consultation

Key stakeholders who reviewed this version:

- Director and SMOs Critical Care
- Director ED
- Director Renal Medicine

Definition of terms

Term	Definition	Source
Severe Hyponatraemia	Serum sodium < 120 mmol/l	European and US guidance –see reference list
Chronic/Acute	More than 48h/less than 48h	

References and suggested reading

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2. Spasovski G, Vanholder R, Allolio B, Annane D, Ball S, Bichet D, Decaux G, Fenske W, Hoorn EJ, Ichai C, Joannidis M, Soupart A, Zietse R, Haller M, van der Veer S, Van Biesen W, and Nagler E on behalf of the Hyponatraemia Guideline Development Group. European Journal of Endocrinology (2014) 170, G1–G47 & Errata EJE 2014 171.1
3. Michael L. Moritz & Juan Carlos Ayus. New aspects in the pathogenesis, prevention, and treatment of hyponatremic encephalopathy in children. Pediatr Nephrol (2010) 25:1225–1238
4. Smith DM; McKenna K; Thompson CJ. Hyponatraemia. Clinical Endocrinology. 52(6):667-678, June 2000

Guideline revision and approval history

Version No.	Modified by	Amendments authorised by	Approved by
1.0	Jerry Wales	Director Endocrinology	
2.0	Legal Governance and Risk – update review date	Divisional and Medical Director, Division of Medicine	Executive Leadership Team 17/10/2019

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Appendix 1:

Hyponatraemia as part of diabetic ketoacidosis (DKA).

Hyponatraemia developing as part of treatment of DKA is a risk factor for cerebral oedema *per se* but not cerebral demyelination as it is non-hypotonic hyponatraemia. Glucose "holds water" in the circulation lowering the measured sodium value whilst the total amount of sodium in the circulation remains the same.

In DKA the true sodium value needs to be corrected to take into account the hyperglycaemia according to the flowing formula.

$$\text{Corrected sodium} = \text{Measured Sodium} + 2.4 \times \frac{\text{(Measured Glucose (mmol/l) - 5.5 mmol/l)}}{\text{5.5 mmol/l}}$$

(This is the same as adding 2.4 mmol/l to the measured serum sodium concentration for every 5.5 mmol/l incremental rise in serum glucose concentration above a normal serum glucose concentration of 5.5 mmol/l).

The sodium level should rise as glucose is removed from the circulation with treatment of DKA. A failure to do so is a worrying sign. Please see the State Guidelines for treatment of DKA 2016 edition.

Appendix 2: Establishing a Cause of Severe Hyponatraemia.

Adapted from European Journal of Endocrinology (2014) 170, G1–G47