The Newcastle upon Tyne Hospitals NHS Foundation Trust

Disorders of Sodium and Water balance in NICU

1 Introduction

Disorders of sodium and water balance, manifesting as hypo- or hypernatraemia, are a significant problem in neuro-critical care. They are common phenomenae (occurring in up to 50% of patients) which require additional therapies, and are associated with increased risk of morbidity and mortality.

Appropriate management is vital in order to prevent or reverse the life threatening complications of severely abnormal serum sodium levels and to mitigate against the risk of iatrogenic complications.

2 Guideline scope

This guideline applies to patients who are hyponatraemic (serum sodium concentration <135mmol/l), or hypernatraemic (serum sodium concentration >145mmol/l) and whose primary diagnosis is neurosurgical (e.g. SAH, ICH, TBI). There is significant crossover with non-neuro critically ill patients with disorders of sodium balance, but these groups should not be considered to be equivalent.

3 Main body of the Guideline

3.1 Hyponatraemia

Hyponatraemia occurs as a result of a relative excess of body water compared to total body sodium. This can occur as a result of increased water retention or excess sodium loss. As many as 30% of patients in neurocritical care develop hyponatraemia, and the clinical consequences range from none/minimal to severe and life threatening. Hyponatraemia is associated with prolonged length of stay, excess morbidity and mortality.

3.1.1 Symptoms of hyponatraemia

Severity	*Symptom*
Moderately severe	Nausea without vomiting
	Confusion
	Headache
Severe	Vomiting
	Cardio-respiratory distress
	Deep somnolence
	Seizures

GCS>8

Severe symptoms of hyponatraemia are caused by cerebral oedema and raised ICP, caused by water shifting to the intracellular compartment due to the lower effective osmolality in the extracellular compartment. This occurs more commonly in acute onset hyponatraemia and is associated with a higher risk of death.

3.1.2 Causes

Hypotonic hyponatraemia:

Syndrome of inappropriate ADH (SIADH)

Salt wasting syndrome (renal or cerebral)

Adrenal insufficiency

Fluid and salt losses – diuretics, vomiting, diarrhoea

Heart failure

Cirrhosis

Nephrotic syndrome

Kidney disease

Isotonic or hypertonic hyponatraemia

- Presence of effective osmoles (eg glucose, mannitol, glycine) causing increased serum osmolality and sodium shifts
- Presence of ineffective osmoles (eg alcohol, urea, ethylene glycol causing increased serum osmolality without sodium shifts

Pseudohypernatraemia

Hypertriglyceridaemia

Hypercholesterolaemia

IVIg

Monoclonal gammopathies

Pseudohyponatraemia can occur due to the measurement technique for sodium in the setting of hyperlipidaemia or hyperproteinaemia. Where a larger proportion of circulating volume is lipid or protein, the serum sodium levels appear artefactually low if assumed to be in solution in a normal (rather than reduced) plasma volume. Direct measurement techniques can be used to measure the true serum sodium value.

3.1.3 Initial Assessment

History

Does the patient feel thirsty?

Is there a history of fluid loss, diuretic therapy?

What is the fluid input/output balance?

Examination

Assess volume status - skin turgor, mucous membranes, CVS parameters.

Look for signs of other conditions associated with hyponatraemia – liver disease/ascites, heart failure, hypothyroidism, adrenal insufficiency.

Biochemical tests

Confirm serum sodium

- Mild hypernatraemia – Na 130-135 mmol/L
- Moderate hyponatraemia – Na 125-135 mmol/L
- Profound hyponatraemia – Na<125 mmol/L

Serum osmolality

Serum osmolality is primarily determined by serum sodium and its accompanying cations, and hence is reduced in most patients with low serum sodium.

Causes of hyponatremia with normal or raised serum osmolality include hyperglycaemia, renal failure with raised urea, and alcohol intoxication. Assessment and management of hyponatraemia in these conditions should include addressing the primary problem. Consideration may be given to simultaneous management of low sodium under some circumstances – this should be in consultation with senior medical staff.

Urine osmolality

Urine osmolality is helpful in determining if a patient has impaired water excretion. In normal individuals, low serum sodium should result in maximal ADH suppression and a very low urine osmolality (<100mosm/kg). Urine osmolality above this value indicates a failure of free water excretion.

Urine sodium

Urine sodium can be used to distinguish between hyponatraemia caused by volume depletion and that caused by euvolaemic hyponatraemia (eg SIADH).

Urine sodium is usually <30meq/L in hypovolaemia unless there is renal salt wasting (eg diuretic use, CSW). In these conditions the kidney is avidly retaining sodium, and hence water. Restoration of circulating volume occurs at the expense of hyponatraemia.

In patients with SIADH the urine sodium is usually above 40meq/L. These individuals are euvolaemic and excrete salt in a normal fashion.

Urine osmolality and urine sodium must be interpreted with caution in patients with renal impairment whose results may not reflect hormone axis function.

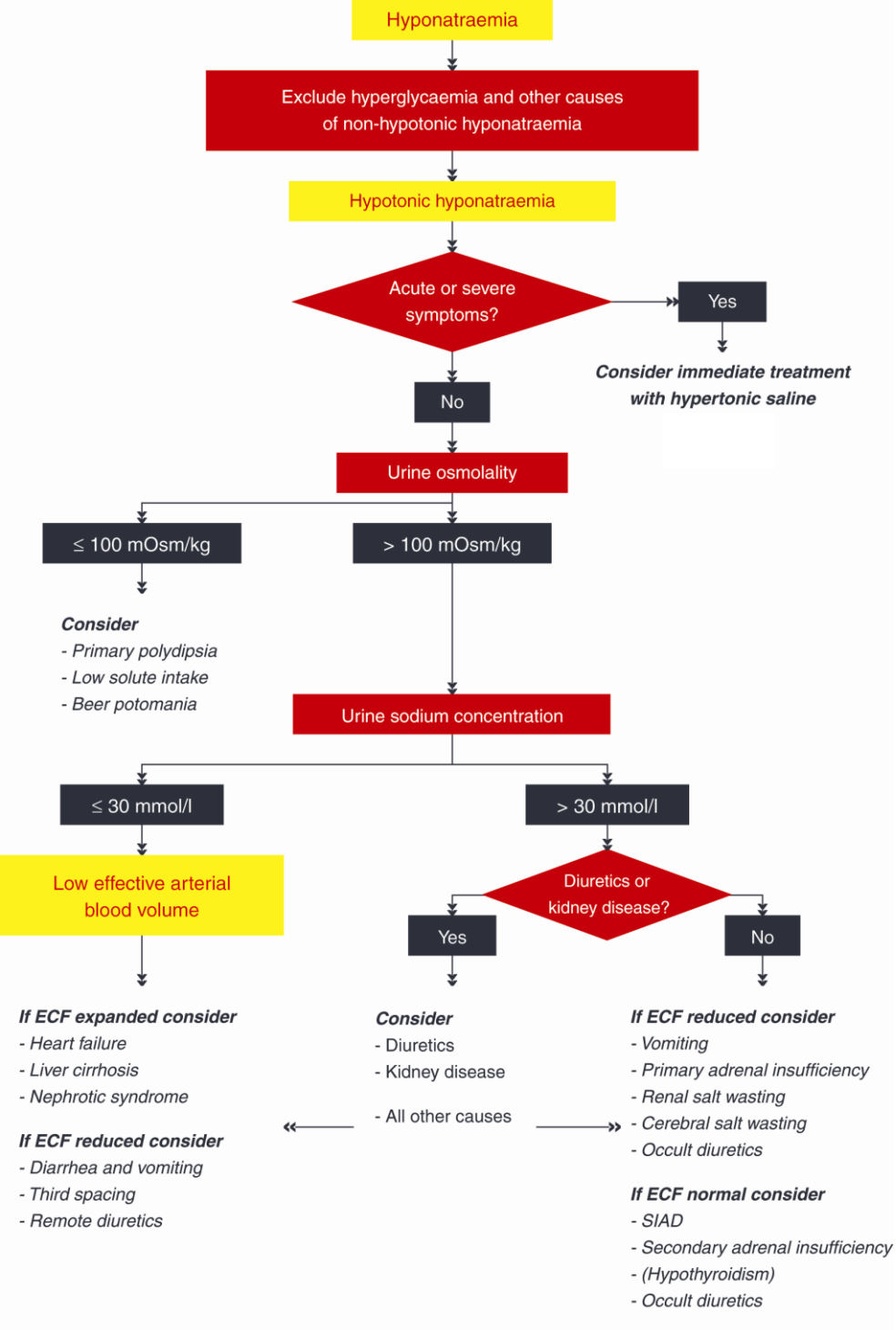
TFTs

Random cortisol

Serum glucose

Additional tests (eg lipids, alcohol concentration) may be appropriate depending on the clinical scenario.

3.1.4 Diagnosis



Distinguishing CSW from SIADH
The most common causes of hyponatraemia on ward 18 are SIADH and CSW. These are impossible to distinguish biochemically but may be clinically distinct due to the difference in volume status. In practise the distinction can be very challenging.

	SIADH	**CSW**
Serum sodium	Low	Low
Urine osmolality	Inappropriately high	Inappropriately high
Urine sodium	High	High
Volume status	Euvolaemic/hypervolaemic	Hypovolaemic

3.1.5 Medical management

Sodium correction

When considering correction of hyponatraemia the following must be considered:

- Speed of onset
- Duration of hyponatraemia
- Severity of symptoms
- Degree of hyponatraemia

Duration and speed of onset.

A threshold of 48h is used to distinguish acute from chronic hyponatraemia. In patients who develop hyponatraemia over <48h the risk of cerebral oedema (due to water shift into cells from the hypo-osmolar extracellular fluid) is higher than in individuals with slower onset. After adaptation has occurred, beyond 48h, there is a higher risk of damage to the cells if sodium is corrected too rapidly. This osmotic demyelination syndrome (ODS) causes injury to neurones with associated neurodisability. If it is not possible to determine the speed of onset and duration of hyponatraemia, it should be assumed to be chronic.

In patients with severe or moderately severe symptoms the risk of brain oedema is felt to outweigh the risk of ODS and urgent treatment is indicated. Outwith this group, a less urgent approach can be adopted.

In all groups, management of the underlying disorder is clearly also of importance.

Hyponatremia with severe symptoms:

First hour – all groups:

IV infusion 150ml 2.7% NaCl over 20 minutes

Recheck serum sodium after 20 minutes

Repeat 150ml 2.7% NaCl over 20 mins until serum Na has risen by 5mmol/L

Further management:

If serum sodium has risen by 5mmol/L and symptoms have improved, discontinue hypertonic solution and commence diagnosis specific management.

Rise in serum sodium should be limited to a total of 10mmol/L in the first 24h and 8mmol/L during every 24h thereafter until the sodium concentration reaches 130mmol/L. Serum sodium should be measured every 6 h initially, then every 12 h.

If serum sodium has risen by 5mmol/L and symptoms have not improved, commence IV infusion of 2.7% NaCl aiming for rise in serum sodium of 1mmol/L/h.

Change in serum [Na] = infusate [Na] – serum [Na] / total body water (L) + 1

Discontinue infusion when symptoms improve, when sodium concentration has risen by a total of 10mmol/L or when concentration reaches 130mmol/L, whichever is sooner. Monitor sodium every 4h.

Hyponatremia with moderately severe symptoms:

Commence prompt investigation

Stop all therapies which may be contributing to hyponatremia where possible.

IV infusion 150ml 2.7% NaCl over 20 minutes.

A 5mmol/L rise in serum sodium over 24 h should be *aimed* for. Rise in serum sodium should be *limited* to a total of 10mmol/L in the first 24h and 8mmol/L during every 24h thereafter until the sodium concentration reaches 130mmol/L. Serum sodium should be measured every 6 h initially, then every 12 h.

Cause specific management should be commenced.

Acute hyponatraemia without severe or moderately severe symptoms:

Commence prompt investigation

Stop all therapies which may be contributing to hyponatremia where possible.

Cause specific management should be commenced.

If acute drop in serum sodium exceeds 10mmol/L, administer a single IV infusion 150ml 2.7% NaCl over 20 minutes. Recheck Na after 4 h.

Chronic hyponatraemia without severe or moderately severe symptoms

Stop all therapies which may be contributing to hyponatremia where possible.

In mild hyponatraemia, therapy with the sole aim of increasing serum sodium is not indicated.

In moderate or profound hyponatremia, rise in serum sodium should be limited to a total of 10mmol/L in the first 24h and 8mmol/L during every 24h thereafter until the sodium concentration reaches 130mmol/L. Serum sodium should be measured every 6 h until stabilised.

Cause specific management should be commenced.

SIADH

In moderate to profound hyponatremia, fluid restriction should be first line therapy.

Second line therapy with oral sodium replacement and low dose loop diuretics may be initiated if fluid restriction is ineffective.

The use of demecleocycline, lithium and vasopressin antagonists is not recommended.

Contracted circulating volume

Restore circulating volume with 0.9% NaCl at 0.5-1.0ml/kg/h.

A sudden increase in UO may occur when vasopressin secretion is rapidly suppressed after restoration of circulating volume. This may give rise to overly rapid increase in serum sodium concentration as free water is cleared. If this occurs, serum sodium should be measured every 2 h until stabilised.

Fludrocortisone can be effective in reducing natriuresis in patients who are salt wasting. It's use should be discussed with a senior colleague.

Expanded ECF volume

In mild to moderate hyponatraemia, therapy with the sole aim of increasing serum sodium is not indicated.

Fluid restriction to prevent further overload should be initiated.

The use of demecleocycline, lithium and vasopressin antagonists is not recommended.

Overly rapid sodium correction

If the rise in serum sodium exceeds a total of 10mmol/L in the first 24h, or 8mmol/L during every 24h thereafter, consideration should be given to re-lowering sodium concentration.

Under these circumstances, active therapy should be discontinued. Senior advice should be sought regarding administration of 10ml/kg free water (in the form of dextrose solution) or the use of desmopressin.

3.2 Hypernatraemia

Hypernatraemia is defined as a serum sodium >145mmol/L. Hypernatraemia occurs as a result of a relative deficit of body water compared to total body sodium. This occurs almost exclusively due to excessive unreplaced water loss, but can be caused by administration of hypertonic saline or ingestion of sodium salts. In

independent patients with an intact sense of thirst and access to water, hypernatraemia will not occur.

Approximately 10% of critical care patients have hypernatraemia during their admission. This group may have altered experience or awareness of thirst, and / or require assistance to obtain fluid intake.

3.2.1 Symptoms

Symptoms of hypernatraemia are most likely to relate to the underlying cause, and to the experience of thirst and / or polyuria.

3.2.2 Causes

Unreplaced water losses

Loss of solute free water can occur through skin, GI tract and urine. Urinary losses may be due to diabetes insipidus (with lack of ADH secretion – central DI, or lack of ADH efficacy at the kidney – nephrogenic DI) or due to osmotic diuresis caused by solutes such as glucose, mannitol or urea.

Sodium overload

This can occur due to administration of hypertonic sodium solutions, or due to accidental or deliberate salt poisoning by ingestion. It can also occur with inappropriate replacement of water deficit using isotonic solutions.

3.2.3 Initial Assessment

History

Does the patient feel thirsty?

Is there a history of fluid loss, diuretic therapy?

What is the fluid input/output balance?

Examination

Assess volume status - skin turgor, mucous membranes, CVS parameters.

Biochemical tests

Confirm serum sodium

Serum osmolality

A plasma osmolality above 295mosmol/kg generally leads to sufficient ADH secretion to maximally stimulate urinary concentration.

Urine osmolality

- If the urine osmolality is less than the plasma osmolality then the patient has DI.

- If the urine osmolality is intermediate (300-600mosmol/kg) the hypernatraemia may be due to an osmotic diuresis or DI.
- If the urine osmolality is above 600mosmol/kg the ADH response is intact.

Urine sodium

The urine sodium should be <25mEq/L if water loss is the main problem, but may be somewhat higher if urine volume is low due to avid water retention.

In the case of sodium overload, urine sodium is typically >100mosmol/kg.

3.2.4 Diagnosis

The diagnosis can be ascertained from the biochemical tests. In patients who have an osmotic diuresis whose urine osmolality is in the intermediate range, a trial of exogenous ADH will not be effective in increasing urine and lowering serum osmolality.

3.2.5 Medical management

Sodium correction

Water deficit (ml) can be calculated as follows:

Males:

0.5 x W x ((measured Na / Target Na) - 1)

Females

0.4 x W x ((measured Na / Target Na) - 1)

W = weight in kg

In general, half the estimated deficit should be replaced during the first 24hrs. 5% dextrose IV or the oral/NG route can be used in patients who are absorbing.

Specific treatments

Diabetes insipidus
Patients with confirmed DI should have simultaneous replacement of water and ADH. Synthetic ADH is administered as desmopressin 0.5-1mcg subcutaneous, repeated as required.

Other causes

Treatment of skin, gut or osmotic causes of water loss and of sodium overload should similarly be addressed together with water replacement.

4 Training, Implementation and Resource Implications

Training on this topic should occur via consultant staff and the unit nurse educator.

5 Monitoring Section

Periodic audit should monitor the management of patients with sodium disorders on critical care.

6 Evidence Review and Evaluation

European Society of Intensive Care Medicine (ESICM), the European Society of Endocrinology (ESE) and the European Renal Association – European Dialysis and Transplant Association (ERA–EDTA), represented by European Renal Best Practice (ERBP) Clinical Practice Guideline on diagnosis and treatment of hyponatraemia.

7 References

European Renal Best Practice Clinical Practice Guideline on diagnosis and treatment of hyponatraemia.