IAEM Clinical Guideline

The Assessment and Management of Hyponatraemia in the Emergency Department

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DISCLAIMER

IAEM recognises that patients, their situations, Emergency Departments and staff all vary. These guidelines cannot cover all clinical scenarios. The ultimate responsibility for the interpretation and application of these guidelines, the use of current information and a patient's overall care and wellbeing resides with the treating clinician.

Revision History

Version	Section	Summary of Changes	Author
V1.0	All	Final version	RC/JR

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CONTENTS

GLOSSARY OF TERMS

Ca^{2+}	Calcium
CO_2	Carbon Dioxide
CVA	Cerebrovascular Accident
CXR	Chest X-ray
ED	Emergency Department
HDU	High Dependency Unit
ICU	Intensive Care Unit
IVF	Intravenous Fluids
K^+	Potassium
Mg^{2+}	Magnesium
mmol/L	Millimoles Per Litre
mOsmol/kg	Milliosmoles Per Kilogram
Na^+	Sodium
NaCl	Sodium Chloride
NG	Nasogastric
PO	Per Oral
SIADH	Syndrome of Inappropriate Antidiuretic Hormone Secretion
VBG	Venous Blood Gas

The Assessment and Management of Hyponatraemia in the Emergency Department

INTRODUCTION

This guideline will address the emergency assessment and management of patients with hyponatraemia. It will differentiate patients into life-threatening and non-life-threatening categories. Assessment and management will be explained alongside consideration of the broad differential diagnoses.

Hyponatraemia is defined as a serum sodium level <135mmol/L. It is a common condition featuring in 15-20% of presentations to the ED. There are many causes of hyponatraemia. Symptoms can be similar to clinical features of other pathologies. The emergency physician must consider a broad range of other diagnoses prior to treatment.

Hyponatraemia can be divided into two components: life-threatening and non-life-threatening. **Establishing if the patient has life-threatening or non-life-threatening hyponatraemia is the critical first step in assessing the patient**. This differentiation dictates the subsequent emergency management, even though the primary causes of both can be similar.

The most important clinical features of hyponatraemia are its effect on the brain. Acute hyponatraemia can cause cerebral oedema. Brain injury as a result of cerebral oedema can be irreversible. Emergency treatment with hypertonic saline is required to treat this.

Clinical features of hyponatraemia correlate more with the speed of onset and not the level of sodium. Acute onset hyponatraemia occurs within a 48-hour period. After this time frame, brain cell osmolality begins to fall. Lower osmolality reduces further water uptake. At this stage, the patient is most vulnerable to Osmotic Demyelination Syndrome from over or excessively

rapid correction of sodium. In the ED it is safer to assume duration of hyponatraemia is greater than 48 hours. **The algorithm for non-life-threatening hyponatraemia is on page 13 and the algorithm for life-threatening hyponatraemia is on page 21.**

PARAMETERS

Target Audience	This guideline is developed for emergency physicians managing patients with hyponatraemia in the Emergency Department.
Patient Population	Adult patients presenting with hyponatraemia requiring emergency care.
Population Excluded	-Patients who are pregnant. -Patients under of 16 years of age.

AIMS

- To establish a guideline for the assessment and management of patients with hyponatraemia in the Emergency Department.
- To assist the emergency physician in the assessment and management of this potentially life-threatening electrolyte abnormality.
- To improve the quality and consistency of the management of patients with hyponatraemia in an emergency setting.

MANAGEMENT OF NON-LIFE-THREATENING HYPONATRAEMIA

Non-life-threatening hyponatraemia occurs when a patient's sodium is low but it is not an immediate threat to life. The approach to non-life-threatening hyponatraemia involves establishing an aetiology, treating, and closely monitoring the patient for complications of sodium correction.

History

Perform a clinical history and systems review. Focused questions are also required with regard to symptoms of hypothyroidism, glucocorticoid deficiency, congestive cardiac failure, and renal and liver failure. These pathologies are recognised causes of hyponatraemia. It is important to note any recent change in medications or extra fluid intake. Take a history searching for features of cerebral oedema , including seizures, confusion, and lethargy.

Symptoms of non-life-threatening hyponatraemia can be non-specific and vague. A patient presenting with a sodium <130mmol/L can be asymptomatic or have features including:

- Fatigue
- Lethargy and somnolence
- Nausea and vomiting
- Anorexia

Clinical Examination

Establish the patient's vital signs. Perform a robust physical examination and examine for clinical features of liver, renal, and heart failure. Assess for physical evidence of hypothyroidism and Addison's disease. A comprehensive neurological examination is required due to the potential neurological sequelae of hyponatraemia.

Ascertain the patient's fluid status. This fluid assessment is necessary to identify an aetiology.

Signs to assist you in this fluid assessment include:

- Pulse
- Blood pressure
- Capillary refill time
- Mucous membranes
- Peripheries for skin turgor and pitting oedema
- Respiratory examination
- Jugular venous pressure
- Urinary output
- Trend in weight

Investigations

Core investigations to diagnose hyponatraemia:

- Serum sodium
- Serum osmolality
- Venous blood gas
- Urinary sodium
- Urinary osmolality

Further investigations necessary to establish an aetiology

- Urea and electrolytes
- Full blood count
- Liver function tests
- Thyroid function tests
- CXR to assess for pulmonary oedema

Other investigations may be required on a case-by-case basis to progress through the differential diagnoses.

Diagnosis

The most common form of this metabolic disturbance is **hypo-osmolar hyponatraemia**. Isotonic and hyperosmolar hyponatraemia occur less frequently. The causes of non-life-threatening and life-threatening hyponatraemia are the same. Following the clinical examination and the investigations listed above, you should now be in a position to establish an aetiology.

Diagnosing Isotonic and Hyperosmolar Hyponatraemia

If a patient's measured serum osmolality is normal (275–295mOsmol/kg) or high (>295mOsmol/kg), consider the following diagnoses:

- Renal failure
- High serum measurements of lipids, protein, or glucose
- Infusion of hypertonic solutions (e.g. mannitol)

Diagnosing Hypotonic Hyponatraemia

In this instance the serum osmolality is low (<275mOsmol/kg). Establish the patient's fluid status, and measure the urinary sodium. The likely diagnoses are listed in the third column of the following table (Table 1).

Hypervolaemia	Urinary Sodium <30mmol/L	• Liver failure • Cardiac failure
	Urinary Sodium >30mmol/L	• Renal failure • Diuretic treatment in cardiac failure
Euvolaemia	Urinary Sodium <30mmol/L	• Hypothyroidism • Iatrogenic – intravenous fluids • Water intoxication
	Urinary Sodium >30mmol/L	• SIADH • Adrenocortical deficiency
Hypovolaemia	Urinary Sodium <30mmol/L	• Diarrhoea and vomiting • Reduced PO Intake • Burns
	Urinary Sodium >30mmol/L	• Salt wasting (renal/ cerebral) • Diuretic medication • Addison's disease

Table 1: Diagnosis of Hypotonic Hyponatraemia

Treatment of non-life-threatening hyponatraemia

The majority of treatments for non-life-threatening hyponatraemia involve the treatment of the original cause of the electrolyte disturbance. This includes fluid restriction, fluid replacement, or medication changes.

Urine output should be monitored during treatment while fluid balance is being adjusted. Patient education is a key component of treatment, this may require input from a multidisciplinary team. Depending on the complexity of the case, an endocrine or renal team may be required.

Below includes the management strategies for patients presenting with hyponatraemia of varying levels of volume status.

Hypervolaemia

- Treat the cause
- Fluid restrict if appropriate

Euvolaemia

- Treat the cause
- Stop potential contributing medications
- Fluid restrict if appropriate

Hypovolaemia

- Treatment of cause
- Administer intravenous NaCl 0.9% or Hartmann's Solution at 0.5ml/kg/hr–1ml/kg/hr.
    - Reassess sodium every eight hours for the duration of treatment.
    - Target sodium rise <10mmol/L in 24 hours in an otherwise healthy patient.
    - Target sodium rise <8mmol/L in 24 hours in a patient who is malnourished.

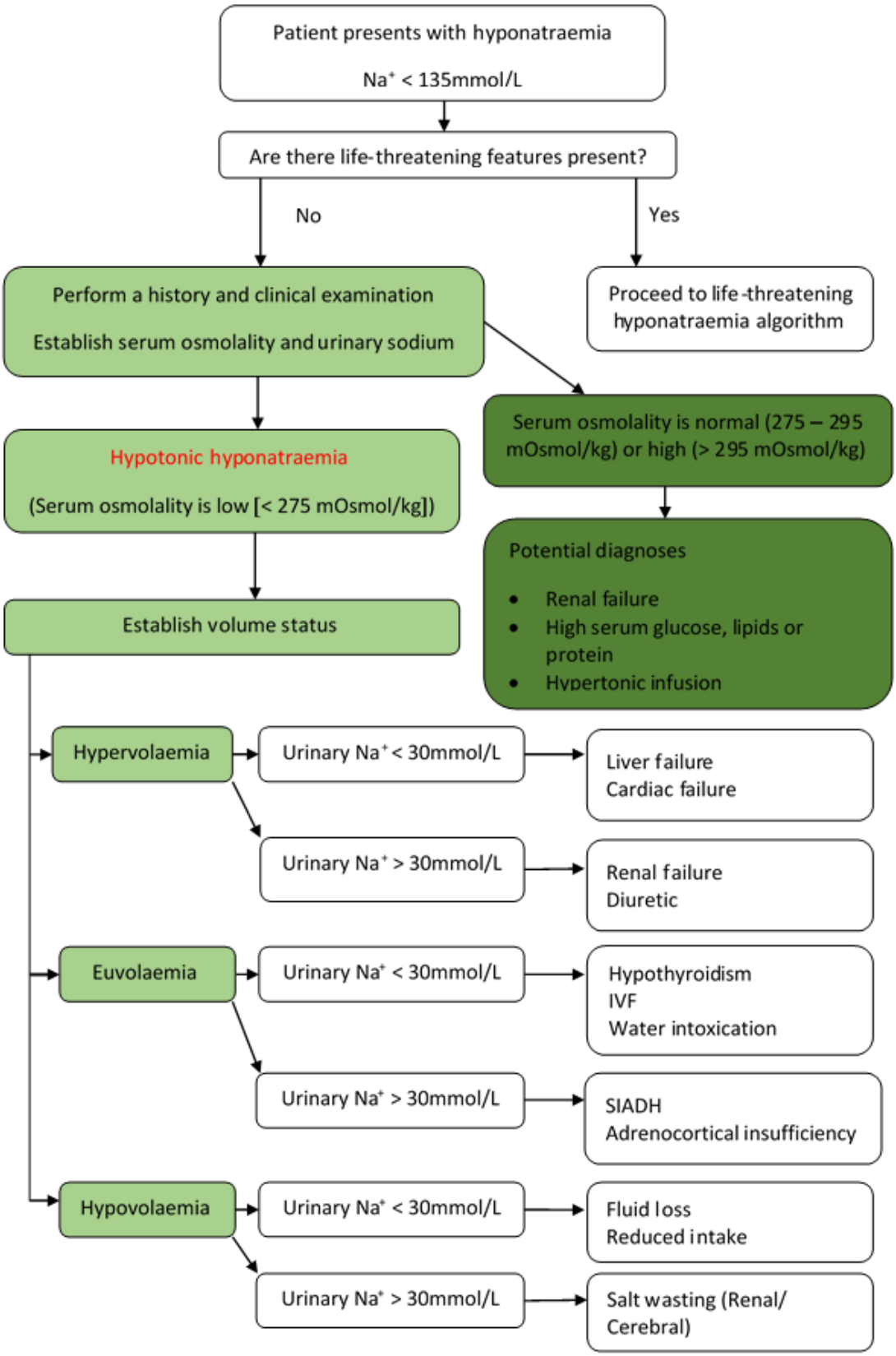
If hyponatraemia has been present for greater than 48 hours, extra care is required in correcting sodium level. In such situations the brain cell osmolality falls. It becomes dehydrated and is at risk of a significant fluid shift. Excessively rapid, or over correction of sodium at this stage can cause **Osmotic Demyelination Syndrome**. This rare presentation can cause paresis, paralysis, seizures, and coma.

Repeat clinical assessment and sodium monitoring is required to reduce the risk of complications of sodium correction. The degree of monitoring depends on the stability of the patient and the rate of change of sodium. An acceptable time frame for repeat assessment early in the patient's treatment is every 8 hours.

Summary

Non-life-threatening hyponatraemia requires a stepwise approach from clinical examination to specific investigations. Assessment of fluid status will guide the likely aetiology. The majority of treatments centre on managing the underlying pathology driving the low blood sodium level.

Figure 1: Non-life-threatening hyponatraemia algorithm



MANAGEMENT OF LIFE-THREATENING HYPONATRAEMIA

This is a medical emergency. Prompt resuscitation and hypertonic saline is required to avoid irreversible brain injury from cerebral oedema. The severity of features depends predominantly on the rate of development of the hyponatraemia. Please refer to Figure 2 for the management algorithm of life-threatening hyponatraemia.

History

The clinical history in life-threatening hyponatraemia follows the same pattern as for the patient with non-life-threatening hyponatraemia. In life-threatening hyponatraemia, other critical diagnoses must also be ruled out early in the assessment.

The differential diagnoses that must considered include:

- Electrolyte imbalances: Ca^{2+}, K^{+}, Mg^{+}, hypernatraemia
- Intracranial haemorrhage
- Brain stem CVA
- Glycaemic emergencies
- Sepsis
- Seizures
- Illicit substance use

Clinical Examination

The physical examination must also aim to outrule other differential diagnoses. A neurological examination is essential. Your neurological examination will be required again during treatment. It will be used to reassess the patient following hypertonic saline.

Clinical features of life-threatening hyponatraemia

The severity of features depends on the rate of development of the hyponatraemia and the sodium level.

The clinical features of life-threatening hyponatraemia include:

- Agitation
- Neurological deficit
- Confusion and disorientation
- Hyporeflexia
- Seizures
- Coma
- Respiratory arrest

Assessment and Investigation

The essential emergency investigation for life-threatening hyponatraemia is a **blood gas sodium level**. Samples for laboratory serum sodium, serum osmolality, urinary osmolality and urinary sodium should also be taken at this time to aid diagnosis and further treatment.

Other investigations are required to rule out differential diagnoses and further investigate the patient with hyponatraemia. These investigations may not be urgent. They can be revisited following emergency resuscitation and treatment of life-threatening hyponatraemia.

Treatment of Life-threatening Hyponatraemia

Treatment of the patient with life threatening hyponatraemia is in the resuscitation area of the ED and requires continuous monitoring.

Airway and Breathing

Due to symptoms of cerebral oedema, patient with life-threatening hyponatraemia may have airway compromise. Standard airway interventions are appropriate including oxygen via a non-rebreather mask, basic airway manoeuvres, airway adjuncts and end-tidal CO_2 monitoring.

Advanced airway and ventilation interventions may be required if basic manoeuvres are inadequate. This approach does not deviate from conventional advanced airway management of the critically unwell patient in the ED.

Circulation

The shocked hypovolaemic hyponatraemic patient requires treatment with intravenous fluids. Boluses of 250ml of NaCl 0.9% or Hartmann's Solution are appropriate. When the patient is no longer fluid responsive it is advised to progress to vasopressor use under the supervision of a senior ED clinician.

In resuscitation of the patient in shock, two-hourly venous blood gas sodium levels, and hourly urine output monitoring is advised. If urine output is >100ml/hr for two hours the patient is at risk of over-correction of sodium. Response of heart rate, blood pressure, and capillary refill to intravenous fluids are all methods to aid in assessment of fluid responsiveness. Advice on rate of correction of sodium is available on **page 19**.

In the treatment of hypovolaemic shock, the choice of intravenous fluid is at the discretion of the treating clinician. Hartmann's Solution has a sodium concentration of 131mmol/L. NaCl 0.9% has a sodium concentration of 154mmol/L.

The Adrogué formula is helpful in predicting changes in serum sodium following an infusion of 1000ml of intravenous fluids. It is useful to predict the change in serum sodium following an infusion of one litre of fluids for hypovolaemic shock. This helps avoid over-correction. The accuracy of the Adrogue formula varies depending on the patient's urine output.

The formula is:

$$\text{Change in Serum Na} = \frac{(\text{Infusion Fluid Na} + \text{Infusion Fluid K}) - \text{serum Na}}{\text{Total Body Water} + 1}$$

$$= \frac{(131 + 5) - 127}{42 + 1} = 0.21\text{mmol/L}$$

For example, a 70kg 60 year old man with a sodium of 127mmol/L in hypovolaemic shock is infused with one litre of Hartmann's solution. The expected rise in sodium following a one litre infusion is 0.21mmol/L.

Estimated total body water (TBW) is 60% of total body weight. An approximation of a patients TBW in 70kg man is,

$$0.6 \times \text{weight (kg)} = 42$$

Decision to Treat

Following resuscitation and identification of life-threatening hyponatraemia, the patient may require treatment with hypertonic saline (NaCl 3%). This should be considered following discussion with a senior ED physician familiar with the management of patients with life-threatening hyponatraemia.

Emergency Investigations

- As described in the earlier section, the only emergency investigation required is a **blood gas sodium level.**
- Treatment of life-threatening hyponatraemia is guided by the blood gas result. A serum sodium should be taken and sent to the laboratory with each blood gas sample.
- **Base your treatment on the blood gas measurement to avoid delay.**
- The same blood gas analyser should be used for each sample. This is to avoid potential differences in measurement between analysers.

A urine sample is required for analysis prior to treatment with NaCl 3%. A urinary sodium level and urine osmolality are needed to aid diagnosis. The result is not required prior to emergency treatment.

Treatment Steps

Steps in the treatment of life-threatening hyponatraemia:

1. Manage patient in the resuscitation area of the ED.
2. Insert a urinary catheter and monitor urine output.
3. Measure serum sodium on the VBG. Send a serum sample to the laboratory for urea & electrolytes, serum osmolality and liver function tests.
4. Confirm the patient has hyponatraemia and is demonstrating life-threatening clinical features.

5. Exclude other aetiology of symptoms.
6. Commence an infusion of 150ml of NaCl 3% over 20 minutes.
7. Following completion of this infusion, **commence a second infusion of 150ml of NaCl 3%** over 20 minutes.
8. Obtain a second serum sodium and VBG sample.
9. If the blood gas sodium **has not risen** by 5mmol/L **AND** the patient's neurological signs have not improved, continue the second infusion of 150ml of NaCl 3% over 20 minutes.
10. If the blood gas sodium **has risen** by 5mmol/L **OR** the patients neurological signs have improved, stop the second infusion.
11. If there is no change in symptoms at this stage and sodium has not risen by 5mmol/L a third infusion can be considered, however discussion with critical care is advised.

Rate of Correction in Life-threatening Hyponatraemia

The following guidance is to be used after the initial correction of sodium by 5mmol/L or when the patient's neurological signs have improved with NaCl 3%.

- An increase in sodium to a maximum of 10mmol/L over 24 hours is advised. The rate of increase in sodium should be no greater than 0.5mmol/L/hr.
- In alcoholic, anorectic, or nutritionally-depleted patients, the rate of correction is a maximum of 8mmol/L in 24 hours. This patient group also require treatment with Pabrinex® (high-dose Vitamin B and Vitamin C).
- If over-correction of sodium has occurred, oral/nasogastric free water, intravenous dextrose 5%, or desmopressin may be required. This decision should be made in conjunction with a consultant.

Monitoring of Correction in Life-threatening Hyponatraemia

Following treatment with NaCl 3%, assess the patient's sodium level. As mentioned above, sodium level should be from the same blood gas machine as used during the initial resuscitation. A serum sample should also be taken at each time interval for laboratory testing. Time intervals for repeat blood gas and serum samples are:

- 30 minutes.
- Every 60 minutes while sodium levels are changing rapidly.
- Every two hours if sodium levels have not changed rapidly in the previous assessments and there has been no clinical deterioration.
- Every eight hours if sodium levels have stabilised. The duration of monitoring is at the discretion of the treating clinician.

Urine output must be monitored every hour. If urine output exceeds **100ml/hr for two hours**, the patient is at high risk of over-correction and critical care input is required.

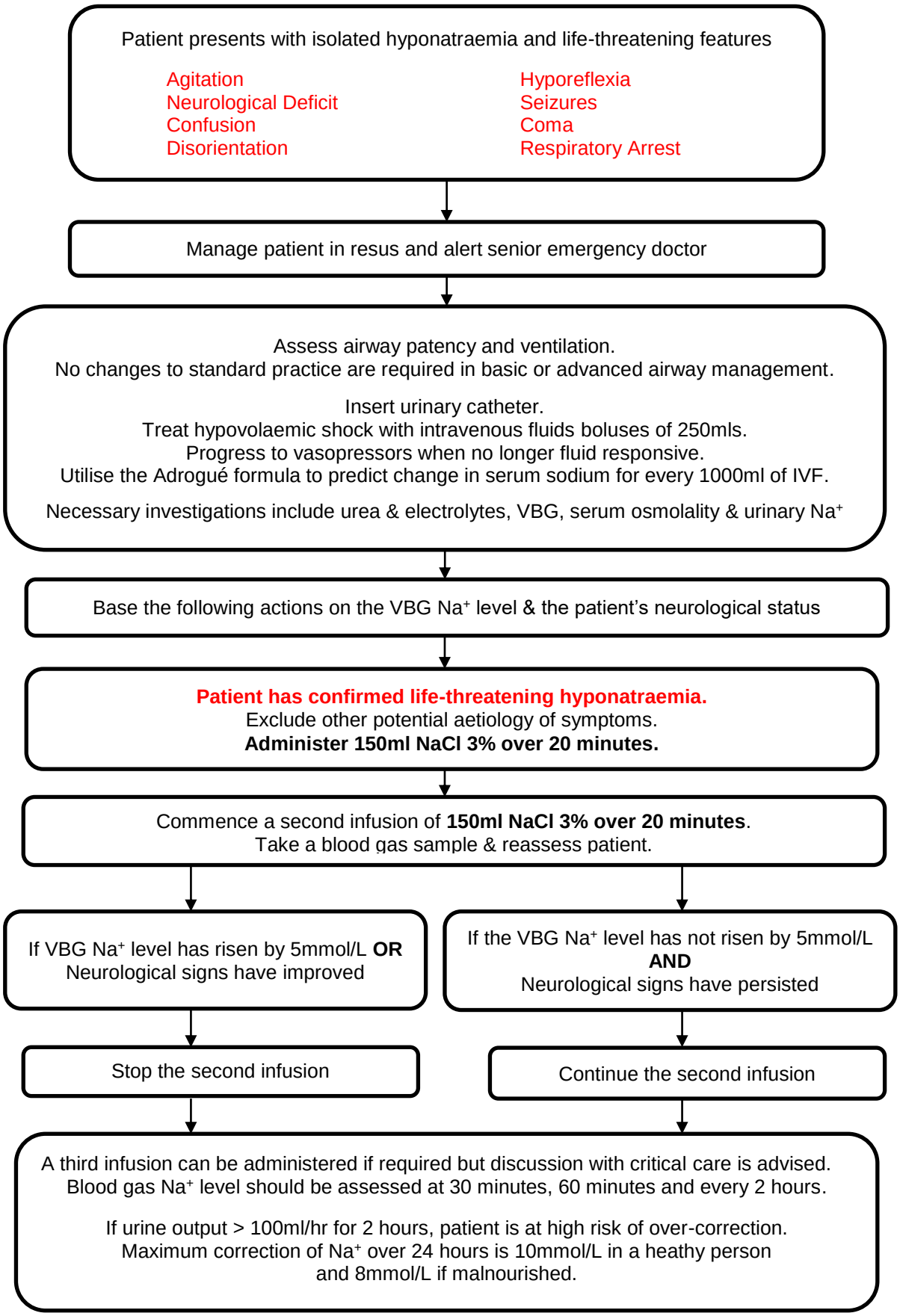
Disposition of Patients with Life-threatening Hyponatraemia

The appropriate disposition for a patient presenting with life-threatening hyponatraemia is a HDU or ICU.

Summary

Life-threatening hyponatraemia is a medical emergency. The symptoms can represent a broad differential diagnosis. The severity depends predominantly on the rate of change in sodium rather than the specific sodium level. A venous blood gas will guide your diagnosis and treatment. Avoid over-correction of sodium through close monitoring, particularly during the early stages of treatment. Treatment of life-threatening hyponatraemia is urgent and will likely occur prior to arriving at a definitive diagnosis.

Figure 2: Emergency management of life-threatening Hyponatraemia



SPECIAL CONSIDERATIONS

- Patients who are elderly, malnourished, suffer from liver disease or alcohol abuse have an increased risk of osmotic demyelination secondary due to over-correction of hyponatraemia. A target sodium rise of 8mmol/L should not be exceeded in 24 hours for these patients. A lower rate of sodium correction may be required on a case-by-case basis.
- **A high index of suspicion** of other pathology is required for elderly patients presenting with mild to moderate symptoms of hyponatraemia. Hyponatraemia may be as a result of another primary diagnosis.
- **Urinary sodium** is an essential investigation and should be taken prior to administration of treatment if possible. A urine osmolality should also be requested as this may help the patients diagnostic process in hospital.

CONCLUSION

Hyponatraemia is a common presentation in patients who require emergency care. Establishing the aetiology underlying the electrolyte imbalance is critical in the early stages of the diagnostic process. This guideline has detailed the assessment and management of patients with hyponatraemia for emergency physicians. The emergency physician must adopt a different approach for life-threatening and non-life-threatening hyponatraemia.

In non-life-threatening hyponatraemia the aetiology needs to be established prior to treatment. In life-threatening hyponatraemia, emergency treatment must occur immediately. The aetiology in this instance is often identified after emergency management.

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