

Medical Management of Metabolic Disturbances - Electrolytes

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Objective of the Guidelines:

These guidelines are intended for use by medical staff outside critical care areas in the hospital and are intended to help in the management of biochemical abnormalities in patients admitted to hospital.

For guidance on the electrolyte replacement therapy for the prevention of re-feeding syndrome please see AHP Guide <https://viewer.microguide.global/guide/1000000308#content,d6576e2a-0616-465e-987d-876edec13152>

Abnormal results should always be interpreted in the clinical context. If there is a concern about their validity this should be discussed with the laboratory and consideration should always be given to repeating the measurement. Treatment of the abnormal result should also be dictated by the rate of change since rapid correction of a chronic state can itself be harmful e.g. chronic hyponatraemia and risk of brain stem demyelination.

For the treatment of hyponatraemia in chronic liver disease see Medical [Hyponatraemia in chronic liver disease \(microguide.global\)](#)

Hyponatraemia (Serum Sodium (Na) < 120 mmol/L)

Low serum Na should be interpreted with the clinical condition and the patient's volume status

Clinically, hyponatraemia can present as:

- Hypovolaemic hyponatraemia: signs and symptoms of dehydration such as hypotension, tachycardia, dry mucosa, poor skin turgor, poor urine output
- Hypervolaemic hyponatraemia: pedal oedema, ascites, raised JVP, history and signs of congestive cardiac failure, renal failure, liver failure [Hyponatraemia in chronic liver disease \(microguide.global\)](#), nephrotic syndrome.
- Euvolaemic hyponatraemia: none of the above.

The following steps should be followed to help in the management of severe hyponatraemia:

1. Rule out contamination from drip line (iv. dextrose).
2. Rule out diabetes mellitus since hyperglycaemia can be associated with hyponatremia. If so, follow standard diabetes management guidelines.
3. Check serum osmolality to exclude pseudo hyponatraemia e.g. hyperlipidaemia, hyperparaproteinaemia.
4. Check for drugs causing hyponatraemia such as diuretics, phenothiazines, tricyclic antidepressants, SSRI and carbamazepine. Potential changes to neuroleptics, antidepressants and anticonvulsants needs to be discussed with the appropriate speciality.
5. Check renal function tests:
 1. **Hypovolaemia:** Both serum urea and creatinine are raised or urea is raised with normal serum creatinine.
 2. **Euvolaemia:** Serum urea is low or borderline low with normal creatinine.

6. Check Serum K:
 1. **Low serum K:** Diuretic induced or GI loss
 2. **High serum K:** Haemolysis, EDTA contamination, K sparing diuretics, renal failure, Addison's disease (check serum cortisol at 9:00AM or perform short synacthen test).
7. Random urine for Na and osmolality:
 1. **Urine Na < 20mmol/L:** Hypovolaemic hyponatraemia.
 2. **Urine Na > 20mmol/L:** Euvolaemic hyponatraemia, diuretic induced or on saline drip.
 3. **Urine osmolality >500mosmol/L:** Hypovolaemic or euvolaemic hyponatraemia, compare urine osmolality with plasma osmolality to check the concentration ability of the kidney.
 4. Remember the syndrome of inappropriate antidiuresis (SIADH) is a diagnosis of exclusion and all other causes of a low serum Na must be thought of and excluded before this diagnosis is assumed. The following criteria must also be fulfilled:-
 - Hyponatraemia with corresponding hypo-osmolality of plasma and extracellular fluid.
 - Continued renal excretion of Na (> 50mmol/day).
 - Absence of clinical evidence of fluid volume depletion or overload.
 - Osmolality of the urine greater than appropriate for the concomitant plasma tonicity.
 - Normal renal function.
 - Normal adrenal function.
 - Normal thyroid function.

Correction of Severe Hyponatraemia

Treatment depends on the patient's estimated volume status, the absolute serum sodium concentration and the chronicity and rate of fall of the serum sodium concentration. Remember that rapid correction of severe chronic hyponatraemia can cause brain stem demyelination and alcoholics or the chronically malnourished are at high risk of this outcome. The rate of correction should be no faster than 0.5mmol/l/h or 12 mmol/L/24 hrs.

1. **Hypovolaemic hyponatraemia:** rehydrate with sodium chloride 0.9% infusion.

2. **Euvoalaemic hyponatraemia:** Commence fluid restriction <1L/day, maintain accurate fluid balance chart, measure weight of the patient daily. If possible treat the cause (e.g. chest infection or malignancy). If serum Na not corrected despite good fluid restriction, consider demeclocycline. Please consult your Consultant or duty medic (clinical chemistry/Lab Medicine) before starting demeclocycline.
3. **Hypervolaemic hyponatraemia:** fluid and salt restriction, commence diuretics, specific treatment of cardiac output in congestive cardiac failure, treat the underlying liver disease in cirrhosis and the renal disease responsible for the nephrotic syndrome. This should be the first approach to the treatment of this oedematous hyponatraemic state.

Infusion of hypertonic saline may be required for life-threatening severe symptomatic hyponatraemia (seizures or glasgow coma score <11) - seek Consultant advice.

The following formula can be used to calculate sodium replacement using hypertonic sodium chloride.

In order to achieve a 0.5 mmol/h increase in serum sodium use this formula to give the amount of iv saline needed per hour (mmol/h):

$0.6 \text{ (total body water)} \times \text{wt(kg)} \times 0.5 \text{ (desired correction rate mmol/h)} = y \text{ mmol/h saline required.}$

If we are using 1.8% saline the rate of infusion required to achieve a 0.5 mmol/h improvement in serum sodium is given by

$(1000/300) \times y = \text{ml/hr of 1.8\% saline required.}$

e.g. for a 80kg patient

$0.6 \times 80 \times 0.5 = 24 \text{ mmol/hr saline required}$

$(1000/300) \times 24 = 80\text{ml/hr of 1.8\% saline needs to be infused.}$

I would suggest the serum sodium is checked every 4 hours and the infusion continued until/unless

- serum sodium > 120 mmol/l
- serum sodium rises faster than 0.5 mmol/h
- serum sodium rises by more than 6 mmol/l in 12 hours or 12 mmol/l in 24 hours

Hypertonic saline infusion is rarely needed and should be used only for acute symptomatic hyponatraemia after obtaining senior advice from the Endocrinology team. It should be infused through a pump. The rate of serum sodium correction should be no more than 0.5 mmol/l/hr (12 mmol/l/24hr) as faster rates may lead to potentially fatal osmotic demyelination syndrome ("central pontine myelinolysis").

The highest concentration that can be given peripherally is 1.8% sodium chloride. Please note that the 1.8% sodium chloride is labelled 'May cause vein damage. For central venous administration only'. If a central line is not available it is considered safe to infuse 1.8% sodium chloride via a large peripheral vein.

Hypernatraemia (Serum Sodium (Na) >160 mmol/L)

This is invariably due to severe volume depletion complicated by an inability to rehydrate e.g. reduced consciousness, immobility, primary thirst disorder.

The following steps should be followed to help with the management of hypernatraemia:

1. Rule out sample contamination with drip such as iv sodium chloride.
2. Exclude DKA and HONK and treat these according to standard management guidelines.
3. Check renal function: an acute rise in urea and creatinine suggests dehydration.
4. Consider the possibility of diabetes insipidus although in the presence of preserved thirst sensation severe hypernatraemia is uncommon. Depressed consciousness after head injury is one situation where diabetes insipidus with hypernatraemia can occur. Lithium can cause diabetes insipidus but changes to lithium therapy would need to be discussed with a psychiatrist.

Management of severe hypernatraemia

The patient should be rehydrated at first with sodium chloride 0.9% (causes less fluid shift) 1L over 6-8 hours. As the sodium comes down alternate 0.9% saline with 5% dextrose every 6-8 hours to rehydrate the intracellular compartment. Continue with alternate rehydration till the serum Na is corrected.

Monitor serum sodium every 12 to 24 hour.

It is preferable to reduce the serum sodium level slowly at the rate of 10-12 mmols in 24 hour. An accurate fluid input/output chart should be kept.

Hypokalaemia (Serum Potassium (K) < 2.6 mmol/L)

The following steps should be followed to manage hypokalaemia:

1. Consider GI loss from diarrhoea and vomiting.
2. Stop diuretics.
3. Alcoholics and patients on parenteral nutrition may also present with hypokalemia.
4. Ask the lab to add Mg to same sample as hypokalemia can exist with low plasma Mg.

Management of severe hypokalaemia

1. Requires continuous cardiac monitoring.
2. Serum K < 2.6mmol/L: give IV KCL 40mmol in 500ml of 0.9% saline over 6 hrs, provided the renal function is normal. Continue the same replacement every 6 hours until serum K reaches >2.6mmol/L. Consider oral replacement after this for full correction of serum K.
3. If renal function is abnormal (eGFR <60ml/min), give IV 20 mmol potassium in 500ml of 0.9% saline over 6 hours. Continue the same replacement every 6 hours till serum K reaches >2.6.

4. Monitor serum potassium after each infusion.
5. Continue giving up to 160 mmol KCL over 24 hours.
6. If Mg \leq 0.5 mmol/L give IV Mg Sulphate to correct Mg (explained under section of hypomagnesaemia).
7. If both K and Mg are low than replace them through same bag (explained with hypomagnesaemia in next section).

Monitor K at least daily. In patients who are symptomatic or have extremely low K, then high dose of K may be given in ITU under ECG monitoring. Currently 40mmol of K in 100ml NS (over at least 2 hours) with central access is given to patients who are on CCU or Tisbury/whiteparish wards.

Following table describes treatment for hypokalemia with intravenous K infusions where use of oral K supplements is inappropriate.

Serum potassium Level (mmol/L)	Degree of Hypokalaemia	Treatment
3.5-5.0 (normal)	Prophylaxis against hypokalaemia	20mmol KCL in 1000ml of 0.9% sodium chloride peripherally (or centrally) over at least 8 hours as part of a normal fluids regimen.
2.6-3.4	Mild/moderate hypokalaemia	40mmol KCL in 1000ml of 0.9% sodium chloride peripherally (or centrally) over at least 8 hours.
<2.6*	Severe hypokalaemia	40mmol KCL in 500ml 0.9% sodium chloride peripherally (or centrally)over 6 hours, or 40mmol KCL in 100ml 0.9% sodium chloride infusion administered in high care area over at least 2 hours via a central line with continuous ECG monitoring of rate and rhythm if arrhythmia present.

1.

- *Serum K <2.6 should be treated by intravenous K infusion.
- **K in 5% dextrose should be used in those patients who are sodium and fluid overloaded such as patients with ascites.**
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Severe Hyperkalemia (Serum Potassium (K) > 6.5 mmol/L)

The following steps should be followed for the management of hyperkalaemia:

1. Serum K>6.5mmol/L needs urgent treatment but first ensure it is not an artefact (ask lab)
2. Arrange ECG urgently in such patients
3. Follow the pathway for the Emergency Management of Hyperkalaemia in Adults ([link to pathway](#)) and the guidance for the administration of insulin and glucose [Insulin and Glucose infusion for the management of acute hyperkalaemia in adults \(microguide.global\)](#)
4. Print pathway off microguide and record blood results on printed sheet.
5. Prescribe medicines for the management of hyperkalaemia on the main drug chart.
6. Monitor serum glucose every 30 minutes and serum potassium every hour after starting glucose/insulin infusion.
7. Stop further potassium accumulation

Stop all potentially offending medicines immediately. These include ACE inhibitors, angiotensin receptor blockers, potassium retaining diuretics e.g. spironolactone, eplerenone, amiloride, triamterene, and trimethoprim, Septrin (co-trimoxazole), NSAIDs, potassium containing laxatives (Movicol®, Klean-Prep®, Fybogel®) and potassium supplements such as Sando-K® and Kay-Cee-L Liquid®. Beta-blockers and digoxin should also be stopped as they prevent intracellular buffering of potassium and reduce the effectiveness of insulin-glucose and beta-2 agonists.

Place the patient on a low potassium diet. It is imperative that whilst waiting for this diet that the patient does not consume fruit juice, fruits, chocolate, fruit gums, biscuits, coffee or potatoes.

Hypocalcaemia (Serum Corrected Calcium (Ca) < 2.00 mmol/L)

The following steps should be taken to manage severe hypocalcaemia:

1. Exclude EDTA contamination (ask the lab) if hypocalcaemia is unexpected.
2. Ask the lab to add Mg to the same sample as hypomagnesaemia can coexist with hypocalcaemia.
3. Consider causes of hypocalcaemia such as: renal failure, vitamin D deficiency,
4. hypoparathyroidism. You should contact the Endocrine team or the lab if you are unable to find the cause of hypocalcaemia or need advice on further tests to help in finding the cause.

Management of severe hypocalcaemia

Acute symptomatic hypocalcaemia presenting with signs and symptoms of tetany such as tingling or numbness around mouth or in fingers or muscle spasm or serum corrected calcium <1.5 mmol/l:

1. Give 10 ml 10% calcium gluconate (2.25 mmol) by slow IV injection over 10-15 min.
2. Follow with 40ml 10% calcium gluconate (9 mmol) in 500 ml sodium chloride 0.9% IV over 12 hours.
3. Contact duty medic (clinical chemistry or your Consultant) if you think the patient needs further calcium gluconate.
4. Monitor serum corrected Ca every 4 hours for first day, then daily.
5. Refer to the Endocrine team for advice on further calcium and vitamin D therapy.

Asymptomatic hypocalcaemia

1. If serum Mg \leq 0.5mmol/L, start IV Mg (described in Mg section).
2. Continue with Mg infusion till the serum corrected calcium within normal range as hypomagnesaemia causes hypocalcaemia.
3. Start the patient on calcium and vitamin D supplements preferably Calcichew D3 Forte 1 BD and monitor the dose as calcium gets corrected.
4. If both K ($<$ 2.6mmol/L) and Mg (\leq 0.5mmol/L) are low, than they can be replaced as 40mmol of K and 5 mmol of Mg in 500mls of NS over 6 hours. Give the same over next 6 hours. Check serum K and Mg and repeat the same if they are still low.

Do not treat hypocalcaemia of pancreatitis, septicaemia or rhabdomyolysis unless symptomatic. If symptomatic, give IV calcium gluconate cautiously.

Hypercalcaemia (Serum Corrected Calcium (Ca) $>$ 3.00 mmol/L)

The following steps should be taken to manage severe hypercalcaemia:

1. Exclude drugs causing hypercalcaemia such as calcium and vitamin D, thiazides. Stop these medications if patient is on them.
2. Find out if there is history of malignancy.
3. Send sample for PTH before starting therapy to correct hypercalcaemia. Duty medic (laboratory) can help in the interpretation of PTH result.

Management of severe hypercalcaemia

1. The immediate treatment of any patient with hypercalcaemia must be rehydration. Provided the patient has adequate renal and cardiac function advise at least 3L of 0.9% saline IV over 24hrs with a good fluid input/output chart.
2. Once the patient has been adequately rehydrated (at least 24hours) check the serum corrected calcium.
3. If hypercalcaemia is due to non-parathyroid disease than it requires rapid correction as follows:
 - a. $>$ 3mmol/L advise 90mg Pamidronate in 500 mls of normal saline over 4 hours IV.
 - b. $<$ 3mmol/L advise 60mg Pamidronate in 500 mls of normal saline over 4 hours IV.
4. If patient is in renal failure, give half dose of pamidronate as suggested above over 4 hours.
5. Continue with rehydration after the pamidronate infusion. Check corrected calcium daily.

6. If no response in 5 days after adequate hydration and Pamidronate, give Zoledronic Acid (Zometa) 4 mg in 100 ml normal saline over 1 hour intravenously (this drug is licensed for malignancy induced hypercalcaemia).
7. Refer to the Endocrine team for advice on on-going management and the potential use of other agents depending on the underlying cause.

Hypophosphataemia (Serum Phosphate \leq 0.3mmol/L)

The following steps should be taken to manage severe hypophosphataemia

1. Repeat serum phosphate after 24 hours.
2. If serum phosphate is \leq 0.3mmol/L on two consecutive occasions then consider replacement.
3. Check serum corrected calcium, K, Mg as you can have co-existent low K, Mg and phosphate.
4. Check renal function.
5. Find the cause of hypophosphataemia: GI loss, alcohol abuse.

Management of severe hypophosphataemia

1. Replace phosphate if serum phosphate level is less than 0.30mmol/L on two consecutive occasions or in alcoholics on one occasion.
2. Give 20 mmol of phosphate over 24 hours, if corrected calcium and K are within the normal range with normal renal function. Use a phosphate polyfusor (50mmol phosphate in 500ml) which also contains 9.5mmol of potassium in 500ml. Do not infuse the entire contents of the Polyfusor. Infuse the required volume from the polyfusor via an infusion pump. Set the pump to administer the required volume of infusion over 24 hours. For a dose of 20mmol phosphate the volume of infusion is 200ml (8.4ml/hour over 24 hours). Discard the remainder of the polyfusor after 24 hours. Do not infuse phosphate via the same line as any other drugs or infusion fluids apart from sodium chloride 0.45% or 0.9% and Glucose 5% or 10%.
3. This can be repeated every 24 hours with monitoring of phosphate, calcium and K till the serum phosphate reaches above 0.4mmol/L.
 - **If the patient is in renal failure or suffering from pancreatitis do not give phosphate unless the plasma phosphate is persistently low, and even then treat cautiously i.e. advise 10 mmol of phosphate over 24 hours 100ml of phosphate 50mmol in 500ml polyfusor at a rate of 4.2ml/hour).**
 - **If patient has DKA with severe hypophosphataemia then discuss with endocrine team.**

Hypomagnesaemia (Serum Mg \leq 0.4 mmol/L) (Decision to give replacement if serum magnesium level $>$ 0.4mmol/l should be based on whether the patient is showing any signs of hypomagnesaemia)

The following steps should be taken to manage severe hypomagnesaemia:

1. Check serum corrected Ca and K.
2. Check renal function.

Management of severe hypomagnesaemia

1. Correct low serum Mg by replacing 20 mmol of Mg sulphate intravenously in 1L of sodium chloride 0.9% over at least 5 hours in patients with normal renal function (eGFR \geq 60ml/min). Continue with the same replacement until the magnesium level is within the normal range. The total amount of 100 mmol of Mg over 5 days may be required.
2. In patients with renal impairment (eGFR <60ml/min) reduce the dose to 10 mmol of Mg sulphate over at least 5 hours.
3. If serum corrected calcium is low along with hypomagnesaemia, continue to replace Mg until the serum corrected calcium is within normal range.
4. If serum K is low along with low Mg, then replace K intravenously along with Mg in the same bag (40 mmol of K and 5 mmol of Mg in 1000 ml sodium chloride 0.9% 6hrly and this should be continued over a period of 24hrs. This will replace 20 mmol of Mg and 160 mmol of K in 24hrs).
5. For outpatients severe hypomagnesaemia should be treated with 20mmol of Mg in 1 L sodium chloride 0.9% over at least 5 hours intravenously
6. Cardiac monitoring during magnesium infusions is only required if the rate of infusion exceeds 4mmol of magnesium per hour.

Authors: Dr Martin Smith, Consultant Physician & Endocrinologist.

Mr Peter Davies, Senior Pharmacist.

Contact numbers: Dr Martin Smith, Dr James Lawrence (through switch board).

Last modified 11/6/19

Severe Hyperkalemia (Serum Potassium (K) > 6.5 mmol/L) section was updated 24/11/2022, by Peter Davies (following SII428)

Link to Insulin & Glucose infusion guideline was added to Seve Hyperkalemia section on 9/12/2022