Blood and electrolyte disorders, and vitamin deficiencies

Contents:

For full information on treatment side effects, cautions and contraindications, see electronic British National Formulary (www.bnf.org) or the relevant summary of product characteristics (www.medicines.org.uk).

For information on preparing intravenous medicines for administration, see Medusa Injectable Medicines Guide for the NHS (see Clinical Guidance home page)

1. Anaemia

A. Non-renal patients

When treating anaemia, a patient's haemoglobin concentration should increase by 10g/L each week. Therapy should be continued for 3 months after the haemoglobin levels have normalised to replenish the body's iron stores.

Options for treatment include:

i) Oral iron
ii) Parenteral iron

i) Oral iron

First choice in secondary care
Ferrous sulphate 200mg (60mg elemental iron), orally, three times daily
First choice in primary care
Ferrous fumarate 305mg (100mg elemental iron), orally, twice a day

Alternative, if a liquid formulation is required
Sodium feredetate elixir (Sytron®) 190mg/5mL (27.5mg/5mL elemental iron) 5mL, orally, three times a day; increase if needed to 10mL three times daily

ii) Parenteral iron

Parenteral iron supplementation may be required for patients with:

- Proven iron deficiency in whom oral therapy has failed
- Functional iron deficiency
- Serum ferritin less than 200micrograms/L after taking oral iron for 3 months

Functional iron deficiency is defined as a serum ferritin less than 100micrograms/L and either a percentage of hypochromic red blood cells greater than 6% or transferrin saturation less than 20%.

Iron dextran (Cosmofer®) for details of dose and administration contact Pharmacy

Parenteral iron therapy is not without risk.
NOTE: A test dose is essential prior to administering iron intravenously. Patients should be observed for the entire period of the infusion and for one hour afterwards due to the risk of anaphylactic reactions.

NOTE: Ferritin is an acute phase reactant protein and may be elevated in the presence of infection and inflammation. Serum iron, total iron binding capacity, the percentage of hypochromic red cells and transferrin saturation can be useful for determining whether patients are experiencing true iron-deficiency anaemia.

B. Patients with chronic kidney disease under the care of a nephrologist

Aim of therapy is to maintain haemoglobin (Hb) between 100–120g/L and serum ferritin between 200–500micrograms/L.

For comprehensive information, see **Anaemia: Treatment for Adult haemodialysis patients (secondary care guidance)**
And
Iron deficiency anaemia: Management in chronic kidney disease with intravenous iron (Ferinject®) – secondary care guidance.

Treatment options include:

i) Oral iron
ii) Parenteral iron
iii) Erythropoietins

i) Oral iron

First choice in secondary care
Ferrous sulphate 200mg (60mg elemental iron), orally, three times daily

First choice in primary care
Ferrous fumarate 305mg (100mg elemental iron), orally, twice a day

ii) Parenteral iron

Ferric carboxymaltose (Ferinject®) for details of dose and administration, see **Iron deficiency anaemia: Management in chronic kidney disease with intravenous iron (Ferinject®) – secondary care guidance.**

NOTE: Ferric carboxymaltose is for use by the renal directorate ONLY — ie, for patients attending pre-dialysis anaemia clinic and haemodialysis/peritoneal dialysis patients

All other patients should be treated as indicated in **Non-renal patients**.

iii) Erythropoietins

NOTE: Initiation by specialist only — refer to nephrology

Erythropoietins are used to maintain red blood cell production in patients with chronic kidney disease. The aim of treatment is to increase haemoglobin concentration by 10–20g/L per month to a target of 100–120g/L. Deficiency of iron, folate and vitamin B12 should be evaluated for all patients prior to and during treatment.
NOTE: Serum ferritin should be greater than 200micrograms/L before commencing erythropoietin.
NOTE: Ferritin is an acute phase reactant protein and may be elevated in the presence of infection and inflammation. Serum iron, total iron binding capacity, the

percentage of hypochromic red cells and transferrin saturation can be useful for determining whether patients are experiencing true iron-deficiency anaemia.
If Hb rises above 130g/L, suspend treatment.

For pre-haemodialysis and peritoneal dialysis patients
NOTE: Initiation by specialist only — refer to nephrology

Darbepoetin alfa (Aranesp®) Give 450 nanograms/kg, by SC injection, once weekly (or 750 nanograms/kg once every 2 weeks); adjust dose according to response in increments of approx. 25% of initial dose over intervals of at least 4 weeks.
Maintenance dose (amount required to maintain haemoglobin concentration of 110 to 130g/L) can be given once weekly, every 2 weeks or monthly.

For haemodialysis patients
Epoetin alfa (Eprex®) Give 50 units/kg, by IV injection over 1 to 5 minutes (during or at the end of dialysis), 3 times a week. Adjust dose to achieve and maintain target haemoglobin concentration: 110 to 130g/L. Any change in dose should be no more than 25units/kg every 4 weeks. Contact the renal team for further advice.

2. Megaloblastic anaemia

Megaloblastic anaemia is usually caused by malabsorption of vitamin B12 or by a lack of dietary folate; it is essential to establish the cause in every case. In an emergency, folic acid **and** vitamin B12 should be given initially, after taking blood samples for serum folate levels.

Folic acid is only indicated for the ***correction*** of folate deficiency. It should never be given for undiagnosed megaloblastic anaemia, unless vitamin B12 is administered concurrently, since neuropathy could be precipitated.

For vitamin B12 replacement
Hydroxocobalamin 1mg, by IM injection, repeated 5 times every 2 to 3 days for initial treatment. Maintenance: 1mg IM every 3 months

For folate replacement
Folic acid 5mg, orally, daily for 4 months; up to 10mg daily (given as 1 or 2 divided doses) may be required

NOTE: In severe megalobastic anaemia, replacement can induce hypokalaemia and patients should have U&Es monitored.

3. Secondary hyperparathyroidism

For information on treating secondary hyperparathyroidism in patients with chronic kidney disease, refer to:

- **Bone Chemistry Management for pre-dialysis adult patients (CKD stage 3–5) – secondary care guidance**

- **Bone Chemistry Management in adult renal patients on dialysis – secondary care guidance**

Pre-dialysis patients should be treated with alfacalcidol. Several options are available for patients on dialysis.
Options include:

- **Alfacalcidol** 250nanograms, orally, daily. Increase dose as tolerated. Treatment can be given as daily or pulsed weekly dosing.
- **Calcitriol** 250nanograms, orally, daily or three times per week. Increase dose as tolerated. Maximum: 12micrograms per week.
- **Paricalcitol** 2micrograms, orally, three times per week. Increase dose as tolerated.
- **Cinacalcet** 30 mg, orally, once daily with or after the largest meal of the day; adjust dose every 2 to 4 weeks to a maximum of 180mg daily.

NOTE: Cinacalcet and paricalcitol should be prescribed by Consultant Nephrologists ONLY.

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4. Hypokalaemia

The average adult requires 1mmol/kg/day of potassium; this is usually obtained from the diet. If potassium salts are used for the prevention of hypokalaemia, then doses of 25 to 50mmol daily are suitable in patients taking a normal diet.

Larger doses may be required in established potassium depletion.
Treatment options include:

i) Oral potassium supplements
ii) Intravenous potassium

i) Oral potassium supplements

Potassium chloride effervescent tablet (Sando K® - 12mmol K^+ and 8mmol Cl^-)
Prophylaxis: 24mmol, orally, twice daily; dissolve in a whole glass of water and take after meals

ii) Intravenous potassium

Before starting intravenous therapy, the following require careful consideration:

- Is intravenous replacement essential? – where possible use the oral route
- How urgent is the need for potassium replacement – have cardiac arrhythmias developed? Does the patient need surgery urgently? Is the serum potassium very low (<2.5mmol/L)?
- Does the patient have comorbidities (eg, fluid restriction, impaired renal function, concurrent digoxin or antiarrhythmic therapy)?

All hypokalaemic patients treated with intravenous potassium **MUST have their serum potassium measured at least once a day**. Serum magnesium levels should be checked and corrected in severe hypokalaemia. For further information on prescribing, storing or administering IV potassium, see the **Intravenous potassium policy (secondary care guidance).**

Suggested infusion rates of potassium-containing preparations:

Serum potassium level (mmol/L)	**Patients with NORMAL Renal Function and NO fluid restriction**
Normal = 3.5 to 5 Prophylaxis of hypokalaemia	Oral replacement therapy. If nil by mouth: 20mmol in 1,000mL sodium chloride 0.9% or glucose 5%; administer peripherally (or centrally) over ***at least*** 8 hours
Potassium 2.5 to 3.4 Replacement required	Sando K 24mmol TDS until potassium is >4.0mmol/L ***Or*** 40mmol in 1,000mL sodium chloride 0.9% or glucose 5%; administer peripherally (or centrally) over ***at least*** 4 hours. **ON GENERAL WARDS, THE INFUSION RATE IS NOT TO EXCEED 10mmol/hour**
Potassium <2.5 Urgent replacement required	40mmol in 500mL sodium chloride 0.9%; administer peripherally (or centrally) over ***at least*** 4 hours. ***Or*** 40mmol in 100mL sodium chloride 0.9% ***Administer in Critical Care Units ONLY over at least 2 hours (usually via a central line) with continuous ECG monitoring of rate & rhythm.*** **IN CRITICAL CARE, THE INFUSION RATE IS NOT TO EXCEED 20mmol/hour**

NOTE: Where possible use sodium chloride ready made bag.
Use of glucose or dextrose will encourage the release of insulin, which in turn will push the potassium in the serum plasma back into the cells — thus giving a false, low reading.

Use pre-prepared IV potassium infusions. The following preparations are available.

Licensed preparations:

- 10mmol potassium chloride (0.15%) in 500mL sodium chloride 0.9%
- 10mmol potassium chloride (0.15%) in 500mL glucose 5%+sodium chloride 0.45%

- 20mmol potassium chloride (0.15%) in 1,000mL sodium chloride 0.9%
- 20mmol potassium chloride (0.15%) in 1,000mL glucose 5%
- 20mmol potassium chloride (0.15%) in 1,000mL glucose 4%+sodium chloride 0.18%
- 20mmol potassium chloride (0.3%) in 500mL glucose 4%+sodium chloride 0.18%
- 20mmol potassium chloride (0.3%) in 500mL glucose 5%

- 40mmol potassium chloride (0.3%) in 1,000mL sodium chloride 0.9%

Unlicensed "special" preparations — kept and used in restricted areas:

- 10mmol potassium chloride (0.15%) in 500mL glucose 10%
- 20mmol potassium chloride (0.3%) in 500mL glucose 10%

Unlicensed "special" preparations — kept and used in restricted areas and treated as Controlled Drugs:

- 40mmol potassium chloride (0.6%) in 500mL sodium chloride 0.9%
- 40mmol potassium chloride (3%) in 100mL sodium chloride 0.9%

NOTE: When managing diabetic ketoacidosis, the initial rate of infusion may exceed 40mmol over 4 hours. For more information, see the **Diabetic ketoacidosis [Adult] Care pathway (secondary care guidance).**

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5. Hyperkalaemia

Treatment varies depending on potassium level

i) Mild to moderate hyperkalaemia
ii) Severe hyperkalaemia
iii) Severe hyperkalaemia with ECG changes or potassium >7mmol/L

i) Mild to moderate hyperkalaemia (serum potassium = 6.1 to 6.4mmol/L, no ECG changes)

Calcium polystyrene sulphonate (Calcium Resonium®) and sodium polystyrene sulphonate (Resonium A®) exchange potassium in the blood for either calcium or sodium. Both can be used for non-urgent hyperkalaemia.

First choice
Calcium resonium 15g, orally, 3 to 4 times per day in water (not in fruit juice due to high potassium content). Discontinue treatment when serum potassium falls below 5mmol/L.

Second choice
Resonium A 15g, orally, 3 to 4 times per day in water (not in fruit juice due to high potassium content). Discontinue treatment when serum potassium falls below 5mmol/L.

ii) Severe hyperkalaemia (serum potassium 6.5-7mmol/L; no ECG changes)

Rapid but temporary serum potassium reduction can be achieved using an injection of glucose and insulin.
Soluble insulin (Actrapid®) 10 units, by slow IV injection (give over 30 minutes), in 50mL glucose 50% (mini-jet available); monitor for possibility of hypoglycaemia (ie, monitor BMs every 30 mins for one hour after administration) and recheck potassium after one hour.
A further dose of glucose and insulin can be given if required.
NOTE: All doses of insulin should be measured using an insulin syringe.

iii) Severe hyperkalaemia with ECG changes or serum potassium >7mmol/L

Add to existing treatment
Calcium gluconate 10% Give 10mL by slow IV injection (over 10 minutes) to reduce cardiotoxicity

Salbutamol nebules can also be given to reduce potassium levels. A 5mg nebule can be given, and potentially repeated after 30 minutes, while other treatments are considered. Caution is required as nebulised salbutamol may induce tachycardia.

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6. Hyponatraemia

Due to the many causes of hyponatraemia (eg, fluid overload, high GI losses, Addison's disease, syndrome of inappropriate secretion of antidiuretic hormone [SIADH]), clinical assessment is important.

Comprehensive advice can be found in the **Hyponatraemia prevention and management clinical guideline (secondary care guidance).**

For sodium replacement in chronic condition with mild or moderate degrees of sodium depletion

Sodium chloride slow release (Slow Sodium® approx. 10mmol Na^+ and Cl^- per tab)
Prophylaxis: 4 to 8 tablets, orally, per day in divided doses; take with a whole glass of water. Adjust dose according to serum sodium.

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7. Hypernatraemia

Sodium excess is usually caused by renal failure or drug therapy. Other causes of hypernatraemia include diarrhoea, vomiting, burns, sweating, diabetes insipidus, osmotic diuresis, primary hyperaldosteronism.

Treatment depends on the underlying cause and whether there is overall fluid depletion or sodium excess. Efforts should be made to identify and rectify the underlying cause.
NOTE: If a patient's sodium level is above 160mmol/L, the patient MUST be reviewed by a consultant

Calculation of total body water (TBW) deficit:

$$\text{Water deficit} = \text{Current TBW} \times \left(\frac{\text{serum [Na]}}{140} - 1 \right)$$

Current TBW:

- Young men: 60% actual body weight (kg)
- Young women: 50% actual body weight (kg)
- Elderly men: 50% actual body weight (kg)
- Elderly women: 45% actual body weight (kg)

This formula gives an estimate of the volume of additional fluid required to correct the serum sodium concentration to 140mmol/L.

Replace water enterally where possible. In severe cases, or if the patient is nil by mouth, IV glucose 5% may be used. Total water deficit may exceed 5L, this should be corrected over 2 to 3 days (monitor sodium regularly and make sure sodium levels are not corrected too quickly). In diabetes insipidus, treatment with desmopressin may be needed. This should be initiated by a consultant only.

Over rapid correction of hypernatraemia may rarely lead to central pontine myelinolysis. Serum sodium should be checked every 4 hours when correcting sodium levels. Central nervous system observations should also be carried out.
NOTE: The maximum recommended reduction in serum sodium concentration is 12mmol/L in 24 hours.

For further information, see the **Hypernatraemia management clinical guideline – secondary care guidance.**

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8. Hypocalcaemia

For patients deemed to be at risk of hypocalcaemic tetany
Calcium gluconate 10% Give 10mL, by slow IV injection (over at least 10 minutes), repeated as required or followed by a continuous infusion. For infusion, dilute 100mL calcium gluconate 10% in 1L sodium chloride 0.9% or glucose 5% then administer at an initial rate of 50mL/hour (adjust dose according to response).
(2.25mmol calcium is provided by 10mL calcium gluconate 10%)

Calcium supplements are usually only required where dietary calcium intake is deficient. A suggested dose of calcium in simple deficiency states is up to 40 mmol daily, adjusted according to the individual patient's requirements.

In resistant cases, check magnesium levels as hypomagnesaemia can cause secondary hypocalcaemia.

For mild cases
Sandocal 1000® effervescent tablets (25mmol Ca^{2+} per tablet) 1 to 2 tablets, orally, daily.

For patients deemed to be at risk of hypocalcaemic tetany
Calcium gluconate 10%
i) Give 10mL, by slow IV injection, over at least 10 minutes
ii) Repeat as required or follow by a continuous infusion.

For infusion, dilute 100mL **calcium gluconate 10%** in 1,000mL sodium chloride 0.9% or glucose 5% then administer at an initial rate of 50mL/hour (adjust dose according to response).
NOTE: 2.25mmol calcium is provided by 10mL calcium gluconate 10%

9. Hypomagnesaemia

Normal reference levels for magnesium are 0.7–1.0mmol/L.
Hypomagnesaemia occurs when patients' magnesium levels fall below 0.7mmol/L

Treatment is dependent on the level of deficiency:

i) Mild
ii) Severe

i) Mild (serum magnesium: 0.4 to 0.7mmol/L)

Mild hypomagnesaemia can be treated orally. Magnesium salts are not well absorbed from the GI tract and can act as an osmotic laxative when given orally.

First choice
Magnesium citrate (6.2mmol Mg^{2+} per 150mg tablet) 150mg, orally, once a day. Plasma magnesium levels should be monitored to determine further dose requirements.
NOTE: This product is unlicensed.

Second choice
Magnesium glycerophosphate (2mmol Mg^{2+} per 500mg capsule) 500mg, orally, once daily. Plasma magnesium levels should be monitored to determine further dose requirements.
NOTE: This product is unlicensed.

Alternative for PEG/NG administration
Magnesium-L-aspartate (Magnaspartate®; 10mmol Mg^{2+} per 6.5g sachet) Dissolve 1 sachet in 200mL water and give orally once daily. Plasma magnesium levels should be monitored to determine further dose requirements.
NOTE: This product is unlicensed.

ii) Severe (serum magnesium <0.4mmol/L or if patient is symptomatic)

Symptomatic hypomagnesaemia is associated with a deficit of 0.5 to 1mmol/kg; up to 160mmol magnesium, given IV over up to 5 days, may be required.
Hypomagnesaemia often causes secondary hypocalcaemia, hypokalaemia and hyponatraemia.

Magnesium sulphate injection 50% (2mmol/mL) 20mmol, by IV infusion in 250mL sodium chloride 0.9% over 2 to 4 hours, daily. Monitor plasma magnesium to determine further dose requirements. Continue daily infusions until the patient's magnesium level is corrected.

To prevent recurrence of deficit, 24mmol of oral magnesium can be given daily (in divided doses).
WARNING: Magnesium is mainly excreted by the kidneys; reduce dose in renal failure.

10. Hypophosphataemia

Normal reference levels for phosphate are 0.8 to 1.4mmol/L.
Treatment is dependent on level of deficiency:

i) Mild
ii) Moderate to severe

i) Mild (phosphate 0.5 to 0.8mmol/L)

For mild deficiency oral therapy is safer and should be used wherever possible. Adverse effects associated with oral phosphate replacement include diarrhoea.

First choice
Phosphate Sandoz® effervescent tablets (16.1mmol PO_4^- per 500mg tablet) 1 tablet, orally, twice a day. Up to 6 tablets daily (in divided doses) can be given. Dissolve tablets in a full glass of water (can be given via feeding tubes).

Second choice — if parenteral therapy is essential

Treatment of hypophosphataemia in adults **Phosphate dose**	**Dose of phosphate polyfusor (by IV infusion)** **DO NOT GIVE ENTIRE POLYFUSOR – DISCARD REMAINDER**
Day 1 – 40mmol (if phosphate less than 0.5mmol/L)	40mmol (400mL) over 6 hours i.e. Rate: 66mL per hour for 6 hours. INFUSION MUST BE STOPPED AFTER (400ML) 6 HOURS (400mL of Phosphate polyfusor contains Phosphate 40mmol, Potassium 7.6mmol, Sodium 64.8mmol)
Day 2 – 20mmol (if phosphate not above 1.5mmol/L)	20mmol (200mL) over 6 hours i.e. Rate: 33mL per hour for 6 hours. INFUSION MUST BE STOPPED AFTER (200ML) 6 HOURS (200mL of Phosphate polyfusor contains Phosphate 20mmol, Potassium 3.8mmol, Sodium 32.4mmol)

Critical care patients on ITU/HDU

For peripheral administration: Use phosphate polyfusor (as above)

For central administration: Dilute 40mL of sodium glycerophosphate 21.6% in 100mL Glucose 5% and give over 6hours. This contains phosphate 40mmol (equivalent to Addiphos 40mmol) and sodium 80mmol (no potassium). Sodium glycerophosphate 21.6% injection is available as stock on ITU.

11. Hyperphosphataemia

For comprehensive information on treating hyperphosphataemia, see:

- **Bone Chemistry Management for pre-dialysis adult patients (CKD stage 3–5) – secondary care guidance.**
- **Bone Chemistry Management in adult renal patients on dialysis – secondary care guidance.**

Phosphate binders are initiated in patients with serum phosphate >1.4mmol/L unresponsive to dietary restriction, or patients with serum phosphate >1.3mmol/L who are starting vitamin D therapy. Normal reference levels for phosphate are 0.8 to 1.4mmol/L.

When determining treatment for hyperphosphataemia, calcium levels must be corrected for low albumin and calculated as below:

Corrected calcium (mmol/L) = [(40 – serum albumin) x 0.02] + serum calcium.

The appropriate treatment will depend on the corrected calcium level:

i) *Corrected calcium greater than 2.13 mmol/L*
ii) *Corrected calcium less than 2.13mmol/L*

i) Corrected calcium greater than 2.13

If patient prefers to swallow tablets whole
Sevelamer 800mg, orally, three times daily with meals. Increase by 800mg three times a day until phosphate falls to 1.4mmol/L or less. Maximum: 2,400mg three times a day (9 tablets per day).

If patient prefers to chew tablets
Lanthanum carbonate 500mg, orally, three times a day with meals. Increase to 750mg three times a day, and then 1,000mg three times a day until phosphate falls below 1.4mmol/L. Maximum: 3g per day.

ii) Corrected calcium less than 2.13

First choice
Calcium carbonate (Calcichew® 1.25g) One tablet, orally, twice daily with meals. Each tablet contains 500mg of elemental calcium.

Second choice
Calcium acetate (PhosLo® 667mg) Five capsules, orally, daily in divided doses with meals. Each capsule contains 169mg of elemental calcium.

- If corrected calcium remains below 2.13mmol/L refer patient to a Nephrology Consultant.
- If serum phosphate remains above 1.4mmol/L and corrected calcium increases to 2.13mmol/L or more, switch to **sevelamer** or **lanthanum** carbonate — doses as above.

NOTE: Phosphate binders must not be taken within 2 hours of oral iron supplements.

Check compliance with low phosphate diet and phosphate binder therapy before increasing dose of therapy.

12. Hyperaluminaemia

Ingested aluminium is normally excreted by the kidney. When there is a markedly reduced or absent kidney function, there is little or no ability to excrete aluminium and hence accumulation can occur.

For more information, see **Bone Chemistry Management in adult renal patients on dialysis (Appendix 1) – secondary care guidance.**

13. Vitamin D deficiency

For comprehensive information on vitamin D deficiency and supplementation, see the clinical guideline **Vitamin D — for adults**.

14. Vitamin K deficiency

Treatment dependent on indication:

i) Reversal of vitamin K antagonists
ii) High INR (not due to anticoagulation)

i) Reversal of warfarin and other vitamin K antagonists

Information on how to treat haemorrhage / warfarin overdose can be found in the **Oral Anticoagulant Prescribing Guideline** or on the reverse of the WUTH Oral Anticoagulant Chart (available on all wards).

Advice on reversal of all anticoagulants can be found in **Bleeding — management of patients taking oral anticoagulants (secondary care guidance)**.

ii) High INR (NOT due to warfarin or other oral anticoagulation)

Vitamin K is fat soluble so patients with fat malabsorption (eg, those with hepatic disease) may become deficient. The water soluble preparation menadiol sodium phosphate should be used in these patients to prevent deficiency. Patients on long term treatment should be under the supervision of a gastroenterologist.

Phytomenadione injection (Konakion MM® 10mg/mL)
10 to 20mg, by slow IV injection (1mg/minute) or by IV infusion in 50mL glucose 5% over 20 to 30 minutes, daily for up to 3 days

NOTE: Phytomenadione may cause anaphylactic reactions if injected too rapidly. Do not give Konakion MM® by IM injection.