POTASSIUM MANAGEMENT

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

Caution: potassium is a high risk medication, and can be fatal if given inappropriately. Causes of error are multifactorial and relate to errors in prescribing, preparation and/or administration.

- Potassium supplements are to be given orally/enterally whenever possible
- Only one form of potassium replacement should be prescribed at a time.
- If intravenous potassium is required premixed solutions should be used.
- If premixed potassium solutions do not meet clinical needs, the prescribing medical officer should discuss the order with the medical consultant prior to prescribing potassium to be added to intravenous solutions.
- ***High dose*** potassium **containing fluids** are defined as doses:
    - IV fluids containing potassium greater than 40 mmol/L **OR**
    - Rate of potassium greater than 0.25 mmol/kg/hour **OR**
    - Rate of potassium greater than 10mmol/hr for patients weighing more than 40kg
- ***Concentrated*** potassium infusions refer to strengths of 0.5 mmol/mL or greater.
- Any infusion being given at a rate greater than 0.25 mmol/kg/hour or 10 mmol/hour must be cardiac monitored
- *Concentrated* potassium infusions must only be undertaken in identified clinical areas:

CHW	SCH
PICU	CICU
Emergency Department	Emergency Department
Camperdown Ward	C2W
Exley Ward / Variety (Oncology)	C3W
Clancy Ward	
Grace Centre for Newborn Intensive Care	
Edgar Stephen Ward	

- Administration of IV fluids containing potassium greater than 40 mmol/L must be given via a central venous catheter unless authorised by a consultant.
- Nursing staff must undertake prescribed education to prepare and administer potassium solutions greater than 40 mmol/L.
- Intravenous potassium comes in a number of different salts: potassium chloride (most widely used); potassium dihydrogen phosphate and potassium acetate.
- **Department specific advice must be sought for neonatal patients**.

This document reflects what is currently regarded as safe practice. However, as in any clinical situation, there may be factors which cannot be covered by a single set of guidelines. This document does not replace the need for the application of clinical judgement to each individual presentation.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	1st February 2021	**Review Period:** 3 years
Team Leader:	Director of Nursing	**Area/Dept:** CHW Nursing

CHANGE SUMMARY

- The document replaces
  - Potassium Administration – CHW and
  - Potassium Administration – SCH
  - Hyperkalaemia: Management in the ED – SCH
- Availability of 40 mmol/L potassium chloride premix bags now available.
- Hyperkalaemia management can be achieved by using 10% or 50% glucose solution with insulin as clinically relevant.
- The use of undiluted potassium can be used for infusions as per consultant approval.
- **23/07/21**: Minor review, updated insulin on pages 18 and 19.
- **14/12/21**: minor review to add C3W to the list of wards for SCH imprest availability (p27)
- **10/3/22**: minor review – Feedback received - Table 7 (p19) amended to re-word the row on sodium bicarbonate in hyperkalaemia. Drawing up procedures have been updated.
- **18/03/22**: Minor review - Undiluted potassium infusions are to be administered via a syringe pump with "smart infusion software" at the SCH campus only. Removal of mention of Alaris GH pumps as these are no longer used across SCHN.
- **21/06/22**: Minor review. Updated Section 11 Education for Registered Nurses section as the "workbook" has become an electronic learning module on My Health Learning - **SCHN High dose potassium administration eAssessment** (course code 417895890).
- **16/12/22**: Minor review. Updated section 6, pg 12, to specify management for patients within Grace Centre for Newborn Intensive Care should follow the ANMF monograph.

READ ACKNOWLEDGEMENT

- All clinical staff who are responsible for prescribing, dispensing and administering IV potassium are to read and sign-off having read this document.

Related policies:

- Intravenous Extravasation - Management
- Adrenal Insufficiency – Emergency Management
- Recognition and Management of Patients who are Deteriorating
- Cardiopulmonary Resuscitation and Equipment
- Intravenous Fluids and Electrolytes (Randwick version) (CHW version)

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1 Considerations

- Potassium supplements (See Appendix 1) are to be given orally/enterally whenever possible.
- All patients must have an accurate measured weight. In rare circumstances where a measured weight is not possible, an estimated weight must be calculated.
- Potassium should never be administered until the serum potassium and urine output is known.
- When prescribing, the words potassium chloride (or potassium dihydrogen phosphate or potassium acetate) **MUST** be written in full, not expressed as chemical symbols.
- Rapid intravenous administration of potassium by any route can cause death and is **NEVER** recommended. Refer to Table 2.
- Lines administering potassium must not be used to administer boluses of other medications. If the basal IV fluid rate is increased, the rate of potassium administration must not exceed 0.5 mmol/kg/hour (maximum 20 mmol/hour)
- Pre-mixed solutions containing potassium chloride must be used wherever possible.
- Never add undiluted potassium (Chloride/ Dihydrogen Phosphate, acetate) ampoules to a burette or intravenous (IV) bag which is already hanging as the solution cannot be adequately mixed, resulting in inadvertent bolus dosing of concentrated potassium.

2 Potassium Reference Ranges

Table 1: Reference ranges for normal serum potassium

Age	Reference range for serum potassium
Less than 1 week of age	4.5 – 6.5 mmol/L
1 week to 1 month of age	3.8 – 6.0 mmol/L
Children over 1 month of age	3.5 – 5.5 mmol/L

3 Potassium Replacement

The normal maintenance requirements for potassium for paediatric patients, is approximately 2 – 4 mmol/kg/day. Potassium containing fluids should be utilised for maintenance fluids for the majority of patients after urine output and potassium levels are established and considered. The early introduction of potassium containing fluids can prevent hypokalaemia (See Section 4 for further information on Hypokalaemia Management).

Table 2 is a guide to potassium delivery based on potassium concentrations in fluids.

Table 2: Approximate potassium delivery based on potassium concentrations in fluids

	***Approximate potassium replacement in children receiving maintenance intravenous fluids**									
Potassium concentrations		**Units**								
	Patient weight	kg	3	5	10	20	30	40	50	70
Maintenance fluid	Maintenance fluid intake	mL/day	300	500	1000	1500	1700	1900	2100	2500
20 mmol/L bag	Potassium intake	mmol/kg/day	2	2	2	1.5	1.1	1	0.8	0.71
	Potassium infusion rate	mmol/kg/hr	0.08	0.08	0.08	0.06	0.04	0.04	0.04	0.03
40 mmol/L bag	Potassium intake	mmol/kg/day	4	4	4	3	2.3	1.9	1.7	1.4
	Potassium infusion rate	mmol/kg/hr	0.16	0.16	0.16	0.12	0.08	0.08	0.08	0.06

**Numbers have been rounded*

4 Management of Hypokalaemia

The management of hypokalaemia (serum Potassium less than 3.5 mmol/L) must be individualized. The underlying cause should be identified and managed where possible.

Table 3 provides guidance for the therapy appropriate for the degree of hypokalaemia in patients over 1 month of age.

Table 3: Management of Hypokalaemia Reference Guide, including rates of IV replacement

Degree of Hypokalaemia	Serum Potassium (mmol/L)	Essential minimum Observation and Monitoring	Potassium Prescription
CRITICAL	**Less than 2.0**	• Patient must have continuous ECG monitoring, • Strict hourly observations, • Strict fluid balance and • Serum Potassium levels hourly until potassium corrected. • Serum Urea and Creatinine should be monitored	**Critical Emergency** • Notify primary consultant and consult *ICU URGENTLY* (regarding management in ICU). • **IV** Emergency replacement 0.5 mmol/kg/hour (maximum 20 mmol/hour unless discussed with ICU or treating consultant) up to 2 hours, then replace at 0.1-0.3 mmol/kg/hr (Recommended maximum of 20 mmol/hour unless discussed with ICU or treating consultant).
SEVERE	**2.0 – 2.4**	• Patient must have continuous ECG monitoring, • Strict 2 hourly observations, • Strict fluid balance including 4 hourly urine mL/kg/hour • Potassium levels 2- 6 hourly until potassium corrected.	• **Oral** 1-1.5 mmol/kg/dose, up to four times a day (4-6 mmol/kg/day); ***OR*** • **IV** 0.1-0.25 mmol/kg/hr (recommended maximum of 20 mmol/hour unless discussed with ICU or treating consultant) – this will usually require potassium concentrations greater than 40 mmol/L.
MODERATE	**2.5 – 2.9**	• Strict 2 hourly observations, • Strict fluid balance including 4 hourly urine mL/kg/hour • Potassium levels between 8 hours and a maximum of 24 hrs after initiating treatment, until potassium corrected. **Note:** Any patient on greater than 0.25 mmol/kg/hr (or greater than 10 mmol/hour if over 40kg) will require ECG monitoring.	• **Oral** 0.5-1.5 mmol/kg/dose, up to four times daily (2-6 mmol/kg/day) ***OR*** • **IV** 0.1-0.25 mmol/kg/hr (recommended maximum of 10 mmol/hour unless discussed with ICU or treating consultant) – the usual restrictions on potassium concentrations in clinical areas applies.
MILD	**3.0 – 3.5**	• Strict 4 hourly observations, • Strict fluid balance • Biochemistry as clinically indicated. Consider the patient's underlying condition.	• **Oral** normal diet or 0.5-1 mmol/kg/dose up to four times daily. ***OR*** • **IV** maintenance - Use solution containing 20 to 40 mmol/L of potassium. Run infusion at a rate that meets the patient's fluid needs (maximum rate of potassium 0.25 mmol/kg/hour up to 10 mmol/hour)

Hypokalaemia can be life-threatening due to cardiac arrhythmia.

Hypokalaemia may be due to excess renal losses, non-renal losses, inadequate intake or redistribution of potassium between body compartments. The most common causes of hypokalaemia include:

- Sepsis
- Non-renal losses and renal losses
  - Vomiting
  - Diarrhoea
  - Skin losses
  - Renal tubular defects
- Diabetic ketoacidosis
- Cushing's syndrome
- Primary or secondary hyperaldosteronism

Medications causing hypokalaemia include diuretics, those which cause nephrotoxicity and renal tubular dysfunction such as aminoglycosides, amphotericin B, platinum agents (e.g. cisplatin), salbutamol and catecholamines e.g. dopamine.

Hypokalaemia is usually asymptomatic, except when it's severe. The signs and symptoms of hypokalaemia are non-specific but include: Muscle weakness, lethargy, drowsiness, cramps, paralytic ileus and cardiac arrhythmias (heart block, ventricular tachycardia and ventricular fibrillation).

4.1 ECG changes evident with hypokalaemia

Hypokalaemia produces one of the least specific ECG changes. These are more likely to occur when potassium is less than 2.5 mmol/L:

- Prominent U wave
- ST segment depression
- Flat, low or diphasic T waves. Normal T wave amplitude in

V5:	greater than 1 year of age	11mm
	greater than 1 year of age	14mm
V6:	less than 1 year of age	7mm
	greater than 1 year of age	9mm

- With further lowering of serum potassium the PR interval may become prolonged and sinoatrial block may occur.

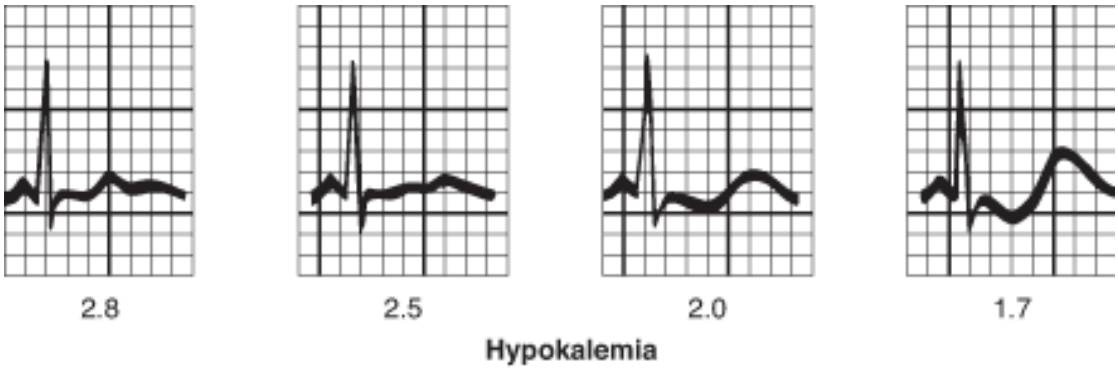


Figure 1: ECG manifestations of hypokalaemia with correlating serum potassium levels

4.2 Management of hypokalaemia

- **For mild to moderate hypokalaemia (serum potassium 2.5 – 3.5 mmol/L)**
  - Enteral potassium administration 0.5-1 mmol/kg/dose up to 4 times a day as per Table 3.
  - If enteral route not possible then potassium containing IV fluids to be used. Use Table 3 as a guide to prescription.
  - Check serum potassium levels at least daily.
- **Other points**
  - **i.** Always check and correct for hypomagnesemia when correcting for moderate to severe hypokalaemia (magnesium depletion may cause renal potassium wasting)
  - **ii.** For patients on complex chemotherapy, at risk of tumour lysis syndrome (oncology) or with underlying renal and endocrine conditions seek specialist advice on potassium supplementation
  - **iii.** **In intensive care units** the underlying condition of the patient, fluid restriction, ability to use enteral route, co-administration of various medications that affect serum potassium levels and/or need for renal replacement therapy will determine potassium delivery. Potassium concentrations of up to 1 mmol/mL maybe used at the discretion of the intensivist. High concentration of potassium may only be delivered by smart pumps with appropriate dose error reduction software capabilities, also having haemodynamic monitoring by appropriately skilled staff.

5 Use of high dose Potassium containing fluid

High dose potassium containing fluids are defined as doses

- IV fluids containing potassium greater than 40 mmol/L **OR**
- Greater than 0.25 mmol/kg/hour **OR**
- Greater than 10 mmol/hr for patients weighing more than 40kg

Patients with severe hypokalaemia or those with risk factors for severe hypokalaemia (including oncology patients, patients in diabetic ketoacidosis (DKA) and those with persistent and substantial potassium losses may not always be able to be managed with premixed fluids containing potassium. Where premixed fluids are not suitable (i.e. greater than 40 mmol/L concentration is required), the prescription must be discussed with a medical consultant.

The administration of intravenous potassium solutions greater than 40 mmol/L concentration *should not be considered routine* outside of the following clinical/ward areas:

Table 4: Wards/Departments using *high dose* intravenous potassium containing fluids

CHW	SCH
PICU	CICU
Emergency Department	Emergency Department
Camperdown Ward	C2W
Exley Ward / Variety(Oncology)	C3W
Clancy Ward	
Grace Centre for Newborn Intensive Care	
Edgar Stephen	

There are occasions where potassium concentrations of greater than 40 mmol/L will be required by patients outside of these clinical areas. In these circumstances, the patient must be cared for in the most appropriate clinical environment, taking into consideration the patient's clinical condition, the level of nursing care required and the availability of staff who have completed the necessary education and training.

Note: Any infusion being given at a rate greater than 0.25 mmol/kg/hour or 10 mmol/hour must be cardiac monitored.

6 Infusion preparation

Ampoules of potassium will be required to prepare the infusions below

Patients with peripheral and midline access only

- Potassium is a vesicant and at concentrations of greater than 30 mmol/L, pain and phlebitis is more likely to occur. Extravasation may cause severe consequences. *A large peripheral vein must be used for concentrations greater than 40 mmol/L.*
- The maximum **recommended** concentration of intravenous potassium administered via **peripheral cannula** is **40 mmol/L in both adults and children**.
- However, concentrations of up to **60 mmol/L** of potassium may be prescribed and administered when deemed necessary by the treating consultant.
- Thorough hourly insertion site checks are essential for all potassium infusions.

Patients with central access

- Concentrations of up to 80 mmol/L may be administered in maintenance fluids or in parenteral nutrition.
- Where patients have high potassium requirements and are fluid restricted, a concentrated potassium infusion (minimally diluted to 0.5 mmol/mL or undiluted) may be considered, administered via syringe pump. Approval to administer a concentrated potassium infusion via a syringe pump must be obtained from the appropriate Consultant.
- Concentrated potassium infusions must:
    - **i.** Be administered centrally via a dedicated side line. No other fluid or medication should be co-infused via the potassium side line if it can be avoided. Bolusing of the potassium infusion must not occur. If the basal IV fluid rate is increased, the rate of potassium administration must not exceed 0.5 mmol/kg/hour (maximum 20 mmol/hour)
    - **ii.** Have a clearly labelled line stating "**Potassium"** and **"DO NOT BOLUS**"
    - **iii.** Be administered via syringe pump.
    - **iv.** When ceased have the lumen flushed by a 0.9% sodium chloride infusion commenced and infused at the same rate to ensure that at least two times the volume of the lumen, or 4mL (whichever is smallest) is cleared.

Concentrated potassium infusions (0.5 mmol/mL or undiluted potassium) are generally only used in oncology patients in ward areas, although there are rare occasions where they may be required by other patients such as those in chronic liver failure.

Undiluted potassium infusions are only to be administered at SCH, require consultant approval and MUST be administered via a syringe pump with smart infusion software.

Patients receiving concentrated potassium infusions must be cared for by staff who have completed the high dose potassium learning package and are able to care for a patient requiring ECG monitoring.

Concentrated Potassium infusions must be given through a central venous catheter

Table 5: Concentrated potassium preparations

SCHN - If using a normal syringe driver without "smart infusion software" **OR** **At CHW - If using a syringe pump with "smart infusion software"** **0.5 mmol/mL**	**SCH ONLY** **If using a syringe pump with "smart infusion software"** **1 mmol/mL (Undiluted)**
Draw up 2.5 x 10 mmol/10mL (25mL) potassium ampoules into a 50mL syringe. E.g. Make up to 50mL using sodium chloride 0.9%. = 25 mmol potassium chloride in 50mL = 0.5 mmol/mL	Draw up 5 x 10 mmol/10mL potassium ampoules into a 50mL syringe E.g. = 50 mmol potassium chloride in 50mL = 1 mmol/mL

Recommended infusion time not greater than 12 hours without medical review

Patients requiring concentrated potassium infusions who are admitted to Grace Centre for Newborn Intensive Care should be managed as per the Australasian Neonatal Medicines Formulary (ANMF) potassium chloride – Intravenous monograph.

7 Preparation Considerations

The use of premixed bags of potassium should be used wherever possible.

- If preparation of infusions using potassium ampoules is required it should follow:
  - SCHN ANTT guidelines
  - SCHN fluid preparation guidelines and
  - Labelling of intravenous solutions as per PD2016_058, *User-applied Labelling of Injectable Medicines, Fluids and Lines*.

- Orders without instructions for dilution or infusion rate are **not complete** and should not be prepared or administered without clarification from the medical officer.

- Where potassium solutions are prepared from potassium ampoules, the solution **must be inverted at least 10 times** to ensure that the solute (e.g. potassium chloride) is thoroughly mixed throughout the solution.

Unshaken bags are prone to layering of added concentrate and are extremely hazardous. Figure 2 is a visual representation of 20 mmol concentrated potassium chloride added to an IV bag without thorough mixing. **Note** *the potassium pools at the bottom of the bag*.

Figure 2: Visual representation of 20 mmol concentrated potassium chloride added to an IV bag without thorough mixing

Note:

- Potassium must NEVER be added to a hanging bag or burette due to the difficulty in mixing the solution thoroughly.

- Potassium must NEVER be added to a premixed bag containing potassium to increase the final concentration of potassium

8 Prescribing potassium

Before prescribing potassium all sources of potassium should be considered and where possible a single route should be chosen.

8.1 Prescription Requirements for Intravenous Potassium

Where intravenous potassium is required standard (pre-mixed) solutions should be used where clinically feasible.

Any intravenous fluid order that requires potassium to be added to the infusion bag by nursing staff on the ward requires **authorisation from the treating Consultant**.

If the patient is receiving Total Parenteral Nutrition (TPN) consider the potassium in the TPN, if additional potassium is required. All intravenous potassium infusions must be prescribed in accordance with the SCHN Safe Prescribing Guideline and:

- Name the potassium salt to be used,
  - e.g. “potassium chloride” (NOT KCl)
- Route, e.g. IV
- Concentration of potassium, e.g. mmol/L
- Fluid to which the potassium is to be added
- Rate of administration in mL/hr **AND** mmol/kg/hr

The intravenous potassium order should be documented in the medical notes including calculation of the patient’s total potassium intake from all sources over 24 hours.

Alert: Orders without instructions for dilution and infusion rate, ordered as ‘stat’ or ‘bolus’ are not complete and will not be accepted for either dispensing or administration and clarification must be sought from the prescriber.

9 Patient Monitoring requirements during IV potassium administration

9.1 Insertion Site

The IV administration source must have hourly insertion site observations with any concerns documented in the medical record. Where there is evidence of phlebitis or pain the infusion should be ceased and the medical officer contacted. Manage according to SCHN Intravenous Extravasation Management Guideline.

9.2 Electrolytes

If potassium is administered too rapidly or if excretion is impaired, potentially fatal hyperkalaemia can result; it can develop rapidly and asymptomatically. Careful monitoring of serum potassium concentration with dosage adjustment is recommended (see Table 3, Management of Hypokalaemia reference guide)

See relevant sections on hypokalaemia and hyperkalaemia for signs and symptoms of potassium imbalance.

9.3 Renal Function

Renal function must be monitored as clinically indicated including:

- Regular assessment of urine output, a minimum of 6th hourly urine output (normally greater than or equal to 1mL/kg/hour)

AND

- Measurement of plasma urea and creatinine.

If there is a falling urine output or deteriorating renal function the medical officer must be contacted and the infusion should be slowed or stopped. Potassium replacement should be urgently reassessed.

Extreme care should be taken if oliguria or renal impairment is present.

9.4 Cardiac Monitoring

In addition to the patients who are hypokalaemic and hyperkalaemic, continuous ECG monitoring is required in the following patient groups:

- **Patients under 40kg:**
  - Continuous ECG monitoring is compulsory for **ALL** patients receiving potassium at a rate greater than **0.25 mmol/kg/hour**.

- **Patients over 40kg ideal body weight**:
  - Continuous ECG monitoring is compulsory for **ALL** patients receiving potassium at a rate greater than **10 mmol/hour**.

10 Hyperkalaemia Management

10.1 Definition and general principles

- Infants and Children : Serum Potassium greater than 5.5 mmol/L
- Neonates : Serum Potassium greater than 6.5 mmol/L

Serum potassium level alone doesn't necessarily predict risk of arrhythmia. The clinical history and rate of rise are also important. For example, an acute rise in serum potassium due to tumour lysis syndrome may present a higher risk situation than hyperkalaemia in a child with chronic renal disease.

Hyperkalaemia is a life threatening emergency and can result in critical ECG changes, cardiac arrhythmias and sudden death. Management of hyperkalaemia is guided by ECG changes and the absolute serum potassium level. If there are ECG changes, do not delay management waiting for a repeated laboratory level. The potassium level and its effects may vary with rate of rise and coexistent metabolic conditions.

The child should have continuous cardiac monitoring.

Prompt recognition and appropriate treatment of hyperkalaemia are essential to ensure a positive outcome.

10.2 Signs and symptoms of hyperkalaemia

Clinical features of acute hyperkalaemia

- Hyperkalaemia causes cardiac arrhythmia /asystole via a direct effect on the myocardium, which can cause cardiac arrest or death.
- There may be no symptoms prior to cardiac arrest.
- There may be muscle weakness, from mild up to flaccid paralysis.

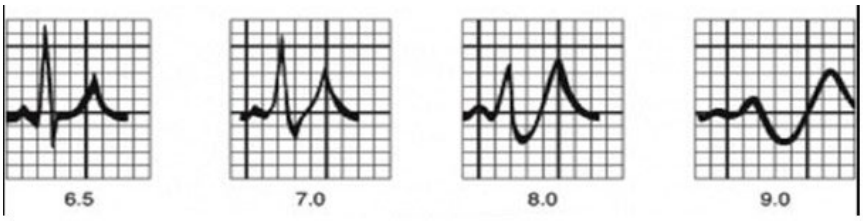
ECG manifestations of hyperkalaemia

- The ECG is a sensitive indicator of potassium's effect on the heart.
- ECG manifestations of hyperkalaemia are detailed in Table 6. However it must be remembered that potassium levels at which specific ECG abnormalities are seen can vary widely from patient to patient.

Table 6: ECG manifestations of hyperkalaemia

Serum Potassium (mmol/L)	ECG Manifestations
5.5 – 6.5	Tall, peaked, "tent-like" T waves, normal or decreased QT interval, PR interval shortening
6.5 – 7.5	Widening of QRS complex, increased PR interval
7 - 8	Broad, low-amplitude P waves, T prolongation, ST elevation or depression
Greater than 8	P waves disappear, marked widening of QRS, "sine wave" pattern, high risk of VF or asystole

Figure 3: ECG manifestations of hyperkalaemia with correlating serum potassium levels



10.3 Causes of hyperkalaemia

High potassium associated with a low sodium should prompt clinicians to think about adrenal insufficiency as a diagnosis – see Adrenal Insufficiency – Emergency Management Guideline. A false result of hyperkalaemia may occur as an artefact of collection process or technique.

- Decreased excretion (frequent cause of hyperkalaemia)
  - Renal diseases: Acute/chronic renal failure, renal anomaly (e.g. Sickle cell disease)
  - Adrenal mineralocorticoid deficiency
- Transcellular shift
  - Acidosis (e.g. Diabetic ketoacidosis, lactic acidosis)
- Increased production (Most often if in association with renal dysfunction)
  - Extensive trauma
  - Rhabdomyolysis (Crush injury, convulsion, infection)
  - Haemolysis
  - Tumour lysis syndrome
  - Burns
- Exogenous source
  - Iatrogenic potassium administration (oral, IV)
  - Increased ingestion
  - Massive Transfusion
- Medications
  - Common medications include NSAIDs, trimethoprim, heparin, cyclosporine, potassium-sparing diuretic, ACE inhibitor, beta-blockers, succinylcholine, digoxin and mannitol

10.4 Principles for treating hyperkalaemia

Where **plasma potassium level is greater than 5.5 mmol/L** an urgent 12 lead ECG is required to look for features supporting the diagnosis of hyperkalaemia. Ask for Senior Medical input with interpretation of ECG

1. Escalate via CERS and initiate resuscitation as per APLS algorithms
2. Cease all exogenous sources of potassium (IV and oral) and potassium sparing diuretics
3. Treat hyperkalaemia as per Section 10.5:
    i. Stabilise cardiac tissue
    ii. Shift potassium from extracellular to intracellular compartments
    iii. Promote potassium loss from the body
4. Establish urine output and consider renal function biochemistry

    Senior Medical advice should be sought early in patients who have elevated urea and/or creatinine, anuria, established or known renal impairment, as well as associated electrolyte abnormalities, such as hyper/hyponatraemia, or acid-base disturbances.
5. Urgent dialysis may be required in patients who are already on chronic dialysis or those with impaired GFR and/or oliguria. Advice from nephrology should be sought early.

10.5 Medications used to treat Hyperkalaemia

The choice of agents will depend on the circumstances and response to therapies. Hyperkalaemia with ECG changes will require urgent cardiac protection with IV calcium followed by other interventions commenced urgently over a short period. Mild hyperkalaemia with no ECG changes may only require rehydration and resonium. Seek Senior Medical advice regarding choice of agent and order of administration.

10.5.1 Stabilise cardiac tissue

- The administration of IV calcium provides cardiac protection
- Calcium should not be given if digoxin toxicity or tumour lysis syndrome is suspected.

  Calcium Chloride and Calcium Gluconate: Do not give with bicarbonate as this will cause precipitation in the line.

10.5.2 Shift potassium from extracellular to intracellular compartments

- Intravenous sodium bicarbonate, 8.4% (1 mmol/mL), 1 mmol/kg, slow push

  Sodium Bicarbonate requires dilution 1:1 with water for injection to 4.2%, which has 0.5 mmol/mL, then 2mL/kg (= 1 mmol/kg) is given as IV push over a minute.
  Do not give with calcium as this will cause precipitation in the line.
- Salbutamol, either via nebuliser or intravenously:

- Salbutamol nebuliser: 2.5 – 5 mg as a single dose and repeat if necessary.[8]
- Salbutamol intravenous: 4micrograms/kg as a single dose and repeat if necessary.[8]

- Salbutamol as IV or nebulisation, ideally after the above IV therapies have been given. There is some evidence that salbutamol causes a small increase in potassium before lowering the level and due caution should be exercised, with senior consultation. Salbutamol nebulisation may be considered for use earlier if IV access is not available.
- Insulin (ultra short acting –- Novorapid, or short acting – Actrapid or Humulin R) – 0.1 unit/kg, given with glucose 10% over 5 – 30 minutes OR (short acting - Actrapid) – 0.1 unit/kg, given with glucose 50% over 5-30 minutes. [8, 10]
  This is the **most potent temporary** treatment for hyperkalaemia.

  Do not administer insulin without glucose; glucose alone *will not* treat hyperkalaemia.

  IV Glucose 10% or 50% (+/- 0.1 units/kg insulin). Check BSL every 30 mins as glucose bolus may not meet the needs of the insulin bolus and hypoglycaemia may occur in the first 2 hours.

10.5.3 Remove potassium from the body

- A loop diuretic e.g. frusemide (1 mg/kg), for patients not in renal failure
- Resonium A (polystyrene sulfonate sodium), 1g/kg orally (max 15g) or rectally (max 30g) (Oral administration only for Oncology patients)

  OR
- Calcium Resonium (polystyrene sulfonate calcium) for patients who are fluid overloaded or have a history of being at risk of hypernatraemia. See Table 7 (below) for dosing.
  - **NB: Rectal route should NOT be used for oncology patients unless approved by the treating oncologist**

  Oral polystyrene sulfonate sodium or calcium (Resonium A or Calcium Resonium) is slower in onset, but longer lasting in effect compared with rectal administration. Resonium should only be used *rectally* in term neonates and is ***contraindicated in neonates with reduced gastric motility, ileus, recent abdominal surgery or perforation and in all Oncology/Haematology patients***.

  Use Calcium Resonium only in patients who have hypernatremia or fluid overloaded.
- Renal replacement therapy

If the child is not already in ICU, arrange review and/or transfer to ICU.

Table 7: Medication doses and formulations to treat Hyperkalaemia

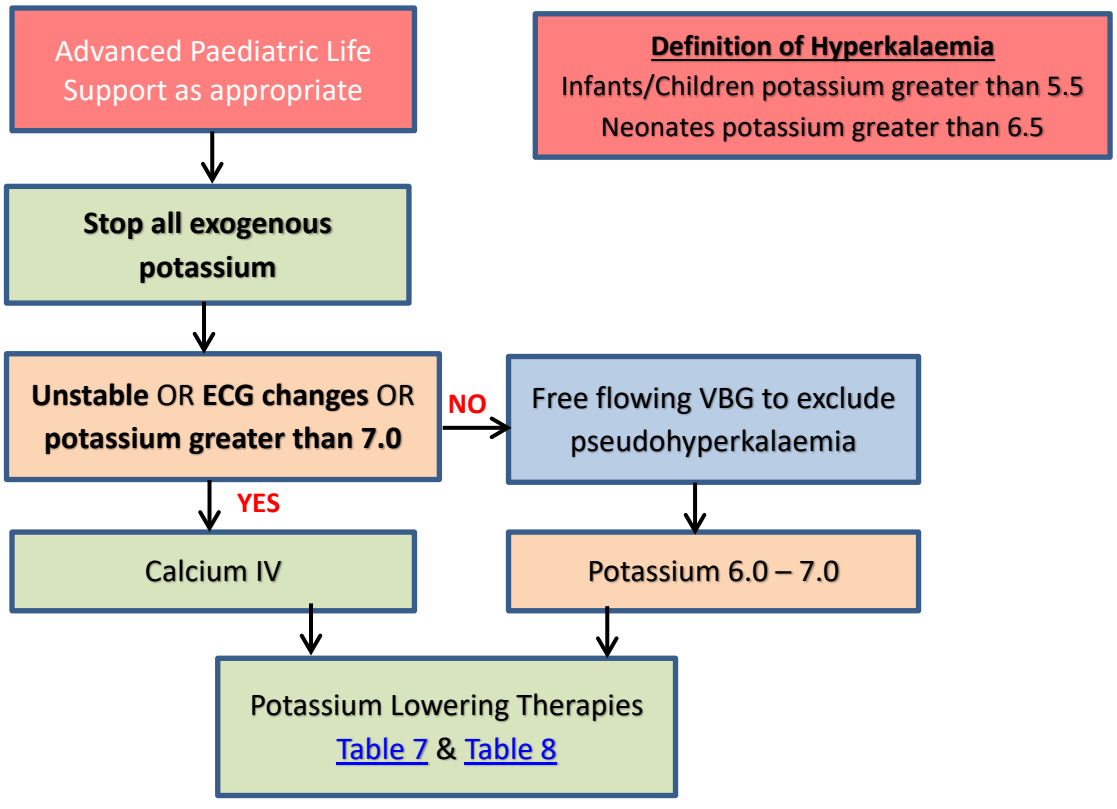
	Medications used to treat hyperkalaemia	Dose	Time to effect	Comment
Stabilise cardiac tissue	**1.** Calcium chloride 10% (0.68 mmol/mL)	0.2mL/kg (maximum 10mL) [8]	1-3 min	Do not give with bicarbonate as this will cause precipitation in the line
	2. Calcium gluconate 10% (0.22 mmol/mL)	0.5mL/kg (maximum 20mL) [9]	Immediate[9]	
Shift potassium from extracellular to intracellular compartments	**3.** Glucose + insulin	0.5 g/kg/dose (5mL/kg/dose of 10% glucose solution) **OR** 0.5 g/kg/dose (1 mL/kg/dose of 50% glucose solutions) via central line only with or without regular insulin 0.1 unit/kg dose Note: only Actrapid is compatible with 50% glucose solution.	10 – 20 min[9]	If insulin given, check BSL every 30 mins for 2 hrs, as glucose bolus may not meet the needs of the insulin bolus and hypoglycaemia may occur in the first 2 hours.
	4. Sodium bicarbonate ($NaHCO_3$) 8.4%	1mL/kg (1 mmol/kg) of 8.4% solution [9]	15 -60 min[9] (depending on acid base status of patient)	• <2 years: Further dilute dose with an equal amount of 5% glucose or water for injection and administer as an IV push over 2-5 minutes. • ≥ 2 years: Administer dose undiluted as an IV push over 2-5 minutes. **Do not** give with calcium as this will cause precipitation in the line.
	5. Salbutamol nebulised	2.5mg – 5mg as a single dose. Repeat if necessary [8]	20 – 30 min[9]	Ideally given after the above IV therapies Salbutamol may cause a small increase in potassium before lowering the level and caution should be exercised, with senior consultation. Salbutamol nebulisation may be considered for use earlier if IV access is not available.
	6. Salbutamol IV	4 micrograms / kg IV (maximum 250 microg)[8]	20 - 30 min[9]	
Remove potassium from the body	**7.** Ion exchange resin – oral or rectal [polystyrene sulfonate sodium: Resonium A® (preferred) or polystyrene sulfonate calcium Calcium Resonium® for fluid overloaded patients] (Oral administration only for Oncology patients)	0.5 - 1g/kg orally/rectally (max dose orally 15g; rectally 30g)	1-2 (variable)	Oral administration only for Oncology patients
	8. Establish urine output – fluid replacement and resuscitation, diuretics and dialysis	variable	variable	

The effects of calcium, glucose and insulin, sodium bicarbonate and salbutamol are transient and ongoing potassium monitoring is required

Table 8: Treatment strategies/options based on ECG changes and potassium level. Note these are suggestions and not prescriptive

Potassium / ECG	Treatment Strategy
Abnormal ECG (Table 6, Figure 3) and/or Potassium level greater than 7.0 mmol/L MEDICAL EMERGENCY – assess signs of life and resuscitate as necessary as per CERS guidelines	IV Calcium Salbutamol Insulin / Glucose Bicarbonate if metabolic acidosis **(do not give through same line as calcium)** +/- Resonium A (polystyrene sulfonate sodium)
Potassium 6.0 mmol/L to 7 mmol/L No ECG changes	Salbutamol Resonium A (polystyrene sulfonate sodium) Bicarbonate if metabolic acidosis **(do not give through same line as calcium)**
Potassium less than 6.0 mmol/LL No ECG changes	May not require active treatment Salbutamol Resonium A (polystyrene sulfonate sodium)

Flowchart for the Management of Hyperkalaemia



Potassium lowering therapies either:

a. Shift potassium into cells: Sodium bicarbonate, glucose/insulin, salbutamol
b. Remove potassium from body: Resonium A (polystyrene sulfonate sodium), Diuresis, Dialysis.
c. See Table 7 – Medication Doses and Formulations to treat Hyperkalaemia

11 Education for Registered Nurses

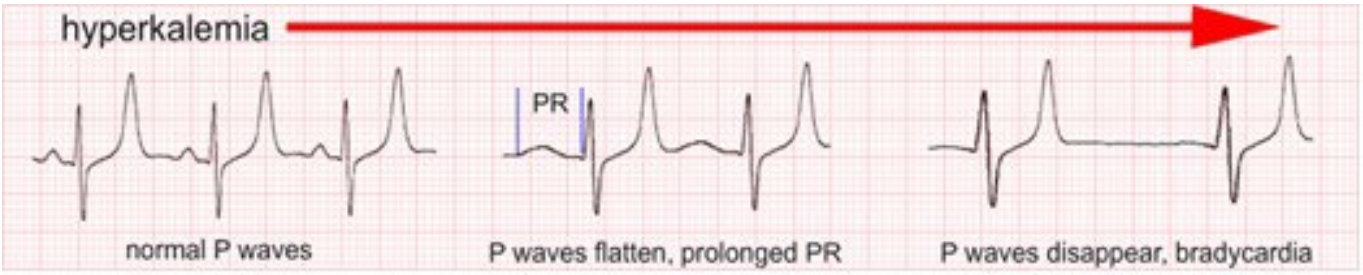
Registered Nurses preparing, administering and managing patients receiving potassium replacement greater than 40 mmol/L must:

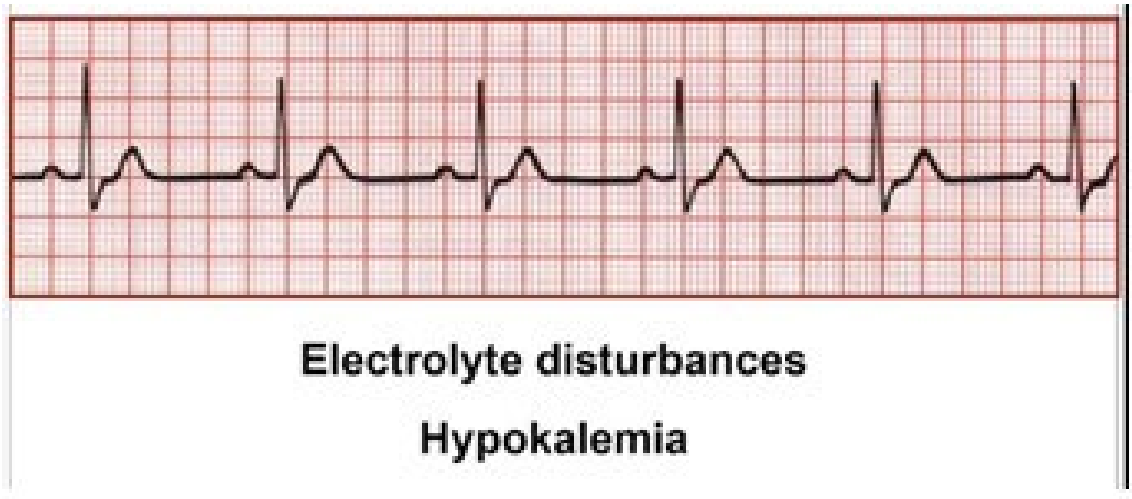
- Successfully completed the SCHN High dose potassium administration eAssessment (course code 417895890) on My Health Learning or recognition of prior learning attained of this module by completion of "RN Worksheet – High Dose Intravenous Potassium Administration" since the 4-April-2022.
- When managing a patient with IV high dose potassium replacement for the first time, perform administration skills (commencement of infusion/syringe change) with the unit Clinical Nurse Educator or delegate.
- Discuss patient progress, clinical changes and patient management with the team leader, CNE or delegate regularly throughout their clinical shift
- Complete further education for cardiac monitoring at the discretion of the clinical unit leadership team

A brief reference for ECG changes for nurse caring for patients receiving potassium replacement greater than 40 mmol/L can be found in Table 6, Figure 3 and the below images in Figure 4.

Please see Section 4 and Section 10 for detailed information for the manifestations and management of hypo/hyperkalemia.

Figure 4: ECG changes in patients receiving potassium replacement greater than 40 mmol/L





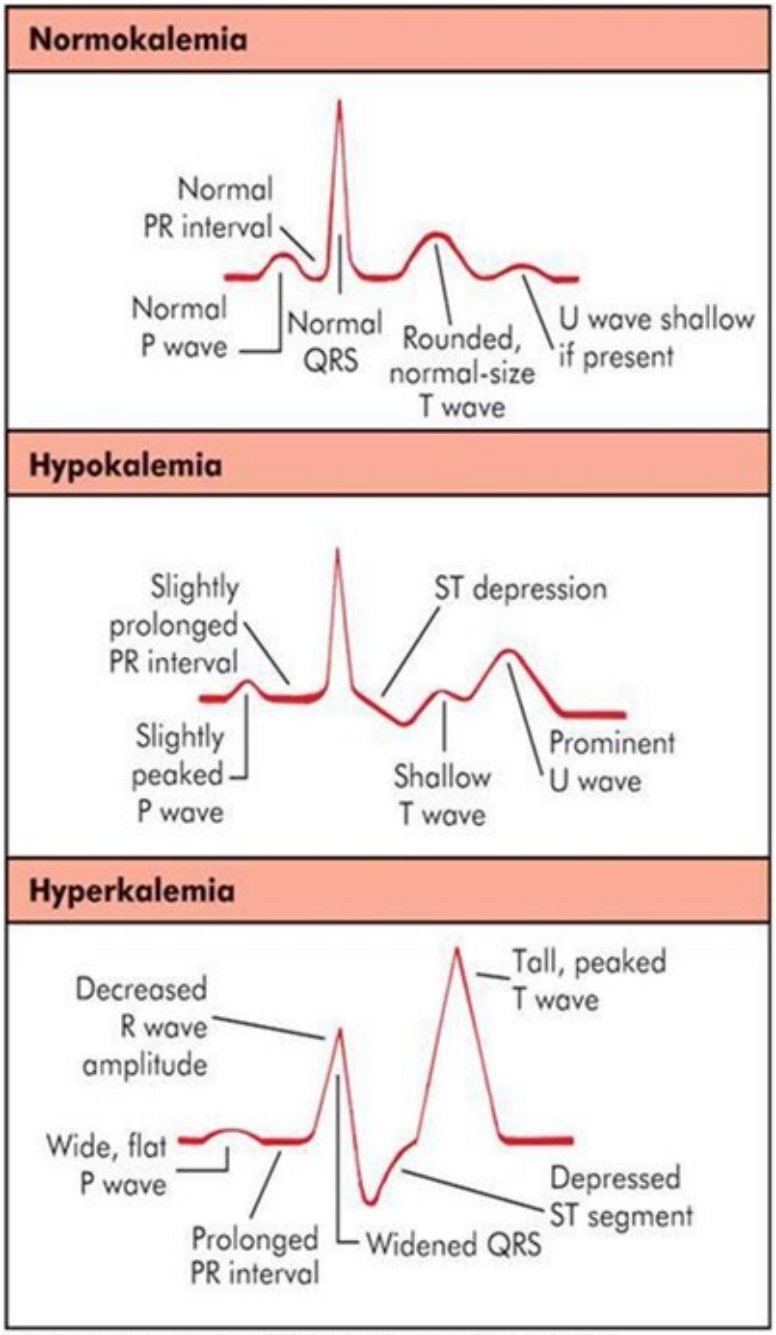


Fig. 4-7. Electrocardiogram Changes with Potassium Imbalance

- Further information on ECG changes associated with potassium can be found at:
  - https://litfl.com/hyperkalaemia-ecg-library/
  - https://litfl.com/hypokalaemia-ecg-library/

12 References

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Appendix 1: Potassium containing products

1. Oral potassium

The oral/enteral route is effective and appropriate in patients with asymptomatic hypokalaemia and can produce rapid correction without the limitations imposed by the rate of intravenous potassium. Oral/enteral administration of potassium should be used for the treatment if hypokalaemia whenever clinically feasible.

Table 9: Oral potassium preparations

Product	Brand Name	Potassium dose in mmol	Notes
Potassium chloride, carbonate and bicarbonate	Chlorvescent®	14 mmol per tablet	Effervescent tablet to be mixed with water and taken after food. Manufacturer recommendations: 1-2 tablets in 120-240 mL of water or as advised by pharmacy or local protocols
Potassium chloride 600 mg modified released tablet	Span K® tablets	8 mmol per tablet	Modified release tablet. Cannot be crushed. Give with or soon after food preferably.
Potassium chloride 10% oral mixture		20 mmol per 15mL	Dose should be diluted in water or juice

2. Intravenous potassium in maintenance fluid bags

Where the oral/enteral route is not available, or administration via the oral/enteral route may not achieve the required elevation of serum potassium within a clinically acceptable timeframe, IV potassium should be considered.

In most clinical situations where intravenous potassium replacement is required, the use of the standard pre-mixed solutions containing 20 to 40 mmol/L is appropriate.

It is far safer to use pre-mixed potassium chloride solutions than to make up a solution using ampoules, due to the potential for error in calculation, preparation and mixing. For this reason, standard, premade solutions should be used wherever possible.

Additional potassium must NEVER be added to a bag already containing potassium, as this may lead to confusion regarding the final concentration.

Patients prescribed fluids using premixed bags containing potassium and delivering potassium at rates higher than 0.25 mmol/kg/hr will receive standard potassium observations.

Premixed IV potassium solutions are labelled in red and have a pink outer packaging.

Premade solutions available at SCHN are listed in Table 10 (below).

Table 10: Premixed bags containing potassium available at SCHN

Note: 20 mmol/L and 40 mmol/L bags must be stored in separate areas of the store room to reduce risk of wrong dose being given. Also, potassium bags must be kept separately & labelled clearly from the non-potassium IV fluids.

Potassium Content	Base Fluid	Volume of bag (mL)	Availability at SCH	Availability at CHW
5 mmol	Plasma-Lyte 148	**1000**	CICU Children's Recovery	Theatres
	Plasma-Lyte 148 + 5% glucose		CICU Children's Recovery	
10 mmol	10% glucose + 0.225% sodium chloride	**500**	C1S	
	10% glucose + 0.45% sodium chloride		Emergency	**From pharmacy** Hunter Baillie Emergency
20 mmol	5% glucose + 0.45% sodium chloride	**1000**	C1N C1S C1SW C2N C2S C2W C3S C3W Children's Recovery CICU Emergency	Camperdown Clancy Clubbe CT Ward Edgar Stephens Emergency Hunter Baillie Orthopaedic OTC PICU Surgical Theatres Exley (Oncology) Variety (COVID) Wade
	5% glucose + 0.9% sodium chloride		C1N C1S C1SW C2S C3S C3W Children's Recovery CICU Emergency	Camperdown Clancy Clubbe CT Ward Edgar Stephens Emergency Hunter Baillie Orthopaedic OTC PICU Surgical Theatres Exley (Oncology) Variety (COVID) Wade
	0.9% sodium chloride		C3S	
40 mmol	5% glucose + 0.9% sodium chloride	**1000**	C1SW C2W C3S C3W CICU	**From pharmacy** Camperdown PICU Exley (Oncology)

3. Concentrated potassium ampoules

Restrictions apply to potassium chloride, potassium dihydrogen phosphate and potassium acetate ampoules.

Storage

Potassium ampoule must be stored in a designated potassium container. This must be sealed and should be labelled 'POTASSIUM' with the potassium salt (e.g. chloride). Examples of potassium containers are shown below.

Potassium containers for imprest supply

NB: *These imprest containers must be separated from all other ampoules stored on imprest*

Potassium containers for individual patient use

Potassium ampoules must not be stored in a cupboard or shelf with products of similar appearance (e.g. water for injection ampoules). Where storage space allows, the potassium container should be stored on a single shelf with no other items. In those locations that store more than one type of potassium ampoule, these must be kept in separate containers as highlighted above.

Resuscitation trolley: Potassium ampoules must not be stored on resuscitation trolleys due to the risk of inadvertent bolus administration. Potassium ampoules must be securely stored and readily accessible for resuscitation purposes when needed.

Supply

Potassium ampoules are supplied via the pharmacy-led imprest at CHW and via imprest requestion at SCH. Where potassium ampoules are picked up from pharmacy, the clinical

area must bring their potassium container to pharmacy to ensure the new supply is placed into the container.

Where imprest supply is performed by pharmacy technicians, potassium must be placed into the ward potassium container. If the potassium container cannot be found, the team leader must be informed. **Under no circumstances is potassium to be supplied without being placed in a potassium container**.

Table 11: Wards at SCHN permitted to keep potassium on imprest

Product	Description	SCH Imprest availability	CHW Imprest availability
Potassium chloride	10 mmol potassium in 10mL	Emergency CICU C2W C3W	Emergency PICU GCNIC Theatres Cardiac Cath Lab Camperdown Exley / Variety (Oncology) Clancy Renal Treatment Centre NETS Edgar Stephen Ward
Potassium dihydrogen phosphate	10 mmol potassium, 10 mmol phosphate in 10mL	Emergency CICU C2W C3W	Emergency PICU Camperdown
Potassium Acetate	25 mmol/ 5mL potassium, 25 mmol/ 5mL of acetate	Order from pharmacy	PICU

All other clinical areas may order potassium ampoules when accompanied by an individual patient prescription. Any unused potassium must be returned to pharmacy as soon as this is no longer required for the individual patient.

4. Access to Potassium after hours

Outside of pharmacy working hours, potassium ampoules are available from the After Hours Medication Room. Follow standard procedures for accessing medications for this supply.

All unused ampoules must be returned to pharmacy as soon as no longer required.

5. Automated Dispensing Cabinet (ADC)

In an automated dispensing cabinet (ADC), potassium ampoules must be stored in a lockable bin where practicable.

Each bin must be labelled with the appropriate warning sign on both the outside and inside of the lid to identify the contents as a particular potassium ampoule.

If more than one type of potassium is kept in the ADC, these must not be collocated or stored in the same bin.