POTASSIUM ADMINISTRATION

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- The reference range for plasma Potassium in our laboratory for children over the age of one month is **3.5 to 5.5mmol/L**. (For children less than one week of age it is 4.5 to 6.5mmol/L, and for one week to one month it is 3.8 to 6mmol/L).
- When considering using intravenous Potassium, ask yourself: "Can I administer the Potassium to this patient via the enteral route (orally or by intragastric tube)?"
- In general, Potassium should only be administered by one route at any one time. All intravenous and enteral sources of Potassium, including TPN, must be totalled and recorded on the IV fluid order and in the continuation notes.
- Many patients can be treated with intravenous Potassium administered within maintenance intravenous fluids via a peripheral vein.
- Administration of any potassium containing fluid should be via an infusion pump OR syringe pump driver.
- For intravenous Potassium, pre-mixed solutions with intravenous Potassium concentrations of **up to** 40mmol/L (**20mmol/500mL**) are available and should be used wherever possible.
- Potassium solutions greater than 40mmol/L should only be prescribed and administered in approved areas (NICU, PICU, RTC, Camperdown Ward, Variety Ward, Edgar Stephen Ward, Clancy Ward and the Emergency Department). In exceptional individual patient circumstances where the child requires solutions greater than 40mmol/L and it is unsafe to move the child to a ward aforementioned, approval may be granted by the Director of Clinical Governance (DCG) or the Executive On-Call to administer the infusion outside of the above mentioned ward areas. Appropriately skilled staff and monitoring will still be required as per this Practice Guideline.
- PICU is the only ward area authorised to keep potassium chloride ampoules, potassium dihydrogen phosphate and potassium acetate ampoules on the ward imprest. A selection of Wards (see Appendix 5) are authorised to keep potassium chloride ampoules on the ward imprest. All other wards are not permitted to keep potassium chloride, potassium dihydrogen phosphate or potassium acetate ampoules on the ward imprest stock.

Approved by	SCHN Policy, Procedure and Guideline Committee	CHW Drug Committee
Date effective	1st December 2013	**Review Period**: 3 year
Team Leader	Staff Specialist	**Area/Dept:** PICU

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- Nurse Unit Managers (NUM) of ward areas wishing to have potassium chloride and potassium dihydrogen phosphate ampoules added to the imprest stock are required to obtain approval from the Drug Committee.
- Concentrations greater than 40mmol/L should be administered via a central line. Concentrations greater than 40mmol/L and up to 80mmol/L may be used peripherally only if urgent replacement is necessary and only for a short time because there is an increased risk of thrombophlebitis and pain at these higher concentrations
- Extravasation should be AVOIDED for all potassium containing intravenous fluids.
- Concentrations of greater than 80mmol/L (40mmol/500mL bag) may only be administered via a central venous access device (CVAD) in an approved ward area. This may only be done via an infusion pump.
- Approval to administer a concentrated Potassium infusion (greater than 40mmol / litre) must be obtained from the appropriate Consultant.
- The maximum concentration of Potassium to be used by syringe pump for infusion via a CVAD is 0.5mmol/mL.
- The maximum rate of infusion of Potassium should not exceed 0.5mmol/kg/hour: Continuous ECG monitoring is required for rates exceeding or equal to 0.25mmol/kg/hr (as per section 5).
- Patients greater than 40kg who require rates of greater than 10mmol/hr must have continuous ECG monitoring. Note: The maximum rate for patients greater than 40kg is usually 20mmol/hr.
- Prescribing of all intravenous Potassium must be in millimoles (mmol).
- The infusion rate must be recorded on the IV Orders and in the continuation notes as mL/hr, mmol/hr and mmol/kg /hr.
- The Total Potassium Intake must be calculated in mmol/kg/hour.
- Monitoring with a continuous ECG and regular blood sampling is extremely important.
- Warning: Potassium containing fluids must not be used to prepare the IV administration of other drugs due to the high risk of incorrect rate of potassium being inadvertently administered.

CHANGE SUMMARY

- Mandatory review – no changes were made.

READ ACKNOWLEDGEMENT

- Training/Assessment Required – RN Potassium Infusion Accreditation Package is in this document.
- Read/Acknowledge:
  - RNs undertaking Potassium Infusion accreditation are required to read and acknowledge they understand the contents of this document.
  - RNs with Potassium Infusion accreditation are required to read document revisions.
  - Medical Staff in clinical areas are required to read the document & document revisions.

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1 Background

1.1 Rationale

- Potassium is well established as one of the most hazardous drugs in use in hospitals. It has been involved in catastrophic outcomes in hospitals worldwide[1], including our own.
- Intravenous Potassium is potentially lethal because hyperkalaemia can cause cardiac arrhythmia /asystole via a direct effect on the myocardium.
- Hyperkalaemia can occur if infusions are run too quickly, intentionally or accidentally[2], causing arrhythmia and cardiac arrest.
- Hypokalaemia, which can be debilitating and even life-threatening (due to cardiac arrhythmia), sometimes requires correction by the intravenous route.
- Correction of hypokalaemia must be approached carefully and concentrated Potassium solutions should be avoided wherever possible.
- Hyperkalaemia is more likely to be life-threatening than hypokalaemia.
- **WARNING**: Unrestricted availability of Potassium Chloride (KCl) ampoules (10 mmol/10mL) may lead to the inadvertent injection of Potassium Chloride instead of Sodium Chloride and Water for Injection for line flushing and for the reconstitution of drugs.[3]

1.2 Goals

- To appropriately restrict the storage and administration of concentrated intravenous Potassium solutions at CHW.
- To standardise the administration of intravenous Potassium at CHW, ensure safe practice and reduce risk to patients.

1.3 Questions to ask when considering the use of Potassium intravenously.

- Can I administer the Potassium enterally (orally or by intragastric tube) to this child?
- How quickly do I really need to correct the hypokalaemia?
- Can I use a pre-mixed maintenance intravenous fluid solution which already contains Potassium to meet the child's needs?
- Is the child receiving Potassium in any other form (eg TPN, oral Potassium supplement)?
- Is the child receiving Potassium-retaining medications, such as spironolactone, ACE inhibitors, angiotensin-2 receptor blockers, or is the child oliguric with renal dysfunction?

1.4 Availability

- Pre-mixed bags of intravenous fluids containing Potassium chloride are available for use at CHW:
  - 10mmol Potassium chloride in 500mL 0.225% Saline + 3.75% Dextrose
  - 10mmol Potassium chloride in 500mL 0.45% Saline + 2.5% Dextrose
  - 20mmol Potassium chloride in 500mL 0.45% Saline + 5% Dextrose
- Concentrations of Potassium greater than 20mmol in 500mL (i.e. 40mmol/L) should be avoided.
- In exceptional circumstances, Potassium may be added to intravenous solutions by accessing Potassium chloride ampoules (10mmol in 10mL). The supply of Potassium chloride ampoules to different areas in CHW is to be carefully regulated through Pharmacy (see 1.7 below).

1.5 Applicability

- The same rules and conditions apply to the use of Potassium Dihydrogen Phosphate and Potassium Acetate, which are used instead of Potassium Chloride in special circumstances in Intensive Care, Renal and Oncology patients at CHW.

1.6 Critical Alert

- Potassium should NEVER normally be administered by intravenous push /bolus.
- Rarely, in the management of documented severe hypokalemic cardiac arrest (plasma Potassium <2mmol/L), a rapid infusion of potassium may be given as ordered by the paediatric intensive care specialist on duty.

1.7 Storage and Handling

- Potassium concentrate solutions (e.g. Potassium Chloride (KCl), Potassium Dihydrogen Phosphate and Potassium Acetate ampoules) should be restricted to Pharmacy and to approved clinical areas where they are needed for urgent use.
- PICU is the only ward area authorised to keep potassium chloride ampoules, potassium dihydrogen phosphate and potassium acetate ampoules on the ward imprest. A selection of Wards/Departments (see Appendix 5) are authorised to keep potassium chloride on the ward imprest. All other wards are not permitted to keep potassium chloride, potassium dihydrogen phosphate or potassium acetate on the ward imprest stock.
- Wards wishing to have potassium chloride and potassium dihydrogen phosphate added to the imprest stock are required to obtain approval from the Drug Committee
- Potassium concentrate solutions should NOT be available as routine stock in wards and other clinical areas. If Potassium concentrate solutions are found in an unapproved area, they should be REMOVED immediately, the area manager should be informed and an incident report completed via IIMS.

- Potassium concentrate solutions (i.e. potassium chloride, potassium dihydrogen phosphate and potassium acetate ampoules) must be stored SEPARATELY in a clearly marked container in a lockable box /cupboard away from common diluting solutions such as sodium chloride (normal saline) or other solutions with similar packaging. Currently all wards place their potassium containing ampoules in a RED container to highlight the special procedures required when selecting these ampoules for use. Potassium concentrate solutions must be returned to pharmacy if they remain unused after being dispensed to a ward area on a named patient basis.
- Potassium concentrate solutions (i.e. potassium chloride, potassium dihydrogen phosphate and potassium acetate ampoules) must NEVER be transferred between clinical areas. All supplies should be made directly from the Pharmacy Department.
- Wards that do not have potassium on their imprest will be supplied potassium on prescription only (not requisition) and it will be labelled with the patients' name for whom it is dispensed.
- After hours, potassium chloride ampoules may be obtained from the After Hours Drug Room. Only the ADON may access this room. To obtain potassium dihydrogen phosphate or potassium acetate ampoules, the on call pharmacist may be contacted to authorise the ADON to access the pharmacy after hours.
- Documentation should follow the pattern for controlled drugs and should record the, supply, receipt and administration of Potassium concentrate solutions (administration should also be recorded on the chart on which it is prescribed). Refer to Appendix 4: A. Potassium Chloride Log, b. Potassium Dihydrogen Phosphate Log and c. Potassium Acetate Log.
- Ward areas that are authorised to keep potassium chloride, potassium dihydrogen phosphate or potassium acetate ampoules on the imprest stock will be reviewed regularly by the Drug Committee for its continued need or otherwise.
- Nurse Unit Managers (NUM) of ward areas who wish to have potassium chloride or potassium dihydrogen phosphate ampoules added to the imprest stock will be required to obtain approval from Drug Committee.
- PLEASE NOTE: Potassium chloride and potassium dihydrogen phosphate ampoules are available from Pharmacy to ALL ward areas on presentation of a prescription. The quantity supplied will be limited to the quantity prescribed for the individual patient. After hours supply is available from the After Hours Drug Room (contact the AHNM).

1.8 Education and competency of staff

- Nursing staff caring for children receiving intravenous Potassium must have undertaken the related accreditation package in the safe administration of Potassium under the supervision of a Clinical Nurse Educator or Nurse Educator. (See appendix 2 for accreditation package)

2 Hypokalaemia

2.1 What is Hypokalaemia and what is its significance?

- The reference range for plasma Potassium in our laboratory for children over the age of one month is 3.5 to 5.5mmol/L. (For children less than one week it is 4.5 to 6.5 mmol/L, and for one week to one month it is 3.8 to 6 mmol/L).
- Hypokalaemia is defined as a Plasma Potassium of less than 3.5mmol/L.
- Severe hypokalaemia (plasma Potassium <2 mmol/L) can be life-threatening due to cardiac arrhythmia, particularly in the post-operative cardiac patient where any hypokalaemia may be symptomatic.
- Hypokalemic states occur either because of a net loss of Potassium from the body or as a result of intracellular shift of Potassium.
- Hypokalaemia enhances the cardiac toxicity of digoxin.
- Oncology patients are often on medications [Aminoglycosides (eg Gentamicin), Amphotericin B, Platinum] that cause nephrotoxicity and renal tubular dysfunction, resulting in Potassium loss in the urine.
- Children with diabetic ketoacidosis suffer from intracellular Potassium depletion and require approximately 5mmol/kg/day in the first 24 hours after presentation, i.e. twice the normal daily requirements.
- Hypomagnesaemia may coexist with hypokalaemia and can also cause cardiac arrhythmia. Hypomagnesaemia must be excluded and treated.

Table 1. Causes of hypokalaemia[5]

Cause	
Decreased extracellular or effective Potassium	Shift from Extracellular to Intra-cellular Compartments (may have normal total body Potassium) Glucose and insulin cause potassium to shift/move intracelluarly
Excessive renal loss	Tubular disease (drug induced or other) Steroids (primary or secondary hyperaldosteronism, glucocorticoids) Diuretics Non-reabsorbable anions (eg penicillins, bicarbonate) Diabetic ketoacidosis β_2 adrenergic agonists Alkalosis
Non renal loss	Vomiting Diarrhoea Laxatives Skin losses (eg Burns, excessive sweating)
Inadequate intake	

2.2 Clinical Features of Hypokalaemia

- The clinical picture varies considerably, depending on whether hypokalaemia is acute or due to chronic loss
- Symptoms and signs are more often encountered when hypokalaemia occurs acutely
- Symptoms /signs are not specific, but include:
  - drowsiness, lethargy, cramps, nausea, vomiting
  - skeletal muscle weakness
  - paralytic ileus (due to decreased contractility of smooth muscles)
  - cardiac arrhythmia

2.3 ECG Findings in Hypokalaemia

Electrocardiographic findings:

- Sagging of the ST segment,
- Decrease in T wave amplitude
- Appearance of a U wave.
- Ectopic activity (automaticity is increased).
- Arrhythmias:
  - heart block (of varying degrees)
  - ventricular tachycardia
  - bigeminy
  - ventricular fibrillation.

3 Prescription of Potassium

- Potassium must be prescribed in millimoles (mmol) clearly.
- The word Potassium must be used in the prescription, rather than the chemical symbol (K+).
- The salt must be included. For example potassium chloride, potassium dihydrogen phosphate or potassium acetate.
- The route of administration must always be prescribed.
- If the route is intravenous specify if to be given by peripheral or central route. For example for concentrations greater than 40mmol/L it is recommended that they be administered via a Central Venous Access Device (CVAD).
- Orders for intravenous Potassium must be signed and checked as per Policy for the Administration of Medications.
- All intravenous and enteral sources of Potassium, including TPN, must be totalled and recorded on the IV fluid order and in the continuation notes
- The Total Potassium Intake must be calculated in mmol/kg /hour.
- The infusion rate must be recorded on the IV Orders and in the continuation notes as mL/hr, mmol /hr, and mmol /kg /hr.

Example of a Potassium infusion order:

Fluid /Infusion Orders Current weight 20kg

Name: MRN:

Contents (including diluent)	**Total Volume (including diluent)**	**Route**	**Rate**	**Duration**	**Remarks**	**RMO Signature**
Potassium Chloride 25mmol in NaCl0.9%	50mL	IV via PICC	20mL/hr =10mmol/hr =0.5mmol/kg/hr	2 hours only then cease	Continuous ECG monitoring required	

Please note:

A small increase in infusion rate can substantially increase the amount of Potassium delivered.

4 Administration of Potassium

- **Maintenance Potassium requirements for normal children range from 1 to 2 mmol/kg/day, whether it is received orally or intravenously.**
- In most circumstances, hypokalaemia can be adequately corrected via the oral or intragastric route, so enteral administration should always be considered first.
- The daily dose of Potassium is determined based on maintenance requirements, deficit, and ongoing losses. In Potassium-losing states, very large amounts may be needed. (See Section 2.1).
- Children with oliguric renal failure should not receive any Potassium supplements without consultation with the Consultant in charge.
- The maximum rate of infusion of Potassium should not exceed 0.5mmol/kg/hour: Continuous ECG monitoring is required for rates exceeding or equal to 0.25mmol/kg/hr (as per section 5).
- Patients greater than 40kg who require rates of greater than 10mmol/hr must have continuous ECG monitoring. Note: The maximum rate for patients greater than 40kg is usually 20mmol/hr.
- Warning: Potassium containing fluids must not be used to prepare the IV administration of other drugs due to the high risk of incorrect rate of potassium being inadvertently administered.

4.1 Enteral Administration

Oral Potassium preparations are rapidly absorbed and can be utilised in lieu of the intravenous route. Commence with a dose of 2 mmol /kg, but higher doses may be needed. Be aware that many children may not tolerate the taste of Potassium supplements and that gastrointestinal disturbances can occur with the oral administration of Potassium.

Oral preparations available at CHW:

Name	Preparation	Dose
Chlorvescent	Effervescent tablet	14mmol K^+ per tab
Span K^+	Tablet for swallowing whole. Slow release	8mmol K^+ per tab
KCl 10% suspension	Solution	20mmol K^+ per 15mL

4.2 Intravenous Administration

4.2.1 Principles

The concentration of Potassium administered via a peripheral vein should not normally exceed 40mmol/L (20mmol /500mL) unless specific approval has been obtained.

The only indications for using higher concentration of Potassium via the peripheral intravenous route (and NOT to exceed 80mmol/L) are:

- Neuromuscular weakness caused by the hypokalaemia
- Cardiac rhythm disturbance caused by hypokalaemia
- Other symptomatic hypokalaemia, with plasma Potassium <3 mmol/L
- Extreme Potassium depletion (plasma Potassium <2 mmol/L)

The important safety components of intravenous Potassium replacement are:

- The rate at which the Potassium is to be delivered. This should NEVER exceed 0.5 mmol Potassium / kg / hour, regardless of route of administration. (for children greater than 40kg, maximum 20mmol/hr)
- The concentration at which the Potassium is to be delivered,
- The mode of infusion, via intravenous bag or syringe NOTE: Administration of all potassium containing fluids should be via infusion pump OR syringe pump, and
- Whether it is to be delivered via a peripheral or a central vein.
- Monitoring of patient and plasma levels (see section 5.0)

4.2.2 Concentrations of Potassium up to 40 mmol /L (20mmol / 500mL)

- Many patients can be successfully treated with intravenous Potassium concentrations of up to 40mmol /L (20mmol / 500mL), administered within maintenance intravenous fluids via a peripheral vein.
- Pre-mixed solutions containing 10mmol /500mL bag (20mmol /L) are available (see section 1.4).
- Table 2 demonstrates the Potassium intake in children on maintenance fluids using 10mmol /500mL and 20mmol /500mL solutions.

Table 2: Approximate Potassium intake in children receiving "maintenance" fluids with solutions containing 10mmol KCl / 500mL and 20mmol KCl / 500mL

Patient weight	10 kg	15 kg	20 kg	25 kg	30 kg	40 kg
Maintenance fluid intake (mL/day)	1000	1250	1500	1625	1750	2000
K^+ administered (mmol/kg/day) using 10mmol / 500mL bag	2	1.7	1.5	1.3	1.2	1
K^+ administered (mmol/kg/day) using 20mmol / 500mL bag	4	3.3	3	2.6	2.4	2

When adding Potassium concentrate solutions to any bag or infusion, it needs to be mixed vigorously to ensure even distribution because neat KCl is viscous. It is recommended to tip the container upside down *at least* ten (10) times.

4.2.3 Concentrations of Potassium of greater than 40mmol/L (>20mmol / 500mL)and up to 80mmol/L (=up to 40mmol / 500mL)

- Potassium concentrations between 41-80mmol/L are usually administered via a central vein.
- Administration of concentrations of Potassium from 41 to 80mmol/L may only be given if approved by one of the following **Consultants**:
    - **i.** An Intensivist in an Intensive Care Unit (Grace NICU and Paediatric ICU)
    - **ii.** An Emergency Physician in the Emergency Department* (see below)
    - **iii.** An Oncologist for oncology patients
    - **iv.** An Endocrinologist for diabetic keto-acidosis
    - **v.** A Gastroenterologist for Gastroenterology patients
    - **vi.** A Nephrologist for all other patients

    *NOTE: All orders for concentrations of Potassium greater than 40 mmol/L must be reviewed and re-approved once the patient leaves the Emergency Department.
- Peripherally administered concentrations of Potassium of greater than 40mmol/L (=20mmol / 500mL bag) should be avoided wherever possible as:
    - It may lead to painful sclerosis of small vessels, and extravasation causes tissue sloughing and necrosis.
    - Peripheral infusion into a vein in the hand or forearm is unsafe due to the risk of pooling with bending of the elbow, leading to sudden delivery of Potassium when the elbow straightens
- In the event that Potassium concentrations between 41-80mmol/L are administered via a peripheral vein, the following guidelines must be observed at all times:

i. Patients must be located in or transferred to a ward area where staff have been trained in the safe administration of Potassium

ii. The approved ward areas are NICU, PICU, RTC, Camperdown Ward, Variety Ward, Edgar Stephen Ward, Clancy Ward and the Emergency Department.

iii. Potassium is infused into a large, clearly patent, freely flowing vein, with no risk of intermittent occlusion.

iv. The intravenous site must be inspected hourly and infusion ceased if there is any evidence of phlebitis or extravasation or if the patient experiences pain.

v. Consider insertion of a Central Venous Access Device (CVAD) if replacement is required for a more than a few hours.

- Potassium solutions greater than 40mmol/L should only be prescribed and administered in approved areas (NICU, PICU, RTC, Camperdown Ward, Variety Ward, Edgar Stephen Ward, Clancy Ward and the Emergency Department). In exceptional individual patient circumstances where the child requires solutions greater than 40mmol/L and it is unsafe to move the child to a ward aforementioned, approval may be granted by the Director Clinical Governance (DCG) or the Executive On-Call to administer the infusion outside of the above mentioned ward areas. Appropriately skilled staff and monitoring will still be required as per this Practice Guideline.

4.2.4 Concentrations of Potassium of greater than 80mmol/L (greater than 40mmol Potassium / 500mL)

- Concentrations of greater than 80mmol/L (40mmol / 500mL bag) may only be administered via a central venous access device (CVAD) and only in the following areas: NICU, PICU, RTC, Camperdown Ward, Variety Ward, Clancy Ward and the Emergency Department
- The only indication for the use of such high concentrations of Potassium is a child with symptomatic hypokalaemia who is on severe fluid restriction, such that the required amount of Potassium may not be safely administered in a more dilute solution.
- Every effort should be made to replace Potassium via the enteral route or via a more dilute solution.
- Potassium solutions greater than 40mmol/L should only be prescribed and administered in approved areas (NICU, PICU, RTC, Camperdown Ward, Variety Ward, Edgar Stephen Ward, Clancy Ward and the Emergency Department). In exceptional individual patient circumstances where the child requires solutions greater than 40mmol/L and it is unsafe to move the child to a ward aforementioned, approval may be granted by the Director of Clinical Governance (DCG) or the Executive On-Call to administer the infusion outside of the above mentioned ward areas. Appropriately skilled staff and monitoring will still be required as per this Practice Guideline.

4.2.5 Infusions of Potassium by Syringe Pump- To be administered via central line only

- Infusions of highly concentrated Potassium via a syringe pump should, where possible, be avoided, because of the potential risk of an accidental rapid delivery of Potassium.
- Approval to administer a concentrated Potassium infusion via a syringe pump must be obtained from the appropriate Consultant as in section 4.2.3 above.
- The Nursing Team Leader must be notified that a Potassium infusion is to be employed.
- Potassium infusion via syringe pump may only be used in NICU, PICU, RTC, Emergency Department, Camperdown Ward, Variety Ward and Clancy Ward. The maximum concentration of KCl to be used is 0.5mmol /mL. Maximum rate of infusion must not exceed 1mL/kg/hr (=0.5mmol Potassium/kg/hr), to a maximum of 20mmol/hr in children greater than 40kg.
- Concentrated Potassium Chloride ampoules contain 10mmol of Potassium Chloride in 10mL and must always be diluted before use:
- Constituting a Potassium chloride infusion: Dilute Potassium chloride to a final concentration of 0.5mmol /mL by combining **equal** amounts of concentrated Potassium chloride and sterile water into a 50mL syringe, eg:
    - 25mL of Potassium chloride solution with 25mL of sterile water (=25mmol Potassium in 50mL), or
    - 20mL of Potassium chloride solution with 20mL sterile water (=20mmol Potassium in 40mL)
    - This MUST be administered via a Central Venous Access Device (CVAD) Only

    Infusion of Potassium may be administered via a syringe pump peripherally if the concentration is less than or equal to 40mmol/L

5 Monitoring of Children Receiving Intravenous Potassium

5.1 Monitoring

5.1.1 Intravenous site

For all peripheral infusions of Potassium, the intravenous site must be inspected hourly and the infusion ceased immediately if there is any evidence of phlebitis (redness at the site, or along the path of the vein) or extravasation, or if the patient complains of pain.

Table 3. Required Biochemical and Vital Sign Monitoring

Equivalent Total Potassium intake per day	Total Potassium Intake per hr	Required Monitoring
< 4mmol/kg/day	<0.17mmol/kg/hr	Plasma Potassium at least daily Vital Sign Monitoring 4th hourly
4 – 6mmol /kg /day	0.17 – 0.25mmol/kg/hr	Plasma Potassium at least 12th hourly Vital Sign Monitoring 2nd hourly
6 – 7.2mmol /kg /day	0.25 – 0.3mmol/kg/hr	Plasma Potassium at least 4th hourly until stable, then 6th - 12th hourly thereafter Continuous ECG initially and Vital Sign Monitoring hourly then 2nd hourly if stable.
> 7.2mmol /kg /day	>0.3mmol/kg/hr	Plasma Potassium must be checked 1 - 2 hours after initiation of therapy or increase in infusion rate and every 2 to 4 hours thereafter Continuous ECG monitoring & Vital Sign Monitoring hourly

- The maximum rate of infusion of Potassium should not exceed 0.5mmol/kg/hour: Continuous ECG monitoring is required for rates exceeding or equal to 0.25mmol/kg/hr.
- Patients greater than 40kg who require rates of greater than 10mmol/hr must have continuous ECG monitoring. Note: The maximum rate for patients greater than 40kg is usually 20mmol/hr.

Rarely, less frequent blood sampling may be indicated in some patients, depending on clinical circumstances. In these cases, the Medical team at the time of initiation of therapy must determine the frequency of sampling and designate a target Plasma Potassium level. These will be **documented in the continuation notes**.

5.1.2 Monitoring for children receiving Potassium at greater than 6mmol / kg / day (>0.25mmol/kg/hr)

1. **Location of the patient**:
   - The patient must be located in an intensive care area or other designated ward (PICU, Emergency, Camperdown Ward, Variety Ward or Clancy Ward)
   - In exceptional individual patient circumstances where it is unsafe to move the child to a ward listed above, approval may be granted by the Director of Clinical Governance (DCG) or the Executive On-Call to administer the infusion outside of the above mentioned ward areas. Appropriately skilled staff and monitoring will still be required as per this Practice Guideline.
2. **Vital signs:**
   - Hourly vital signs
3. **Cardiac monitoring**:
   - ECG monitoring
   - The ward area should have defibrillation equipment immediately available.
4. **Biochemical monitoring:**

   Potassium
   - Plasma Potassium must be performed within 1-2 hours after initiation of therapy and after any increase in infusion rate, and at least every 2 - 4 hours thereafter.
   - Less frequent blood sampling may be indicated in some patients, depending on clinical circumstances. The Medical Team at the time of initiation of therapy will determine the frequency of sampling and designate a target Potassium level. These will be documented in the continuation notes. For example, maintaining Potassium of less than 3mmol/litre may be appropriate for an oncology patient.
   - Each and every Plasma Potassium result must be reviewed by both nursing and medical staff.
   - NB: Point-of-care Gas and Electrolyte Analysers are located in NICU, PICU, ED and Camperdown Ward. These machines are accurate and reliable and are available 24 hours a day.

   Renal function
   - Renal function must be monitored regularly.
   - This includes:
     - **i.** Frequent assessment of urine output (normally greater than or equal to 1mL/kg/hour), and
     - **ii.** Measurement of plasma urea and creatinine.
   - If there is falling urine output or deteriorating renal function, then the infusion should be slowed or stopped and the need for Potassium replacement urgently reassessed.

6 Recognition of Hyperkalaemia

6.1 What is hyperkalaemia?

- The reference range for plasma Potassium in our laboratory for children over the age of one month is 3.5 to 5.5mmol/L. (For children less than one week it is 4.5 to 6.5mmol/L, and for one week to one month it is 3.8 to 6 mmol/L).
- Thus, hyperkalaemia is a value of Plasma Potassium above these levels.
- Should hyperkalaemia occur as a consequence of Potassium infusion, the infusion should be stopped immediately. Prompt recognition and appropriate treatment of hyperkalaemia are essential if a good outcome is to be achieved.

Note: If the blood specimen used for Plasma Potassium measurement is haemolysed, then the Plasma Potassium result may be spuriously elevated. However, **NEVER** assume a sample is haemolysed in any patient receiving intravenous potassium, and always suspend administration of all Potassium containing fluids while the plasma level is rechecked **urgently**.

6.2 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.

6.3 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 4. However it must be remembered that Potassium levels at which specific ECG abnormalities are seen can vary widely from patient to patient.
- Representative ECG rhythm strips are shown in the Appendix 1.

Table 4: ECG manifestations of hyperkalaemia

Serum K^+ (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
> 8	P waves disappear, marked widening of QRS, "sine wave" pattern, high risk of VF or asystole

7 Treatment of Hyperkalaemia

7.1 General principles for treating hyperkalaemia

1. Cease all exogenous sources of Potassium (intravenous and oral supplements)
2. Change the electrical threshold potential for arrhythmias
3. Shift Potassium from extracellular to intracellular compartments
4. Promote Potassium loss from the body

7.2 What to do in the event of severe hyperkalaemia

- Treat any report of Hyperkalaemia as a potential medical **emergency** and act promptly.
- Any arrhythmia on ECG is a MEDICAL EMERGENCY.
- Stop all exogenous sources of Potassium.
- If no palpable pulse or no signs of life, or HR < 60 B.P.M.:
    - Commence CPR
    - Put out an arrest call (phone 444: state "Arrest Team to …*location*"

7.3 Treatment of Hyperkalaemia

All or some of the following may be indicated, depending upon circumstances (eg Plasma Potassium level):

- Intravenous calcium chloride 10%, 0.2mL/kg, over 5 minutes (central administration preferred if possible)
- Intravenous sodium bicarbonate, 8.4%, 1mmol/kg, slow push
- Salbutamol, either via nebuliser or intravenously:
    - Salbutamol nebuliser: weight <25 kg , 2.5 mg
      weight >25 kg, 5 mg
    - Salbutamol intravenous: 4-5 micrograms/kg over 15-20 minutes
- Intravenous Glucose, 50% 0.5 g/kg (=1mL/kg) stat.
- Insulin, 0.1 U/kg, may be given with the glucose. This is the most potent temporary treatment for hyperkalaemia. However the patient will need to be monitored for hypoglycaemia.
- Remove Potassium from the body by treating with:
    - A loop diuretic eg Frusemide 1mg/kg, for patients not in renal failure
    - Resonium (1g/kg) orally or rectally.
    - Dialysis (haemodialysis or peritoneal dialysis).
- If the child is not already in the PICU, arrange review and/or transfer to PICU.

References

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5. Harrison's Online, 2001-2002. Chapter 49, Page 21. McGraw-Hill.
6. National Patient Safety Agency. *Patient Safety Alert 23 July*. London: National Patient Safety Agency, 2002
7. Australian Council for Safety and Quality in Healthcare Medication Safety Taskforce. *Intravenous Potassium chloride can be fatal if given inappropriately*. Australian Council for Safety and Quality 2003
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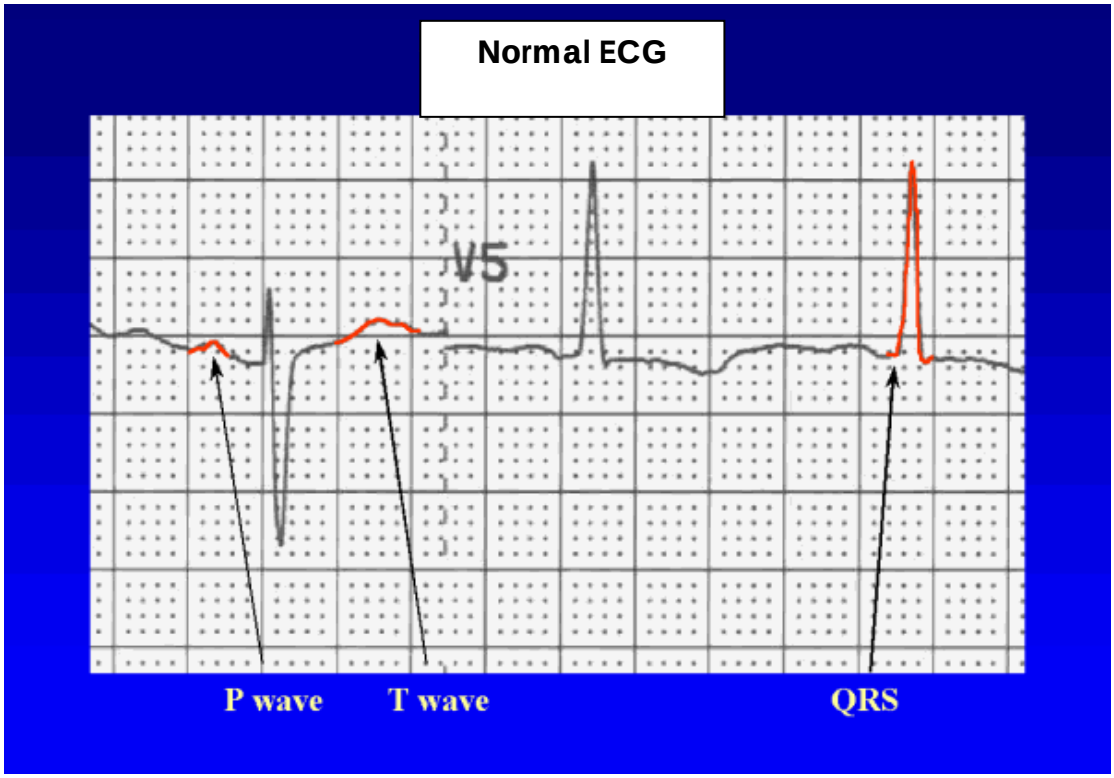
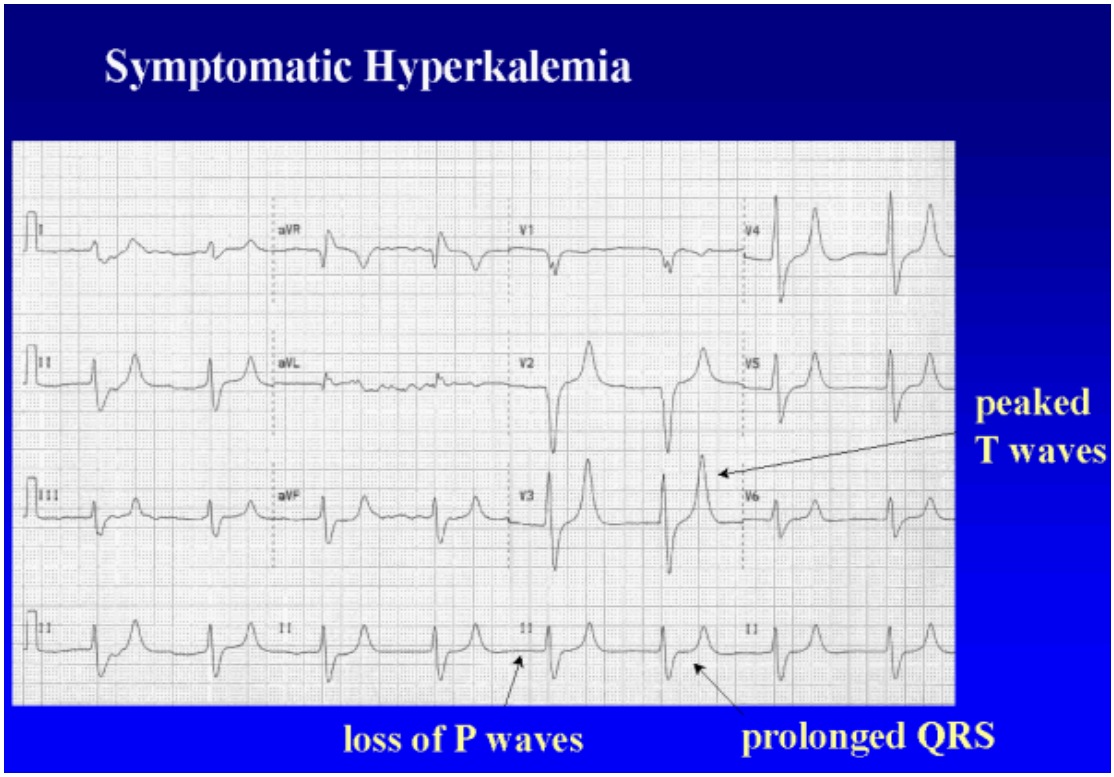
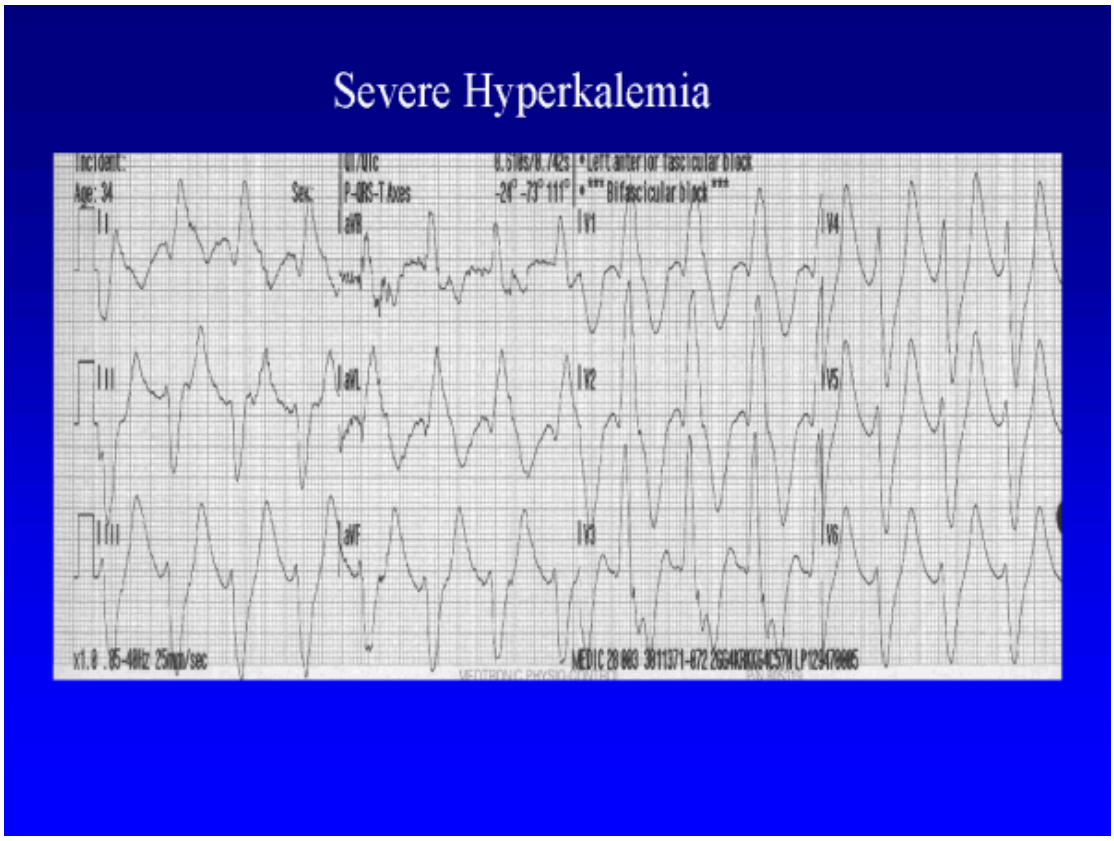
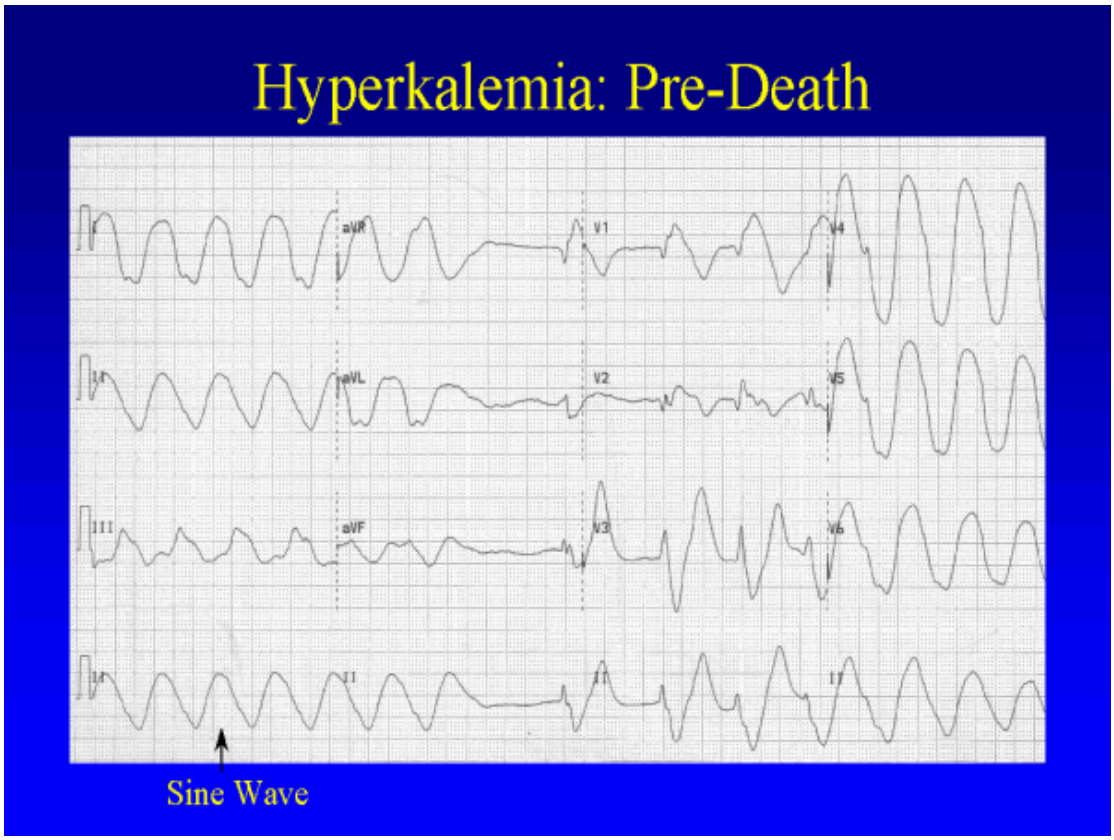
9. NSW Health Policy Directive PD2005_342. *Safe Handling of Intravenous Potassium Chloride in Health Care Facilities – Policy.* http://www.health.nsw.gov.au/policies/PD/2005/pdf/PD2005_342.pdf (accessed August 2010)

Appendix 1: ECG Rhythm Strips

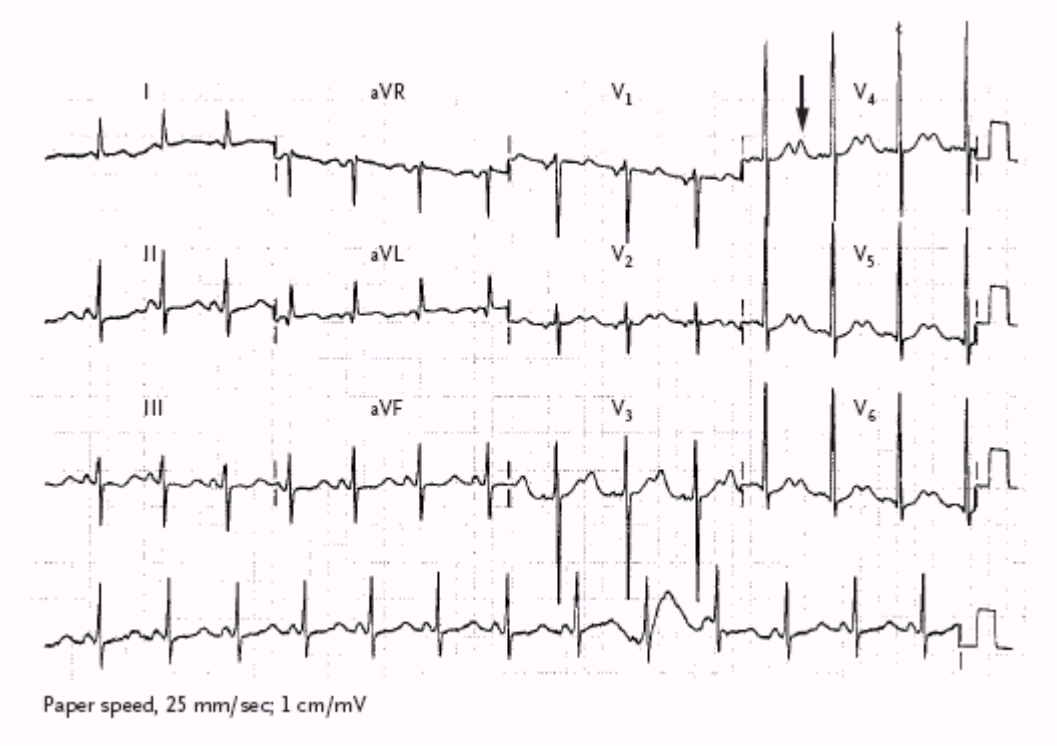





Severe Hyperkalemia


Hyperkalemia: Pre-Death
Sine Wave

Hypokalaemia



This ECG shows sinus rhythm with prominent U waves (arrow) and a prolonged QT interval.

(The patient's serum Potassium was 1.4 mmol/L)

Appendix 2: Potassium Infusion Accreditation Package for RNs

Worksheet for High Dose Intravenous Potassium Administration

Before administering high dose Potassium you must complete this worksheet.

Please refer to the Potassium Administration Guidelines for the completion of this worksheet.

Name: _____ ID No: _____

Date: _____

Assessors Comments

_____

_____

_____

Name_____ Signature_____

Rationale (as per Potassium Administration Guidelines)

- Potassium is well established as one of the most hazardous drugs in use in hospitals. It has been involved in catastrophic outcomes in hospitals worldwide, including our own.
- Intravenous Potassium is potentially lethal because hyperkalaemia can cause cardiac arrhythmias/asystole via a direct effect on the myocardium.

Goal

To provide a standardised education program for registered nurses to complete prior to administering high dose intravenous Potassium to ensure safe practice and to reduce risk to patients.

Objectives

After completion of this worksheet, you will be able to demonstrate:

- A knowledge and understanding of the risks associated with the administration of high dose intravenous Potassium.
- Competence in the calculations associated with administering high dose intravenous Potassium.

There are many forms of Potassium supplementation including oral supplements such as Span K and Chlorvescent, and IV additives such as Potassium Chloride, Potassium Dihydrogen Phosphate and Potassium Acetate, throughout this worksheet when referring to IV Potassium we have used Potassium Chloride as the example.

Section One

1. What is accepted as the normal serum Potassium range for a child aged
   - i. Less than a week? _____
   - ii. One week to one month? _____
   - iii. Over one month? _____

2. List 4 of the causes of Hypokalaemia.

_____

_____

_____

3. A four year old child, who has vomiting and diarrhoea, has a serum Potassium level of 2.4mmol/L.
   - i. What symptoms would be consistent with low serum Potassium?

     _____
     _____
     _____
     _____
   - ii. What actions would you take/initiate?

     _____
     _____
     _____
     _____

Section Two

4. What is the maximum concentration, per 500mL, of Potassium chloride that can be:
   - i. administered peripherally? _____
   - ii. administered via a CVAD? _____

5. Name five of the wards at CHW that are approved to administer high dose intravenous Potassium chloride.

   _____
   _____

6. What is the maximum concentration of Potassium chloride, in mmol/mL that can be administered via a syringe pump? _____

7. Please fill in the blank spaces in the table below.

Required Biochemical and Vital Sign Monitoring

Total Potassium Intake per hr	Equivalent Total Potassium intake per day	Required Biochemical Monitoring	Required Vital Sign Monitoring
<0.17mmol/kg/hr	<4mmol/kg/day		
0.17-0.25mmol/Kg/hr	4 – 6mmol/kg/day		
0.25 –0.3mmol/kg/hr	6 – 7.2mmol/kg/day		
>0.3mmol/kg/hr	>7.2mmol/kg/day		

Section Three

8. A child with vomiting and diarrhoea, who is receiving a concentrated Potassium infusion for hypokalaemia, has a serum Potassium of 6mmol/L. He is asymptomatic.

i. What is the child at risk of?_____
_____
_____

ii. What are the appropriate nursing actions? _____
_____
_____
_____
_____

9. List the treatment options that may be utilised when responding to patient with Hyperkalaemia? _____
_____
_____
_____
_____
_____
_____

Section Four

Drug calculations

- See Appendix 3 for examples

10. A 3.5 kg infant is ordered Potassium chloride 20 mmol/500mL running at 17.5mL/hr, what is this in mmol/kg/day? _____

11. A 15 Kg patient is requiring Potassium chloride via a syringe pump at 15mL/hr with Potassium chloride 25mmol/50mL. What is the mmols/kg/hr?

12. A 10 kg patient is ordered a Potassium chloride infusion of 25 mmol/50mL to run at 0.2mmol/kg/hr. What is the rate in mL/hr?

13. A 14 kg patient is receiving TPN, with running at 40mL/hr which has 60mmol/L of Potassium chloride . They are also receiving a twice daily nasogastric dose of Chlorvescent of 14mmol. How many A) mmol/kg/day and B) mmol/kg/hr of Potassium is this patient receiving?

Appendix 3: Infusion Dose and Rates - Examples

Example 1:

A 2.5 kg infant is receiving IV therapy with 30mmol/L of Potassium chloride at 12.5mL/hr. What is the mmol/kg/hr?

- This is calculated by multiplying the infusion rate by 24 (hours in the day).
  - 12.5 x 24 = 300mL

- The child is receiving 0.3 L of fluid in a 24 hour period with 30mmol of Potassium chloride/L added.
- Next you multiply the amount of fluid in Litres by the amount of Potassium chloride
  - 0.3 x 30 = 9 mmol

- This is then divided by the child's weight and converted to mmol/kg/day
  - 9 / 2.5 kg's = 3.6mmol/kg/day

- This is then divided by 24, to get mmol/kg/hr
  - 3.6 / 24 = 0.15mmol/kg/hr

Example 2:

A 10 kg child is requiring a concentrated Potassium chloride infusion via a syringe pump at 3mL/hr with Potassium chloride of 25 mmol/50mL. What is the mmol/kg/hr?

- Multiply the infusion rate by 24 to get the amount in a day
  - 3 x 24 = 72mL/day

- Next divide this by the child's weight
  - 72 / 10 = 7.2 mmol

- Next divide this by 24 and then by 2 to get the mmol/kg/hr
  - 7.2 / 24 = 0.3/2 = 0.15mmol/kg/hr

Example 3:

An 8kg child is receiving a concentrated Potassium chloride infusion of 0.5mmol/mL at 0.4mmol/kg/hr via a syringe pump. What is the rate in mL/hr?

- This is calculated by multiplying the weight by the mmol/kg
  - 8 x 0.4 = 3.2mmol/hr

- This is then divided by the strength of the infusion =0.5mmol/mL
  - 3.2 / 0.5mmol = 6.4mL/hr

Note that a syringe pump infusion is made up to the Potassium concentration of 0.5mmol/mL.

Example 4:

A 55 kg patient is receiving TPN, running at 85 mL/hr, with 140 mmol/L of Potassium, and they are also receiving oral Span K two tablets three times a day. (Please note that each Span K tablet has 8 mmol of Potassium chloride). How much Potassium in **A)** mmol/kg/day and **B)** mmol/kg/hr is this patient receiving?

- Vamin, Times the rate by 24 to get the daily fluid intake
  - 24 x 85= 2040 mL/day = 2.04 L/day

- The child is receiving 2.04 L of Vamin in a 24 hour period with 140 mmol of Potassium chloride/L added
- Next you multiply the amount of Vamin in Litres by the amount of Potassium
  - 2.04 x 140 = 285.6 mmols

- Span K, Two tablets, three times a day (each tablet contains 8 mmol of Potassium)
  - 2 x 3 x 8 = 48 mmol

- Total the amount of Potassium received in one day
  - 48 + 285.6 = 333.6 mmol/day

- **A)** Then divide this by the child's weight and converted to mmol/Kg/day
  - 333.6 / 55 = 6.06 mmol/kg/day
- **B)**Then divide this by 24 to convert to mmol/kg/hr
  - 0.25 mmol/kg/hr

Appendix 4: Log book documentation

The information below should be documented in a bound log book or folder

A) Potassium Chloride Log (10mmol/10mL ampoules)

Date	Patient Name	MRN	Potassium Amount in mmol in bag/syringe	No. amps received from pharmacy	No. amps taken	Balance	Name and Sign	Name and Sign

The information below should be documented in a bound log book or folder

B) Potassium Dihydrogen Phosphate Log (10mmol/10mL ampoules)

Date	Patient Name	MRN	Potassium Amount in mmol in bag/syringe	No. amps received from pharmacy	No. amps taken	Balance	Name and Sign	Name and Sign

The information below should be documented in a bound log book or folder

C) Potassium Acetate Log (25mmol/5mL ampoules –FOR PICU ONLY)

Date	Patient Name	MRN	Potassium Amount in mmol in bag/syringe	No. amps received from pharmacy	No. amps taken	Balance	Name and Sign	Name and Sign

Appendix 5: Authorised Wards/Departments with Potassium Chloride Ampoules (10mmol/10mL) on their Imprest

The wards and areas outside of the Pharmacy Department currently authorised to keep Potassium Chloride ampoules 10mmol/10mL on the imprest are:

- Anaesthetics Department
- Camperdown Ward
- Clancy Ward
- Edgar Stephens Ward
- Emergency Department
- Grace Centre for Newborn Care (GCNC)
- PICU
- Renal Treatment Centre
- Variety Ward
- Wade Ward