The Regulation and Quality Improvement Authority

Guidelines for the Treatment of Hyperkalaemia in Hospitalised Adults

March 2021

www.rqia.org.uk

Assurance, Challenge and Improvement in Health and Social Care

PREFACE

Guidelines for Treatment of Hyperkalaemia in Hospitalised Adults

The functions and work previously undertaken by The Guidelines & Audit Implementation Network (GAIN), relating to facilitating and funding of Guidelines and Audit were transferred to Regulation and Quality Improvement Authority on 1 April 2015 are now part of the Improvement Directorate sitting within the Reviews and Audit Team.

This guideline is a review of the GAIN 2014 guideline and was produced by a subgroup of health care professionals from varied backgrounds and was chaired by Professor Peter Maxwell, Professor of Renal Medicine.

RQIA wishes to thank all those who contributed in any way to the development of these guidelines and in particular reviewers of earlier draft guidelines.

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FOREWORD

Hyperkalaemia is a common electrolyte disorder. The reported incidence of hyperkalaemia in hospitalised in patients is between 1% and 10%. It is arguably the most serious of all electrolyte abnormalities as the symptoms can be non-specific or absent, even in severe hyperkalaemia, before causing cardiac arrest. The common predisposing factors are kidney failure and drugs. Many cases are associated with medicines known as renin-angiotensin-aldosterone system inhibitors (RAASi) or other medicines that interfere with renal potassium excretion. Hyperkalaemia usually occurs in the setting of chronic kidney disease and/or acute kidney injury.

This guideline updates the previous 2014 GAIN Guideline for the Treatment of Hyperkalaemia in Adults. The major changes in the updated guidance are revised recommendations for monitoring of blood glucose before and after treatment of hyperkalaemia. This change is in recognition of the risk of hypoglycaemia in patients receiving insulin and glucose as part of the treatment for hyperkalaemia.

The instructions accompanying the hyperkalaemia kit have been updated to provide concise information that will enable doctors to effectively manage patients presenting with hyperkalaemia. In particular, the safe and effective use of insulin and glucose in the treatment of hyperkalaemia is highlighted, the requirement to always use an insulin syringe in drawing up insulin is emphasized and the importance of having a check of insulin dose by a senior nurse before insulin is administered to the patient is outlined. **Blood glucose monitoring before and after treatment of hyperkalaemia is an essential component of the overall management of the patient**.

I would like to thank Ms Sharon O'Donnell, Lead Medication Safety Pharmacist, BHSCT, Dr Paul Hamilton, Consultant Chemical Pathologist, Dr John Harty, Consultant Nephrologist and Dr Neal Morgan, Consultant Nephrologist for their help in producing this updated guidance. I also wish to thank the many reviewers who provided valuable feedback.

Professor Peter Maxwell
Professor of Renal Medicine

INTRODUCTION

Hyperkalaemia in Hospitalised Adults

The reported incidence of hyperkalaemia in hospitalised patients is between 1 and 10%. **The vast majority of cases occur in individuals with pre-existing chronic kidney disease (CKD) or new onset acute kidney injury (AKI).**[1-3]

Hyperkalaemia is more likely to occur when persons with kidney disease are prescribed renin-angiotensin-aldosterone system inhibitors (RAASi), such as angiotensin converting enzyme inhibitors (ACEi) or angiotensin II receptor blockers (ARBs), and the mineralocorticoid receptor antagonists spironolactone or eplerenone. These drugs are commonly prescribed to manage chronic conditions in patients with diabetes, cardiovascular and/or renal disease.

Hyperkalaemia is classified based on the potassium concentration [K^+]

Mild hyperkalaemia	[K^+] 5.5 – 5.9 mmol/L
Moderate hyperkalaemia	[K^+] 6.0 - 6.4 mmol/L or
Severe hyperkalaemia	[K^+] ≥ 6.5 mmol/L

Mild hyperkalaemia is usually of no immediate clinical significance and urgent treatment is not recommended.

Moderate and severe hyperkalaemia can show ECG changes or symptoms (muscle weakness or flaccid paralysis, palpitations, paraesthesia) at ANY level of potassium concentration ≥ 6.0 mmol/L, especially if associated with hypoxia.

These guidelines briefly describe the causes of hyperkalaemia and the mechanisms responsible for hyperkalaemia. The written guidelines outline initial steps in assessment of hospitalised patients with hyperkalaemia and describes when treatment is appropriate. The importance of monitoring patients for recurrent hyperkalaemia and/or hypoglycaemia following initial treatment is emphasised. The initial assessment and management of hyperkalaemia in hospitalised adults is also summarised in an algorithm (Appendix 1). Recommended glucose monitoring intervals pre- and post-treatment with insulin and glucose are outlined (Appendix 1).

AETIOLOGY OF HYPERKALAEMIA

Renal Causes

- Acute kidney injury (AKI) or chronic kidney disease (CKD)
- Medicines that interfere with renal potassium excretion (amiloride, spironolactone, eplerenone, trimethoprim)
- Medicines that interfere with the renin-angiotensin-aldosterone system (angiotensin converting enzyme inhibitors, angiotensin II receptor blockers, nonsteroidal anti-inflammatory agents, heparins)
- Mineralocorticoid deficiency (hypoaldosteronism states), including hyperkalaemic renal tubular acidosis (type IV)

Transcellular shift (intracellular to extracellular compartment)

- Acidosis (including diabetic ketoacidosis)
- Medicines (digoxin poisoning, suxamethonium, beta-blockade)

Increased circulating potassium - Exogenous or Endogenous

- Exogenous (potassium supplementation)
- Endogenous (tumour lysis syndrome, rhabdomyolysis, trauma, burns)

Mechanisms of Hyperkalaemia in Adult Inpatients

Hyperkalaemia commonly results from either:

1. **Shift of potassium from intracellular (inside cells) to extracellular (outside cells)** that is caused by reduced activity of the sodium/potassium (Na^+/K^+) ATPase pump, or
2. **Decreased excretion of potassium** from the body because of renal impairment (chronic kidney disease or acute kidney injury)

In acute illness, there is often a **shift of potassium from intracellular stores** due to reduced activity of the sodium/potassium (Na^+/K^+) ATPase pump. Reversing this process by stimulating the Na^+/K^+ ATPase pump action with insulin and salbutamol helps to correct life-threatening hyperkalaemia. Glucose must be co-administered with insulin to limit the risk of subsequently developing life-threatening hypoglycaemia.[1-5]

Patients prescribed long-term RAASi, and other potassium-sparing medications, will tend to have **decreased renal potassium excretion** and therefore can have chronic mild hyperkalaemia. Patients with chronic kidney disease prescribed RAASi are particularly likely to have hyperkalaemia even during periods of stable health. These patients have an excess of total body potassium. This has important clinical implications for the safe and effective management of hyperkalaemia in patients prescribed RAASi when they may present with moderate or severe hyperkalaemia. Since the total body potassium is increased, it is predictable that the hyperkalaemia will take longer to resolve, despite RAASi being temporarily withheld. If choosing to manage such patients with insulin (and glucose) and salbutamol, which transiently shift potassium into cells for several hours, it may be expected that the patients will have rebound hyperkalaemia when the effects of insulin (and glucose) and salbutamol diminish. **If repeated insulin and glucose infusions are required to correct the potassium level to a target concentration (i.e. $[K^+]$ <6.0 mmol/l), then this increases the cumulative risk of iatrogenic hypoglycaemia in these patients**. The potassium concentration can be measured in a whole blood, plasma or serum specimen.

Increasing elimination of potassium from the body

For patients with an excess of total body potassium it is possible to enhance gastrointestinal potassium loss with potassium binding agents. Two agents, **Sodium Zirconium Cyclosilicate** and **Patiromer**, are licensed for use in outpatients with persistent moderate hyperkalaemia (potassium at least 6.0 mmol/L) and chronic kidney disease or heart failure if hyperkalaemia is preventing an optimal dosage of RAASi.[6,7] **NICE has approved the use of Sodium Zirconium Cyclosilicate or Patiromer as options in the treatment of acute life-threatening hyperkalaemia, alongside medical therapy with insulin and glucose, in hospitalised patients**

Pseudo-hyperkalaemia

Sometimes the measured potassium concentration is higher than the actual potassium concentration in the body. This is pseudo-hyperkalaemia and can occur due to the process of drawing or transporting a sample prior to analysis e.g.

- Prolonged tourniquet time or excessive fist clenching during sampling
- Test tube haemolysis (at time of sampling, vigorous tube inversion or use of pneumatic tube transport systems)
- Undetected sample haemolysis. Haemolysis will be detected in the laboratory, but not when using a point-of-care whole blood analyser
- Delayed centrifugation of sample (a particular problem when a sample is taken in a remote location and needs to be transported to a central laboratory)
- Marked leucocytosis and thrombocytosis (measurement of plasma rather than serum potassium concentration is usually helpful in these disease states)
- Sample taken from a limb infused with IV fluids containing potassium

Point-of-care testing (POCT) analysers

POCT analysers provide a convenient and rapid means of determining the potassium concentration in whole blood. As such, POCT analysers are often used to identify hyperkalaemia and in patient monitoring following emergency treatment. However, users must be aware that the **POCT analysers currently in use in Northern Ireland <u>cannot</u> test for haemolysis**. This means that an apparently elevated potassium concentration reported on a POCT analyser may either be correct (hyperkalaemia is present) or false (haemolysis has caused the elevated potassium level).

A POCT analyser result can rule out hyperkalaemia (when a normal or reduced potassium concentration result is returned) but cannot be relied upon to establish if hyperkalaemia is truly present. Anyone interpreting potassium results from a POCT analyser must be fully aware of these limitations.

A blood sample sent to the laboratory can establish if hyperkalaemia is actually present. Such samples are generally preferred as laboratory analysers test for haemolysis and only report potassium results if appropriate to do so. Results can be obtained urgently following liaison with the local biochemistry laboratory.

ASSESSMENT OF THE PATIENT

Is this 'true' hyperkalaemia?

As pseudo-hyperkalaemia is relatively uncommon in hospitalised patients, clinicians should urgently correct severe hyperkalaemia unless they are very confident that the measured potassium result is spuriously elevated.[8]

A repeat potassium concentration should be sent urgently in a green top tube (lithium heparin) if the hyperkalaemia is unexpected and/or out of the usual context where acute hyperkalaemia occurs (e.g. ill patient with acute kidney injury or chronic kidney disease, hypoxia, recent RAASi use).

How severe is the hyperkalaemia?

Hyperkalaemia is classified as –

- mild hyperkalaemia ($[K^+]$ 5.5 – 5.9 mmol/L)
- moderate hyperkalaemia ($[K^+]$ 6.0 - 6.4 mmol/L) or
- severe hyperkalaemia ($[K^+] \geq 6.5$ mmol/L)
- mild hyperkalaemia is usually of no immediate clinical significance and urgent treatment with insulin and glucose is not recommended
- moderate and severe hyperkalaemia can show ECG changes or symptoms (muscle weakness or flaccid paralysis, palpitations, paraesthesia) at **ANY** level of potassium concentration ≥ 6.0 mmol/L, especially if associated with hypoxia

Situations associated with a rapid rise in potassium (acute kidney injury, rhabdomyolysis and hypoxia of any cause) are more strongly associated with the development of cardiac conduction disturbances.

Mild hyperkalaemia is common and often well tolerated in patients with chronic kidney disease. Mild hyperkalaemia (potassium concentration 5.5-5.9 mmol/L) does not require urgent treatment.

Is urgent treatment required?

Urgent treatment is required if the potassium concentration is ≥ 6.5 mmol/L.

Urgent treatment is needed if hyperkalaemia is accompanied by ECG changes and/or hyperkalaemic symptoms that can be directly attributed to an increased potassium concentration ≥ 6.0 mmol/L.

Urgent treatment is needed if the potassium concentration is ≥ 6.0 mmol/L and expected to continue rising rapidly e.g. patients with massive cell injury such as rhabdomyolysis or tumour lysis syndrome

For all patients with moderate and severe hyperkalaemia (i.e. potassium concentration ≥ 6.0 mmol/L), the decision to proceed or not proceed with potassium lowering treatment should be agreed with a senior doctor. ECG changes can be non-specific and difficult to interpret.[4-5]

Why has the patient got hyperkalaemia?

A comprehensive medical and medication history and clinical examination should be performed. The reason for the hyperkalaemia should be identified by considering if there is a problem with

a. shift of potassium from the intracellular (inside cells) to extracellular (outside cells) compartment due to reduced activity of the Na^+/K^+ ATPase pump;

b. decreased excretion of potassium from the body;

c. or both.

Action should be taken to prevent further accumulation of potassium in the body e.g. withhold RAASi; stop potassium supplements; commence a low potassium diet. Patients with suspected or known hyperkalaemia should have an urgent clinical assessment using the national early warning score (NEWS) criteria. A history of renal disease and determination of the medications or fluids prescribed will often reveal the cause of the hyperkalaemia.

PATIENT MONITORING

The 12 lead ECG

- An urgent ECG is recommended in all hospitalized patients with potassium concentration [K+] ≥ 6.0 mmol/L

- Many patients, without hyperkalaemia, have an abnormal baseline ECG. Therefore, caution is necessary interpreting an ECG. Urgent treatment is needed if the patient has hyperkalaemia (confirmed by U&E result) and the ECG features are consistent with hyperkalaemia

- ECG features that can be present in a patient with hyperkalaemia include decreased or absent P-waves, PR prolongation, peaked T waves, QRS widening, sine wave QRST, AV dissociation or asystole. It is often difficult to judge if T waves are truly peaked and this finding on its own should not be an automatic indication for urgent treatment. Comparison with previous ECGs for the patient is helpful to see if the ECG changes are new.

- **The ECG does not always demonstrate hyperkalaemic changes, even in the presence of severe hyperkalaemia**. A normal ECG does not exclude the need for urgent treatment if severe hyperkalaemia, [K+] ≥ 6.5 mmol/L, has been confirmed.

- An ECG can be considered if hyperkalaemia is mild ($[K^+]$ > 5.5-5.9 mmol/L) however ECG changes (due to hyperkalaemia) are very unlikely when [K+] <6.0 mmol/L. Be wary of misinterpreting ECG abnormalities as indicating features of hyperkalaemia when the potassium concentration is <6.0 mmol/L

Continuous ECG Monitoring (Telemetry)

Continuous ECG monitoring is recommended in all patients with a potassium concentration [K+] ≥ 6.5 mmol/L, and in patients with potassium concentration $[K^+]$ 6.0-6.4 mmol/L and associated ECG features of hyperkalaemia. When available, continuous ECG monitoring should be considered for patients with potassium concentration $[K^+]$ 6.0-6.4 mmol/L without hyperkalaemic ECG features BUT in whom a rapid rise in potassium concentration is expected (e.g. acute illness, hypoxia).

A high dependency environment may be the most appropriate care setting for patients with severe hyperkalaemia complicating acute illness. Senior decision makers should be involved early in the patient's care to help co-ordinate the management of such cases.

Potassium Monitoring

Hyperkalaemia should always be confirmed by measuring potassium concentration (U&E test).

Blood Glucose Monitoring

There is a risk of hypoglycaemia after the administration of treatment for hyperkalaemia (with insulin and glucose) that may not be appreciated.

It is essential that blood glucose is measured prior to and following insulin and glucose treatment.

Every effort should be made to measure glucose at the time points outlined in the guidelines and hyperkalaemia treatment kit, and act on abnormally low or high glucose levels if appropriate.

The potential risk of hypoglycaemia needs to be highlighted to the clinical team including the nursing staff monitoring the patient. The key issue is for the clinical team to be aware of the risk of hypoglycaemia for **up to 12 hours** following treatment with insulin and glucose.

The doctor prescribing the treatment plan for hyperkalaemia needs to inform the nurse looking after the patient. The doctor should write the treatment and monitoring plan together in the medical notes and make a record of verbal instruction to nursing staff in the medical notes.

The nurse will record the hyperkalaemia treatment and monitoring plan in the Nursing Assessment & Plan of Care Document, and provide this information at handover. As the monitoring plan will span 12 hrs, the information needs to be shared at the Ward ‘Safety Brief’.

Additional blood tests

Renal function should always be checked (it is included in the U&E test). Additional blood investigations, including blood gas analysis (for pH, blood oxygen, lactate concentration and acid-base balance) and/or creatine kinase (for suspected rhabdomyolysis) and LDH and uric acid (for tumour lysis syndrome) are performed if clinically appropriate.

TREATMENT OF HYPERKALAEMIA

Stop further potassium accumulation

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

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

Use the Hyperkalaemia Kit

Information on how to use the kit is contained in Appendix 2. The kit contains:

- 5 x 10ml calcium gluconate 10% ampoules
- 2 x 50ml glucose 50% vials
- 20 x salbutamol 2.5 mg nebules
- 2 x insulin syringes
- 2 x Chemoprotect syringes

NB. Actrapid® insulin is stored in the pharmaceutical refrigerator.

TREATMENT OF HYPERKALAEMIA

Protect the heart (use of intravenous calcium)

- Give 10ml of calcium gluconate 10% intravenously over 5 minutes (the hyperkalaemia kit contains five 10ml calcium gluconate 10% ampoules).

- This intervention will not lower the potassium, but if ECG changes due to hyperkalaemia are present, there should be improvement in the ECG changes that will be seen within 1 to 5 minutes.

- If the ECG changes do not resolve a further 10 ml of calcium gluconate 10% can be given intravenously every 10 minutes until the ECG normalises (patients may require up to 50 ml). The effect of this intervention is transient (approximately 30-60 minutes).

- Digoxin toxicity may contribute to hyperkalaemia. If the patient is taking digoxin and a decision is made to administer intravenous calcium there is a theoretical risk that rapid calcium infusion might precipitate myocardial digoxin toxicity. In clinical practice and experimental models, this risk of calcium associated myocardial digoxin toxicity has not been seen.[9,10] Consult with senior colleagues. Infusion of intravenous calcium more slowly, over 20 minutes, may be advised

N.B.: The resuscitation (‘cardiac arrest’) trolley has 10 ml 10% calcium chloride for use in treatment of hyperkalaemia in cardiac arrest scenarios. 10 ml 10% **calcium chloride contains** approximately **three times as much calcium per vial** as 10 ml 10% **calcium gluconate**. Calcium chloride will be used in cardiac arrest scenarios where hyperkalaemia is a contributing factor.[11]

TREATMENT OF HYPERKALAEMIA

Shift potassium into cells (use of insulin and glucose)

- **Obtaining a baseline glucose concentration (time 0 min sample) prior to glucose and insulin treatment is ESSENTIAL.** Several studies have demonstrated that the most consistent risk factor contributing to hypoglycaemia following insulin and glucose treatment is a low pre-treatment blood glucose concentration (<7 mmol/L).[2,3,12,13]

- **The risk of hypoglycaemia following insulin and glucose treatment in patients with low pre-treatment glucose concentration (<7 mmol/L) may be reduced by providing additional glucose (as a 10% glucose infusion at 50mL/hour for 5 hours).**

- Withdraw **10 units of Actrapid® insulin** using an **INSULIN syringe**. There are two insulin syringes in the hyperkalaemia kit (see images in Appendix 2)

- Always obtain a check of volume of insulin from a senior nurse before proceeding.

- Add to **50 ml glucose 50% vial** (this provides 25g glucose) as shown in the Standard Operating Procedure (SOP) in the hyperkalaemia kit (Appendix 2).

- Administer the combination of glucose and insulin by slow IV injection over 5 minutes

- The onset of the hypokalaemic action occurs within 15 minutes of administering insulin and glucose. The reduction in potassium observed ranges from 0.6 to 1.0 mmol/L and can last up to 4 hours.

- We recommend monitoring urea and electrolytes (U&E) at 1-hour post-treatment with insulin and glucose.

- If there has been a satisfactory response to treatment and the potassium concentration is <6.0 mmol/L then we advise monitoring the U&E at 4, 6, 8 and 12 hours in acutely unwell patients (e.g. high NEWS, hypoxia). This monitoring is to detect rebound or recurrent hyperkalaemia.

- If the potassium concentration is ≥ 6.5 mmol/L on ANY follow-up test then repeat full ABCDE assessment of the patient, start a new monitoring form (see Appendix 1) and complete the treatment algorithm (see Appendix 1). Discuss with nephrology team because by definition this is resistant or recurrent hyperkalaemia.

- If the potassium concentration is 6.0 – 6.4 mmol/L on a POCT at 1-hour post-treatment with insulin and glucose we recommend checking the potassium concentration on an urgent U&E sample. If the potassium concentration is confirmed as between 6.0 – 6.4 mmol/L we recommend sending another urgent U&E sample in

2 hours to determine the trend in potassium concentration. We recommend discussing these results with a senior doctor.

- Monitoring of blood glucose is recommended at 0 min, 15 min, 30 min, 60 min, 90 min, 2 hr, 3 hr, 4 hr, 6 hr, 8 hr and 12 hr as delayed hypoglycaemia has been reported frequently.

- In some circumstances (circulatory shock, diabetic ketoacidosis) capillary glucose testing with a glucometer may not provide an accurate or reliable measure of blood glucose. In these circumstances or if the glucose level measured by capillary testing does not correspond with the clinical picture, a venous blood sample should be sent to the laboratory for analysis.

- The venous blood sample should never be taken from the IV cannula through which the glucose has been administered.

- The POCT glucose measurement should only be undertaken by a trained operator using an instrument that has had appropriate quality control checks (performed in line with local Trust requirements).

TREATMENT OF HYPERKALAEMIA

Shift the potassium from the blood into the cell (use of salbutamol)

- Administer **10mg of nebulised salbutamol** (there is a box of 20 salbutamol 2.5mg nebules in the hyperkalaemia kit)

- Salbutamol for nebulisation is normally 2.5 mg/2.5ml strength and the nebuliser chamber will hold 10 ml i.e. 10 mg salbutamol. This can lower the potassium by 0.5 to 1.0 mmol/L by 15-30 minutes with the effect lasting at least 2 hours. The degree of potassium lowering is variable.

- Patients prescribed non-selective beta-blockers and patients with end-stage renal disease may have a limited response to salbutamol.

- Nebulised salbutamol should not be used as monotherapy in the treatment of hyperkalaemia unless in the exceptional circumstance where there is no intravenous access to deliver insulin and glucose therapy.

- There is evidence that the combination of nebulised salbutamol and insulin and glucose display additive effects in lowering the serum potassium. These interventions buy time for more definitive therapy.

- The use of intravenous insulin (and glucose) and nebulised salbutamol do not remove potassium from the body but act to shift potassium into cells

- *Sodium bicarbonate* – ***is not recommended for the acute management of hyperkalaemia.*** *While this has been a historic treatment for hyperkalaemia, many studies show that sodium bicarbonate fails to lower the serum potassium. There are potential risks in giving sodium bicarbonate in terms of fluid volume and sodium overload and tetany in patients with chronic kidney disease and co-existent hypocalcaemia. The risks therefore generally outweigh any potential benefits and sodium bicarbonate use should only be considered for metabolic acidosis and hyperkalaemia after discussion with senior clinicians experienced in its use.*

TREATMENT OF HYPERKALAEMIA

Remove potassium from the body

Oral potassium-binding agents (that increase gastrointestinal loss of potassium)

Both **sodium zirconium cyclosilicate** and **patiromer** bind potassium in the gastrointestinal tract and increase gastrointestinal elimination of potassium.

Standard medical therapy with intravenous insulin (and glucose) and nebulised salbutamol increases the activity of the Na^+/K^+ ATPase pump and shifts potassium from extracellular fluid to inside cells - but does not remove potassium from the body.

Sodium zirconium cyclosilicate has a rapid onset of action (within 1 hour) and has been studied in clinical trials of acute hyperkalaemia in hospitalised patients where it was used as an adjunct to standard medical therapy with insulin and glucose.[14]

We recommend that sodium zirconium cyclosilicate can be used as an option in the emergency management of acute life-threatening hyperkalaemia (serum $K^+ \geq 6.5$ mmol/l or ≥ 6.0mmol/l with associated ECG changes/hyperkalaemic symptoms) in addition to standard medical therapy.

Sodium zirconium cyclosilicate 10g three times daily can be used for up to 72 hours (correction phase), but if hyperkalaemia is not controlled by this time, it should be discontinued.[3]

Patiromer is also NICE approved as an adjunct to standard medical therapy for the emergency management of acute life-threatening hyperkalaemia (serum $K^+ \geq 6.5$ mmol/l or ≥6.0mmol/l with associated ECG changes/hyperkalaemic symptoms), but its onset of action is 4 to 7 hours, considerably slower compared to sodium zirconium cyclosilicate, and patiromer can potentially bind co-administered drugs.

Patiromer is however effective in selected patients for longer-term prophylaxis of hyperkalaemia – discuss with a renal physician for advice.

N.B. All medicines administered for the treatment of hyperkalaemia must be prescribed on the medicine prescription chart (Kardex). The term 'units' must not be abbreviated when prescribing insulin.

TREATMENT OF HYPERKALAEMIA

Remove potassium from the body

Haemodialysis (for removal of potassium)

If, despite the treatment measures described, the potassium remains greater than 6.5 mmol/L or if hyperkalaemic ECG changes/symptoms persist then repeat the hyperkalaemia treatment algorithm and contact the renal team who may need to arrange urgent dialysis if appropriate.

- Haemodialysis is a definitive but invasive method of treating hyperkalaemia. Early nephrology input should be sought if life-threatening hyperkalaemia persists despite first-line treatment, or if there is ongoing tissue damage and continued release of intracellular potassium is expected (e.g. severe rhabdomyolysis), or if renal function is significantly impaired (e.g. severe acute kidney injury or chronic kidney disease with eGFR <30ml/min).

- In some patients, hyperkalaemia will be one manifestation of the dying process. The patient benefits from repeated blood testing and hyperkalaemia treatment in these situations are minimal. If an individual were close to end-of-life then it would be appropriate to have discussions with the patient, the patient's consultant (and the patient's family) about whether blood testing and urgent treatment of hyperkalaemia is actually necessary for their care.

CLINICAL PEARLS

- Always consult with a senior doctor responsible for the patient with hyperkalaemia

- Always stop medicines/food and fluids that exacerbate hyperkalaemia (e.g. ACEi/ARBs, spironolactone, potassium-sparing diuretics, digoxin, NSAIDs)

- Careful cardiac monitoring and repeated blood testing including glucose monitoring is mandatory

- There is a risk of hypoglycaemia after the administration of treatment for hyperkalaemia (insulin and glucose) that may not be appreciated.

- The baseline glucose (time 0 sample) prior to glucose and insulin treatment is ESSENTIAL. Hypoglycaemia following insulin and glucose treatment is more likely if the pre-treatment blood glucose concentration is <7 mmol/L

- It is essential that blood glucose concentrations are measured before and after treatment with insulin and glucose at time points indicated in the guidelines and included in the hyperkalaemia kit.

- The potential risk of hypoglycaemia needs to be highlighted to the clinical team looking after the patient including nursing staff monitoring the patient

- A normal ECG does not negate the need for treatment of individuals with severe hyperkalaemia (potassium concentration ≥ 6.5 mmol/L)

- An abnormal ECG (on its own) is not sufficient to diagnose hyperkalaemia. Hyperkalaemia must be confirmed by measuring potassium concentration with a U&E test before commencing treatment unless there are exceptional circumstances e.g. suspected severe hyperkalaemia in a chronic dialysis patient with abnormal ECG.

- Digoxin toxicity (probable in renal failure when GFR is reduced) can increase potassium concentration.

- If doubts exist confirm the accuracy of capillary blood glucose values by using a sample of venous blood for glucometer testing and sending the remainder of the sample to the laboratory for analysis

- Beta-2 agonists may not lower serum potassium especially in dialysis patients or those taking beta-blockers or digoxin. They are not recommended as a single agent

- Calcium gluconate/insulin/beta-2 agonists are not definitive therapies - they simply buy time for more definitive therapy

- Ensure that the patient is placed on a ‘low potassium diet’ and stop the patient from consuming food with a high potassium content e.g. chocolate, fruit juices, until a dietetic assessment has been undertaken

- For all patients with moderate and severe hyperkalaemia (i.e. $[K^+] \geq 6.0$ mmol/L), the decision to proceed or not proceed with potassium lowering treatment should be agreed with a senior doctor. ECG changes can be non-specific and difficult to interpret.

- Severe hyperkalaemia in a dialysis patient (haemodialysis or peritoneal dialysis) can be difficult to manage. These patients will usually need additional dialysis to lower potassium concentrations and urgent consultation with a nephrology team is recommended

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Sub-Group and Reviewers for Guidelines on the Treatment of Hyperkalaemia in Hospitalised Adults

Chairperson

Prof Peter Maxwell, Consultant Nephrologist, Belfast HSC Trust

Sub-Group Members

Dr Paul Hamilton, Consultant Chemical Pathologist, Belfast HSC Trust
Ms Sharon O'Donnell, Lead Medication Safety Pharmacist, Belfast HSC Trust
Dr John Harty, Consultant Nephrologist, Southern HSC Trust
Dr Neal Morgan, Consultant Nephrologist, Southern HSC Trust

Reviewers

Dr Maurice O'Kane, Consultant Chemical Pathologist, Western HSC Trust
Dr Oonagh McCloskey, Consultant Nephrologist, Western HSC Trust
Dr Peter Sharpe, Consultant Chemical Pathologist, Southern HSC Trust
Dr Declan Keenan, Consultant Nephrologist, Southern HSC Trust
Dr Stephanie Bolton, Consultant Nephrologist, Northern HSC Trust
Dr Gareth Lewis, Consultant Physician, Northern HSC Trust
Dr Niall Leonard, Consultant Nephrologist, South Eastern HSC Trust
Ms Karen Devenney, Senior Nurse, Belfast HSC Trust
Dr Brian McCloskey, Consultant Anaesthetist, Belfast HSC Trust
Dr Eoghan Ferrie, Consultant in Emergency Medicine, Belfast HSC Trust

APPENDIX 1

This is the 2-sided sheet that has the algorithm for management of hyperkalaemia on one side and the glucose monitoring times on the reverse side. This will be included in the hyperkalaemia kit boxes.

APPENDIX 2

How to make up 10 units of Actrapid® (soluble) insulin in 50 ml glucose 50% vial using the hyperkalaemia kit (illustrated guide).

The Regulation and Quality Improvement Authority

Addressograph label

Surname: _____

First Name: _____

H&C: _____

D.O.B _____

Date : _____/_____/_____

Mandatory Blood Glucose Monitoring following insulin and glucose to treat hyperkalaemia

Time sample taken (24hr)	Monitoring schedule	Capillary glucose (mmol/l)	K^+ (mmol/l)
____:____	Baseline		
____:____	15 min		
____:____	30 min		
____:____	60 min*		
____:____	90 min		
____:____	2 hr		
____:____	3 hr		
____:____	4 hr		
____:____	6 hr		
____:____	8 hr		
____:____	12 hr		

Advice on potassium monitoring

1. Insulin and glucose & salbutamol normally lower K^+ by ~1.0mmol/l at 60 min

2. **An urgent K^+ level at 60 min post-treatment*** informs acute monitoring, specifically:

- Point of Care Test (POCT) analysers do not detect spurious hyperkalaemia (cell lysis) but provide reassurance in the emergency setting if reporting a K^+ <6.0mmol/l
- If relying on an urgent U&E lab sample for the 60 min K^+ test the result should ideally be available within 1 hr to inform management
- A K^+ <6.0mmol/l at 60 min on a POCT *or* lab test indicates a safe initial response. In such instances, check K^+ again in 3 hr (i.e. 4 hr post treatment) on a lab sample, **not** a POCT (unless no alternative)
- If K^+ 6.0-6.4mmol/l at 60 min on a POCT then check on an urgent U&E lab sample. If K^+ confirmed between 6.0-6.4mmol/l send another urgent lab sample in 2 hr to determine the trend and discuss these results with senior member of staff

3. Tests beyond 4 hr are to detect rebound / recurrent hyperkalaemia. In acutely unwell patients (e.g. high NEWS, hypoxia) tests at 6, 8 and 12 hr are advisable; in stable cases tests at 8 and 24 hr may suffice. Discuss monitoring frequency with a senior member of staff.

If K+ ≥6.5mmol/l on ANY follow-up test (unless strongly suspecting a spurious result)

- Repeat an ABCDE assessment
- Start a NEW monitoring form
- Complete steps 1-6 of the treatment algorithm
- Discuss with nephrology as by definition this is *resistant* or *recurrent* hyperkalaemia

MONITORING (Key Roles and Responsibilities)

MEDICAL STAFF	NURSING STAFF
Monitor and record potassium levels in the table provided and **sign off on ECR**	Monitor and Record blood glucose in the table
	Contact the *on-call doctor* if informed of any repeat $K^+ \geq 6.5$mmol/l

Management of Hyperkalaemia in Adult Inpatients

The Regulation and Quality Improvement Authority

K^+ ≥6.0mmol/l ⇨ Perform urgent ABCDE assessment & 12-lead ECG

Monitor via telemetry (if available) patients with K^+ 6.0 – 6.4mmol/L AND *AT RISK of a sudden rise in potassium**

Telemetry monitoring is essential FOR K^+ ≥6.5mmol/l OR when K^+ 6.0 – 6.4mmol/L is associated with hyperkalaemic ECG changes

Mild hyperkalaemia
K^+ 5.5 - 5.9 mmol/L

Plan monitoring based on the risk of sudden rise in potassium*

***Acutely unwell**
Repeat <12 hr

Stable patient
Daily monitoring

Moderate hyperkalaemia
K^+ 6.0 - 6.4 mmol/L

Are there ECG changes OR symptoms DUE TO hyperkalaemia?
If YES ⇨ DISCUSS WITH A SENIOR DOCTOR & treat as Life-threatening

ECG Changes ***(in order of severity)***
- Peaked T waves
- PR prolongation
- Decreased amplitude or absent P waves
- QRS widening
- AV block

NO

Plan monitoring based on the risk of sudden rise in potassium*

***Acutely unwell** patient (e.g. high NEWS, hypoxia) ⇨ *repeat at 2hr*

Stable patient (e.g. chronic RAASi use, within 0.5mmol/L of a chronic baseline value) ⇨ *repeat at 8-12 hr*

K^+ < 6.5mmol/L ***K^+ ≥ 6.5mmol/L***

Continue monitoring

Life-threatening hyperkalaemia
K^+ ≥ 6.5 mmol/L

DISCUSS WITH A SENIOR DOCTOR

STEP 1: Protect the Heart
10ml 10% IV Calcium Gluconate over 5 mins
**If on digoxin give over 20mins **

STEP 2: Check Capillary Blood Glucose (CBG)

STEP 3: Move Potassium Into Cells
a) Administer Insulin and Glucose Bolus:
10 units ACTRAPID insulin &
50ml of 50% Glucose IV over 5 minutes
b) Stat Salbutamol: 10mg Nebulised

CBG < 7mmol/L

CBG ≥ 7mmol/L

STEP 4: Protect against Hypoglycaemia
Start a 25g Glucose Infusion:
250mls of 10% Glucose @50ml/hr

STEP 5: Minimise Rebound Hyperkalaemia
As Per local guidance consider a NICE approved potassium binder alongside standard care (steps 1-4). *Do not use calcium resonium*

STEP 6: Intensive monitoring (reverse page)

ESSENTIAL MANAGEMENT STEPS IN ALL CASES OF HYPERKALAEMIA (K+ ≥5.5mmol/L)

- **REDUCE INTAKE**: Start a low potassium diet & stop any potassium supplements (e.g. Sando-K)
- **REVIEW KARDEX**: When safe to do so hold RAAS inhibitors (Spironolactone, ACEi/ARB/Entresto), trimethoprim, Septrin, potassium sparing diuretics and NSAIDs. Treat any constipation. *Exclude digoxin toxicity if indicated*
- **MANAGE AKI:** If present manage AKI as per GAIN AKI Guidelines (link to guidance via NIECR AKI e-Alert)
- **CORRECT ACIDOSIS:** If $HCO3^-$ < 20mmol/L and K^+ ≥6.0mmol/L discuss with Nephrology
- **EXCLUDE PSEUDOHYPERKALAEMIA**: Spurious hyperkalaemia results from cell lysis: e.g. delayed sample processing / platelet count>750/WCC>20). Exclude by repeating potassium on paired lithium heparin and clotted serum samples

*Within the appropriate clinical context consider Addison's and tissue breakdown (burns/tumour lysis/rhabdomyolysis).

INDICATIONS FOR SEPCIALIST REFERRAL (NEPHROLOGY/CLIN. BIOCHEM)

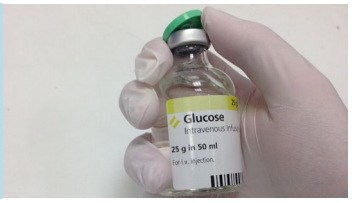
1. **Moderate hyperkalaemia** (K^+ ≥6.0mmol/L) **& severely impaired renal function** (creatinine >350umol/L)
2. **Resistant or recurrent severe hyperkalaemia** (K^+ ≥6.5mmol/L despite treatment or recurring ≥6.5mmol/L within 24 hr)
3. **Severe hyperkalaemia in a dialysis patient** (K^+ ≥ 6.5mmol/Land on haemodialysis or peritoneal dialysis)
4. **Moderate hyperkalaemia** (K^+ ≥6.0mmol/L) **& significant metabolic acidosis** ($HCO3^-$ <20mmol/L)

How to make up **10 units** of Actrapid® (soluble) insulin in 50ml glucose 50% vial using the hyperkalaemia kit

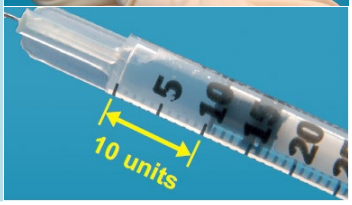
Protect the cardiac membrane: give 10ml of calcium gluconate 10% IV over 5 mins

1. With the nurse in charge, obtain an Actrapid® vial from the pharmaceutical fridge.

2. Take the glucose 50% glass vial from the kit.
   Remove its protective cap.



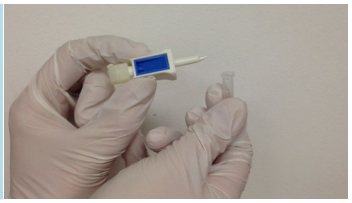
3. Measure **10 units** of insulin using an insulin syringe from the kit:
   a. Draw the plunger back to the **10 unit** mark on the insulin syringe. Check the **10 units** of insulin obtained with the senior nurse on duty.
   b. Note **10 units** of insulin is contained in 0.1ml.
   c. Record administration of this and other medicines used to treat hyperkalaemia on the Kardex. Ensure both signatures for double check are documented on the Kardex.



4. Inject the **10 units** of insulin into the glucose 50% glass vial.

5. Mix.

6. Take Chemoprotect® Spike from kit and remove protective sheath.



7. Pierce the glucose 50% glass vial with the Chemoprotect® Spike.

8. Screw the 50ml syringe onto Chemoprotect® Spike and draw up the contents of the vial.
9. Remove syringe from Chemoprotect® Spike and expel air from 50ml syringe.
10. Administer into a large vein by slow IV injection over 5 mins.

Monitor blood glucose at 0 min, 15 min, 30 min, 60 min, 90 min, 2 hr, 3 hr, 4 hr, 6 hr, 8 hr & 12 hr as delayed hypoglycaemia is possible.

Document the blood glucose using the monitoring chart provided in the hyperkalaemia kit

HSC Belfast Health and Social Care Trust

Adapted from GAIN Guidelines for the treatment of hyperkalaemia in adults (revised 2021).
Available at http://www.gain-ni.org / Publications/Guidelines / hyperkalaemia_ guidelines.pdf

The **Regulation** and
Quality Improvement
Authority

The Regulation and Quality Improvement Authority
9th Floor
Riverside Tower
5 Lanyon Place
BELFAST
BT1 3BT

Tel 028 9536 1111
Email info@rqia.org.uk
Web www.rqia.org.uk
@RQIANews