Hyperkalaemia - Full Clinical Guideline

Reference No: CG-T/2023/060

Aim and Scope

Hyperkalaemia occurs in 1-10% of hospitalized patients, and when severe, consequences include arrhythmias and death[1]. The majority of cases are related to pre-existing or new renal failure, potassium supplementation, or use of diuretics/drugs with potassium-sparing properties.

This guideline has been developed to give advice on the appropriate management of this common electrolyte derangement.

Hyperkalaemia is classified as:

Mild (K+ 5.5 – 5.9 mmol/L)

Moderate (6.0 – 6.4 mmol/L)

Severe ≥ 6.5 mmol/L **or** if K+ > 6 with ECG changes or symptoms

Severe hyperkalaemia should be treated as a medical emergency

Patient Information Required in Order to Treat

- Serum potassium (normal range is 3.5 – 5.3 mmol/L)
- Serum bicarbonate (normal range 23 to 26 mmol/L)
- Presence of any symptoms e.g. muscle aches/ weakness
- ECG changes. If K+ is > 6 mmol/L ensure the patient has an ECG checked or is on an ECG monitor[2]
- Investigation of possible causes – a thorough medical history, including review of medications, fluids prescribed and urine output. A history of renal disease will often reveal the cause of the hyperkalaemia.

Consider possible causes of hyperkalaemia and whether these are correctable:

- Medications (see below) including digoxin overdose
- History of renal disease (acute/chronic renal failure, renal tubular acidosis)
- Dehydration
- Acidosis (including diabetic ketoacidosis)
- Mineralocorticoid deficiency
- Diet
- Urinary tract obstruction e.g. bladder distension/prostate hypertrophy
- Consider the possibility of pseudohyperkalaemia (e.g. with a haemolysed sample, or in the presence of polycythaemia, thrombocythaemia, or leukaemia), a repeat serum potassium (in a lithium-heparin) should be ordered urgently if hyperkalaemia is an unexpected or isolated finding, and there are no ECG signs of hyperkalaemia.

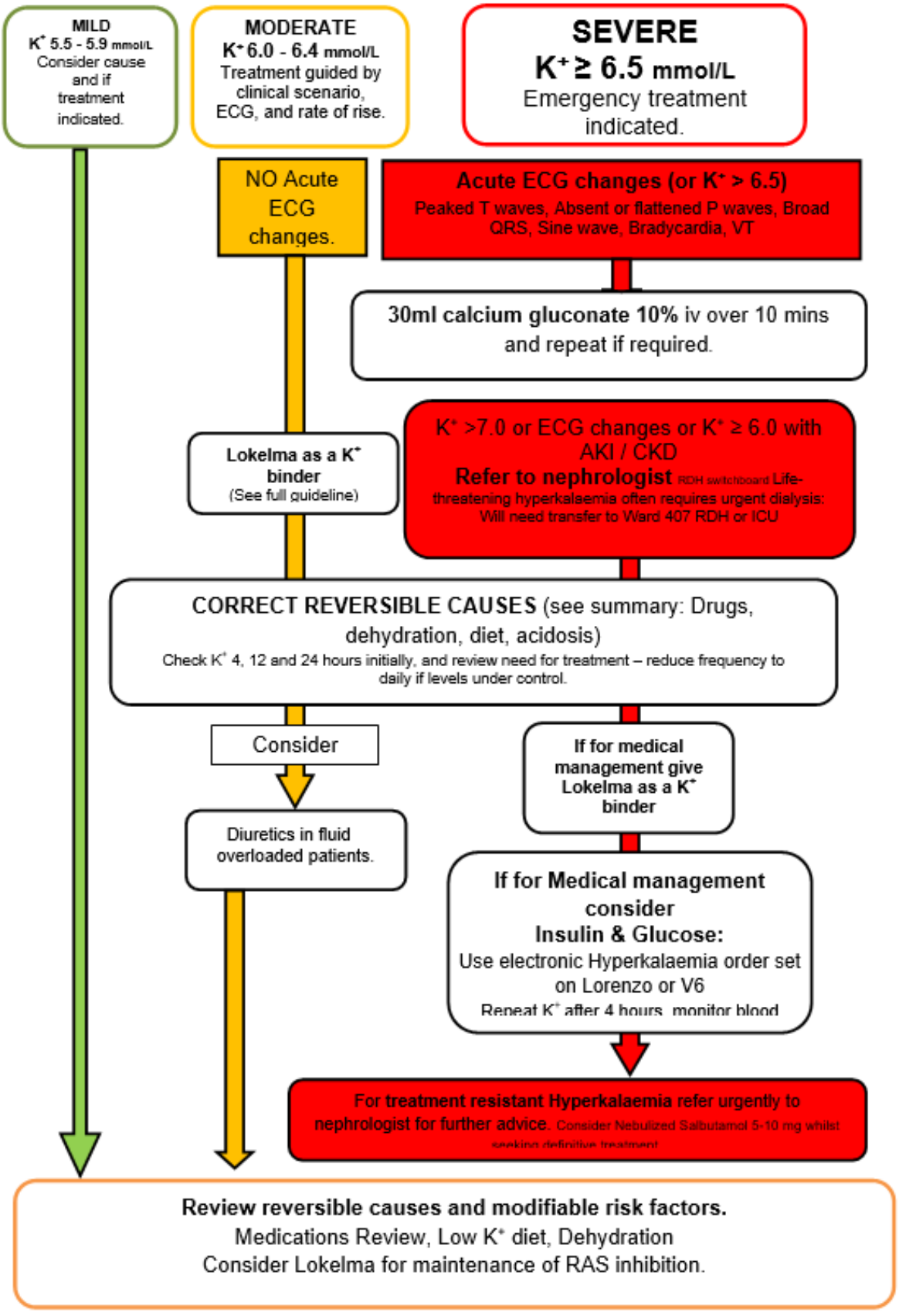
Institute interventions aimed at correctable causes of hyperkalaemia:

- Discontinue potassium supplements including potassium-containing iv fluids, potassium- sparing diuretics (e.g. spironolactone, amiloride, co-amilofruse), ACE inhibitors / angiotensin-II receptor antagonists, NSAIDs, trimethoprim
- Discontinue beta-blockers and digoxin (measure levels)
- Rehydrate if intravascular volume reduced
- Correct acidosis (consider the use of sodium bicarbonate, refer to later in this guideline for details)
- Catheterize if urinary retention is proven or suspected
- Seek dietetic advice

Consult with renal physician before proceeding:

- in all patients with K+≥7
- patients with K+ > 6.5 with ECG changes or with underlying renal impairment

Treatment Algorithm Emergency Management of Hyperkalaemia (K+ ≥ 5.5mmol/L)



Clinical Presentation of hyperkalaemia

The severity of clinical effects depends not only on the potassium level, but also on whether the rise is acute or chronic, with a chronic rise being better tolerated than an acute one.

Cardiac effects of hyperkalaemia (approximate guide only)

K+ 6 – 6.5 mmol/L	Tall T waves
K+ 6.5 – 7.5mmol/L	Flattened or absent P wave, widened PR interval, widening of QRS with development of deep S wave
K+ > 7.5mmol/L	QRS merges with T wave resulting in sine wave pattern, which may deteriorate to VF or asystole

Neuromuscular effects

Fatigue, paresthesia, weakness and palpitations may occur but severe cardiac toxicity usually precedes these symptoms.

Treatment

1. Cardiac Protection

Calcium

Dose: 30ml calcium gluconate 10% over 10 minutes – rapid administration can cause vasodilation, decreased blood pressure, bradycardia, arrhythmias, syncope and cardiac arrest.

Calcium does not lower K+ level, but protects the heart from the cardiac effects of the high potassium level. It should be given to **all** patients with a K+ >6.5, as well as those with any level of K+ but with evidence of potassium-related ECG changes (see above). If the ECG changes include peaked T waves, small broad or absent P waves, and widening QRS complexes, intravenous calcium should be given immediately, with repeat doses given until the ECG has returned to normal (Patients may require up to 80ml).The onset of calcium's protective effect occurs within 1-3 minutes, but is short lived, (30-60 minutes) **so the dose may need to be repeated e.g. every 10 minutes, if necessary, until the ECG normalizes.**

Care should be taken with intravenous administration of calcium salts, as extravasation may cause severe tissue damage and necrosis. Always check quality of venous access before administration. DO NOT GIVE CALCIUM CHLORIDE EXCEPT IN CASES OF CARDIAC ARREST (Calcium Chloride stored in arrest boxes on resus trolley).

Digoxin blood levels should be measured in all hyperkalaemia patients taking digoxin, as hyperkalaemia is a feature of digoxin toxicity. However, if the patient is on digoxin, and calcium is deemed to be useful, it must be given slowly over 20 minutes (30 ml of Calcium gluconate 10% in 100 ml glucose 5%) as in such cases rapid calcium administration can lead to digoxin toxicity. Calcium must be avoided in the presence of digoxin toxicity as this increases ventricular automaticity, and may precipitate ventricular arrhythmias. **Therefore,** t**he management of hyperkalaemia in the setting of digoxin toxicity requires specialist advice.**

2. Identification and management of correctable causes

Correct reversible causes of hyperkalaemia:

- Withhold and review all drugs that may contribute e.g.:
  ACE inhibitors, angiotensin-II receptor antagonists, potassium supplements including potassium-containing iv fluids, potassium-sparing diuretics, NSAIDs, beta-blockers, digoxin, ciclosporin, trimethoprim, heparin.

- Ensure adequate hydration. Intravascular hypovolaemia is an under-appreciated cause of hyperkalaemia.

- Correct any underlying acidosis (see sodium bicarbonate, below). Acidosis is relatively common in acutely unwell patients, particularly if AKI or CKD are also present. Hyperkalaemia in the setting of DKA usually settles with rehydration and insulin.

- Relieve Urinary tract obstruction if confirmed

3. Redistribution of potassium

The following should be viewed as temporary "holding" measures to be introduced whilst other measures, such as discontinuation of medication take effect. Redistribution of potassium should be considered if correction of intravascular hypovolaemia and acidosis have not been effective. Redistribution does not remove excess potassium from the body.

a) Insulin and glucose

Insulin lowers serum potassium by stimulating its intracellular uptake - it does not remove potassium from the body. Glucose is given to prevent hypoglycemia. **Note: if dialysis is planned, it may be counter-productive to give insulin + glucose – seek renal opinion.**

How to prescribe Insulin & Glucose for Hyperkalaemia

Use the Hyperkalaemia order set in the electronic prescribing system[†]:

10 units of soluble insulin (Actrapid) in 10 ml sodium chloride 0.9% is infused over 30 minutes using a syringe driver, at the same time as 125ml 20% glucose infusion over 30 minutes into a large vein via two lumen needle free device.

The insulin and glucose are pre-selected for the standard regimens and there is an option to add calcium gluconate if it has not already been prescribed/administered.

If the blood glucose is > 15 mmol/l, insulin alone can be given, with close monitoring of blood glucose (ensure to deselect the glucose checkbox on the order set and modify the

[†††] Search 'Hyperkalaemia': order sets have been set up in Lorenzo (Derby) and a reflex set in Meditech V6 (Burton)

administration comments to make this intention clear to pharmacy and nursing staff).

Insulin should not be added to the glucose infusion as it adsorbs on to the PVC bag. Giving the two separately also allows titration of the glucose infusion to prevent hypoglycemia if required. Glucose 50% is NOT used as it is hypertonic and very irritant to veins.

Administration of insulin and glucose treatment

Appendix 1 (Derby) and 2 (Burton/SRP/SJH) provide an overview of the administration process for insulin-glucose which is a useful aid to highlight or print for nursing staff to facilitate prompt and safe treatment.

Monitoring of insulin and glucose treatment

This regime should lower serum K+ by around 0.5 – 1 mmol/l within 30 minutes of completion of the infusion. The effect should last for 2-6 hours. Check the potassium 4 hours later to determine if the regimen needs to be repeated.

There is a significant risk of hypoglycaemia. Therefore, monitor blood glucose at 15 minutes, 30 minutes, and hourly thereafter for 6 hours. The elderly and patients with acute kidney injury or advanced chronic kidney disease are more prone to hypoglycemia, and, should be monitored until their blood glucose has normalised.

b) Salbutamol

Salbutamol has limited clinical usefulness. It also acts by stimulating re-uptake of potassium into cells. Again, this is a temporary effect seen within 30 minutes, and lasting up to 4 hours. It may be ineffective if beta-blockers or digoxin are given. Nebulised salbutamol may be the preferred route. One study[3] comparing 500 microgram salbutamol given intravenously with 10mg given via a nebuliser found they gave a similar reduction in potassium levels, but the nebulised salbutamol caused less tachycardia (and so this route should be used if there is evidence of ischemic heart disease). Another study[4] found that patients given insulin and glucose were less likely to develop hypoglycemia if they were also given 20mg nebulised salbutamol.

Nebulised salbutamol 10-20mg may be given in severe cases as it is readily available on the wards, safe to give and can be given whilst waiting for the insulin and glucose to be set up. Onset of action is within 15-30 minutes. (Note: this is an unlicensed indication for salbutamol). The combination of salbutamol and insulin/glucose is more effective than insulin alone.

If intravenous salbutamol is used, the dose is 500 microgram in 250 ml IV over 30 mins.

Calcium gluconate, insulin/glucose, and salbutamol buy time but are not definitive treatments for hyperkalaemia. They can be

repeated multiple times while definitive measures are pursued.

c) Sodium bicarbonate

Sodium bicarbonate is useful to reduce K as it causes shift of K into the cell with the change in ph. It does not reverse the cause of acidosis. The preferred bicarbonate strength is 1.4%, however, in severe acidosis and where fluid overload may be of concern, 500 ml of 4.2% Sodium bicarbonate can be administered slowly over 4 to 6 hours. Following precautions should be taken while administering bicarbonate:

1) IV lines must be flushed between administration of calcium and sodium bicarbonate, otherwise precipitation may occur. A separate venflon is preferred

2) Fluid assessment should be performed before administering bicarbonate and, if patient is passing urine, furosemide may help to reduce fluid overload and at the same time remove potassium in urine.

4. Removal of potassium from the body

a) Diuresis

Renal excretion of potassium is urine flow-dependent, thus measures to increase urine output should be instituted. Give intravenous fluids to volume-depleted patients. Consider catheterisation or a nephrostomy, to relieve obstruction if present. Loop diuretics increase potassium excretion by increasing delivery of sodium to the distal nephron. Assisted diuresis with non-potassium-retaining diuretics (e.g. furosemide) may be appropriate, if the patient is euvolaemic or fluid overloaded.

b) Haemodialysis

Haemodialysis represents the most effective and definitive, but also the most invasive, approach to lowering serum potassium. It should be strongly considered if K+ is > 7 mmol/l, if there is accompanying fluid overload, or if pathological ECG changes/symptoms persist. In such cases, the renal team should be contacted at an early stage to arrange urgent dialysis, if appropriate. If the patient has been given treatment to push the potassium into the cells, there may be a possible rebound hyperkalaemia when this effect has worn off, and haemodialysis may need to be continued for longer[4]

Life-threatening hyperkalaemia will often require dialysis – discuss with a renal physician at an early stage. (Bleep 8121 9am to 10 pm or discuss with on call consultant after hours).

c) Sodium zirconium cyclosilicate **(Lokelma)**

Sodium zirconium cyclosilicate has been appraised by NICE and approved for use in emergency care for acute life-threatening hyperkalaemia alongside standard care. It is a non-absorbed, non-polymer inorganic powder that preferentially captures potassium in exchange for hydrogen and sodium cations[6]. Sodium zirconium cyclosilicate captures potassium throughout the entire gastrointestinal (GI) tract and reduces the concentration of free potassium in the GI lumen, thereby lowering serum potassium levels and increasing faecal potassium excretion to resolve hyperkalaemia.

Sodium zirconium cyclosilicate starts reducing serum potassium concentrations as soon as 1 hour after ingestion and normokalaemia can be achieved typically within 24 to 48 hours. Sodium zirconium cyclosilicate does not affect serum calcium or magnesium concentrations, or urinary sodium excretion. There is a close correlation between starting serum potassium levels and effect size; patients with higher starting serum potassium levels have greater reductions in serum potassium [6].

The dose is 10g three times a day for up to 3 days, if normal K not achieved within this timeframe then other measures should be considered.

Sodium Zirconium (Lokelma) is stocked in renal, ED and admissions areas and via pharmacy emergency/out-of-hours cupboards.

5. Diet

The patient should be placed on a low potassium diet. Specifically ask the nurse caring for the patient to request this from catering services. It is imperative that whilst waiting for a dietetic assessment, the patient does not consume fruit juices, fruits (particularly bananas and oranges), chocolate, fruit gums, biscuits, coffee or potatoes. Referral to a dietician should be considered. Patients should avoid salt substitutes e.g. “Lo Salt”.

Appendix 1 – DERBY SITES ONLY

Administration and monitoring of Insulin and Glucose in the treatment of Hyperkalaemia

Background: Why is Insulin used in hyperkalaemia (high potassium)?

Insulin can be used in the treatment of hyperkalaemia to help transfer potassium in to the cells. The insulin syringe provided may be the same as those used for insulin infusions in diabetes ("fixed rate" &"sliding scale"). However, the administration and monitoring for treating hyperkalaemia may be indicated in both diabetic and non-diabetic patients.

DERBY SITES - Products and pumps required

Product required	Dose and Presentation	Where from	Pump and programme required
Insulin pre-filled syringe (1unit/1ml)	**10units in 10ml administered from a prefilled syringe** (Note: excess volume should be discarded after priming the line)	Fridge or Pharmacy Emergency Cupboard or via Stock Locator on intranet	Syramed Syringe pump: Using '**Insulin - K+**'
Glucose 20%*	**125ml administered from a 500ml** bag	Ward stock & resus trolley (or locate as above)	Baxter EvoIQ pump. Using 'Glucose K+'

*If baseline blood sugar is > 15mmol/L, the prescriber may request that insulin is given alone. If unsure, confirm with the prescriber. Ensure monitoring is undertaken as below in ALL patients.

Setting up the insulin in the Syramed syringe pump

- Load and confirm syringe
- Prime the line and then discard excess volume
- Select '**Insulin-K+**' setting
- Confirm volume to be infused (VTBI) *[For standard 10 unit prescription, VTBI = 10ml]*
- Change/confirm infusion time *[For standard prescription = 30 minutes]*
- Perform final checks and commence at the same time as glucose infusion
- Disconnect and discard syringe and line as soon as infusion complete.
- Flush the cannula after the line has been detached.

Setting up the Glucose in the volumetric pump

- Select 'Glucose K+'Set *volume* as 125ml over 30 minutes ('Volume / Time' mode)
- Perform final checks and commence at the same time as insulin infusion
- When infusion complete, clamp/pause and monitor as below. It may be useful to retain glucose bag/pump until blood sugar monitoring is complete (in case the prescriber requires an additional glucose load to treat hypoglycaemia).

Monitoring

Monitor blood glucose at 15 minutes, 30 minutes, and hourly thereafter for 6 hours. Escalate any concerns in blood glucose control to the prescriber as soon as identified. Potassium level is checked at 6 hours. Patients with acute kidney injury are more prone to hypoglycaemia, and should be monitored until their blood glucose has normalised.

Appendix 2 – BURTON/TAMWORTH/LICHFIELD ONLY
Administration and monitoring of Insulin and Glucose in the treatment of Hyperkalaemia

Background: Why is Insulin used in hyperkalaemia (high potassium)?

Insulin can be used in the treatment of hyperkalaemia to help transfer potassium in to the cells and protect the heart from arrhythmias. The administration and monitoring of insulin for treating hyperkalaemia may be indicated in both diabetic and non-diabetic patients.

BURTON / TAMWORTH / LICHFIELD - Products and pumps required

Product required	Dose and Presentation	Where from	Pump required
Insulin Actrapid vial	Final infusion is 10 units in 10ml following dilution and line priming. • Draw up 14units of Actrapid using an insulin syringe • Transfer to 20ml luer lock syringe and make up to 14ml with sodium chloride 0.9%. • Attach IV line and prime to leave 10units in 10ml in the syringe	Refrigerated ward stock or Pharmacy OOH cupboard	Braun Perfusor Syringe Pump
Glucose 20%*	**125ml administered from a 500ml** bag	Ward stock or Pharmacy OOH cupboard	Baxter EvoIQ pump. Using 'Glucose K+'

*If baseline blood sugar is > 15mmol/L, the prescriber may request that insulin is given alone. If unsure, confirm with the prescriber. Ensure monitoring is undertaken as below in ALL patients.

Setting up the insulin in the syringe pump

- Load syringe and prime line to leave only the desired dose of 10units in 10ml in the syringe
- Set to infuse 10units in 10ml over prescribed time *[For standard prescription = 30 minutes]*
- Perform final checks and commence at the same time as glucose infusion
- Disconnect and discard syringe and line as soon as infusion complete.
- Flush the cannula after the line has been detached.

Setting up the Glucose in the volumetric pump

- Select 'Glucose K+'
- Set *volume* as 125ml over 30 minutes ('Volume / Time' mode)
- Perform final checks and commence at the same time as insulin infusion
- When infusion complete, clamp/pause and monitor as below. It may be useful to retain glucose bag/pump until blood sugar monitoring is complete (in case the prescriber requires an additional glucose load to treat hypoglycaemia).

Monitoring

After commencing the insulin/glucose infusions: Monitor blood glucose at 15 minutes, 30 minutes, and hourly thereafter for 6 hours. Escalate any concerns in blood glucose control to the prescriber as soon as identified. Potassium level is checked at 6 hours.

Patients with acute kidney injury are more prone to hypoglycaemia, and should be monitored until their blood glucose has normalised.

References

1. Paice B, Gray JMB, McBride D, et al. Hyperkalaemia in patients in hospital. BMJ 1983; 286: 1189-1192
2. Montague BT, Ouellette JR, Buller GK. Retrospective review of the frequency of ECG changes in hyperkalemia. *Clin J Am Soc Nephrol*. 2008;3(2):324-30.
3. Mahoney BA, Smith WAD, Lo DS, Tonelli M, Clase CM. Emergency interventions for hyperkalaemia. The Cochrane Database of Systematic Reviews 2005, Issue 2.
4. Ahee P, Crowe AV. The management of hyperkalaemia in the emergency department. J Acc Emerg Med 2000;17:188-91
5. Renal Association Guidelines for the treatment of hyperkalaemia in adults. https://renal.org/wp-content/uploads/2017/06/hyperkalaemia-guideline-1.pdf
6. NICE. SodiumZirconium cyclosilicate for treating hyperkaleamia, NICE Technology Appraisal [TA599], pub September 2019

Documentation Control:

Development of Guidelines:	Dr Pittman Consultant Nephrologist Prof Taal Consultant Nephrologist
Consultation with:	Drugs and Therapeutics Committee (17/10/23) Medicines Safety Officer (06/10/23) Pharmacy BU (06/10/23)
Approved by:	Divisional Governance - Medicine
Approval Date:	26/10/2023
Review Date	October 2026
Distribution and location of policy:	All wards and Departments (Excluding Renal)