Great Ormond Street Hospital for Children
NHS Foundation Trust

Clinical Guideline

Disclaimer

Clinical guidelines are best practice recommendations that are intended to assist clinical teams in the delivery of patient care at GOSH. Clinical guidelines attempt to reflect the best available research at the time of writing, but the interpretation and application of clinical guidelines remains the responsibility of the individual clinician. Caution is advised if using a GOSH clinical guideline outside of the organisation and/or beyond its review date.

Hyperkalaemia in Children (Outside of ICU)

Document Details	
Guideline Author/s:	Sarit Shah, Anna Forbes, Iona Madden, Deirdre O' Sullivan
Guideline summary (up to 100 words):	Hyperkalaemia in Children: Causes, clinical manifestations, diagnosis and management
Key words:	Hyperkalaemia
Exclusions:	**This guideline does NOT relate to Neonates/Children within ICU – Please see separate guidelines on Our GOSH**

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1 Introduction

This protocol was designed and developed to standardise the evaluation and management of hyperkalaemia in paediatric patients across the trust to ensure safe and effective care.

Hyperkalaemia in children can be life-threatening and lead to cardiac arrhythmias and to sudden cardiac arrest.

Children's unique physiology increases the vulnerability, requiring prompt and specialised management.

Aims of the protocol:

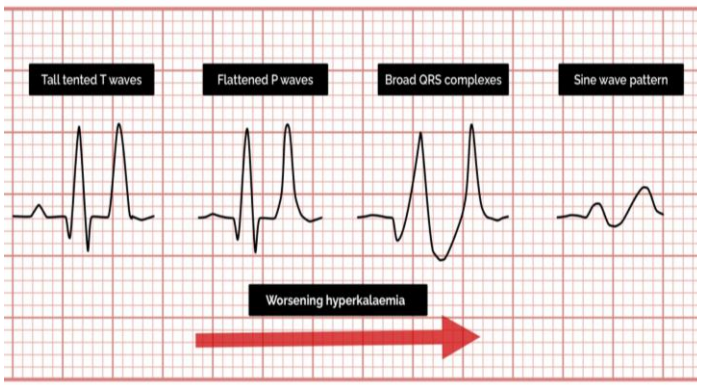
- Rapid identification and assessment of hyperkalaemia
- Initiation of timely interventions
- Reduction of morbidity and mortality associated with hyperkalaemia
- Guidance in safe and effective dosing for various age groups
- Standardisation of care across the trust

2 Treatment Algorithm

Hyperkalaemia

Start **Cardiac Monitoring**, urgent **ECG** and **repeat free flowing venous blood sample (Gas & Renal Function Profile)***
(*DO NOT DELAY TREATMENT for repeat result in moderate - severe hyperkalaemia or hyperkalaemia with ECG changes)

Classification:
Mild: 5.5 – 5.9 mmol/L
Moderate: 6.0 – 6.9 mmol/L
Severe: >6.9 mmol/L



Mild Hyperkalaemia (<6.0 mmol/L) WITHOUT ECG Changes or symptoms

- Is hyperkalaemia confirmed on repeat sample?
- If so, and remains in mild category then consider:
  1. Removal of exogenous potassium sources in IV fluids/PN/medications
  2. Medications that can increase serum potassium (P11)
  3. Consider underlying cause of hyperkalaemia & further investigations (P10)
  4. Address likely underlying cause and repeat potassium level at an interval deemed appropriate by treating consultant.

Moderate - Severe Hyperkalaemia OR Hyperkalaemia WITH ECG Changes or symptoms

Step 1: **Stabilisation**
- Escalate to CSP/ICON
- Stop all exogenous potassium (in fluid or medication)
- **STABILISE CARDIAC MEMBRANE:** IV Calcium Gluconate (P5)
- Salbutamol Nebuliser (P6) Not suitable as sole therapy, proceed to Step 2.

Step 2: **Sustaining Reduction in serum potassium/Intra-Cellular K+ Shift:**
- Insulin/Dextrose Infusion (P7)
- Consider Sodium Bicarbonate if acidotic **(DO NOT GIVE if Ionised Calcium is < 1.0 mmol/L)** (P8)
- Check potassium every 30 minutes after intervention

Step 3: **Ongoing Management (In liaison with CSP/PICU/Paediatric Nephrology)**
- Consider underlying cause of hyperkalaemia and further investigations/management (P10)
- Furosemide (P9)
- Resoniums (P9) or Sodium Zirconium (P9)
- Dialysis/Renal Replacement Therapy
- Dietetic Review: Low Potassium Feed/PN

CARDIAC ARREST Secondary to Hyperkalaemia

Follow APLS Cardiac Resuscitation Algorithm

Reversal of Hyperkalaemia in CARDIAC ARREST

- **Insulin/Glucose BOLUS:** **(See Appendix 1 for dosing, preparation and administration)**
  - **Dose: 0.1 unit/kg Actrapid (Max 10 units) with 5ml/kg Glucose 10% (Max 250ml)**
- **Intravenous/IO Short acting Beta Agonist/Salbutamol:**
  - **Dose: 4 micrograms/kg (maximum 250 micrograms)**
  - **Preparation: Dilute to 50 microgram/ml in sodium chloride 0.9%**

Nebulised / Intravenous Salbutamol

Nebulised salbutamol

- ✓ **Give nebulised salbutamol (ease of administration, no need for IV access) to drive intracellular uptake of potassium.**
- ✓ **Dose can be repeated every 15-20 minutes until serum potassium declines or adverse effects from salbutamol toxicity arise**

➢ **Dose:** **< 2 years of age: 2.5mg** **> 2 years of age: 5mg (repeat every 15-20 minutes)**

Intravenous Salbutamol

- ✓ **Useful only if child has IV access in place**

➢ **Dose:** **4 micrograms/kg (maximum 250 micrograms) over 5 minutes, can be repeated 2 hourly.**

Dilute to 50 microgram/ml in sodium chloride 0.9% and give over 5 minutes

Additional information

- **Do not use as sole therapy in moderate to severe hyperkalaemia**. 40% of people do not show hypokalaemic response with salbutamol and effects will also be temporary.
- Salbutamol therapy can be safely combined with insulin/glucose, there is evidence to show both drugs are more effective when combined.
- Adverse effects: Tremor and tachycardia (more prominent with intravenous doses), lactic acidosis

Calcium Gluconate 10% Injection
Membrane stabilisation

- ✓ **Indicated in hyperkalaemia as per treatment algorithm.**
  - ➢ **or hypocalcaemia (iCa2+ < 1 mmol/L)**
  - ➢ **promptly give a 0.5ml/kg dose (maximum 30ml) of calcium gluconate 10%**
  - ➢ **Each 0.5ml contains 0.11mmol of calcium**

- ✓ **** Central line: Give neat over 5-10 minutes**
- ✓ **** Peripheral line: Dilute to a maximum concentration of 0.045mmol of calcium in 1ml where volumes permit. In larger children can be given neat in an emergency over 10 minutes with careful site monitoring for extravasation.**
- ✓ **If not deemed an immediate emergency, give over 60 minutes diluted**
- ✓ **Repeat 12 lead ECG monitoring after 1st dose**
- ✓ **Continue ECG monitoring, Sp02, heart rate, blood pressure and blood gas (calcium & potassium)**

It is effective within 3 minutes of administration at improving the ECG appearance. If there is no or minimal response repeat dose after 5 minutes, can be repeated for a 3rd time after further 5-10 minutes if required. After 3 doses if ECG changes are still present check blood gas for potassium, ionised calcium and discuss with CSP/ICON/On Call Nephrology Consultant.

- ➢ Where response is adequate note the duration of action of calcium is only **30-60 minutes**, so further doses maybe necessary with ongoing hyperkalaemia. **Calcium only stabilises the cardiac membrane by antagonising the effects of excess potassium. It will not alter the serum potassium level.**

Additional information (refer to medusa)

- Undiluted calcium gluconate has a high osmolarity and may cause venous irritation and tissue damage in cases of extravasation. Concentrations greater than 0.045mmol of calcium in 1ml should be given via central access device. If central device is not available dilute as above and administer via large peripheral vein unless in case of clinical emergency
- Can be given neat via peripheral line if dilution volumes are too large but close monitoring is required.
  Dilute each 1ml of calcium gluconate 10% with 4ml of sodium chloride 0.9% or glucose 5%.
- **Do not give in the same line as bicarbonate as precipitation is likely to occur and block the line.**

- There are 2 injectable calcium salts available, they are NOT equivalent in terms of calcium.

  Calcium gluconate 10% contains 2.2mmol of calcium per 10ml **(1st line)**
  Calcium chloride 10% contains 6.8mmol of calcium per 10ml (only if gluconate is not available 0.1mmol/kg/dose over 5 minutes undiluted via central line only). Higher risk of necrosis if extravasation occurs.

Side effects most noted: hypotension, peripheral vasodilation, hot flushes, brady cardia, tissue necrosis if extravasation occurs.

Insulin (ACTRAPID) in saline with dextrose

- ✓ **Give intravenous insulin as a continuous infusion, glucose must also be prescribed to always maintain adequate blood sugars.**
- ✓ **>/= 10 kg: Make up Insulin in sodium chloride 0.9%: 50 units of Actrapid in 50 ml of sodium chloride 0.9% (1 unit/ml).** *Actrapid comes as 100 units in 1ml vials.*
- ✓ **<10kg kg: Make up Insulin in sodium chloride 0.9%: 25 units of Actrapid in 50 ml of sodium chloride 0.9% (0.5 unit/ml).**

- ✓ **Insulin must always be given via the same line as glucose using a Y site with glucose.**
- ✓ **Children over 1 month: Start soluble insulin (ACTRAPID) infusion at an initial rate of 0.05 units/kg/hour. Doses can be increased up to a maximum of 0.2 units/kg/hour.**

- ✓ **For neonates start at 0.3 units/kg/hour: Can increase up to a maximum of 0.6 units/kg/hour.**
- ✓ **(if concerns of hypoglycaemia, insulin can be started at a lower rate of 0.1units/kg/hour and titrated accordingly)**

- ✓ **Prescribe glucose side arm to maintain adequate blood sugars:**
- ✓ Initiate at 0.5g/kg/hour: **5ml/kg/hour of 10% glucose** or **2.5ml/kg/hour of 20% (central line only)**. Can be increased up to 1g/kg/hour: **10ml/kg/hour of 10%glucose** or **5ml/kg/hour of 20% (central line only)**.

- ✓ **Titrating Insulin/Dextrose Infusions:**

The aim of this infusion is to correct hyperkalaemia whilst maintaining normoglycaemia.

Whilst hyperkalaemia is ongoing, infusion titration may be necessary (medically lead). Suggested maximum doses of insulin and glucose are listed above. Potassium and glucose should be monitored at least every 30 minutes whilst infusion is ongoing and following cessation, at appropriate intervals to assess for rebound hyperkalaemia.

Symptomatic hypoglycaemia should be treated promptly with Glucose 10% Bolus of 2ml/kg and cessation of insulin.

- ✓ **Please prescribe the actual rates on EPIC and not a range, adjust prescription if rate is subsequently changed, document changes to rates and rationale for changes in notes.**

Additional information

- **Prescribe via Insulin for hyperkalaemia order set on Epic:** Choose with saline and prescribe the glucose arm in addition.
- Choose glucose strength based on the type of access available for the patient – if in doubt 10% can be run via both central and peripheral.

Intravenous Sodium Bicarbonate

Acidosis results in leakage of potassium from cells, Sodium Bicarbonate can help counteract this to some extent.

- ✓ Sodium Bicarbonate is available as 1mmol in 1ml (8.4% injection/infusion)
- ✓ In severe renal hyperkalaemia consider a dose **1-2mmol/kg (max 50mmol)** per dose. This can be repeated if required.
- ✓ **In an emergency/unstable patient:**

  8.4% (1mmol in 1ml) in children over 2 years of age

  4.2% (0.5mmol in 1ml) for under 2 years of age

  Can be given via large peripheral vein if central line is not available. Use central line where possible.

  Administered over 30 minutes whilst monitoring infusion site carefully. Can be repeated if required.
- ✓ **Ideally dilution is preferential as concentrations > 1.4% have high osmolarity and extravasation may result in severe tissue damage.**
- ✓ In **non-emergency situations/stable patient,** concentrations over 1.4% (0.17mmol/ml) should be given via central line as a continuous infusion over 3 hours. Dilute to 1 in 6 (1.4%) or less (1.26%) for peripheral line.

Check ionised calcium (on blood gas), if hypocalcaemia, this needs to be treated BEFORE giving sodium bicarbonate as there is RISK OF SEVERE HYPOCALCAEMIA WITH ASSOCIATED SEIZURES/TETANY.

Additional information

- Useful in correcting acidosis
- Effects of Sodium Bicarbonate can be variable and may not always reliably lower serum potassium
- Onset of action is 10- 30 minutes and duration of action is up to 2 hours
- Incompatible to mix with most medicines, do not give via same line

Other Drugs:

Furosemide

- 1 – 2 mg/kg IV may be effective depending upon renal status – if impaired renal function, discuss with on call renal team. **Caution** Administration in intravascular depletion may precipitate worsening hypovolaemia.

Resoniums

- Calcium polystyrene sulfonate or Sodium polystyrene sulfonate (collectively known as resoniums) can be used as treatment for acute cases of mild to moderate hyperkalaemia for **short-term use only**.
- These resins are only holding measures and the underlying cause for hyperkalemia must be identified. Can be used as add on therapy only for severe hyperkalemia.

- **Oral (Not for Neonates):** 0.5–1 g/kg daily in divided doses; maximum 60 g per day. If given orally should be given with lactulose 5 - 10 mL 4 times a day.
- **Rectal (Includes neonates):** 0.5–1 g/kg daily, irrigate colon to remove resin after 8–12 hours; maximum 30 g per day.

Sodium Zirconium

- Sodium Zirconium Cyclosilicate (SZC) is a non-absorbable **ion exchange resin,** that can be utilised for short- and longer-term use in patients with progressive kidney disease (late stage 4 and 5).
- Potential side effects include hypernatremia and worsening oedema (5g sachet contains 400 mg sodium)
- Can be prescribed **on the advice of the on-call nephrology consultant**.

- Dose:

Oral (child)	**Children 18 months and over**
6 months – 3 years	Initially 0.5g to 2.5g daily or on non-dialysis days. Titrate as per response up to a maximum of 5g.
3 years – 12 years	Initially 2.5g – 5g daily or on non-dialysis days. Titrate as per response up to a maximum of 5g.
12 years to 18 years	5 g daily or on non-dialysis days. Doses must be individualised based on patient needs. Where serum potassium is rising rapidly higher initial doses maybe used.

- See specific guideline (intranet)

Renal replacement therapy (CRRT, PD or HD)

- Discuss with on-call PICU or Paediatric Nephrology consultant as appropriate.

3 Pathophysiology and Causes

Paediatric hyperkalaemia is due to one or a combination of the following mechanisms (Table 2 – non exhaustive):

- Transcellular movement of intracellular potassium into the extracellular space
- Decreased renal excretion of potassium
- Excessive increase in potassium intake

Table 2. Causes (non-exhaustive) of hyperkalaemia in children based on pathophysiology

Category	Cause
Transcellular potassium movement	Cellular injury ▪ Haemolysis ▪ Rhabdomyolysis ▪ Tumour lysis ▪ Burns ▪ Trauma
	Metabolic acidosis ▪ Often caused or associated by decreased effective arterial blood volume ▪ Diabetic ketoacidosis
	Familial Hyperkalaemia Periodic Paralysis ▪ Autosomal dominant ▪ needs to be considered in any young child with hyperkalemia and concomitant muscle weakness
Abnormal renal potassium excretion/Decreased excretion	Decreased effective circulating volume (common) ▪ Sodium and water reabsorption is increased in the proximal portion of the nephron, resulting in a reduction in sodium delivery to the collecting tubule. This leads to functional impairment of urinary potassium excretion as there is a limited amount of sodium available for potassium exchange in the collecting tubule
	Acute and/or chronic kidney disease ▪ Reduced Glomerular filtration rate: not commonly observed until the GFR falls below 30 mL/min per 1.73 m2 ▪ Impaired tubular potassium secretion: UTI, obstructive uropathy, sickle cell disease, hyperaldosteronism (type IV renal tubular acidosis), medications (i.e. potassium-sparing diuretics)
	Decreased renin-angiotensin-aldosterone system activity ▪ Congenital adrenal hyperplasia ▪ Primary hypoaldosteronism/pseudohypoaldosteronism ▪ Medications: ACEi/ARB, spironolactone etc.
Increased potassium intake	Iatrogenic administration: IV or oral
	Increased ingestion
	Massive transfusion/transfusion of “old” blood
Pseudohyperkalaemia	Haemolysed specimen
	Thrombocytosis > 1000 G/L
	Leucocytosis > 70 G/L

Drugs that can cause hyperkalaemia:

Drugs that affect aldosterone secretion:

- ACE inhibitors
- Angiotensin Receptor Blockers
- Non-steroidal anti-inflammatory drugs
- Calcineurin inhibitors
- Heparins
- Anti-fungal (Ketoconazole, fluconazole, Itraconazole)

Drugs that block aldosterone binding to mineralocorticoid receptor:

- Spironolactone
- Eplerenone
- Drospirenone

Drugs that inhibit activity of the epithelial sodium channel:

- Potassium sparing diuretics (Amiloride)
- Trimethoprim/Co-Trimoxazole
- Pentamidine

Drugs that alter transmembrane potassium movement:

- B-blockers
- Digoxin
- Intravenous cationic amino acids
- Hyperosmolar solutions (e.g. Mannitol, glucose)
- Suxamethonium

Potassium containing agents:

- Potassium Supplements (Sando-K, Kay-Cee-L)
- Salt substitutes
- Red blood cell transfusions
- Macrogol/Movicol
- Herbal remedies e.g. Alfalfa, dandelion, nettle

4 Determining the underlying cause of hyperkalaemia

History and physical examination

The history may be indicative of a specific aetiology:

- History of chemotherapy in a child with a large tumour load is indicative of tumour lysis syndrome
- History of an unusually large intake of potassium due to intravenous (IV) fluids, parenteral nutrition, medications (e.g., potassium penicillin), or massive transfusion
- Known kidney disease
- Decreased urine output may be suggestive of kidney disease or reduced effective arterial perfusion
- History of massive trauma, excessive exercise, and/or muscular cramp (which also can be a finding of hyperkalaemia) is suggestive of rhabdomyolysis.
- History of significant haemolysis

Physical findings

- Hypertension and oedema may be indicative of kidney disease
- Decreased peripheral pulses, low blood pressure, tachycardia, and delayed capillary refill are often signs of significant reduced effective arterial perfusion
- Muscular tenderness may be seen in patients with rhabdomyolysis

Further Laboratory Investigations (if not sampled during initial assessment)

Bloods:

- FBC, platelets, and serum LDH to assess for blood dyscrasia or haemolysis
- Serum creatine kinase to detect muscle injury (context)
- Blood electrolytes (sodium, potassium, bicarbonate, chloride) to detect other electrolyte abnormalities such as metabolic acidosis
- Serum creatinine and urea to assess kidney function
- If there is a clinical concern for endocrinopathy, obtain serum aldosterone and plasma renin activity

Urinalysis to detect kidney disease

- Urine chemistries (urine should be obtained at same time or within a brief time of blood studies):
- Urine potassium values should be greater than 20 mEq/L
- Urine sodium values less than 20 mEq/L suggest increased proximal sodium absorption and a decrease in sodium delivery in the distal tubule, resulting in impaired potassium excretion due to limited availability of sodium for exchange

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6 Appendix 1

Administration of Insulin/Glucose Bolus for Hyperkalaemic Cardiac Arrest:

Dosing:

Patient <50 kg:
0.1 units/kg insulin with 0.5 g/kg glucose (Glucose 10% = 5 ml/kg, Glucose 20% = 2.5 ml/kg)

Patient >50 kg:
10 units insulin with 25 g glucose (Glucose 10% = 250 ml)

Preparation & Administration:

STEP ONE:
Draw 1ml of human soluble insulin (Actrapid ®) 100 units in 1ml into an insulin syringe and make up to 10 ml using sodium chloride 0.9%.

This gives a 10 unit in 1 ml solution.

Then dilute this insulin solution (10 units in 1 ml) with one of the glucose strength options below.

STEP TWO:
Patient <50kg:

Select Glucose concentration based on IV access.

Using **10% glucose** 500mL	Using **20% glucose** 500mL
• Add ***10 units*** (1ml) of the diluted human soluble insulin solution from step one to a 500mL bag of glucose 10%. • This provides 0.1 units of insulin per 5 ml • Label and mix well. • **Give 5mL/kg of this solution over 5 mins** via **peripheral or central line.**	• Add ***20 units*** (2ml) of the diluted human soluble insulin solution from step one to a 500mL bag of glucose 20%. • This provides 0.1 units of insulin per 2.5ml • Label and mix well. • **Give 2.5mL/kg of this solution over 5 mins** via **central line only.**

Transfer the required amount of insulin/glucose solution to 20ml or 50ml syringes for bolus administration in setting of cardiac arrest, ideally over 5 minutes.

Use a needle-free bag spike for drawing up and label syringes.

Patient ≥50 kg:

Using **10% glucose** 500 ml

• Remove and discard 250 ml from the 500 ml bag so that 250 ml remain in the bag of glucose 10%. Use a needle-free bag spike for drawing up.

• Add ***10 units*** (1ml) of the diluted human soluble insulin solution from step one to the remaining 250mL bag of glucose 10%.

• Label and mix well.

• **Give the 250 ml** via **peripheral or central line** ideally over 5 minutes.

Transfer the required amount of insulin/glucose solution to 50ml syringes for bolus administration in setting of cardiac arrest, ideally over 5 minutes.

Use a needle-free bag spike for drawing up and label syringes.

7 Document control

Document Control	
Hosting Clinical Directorate:	BBM
Clinical specialty/specialties to be published under:	Nephrology
Version Information	
New guideline ☒ Scheduled review ☐ Amended due to updates ☐	
Version number:	1
Previous title (if applicable):	n/a
Last version number (if applicable):	n/a
Last approval date (if applicable):	n/a
Major amendments made (if applicable):	n/a
Consultation	
Individuals/groups/teams consulted on the guideline development/updates:	Rukshana Shroff, Matko Marlais, Stephen Marks, Zainab Arslan, Faidra Veligratli, Samiran Ray, Sophie Skellet
Local Ratification Process	
Committees that have ratified the guidelines prior to presentation at Clinical Guidelines Committee:	
Legal Team sign off (if applicable):	
Does the guideline include information about consent?	No
If yes, has the Legal Team reviewed the guideline and signed it off?	n/a
Drugs and Therapeutics Committee sign off (if applicable):	
Does the guideline include information about drugs or therapeutic agents?	Yes
If yes, and the specialist pharmacist has confirmed that DTC approval is required, has this been done?	Approved at DTC June/May 2025
Nutrition Steering Committee sign off (if applicable):	

Does the guideline include information about nutrition or feeds or nutrition-related products?	No
If yes, has the NSC approved the described nutrition or feeds or nutrition-related product guidance?	N/A
Medicines and Therapeutics Oversight Assurance Committee sign off (if applicable):	
Does the guideline include information about use of a medical device or medical equipment that is to be used innovatively / is not what the manufacturer has intended as its use?	No
If yes, has the MTOAC approved the described innovative use of medical devices/equipment?	N/A
Clinical Guidelines Committee approval:	
Date Approved by Guideline Committee:	**29th July 2025**
Guideline Expiry Date:	**29th July 2028**