
بسم الله الرحمن الرحيم

# Potassium imbalance in the emergency department

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# Hypokalemia

**Hypokalemia** is defined as a serum or plasma potassium **level below** the normal value, which is usually defined as **3.5 mEq/L**.

Normal serum potassium concentrations in children and adolescents are similar to levels in adults. However, infants have a higher normal range of potassium.

# Causes of hypokalemia

**Decreased dietary potassium intake** is unlikely to cause hypokalemia in healthy children. However, prolonged decreased intake can contribute to potassium depletion caused by other disorders.

**Intracellular potassium uptake** results in transient hypokalemia. Increased potassium entry into the cells is promoted by the following conditions: alkalosis, increased insulin activity (eg, exogenous insulin administration) and beta-adrenergic activity (eg, albuterol administration), and hypokalemic periodic paralysis.

# Causes of hypokalemia

**Increased gastrointestinal (GI) loss** is the **most common cause** of pediatric hypokalemia.

**Increased urinary losses** is usually due to either increased delivery of sodium to the distal nephron in exchange for potassium (eg,diuretic therapy, genetic tubular disorders [Bartter and Gitelman syndromes], and osmotic diuresis) or increased mineralocorticoid activity (eg, hyperaldosteronism due to hypovolemia)

# Clinical manifestations

- Clinical manifestations vary depending on the severity and acuity of hypokalemia.
- **Symptoms** generally do not become manifest until the serum potassium is below 3 mEq/L, unless there is a rapid significant fall in serum potassium.
- Clinical findings include muscle weakness and paralysis, cardiac arrhythmias and electrocardiogram (ECG) changes (waveform 1), and polyuria due to impaired urinary concentration.

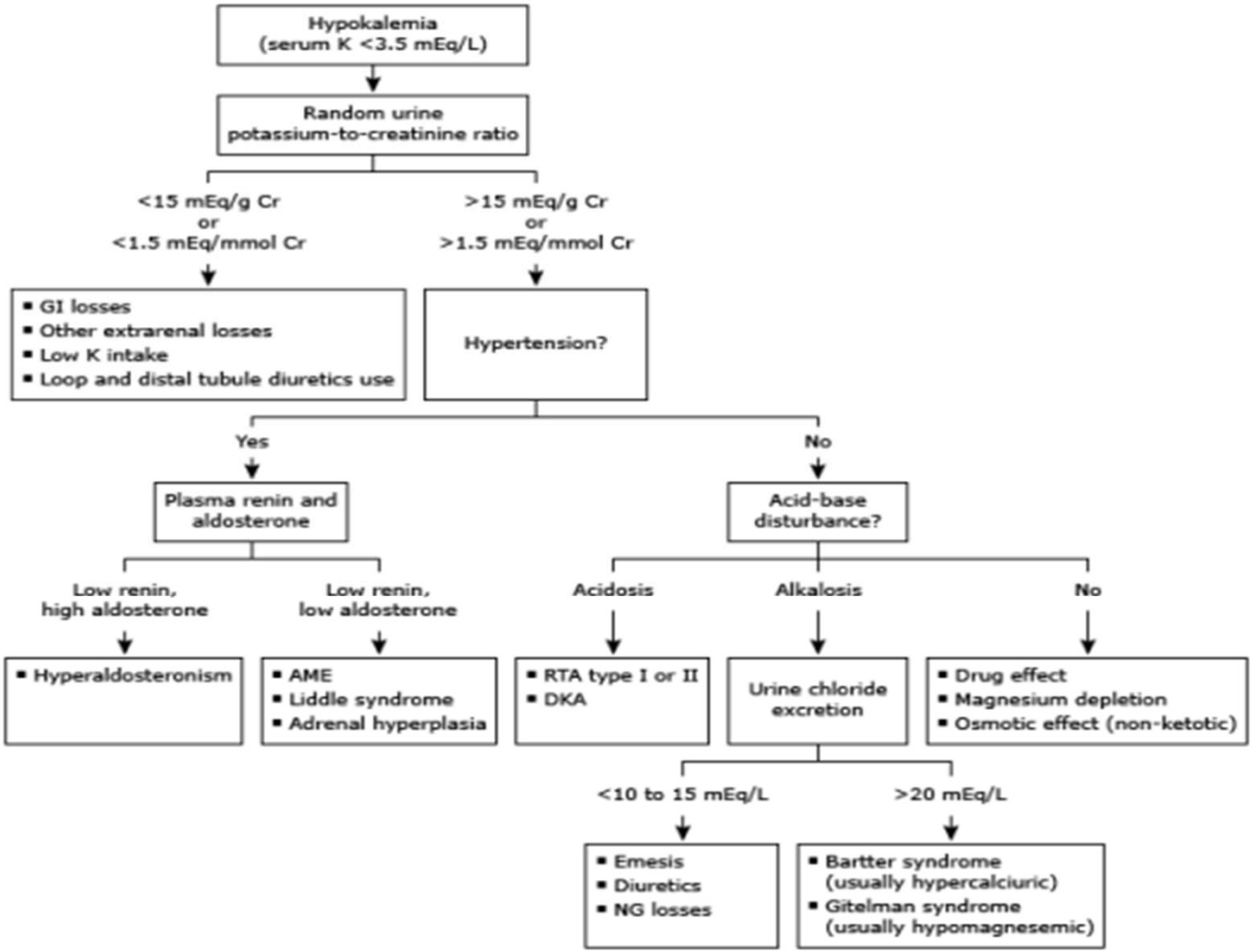
# Hypokalemia


An increase in the amplitude of U waves, which occur at the end of the T wave, are characteristic of hypokalemia.

## Laboratory testing for pediatric hypokalemia of unknown etiology

| |
|---|
| **Blood tests** |
| Chemistries (sodium, potassium, chloride, bicarbonate, magnesium, creatinine) |
| Venous pH |
| Plasma renin activity |
| Plasma aldosterone |
| **Urine tests** |
| Chemistries (sodium, potassium, chloride, calcium, creatinine) |

# Diagnostic approach to determine the etiology of pediatric hypokalemia



# Management

The acuity and degree of the hypokalemia influence the clinical approach to therapy.

The goals of therapy are to prevent or treat life-threatening complications (arrhythmias, paralysis, rhabdomyolysis, and diaphragmatic weakness) associated with severe hypokalemia, replace the potassium deficit, and correct the underlying cause.

# Severe or symptomatic Management

Patients with severe or symptomatic hypokalemia (**arrhythmias, marked muscle weakness, or paralysis**) require urgent potassium supplementation.

For these patients, we recommend intravenous (IV) administration of potassium chloride, particularly in those who are unable to take oral medication .

In this setting, an infusion with a potassium concentration of no more than 40 mEq/L is given at a rate **not to exceed 0.5 to 1 mEq/kg of body weight per hour.** The goal is to raise the potassium level by **0.3 to 0.5 mEq/L**.

These patients require continuous ECG monitoring to detect changes due to hypokalemia and also possibly rebound hyperkalemia during replacement therapy.

# asymptomatic patients

the need for potassium supplementation is based on the underlying cause and severity of hypokalemia.

If potassium supplementation is needed, we recommend that oral potassium therapy be given .

The **formulation of potassium** is also dependent on the underlying condition.

# formulation of potassium

- **Potassium chloride** tends to result in quicker potassium repletion per dose than phosphate or citrate and is the most common pharmacologic supplement. It is also preferred in patients with concomitant hypochloremia or metabolic alkalosis.

  **Potassium phosphate** is often used in the setting of **proximal tubule dysfunction**, such as Fanconi syndrome or cystinosis, where there is loss of both potassium and phosphorus.

  **Potassium acetate** is also commonly used in diabetic ketoacidosis, allowing for correction of hypokalemia as well as acidosis upon the metabolism of acetate to bicarbonate.

  **Potassium citrate** is generally used in children with hypokalemia and acidosis, as seen in types I and II RTA

# Hyperkalemia

- **Hyperkalemia** is typically defined as a serum or plasma potassium greater than 5.5 mEq/L (mmol/L). However, the upper limit of normal in infants may be as high as 6.5 mEq/L (mmol/L).
- Although children are less likely to develop hyperkalemia compared with adults, pediatric hyperkalemia is not an uncommon occurrence and severe hyperkalemia (potassium level ≥7 mEq/L [mmol/L]) is a serious medical problem and potentially life-threatening condition that requires immediate attention.

## Normal serum potassium levels in children*

| Age | Range (mEq/L or mmol/L) |
|---|---|
| Premature infant | 4 to 6.5 |
| Newborn | 3.7 to 5.9 |
| Infant | 4.1 to 5.3 |
| Child >1 year old | 3.5 to 5 |

* Local laboratory reference ranges for normal may vary depending on laboratory and assay technique. Clinical implications of variation from normal or reference range levels must be considered individually.

# Clinical features

**Muscle weakness, paralysis, and cardiac changes on ECG and arrhythmias**.

Sudden arrest may occur.

**ECG findings** commonly progress as follows:

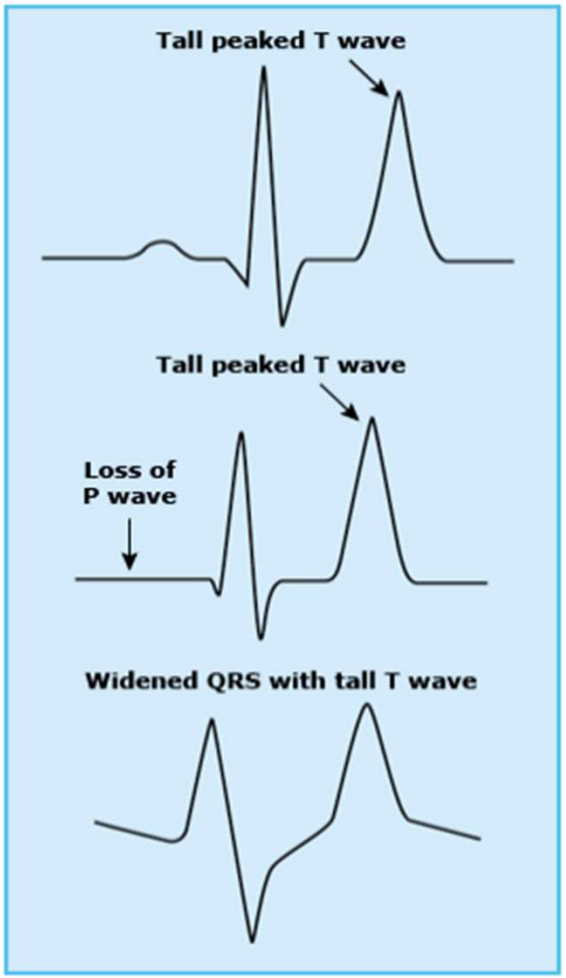
Peaked T waves

Prolonged PR and QRS intervals and small P waves

Loss of P wave, further prolongation of QRS interval, and conduction delay that can manifest as bundle branch or atrioventricular nodal block

Ventricular fibrillation or asystole

# Typical electrocardiographic features of hyperkalemia




| Serum potassium | Major change |
|---|---|
| 5.5-6.5 | Tall peaked T waves |
| 6.5-7.5 | Loss of P waves |
| 7.0-8.0 | Widening of QRS |
| 8.0-10.0 | Sine wave, ventricular arrhythmia, asystole |

# Pseudohyperkalemia

- usually due to hemolysis of the blood specimen, is the most likely cause of an elevated serum or plasma potassium level in children.

- It does not reflect true hyperkalemia and is not associated with cardiac conduction disturbances.

# major mechanisms of true hyperkalemia

**Increased potassium release from cells**, most commonly due to rhabdomyolysis (eg, crush injury, prolonged seizure, hyperthermia, or exercise), tumor lysis syndrome, massive transfusion, and metabolic acidosis

**Reduced urinary potassium excretion**, most commonly due to severe hypovolemia, impaired kidney function, or hypoaldosteronism (eg, adrenal insufficiency)

# Laboratory evaluation

- BUN/Creatinine/Blood glucose/Serum electrolytes/Urinalysis/Urine electrolytes

In cases where **rhabdomyolysis** is suspected, the following studies are also indicated:

- Serum creatine kinase and lactic dehydrogenase/Urine for myoglobin/Blood gas

In cases where **adrenal insufficiency** is suspected, additional testing includes:

- Serum cortisol and ACTH (prior to administration of exogenous corticosteroids)

# Emergency management before diagnostic evaluation

As therapy is initiated, it is important to **confirm that the child is hyperkalemic, especially if the clinical setting makes the diagnosis of hyperkalemia unlikely**, and to obtain an ECG in children with potassium >6 mEq/L (mmol/L) who are otherwise healthy or in whom there is a suspected rapid rise in potassium.

# Emergency management

- For patients with severe hyperkalemia (potassium level >7 mEq/L [mmol/L])
- signs or symptoms of hyperkalemia (ECG changes or muscular weakness or paralysis)
- potassium levels between 6 to 7 mEq/L(mmol/L) who are at risk for further increases in potassium

# Emergency management

**Stabilize cardiac membranes with calcium:**

Intravenous (IV) infusion of **calcium gluconate** 10 percent solution at a dose of 0.5 mL/kg (maximum dose 20 mL [2 g]) over five minutes.

In the clinical setting of a **cardiac arrest** or impending arrest, **calcium chloride** is typically used rather than calcium gluconate because it results in a more rapid increase in the serum ionized calcium. The dose of IV calcium chloride is 20 mg/kg (maximum dose 1000 mg) given over 5 to 10 minutes.

Although the protective effect of infused calcium is rapid in onset, its duration may be short lived and a repeat dose may be needed for persistent ECG changes or arrhythmias.

# Shift potassium into cells

- Insulin and glucose – Onset of action is 10 to 20 minutes. Only give if significant ECG changes or

confirmed serum potassium ≥7 mEq/L.

**Give regular insulin (dose of 0.1 units per kg, maximum dose of 10 units) along with dextrose(glucose) dose of 0.5 g/kg over 30 minutes**.

The administration of dextrose is based on the age of the patient as follows:

- **Children younger than 5 years of age – Give 10% dextrose (100 mg/mL) at a dose of 5 mL/kg**
- **Children 5 years of age and older – Give 25% dextrose (250 mg/mL) at a dose of 2 mL/kg**

# Insulin and glucose

- For patients with **severe acute symptoms, ECG changes, arrhythmias, or impending arrest** – Larger doses of regular insulin (0.2 units/kg) and dextrose (1 g/kg, 10 mL/kg of 10% dextrose or 4 mL/kg of 25% dextrose) can be administered.

- Repeat dosing can be given after 30 minutes if needed. The major adverse effect is hypoglycemia, and serum glucose level should be monitored closely and additional dextrose administered as needed.

# Beta-2 agonist

Onset of action is 20 to 30 minutes.

Give nebulized albuterol (salbutamol) with dosing based on patient weight as follows:

- **Neonates – 0.4 mg in 2 mL of saline**
- **Infants and small children <25 kg – 2.5 mg in 2 mL of saline**
- **Children between 25 and 50 kg – 5 mg in 2 mL of saline**
- **Older children and adolescents >50 kg – 10 mg in 2 to 4 mL of saline (doses up to 20 mg have been used)**

Inhalation may be repeated after 20 minutes.

Inhaled albuterol may also be administered by metered-dose inhaler as 4 to 8 puffs with spacer.

# Sodium bicarbonate

Onset of action is 15 minutes.

Provides minimal effect on shifting potassium intracellularly and should not be the only therapy used in the management of hyperkalemia, even in acidotic children.

- **Give 1 mEq/kg (1 mmol/kg) Maximum single dose of 50 mEq (50 mmol), which can be provided as 1 mL/kg of 8.4% solution or, for children younger than 6 months of age, 2 mL/kg of 4.2%**

solution administered over **10 to 15 minutes**.

A repeat dose may be given 10 to 15 minutes after last administration. Do not give in the same IV line as calcium, because of a risk of precipitation.

# Remove potassium

since the effect of above therapies is transient, treatments to remove potassium are also required.

**Stop all potassium intake.**

# Remove potassium

- Loop diuretic  Provides only limited short-term effect.

- Give **furosemide 1 mg/kg IV (maximum single dose of 40 mg);** fluid losses must be replaced unless the patient is volume expanded.

- The onset of effect is 1 to 2 hours. May be repeated after 6 hours.

# Remove potassium

- **Cation exchange resin** (sodium polystyrene sulfonate) – **Give sodium polystyrene sulfonate (without sorbitol) at a dose of 1 g/kg (maximum dose of 30 g) orally,** through nasogastric tube, or as a retention enema.
- 1 g of resin will bind 1 mEq (mmol) of potassium.
- Onset is approximately 1 to 2 hours; may repeat dose after 4 to 6 hours based on repeat serum potassium.

# Remove potassium

- Sodium polystyrene sulfonate **should not be used in preterm neonates**, term neonates with intestinal hypomotility and/or those at risk for necrotizing enterocolitis, postoperative patients, or those with bowel obstruction or ileus. Sorbitol can cause intestinal necrosis and should be avoided.

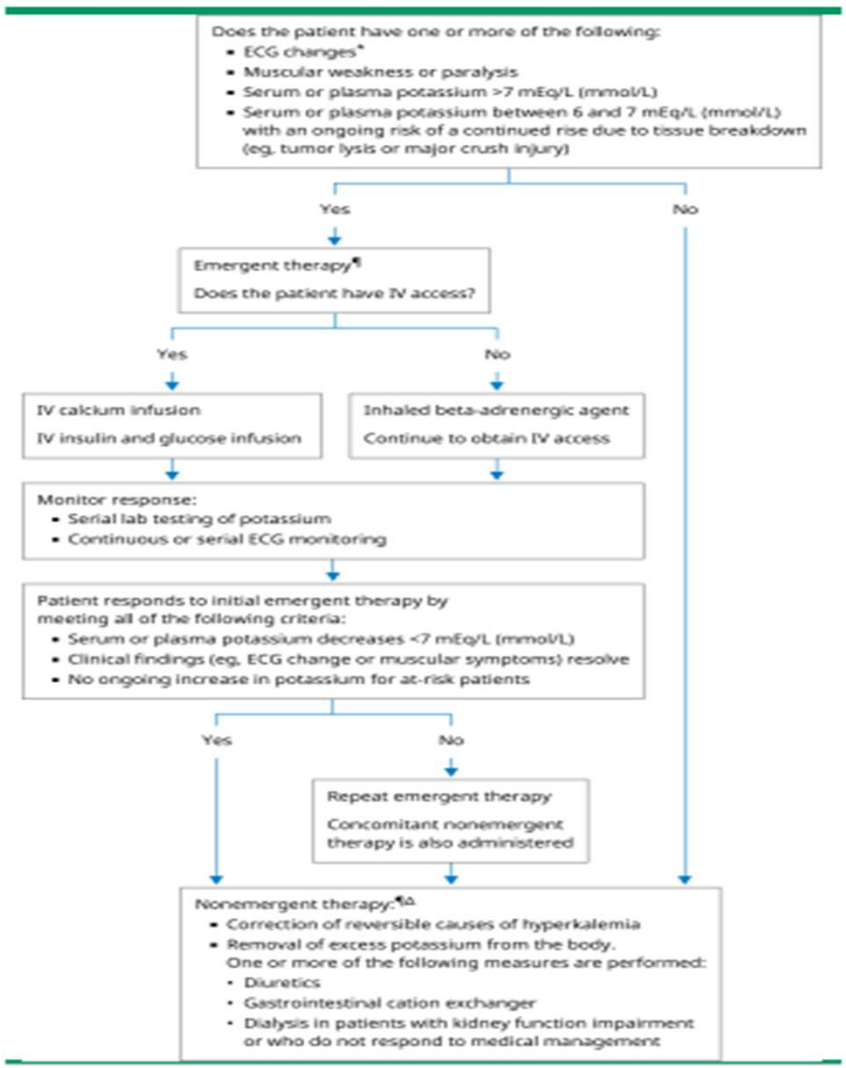
- A laxative that contains no magnesium or potassium (eg, lactulose) is an alternative to sorbitol use to prevent colonic impaction.

# Remove potassium

- Hemodialysis – In children unresponsive to diuretic or cation exchange resin therapy, or with severe kidney function impairment, dialysis may be necessary to remove excess potassium from the body.

- Hemodialysis is the preferred modality to reduce potassium levels as it is the quickest and most controlled kidney replacement treatment.

## Management of acute pediatric hyperkalemia



از توجه شما
متشکرم!