Hyperkalemia — Causes and Definition

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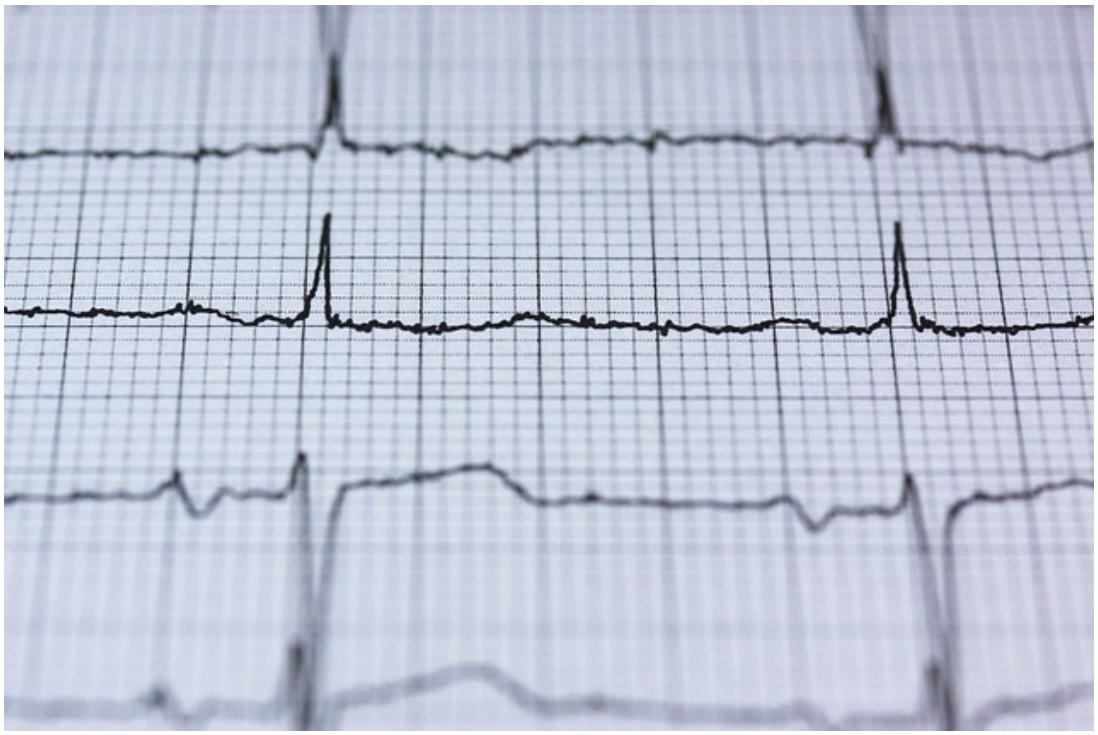
Hyperkalemia is defined by the serum potassium level when it is higher than 5.5mEq/L. It is usually an incidental finding in the general population but affects 10 % of hospitalized patients. Severe hyperkalemia is rare but catastrophic as it causes respiratory paralysis, generalized muscle paralysis, and cardiac arrest.



Definition

Hyperkalemia is a disorder characterized by serum potassium level greater than 5.5 mEq/L. A level greater than 7 mEq/L leads to a compromised cardiac and neurologic system.

Cardiac arrest and paralysis sets in when the level exceeds 8.5 mEq/L thus necessitating emergency treatment. The normal potassium level varies with age. Neonates less than 10 days old have an upper limit of up to 6.5 mEq/L.

Epidemiology of Hyperkalemia

The worldwide prevalence of hyperkalemia is estimated to be 5 % of the general population and 10 % of the hospitalized patients. Among the general population, **hyperkalemia is usually an incidental finding during routine workup** or workup for other diseases while among the hospitalized patients iatrogenic hyperkalemia is

symptomatic.

The prevalence is even higher with the extremes of ages. Among the elderly, hyperkalemia arises due to chronic diseases such as diabetes and is associated with renal failure. However, in very young children, hyperkalemia is higher due to renal congenital anomalies that lead to insufficiency.

Classification of Hyperkalemia

Hyperkalemia is classified into:

- Mild hyperkalemia: 5.5–6.0 mEq/L
- Moderate hyperkalemia: 6.1–7.0 mEq/L
- Severe hyperkalemia: > 7.1 mEq/L

Etiology and Pathophysiology of Hyperkalemia

Normal control of potassium level

Potassium is the principal intracellular cation that is needed for the maintenance of the membrane potential across the cells of nerves and muscles during transmission of impulses. The source of potassium could be from a diet rich in potassium, such as intake of bananas, beans, and meat, or the intravenous/oral administration of supplemental potassium.

Upon intake or infusion, the cation is absorbed in a rate of 1 mEq/Kg/day. Most of the absorbed ions (up to 90 %) are excreted via the kidneys. This is important in maintaining a normal serum level of potassium as well as a normal storage level.

The **total body potassium stored in the muscles is estimated to be 50 mEq/kg**. The cations are either intracellular (98 %) or extracellular (2 %). The extracellular potassium is the measurement in reference during laboratory testing and it is maintained at a range of 3.5-5.0 mEq/L via a homeostatic mechanism across the cell membrane aided by the Na+/K+/ATPase pumps.

Note: A change in the rate of intake, absorption, excretion or transport across the cell membranes leads to an abnormal level of serum potassium concentration.

Etiology

The cause of hyperkalemia is discussed in the following topics:

Increased intake of potassium

It is rarely a single cause of hyperkalemia especially in patients with a GFR> 60 ml/min. However, some situations have been reported, such as massive parenteral administration of potassium supplementation or massive transfusion with packed red blood cells, which may cause a slight increase in potassium level.

Decreased excretion of potassium

Dysfunctional kidneys lead to an elevated serum potassium level in several ways. First, when the removal of the potassium delivered to the kidneys for excretion is impaired, accumulation occurs and hyperkalemia ensues. Also, the majority of patients

with renal dysfunctions are on diuretic medications. Most of these medications work by eliminating the water but sparing potassium, thus leading to a high concentration of potassium in the body. Moreover, the drugs are not easily removed from the body, and very minimal doses may have a huge impact on the level of potassium.

Shifting of potassium to the extracellular compartment

High levels of glucose around the cell extract water out of the cells. If the **water is accompanied by the movement of potassium in the same direction, this leads to hyperkalemia**. It is seen in diabetic patients with ketoacidosis who have a compromised renal excretory mechanism.

The **shift may also occur with the destruction of cells freeing the intracellular potassium**.

This is seen in cases of:

- Trauma
- Burns
- Hemolysis
- Tumor lysis syndrome
- Malignant hyperthermia

Clinical features of Hyperkalemia

Mild hyperkalemia occurs as an incidental finding during routine workup or during workup for other diseases. The patient is asymptomatic.

Potassium is the cation required for membrane stability and signal transmission in muscles and nerves. Therefore, **excessive levels of potassium destabilize the membrane potentials and lead to a compromised muscle function** which can be seen in the following incidences:

1. Initially, vague symptoms such as nausea, weakness, and fatigue as muscles in the extremities are unable to contract.
2. Continued compromise of the function leads to tingling sensation and frank paralysis.
3. Later muscle pains set in with the onset of rhabdomyolysis
4. Compromised gut muscles may lead to reduced bowel movements and constipation.
5. Compromised cardiac muscles lead to bradycardia and cardiac arrest.
6. Compromise of respiratory muscles leads to difficulty in breathing.

Other symptoms occur due to associated conditions

1. A recent history of parenteral administration of potassium may give a clue in a hospitalized patient.
2. Polyuria and poor glucose control may be the presenting symptoms in a patient with diabetes.
3. Vomiting and reduced urine output may be the presenting features of a patient with renal failure.

Examination findings in hyperkalemia

1. Absent deep tendon reflexes due to muscle paralysis.
2. Hypoactive/absent bowel sounds and constipation/ileus.
3. Bradycardia due to compromise of the heart muscle function
4. Tachypnea due to respiratory muscle weakness

Investigations of Hyperkalemia

Laboratory investigations are done mainly to define the severity of hyperkalemia and as a baseline before initiation of therapy. They include:

Serum potassium level greater than 5.5 mEq/l. This is **usually the initial test if hyperkalemia is suspected.**

Electrocardiogram (ECG) is the next best test for hyperkalemia. It's done to establish ECG findings in hyperkalemia that are an indication of severity.

- Early changes: ST wave depression and peaked T waves best seen in precordial leads

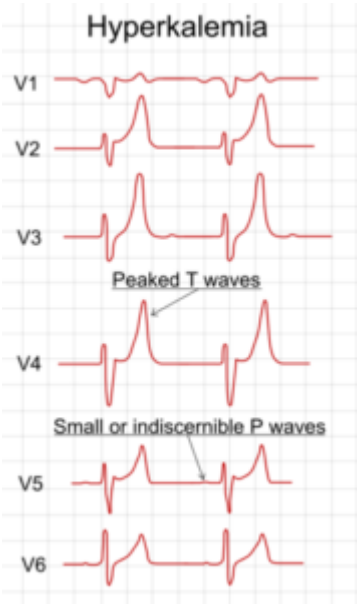


Image: "Electrocardiography showing precordial leads in hyperkalemia" by Frank G.Yanowitz, M.D. & The Alan E. Lindsey ECG Learning Center. License: Public Domain

- Intermediate changes (potassium level 6.5-8.0): reduced amplitude of P waves, amplified R waves, prolonged PR interval, and a widened QRS complex
- Late changes (potassium level > 8.1 mEq/L): absent P waves, progressive widening of the QRS complex, sine wave pattern and bundle bunch blocks

Urine potassium levels and osmolality.

Tests to rule out differential diagnoses

- Thyroid function tests
- Renal functional tests to rule out kidney dysfunction
- Cortisol levels to determine mineralocorticoid deficiency

- Blood sugar level in patients with suspected diabetes
- Uric acid and phosphorus level if tumor lysis syndrome is suspected

Differential Diagnosis of Hyperkalemia

Pseudo hyperkalemia	• An important differential diagnosis due to poor sample collection techniques such as clenching or milking of the extremity that leads to hemolysis and hyperkalemia. • Can also arise after hemolytic transfusion reaction.
Tumor lysis syndrome	• Differentiated by the presence of hyperuricemia and hypocalcemia
Chronic kidney disease	• Associated symptoms such as reduced urine output and uremic symptoms • Deranged creatinine clearance and GFR
Digitalis toxicity	• Drug screen indicates the presence of digitalis in circulation in a patient with a history of heart disease.
Injuries (trauma, burns)	• History of occurrence preceding the onset of hyperkalemia
Malignant hyperthermia	• History of anesthetic use with other symptoms such as temperature change and tachycardia

Treatment of Hyperkalemia

The **cause and severity of hyperkalemia guide the management of the condition**.
Mild hyperkalemia is treated on an outpatient basis using modalities such as:

- Dietary restriction of potassium-rich fruits and vegetables
- Discontinuation of all medications that increase potassium levels
- Administration of diuretics other than potassium-sparing diuretics to increase excretion of excess potassium

Moderate to severe hyperkalemia requires additional methods of management for symptomatic relief and avoidance of recurrence.

Membrane Cell Stabilization

The first intervention is the administration of 10 % calcium chloride for the protection of cardiac muscles against extreme compromise. The drug increases the threshold potential that is necessary in restoring resting membrane potential.

Increased excretion of potassium

The next intervention is increasing the excretion of potassium from the body by:

- Administration of diuretics other than potassium-sparing diuretics, such as furosemide 40 mg twice a day. The dose is followed by the administration of IV fluids to avoid hypotension.
- Other **drugs such as aldosterone analogs may increase potassium excretion and are administered**.
- Hemodialysis is especially useful if the cause is related to renal failure as the method treats hyperkalemia and renal failure concurrently, or the patient has severe hyperkalemia that is refractory to medical treatment.

Intracellular potassium shift

Another modality of treatment is the shifting of excess potassium from the extracellular space to the intracellular space which is achieved by:

- Intravenous administration of 10 I.U of insulin, which leads to the escape of potassium back into the cells.
- Insulin dose is followed by an infusion of 50 ml of 50 % dextrose solution to control hypoglycemia.
- 10 mg of nebulized salbutamol a β-adrenergic agonist also forces a similar shift in potassium concentration.
- Sodium bicarbonate administration is important in controlling metabolic acidosis in addition to forcing a shift of potassium into the intracellular compartment.

Drugs such as kayexalate, a cation exchange resin, bind to the free potassium reducing its damaging effects.

Complications of Hyperkalemia

Due to high potassium levels, cardiac arrhythmias manifest as dysfunctional heart muscles leading to bradycardia and bundle branch blocks.

Muscle weakness and paralysis may be life-threatening, especially if involving the respiratory muscles.

Rebound hypokalemia and hypotension are also seen with aggressive diuresis.

References

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Notes