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Hyperkalemia: A Quick Reference

Marcia Mery Kogika, DVM, MS, PhD[a,*],
Helio Autran de Morais, DVM, PhD[b]

[a]Departamento de Clínica Médica, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Av. Prof. Dr. Orlando Marques de Paiva, 87, 05508-270 São Paulo, SP, Brazil
[b]Department of Medical Sciences, University of Wisconsin–Madison, 2015 Linden Drive, Madison, WI 53706, USA

- Potassium is the main intracellular cation. Intracellular potassium represents approximately 95% of total body potassium. The extracellular content is much lower, but small changes in extracellular concentration can have major clinical implications.
- Total body potassium is regulated by the kidneys and colon under the influence of aldosterone.
- Intracellular potassium balance is maintained by transcellular shifts regulated mostly by insulin and catecholamines.
- Potassium maintains resting membrane potential. Changes in potassium concentration are associated with a decrease in the excitability of membranes, especially in cardiac and skeletal muscles.
- Changes in serum potassium concentration attributable to acid-base imbalance are variable and mostly clinically irrelevant.
- Hyperkalemia is uncommon if renal function and urine output are normal.

ANALYSIS

- Indications: Serum potassium should be measured in patients at high risk to have or develop hyperkalemia. This includes dogs and cats with vomiting, diarrhea, dehydration, oliguria or anuria, unexplained bradycardia, and muscular weakness. Potassium should also be measured if hypoadrenocorticism, renal failure, urethral obstruction, or uroabdomen is suspected.
- Typical reference range: Reference values for dogs and cats range from 3.5 to 5.5 mEq/L. These values may vary slightly among laboratories. Serum potassium concentrations exceed plasma concentration because potassium is released from platelets during clotting.
- Danger values: Concentrations greater than 7.5 mEq/L may be associated with substantial cardiac conduction disturbances and muscle weakness.

*Corresponding author. *E-mail address*: mmkogika@usp.br (M.M. Kogika).

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Box 1: Principal causes of hyperkalemia

Pseudohyperkalemia

- Thrombocytosis (usually mild but can have marked changes)
- White blood cell counts greater than 100,000 cells/μL (rare but can cause significant changes)
- Hemolysis in breeds or individuals with a high red blood cell potassium concentration (eg, akitas, English springer spaniels, neonates, occasional other dogs)

Decreased urinary excretion (most common)

- Urethral obstruction (common and important)
- Ruptured bladder or ureter (uncommon but important)
- Anuric or oliguric renal failure (common and important)
- Hypoadrenocorticism (uncommon but important)
- Selected gastrointestinal diseases (eg, trichuriasis, salmonellosis, perforated duodenal ulcer)
- Chylothorax with repeated pleural fluid drainage (rare)
- Hyporeninemic hypoaldosteronism (with diabetes mellitus or renal failure) (rare)
- Drugs (ACE inhibitors [eg, enalapril],[a] potassium-sparing diuretics [eg, spironolactone, amiloride, triamterene],[a] prostaglandin inhibitors,[a] or heparin[a])

Increased intake

- Unlikely with normal renal or adrenal function unless administration is greatly excessive (eg, intravenous administration of fluids with high potassium chloride [KCl] concentrations, administration of large doses of potassium penicillin G)

Translocation (intracellular fluid → extracellular fluid)

- Insulin deficiency (eg, diabetic ketoacidosis) (uncommon and transient)
- Acute inorganic acidosis (eg, hydrogen chloride [HCl], NH_4Cl) (rare)
- Massive tissue damage (eg, acute tumor lysis syndrome [rare], reperfusion of extremities after aortic thromboembolism in cats with cardiomyopathy [rare], crush injuries)
- Hyperkalemic periodic paralysis (rare)
- Drugs (nonspecific beta-blockers [eg, propranolol[a]])

[a]Only likely to cause hyperkalemia in conjunction with other contributing factors (eg, decreased renal function, concurrent administration of potassium supplements).

Adapted from DiBartola SP, de Morais HA. Disorders of potassium: hypokalemia and hyperkalemia. In: DiBartola SP, editor. Fluid therapy in small animal practice. 2nd edition. Philadelphia: WB Saunders; 2000. p. 100; with permission.

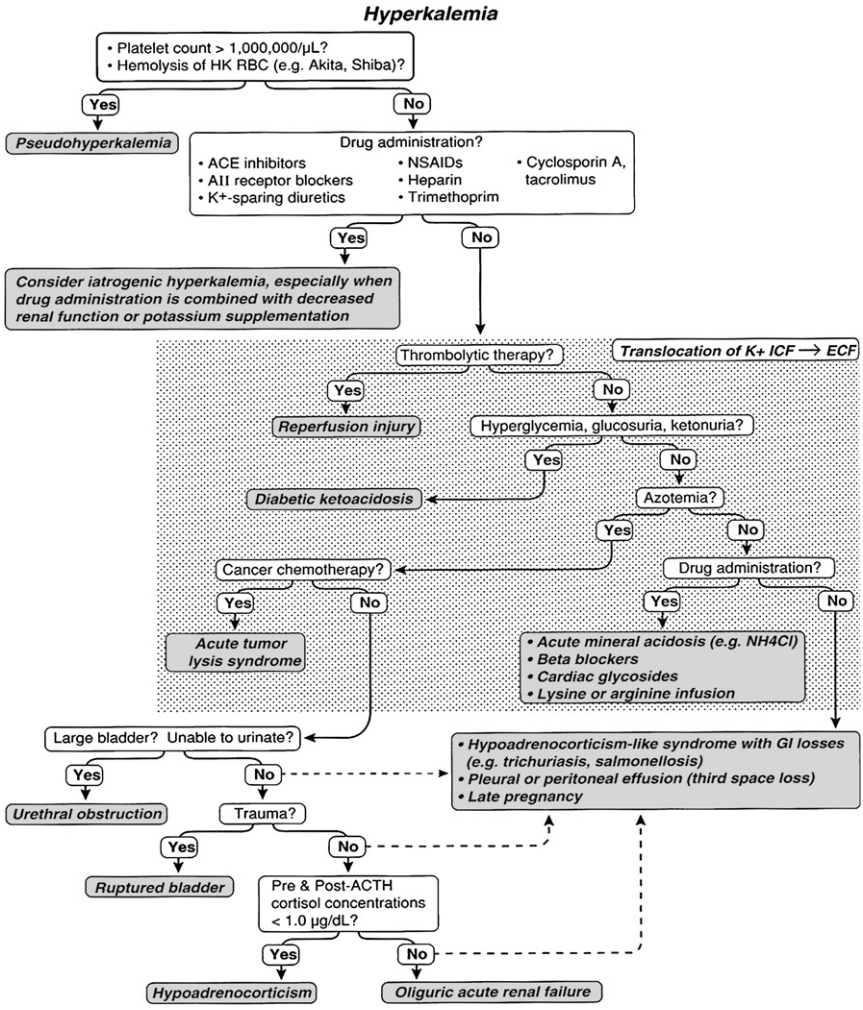

Fig. 1. Algorithm for the clinical approach for hyperkalemia. ACTH, corticotropin; ECF, extracellular fluid; GI, gastrointestinal; HK, genetic mutation associated with high intracellular potassium concentration in RBC of dogs; ICF, intracellular fluid; NSAIDs, nonsteroidal anti-inflammatory drugs; RBC, red blood cell. (*From* DiBartola SP, de Morais HA. Disorders of potassium: hypokalemia and hyperkalemia. In: DiBartola SP, editor. Fluid, electrolyte, and acid-base disorders. 3rd edition. St. Louis (MO): Elsevier; 2006. p. 112; with permission.)

- Artifacts
  - Pseudohyperkalemia, an in vitro increase in potassium concentration, may be observed in the following:
    - Hemolysis in neonates or canine breeds with high intracellular potassium (eg, akita, shiba, kindo).
    - Thrombocytosis: severe thrombocytosis may artificially increase serum potassium concentration because potassium is released from platelets

during clotting. Plasma potassium concentration should be measured in patients that have thrombocytosis.
    - Leukocytosis: animals with white blood cell counts greater than 100,000 cells/μL also may have substantial hyperkalemia because of transcellular leakage of potassium.
  - Use of ethylenediaminetetraacetic acid (EDTA) or potassium oxalate may markedly increase measured values.
- Drug effect: Excessive potassium administration in fluids can lead to hyperkalemia. Use of spironolactone, angiotensin-converting enzyme (ACE) inhibitors, and nonselective beta-blockers may be associated with hyperkalemia.

HYPERKALEMIA

- Causes: Hyperkalemia may result from the causes listed in Box 1.
- Stepwise approach: An algorithm for the differential diagnosis of hyperkalemia is presented in Fig. 1.
  - Increased intake of potassium if there is concomitant impairment of renal excretion or drugs that interfere with potassium renal excretion are being used.
  - Decreased urinary excretion associated with urethral obstruction, oliguric or anuric renal failure, ruptured bladder, and hypoadrenocorticism.
  - Translocation of potassium may be observed with insulin deficiency and in massive tissue breakdown (eg, acute tumor lysis syndrome, reperfusion). Translocation attributable to metabolic acidosis is only clinically important in acute mineral acidosis (eg, infusion of NH_4Cl or HCl).
  - Hyperkalemia and hyponatremia are classically found in dogs with hypoadrenocorticism. They also may occur in renal failure, secondarily in selected gastrointestinal diseases (eg, trichuriasis, salmonellosis, perforated duodenal ulcer), in ruptured bladder, and in pleural and peritoneal effusions, however.
- Signs: Muscle weakness, bradycardia, and typical electrocardiographic abnormalities.

Further Readings

DiBartola SP, de Morais HA. Disorders of potassium: hypokalemia and hyperkalemia. In: DiBartola SP, editor. Fluid, electrolyte, and acid-base disorders. 3rd edition. St. Louis (MO): Elsevier; 2006. p. 91–121.

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