Coffee and Hypokalemia

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Though caffeine has been shown experimentally to lower serum potassium,[1] this effect has not generally been appreciated as having clinical significance. As a xanthine derivative, caffeine might be expected to share properties of theophylline, which has been found to produce significant hypokalemia in accidental and intentional overdose.[2–4] Little has been written on the subject of xanthines and potassium and the possibility of hypokalemia occurring in association with excessive use of caffeine.

CASE REPORT

A 41-year-old woman was seen in the Family Practice Center for longstanding symptoms of syncope, muscle spasm, paresthesias, and irritable bowel syndrome consisting of epigastric and periumbilical pain. She gave a history of undocumented ulcers and gallbladder problems. In the course of outpatient workup, a serum potassium of 2.7 mmol/L (2.7 mEq/L) was discovered.

She was admitted to Monsour Medical Center on June 2, 1986, for study. In the hospital additional history was obtained. Hypokalemia was known to be a problem since her last child was born 20 years previously. She denied vomiting of any kind, bulimia, diarrhea, purging by laxatives, ingestion of licorice, use of diuretic medication, and history of high blood pressure. She admitted to drinking 20 or more cups of coffee per day from the age of 15 years.

She had been treated elsewhere for syncope in 1963 and 1981. The serum potassium determination, though not retrieveable from the first admission, was said to be low, whereas during the latter admission, the serum potassium level was 2.6 mmol/L (2.6 mEq/L). On both occasions serum potassium recovered to normal levels after potassium repletion in the hospital.

On physical examination her pulse was 84 beats per minute and regular, and her blood pressure was 104/76 mmHg. Her weight was 81 lb, and height was 4 ft 11 in. Carpopedal spasm was observed during the blood pressure determination. Repeated positive Trousseau signs were obtained. The remainder of the physical examination was within normal limits with the exception of findings of nummular eczema.

The laboratory results showed the complete blood count to be normal with white blood cell count of $8.1 \times 10^3/\mu L$ ($8.1 \times 10^9/L$), normal differential, a hemoglobin of 150 g/L (15 g/dL), hematocrit of 0.43, and adequate platelets; electrolytes showed a serum potassium of 2.9 mmol/L (2.9 mEq/L), chloride of 103 mmol/L (103 mEq/L), sodium of 132 mmol/L (132 mEq/L), magnesium of 0.95 mmol/L (1.9 mEq/L); venous pH was 7.39 (equivalent to 7.44 arterial); urea nitrogen 2.9 mmol/L (8 mg/dL); creatinine was 60 μmol/L (0.7 mg/dL); calcium was 2.49 mmol/L (10 mg/dL); and inorganic phosphates were 1.36 mmol/L (4.2 mg/dL). When she was having peak symptoms, urinary electrolytes were sodium 82 mmol/L (82 mEq/L), potassium 41.6 mmol/L (41.6 mEq/L), and chloride 90 mmol/L (90 mEq/L), while plasma renin activity was 1.72 ng/(L·s) (6.19 ng/mL/h) and serum aldosterone was 400 pmol/L (14.5 ng/dL). Repeated urinary electrolytes were sodium 1.1 mmol/L (1.1 mEq/L), potassium 4.3 mmol/L (4.3 mEq/L), and chloride 16.6 mmol/L (16.6 mEq/L). Arterial blood gases were partial pressure of oxygen 100 mmHg, partial pressure of carbon dioxide 39 mmHg, bicarbonate 27 mmol/L (27 mEq/L), and pH 7.45. Urine screening test for diuretics was negative.

While in the hospital, without potassium repletion or other specific therapy, daily serial potassium determinations were 3.1, 3.3, 3.3, and 3.4 mmol/L (3.1, 3.3, 3.4 mEq/L). The diagnosis of caffeine-induced hypokalemia was made. Discharge instructions were to forego caffeine-containing beverages.

For the next three months she remained free of symptoms of syncope and muscle cramps. Her serum potassium measurements ranged from 3.5 to 3.7 mmol/L (3.5 to 3.7 mEq/L) during this period. The patient experienced a recurrence of all her initial symptoms approximately six months later, including syncope. She readily admitted a

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return to her habit of 20 cups of coffee per day. Her serum potassium level was 2.5 mmol/L (2.5 mEq/L). With oral potassium therapy her potassium level recovered to a level of 5.1 mmol/L (5.1 mEq/L). After renewed determination to abstain from caffeine, her symptoms once again abated and her serum potassium reverted to normal. As a precaution, however, she has been placed on 60 mmol (60 mEq) of oral potassium per day.

DISCUSSION

Accurate diagnosis of hypokalemia in clinical practice is important, as definitive treatment can be quite different depending on the cause. The first point of determination is whether potassium loss is renal or extrarenal. In renal loss urinary potassium is inappropriately high, usually above 30 mmol/24 h (30 mEq/24 h), compared with the serum potassium. This patient's urine potassium was 41.6 mmol/24 h (41.6 mEq/h). Her loss, therefore, was through the kidney. This patient was normotensive with metabolic alkalosis. In such a setting, hypokalemic metabolic alkalosis with renal potassium loss is usually approached by probing for diuretic effect, laxative abuse, Bartter's syndrome, and surreptitious vomiting.

If there were vomiting, the urine potassium would be high (as in this patient) but urinary chloride would be quite low, unlike this case (90 mmol/L, 90 mEq/L). Diuretics would cause a renal loss, but her urine was negative for diuretics. Bartter's syndrome as a renal cause of hypokalemia is characterized by hyperreninemia and hyperaldosteronemia with normal blood pressures. Renin and aldosterone levels were unremarkable. While this woman was habituated to laxatives, they would not be the cause of her hypokalemia, as she then would have manifested low urine potassium.

While excessive coffee drinking is not listed as a cause of hypokalemia in standard textbooks, it is well documented in the literature. In this case her urine and serum potassium returned to normal without potassium repletive therapy. While she was in the hospital, she ingested a regular hospital diet without access to unusual amounts of coffee.

The episodes of tetany were probably the result of hypokalemia and alkalosis combined.[5] There was no hypocalcemia. Her gastrointestinal and dermatologic symptoms were due to pharmacologic effects of caffeine.

Hypokalemia has been observed in research studies of theophylline both at therapeutic levels and in intentional overdose.[1–3] Passmore et al[1] showed experimentally that 180 and 360 mg of caffeine may result in average serum potassium decreases of 0.26 and 0.44 mmol/L (0.26 and 0.44 mEq/L), respectively. Certain individuals in each of their four groups, ingesting 45, 90, 180, and 360 mg of caffeine, manifested decreases in serum potassium of 0.5 mmol/L (0.5 mEq/L) or more. Peak caffeine levels were reached after one to two hours and began to subside after four hours. Falling potassium levels were significant after four hours. Our patient's caffeine intake averaged 20 cups per day. With 74 mg caffeine per cup, she ingested 1,580 mg/d, or approximately 100 mg for each waking hour.[6]

Though the basis of hypokalemia associated with caffeine is not known for certain, there may be three possible causes. Support is given to xanthine stimulation of adenosinetriphosphatase, resulting in acceleration of the sodium pump.[1] As sodium leaves the cellular compartment, potassium enters. This mechanism explains only the lowering of serum potassium, not the net loss through the urine as reflected by the high urinary concentration of potassium. The effect would be only temporary and reversible as the caffeine level abates between peaks of absorption.

Two effects of heavy coffee drinking may result in lowering of serum potassium by total body loss through the kidney. First is the diuretic effect of caffeine, comparable to the effect of theophylline, with which it is structurally similar. Such diuresis results in kaluresis.[3,7] Second, and probably not insignificant, is the effect of volume of fluid intake involved in ingesting 20 cups of coffee, as in the case presented. More than 2 L of extra fluid consumed repeatedly per 24-hour period would in itself cause a diuresis and potassium loss.

This case is presented to point out that caffeine intoxication should be included in the differential diagnosis of hypokalemia in the outpatient setting, especially when associated with other symptoms of caffeinism.

References

1. Passmore AP, Kondowe GB, Johnston GD: Caffeine and hypokalemia, letter. Ann Intern Med 1986; 105:468
2. Zantwoort FA, Derkx FHM, Boomsma F, et al: Theophylline and serum electrolytes, letter. Ann Intern Med 1986; 104:134–135
3. Hall KW, Dobson KE, Dalton JG, et al: Metabolic abnormalities associated with intentional theophylline overdosage. Ann Intern Med 1984; 101:457–462
4. Addis GJ, White KG, Reid JL: The effects of steady state theophylline on catecholamine kinetics and adrenaline induced hypokalemia. In Turner-Warick M, Levy J (eds): New Perspectives in Theophylline Therapy. International Congress and Symposium Series, No. 78. London, Royal Society of Medicine, 1984
5. Fourman P: Experimental observations on the tetany of potassium deficiency. Lancet 1954; 2:525–528
6. Gilbert RM, Marshman JA, Scwieder M, et al: Caffeine contents of beverages as consumed. Can Med Assoc J 1976; 114:205–208
7. Ludens JH, Willis LR, Williamson HE: Effect of aminophyllin on renal hemodynamics and sodium excretion. Arch Int Pharmacodyn Ther 1970; 185:274–286