Mild hyperkalemia and low eGFR a tedious recipe for cardiac disaster in the elderly: an unusual reversible cause of syncope and heart block

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Abstract

Hyperkalemia affects the myocardial tissue producing electrocardiographic abnormalities, such as prolongation of the P-R interval, tall peaked T waves, a reduction in the amplitude and an increase in the duration of P wave, and atrial and ventricular arrhythmias, including variable degree heart blocks. Elderly patients are particularly predisposed to developing hyperkalemia and the associated abnormalities due to an age-related reduction in glomerular filtration rate and pre-existing medical problems. Therefore, the impact of aging on potassium homeostasis must be taken into consideration, and preventive measures, such as early recognition of possible hyperkalemia in the geriatric population treated with certain medications or supplements must be investigated. The threshold for cardiac arrhythmias in the elderly can be lower than the general population. We report 3 unusual cases of mild hyperkalemia in elderly patients presenting with hypotension, syncope and variable degree heart blocks which resolved spontaneously with the correction of hyperkalemia.

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Introduction

Hyperkalemia affects the myocardial tissue producing electrocardiographic abnormalities, such as prolongation of P-R interval, tall peaked T waves, a reduction in the amplitude and an increase in the duration of P wave, and atrial and ventricular arrhythmias, including variable degree heart blocks.[1,2]

Case Report #1

A 97-year-old female presented to the emergency department complaining of dizziness and syncope. The syncope occurred at rest, without incontinence, tongue bite or residual neurological deficit. It was not precipitated by chest pain, difficulty in breathing or any other symptoms. The patient's medical history included diabetes mellitus, hypertension and asthma. On initial examination, her blood pressure was 100/62 mm/Hg, heart rate 56 beats-per-minute and regular with no orthostatic changes in vital signs. Cardiovascular examination revealed normal first and second heart sounds with grade 2 systolic murmur in the mitral and pulmonary auscultation areas. Other parameters were unremarkable. Home medications include: valsartan, metformin, aspirin and amlodipine. Laboratory findings included hemoglobin 13.1 g/dL, troponin 0.029, urea nitrogen 19 mg/dL, creatinine 1.6 mg/dL, potassium 6.3 mEq/L, sodium 128 mEq/L, chloride 97 mM/L, glucose 262 mg/dL. Echocardiogram (ECG) showed sinus arrest and ventricular escape rhythm at a rate of 30 beats per minute with left axis deviation (Figure 1A).

The patient was initially treated with intravenous calcium chloride, and intravenous infusion of normal saline, insulin and glucose. Serum potassium subsequently decreased to 3.8 mEq/L within a 24 h period and the ECG showed normal sinus rhythm at a rate of 68 with no signs of heart block (Figure 1B). Altered atrioventricular conduction was attributed to the presence of mild hyperkalemia with decreased creatinine clearance and this was most likely the cause of the syncope. The resolution of the hyperkalemia was achieved after withdrawal of valsartan therapy suggesting that this drug was responsible for the electrolyte disturbance in conjunction with diabetes and an age-related reduction in glomerular filtration rate (GFR).

Case Report #2

An 86-year old female with medical history significant for hypertension, asthma and atrial fibrillation was brought to the emergency department by her family after they had noticed changes in her mental status. She was found to have bradycardia and hypotension. Initial blood pressure was 70/46 mmHg, and heart rate 30 beats-per-minute. On physical examination, the patient was diaphoretic and in mild respiratory distress. Cardiovascular examination revealed normal heart sounds with no murmurs, lung sounds were clear bilaterally, and mucosa membranes were dry. Laboratory findings were significant for hemoglobin 11.4 g/dL, troponin 0.035 ng/mL, urea nitrogen 67 mg/dL, creatinine 2.2 mg/dL, potassium 5.7 mEq/L, sodium 137 mEq/L, chloride 101 mM/L, glucose 170 mg/dL. ECG revealed third degree heart block at a rate of 34 beats per minute.

The patient was given 1 mg of atropine and 2 L of normal saline followed by transvenous pacemaker due to refractory hypotension with bradycardia. Her treatment also included insulin with dextrose and continuous administration of normal saline for presumptive dehydration. Potassium levels normalized to 4.2 over the next two days and no further heart block was observed. Dehydration and acute renal failure were determined to be the cause of the patient's hyperkalemia. The patient's family was advised to monitor her volume status and oral intake of food containing potassium.

Case Report #3

A 70-year old male with significant medical history of diabetes, hypertension and atrial fibrillation was admitted to the hospital for difficulties in breathing and weakness. The patient's medications were: valsartan, spironolactone, carvedilol and insulin. Blood pressure on presentation was 86/50 mmHg, heart rate 38 beats-per-minute, respiration 24 times a minute, and temperature 96.4° F. On physical examination, he was in mild respiratory distress. Cardiovascular examination revealed normal heart sounds, bibasilar crackles, and (+1) pitting edema. Laboratory findings included: hemoglobin 10.8 g/dL, troponin 0.020 ng/mL, urea nitrogen 47 mg/dL, creatinine 2.1 mg/dL, potassium 6.1 mEq/L, sodium 136 mEq/L, chloride 105 mM/L, glucose 226 mg/dL. ECG revealed sinus arrest with high-grade heart block and a junctional escape rhythm (Figure 2A).

The patient was treated with calcium chloride 1 gm i.v., insulin 10 units i.v. and dextrose 50 mL of 50% solution. Consequently, serum potassium normalized to 4.0 mEq/L within 24 h, and follow-up ECG revealed normal sinus rhythm (Figure 2B) with no signs of a heart block. Complete heart block was attributed to the presence of mild hyperkalemia caused by the patient's medication in the setting of renal insufficiency and was most likely the cause of the patient's symptoms.

Discussion

Early in the 19th century, prior to the introduction of more acceptable antiarrhythmics, potassium salts were used clinically to treat atrial and ventricular arrhythmias. It was hypothesized that such an alteration could terminate an arrhythmia by suppressing ectopic foci.[3,4] However, the use of this agent fell out of favor, as potassium on its own can provoke arrhythmia and heart blocks.[5-7] It is worth noting that the occurrence of hyperkalemia in hospitalized patients is close to 8% and untreated hyperkalemia-associated mortality can reach up to 67%.[8-10] Acute renal failure complicates about 5% of hospital admissions but this percentage is much higher in elderly patients and probably contributes to renal hypoperfusion (prerenal azotemia) which is rapidly reversible upon restoration of renal blood flow.

Elderly patients are principally predisposed to developing hyperkalemia due to age-related decline in their renal function, environmental challenges leading to volume depletion, the presence of diabetes mellitus, cardiovascular diseases, obstructive nephropathy, the use of certain medications and overzealous potassium diets[7,11] (Table 1). Drug induced hyperkalemia is of clinical importance as the concept of polypharmacy is more common in the geriatric population because of the presence of multiple co-morbidities. Usually causes of hyperkalemia can be identified by taking a careful detailed history and evaluating relevant laboratory findings. It is not uncommon to see a geriatric patient with a heart block or a presentation of syncope due to the presence of multiple medical problems and lower tolerance for electrolyte disturbances. However, it is imperative to make an attempt to correct the underlying disorder causing electrolyte imbalance prior to making a decision which could subject the patient to a more invasive workup. Most of the total body potassium is present in the intracellular space and is estimated to be close to 98%, with the rest of the potassium found in the extracellular space.[14,15] Under normal circumstances, almost 90% of potassium is eliminated by renal excretion and the rest by the colon. Nevertheless, age-related decline in eGFR impairs renal potassium excretion which is mainly associated with loss

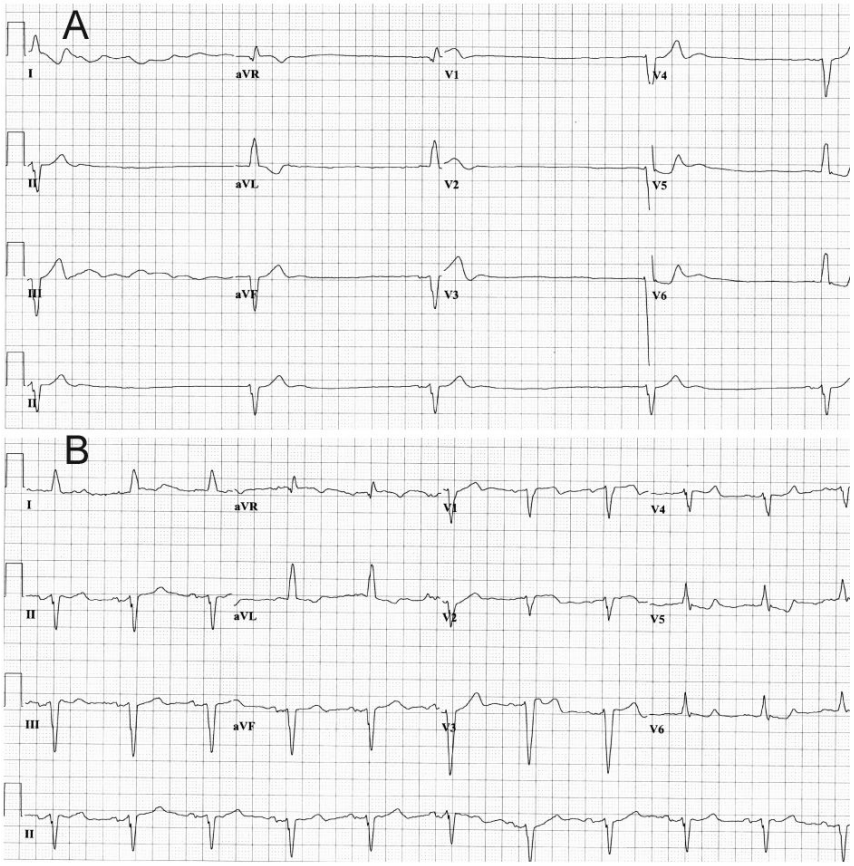

Figure 1 (A) 97-year-old female with Syncope, initial ECG. (B) A 97-year old female with syncope: heart block resolved within 24 h.

Table 1. Causes of hyperkalemia in the elderly.

Drugs	Potassium sparing diuretics (spironolactone, eplerenone, triamterene, amiloride), NSAIDs, ACE inhibitors, ARBs, beta blockers, heparin, digoxin intoxication, trimethoprim, succinylcholine
Pseudohyperkalemia	Leukocytosis, thrombocytosis, hemolysis, rheumatoid arthritis, mononucleosis.[12,13]
Renal failure	Acute or chronic (dehydration, obstructive nephropathy, ATN, etc.).
Mineralocorticoid deficiency	Addison's disease, hyporeninemic hypoaldosteronism.
Tissue necrosis	Crush injury, tumor lysis, burns.
Metabolic derangement	Acidosis, insulin deficiency.
Potassium intake	Supplements, e.g. Kdur, food (orange, banana, mango, etc.), salt substitutes, enteral nutritions (Ensure®, pulmocare, glucerna), blood transfusions

of nephron mass, as the process involves renal tubular secretion.[7,16] The number of collecting ducts is directly related to the eGFR and renal potassium excretion. Therefore, geriatric patients are more prone to electrolyte disturbances causing abnormal conduction through the heart tissue.[7]

The presence of hyperkalemia causes a reduction in the resting transmembrane potential, a decrease in the rate of rise of the action potential, and a decrease in myocardial cell conduction velocity, with an increase in the rate of repolarization.[7,11,17] As the action potential shortens with increasing potassium levels and the conduction velocity decreases, the PR-interval is prolonged, the P-wave ultimately disappears, T-waves become *peaked*, QRS widens and R-R intervals become irregular. Consequently, electrocardiographic findings include the changes in the underlining atrioventricular junctional rhythm accompanied by acceleration of junctional pacemaker, leading to conduction delays in the His-Purkinje system with generation of heart blocks.[18] A rapid increase in potassium levels can lead to bradycardia and depression of contractile force, and could be associated with ventricular fibrillation. On the other hand, a slow increase in potassium levels are more likely to cause conduction prolongation followed by asystole, as reported by Ettinger in 1974.[18] In one study of 26 patients with mild to moderate hyperkalemia, 81% presented with third degree heart block, with 50% of these patients requiring temporary pacing.[19] Prevention of hyperkalemia can be achieved by adjusting the medication regimen and taking into consideration reduced renal function. For example, potassium sparing diuretics can lead to dehydration and volume depletion, in addition to impairment of potassium secretion, and should be used with caution in patients with a history of diabetes or urinary tract obstruction.[20] Use of non-steroidal anti-inflammatory drugs (NSAIDs) should be avoided in geriatric patients with renal insufficiency, heart failure or liver cirrhosis as it can exacerbate pre-existing condition and electrolyte balance. ACE inhibitors and beta blockers are commonly prescribed for the treatment of hypertension. Therefore, any dose increase must be managed with caution as hyperkalemia can occur[16,21] (Table 2). Management of hyperkalemia includes stabilizing the myocardium to prevent deadly arrhythmias and shifting of potassium into the cells.[32,33] Calcium gluconate 10% solution or calcium chloride can rapidly antagonize the toxic effect of hyperkalemia by lowering the threshold potential, and its onset of action is usually within a few minutes.[33] Reducing plasma potassium concentrations by increasing intracellular movement of potassium can be achieved by using regular insulin 10 units with dextrose 50% solution intravenously. Also, beta agonist such as albuterol 10-20 mg when administered by a nebulizer can decrease potassium within two hours by cellular potassium uptake.[16,34] Sodium polystyrene 30-60 gm binds to potassium in the colon and can prevent further absorption of potassium; hence, removing excess potassium.[7] Intravenous hydration with the use of loop diuretics is also an efficient way of removing potassium from the body. Sodium bicarbonate therapy is controversial and should be reserved for patients with academia.[35-37] In patients presenting with severe hyperkalemia and decreased renal function, hemodialysis should be considered as this would be the fastest way to correct hyperkalemia.[38] In geriatric patients presenting with renal failure and hyperkalemia, urinary tract obstruction investigation should be included in the initial workup and a high emphasis should be placed on the evaluation of the medications which can disrupt potassium balance in the context of the clinical picture

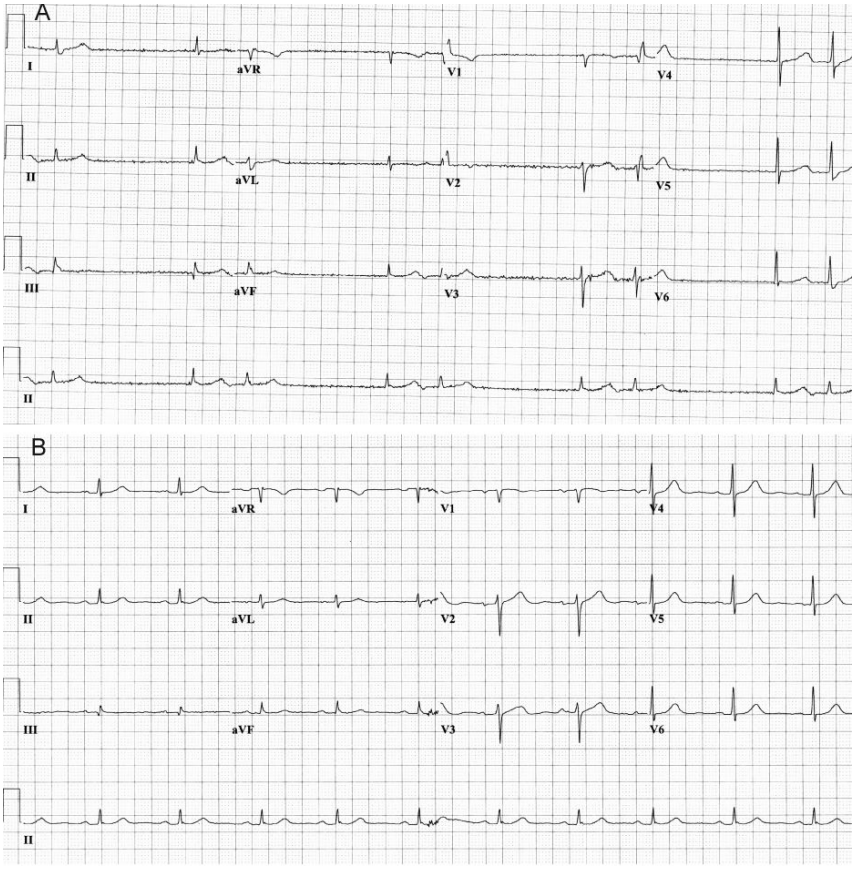

Figure 2. (A) 70-year old male with complete heart block. (B) A 70-year old male after resolution of heart block following treatment.

Table 2. Mechanism of action for drug-induced hyperkalemia.

Spironolactone, eplerenone	Aldosterone antagonist by binding to cytoplasmic aldosterone receptors,[16,22] inhibits potassium secretion and sodium reabsorption.
Triamterine/amiloride	Blocks Na channels in principal cells.
NSAIDs	Reduce renal blood flow, inhibit renal prostaglandin synthesis,[23] decrease renal blood perfusion.
Beta blockers	Suppress catecholamine stimulated rennin release, decrease aldosterone levels and impair cellular uptake of potassium.[24,25]
Angiotensin converting enzyme inhibitors	Decrease renal blood perfusion, decreases GFR, aldosterone.[26]
Heparin	Inhibits adrenal aldosterone production.[27]
Trimethoprim (component of bactrim)	Blocks potassium secretion by blocking Na channels in principal cells.[28,29]
Digoxin intoxication	Disrupts Na K ATPase transporter, prevents intracellular potassium uptake.[30,31]

and pre-existing medical problems such as diabetes, chronic kidney disease, hypertension, hypoaldosteronism and excessive potassium intake.

Conclusions

In our patients, mild hyperkalemia secondary to the use of ACE inhibitor and dehydration, generated depression of the excitability and conduction velocity of the pacemaker cells causing variable degree heart blocks, hypotension and cardiogenic syncope. Elderly patients should be monitored closely as hyperkalemia and reduced renal function can predispose them to complete heart blocks, cardiac syncope and sudden cardiac death.[11,18] Consequently, physicians should be more vigilant even in the case of a mild rise of potassium in the geriatric population presenting with heart blocks since sinus rhythm can be appropriately restored without subjecting the patient to further invasive workup.

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