Complete heart block without ventricular escape secondary to hyperkalemia induced by herbal tea

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Introduction

Complete heart block is a result of complete atrioventricular dissociation, and the clinical presentation varies from incidental detection to asystole from lack of ventricular escape rhythm. Etiologies range from ischemia to electrolyte derangements, or even atrioventricular (AV) nodal blocking agent overdose. Recognition of etiology remains important to guide initial management. The use of herbal therapies continues to increase in the United States and remains an important cause of unexpected hospitalization. Various renal complications have been described following herbal supplement ingestion, including acute tubular necrosis, hyperkalemia and hypokalemia, and acute interstitial nephritis, among others. We present a case of a patient with underlying chronic kidney disease who presented with complete heart block without a ventricular escape due to hyperkalemia, deemed secondary to significant herbal tea consumption.

Case report

A 74-year-old man with a past medical history of coronary artery disease with 5-vessel coronary artery bypass grafting (CABG), hypertension, and chronic kidney disease stage IIIb (baseline creatinine of 1.9) presented to our medical center for a near syncopal event at home. On arrival he was alert and oriented without any acute concerns. He was able to answer questions appropriately and denied any symptoms. He was a former smoker but denied any alcohol or illicit drug use. Prior to his cardiac event he was taking amlodipine 10 mg daily, aspirin 81 mg daily, atorvastatin 80 mg daily, and carvedilol 25 mg twice daily.

On presentation his blood pressure was 159/83 mm Hg, heart rate was 88 beats per minute, and oxygen saturation was 96% on room air. Physical exam revealed a regular rate and rhythm, normal S1 and S2, and no appreciable murmurs. He had 2+ peripheral pulses and no jugular venous distension or lower extremity edema.

The initial electrocardiogram (ECG) showed sinus bradycardia with first-degree AV block, a right bundle branch block, and left anterior fascicular block (Figure 1A). His first-degree AV block was new compared to ECGs from previous hospitalizations. His PR interval measured at 210 ms compared to previous ECGs, where it measured at 170 ms. His QRS complexes were also noticeably more prolonged, at 162 ms, compared to his baseline of 135 ms (Figure 1B). While we were speaking to the patient he remained in a

KEY TEACHING POINTS

- Classically chronological electrocardiogram (ECG) changes of hyperkalemia progress from peaked T waves to PR prolongation to widening of the QRS complex, eventually resulting in a "sine wave" and asystole. However, an ECG alone is not enough to determine the severity of hyperkalemia and clinicians must be cognizant that hyperkalemia may present in the absence of typical ECG findings.
- It is important to suspect hyperkalemia in a patient presenting with a new bradyarrhythmia or atrioventricular block, especially in patients with underlying kidney disease or new medication changes including angiotensin-converting enzyme inhibitors or beta blockers.
- The treatment regimen for hyperkalemia involves membrane stabilization with calcium gluconate, shifting potassium intracellularly with insulin or albuterol, and excreting potassium with furosemide or sodium polystyrene sulfonate.

KEYWORDS Bifascicular block; Electrocardiogram; Hyperkalemia; Nutrition; Supplements
(Heart Rhythm Case Reports 2022;8:45–49)

Funding: None. Conflict of Interest: All authors have no disclosures.
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https://doi.org/10.1016/j.hrcr.2021.11.004

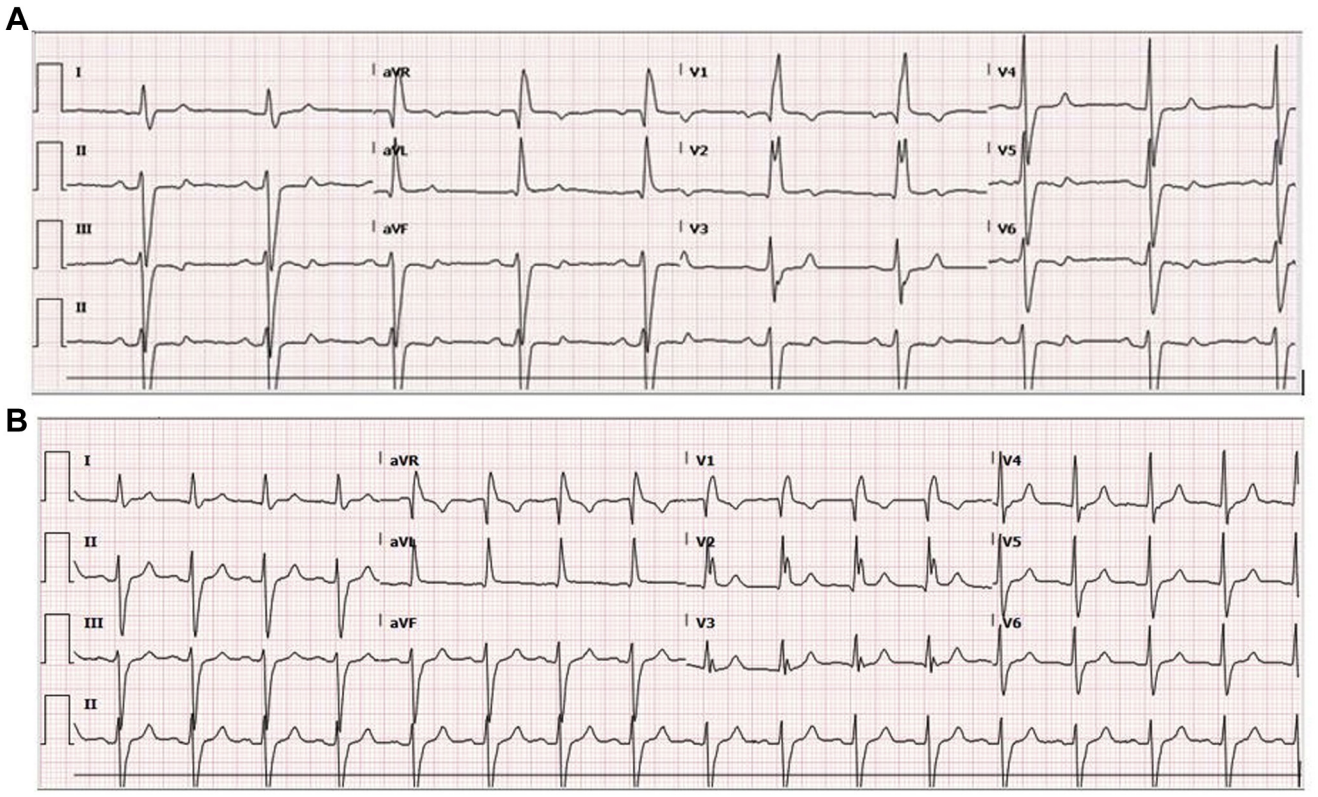

Figure 1 **A:** Initial electrocardiogram (ECG) on presentation. His first-degree atrioventricular block was new compared to baseline. Elevated serum potassium leads to progressive paralysis of the atria, which manifests as a prolonged PR interval. His QRS complex had also widened, which is an ECG feature of hyperkalemia that typically precedes conduction block, as seen in this case. **B:** An ECG from a previous hospitalization demonstrating his underlying conduction disease (right bundle branch block and left anterior fascicular block).

normal sinus rhythm on telemetry. Approximately an hour after our initial encounter, he progressed to complete heart block without a ventricular escape (Figure 2A). He required 2 minutes of chest compression before return of spontaneous circulation. Transcutaneous pacing was initiated, and his telemetry showed a paced rhythm as the third-degree AV block persisted. Transcutaneous pacing, atropine, and a dopamine drip were all unsuccessful in maintaining his heart rate, and the patient ultimately required emergent bedside transvenous pacemaker placement.

Labs obtained during his ventricular asystole revealed a serum creatinine of 2.8 mg/dL, bicarbonate of 19 mMol/L, magnesium of 2.7 mMol/L, potassium of 7.0 mMol/L, and a pH of 7.283. His initial basic metabolic panel from admission resulted during his cardiac event and reconfirmed a severely elevated potassium at 7.6 mMol/L. B-type natriuretic peptide was 488 pg/mL (normal range $<$100 pg/mL), high-sensitivity troponin-I was 69 ng/L (normal range $<$20 ng/L), and lactic acid was 1.5 mMol/L.

A chest radiograph showed cardiomediastinal silhouette within normal limits and clear lungs without signs of pneumothorax or pleural effusion.

He received 1 ampule of calcium gluconate, 10 units of regular insulin with dextrose, and 10 grams of sodium zirconium cyclosilicate. Repeat serum potassium after these measures decreased to 5.5 mMol/L. The patient's hyperkalemia was deemed to be out of proportion to his acute kidney injury. A detailed review of medications did not reveal any medications that would contribute to hyperkalemia. The patient had not been prescribed an angiotensin-converting enzyme inhibitor, angiotensin II receptor blocker, potassium-sparing diuretics, or nonsteroidal anti-inflammatory drugs.

A few hours later his mentation had returned to baseline, and he was able to answer additional questions. He denied use of any potassium supplements or over-the-counter supplements. He did endorse a diet high in potassium, including potatoes, avocados, and salmon, over the past few years (Figure 3A). However, he had also recently started drinking a gallon of a tea comprising a botanical formulation of multiple herbs including burdock root, slippery elm, and seaweed daily for the last 2 months. He started drinking it for its reported "anticancer" properties. He stated he would add 1.5 ounces (approximately 43 grams) of this herbal blend into 128 ounces (a gallon) of boiling water. Detailed review of the ingredients and nutritional value revealed the patient was taking a large potassium load, approximately 55 mEq of potassium, daily through this tea (Figure 3B). His hyperkalemia and consequent complete heart block were determined to be secondary to his diet, acutely worsened by the addition of an herbal tea.

A repeat ECG (Figure 2B) was completed the following morning and showed a return to his innate

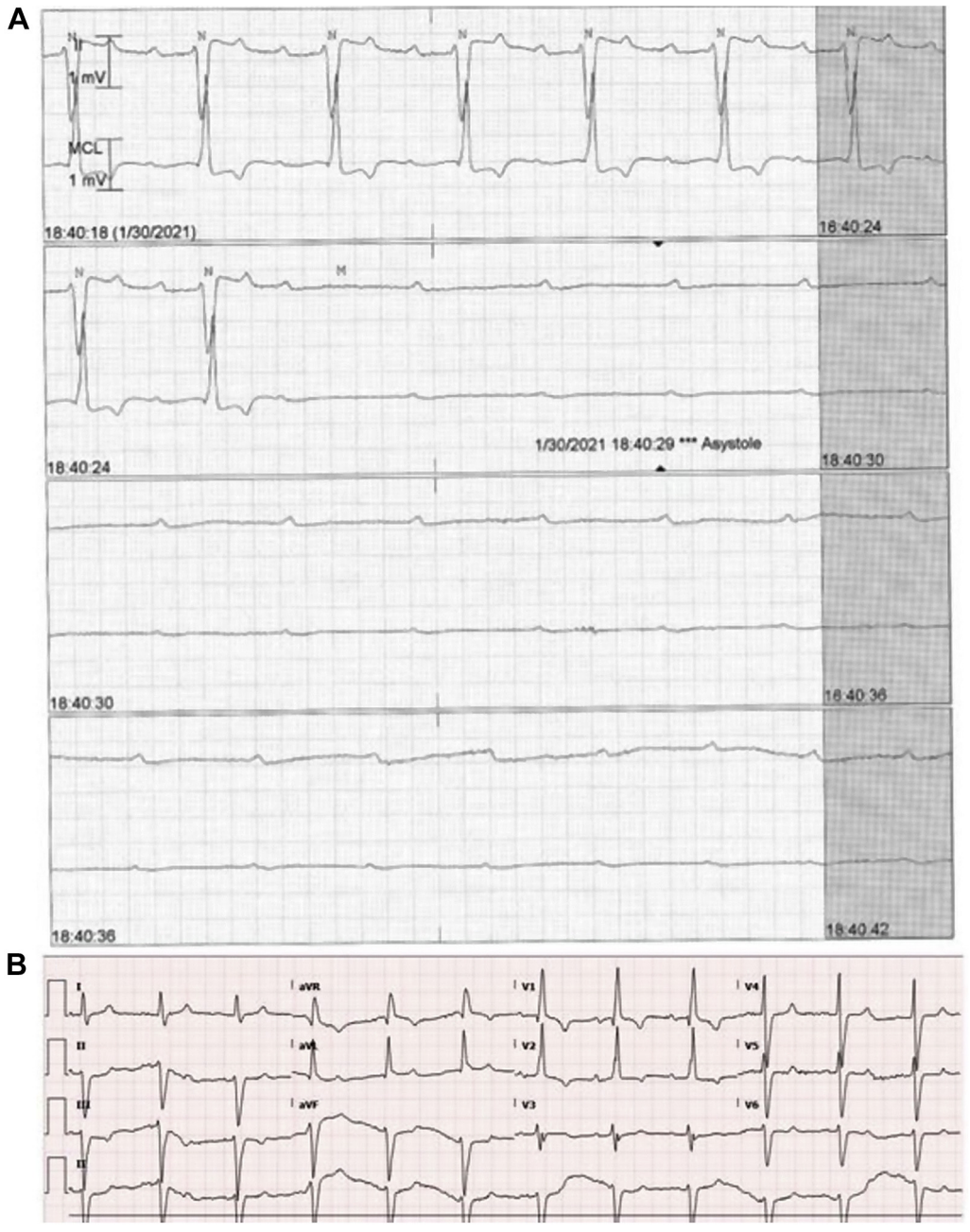

Figure 2 **A:** Telemetry strip showing complete heart block without a ventricular escape rhythm. **B:** Electrocardiogram after correction of his hyperkalemia. His previously noted first-degree atrioventricular block and QRS prolongation resolved with correction of his serum potassium. Unfortunately, on telemetry he was found to intermittently go into complete heart block and subsequently had a permanent pacemaker placed.

rhythm. He redemonstrated his chronic bifascicular block with resolution of his previously noted first-degree AV block (PR interval decreased to 194 ms) and QRS widening (QRS width decreased back to 135 ms). However, despite correction of his hyperkalemia, he would continue to intermittently go into complete heart block. After further discussion and given his advanced bifascicular block at baseline, a permanent dual-chamber pacemaker was implanted. His pacemaker was programmed to be AV paced in DDDR mode at 60 beats per minute with paced and sensed AV delays of 180–250 ms along with RYTHMIQ AAIR with VVI backup to minimize ventricular pacing.

He was instructed to implement a low-potassium diet. At discharge his potassium level was 4.0 mEq/L and his pacemaker was functioning appropriately. At his 2-week follow-up he endorsed maintenance of a low-potassium diet and cessation of herbal tea consumption.

At a 3-month follow-up appointment, pacemaker interrogation showed in the first 25 days he was 10% atrial paced

A

Ingredients in our patients' daily diet	Potassium Content (per 100 grams)
Raw Tomatoes	237 mg
Potatoes	327 mg
Salmon	366 mg
Avocados	485 mg

B

Ingredients in Herbal Tea	Potassium Content (per 100 grams)
Burdock Root (Arcticium)	308 mg
Sheep Sorrel (Rumex acetosella)	390 mg
Indian Rhubarb Root* (Rheum Officinale)	288 mg
Watercress (Nasturtium officinale)	330 mg
Kelp (Laminaria Digaturm)	**1.3-3.8 grams**
Red Clover, Slippery Elm Inner Bark, Blessed Thistle	No data available

Figure 3 **A:** Potassium content in foods our patient commonly ate, demonstrating his high-potassium diet. **B:** Our patient's herbal tea is marketed to provide an alternative treatment for common illnesses and even cancers. Each individual herb was found to have a high potassium content, especially when compared to foods commonly associated with high potassium, as seen in panel A. However, *Laminaria digitata* has an extremely large potassium content and surpasses the recommend allowance for potassium in nondialysis chronic kidney disease patients by itself. *Directly nephrotoxic.

and less than 1% ventricularly paced. After 25 days he was noted to be 82% atrial paced and 42% ventricularly paced. There was no evidence of retrograde AV conduction during ventricular pacing. We suspect while he initially had a reversible cause of his complete heart block, his underlying conduction disease progressed to becoming pacemaker dependent.

Discussion

In normal individuals, the potassium homeostatic system stimulates renal potassium excretion through aldosterone, which prevents hyperkalemia.[1] When a rise in serum potassium occurs, this pathway helps prevent an otherwise fatal potassium load. In patients with impaired renal function this pathway is disrupted, and patients can develop hyperkalemia. Potassium helps regulate electrical activity in the heart by stabilizing both atrial and ventricular myocytes during diastole, which prevents the development of cardiac arrhythmias.[2] When serum potassium persists above the tightly regulated normal range, it leads to a reduction in myocardial excitability, which can manifest as bradycardia, conduction block, and even complete heart block, as seen in our case.[3,4]

Herbal supplements are traditionally touted for their effects on promoting general health but remain unregulated by the Food & Drug Administration. These substances can have varying effects. Numerous agents have been known to affect both renal function and electrolytes. These include alfalfa (*Medicago sativa*) and dandelion (*Taraxacum officinale*), which have been reported to contain significant amounts of potassium and known to induce hyperkalemia in isolated cases.[5]

Our patient had multiple reasons for developing this severe metabolic derangement. He had a history of chronic kidney disease, which interferes with the body's ability to adapt to a high potassium load compared to an individual with normal kidney function. Total body potassium levels are regulated primarily by the kidneys, with only 5%–10% of ingested potassium excreted in feces.[6] Given his high-potassium diet and impaired urinary potassium excretion, he was inherently at high risk for developing hyperkalemia.

Our patient's medications did not provide a direct etiology of his hyperkalemia. However, he did report taking carvedilol, a nonselective beta blocker. While there are isolated case reports on beta blockers causing hyperkalemia,[7] our patient reported being on the same dose for several years with no previous issues. Thus, it was deemed an unlikely cause for his clinical presentation.

Patients with chronic kidney disease and not receiving dialysis are recommended to limit their potassium intake to 2–4 grams a day.[8] Our patient had poor compliance with a renal diet and ate multiple foods high in potassium. However, it was his recently added herbal tea blend (Figure 3B) that ultimately led to his clinical decompensation. He stated he would add 1.5 ounces (43 grams) of this herbal blend with 128 ounces of boiling water to make a gallon of tea, which he would drink throughout the day. The patient stated he was unaware of the potassium content of each herb but figured the overall benefits outweighed any risks. While all of the ingredients were found to have a large potassium load, one ingredient in the tea was *Laminaria digitata* (ie, seaweed). This ingredient contains as high as 3.8 grams of potassium per 100 grams of dry matter, totaling roughly to an equivalent of 40 mEq of potassium in his tea daily, solely from this 1 ingredient. When considering the other ingredients, his gallon of herbal tea equaled 55 mEq of potassium.[8] To add insult to injury, Indian rhubarb has an abundance of oxalates and anthraquinones, which has been reported to be directly nephrotoxic.[9,10]

His hyperkalemia ultimately precipitated complete heart block without a ventricular escape. Notably, his ECG prior to his cardiac event did not show evidence of peaking T waves or shortening of the QT interval that we would expect to see with an elevated potassium level. However, the patient's ECG did have evidence of prolonged PR interval and more prolonged QRS complexes from baseline, which

may be more specific findings. A retrospective cohort study reviewed the association of specific hyperkalemic ECG abnormalities and the development of cardiac events in patients with hyperkalemia. Interestingly, they found no statistically significant correlation between peaked T waves and short-term adverse events; however, they did find an increased likelihood for cardiac events in patients whose ECG demonstrated QRS prolongation, bradycardia (heart rate <50), and/or junctional rhythm.[11] Another retrospective study also yielded similar results and found that in 14 patients who developed dysrhythmias and/or cardiac arrest from hyperkalemia, only 1 met strict criteria for ECG changes and fewer than half were noted to have new T-wave peaking or symmetry.[12] Thus, while we will continue to use ECGs to risk-stratify patients with severe hyperkalemia at risk for short-term cardiac events, clinicians must be cognizant that hyperkalemia may present in the absence of typical ECG findings.

His PR interval was also noticeably prolonged on telemetry compared to his initial ECG. The definition of a first-degree AV block is a PR interval of greater than 200 ms without disruption of atrial-to-ventricular conduction. However, an hour after his initial ECG was completed, his telemetry showed a PR interval measuring approximately 400 ms. He had developed a "marked first-degree atrioventricular block," which is defined as a PR interval measuring more than 300 ms.[13] This is a direct reflection of the patient's elevated serum potassium causing the rate of phase 0 in the cardiac action potential to decrease, leading to a longer action potential, which manifested on his telemetry with a widened QRS complex and markedly prolonged PR interval.[14] While first-degree AV block is classically considered benign, in this case our patient quickly developed significant electrical disturbances and, ultimately, ventricular asystole requiring permanent pacemaker placement.

Conclusion

The differential diagnosis of hyperkalemia is broad, with chronic kidney disease a common culprit and suspected etiology. However, this case highlights the importance of a thorough history. While not often volunteered during a typical history, dietary supplements and herbal products can have enormous impact on patients with predisposing conditions such as chronic kidney disease.

The effects of hyperkalemia were evidenced by the progression of this patient's ECG changes. In patients with persistent hyperkalemia without immediate intervention, the rhythm can quickly deteriorate to severe conduction abnormalities and lethal arrhythmias. Recognition of hyperkalemic ECG changes, although not always present, provides opportunity for rapid initiation of life-saving treatment.

Unfortunately, herbal supplements do not receive the same level of scrutiny compared to prescription medications by the Food and Drug Administration. Even though they may be marketed as health-conscious items, they can give patients unwanted adverse effects. If a patient develops chronic kidney disease it will be important to educate them on avoiding foods or supplemental herbs that have high potassium content. Developing a complete handout that includes supplemental herbs would be useful in raising awareness to help avoid dangerous outcomes.

Acknowledgment

This case does not include any protected health information and is exempt from institutional review board protocol at this institution.

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