



Toluene toxicity presenting with hypokalemia, profound weakness and U waves in the electrocardiogram

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ABSTRACT

We present the case of a 25-year-old man with progressive limb weakness. His electrocardiogram showed prominent U waves which made us consider hypokalemia. The final diagnosis was toluene intoxication with severe hypokalemia and metabolic acidosis. Intravenous potassium administration and hydration effectively corrected the electrolyte and acid-base alterations; weakness resolved and the patient was discharged. The approach to a patient with acute weakness can be challenging. This case reminds us that the electrocardiogram can be a valuable tool in the evaluation and differential diagnosis of patients presenting to the emergency department with these conditions.

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1. Introduction

The initial approach to a patient with acute progressive weakness in the emergency room can be challenging. It can be attributed to problems in the spinal cord, anterior horns, peripheral nerves, neuromuscular junction, or muscular pathology. These alterations can be secondary to infection, inflammatory processes, toxins, and metabolic abnormalities [1]. Some of these are considered neurologic emergencies and could even compromise the respiratory muscles and cause respiratory failure; therefore, the initial evaluation must be fast and accurate in order to find an etiology. Although the medical history and physical exam are crucial in the diagnosis, in some cases, other tests will be needed, like a CT scan, an MRI, a lumbar puncture, specific serologic markers or neurophysiologic studies [1]. In our case, the ECG was useful.

2. Case report

A 25 year-old-man came to the emergency department with progressive ascending weakness. His past medical history was relevant for substance abuse, including solvent inhalation. Symptoms began 12 h earlier with bilateral lower extremity weakness. At that

moment, he was able to stand on his feet, so he decided to go to work. After a few hours, his symptoms worsened, and he was unable to stand up from the sitting position. He was evaluated at his work and sent home to rest. After 5 h, symptoms progressed and now involved his arms with numbness and weakness. At this moment, he decided to seek medical attention.

The patient was alert and conscious and in no apparent distress. He was able to speak without interruptions or gasping and he referred progressive weakness and distal paresthesias involving his arms and legs. He denied fever, respiratory symptoms, chest pain or diarrhea. On further interrogation, he stated that prior to the beginning of his symptoms he had been sniffing glue.

On physical examination, his blood pressure was 130/80 mmHg with a heart rate of 92 beats per minute, a respiratory rate of 19 breaths per minute, an oxygen saturation of 98% with room air, and a temperature of 36 °C (96.9 °F). Neck muscle strength was normal, and there was no use of accessory respiratory muscles. Neurologic examination showed normal cranial nerve function; however, generalized hyporeflexia and symmetrically diminished muscle strength was found involving all the extremities.

A 12 lead electrocardiogram showed the presence of U waves with a corrected QT of 537 ms (Bazett's formula) and a QTU of 600 ms (Fig. 1). Because of the neurological and ECG findings serum potassium levels were determined. His initial laboratory results showed a serum glucose of 161 mg/dL, blood urea nitrogen

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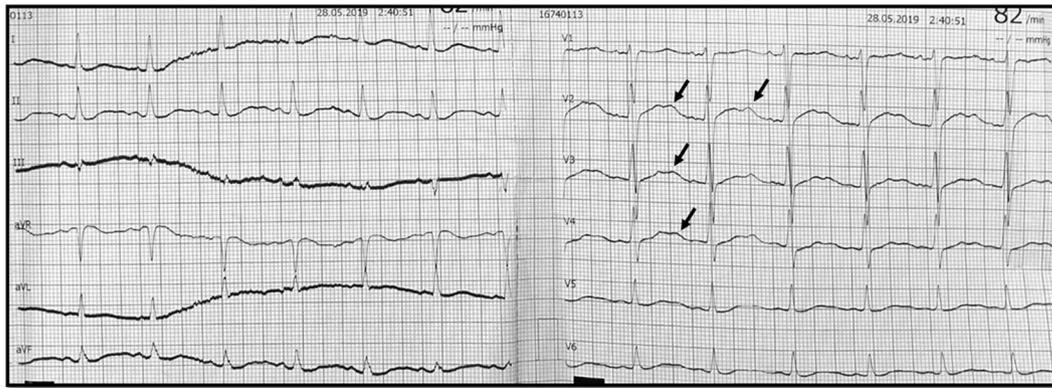


Fig. 1. A 12 lead electrocardiogram on admission with prominent U waves (arrows), ST-segment depression, and QT prolongation, compatible with hypokalemia.

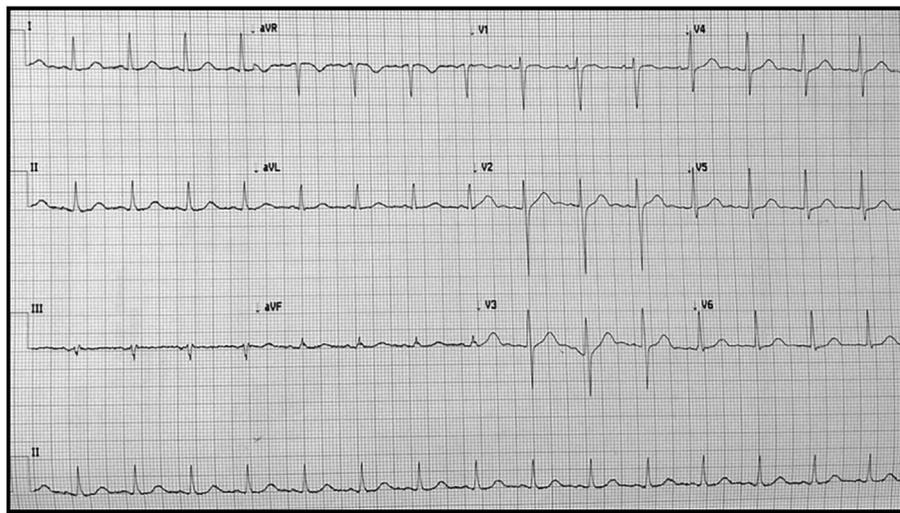


Fig. 2. A 12-lead electrocardiogram showing complete resolution of abnormalities after correction of hypokalemia and acidosis.

of 2 mg/dL and a creatinine of 0.6 mg/dL. Serum electrolytes showed a severe hypokalemia of 1.4 meq/L, hyperchloremia of 113.3 meq/L, with Na^+ of 135.9 meq/L, Ca^{++} of 8 mg/dL, and phosphate of 1 mg/dL. Venous blood gasometry showed a pH of 7.22, pCO_2 of 36 mmHg, lactate of 1.4 mmol/L and HCO_3^- of 9 meq/L. An anion gap of 14 mmol/L and a $\Delta\text{Anion Gap}/\Delta\text{HCO}_3^-$ of 0.1 suggested the presence of a mixed acid-base disorder (a high anion-gap metabolic acidosis and hyperchloremic metabolic acidosis). The patient was placed on continuous cardiac monitoring, with aggressive IV potassium correction, 20–40 mEq/h, and hydration using a central venous line. After 24 h, the hypokalemia and acidosis had resolved. A subsequent electrocardiogram (Fig. 2) showed resolution of the previous abnormalities. The patient was able to move normally and was discharged for outpatient follow-up.

3. Discussion

The combination of progressive weakness and elevated U waves in the ECG made us consider manifestations secondary to hypokalemia. The fact that the patient was sniffing glue before his symptoms pointed to a possible toluene intoxication as the cause of his hypokalemia.

Toluene is an aromatic hydrocarbon commonly found in products such as paints, glue, thinner and cleaning products. It is cheap and accessible, and is one of the most common inhaled volatile

drugs [2]. As a drug, its main acute effect is euphoria, but it is also associated with acute systemic complications, particularly metabolic acidosis and profound hypokalemia [2]. Toluene intoxication has long been associated with the development of type 1 (distal) renal tubular acidosis (RTA), which causes a normal anion gap (AG) hyperchloremic metabolic acidosis and hypokalemia [3]. On the other hand, the final product of toluene metabolism, hippuric acid can accumulate, elevating the anion gap and causing a high anion gap metabolic acidosis. Patients can either present a high AG, a normal AG or a mixed state of metabolic acidosis, as occurred in our patient. When renal function is preserved, excretion of the acid anions in the urine exaggerates potassium waste, and this worsens hypokalemia [2,3]. In the nerves and muscles, hypokalemia causes hyperpolarization of the cell membrane with negativization of the resting membrane potential and decreased excitability. This results in the most common clinical manifestation of toluene intoxication, muscular weakness, which is usually progressive [2]. In the heart, hypokalemia increases the resting membrane potential, with prolongation of the action potential (particularly, phase 3 repolarization) and the refractory periods [4]. Electrocardiographic manifestations include a decreased T wave amplitude, ST-segment depression, and T wave inversion. PR interval prolongation with increased P wave amplitude can also appear. With profound hypokalemia, the classic electrocardiographic feature is the presence of prominent U waves, which are best seen in V2 and V3. Persistent and severe hypokalemia with

prolongation of repolarization times increases the risk of malignant arrhythmias like torsades de pointes and ventricular fibrillation [4].

Guidelines for the management of acute toluene intoxication are lacking [2]. Treatment consists of potassium administration and intravenous hydration. Currently, there is no evidence for the use of HCO_3^- , and it is usually reserved for patients with severe acidosis [2]. The main problem with bicarbonate therapy is that it can paradoxically worsen acidosis and hypokalemia, placing the patient at a higher risk of developing arrhythmias [3]. Close and continuous cardiac monitoring for cardiac arrhythmias and constant clinical reevaluation to detect progression or resolution of muscular weakness are crucial.

This case reminds us that the electrocardiogram can be a valuable tool in patients with systemic conditions in the emergency room, particularly those associated with metabolic alterations, such as toluene intoxication, since heart tissue and the conduction system are particularly sensitive to electrolyte and acid-base disorders. Studies have demonstrated the usefulness of the electrocardiogram as a window for the detection of potassium derangements even without blood tests [5,6].

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Declaration of competing interest

No conflict of interest to disclose.

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