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Clinical Report

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Possible potassium chlorate nephrotoxicity associated with chronic matchstick ingestion*

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Abstract

We present a case of a 48-year-old active duty male soldier with a history of chronic exposure to potassium chlorate, later diagnosed with chronic interstitial nephritis. He reported regular matchstick consumption to prevent chigger (*Trombicula autumnalis*) bites, amounting to ∼5.8 g of potassium chlorate over 3 years. Potassium chlorate can cause anuric renal failure within days of a toxic dose. Its slow excretion and mechanism of action suggest that renal toxicity may result from lower-dose chronic exposure. This case represents possible sequelae of chronic potassium chlorate ingestion.

Keywords: chronic interstitial nephritis; matchstick; potassium chlorate

Background

Potassium chlorate ($KClO_3$) is a highly reactive oxidizing agent commonly used in matchstick heads, explosives, flares, pyrotechnics, textile printing, bleaching and disinfectants [1]. Acute ingestion of 5–10 g of a chlorate salt may cause life-threatening toxicity, including methemoglobinemia, cyanosis, hemolysis, diffuse intravascular coagulation and renal failure; universally fatal prior to the advent of dialysis [2–6]. Effects of chronic low-grade exposure have not been reported. We report a case of otherwise unexplained chronic tubulointerstitial nephritis (CIN) in a patient with a history of chronic $KClO_3$ exposure from matchstick ingestion.

Case report

A 48-year-old active duty Caucasian male Army officer was referred for incidentally discovered renal insufficiency. He reported regular matchstick ingestion 25 years previously, eating paper safety matches daily during field training to prevent chigger (*Trombicula autumnalis*) bites. Specifically, he consumed one pack of safety matches every 4 days during field training for an estimated total of 5.8 g of $KClO_3$ (three 6-month exposures of 1.9 g each). Past medical history was otherwise negative. There was no family history of renal disease. He was a nonsmoker and nondrinker, denied other toxic exposures and had no history of illicit drug, supplement, herbal medication or significant nonsteroidal anti-inflammatory drug use. Physical examination was normal.

Laboratory results were notable with a serum creatinine level of 1.7 mg/dL or 150.3 µmol/L (CKD-EPI eGFR 44 mL/min/1.73m^2) and a platelet count of 942 000/mL (normal range 130–400 ×10^3/mL), with no prior data for comparison. Serial urinalyses (including microscopy) were normal. The spot protein-to-creatinine ratio was normal (0.033 mg/mg) and his urine albumin was non-detectable. Human immunodeficiency virus, hepatitis screening and antinuclear antibody were negative. A renal ultrasonography showed normal kidneys bilaterally.

An adequate diagnostic renal biopsy (Figure 1) demonstrated 5–10% interstitial fibrosis and tubular atrophy most consistent with chronic tubulointerstitial disease; 7–10% of glomeruli were sclerosed and obsolescent. There was no evidence of glomerulopathy, vasculitis or arteriosclerosis, and no active interstitial inflammation. Viable glomeruli were normocellular with open capillary loops and no increased mesangial matrix. No deposits were evident on Masson Trichrome stain. Ultrastructural evaluation demonstrated a normal glomerular capillary basement membrane thickness and no deposits. Immunofluorescence demonstrated low-intensity focal and granular deposition of IgM and C3 in the mesangia of all visualized glomeruli. Staining was negative for Kappa and Lambda light chains, IgG, IgA, albumin and C1q.

The patient was diagnosed with chronic idiopathic tubulointerstitial nephritis (CIN), and managed conservatively. Bone marrow biopsy resulted in a diagnosis of essential thrombocythemia, which improved with hydroxyurea treatment. Renal function has been stable for 3

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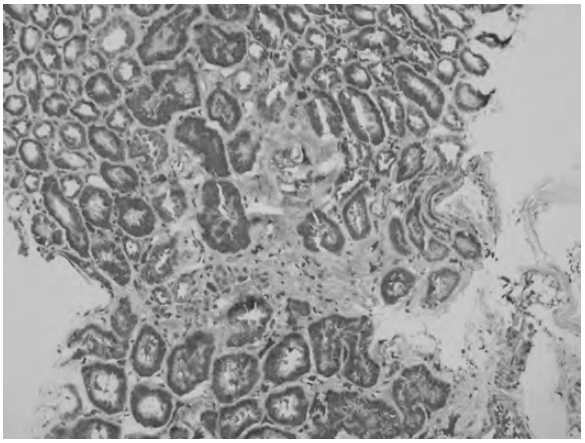

Fig. 1. Renal biopsy. Focal interstitial fibrosis with associated tubular atrophy is seen surrounded by otherwise unremarkable tubulointerstitium. Masson Trichome stain 20× field.

years. He remains active with no lifestyle limitations. His long-term renal prognosis remains uncertain with Stage III chronic kidney disease at a relatively young age.

Discussion

Matchstick head ingestion to prevent chigger, mosquito, and other insect bites is not unusual in the armed services. A Google search for 'chiggers match heads' yielded 802 000 results; the first 3 recommending it as an 'old Army trick'. Many websites include personal testimonials recommending the practice, and identifying sulfur is the active ingredient. Matchstick heads are typically composed of 45–55% $KClO_3$, with a little sulfur and starch, a neutralizer (ZnO or $CaCO_3$), 20–40% siliceous filler, diatomite and glue [4]. A single case report identifies matchstick ingestion as the source of acute $KClO_3$ toxicity [4].

Acutely toxic doses of $KClO_3$ vary from 1 g in children to 5–35 g in adults [4, 7]. The elimination half-life is long at 26.7 h [1]. Effects may be cumulative because of slow chlorate ion excretion, and repeated 1 g ingestions have been fatal [8]. Small, one-time ingestions of up to two matchbooks (220 mg $KClO_3$) have been reported to be nontoxic [9]. Our patient re-dosed potassium chlorate at 4-day intervals, which may have promoted toxic accumulation.

Chlorate stimulates methemoglobin formation, overwhelming glucose-6-phosphate dehydrogenase activity, and directly denaturing the enzyme. Ultimately, a chlorate–methemoglobin complex forms that autocatalytically increases methemoglobin formation and red blood cell destruction [10]. Acute nephrotoxicity appears to be consistent with haeme pigment nephropathy, vasoconstriction and tubular damage [5, 10]. Chlorate may also be directly toxic to the proximal tubule [5]. Renal biopsy specimens support this, demonstrating acute tubular necrosis and pigment nephropathy in humans [2]. Fibrosis and atrophy of the distal renal tubules were reported in cats receiving >0.05 g/kg $KClO_3$ [7]. It is possible that recurrent acute tubular necrosis followed by scarring and fibrosis could lead to chronic tubulointerstitial disease.

Acute treatment consists of gastric lavage, activated charcoal, bicarbonate infusion and intravenous fluids, and early renal replacement therapy with haemodialysis [2–6]. Daily intermittent haemodialysis is favoured over continuous renal replacement modalities, as it provides more rapid and efficient clearance based on the low molecular weight of chlorate [5]. Methylene blue treatment is ineffective as it requires functional glucose-6-phosphate dehydrogenase [10]. Other therapies include fresh frozen plasma, platelets and aggressive supportive care modalities including the molecular adsorbent recirculating system [6]. Darbepoiten alpha was used successfully in a patient who refused transfusion [5].

This case is presented as possible $KClO_3$-associated CIN. Sub-acute or chronic nephrotoxicity due to chlorates has not been previously reported. The diagnosis of CIN associated with remote sub-acute or chronic $KClO_3$ ingestion relies heavily on clinical history and diagnostic exclusion. We speculate that chlorate nephrotoxicity presents as a disease spectrum, and that sub-fulminant cases may be missed.

The diagnosis was made based on the history of remote, but significant, KClO3 exposure and renal biopsy findings consistent with CIN. Other causes of CIN, which has an extensive differential, were excluded. Specifically, there was no history consistent with hereditary interstitial nephritis, no alternative toxic exposure such as to lithium or heavy metals, no metabolic disturbance such as hypokalaemia, hyperuricaemia or hypercalcaemia, no lymphoproliferative disorder, no infection, no obstruction and no hypertension. It is possible that his interstitial disease is not due to chlorate toxicity, but rather to idiopathic or Epstein-Barr Virus-associated CIN; however, chlorate toxicity is the most compelling possibility.

Conclusion

Regular matchstick consumption may be dangerous. The clinical toxicity profile of sub-acute to chronic $KClO_3$ exposure is not well described, and cases may be missed. We present a case of CIN disease associated with remote chronic $KClO_3$ ingestion. Service members and veterans with renal insufficiency should be asked about matchstick ingestion history, matchstick consumption should be strictly avoided and armed service members may benefit from an awareness campaign regarding the potential toxicity of match head ingestion.

Conflict of interest statement. None declared.

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