Introduction

The ingestion of ethylene glycol, an organic solvent used in common household products such as automotive antifreeze and paints, results in toxicity with characteristic chemical, pathological, and imaging findings.

Case Report

A 20-year-old male presented to the emergency department following increasing lethargy and emesis over a twelve hour period. At presentation, the patient's Glasgow coma scale score was 6. Arterial blood gas demonstrated a pH of 6.96, pCO2 25 mm Hg, pO2 225 mm Hg and HCO3 5 mmol/L. The serum osmolality was 337 mmol/L and the osmolality gap was markedly elevated at 32 mmol/L. Microscopic examination of the urine demonstrated cigar and envelope shaped crystals characteristic of calcium oxalate crystals (Figure 1). Based on the clinical picture, laboratory findings and microscopic examination of the urine, the diagnosis of ethylene glycol toxicity was confirmed.

The patient was transferred to the intensive care unit for mechanical respiratory support, fluid management, and hemodialysis. Arterial blood gases were monitored from initial presentation through normalization. pO2 levels ranged from 225 mm Hg (elevated due to supplemental oxygen administration as part of resuscitation) to 84 mm Hg (normal at 36 hours into management). No hypoxic or anoxic periods were demonstrated during hospitalization. Due to clinical concern for seizure activity, head computed tomography (CT) was performed which showed diffuse hypodensity within the bilateral basal ganglia and thalami with loss of differentiation with the subjacent white matter, following increasing lethargy and emesis over a twelve hour period. At presentation, the patient's Glasgow coma scale score was 6. Arterial blood gas demonstrated a pH of 6.96, pCO2 25 mm Hg, pO2 225 mm Hg and HCO3 5 mmol/L. The serum osmolality was 337 mmol/L and the osmolality gap was markedly elevated at 32 mmol/L. Microscopic examination of the urine demonstrated cigar and envelope shaped crystals characteristic of calcium oxalate crystals (Figure 1). Based on the clinical picture, laboratory findings and microscopic examination of the urine, the diagnosis of ethylene glycol toxicity was confirmed.

The patient was transferred to the intensive care unit for mechanical respiratory support, fluid management, and hemodialysis. Arterial blood gases were monitored from initial presentation through normalization. pO2 levels ranged from 225 mm Hg (elevated due to supplemental oxygen administration as part of resuscitation) to 84 mm Hg (normal at 36 hours into management). No hypoxic or anoxic periods were demonstrated during hospitalization. Due to clinical concern for seizure activity, head computed tomography (CT) was performed which showed diffuse hypodensity within the bilateral basal ganglia and thalami with loss of differentiation with the subjacent white matter,
Ethylene Glycol Toxicity: Chemistry, Pathogenesis, and Imaging

Figure 1. Urine microscopy demonstrates “cigar” and “envelope” crystals, a pattern characteristic of calcium oxalate monohydrate and calcium oxalate dihydrate crystals respectively.

Chemistry

Ethylene glycol is metabolized in the liver through a series of enzymes. The intermediate metabolites of the pathway (in order) are: glycoaldehyde, glycolic acid, and glyoxylic acid. Ultimately, glyoxylic acid is converted to oxalic acid, which precipitates in the presence of calcium as calcium oxalate crystals. The most clinically significant metabolite in the pathway is glycolic acid which is primarily responsible for the metabolic acidosis [1,2]. This pathway assists in explaining our patient’s laboratory and urine microscopy findings.

Pathogenesis

Ethylene glycol toxicity can affect multiple organs systems but predominately involves the central nervous, cardiopulmonary and renal systems. Multiorgan damage is mainly due to the various toxic metabolites which have numerous deleterious effects at the cellular level including on the electron transfer chain, oxidative phosphorylation, cellular respiration, glucose metabolism, and DNA replication [1]. The deep grey matter nuclei of the basal ganglia being metabolically more active than the remaining brain parenchyma are affected first by these metabolites, as well as by the associated hypoxia and acidosis. Additionally, human autopsy studies have demonstrated calcium oxalate crystal deposition within the walls of the cerebral blood vessels and accompanying perivascular edema and inflammation [3,4]. The deposition of calcium oxalate crystals within the vasculature likely add up to produce further edema and damage to the deep grey matter nuclei and adjacent white matter.

Imaging

CT in the acute stages of ethylene glycol toxicity reveals edema without significant mass effect with an affinity for the basal ganglia. Edema may also involve the temporal basal regions and brainstem [5,6]. Although the CT scan findings of ethylene glycol toxicity have been documented, there are only a few prior case reports with MR images published in the setting of ethylene glycol intoxication. Morgan et al. reported bilateral putaminal necrosis by
Figure 2. Unenhanced head CT shows diffuse hypodensity in the deep gray matter nuclei with loss of differentiation of the deep gray matter nuclei and subjacent white matter compatible with edema.

Figure 3. Axial T2WI (A) and FLAIR (B) images demonstrate symmetrical increased signal intensity within the basal ganglia, thalami, amygdala, hippocampus, and brainstem bilaterally.

MRI [6]. Caparros-Lefebvre et al. demonstrated bipallidal hemorrhage in the setting of ethylene glycol ingestion [7]. Lewis et al. demonstrated delayed sequelae of ethylene glycol toxicity with bilateral enhancement of the fifth cranial nerves and communicating hydrocephalus in the setting of cranial nerve dysfunction [8]. Our patient’s case demonstrates bilateral symmetrical hyperintensity within the basal ganglia, thalami, amygdala, hippocampus, and brainstem on MRI. Our patient’s case also demonstrates restricted diffusion within the white matter tracts of the corona radiata bilaterally, consistent with cytotoxic edema. This feature has not been previously described in the setting of ethylene glycol ingestion.

Bilateral symmetrical hyperintensity on MRI in the deep gray matter nuclei is challenging for the radiologist. Various acute toxic conditions and chronic metabolic diseases can produce signal abnormalities. Acute causes include hypoxia, carbon monoxide inhalation, or ingestion of toxic materials (methanol, ethylene glycol, or cyanide). Rarely infection and deep venous thrombosis can cause an acute abnormality especially in pediatric patients. Chronic conditions, particularly inborn errors in metabolism such as Leigh’s disease or Wilson’s disease, can give similar MRI findings however these can be differentiated from acute etiologies on clinical grounds.

The authors believe that the best way to formulate an appropriate differential diagnosis in patients with involve-
Ethylene Glycol Toxicity: Chemistry, Pathogenesis, and Imaging

Figure 4. Axial DWI (A) and ADC (B) images at the level of corona radiata demonstrates restricted diffusion bilaterally.

References


8. Lewis LD, Smith BW, Mamourian AC. Delayed sequelae after acute overdoses or poisonings: cranial neuropathy
