Full Recovery from a Potentially Lethal Dose of Mercuric Chloride

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Abstract

Introduction Mercuric chloride poisoning is rare yet potentially life-threatening. We report a case of poisoning with a potentially significant amount of mercuric chloride which responded to aggressive management.

Case Report A 19-year-old female presented to the Emergency Department with nausea, abdominal discomfort, vomiting of blood-stained fluid, and diarrhea following suicidal ingestion of 2–4 g of mercuric chloride powder. An abdominal radiograph showed radio-opaque material within the gastric antrum and the patient's initial blood mercury concentration was 17.9 $\mu\text{mol/L}$ (or 3.58 mg/L) at 3 h post-ingestion. Given the potential toxicity of inorganic mercury, the patient was admitted to the intensive care unit and chelation with dimercaprol was undertaken. Further clinical effects included mild hemodynamic instability, acidosis, hypokalemia, leukocytosis, and fever. The patient's symptoms began to improve 48 h after admission and resolved fully within a week.

Discussion Mercuric chloride has an estimated human fatal dose of between 1 and 4 g. Despite a reported ingestion of a potentially lethal dose and a high blood concentration, this patient experienced mild to moderate poisoning only and she responded to early and appropriate intervention. Mercuric chloride can produce a range of toxic effects including corrosive injury, severe gastrointestinal disturbances, acute renal failure, circulatory collapse, and eventual death. Treatment includes close observation and aggressive supportive

care along with chelation, preferably with 2,3-dimercapto-1-propane sulfonate or 2,3-meso-dimercaptosuccinic acid.

Keywords Mercury poisoning · Mercuric chloride · Inorganic mercury · Case report · Chelation

Introduction

Mercury compounds exist in a variety of forms; from a toxicological perspective, they are broadly divided into elemental mercury, organomercury (alkyl and aryl forms), and inorganic compounds. These large groups differ substantially in their toxicity, including effects on major target organs; this heterogeneity partly arises from significant differences in kinetics. Given their toxicity and/or widespread presence, attention has rightly focused on the former two forms. However, while now comparatively uncommon in the USA [1], acute exposure via ingestion to some inorganic compounds remains a serious, life-threatening event. Arguably, the most toxic of the inorganic mercury salts is mercuric chloride, likely due to its corrosivity and high solubility [2]. A mean lethal dose is thought to be between 1 and 4 g of mercuric chloride, but adult fatalities have been reported from ingestion of 0.5 g [3]. This salt can cause corrosive injury of the gastrointestinal tract, acute renal failure, circulatory collapse, and eventual death if prompt and appropriate treatment is not provided. We report on a patient who ingested a life-threatening dose of mercuric chloride yet made a full recovery following early and appropriate intervention.

Case Report

A 19-year-old, 60 kg woman, with a past medical history of mild asthma and previous deliberate self-harm, intentionally ingested a small amount of mercuric chloride powder from

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the cap of the bottle, estimated to be 2–4 g, obtained from the laboratory where she worked. On arrival at the Emergency Department, she presented with symptoms of nausea, abdominal discomfort, vomiting of blood-stained fluid, and diarrhea. Bloody stools developed 36 h after admission and persisted until day 4. There was no stridor, oral or pharyngeal edema, and no shortness of breath on presentation. Her last menstruation was the day prior to presentation.

On examination, she appeared pale and unwell but with good peripheral perfusion. She was tachycardic (HR=110) with a blood pressure of 113/61, clear chest except for some end-expiratory upper airway noise. The abdomen was soft but with epigastric tenderness. The admission chest radiograph was normal, while an abdominal X-ray 6 h after ingestion revealed radio-opaque material within the gastric antrum (Fig. 1); a repeat abdominal film 24 h later did not demonstrate any persistent gastro-intestinal opacification. An ECG showed inferior T-wave inversion with lateral T-wave flattening and a significantly prolonged QTc of 513 ms. These changes improved significantly, and a repeat ECG 24 h later was virtually normal. The initial full blood count was normal (Hb 135 g/L, Plt 337×10^9 , WCC 10.5×10^9); however, a polymorph leucocytosis developed within 6 h (WCC 25.5, PMN 23.7). Blood biochemistry indices were as follows: plasma sodium, 139 mmol/L (135–145); potassium, 3.3 mmol/L (3.5–5.0); urea, 7.7 mmol/L (3.6–7.1); creatinine, 71 $\mu\text{mol/L}$ (<133); and international normalized ratio (INR), 1.0 (0.8–1.2). The patient's initial blood mercury concentration was 17.9 $\mu\text{mol/L}$ (3.58 mg/L) at 3 h post-ingestion. Mercury blood concentrations were determined daily for 3 days (Table 1). Unfortunately, concentrations thereafter were not obtained.

Treatment with 200 mg intramuscular dimercaprol (“BAL”) was initiated within 2 h of presentation based on the history of a significant ingestion of mercuric chloride. The patient was transferred to the high dependency unit/intensive care unit; a radial arterial line, central line, and urinary catheter were placed anticipating hemodynamic and renal compromise and electrolyte disturbance. Over the first 6 h, she remained stable; however, she later developed a metabolic acidosis with partial respiratory compensation (pH 7.29, bicarb 14 mmol/L, pCO_2 29 mmHg, base excess -10, and anion gap 22) and clear hypokalemia (2.7 mmol/L). There was some evidence of pulmonary involvement on day 2 with increasing breathlessness, fever, cough, escalating oxygen requirement, and hypoxemia. A repeat chest X-ray showed atelectasis at the left lung base probably due to aspiration. Throughout the duration of illness, there was only mild hemodynamic instability. Urine output remained greater than 50 mL/h throughout and kidney function remained within normal parameters. Serum hepatic transaminases remained normal although the INR increased to 1.4 after 48 h, falling again to 1.1 at 72 h.

Fig. 1 Abdominal radiograph performed at 6 h post-ingestion. Radio-opaque material is visualized within the stomach lumen (black arrows). Cardiac monitoring leads and an umbilical jewelry piercing are also noted. Repeat imaging 24 h later showed resolution of the radiographic abnormality

The patient's blood pressure was managed with aggressive intravenous fluid replacement, which maintained adequate hemodynamic parameters and urine output. Hypokalemia was treated with IV potassium replacement. Dimercaprol was continued at 200 mg intramuscularly 4 hourly for 48 h, then 6 hourly for 48 h, reducing to 12 hourly for a further 7 days. Broad spectrum antibiotic cover with IV clindamycin was initiated soon after the development of respiratory involvement and fever, with subsequent improvement in oxygenation and resolution of fever.

The patient's symptoms began to improve 48 h after admission. Her nausea settled slowly and she was able to tolerate a little oral intake. Bowel and other abdominal symptoms resolved fully within a week. Persisting acid base abnormalities (low bicarbonate) eventually returned to normal within a week. Shortness of breath on exertion and a cough also settled within 1 week. The patient made a full recovery and, once medically cleared, was assessed by the mental health services and admitted to the acute psychiatric unit for further observation and treatment. At this time, unfortunately, no further

Table 1 Blood mercury concentrations

Time post-ingestion (h)	Blood concentration— $\mu\text{mol/L}$ (mg/L)
3	17.9 (3.59)
24	10.6 (2.13)
48	8.8 (1.77)
72	5.5 (1.10)

blood or urinary analysis for mercury was undertaken. The decision to halt chelation was based on the cessation of adverse clinical signs and symptoms.

Discussion

While mercuric chloride ingestions are uncommonly reported, they are usually serious, and sometimes fatal. In this patient, the clinical effects indicated mild to moderate poisoning only. The hemodynamic effects were not severe, with only mild hypotension and tachycardia, and minor ECG profile changes that quickly resolved. Apart from polymorph leucocytosis and mild hypokalemia, her hematological parameters and blood biochemistry remained normal. The lowered potassium concentration in this patient is not typical; some case reports have recorded hyperkalemia, sometimes attributed to rhabdomyolysis [4, 5]. However, hypokalemia in this patient is not surprising given the possibility of marked potassium losses as a result of significant vomiting and diarrhea.

Previous case reports have also reported gastrointestinal symptoms including nausea, vomiting, diarrhea, abdominal pain, hematemesis, and melena [5–7]. Due to the corrosive properties of this salt, additional gastrointestinal complications may include mucosal inflammation, ulceration, and necrosis of the gastrointestinal tract [4, 5, 8]. Subsequent to the initial gastrointestinal injury, patients may suffer oliguria and renal failure, due to a combination of impaired perfusion and direct renal toxicity [6], the latter typically involving proximal tubular injury [9]. Tubular impairments and necrosis appear more common than glomerular effects. However, this patient had no clinical evidence of significant renal impairment, with serum creatinine concentrations remaining normal with a stable urine output.

This patient ingested an estimated dose of between 2 and 4 g of mercuric chloride with a blood concentration, taken at 3 h post-ingestion, of 17.9 $\mu\text{mol/L}$ falling to 5.5 $\mu\text{mol/L}$ at 72 h. Toxic or lethal doses of mercuric chloride have not been well established. A probable lethal dose has been reported to range from 1 to 4 g [3, 10–13], although there are also reported fatalities from estimated ingestions of 0.5 g [3] and nonfatal doses in excess of 4 g [11]. Mercury blood concentrations following exposure to mercuric chloride are not frequently reported. However, normal concentrations are considered less than 0.05–0.1 $\mu\text{mol/L}$ while values greater than 2.5 $\mu\text{mol/L}$ measured soon after an acute ingestion have been associated with corrosive gastroenteritis and acute renal insufficiency [11, 12]. The amount allegedly ingested and the blood concentrations found certainly put this case in the significantly toxic and potentially lethal range.

In severe cases of mercuric chloride poisoning, early treatment priorities include assessment and management of

respiratory function, circulation, and urinary output. Due to its corrosive nature, severe gastrointestinal injury may rapidly occur with GI fluid losses and bleeding resulting in hypotension and hypovolemic shock [5]. Early establishment of vascular access is indicated; IV fluid replacement can be required, often followed by inotropic and/or vasopressor agents [6]. Gastrointestinal blood losses may be sufficient to produce anemia, requiring transfusion of blood or blood products [5]. In patients with severe gastric necrosis, surgical intervention may be required [4]. Caustic injury to the oropharyngeal mucosa may produce oropharyngeal and laryngeal edema; developing obstruction requires airway protection and ventilatory support, and tracheostomy may be required [5]. Metabolic acidosis may develop with resultant circulatory compromise [8]. Arterial blood gases should be monitored and any acid–base abnormalities managed supportively.

There is limited scope for gastrointestinal decontamination following ingestion and it was not attempted in this patient. It is not routinely recommended given the rapid onset of significant poisoning and the often severe associated gastrointestinal tract (GIT) injury. In particular, given the corrosive effects, induction of emesis or use of gastric lavage is contraindicated. Any benefit from activated charcoal is uncertain and may be outweighed by risks. While having limited binding capacity for metallic compounds in general, there is *in vitro* evidence for adsorption of mercuric chloride [14], but charcoal could obscure visibility if endoscopy is required [15].

Given concerns regarding the toxicity of mercury plus the acute effects of mercuric chloride specifically, an early decision was made to treat this patient with dimercaprol, the only suitable chelating agent that was immediately available. Its role in the good outcome for this patient is difficult to determine, but some benefit may have occurred. For example, in one historical series of mercuric chloride ingestions, use of dimercaprol within 4 h was associated with a 100 % survival rate (41/41), compared to a 31 % mortality rate (27/86) before it began to be used [16]. In general, the role of chelating agents for mercury poisoning is debated; however, several factors should be considered on a case-by-case basis. It is recognized that the toxic effects of mercury can vary in nature and severity, depending on the type of mercury compound, the route of exposure, the dose(s) involved, and whether acute or chronic exposure occurs. Such factors can also influence the extent to which chelation therapy could be effective. The differences between inorganic mercury, various organomercury (alkyl and aryl) compounds, and elemental mercury partly arise from their different absorption, distribution, and elimination kinetics, which largely determine the major target organs for each group.

With acute inorganic mercury ingestions, the GIT and kidney are the major target organs, with considerable distribution to the latter, in contrast to brain, where its access is

much less than that of elemental mercury and especially smaller alkyl mercury compounds such as methylmercury. Chelation has been advocated for acute inorganic mercury ingestions partly because most available chelating agents are more effective at removing mercury from the kidney, and some other organs, than the brain, into which they have very limited access. Further, inorganic mercury ingestions typically present soon after a single exposure, when there is still scope for minimizing tissue uptake and little previous accumulation and injury has already occurred, thus increasing the likelihood of benefit. Decisions on chelation should be made early as experimental evidence has suggested that when chelation is delayed its efficacy can be diminished [17]. The only available chelator in this case, dimercaprol, is atypical in that it does have significant CNS permeability, with the potential to not only remove any mercury from the brain, but also to carry chelated mercury from other sites and redistribute it into the brain. It is for this reason that it is considered contra-indicated for methyl and ethyl mercury poisoning, as it may further enhance the natural CNS accessibility of these highly lipophilic and particularly neurotoxic forms of mercury.

There are less concerns with its use for acute inorganic mercury poisoning, where chelators used have included dimercaprol as well as penicillamine, DMPS (Unithiol, Dimival, 2,3-dimercapto-1-propane sulfonate), and DMSA (Succimer, 2,3-meso-dimercaptosuccinic acid), though the latter two are likely preferable. Indeed, in humans, DMPS appears to be the chelator of choice [18]. Advantages include that it remains in the body for longer [19], it appears to act more quickly [20], and is more effective than DMSA (animal experiments have shown DMPS is the most effective chelator for enhancing urinary excretion and decreasing tissue concentrations of inorganic mercury) [21]. Preparations are available for oral or parenteral use [22].

If DMPS is unavailable, DMSA or dimercaprol can be used as alternatives. DMSA is water-soluble and is typically administered orally [23]. It can also be given intravenously if the oral route is not suitable due to gastrointestinal effects [11]. It appears to chelate extracellular, but not intracellular, mercury to form a water-soluble mercury-containing complex, resulting in enhanced renal excretion of mercury [24]. While dimercaprol is no longer the chelator of first choice, due in part to its potential toxicity and painful administration, it may still have a role in inorganic mercury poisoning [5]. Thus, if parenteral forms of DMPS or DMSA are not available, dimercaprol via the parenteral route confers advantages in the presence of decreased gut motility [25], persistent emesis, or decontamination procedures [26]. On the other hand, with improvement of GI function, a switch to oral chelator formulations such as oral DMPS or DMSA can obviate the requirement for continuing IM injections, and also provide a higher dose of chelating agent. Unfortunately, these oral chelators were not available in this case.

Penicillamine is a monothiol compound, not considered as effective as DMSA [11] or DMPS, at least for some effects [27]. It should not be considered a first-line agent; partly because of its toxicity profile, its use should be reserved for patients who cannot tolerate other agents [11].

Hemodialysis or other extracorporeal techniques were not used in this case due to limited data on whether any method is particularly efficient in removing toxicologically significant amounts of mercury, either singularly or in combination with chelation [6, 28]. Hemodialysis may have some ability to remove mercury in association with dimercaprol and there is some limited evidence of benefit in this context [29, 30]. Most other evidence suggests a low efficacy of extracorporeal elimination methods including hemodialysis in combination with chelators [18, 31]. One case involving high flux continuous veno-venous hemodiafiltration (CVVHDF) along with DMPS was associated with a possibly significant removal of inorganic mercury [18]. As noted, DMPS is a favored chelator for mercury, and the DMPS/CVVHDF combination may be the preferred elimination treatment. However, even in the above reported case, the removal was limited to 12.7 % of the estimated ingested dose, mainly over the first 72 h [18]. Hemodialysis can become necessary if acute renal failure occurs [5].

In summary, we report a case of poisoning with a potentially fatal amount of mercuric chloride along with elevated blood mercury concentrations that did not develop significant toxicity and responded to prompt supportive care. It is important to realize the potential toxicity of mercuric chloride, and based on this case and a review of the literature, close observation and aggressive supportive care along with early chelation, preferably with DMPS or DMSA, would be our recommendations for treatment of this uncommon poisoning.

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