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CASE REPORT

Sodium fluoroacetate toxicity: a case report of malicious poisoning in dogs across a Phoenix, Arizona neighborhood

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Abstract In May 2016, thirteen dogs housed in backyards within a single neighborhood were reported to have developed convulsions and died within a 24 h period. An investigation of the scene by law enforcement resulted in submission of eight dogs for postmortem examination. It was suspected that a rapid acting toxin was the cause of death. A gas chromatography-mass spectrophotometry (GC-MS) protocol combined with thin-layer chromatography that allows screening for common convulsants failed to identify a toxin in either pooled gastric content or liver samples from select cases. After consultation with a veterinary toxicologist, sodium fluoroacetate poisoning was investigated. Sodium fluoroacetate, also known as 1080, is a pesticide that was available in the United States from the 1940's to the 1970's, but since 1972 has been banned or under EPA restricted use. When gastric content was re-tested using a GC-MS protocol with selective fluoroacetate ion monitoring and carbon 14 radiolabeling to facilitate quantification, 379 ppb sodium fluoroacetate was detected in a pooled gastric content sample. In spite of its banned status, sodium fluoroacetate remains a rarely reported cause of malicious poisoning in domestic dogs in the United Sates. This compound is highly toxic and is capable of causing death in dogs, humans, other mammals, and insects in ingested quantities as small as a few droplets. Even when geographic or historical proximity to a source is not evident, this intoxication should be considered in dogs exhibiting compatible clinical signs.

Keywords Canine · Convulsion · Malicious · Poisoning · Sodium fluoroacetate · 1080

Introduction

Sodium fluoroacetate (1080) is a white, odorless, water soluble, toxic salt that is manufactured as a powder, but may be supplied as solid bait blocks or in a liquid formulation. It was developed in Europe in the 1930's and was further researched and used during World War II in Nazi-occupied countries [1]. In 1946 the compound was introduced in the United States of America (USA) as a rodenticide. Gradual recognition of 1080's extreme toxicity in a wide variety of species, including humans, led to its ban from public use in the USA in 1972. The Environmental Protection Agency (EPA) has rated 1080 as a Category I toxin, the highest rating possible. The LD_{50} for human ingestion has been reported at 0.714 mg/kg, with 0.5–2.0 mg/kg listed as a potentially toxic dose [1]. While this compound is highly toxic to humans, acute oral toxicity studies with coyotes indicate an even lower LD_{50} of 0.12 mg/kg, and an LD50 in dogs of just 0.066 mg/kg [1]. Compound 1080 is also toxic to birds and insects [1].

Today, exclusively under EPA license, 1080 is available in the USA through the United States Department of Agriculture (USDA) in the form of bait collars [1]. Ranchers attach the collars to livestock and if bitten by predators, the collars release the poison. Canids are extremely sensitive to 1080, which induces vomiting, convulsions, and seizures,

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progressing to death within hours. Texas, New Mexico, Wyoming, and Montana are the only states that provide the required certification and training program necessary to comply with EPA 1080 restrictions. In New Zealand, 1080 has been widely used for the control of non-native rodents since the 1950's [2], and is now part of bovine tuberculosis control measures aimed at reducing the Common brush-tailed possum (*Trichosurus vulpecula*), which acts as a reservoir for the disease [3]. A single chemical plant located in the U.S. produces 1080 and supplies it to New Zealand and the USDA. Fluoroacetate is also a natural toxic component of some plants native to Australia, South Africa, South America, and India [4].

Compound 1080 can be absorbed through the gastrointestinal tract, respiratory tract, or open wounds, but only slowly through intact skin [5]. The mechanism of action of fluoroacetate in mammals is blockage of the citric acid cycle (CAC). Similarities in the molecular structure of fluoroacetate and acetate allow fluoroacetate to bind to CoA-SH, replacing acetate in the CAC and resulting in the production of fluorocitrate instead of citrate. Fluorocitrate binds to the enzyme aconitase, effectively stopping the CAC. One effect of CAC blockage is reduction of citric acid metabolites, including glutamate, which allows hyperammonemia and likely contributes to seizure activity. In addition, impaired oxidative metabolism results in lactic acidosis and ketone accumulation. Finally, the accumulation of citric acidchelates calcium, resulting in hypocalcemia [6]. A combination of these metabolic outcomes is believed to cause the convulsions, seizures, and cardiac disturbances reported in mammals following ingestion, with death resulting from cardiac or respiratory arrest [7]. The following case report describes the investigation, necropsy, and toxicological findings in a case series of malicious poisoning using 1080 in domestic dogs.

Case report

History and necropsy

In May of 2016, a report of multiple suspicious deaths in dogs in a west Phoenix, Arizona neighborhood was brought to the attention of the Arizona Humane Society and the Phoenix Police Department. The investigation found that some of the dogs had been observed going into seizures and spasms, which were rapidly followed by death, while others were discovered dead by owners returning home after a short absence. In all cases there was no visible trauma, and there was no known access to toxins or changes in diet. The dogs had access to their fenced yards and were contained on their properties. A total of seven households made similar reports in a small grid area of the city. Within this area the home with the most casualties, referred to as home A, had a total of twelve dogs with access to an enclosed backyard. Eight of these dogs developed vomiting and convulsions and died within hours of each other. Among these, one adult dog and a group of puppies consumed the vomit of other symptomatic dogs, rapidly developed similar symptoms to the deceased, and died. At home B the owner arrived and found her previously healthy dog deceased. The dog was taken to a veterinary clinic and the owner was informed that the dog had consumed poison. At home C, the owner arrived and observed a male subject climbing over her block wall, leaving her yard, and found a suspicious canine treat in the dog bowl in her backyard. At home D, the owner left for a short time and returned home to find both of the family dogs deceased. The owner told police she suspected the dogs were poisoned while they were in the backyard. At home E, the dog owner arrived home after being gone for a few hours and discovered her dog was deceased. The owner from home E took her deceased dog to a veterinarian who informed her that her dog had been poisoned. Similar reports were subsequently called in for two additional homes in the area. No person suspected of committing a crime was identified despite posting a description of the cases in local media outlets and on an anonymous tip hotline called Silent Witness.

Eight dogs that died at home A were submitted to the Midwestern University Diagnostic Pathology Center for postmortem examination with the following history. Seven out of a total of twelve previously healthy dogs developed acute onset tremors, vomiting, and convulsions followed by death within a few hours of the onset of clinical signs. An eighth dog with the same clinical signs was brought to an emergency clinic and hospitalized. Physical examination of the hospitalized dog revealed a temperature of40.9 °C [37.2 °C–39.2 °C], a heart rate of 50 beats per minute [100–160 beats per minute], and a respiratory rate of 35 breaths per minute [16–20 breaths per minute]. The dog was described as comatose with generalized intermittent tremors. Pupils were equal and responsive to light. There was severe sinus bradycardia with no palpable pulses. The only diagnostic test performed was a blood glucose, which was 212 mg/dl. The dog went into cardiorespiratory arrest and died as a fluid line was being placed.

All of the dogs presented for necropsy were in extensor rigidity. Consistent gross and histologic findings across the group included varying degrees of congestion and hemorrhage in the lungs, brain, liver, and pancreas, with pulmonary hemorrhage being the most severe and consistent postmortem finding. One of the dogs had numerous red bite wounds in the skin across the thorax associated with dead ants that were still attached to the carcass. Examination of gastric content revealed chicken bones and meat in 2/8 dogs, and tan viscous fluid in a third. There was no stomach content in 5/8 dogs, presumably due to vomiting. The owner reported that the dogs were not fed chicken, and that the source was unknown.

Toxicology

A convulsants screen and gas chromatography-mass spectrophotometry (GC-MS) was conducted at the Diagnostic Center for Population and Animal Health (DCPAH) at Michigan State University. These tests were conducted on postmortem gastric content and liver samples, each of which was pooled from 3 of the dogs submitted for necropsy (protocol published) [8].The convulsants screen protocol uses thin layer chromatography on an early gel permeation chromatography fraction to detect the mycotoxin penitrem A and bromethalin, and on an aqueous fraction for the mycotoxin roquefortine, and for strychnine, followed by qualitative GC-MSon the combined fractions to further screen the samples (protocol published) [9]. The GC-MS and convulsants testing was negative on all samples. The pooled gastric content sample was then forwarded to the North Dakota State University Veterinary Diagnostic Laboratory for sodium fluoroacetate testing. The sample was extracted with tungstic acid, partitioned into ethyl acetate and evaporated, derivatized with pentafluorobenzylbromide, and analyzed by GC-MS (Agilent 6890 GC/5973 MS; Agilent, Wilmington, DE) using specific ion monitoring. Recovery of fluoroacetate during the procedure was monitored using a 14C–fluoroacetate spike. The pooled gastric content contained 379 parts per billion (0.379 mg per liter) sodium fluoroacetate (detection limit is 10 ppb). The approximate LD50 for the dogs in this case, with average body weights of 5.0 kg, is .33 mg.

Discussion

Given the highly restricted status of 1080 in the U.S., use of this compound for malicious poisoning of dogs in a large metropolitan area has left questions and serious concerns about the source. The compound is manufactured by a single company in the U.S., Tull Chemical Company, located in Oxford, Alabama. Compound 1080 was banned in the USA from 1972 to 1985, and since 1985 it has only been available under restricted use to control predator attacks on livestock. For this use, 1080 is supplied to the USDA for the manufacture of livestock protection collars. These can only be obtained by ranchers via Wildlife Services following EPA-approved certification. It is illegal to remove the poison from these collars. Further, Arizona is not one of four states in the USA approved to use these collars. Despite these restrictions, in 2011 there was a report of sodium fluoroacetate toxicity in a flock of sheep in California. California is also a state that is not approved for bait collar use, and the source of the toxin in that case was not identified. In 2010 there was a report of thirteen pet dogs poisoned with 1080 in Salmon, Idaho, and again, the source of the poison was not identified. In these and the current case report, illegal import, possession of stockpiles, or illegal use of the compound intended for bait collars are the sources considered. Sporadic reports of pet, wildlife, and even human deaths [10, 11] due to 1080 ingestion date back to the 1950's, but given the low index of suspicion and specificity of testing necessary to identify the parts per billion quantities capable of causing death, cases have likely gone unidentified.

In dogs, the time from ingestion to morbidity (vomiting, hyperextension of the limbs, and convulsions) is 30 min to 3.0 h, with central nervous system disturbances that cause convulsions followed by cardiorespiratory failure. There is some variation in pathological findings reported across species poisoned with 1080. Cardiac lesions are not explicitly described in dogs, and myocardial necrosis was not seen in the dogs in this report, but heart lesions have been reported in rabbits, possums [2], goats, horses, and non-human primates [11], and in the referenced intoxicated sheep report, myocardial degeneration and necrosis was also described [12].

In the case presented, 1080 was not on the differential list when samples were originally taken for toxicology, and it was only through consultation with a toxicologist that this toxin was suspected and subsequently identified. At the time of this report only one diagnostic laboratory in the USA offered 1080 testing with parts per billion detection levels needed for veterinary tissue sample diagnosis. This case underscores the importance of cross-agency communication for reaching an accurate postmortem diagnosis, particularly for unusual toxicology cases.

Key points

1. While 1080 has been under EPA regulation for over 40 years in the USA, sporadic malicious poisonings with this compound continue to be reported in dogs and other animals.
2. There are no legal routes for the possession of 1080 in the USA outside of livestock collars.
3. 1080 is a highly toxic compound capable of killing humans and mammals in small quantities.
4. Clinical signs of 1080 toxicity in dogs consist of convulsions and tremors that rapidly progress to death. Pulmonary hemorrhage is a common postmortem finding. The list of toxins commonly considered in dogs with this constellation of findings (bromethalin, metaldehyde, penitrem A, roquefortine, zinc phosphide, drugs of abuse, and strychnine) should also include 1080.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest in the production of this report.

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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