PEER-REVIEWED

Metaldehyde toxicosis

Linda K. Dolder, DVM

Metaldehyde, a tetramer of acetaldehyde, is a common ingredient in commercial snail and slug baits in the United States.[1,2] These products are often used around gardens in the southern United States, Pacific coast, and Hawaiian Islands where snails and slugs are more prevalent.[3] The concentration of metaldehyde is usually 4% or less in commercial liquid, powder, and pellet products. Various trade names include Snarol, Buggetta, Deadline, Slug Death, Slugit Pellets, Slug Pellets, Mini Slug Pellets, Namekil, and Optimol.[1,4] Although less common, metaldehyde baits are also formulated with other chemicals such as carbaryl or arsenic.[3,5] The carbaryl and arsenic constituents are of less concern as toxicants than is the metaldehyde component.[6]

The bran or molasses sometimes added to the bait makes it more attractive to snails and slugs, but it also attracts domestic animals. Animals that ingest metaldehyde, which is a neurotoxicant, may experience vomiting, tachycardia, tachypnea, ataxia, tremors, and seizures. Death can also occur.

Toxicity

The oral LD_{50} of metaldehyde is 100 mg/kg in dogs, 60 mg/kg in horses, and 207 mg/kg in cats,[6,7] though toxicosis in cats is uncommon. Typically, any dose of metaldehyde 2 mg/kg or greater in dogs warrants decontamination (ASPCA Animal Poison Control Center [APCC] Database: Unpublished data, 2003). For example, if a 10-lb (4.5-kg) dog ingests 1 tsp of a 2% metaldehyde bait, the ingested dose would be 22 mg/kg, well over the 2-mg/kg trigger dose (the dose at which decontamination is recommended and treatment may be needed).

Mechanism of action

Metaldehyde is directly absorbed from the gastrointestinal tract, but it is poorly soluble in water.[8] The exact mechanism of action in mammals is unknown, but it is reported that gastric acidity promotes the hydrolysis of metaldehyde to acetaldehyde.[9] The old theory that acetaldehyde causes the agent's toxic effects seems unlikely since acetaldehyde was not found in the plasma or urine of dogs purposefully exposed to metaldehyde.[1,8] Metaldehyde crosses the blood-brain barrier and has been detected in the brain, blood, and liver of mice given metaldehyde.[8]

Signs of metaldehyde toxicosis may be due to decreased brain concentrations of γ-aminobutyric acid, norepinephrine, and serotonin (5-hydroxytryptamine) and increased monoamine oxidase activity. Decreased γ-aminobutyric acid concentrations can lead to seizures because of the amino acid's inhibitory role in neuronal excitation. Also, as γ-aminobutyric acid concentrations decrease, mortality increases.[10] Decreases in norepinephrine and serotonin also have been associated with a decreased threshold for seizures.[8] Since monoamine oxidase breaks down serotonin and norepinephrine, an increase in monoamine oxidase activity results in further decreases in serotonin and norepinephrine concentrations.[8]

Another contributing factor to morbidity and mortality is hyperthermia, which may be secondary to the muscle tremors commonly seen in metaldehyde toxicosis. When body temperatures exceed 107 F (41.6 C), all organ systems begin to experience cellular necrosis within a few minutes. Metaldehyde also affects electrolyte and acid-base balances, which can cause metabolic acidosis that is often associated with central nervous system depression and hyperpnea.[8]

Clinical signs

Signs of metaldehyde toxicosis in dogs may begin after a few minutes or up to three hours after ingestion. Typical signs include anxiety, tachycardia, nystagmus, mydriasis, hyperpnea, panting, hypersalivation, and ataxia. Vomiting, diarrhea, tremors, hyperesthesia, continuous seizures, metabolic acidosis, rigidity, opisthotonos, and severe hyperthermia may also be seen. Delayed signs that may develop are depression and coma. Death from respiratory failure can occur within a few hours of ex-

"Toxicology Brief" was contributed by Linda K. Dolder, DVM, ASPCA Animal Poison Control Center, 1717 S. Philo Road, Suite 36, Urbana, IL 61802; (888) 4ANI-HELP. The department editor is Petra A. Volmer, DVM, MS, DABVT, DABT, College of Veterinary Medicine, University of Illinois, Urbana, IL 61802.

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posure.[6,9] Liver failure may develop two or three days after exposure (ASPCA APCC Database: Unpublished data, 2003).[9] Clinical signs in cats are similar to those in dogs, but nystagmus is often more prevalent in cats.[6]

Diagnosis and differential diagnoses

Diagnosis is often based on a history of exposure and appropriate clinical signs. The animal's vomitus, fluid obtained from gastric lavage, or breath may have an acetaldehyde odor (similar to formaldehyde or acetylene, only not as strong).[3] Some laboratories offer metaldehyde analysis on frozen samples of serum, stomach contents, liver, and urine.[8] Necropsy findings in dogs are nonspecific and may include hyperemia of the liver, lungs, and kidneys; inflammation of the gastric mucosa; and subendocardial and subepicardial hemorrhages.[5,6]

Death from respiratory failure can occur within a few hours of exposure.

Other intoxications to consider include strychnine, compound 1080 (sodium monofluoroacetate), bromethalin, chlorinated hydrocarbons, organophosphates, zinc phosphide, methylxanthines, lead, tremorgenic mycotoxins, and illicit drugs such as amphetamines.

Treatment

The treatment goals in animals exposed to metaldehyde are to prevent metaldehyde absorption, control clinical signs, monitor and correct acidosis and dehydration, and provide supportive care.[5] No antidote exists for metaldehyde toxicosis. Emesis can be induced if the patient is asymptomatic, it has been less than 30 minutes since ingestion, and the patient has no medical conditions precluding emesis (*e.g.* recent abdominal surgery, heart disease, epilepsy). Induce emesis in dogs or cats with either hydrogen peroxide (1 to 5 ml/kg, 45 ml maximum) or apomorphine hydrochloride (crush and dissolve a partial tablet in water and administer it in the conjunctival sac).[11,12] In cases of large ingestions, consider anesthetizing the patient and performing a gastric lavage. Use a cuffed endotracheal tube to prevent aspiration.

In dogs and cats, activated charcoal administration (1 to 4 g/kg) is recommended.[11] Repeated doses given at half the original dose every six to eight hours may be of benefit as well. Activated charcoal with sorbitol (a cathartic) can be used as long as the patient is not dehydrated or having diarrhea but should be limited to use on every third dose of activated charcoal. Warm-water enemas can also be used to help remove metaldehyde from the gastrointestinal tract.

Methocarbamol has been used successfully to control tremors (ASPCA APCC Database: Unpublished data, 2003). In dogs and cats, the recommended dosage is 55 to 220 mg/kg given slowly intravenously (give the first half of the calculated dose rapidly but do not exceed an administration rate greater than 2 ml/min, wait until the animal relaxes, then administer to effect).[11] Methocarbamol administration may be repeated as needed, but do not exceed a maximum daily dosage of 330 mg/kg/day.[11] Diazepam (1 to 5 mg/kg intravenously) has also been used to control tremors and seizures.[11] Other anticonvulsants may be used as needed (*e.g.* gas anesthesia in refractory cases). Use barbiturates cautiously because they can compete with enzymes that degrade acetaldehyde.[3]

In addition to controlling tremors and seizures, monitor and correct electrolytes, blood gases, body temperature, anion gap, and urine pH. Hyperthermia due to tremors and seizures is usually corrected when the tremors and seizures are controlled. Do not use aggressive cooling measures, such as ice water baths, because they may lead to hypothermia. Use intravenous fluids such as lactated Ringer's solution or Normosol-R (Abbott) to correct dehydration, body temperature, electrolyte imbalances, and acidosis. Diuresis is generally not necessary because it doesn't aid in metaldehyde excretion since urinary excretion in dogs is less than 1%.[8] Excessive muscle activity after prolonged tremors or seizures can lead to myoglobinuria and secondary renal dysfunction. In these cases, diuresis is recommended to

prevent renal damage. Sodium bicarbonate may be needed to correct acidosis, although it should only be used if blood gases can be monitored. Acidosis should be corrected once other clinical signs are controlled. Further treatments include general supportive and symptomatic care, such as antiemetics for gastric upset and oxygen administration for dyspnea. Monitor liver enzyme activities at baseline, 72 hours after exposure, and then as needed.

Conclusion

Metaldehyde ingestions are potentially life-threatening. But with timely and appropriate decontamination and treatment, clinical signs can be controlled and the patient's life can be saved.

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