TOXICOLOGY BRIEF

Onion Breath

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A normally active poodle arrives for its appointment appearing weak and listless. On examination, the animal's heart and respiration rates are elevated, a fresh urine sample is tinged dark red, hematocrit is low, and mucous membranes are pale. The client is sure that the poodle has not had access to anything harmful (e.g., garbage, houseplants, mousetraps). In fact, the owner explains that she has taken special steps to enhance both her health and that of her pet. After reading about the numerous benefits of onions, she added grilled Bermuda onions to both of their diets about a week ago. Now, her dog has become depressed and weak. What could be wrong?

Onion Toxicity

Heinz-body hemolytic anemia is what could be wrong. Onions—whether cooked, raw, or dehydrated—contain sulfur compounds (Box 1) that, when chewed, are hydrolyzed to thiosulfinates. Thiosulfinates decompose to a number of disulfides, including dipropenyl disulfide (or *n*-propyl disulfide), which appears to be the most toxic disulfide.[1] These disulfides are oxidizing agents that can cause hemolysis of erythrocytes.

Glutathione, a ubiquitous tripeptide, plays an important protective role against oxidative damage. Glutathione participates in various biologic processes, including protein and DNA synthesis, transcellular amino acid transport, metabolic enzyme activity, and protection of cells against free radicals and carcinogens. The liver, kidneys, intestinal mucosa, and erythrocytes contain the highest amounts of glutathione, perhaps due to their increased risk of exposure to free radicals and/or their susceptibility to autooxidation after free radical injury.[2] Through the hexose monophosphate cycle (also known as the pentose phosphate pathway), glucose-6-phosphate dehydrogenase (G6PD) provides

the reducing power that converts oxidized glutathione to reduced glutathione (GSH; Figure 1). Without GSH, hydrogen peroxide accumulates and causes oxidation of the sulfhydryl groups of the globin chains, leading to denaturation of hemoglobin and formation of precipitates (i.e., Heinz bodies; Figure 2). The erythrocyte cell membrane may be damaged, resulting in the erythrocyte being removed from circulation or possibly lysing within circulation, causing hemoglobinemia and hemoglobinuria.[3]

Species Susceptibility

Dogs

All dogs that eat onions are susceptible to their toxic effects. However, in dogs with G6PD deficiency (a genetic disorder), lower G6PD levels cause lower GSH levels, resulting in a greater risk of oxidative injury.

Yamamoto and Maede[4] reported that dogs may also be more susceptible to onion-induced oxidation if they have innately high concentrations (five to seven times normal) of erythrocyte GSH. In this study,[4] dogs with this trait had increased oxidative injury from the compound 4-aminophenyl disulfide, suggesting that perhaps onions contain a similar oxidant. These dogs also had high potassium and low sodium concentrations, which are attributable to the function of sodium-potassium–ATPase. Normal canine erythrocytes lack this enzyme and have high sodium and low potassium concentrations. This trait is common in many dogs, espe-

- Onions are of the genus *Allium*, in the family Liliaceae. The true onion is classified as *Allium cepa*; the nodding wild onion is classified as *Allium cernuum*; the shallot as *Allium ascalonicum*; and the green onion, or common leek, as *Allium ampeloprasm*.
- Garlic, which is also of the family Liliaceae, is related to onions and has similar chemical characteristics.

Toxicology Brief is contributed by veterinary technicians at the American Society for the Prevention of Cruelty to Animals–Animal Poison Control Center, 1717 S. Philo Rd., Suite 36, Urbana, IL 61802; hotline: 888-4ANI-HELP (888-426-4435) or 900-680-0000 (a $45 consultation fee is charged to the caller's telephone bill); email: callen@napcc.aspca.org (for nonemergency information only); web site: www.napcc.aspca.org.

Box 1. Sulfur Compounds Found in Onions

The toxicity of onions is based on their disulfide concentration, which is increased when they are grown in soil that is high in sulfur. Sulfur is a widely distributed element found in abundance (ranked as the 16th element) in both free and combined states. Huge subterranean deposits are found in many parts of Louisiana and Texas as well as in Colorado, Nevada, Wyoming, and California. In addition, sulfur dioxide is an air pollutant released into the atmosphere during combustion of fossil fuel (e.g., gas, petroleum, coal). Plants can take up this sulfur, thereby increasing their sulfur content.

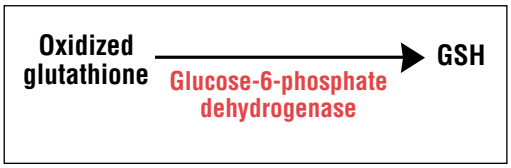

Figure 1—Conversion of oxidized glutathione to reduced glutathione (GSH).

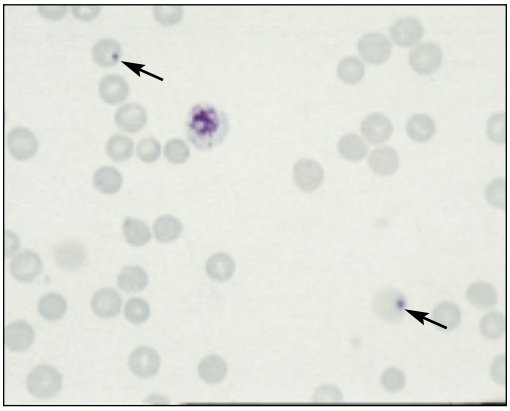

Figure 2—Heinz bodies (*arrows*). (New methylene blue stain, original magnification ×100)

cially Japanese breeds (e.g., Akitas, Shiba Inus).[4]

Cats

Feline erythrocytes are extremely susceptible to oxidative damage, particularly hemoglobin denaturation. Because of its molecular configuration, feline hemoglobin is approximately two to three times more prone to oxidative damage than is that of other animals.[2] Other enzymatic factors increase feline dependence on glutathione for oxidative protection compared with other mammals.[2] Because a small number of Heinz bodies are often found in feline erythrocytes, it is important to interpret the number of Heinz bodies in conjunction with the history and severity of anemia. Cats with only mild anemia may have increased numbers of Heinz bodies as a result of other diseases such as diabetes mellitus, hyperthyroidism, and lymphoma. A cat that has ingested oxidant-containing foods such as onions, however, may develop severe, life-threatening anemia in conjunction with Heinz-body formation. Therefore, cat owners should be cautioned to check labels on foods or herbal remedies to ensure that onions are not among the ingredients.

Large Animals

Of large animals, cattle are the most susceptible to onion toxicity. Horses are not as susceptible, and sheep and goats are somewhat resistant. In areas where onions are grown commercially, sheep may be fed cull onions (deemed unfit for human consumption) free choice without experiencing toxicity; for cattle, ingestion of more than 25% of their diet as onions may be hazardous.[1] While it does not explain the relative resistance of sheep and goats, the oxidative threat to cattle is greater because onions also contain *S*-methylcysteine sulfoxide (SMCO). SMCO is metabolized in the rumen, producing dimethyl disulfide, another oxidant. Because SMCO is absorbed in the intestine and not converted to dimethyl disulfide, it does not affect nonruminants, including hindgut fermentors (e.g., rabbits, guinea pigs, horses).[1]

Exposure

In cool, early spring, wild onions, which can be found in pastures when there is little else growing, will tempt grazing animals. Dogs and cats may ingest onion peels by raiding the garbage or stealing onion pieces from the table or off the floor. Pets can also ingest onions in table scraps or homemade diets provided by owners who are unaware of the toxic effects.

Toxic Doses

An early study[5] revealed onion toxicity in dogs when the amount of onions fed was more than 0.5% of the animal's weight. To induce hemolytic anemia, dogs in one study[6] were fed 30 g of onions/kg of body weight (which is 3% of body weight) once daily for 3 days. In another study,[4] dogs ranging in weight from 9.9 to 12 kg were fed 200 g one time (1.6% to 2% of body weight). Depending on the size and type, an onion's weight can range from 0.5 to 16 oz (14 to 455 g).

A review of the ASPCA Animal Poison Control Center case record database for *Allium cepa* exposure over a 2-year period revealed 23 cases (20 dogs, 3 cats). Six of the affected dogs and one cat showed clinical signs. The data revealed that it takes a fairly large amount of ingested onions before signs are observed but that the dose in the reported cases was consistently over 0.5% of the animal's body weight.

Clinical Picture

Adverse effects from onion ingestion are dependent on species sensitivity and amount ingested (Boxes 2 and 3). In chronic exposures at low doses, the anemic effect is lessened because erythrocytes are being regenerated simultaneously. The hematocrit may not reach its lowest point until several days after onion exposure.[5] In the study in which dogs were fed 30 g of onion/kg of body weight once daily for 3 days,[6] the hematocrit was 40% of preexposure value on day 5 of the study and returned to normal within 10 to 14 days postexposure. A high level of Heinz bodies appeared suddenly on day 2 and continued for 4 days.[7]

Treatment

Severe onion toxicosis can be lethal.[8] As with any toxicosis, the first

Box 2. Common Signs of Onion Poisoning in Dogs and Cats

- Pale or icteric mucous membranes
- Weakness, depression
- Rapid heart and respiration rates (caused by hypoxia)
- Vomiting, anorexia, and/or diarrhea
- Onion odor on breath

step is to remove the source of the toxicity. For cases in which a significant amount of onions have been ingested within the past 2 hours and there are no contraindications to emesis (i.e., hypoxic, comatose, dyspneic, lacking normal pharyngeal and/or gag reflexes), vomiting should be induced by giving the animal 3% hydrogen peroxide orally (1 ml/lb of body weight, not to exceed 45 ml), followed by the administration of activated charcoal. Within the clinic, apomorphine can also be used to induce vomiting. Other emesis methods are not recommended (e.g., syrup of ipecac is unreliable and may cause protracted vomiting, and salt can cause a salt toxicosis if emesis is not successful). For large animals, activated charcoal can be given at 0.5 to 1 g/kg PO with a stomach tube.

The animal's hematocrit should be monitored over a period of time (frequency depends on the overall condition of the animal) to ascertain the severity of anemia and whether it is degenerative or regenerative. It may take several days after onion ingestion for the hematocrit to reach its lowest point. Heinz-body hemolytic anemia is usually regenerative; therefore, the animal's prognosis is good if it has no other preexisting hematologic disorders. Whole-blood transfusions may be necessary for critically ill animals. Another possibility for dogs is the use of Oxyglobin® (Biopure Corp., Cambridge, MA; see product literature for effects on serum chemistry, hematology, urinalysis, and clinical signs). Other supportive therapies depend on the animal's overall condition. If vomiting, diarrhea, renal injury, or shock is present, intravenous fluid therapy and correction of electrolyte and acid–base disturbances is warranted. One case study[9] reported the use of corticosteroids, which, in retrospect, were deemed unnecessary for treatment.

Treatment should also include nutritional intervention. Dietary protein and amino acid quantity and composition have a significant influence on glutathione synthesis. Studies in rats demonstrated that prolonged fasting or a low-protein diet results in a significant reduction in hepatic glutathione levels, potentiating hepatic injury caused by oxidative stress.

Although nutritional therapy is important for all species, it is critical for cats. Dietary imbalance (specifically insufficient taurine) or anorexia has a more rapid and/or more adverse effect on glutathione metabolism in cats than in other species.[2]

Conclusion

Onions can cause potentially serious, life-threatening toxicity when sufficient quantities are ingested. Cats are extremely susceptible because of the differences in their hemoglobin structure and protective enzymes. The

Box 3. Common Laboratory Findings in Onion Toxicity

- Low hematocrit (e.g., dogs <37%, cats <24%, cattle <26%, sheep <24%, goats <20%, horses <32%)
- Hemoglobinuria (dark-colored urine ranging from red wine to almost black)
- Hemoglobinemia
- Methemoglobinemia[7]
- Abnormal erythrocyte morphology
  - —Heinz bodies (refer to a laboratory reference for staining requirements)
  - —Eccentrocytes (hemoglobin concentrated to one side of the cell)
  - —Leukocytosis with a left shift, increased total leukocyte count as cells move from the marginal granulocyte pool to the circulating granulocyte pool, and thrombocytosis due to increased bone marrow activity[7]

heredity of some dogs, specifically Japanese breeds, can significantly increase the severity of the toxicosis. Of the domestic grazing animals, cattle are the most susceptible to onion toxicity. The Heinz-body hemolytic anemia caused by onions is usually regenerative; therefore, prognosis is good with supportive care and recovery usually occurs in 10 to 14 days.

References

1. Cheeke PR: *Natural Toxicants in Feeds, Forages, and Poisonous Plants*, ed 2. Danville, IL, Interstate Publishers, 1998.
2. Fettman MJ: Comparative aspects of glutathione metabolism affecting individual susceptibility to oxidant injury. *Compend Contin Educ Pract Vet* 13(7): 1079–1087, 1991.
3. Robbins SL, Kumar V: *Pathologic Basis of Disease*, ed 5. Philadelphia, WB Saunders Co, 1994, p 591.
4. Yamamoto O, Maede Y: Susceptibility to onion-induced hemolysis in dogs with hereditary high erythrocyte reduced glutathione and potassium concentrations. *Am J Vet Res* 53(1):134–136, 1992.
5. Kay JM: Onion toxicity in a dog. *Mod Vet Pract* 64(6):477–478, 1983.
6. Ogawa E, Shinoki T, Akahori F, Masaoka T: Effect of onion ingestion on anti-oxidizing agents in dog erythrocytes. *Jpn J Vet Sci* 48(4): 685–690, 1986.
7. Coles EH: *Veterinary Clinical Pathology*, ed 4. Philadelphia, WB Saunders Co, 1986, p 40.
8. Beasley VR: *A Systems Affected Approach to Veterinary Toxicology*. Chicago, University of Illinois, 1999, p 886.
9. Solter P, Scott R: Onion ingestion and subsequent Heinz body anemia in a dog: A case report. *JAAHA* 23(5):544–546, 1987.

About the Author

Ms. Simmons works at the ASPCA and the Animal Emergency Clinic in Champaign, Illinois. She lives in a log home with three horses, six dogs, four cats, and seven birds. She has a strong interest in community involvement with animals and animal welfare and plans eventually to move her career in that direction.