PEER-REVIEWED

Allium species poisoning in dogs and cats

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Wild and domesticated *Allium* species have been used for culinary and ethnomedicinal purposes since the beginning of recorded history. About 95 species of native or cultivated leeks, chives, garlic, shallots, scallions, and onions are present in North America, and more than 80 ornamental *Allium* species are available. All *Allium* species and the products derived from them can be toxic to dogs and cats[1]; however, relatively few *Allium* species are of important toxicologic interest.

Table 1 lists the *Allium* species native to North America that are most commonly involved in animal poisonings.[1] The domesticated species commonly involved in toxicosis include *Allium cepa* (onion), *Allium porrum* (leek), *Allium sativum* (garlic), and *Allium schoenoprasum* (chive). The plants form solitary or clustered bulbs and are strongly aromatic, with an onion or garlic odor when crushed. The distinctive aroma distinguishes *Allium* species from morphologically similar poisonous plants, particularly death camas (*Zigadenus* species).[1]

Onions, leeks, garlic, and chives are commonly involved in toxicosis in dogs and cats.

Toxicity

Allium species contain a wide variety of organosulfoxides, particularly alk(en)ylcysteine sulfoxides. Trauma to the plants, such as chewing, converts the organosulfoxides to a complex mixture of sulfur-containing organic compounds. Many of these compounds or their metabolites are responsible for the odors, flavors, and pharmacologic effects of these plants. Many *Allium* species' organosulfur compounds appear to be readily absorbed through the gastrointestinal tract and are metabolized to highly reactive oxidants.[2] Cooking or spoilage of *Allium* species does not reduce their potential toxicity.[1]

Mechanism of action

The primary toxicologic mechanism of *Allium* species-derived organosulfur compounds is oxidative hemolysis, which occurs when the concentration of oxidants in the erythrocyte exceeds the capacity of the antioxidant metabolic pathways. Catalase antioxidant activity in erythrocytes in dogs is low,[3] and normal hemoglobin in cats is about two to three times more susceptible to oxidative damage than the hemoglobin in other species.[4]

Oxidation of the exposed beta-93 cysteine residues present in hemoglobin results in the formation of sulfhemoglobin.[5] Sulfhemoglobin is less soluble than hemoglobin, so it precipitates, aggregates, and binds to the cell membrane and forms Heinz bodies. Other types of oxidation of hemoglobin globin chains result in membrane cross-linking reactions and eccentrocyte formation.[6] The formation of Heinz bodies and eccentrocytes increases erythrocyte fragility and extravascular hemolysis. Direct oxidative damage to the erythrocyte cell membrane and its sodium-potassium pump or the oxidative production of hemin also contributes to cell lysis. Oxidation of the heme ion and associated methemoglobinemia results in a left shift of the hemoglobin-oxygen dissociation curve, decreased blood oxygen transportation capacity, and, ultimately, impaired delivery of oxygen to the tissues.

Thus, the result of the oxidative hemolytic process induced by *Allium* species consumption is the onset of anemia, methemoglobinemia, and impaired oxygen transportation. Although marked Heinz body formation may be present within a day after onions are ingested, the anemic nadir typically develops several days later.

Allicin and ajoene, pharmacologically active agents in garlic, are potent cardiac and smooth muscle relaxants, vasodilators, and hypotensive agents.[7-9] Also, ajoene and other organosulfur compounds derived from onions are potent antithrombotic agents.[10] Thus, hypotensive and antithrombotic effects can exacerbate the physiologic effects of anemia and impaired oxygen transportation. Garlic preparations that have not been aged cause direct damage to the gastric and ileal mucosa, resulting in pain and diarrhea.[11]

Exposure and susceptibility

Allium species toxicosis most commonly occurs after oral consumption. In addition to consuming fresh plant material,

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TABLE 1 ***Allium*** **Species Native to North America Most Commonly Involved in Animal Toxicosis**

Scientific Name	Common Name	Appearance*	Distribution*
Allium canadense	Meadow garlic		
Allium cernuum	Nodding onion		
Allium validum	Pacific onion		
Allium vineale	Wild garlic		

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consuming juice, fresh and aged dietary supplements, powdered cooking preparations, dehydrated material, or food preparations derived from or containing *Allium* species can be potentially toxic to dogs and cats.[1] *Allium* species toxicosis typically ensues after consumption of a single large quantity of the material or repeated small amounts. Dogs and cats are highly susceptible to onion toxicosis: Consumption of as little as 5 g/kg of onions in cats or 15 to 30 g/kg in dogs has resulted in clinically important hematologic changes. Onion toxicosis is consistently noted in animals that ingest more than 0.5% of their body weight in onions at one time.

Dogs with heritable high erythrocyte reduced glutathione and potassium concentrations are more susceptible to the hematologic effects of onions.[12] This trait is relatively common in Japanese breeds. Other inborn errors in metabolism or nutritional deficiencies that result in decreased erythrocyte antioxidant defenses, such as glucose-6-phosphate dehydrogenase deficiency or zinc deficiency, could increase an animal's susceptibility to *Allium* species toxicity.[13] Concurrent treatment with xenobiotics, drugs, or dietary factors that induce erythrocyte oxidative injury (*e.g.* propofol, propylene glycol, dl-methionine, sulfonamides, sulfapyridine, large doses of vitamin K_3, benzocaine) or diminish erythrocyte oxidative defenses (*e.g.* acetaminophen) is likely to increase an animal's susceptibility to *Allium* species toxicosis.

In severely affected animals, a blood transfusion and supplemental oxygen therapy may be required.

Clinical signs and laboratory findings

In dogs and cats, clinical signs of *Allium* species toxicosis may appear within one day of consumption if large amounts of material have been ingested; however, it is more common for clinical signs to develop after a lag of several days. Clinical signs often include depression, hemoglobinuria, hemoglobin and possibly hemosiderin urinary casts, icterus, tachypnea, tachycardia, weakness, exercise intolerance, and cold sensitivity. Inappetence, abdominal pain, and diarrhea may also be present. In cases of recent ingestion, the affected dog's or cat's breath may smell of onions or garlic.

Clinical pathology findings are consistent with intravascular and extravascular hemolysis, Heinz body anemia, eccentrocytosis, hemoglobinemia, hemoglobinuria, hyperbilirubinemia, methemoglobinemia, and, if the animal survives long enough, an accompanying regenerative response.[1]

Necropsy and histologic findings typically indicate hemolytic anemia. Because of the common lag of several days between ingestion and the development of clinical signs, gastrointestinal erosion or *Allium* species in the gut content may not be seen. Histopathologic findings, although consistent with hemolytic anemia, are not specific for *Allium* species toxicosis and may include deposition of hemosiderin in the phagocytic cells of the liver, spleen, and renal tubular epithelium; renal tubular pigment necrosis; and nephrotubular casts and hemoglobin casts in the renal tubules.[1]

Differential diagnoses

Differential diagnoses include other common toxicoses: brassicaceous vegetables, propylene glycol, acetaminophen, benzocaine, vitamin K_3, dl-methionine, naphthalene, zinc, and copper. Common feline disorders associated with Heinz body formation include diabetes mellitus, particularly if ketoacidosis is present; hepatic lipidosis; hyperthyroidism; and lymphoma and other neoplasms.

Diagnosis and treatment

Allium species toxicosis is typically diagnosed through a combination of history, clinical signs, and microscopic confirmation of a Heinz body-type hemolytic anemia.

No specific antidote is available for *Allium* species toxicosis. Treatment involves gastrointestinal decontamination and removing the *Allium* species source, treating the anemia, and providing general supportive care. Inducing emesis can be valuable in asymptomatic dogs and cats provided no complicating factors are present and ingestion was within the last one or two hours. Consider administering activated charcoal after emesis. In severely affected animals, a blood transfusion and supplemental oxygen therapy may be required. Administering intravenous crystalloids is indicated if extensive vomiting and diarrhea have occurred or if hemoglobinuria or hypotension is evident.

Carefully monitor the patient's erythron for several days after ingestion since that is when the anemic nadir usually occurs. Antioxidants, such as sodium ascorbate, vitamin E, and N-acetylcysteine, have minimal overt protective effects in onion powder toxicosis in cats.[14] Diets low in potential oxidants are recommended; semimoist foods that contain propylene glycol should be avoided, particularly in cats.[15] ➤

continued

A patient's prognosis depends on the species of plant involved, the severity of the anemia, and the institution of supportive care. In companion animals, avoiding exposure is the best preventive strategy. Feeding pets onions or other *Allium* species or their derivatives should be stopped.

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