Once absorbed from the gastrointestinal (GI) tract, many toxins lack a specific antidote and are associated with severe systemic effects that are difficult to treat. Therefore, prompt decontamination is the first step in managing patients that have ingested toxic materials. If the toxin ingested is known, therapy should be initiated before clinical signs develop. This article discusses the general principles for minimizing GI absorption of ingested toxins and the clinical presentation and management of toxicosis caused by five commonly ingested household substances: anticoagulant rodenticides, ethylene glycol (EG), marijuana, chocolate, and metaldehyde.

**DECONTAMINATION STRATEGIES FOR ORALLY INGESTED TOXINS**

GI decontamination techniques are used to prevent or limit the absorption of ingested toxins. Because many toxins lack a specific antidote, decreasing the amount of toxin absorbed may be lifesaving, and decontamination strategies should begin as soon as possible after ingestion of a toxic substance. Most decontamination methods practiced in veterinary medicine are derived from the human medical literature. Decontamination and treatment strategies for the toxins discussed in this article are summarized in Table 1.

**Emesis Induction**

If the owner suspects toxicosis and calls the clinic before presenting the animal, the veterinarian must consider the risks and benefits of instructing the owner to administer an emetic.1 Productive emesis requires the presence of food or liquid in the stomach, especially for retrieval of small volumes of toxin.2 Removal of the poison from the stomach is most effective within 1 hour of ingestion, is useful up to 2 hours after ingestion, and is of limited benefit more than 4 hours after ingestion.2,3 Early emesis may remove up to 80% of the ingested material.3

Induction of emesis is contraindicated for corrosive and caustic materials, as well as for petroleum distillates and other volatile materials that may result in aspiration pneumonia.2,3 Vomiting should not be induced in patients that are depressed or have decreased consciousness or those that have seizures or are likely to seizure.2,3 Emetics should not be administered if the patient has already vomited.2
Ipecac and Hydrogen Peroxide
Emetics that may be administered by the owner include syrup of ipecac and hydrogen peroxide, although these may not be effective. Syrup of ipecac (Table 2) causes gastric irritation and directly stimulates the chemoreceptor trigger zone, typically resulting in vomiting within 15 to 20 minutes. If vomiting does not occur after dosing, one repeat dose may be given. Ipecac is ineffective in 50% of dogs treated. Ipecac may cause excessive vomiting or central nervous system (CNS) depression. Repeated dosing can result in cardiotoxicity. The fluid extract is 14 times more potent than the syrup formulation and should not be used. Hydrogen peroxide is a safer emetic that can be administered by owners using a syringe turkey baster. A 3% solution must be used because more concentrated formulations can cause severe mucosal irritation. Potentially dangerous emetics that should not be used include table salt, dishwashing detergent, and copper sulfate.

Apomorphine and Xylazine
Emetics for veterinary use include apomorphine hydrochloride for dogs and xylazine hydrochloride for cats. Apomorphine is not consistently effective in cats, and a safe, effective dose has not been recommended for this species. Apomorphine is a centrally acting agent that may be injected, or the oral tablet may be instilled subconjunctivally. After effective emesis, the conjunctiva should be thoroughly rinsed because this medication is irritating. Apomorphine may cause CNS depression, which, if severe, may be antagonized with naloxone (0.04 mg/kg IV) without altering the emetic effects. Xylazine is an α₂-adrenergic agonist that causes emesis in cats but is not reliably effective in dogs. It may cause sedation and respiratory depression, which can be reversed with yohimbine (0.5 mg/kg SC or IM).

Gastric Lavage
For patients in which induction of emesis is ineffective or contraindicated, GI decontamination may be achieved through gastric lavage, although this procedure requires the patient to be unconscious or anesthetized. Gastric lavage is contraindicated for managing ingestion of caustic substances and volatile petroleum distillates and may be ineffective for congealed or chunky material. The patient is positioned with the head lower than the chest. With a cuffed endotracheal tube in place, a stomach tube is passed no further than the level of the xyphoid. Warm water (5 to 10 mL/kg) is administered slowly, and the stomach contents are aspirated after a few minutes. The procedure is repeated 15 to 25 times and with the animal in different recumbent positions until the lavage fluid is clear. The end of the tube should be occluded or the tube kinked before removal. Potential complications include electrolyte disturbances, esophageal perforation, propulsion of the toxin into the small intestine, and aspiration.

Activated Charcoal Administration
Activated charcoal acts by adsorption—binding of the toxicant to an unabsorbable carrier—and results in elimination of toxin in the feces. It provides
Table 1. Quick Reference for Decontamination and Treatment

<table>
<thead>
<tr>
<th>Toxin</th>
<th>Recommended Decontamination Strategies</th>
<th>Recommended Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticoagulant rodenticides</td>
<td>• If asymptomatic and within several hours of exposure, induce emesis</td>
<td>• Antidote: Vitamin K, (phytonadione)</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal</td>
<td>• Dyspnea: Oxygen therapy</td>
</tr>
<tr>
<td></td>
<td>• If symptomatic, detoxification is not useful</td>
<td>• Hemorrhax: Thoracocentesis</td>
</tr>
<tr>
<td></td>
<td>• If symptomatic and continued or repeated ingestions are suspected, administer activated charcoal and a cathartic agent</td>
<td>• Anemia: Fresh whole blood transfusion or a combination of packed red blood cells and fresh-frozen plasma</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal and a cathartic agent</td>
<td>• Active bleeding: Clotting factors supplied as fresh or fresh-frozen plasma</td>
</tr>
<tr>
<td>Chocolate</td>
<td>• If ingestion was recent, induce emesis</td>
<td>• Seizures: Diazepam and sometimes phenobarbital or pentobarbital</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal and a saline cathartic</td>
<td>• Ventricular tachycardia: Lidocaine</td>
</tr>
<tr>
<td></td>
<td>• Repeated administration of activated charcoal q3–8h for up to 72 hours is beneficial because methylnanthines undergo enterohepatic recirculation</td>
<td>• Tachyarrhythmia: Propanol or metoprolol</td>
</tr>
<tr>
<td></td>
<td>• If a massive dosage was ingested, perform gastric lavage</td>
<td>• Fluid therapy</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>• If asymptomatic and within 4 hours of exposure, induce emesis</td>
<td>• Urinary catheter placement to prevent reabsorption of urinary methylnanthines through the bladder wall</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal and a saline cathartic</td>
<td>• Seizures: Diazepam and sometimes phenobarbital or pentobarbital</td>
</tr>
<tr>
<td></td>
<td>• Repeated administration of activated charcoal is beneficial because methylnanthines undergo enterohepatic recirculation</td>
<td>• Ventricular tachycardia: Lidocaine</td>
</tr>
<tr>
<td>Marijuana</td>
<td>• If asymptomatic and ingestion was recent, induce emesis</td>
<td>• Tachyarrhythmia: Propanol or metoprolol</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal and a saline cathartic</td>
<td>• Fluid therapy</td>
</tr>
<tr>
<td></td>
<td>• Repeated administration of activated charcoal is beneficial because marijuana undergoes enterohepatic recirculation</td>
<td>• Respiratory depression: Oxygen therapy</td>
</tr>
<tr>
<td>Metaldehyde</td>
<td>• If patient is alert without excessive muscle tremors or seizures, induce emesis</td>
<td>• Agitation: Diazepam</td>
</tr>
<tr>
<td></td>
<td>• Administer activated charcoal and a cathartic</td>
<td>• Seizures: Diazepam and sometimes phenobarbital or pentobarbital</td>
</tr>
<tr>
<td></td>
<td>• Perform gastric lavage if emesis is contraindicated</td>
<td>• Muscle tremors and seizures: Methocarbamol</td>
</tr>
<tr>
<td></td>
<td>• Seizures refractory to other therapies: Propofol</td>
<td>• Seizures refractory to other therapies: Propofol</td>
</tr>
<tr>
<td></td>
<td>• Supportive therapy: Fluid therapy</td>
<td>• Supportive therapy: Fluid therapy</td>
</tr>
<tr>
<td></td>
<td>• Tachypnea or dyspnea: Oxygen therapy</td>
<td>• Tachyarrhythmia: Propanol or metoprolol</td>
</tr>
<tr>
<td></td>
<td>• Metabolic acidosis: Sodium bicarbonate</td>
<td>• Metabolic acidosis: Sodium bicarbonate</td>
</tr>
</tbody>
</table>

The most benefit when given within 2 hours of toxin ingestion but may still be useful up to 24 hours after ingestion, especially for toxins undergoing enterohepatic recirculation. It may be administered after emesis or gastric lavage or when these procedures are contraindicated. Activated charcoal is generally accepted as the adsorbent of choice, although it is relatively ineffective against ethanol, methanol, isopropyl alcohol, acetone, petroleum distillates, pine oil, ammonia, and cyanide. It is available in granular and suspension formulations. Activated charcoal should not be given to patients at risk for aspiration pneumonia or those with suspected GI perforation. When the granular formulation is used, a dose of 1 to 4 g/kg is mixed in 50 to 200 mL of water.
to make a slurry. The suspension dose is 6 to 12 mL/kg. Patients without clinical signs may be persuaded to ingest the charcoal. Symptomatic patients may require sedation, endotracheal intubation, and administration of the charcoal through a stomach tube. Oral administration of charcoal via a syringe should be avoided because it may result in aspiration. Oral medications that are administered concurrently with activated charcoal have reduced efficacy. Burnt toast is inert and is not a substitute for activated charcoal.

Charcoal is often combined with a cathartic such as magnesium or sodium sulfate (250 mg/kg PO) or 70% sorbitol (3 mL/kg PO) to help promote movement of the toxicant through the GI tract and to prevent constipation that may result from the charcoal. Cathartics are contraindicated if the toxin itself is a cathartic, if severe diarrhea and dehydration are present, and in cases of ileus. Cathartics should not be dosed repeatedly because this increases the risk for fluid and electrolyte imbalances. Mineral oil should not be used as a cathartic with activated charcoal because it impairs adsorption by the charcoal.

**ANTICOAGULANT RODENTICIDES**

Commercial anticoagulant rodenticides that are warfarin based (4-hydroxycoumarin) or contain indandione are used extensively by exterminators and homeowners. Toxicosis is generally through ingestion of baits and is rarely from consuming poisoned rodents. Warfarin is well absorbed, with peak plasma levels occurring within 12 hours of ingestion. These toxins interfere with normal hemostasis by competitively inhibiting vitamin K epoxide reductase, an enzyme that is necessary to convert vitamin K epoxide to its reduced form. The final step in carboxylation and formation of coagulation factors II, VII, IX, and X depends on reduced vitamin K.

**Clinical Signs**

Abnormal clotting is delayed until the existing clotting factors decay, usually in 24 to 36 hours. Clinical signs typically manifest 2 to 5 days after ingestion and result from internal and external hemorrhage. Non-specific signs include lethargy, depression, and anorexia. The physical examination may reveal pale mucous membranes, weakness, and poor pulse quality. Depending on the site of hemorrhage, epistaxis, hematemesis, hematochezia or melena, hematoma formation, and dyspnea or hemoptysis may be present. Bleeding from venipuncture sites may be prolonged.

Sudden internal hemorrhage may lead to shock or sudden death.

**Laboratory Findings**

Laboratory results that support the diagnosis include prolongations of prothrombin time (PT) and activated partial thromboplastin time (APTT). In animals that present shortly after ingestion, the PT may be prolonged while the APTT remains normal due to the short half-life of coagulation factor VII. In dogs, an activated clotting time longer than 125 seconds supports a diagnosis of intrinsic pathway coagulopathy, which develops in the later stages of anticoagulant rodenticide toxicity. The Thrombotest (Axis-Shield PoC, Oslo, Norway), also known as the *PIVKA test*, is a modified test of extrinsic and common pathway function and is a sensitive test for reduction in factors II, VII, and X. It can be conducted using citrated venous blood or plasma. If the PT is prolonged, a Thrombotest adds no additional information. Serum concentration of many anticoagulant rodenticides can be measured in cases that require further confirmation. Serum levels peak within hours of exposure, and treatment does not interfere with the analysis.

### Table 2. Products Commonly Used to Induce Emesis

<table>
<thead>
<tr>
<th>Product</th>
<th>Dosage</th>
</tr>
</thead>
</table>
| Ipecac syrup<sup>a</sup> | Dogs: 1–2 mL/kg  
                        | Cats: 3 mL/kg  
                        | Dose may be repeated once |
| 3% Hydrogen peroxide<sup>b</sup> | 2 to 5 mL/kg  
                   | Dogs: Do not exceed total dose of 50 mL  
                   | Cats: Do not exceed total dose of 10 mL |
| Apomorphine<sup>c</sup> | Dogs: 0.04 mg/kg IV or IM  
                        | 0.08 mg/kg SC  
                        | 0.025-mg tablet, crushed and dissolved subconjunctivally |
| Xylazine<sup>d</sup> | Cats: 1.1 mg/kg IM |


Decontamination and Treatment

If the patient presents without clinical signs and within several hours of exposure, emesis should be induced unless the patient is recumbent or depressed. Activated charcoal is given orally to reduce systemic absorption of the rodenticide.

Vitamin K₁ (phytonadione) is the antidote. An initial dose of 2.5 mg/kg can be administered SC at multiple sites, using a 25-gauge needle to avoid hemorrhage. Subsequent doses of 2.5 mg/kg/day PO are given in divided doses (bid or tid) for 7 to 30 days, depending on the half-life of the active ingredient in the rodenticide. Ingestion of first-generation products such as warfarin, fumarin, pindone, or valone should be treated daily for 4 to 6 days. Ingestion of long-acting products such as bromadiolone or brodifacoum should be treated for 2 to 3 weeks, and ingestion of diphacinone or chlorphacinone should be treated for 3 to 4 weeks. If the specific compound ingested is not known, treatment should continue for at least 3 to 4 weeks. Intravenous administration of vitamin K must be avoided because of the risk of causing a severe anaphylactic reaction. Oral absorption of vitamin K₁ can be enhanced by concurrently administering a fatty meal. PT or a Thrombotest should be reevaluated 48 hours after completion of therapy to ensure adequate duration of treatment; if the results are still abnormal, treatment should be continued for another 2 weeks. Vitamin K₁ is contraindicated because it is not effective and can cause hemolytic anemia.

In symptomatic patients, detoxification is not useful because of the delay between ingestion and the onset of clinical signs. Induction of emesis and gastric lavage are contraindicated because of the potential to induce hemorrhage and a lack of efficacy due to the time delay. If continued or repeated ingestions are suspected, activated charcoal and a cathartic agent may be administered. Oxygen therapy may be beneficial for dyspneic patients. Thoracocentesis may be lifesaving if hemothorax is present. For anemic patients, fresh whole blood or a combination of packed red cells and fresh-frozen plasma can be given to correct the hematocrit and hypovolemia and to provide active clotting factors. The general rule of transfusion medicine for anemic patients is a blood dosage of 1 mL/kg of packed red blood cells to increase the packed cell volume (PCV) by 1% or 2 mL/kg of whole blood to increase the PCV by 1%; the goal is a PCV of 20% to 30%. The rate of administration varies depending on the cardiovascular stability of the patient. In patients that are normovolemic, it may be as low as 3 to 6 mL/kg/hr; in hypovolemic patients, 10 to 20 mL/kg/hr may be used, or the first 25% of the volume may be administered rapidly, with the remainder infused more slowly if deemed necessary.

If the patient is actively bleeding but is not anemic, clotting factors should be supplied in the form of fresh or fresh-frozen plasma at a rate of 9 to 20 mL/kg, adjusting to effect to control hemorrhage and to normalize PT. Handling and trauma, including venipuncture, should be minimized. Vitamin K₁ should also be administered as outlined above. If activated charcoal has not been administerd, oral vitamin K₁ is effective and avoids injection. However, vitamin K₁ should not be used as a sole therapy in patients with bleeding because synthesis of new clotting factors takes 6 to 12 hours after administration.

Prognosis

With treatment, the prognosis is excellent for animals without signs of abnormal hemostasis. The prognosis is fair to guarded in patients manifesting coagulopathy.

ETHYLENE GLYCOL

EG comprises 95% of radiator antifreeze and is also found in industrial solvents, rust removers, and color film processing fluids. The widespread availability of these products, as well as their accessibility during storage and after disposal, makes this a common toxin in small animals. In cats, a dose of 2 to 4 mL/kg causes clinical signs and death; in dogs, the lethal dose is 4 to 5 mL/kg. EG is rapidly absorbed from the GI tract, and blood levels peak within 1 to 4 hours of exposure.

Clinical Signs

The diagnosis begins with a history of exposure and recognition of compatible clinical signs. There are three typical stages, although disease progression is not always predictable or straightforward.

Stage 1 occurs within 30 minutes to 12 hours after ingestion and is characterized by signs of depression, incoordination, ataxia, and polyneea. In dogs, polydipsia,
diuresis, and dehydration also develop. Cats may become nonresponsive and die within 9 hours of ingestion. Stage 1 signs develop as the intact glycol crosses the blood–brain barrier. Vomiting is common and may be due to a direct effect of the EG on the gastric mucosa. After the initial CNS depression, animals may appear to improve clinically but then rapidly deteriorate.

Stage 2 occurs 12 to 24 hours after ingestion, is characterized by cardiac and pulmonary signs (e.g., tachypnea, tachycardia), and may be attributable to severe metabolic acidosis.

Stage 3 signs develop 24 to 72 hours after ingestion and are indicative of acute, oliguric renal failure. In cats, stage 3 may develop as early as 12 hours after ingestion. Signs of uremia include anorexia, vomiting, ptyalism, and oral ulceration. Animals may initially present with stage 3 signs because the earlier stages were not identified. Oxalate combines with calcium in the blood to form complexes that precipitate in the blood vessels and renal tubules, with the development of azotemia 1 to 3 days postingestion. The prognosis is very poor for animals with stage 3 disease.

Laboratory Findings
Hematologic abnormalities are nonspecific. Biochemical abnormalities include an increase in measured serum osmolality that is detectable 1 hour after ingestion and a normochloremic metabolic acidosis with an elevated anion gap that is present within 3 hours after ingestion. The anion gap is calculated by subtracting the sum of the serum chloride and bicarbonate levels from the sum of the serum sodium and potassium levels. Normally, this difference is about 15 to 25 mEq/L. With EG toxicity, increases in lactic acid, glycolate, glyoxalate, and oxalate often result in anion gap measurements of 40 to 50 mEq/L.

Changes in serum chemistry profiles reflect acute renal failure and include azotemia, hyperphosphatemia, and hyperkalemia. Hypocalcemia is present in 50% of cases and is thought to be due to chelation of calcium by oxalate. Hyperglycemia is commonly noted. On urinalysis, isosthenuria is present, sometimes with glucose, protein, erythrocytes, leukocytes, renal epithelial cells, and casts due to tubular damage. Calcium oxalate crystals form within 3 to 6 hours of toxin ingestion. Monohydrate calcium oxalate crystals may appear as dumbbells or coffin shapes (Figure 1); dihydrate crystals have a classic envelope shape. Colorimetric tests are available for in-house detection of EG in canine patients within the first 24 hours of exposure. Positive test results are possible after 24 hours, depending on the dose of EG. The test is not sensitive enough for use in cats. False-positive results can occur after administration of propylene glycol, which is contained in diazepam and activated charcoal. Glycerol and met-aldehyde will also produce false-positive results.

The Kacey Ethylene Glycol Test (KACEY Inc., Asheville, NC) is intended to provide quantitative...
measurement of EG in plasma. The test detects EG levels in plasma as low as 20 mg/dL with high sensitivity, although false-positive results are possible if alcohols (e.g., ethanol) are present. Laboratory tests for serum levels of glycolic acid are available, and detection of glycolic acid is possible 3 to 60 hours after exposure in dogs and for at least 72 hours in cats.\textsuperscript{16}

Fluorescence of a number of antifreeze solutions containing fluorescent dye compounds may be detected within the oral cavity, vomitus, or urine by using a Wood’s lamp or a black light. Negative fluorescence is meaningless; however, positive fluorescence supports a diagnosis of EG.

**Decontamination and Treatment**

Early diagnosis and treatment are critical for a successful outcome. Emetics should be administered if no signs are observed and the exposure occurred less than 4 hours previously. Activated charcoal and a saline cathartic may be given, although EG is not significantly adsorbed by charcoal.\textsuperscript{13,16}

In dogs, the treatment of choice is intravenous fomepizole (4-methylpyrazole [4-MP]), which is a competitive inhibitor of alcohol dehydrogenase, the enzyme responsible for the metabolism of EG and the generation of toxic acid metabolites. Unmetabolized EG is excreted in the urine.\textsuperscript{13} Fomepizole, which causes minimal depression, is given as a slow IV infusion over 15 to 30 minutes at an initial dosage of 20 mg/kg, followed by 15 mg/kg at 12 hours and 24 hours, and then 5 mg/kg at 36 hours. Fomepizole may not be effective in cats at the dosage schedules used in dogs. However, clinical trials suggest that larger dosages (125 mg/kg initially, followed by 31.5 mg/kg at 12, 24, and 36 hours\textsuperscript{17}) may be effective in cats.

Ethanol (7% to 20% solution) also acts as a competitive inhibitor of alcohol dehydrogenase and is used in cats or when 4-MP is not available.\textsuperscript{14,16} A 7% ethanol solution is recommended by the ASPCA Animal Poison Control Center. The ethanol dosage for dogs is 5.5 mL/kg IV q4h for 5 doses and then q6h for 4 doses, or the same total dose can be given as a continuous rate infusion (CRI).\textsuperscript{16} The dosage for cats is 5 mL/kg IV q6h for 5 doses and then q8h for 4 doses, or the same total dose can be given as a CRI.\textsuperscript{16} The recommendation is to adjust the dose so that the patient does not become more depressed.\textsuperscript{13}

If more than 18 hours have passed since ingestion, administration of ethanol or 4-MP may not be beneficial because most of the EG is already metabolized. However, if there is a positive test for EG and if the patient was exposed to a large dose of EG, ethanol or 4-MP can still be effective to prevent further damage, especially if renal replacement therapies are available to help support renal function, allowing the kidneys to heal from damage already done. Ethanol exacerbates depression and dehydration in patients with renal failure.\textsuperscript{13}

**Supportive Therapy**

Aggressive supportive therapy should be instituted concurrently. Fluid therapy should be administered to correct dehydration and prevent hypoperfusion secondary to EG-induced diuresis and other ongoing losses, such as vomiting.\textsuperscript{16} Maintaining diuresis promotes renal excretion of EG.\textsuperscript{16} Urine output should be monitored, and in patients with oliguric renal failure, central venous pressure monitoring may be necessary to avoid pulmonary edema. In addition to diuresis, treatment with furosemide, mannitol, or dopamine may be necessary to correct anuria.\textsuperscript{16}

Sodium bicarbonate is administered to correct metabolic acidosis. The dose, which is controversial, is determined based on the following formula\textsuperscript{16}:

\[
\text{Amount of } \text{HCO}_3^- \text{ needed (mEq) } = 0.3 \times \text{ weight (kg)} \times \text{ base deficit/L}
\]

Hypocalcemia may result in seizures or tetany, requiring treatment with 10% calcium gluconate (0.5 to 1.5 mL/kg IV to effect with electrocardiographic monitoring).\textsuperscript{16} Calcium gluconate is not recommended for the treatment of asymptomatic hypocalcemia because it may increase the precipitation of calcium oxalate in tissues.\textsuperscript{16} Peritoneal dialysis or hemodialysis may be indicated for severe cases with renal failure, and both can be used in the initial stage to help remove the toxin.\textsuperscript{14}

**Prognosis**

For most dogs that present within 8 hours after ingestion and are treated with 4-MP, the prognosis is fair to
The prognosis for cats is good if ethanol therapy—the therapy of choice—is initiated within 3 hours of ingestion. Hemodialysis can improve prognosis, especially if instituted before azotemia develops. However, for patients that present with oliguric renal failure, the prognosis is grave.

MARIJUANA
Marijuana is produced by drying the leaves and flowers of the hemp plant, *Cannabis sativa*. Hashish is the resin extracted from the plant. Hemp is not considered poisonous if consumed fresh, but drying, smoking, aging, or heating causes the plant to become poisonous. The main toxic principle is 9-tetrahydrocannabinol (THC).

Pets often develop intoxication after ingesting marijuana leaves or baked products containing *C. sativa*. Because the possession of marijuana is illegal in the United States and Canada, the history of exposure may be incomplete or misleading, making diagnosis difficult and possibly contributing to underdiagnosis of this intoxication. Direct, nonthreatening questioning is the best means to try to obtain an accurate history.

Clinical Signs and Laboratory Findings
THC is rapidly absorbed after ingestion and interacts with many neurotransmitters and neuromodulators. Clinical signs begin 30 to 90 minutes after ingestion. Neurologic signs are the most common manifestation and include depression, ataxia, tremors, seizures, mydriasis, disorientation, behavior disorders, hyperesthesia, head bobbing, recumbency, and stupor. Other signs observed in dogs and cats exposed to marijuana include tachycardia, hypotension, bradycardia, hypersalivation, weakness, hypothermia, and urinary incontinence. Less than one-third of dogs develop GI signs, mainly vomiting. Dogs may exhibit unprovoked barking and agitation, which may be manifestations of hallucinations. The severity of clinical signs increases with the amount consumed. Death from acute intoxication is very rare, as the lethal dose in dogs and cats is more than 3 g/kg.

Some laboratories can detect THC in plasma or urine following recent exposure. Over-the-counter drug test kits are available at most pharmacies, but the accuracy of these kits when using dog urine has not been established.

Decontamination and Treatment
If ingestion is recent and the patient has no clinical signs, emesis may be attempted. Activated charcoal and a saline cathartic solution should also be administered. Marijuana undergoes enterohepatic recirculation, so repeating the administration of activated charcoal q8h for the first 24 hours may be beneficial. Respiratory function, cardiac function, and body temperature should be monitored. Most veterinary patients recover with detoxification and supportive care. Oxygen therapy is indicated if respiratory depression occurs, and intravenous fluid therapy may promote elimination of the toxin. Diazepam (0.25 to 0.5 mg/kg IV) may be used to control agitation. Recovery may take up to 3 days, but the prognosis is favorable if no secondary complications are present.

CHOCOLATE
Chocolate toxicity is caused by methylxanthines, particularly theobromine and caffeine. The methylxanthine concentration is determined by the type of chocolate. In general, the darker the chocolate, the greater the theobromine content. According to the ASPCA Animal Poison Control Center, ingestion of 20 mg/kg of theobromine and caffeine can produce mild clinical signs of toxicity in dogs, a dose of 40 to 50 mg/kg can cause severe signs, and 60 mg/kg can cause seizures. The LD₅₀ of theobromine and caffeine is 100 to 200 mg/kg, making the potentially lethal dose of milk chocolate less than 2 oz/kg. Baking chocolate contains about 10 times the amount of theobromine in milk chocolate or other sweetened chocolates; therefore, ingestion of less than 0.2 oz/kg baking chocolate is potentially lethal in dogs. White chocolate contains negligible amounts of theobromine.

Clinical Signs and Laboratory Findings
Methylxanthines are readily absorbed orally. They inhibit cellular phosphodiesterase, causing an increase in cyclic AMP as well as the release of catecholamines. The result is stimulation of the CNS and cardiac muscle, causing hyperactivity, restlessness, incoordination, seizures, tachycardia, and arrhythmias. Methylxanthines induce smooth muscle relaxation and promote diuresis, vomiting, and diarrhea. A diagnosis is established by the history of exposure and clinical signs. Frozen stomach contents, urine, or frozen plasma may be submitted to a toxicology laboratory for analysis.

Decontamination and Treatment
If ingestion is recent, administering an emetic followed by activated charcoal and a saline cathartic is recommended.
It may be beneficial to administer activated charcoal every 3 to 8 hours for up to 72 hours.\textsuperscript{18,24} If a massive dose has been ingested, gastric lavage may be indicated.\textsuperscript{25} Diazepam and sometimes phenobarbital or pentobarbital may be needed to control seizures.\textsuperscript{25} Electrocardiography should be monitored to detect arrhythmias, and arrhythmias should be treated if needed. In dogs, lidocaine (2 to 4 mg/kg IV bolus, followed by an infusion of 2% solution at a rate of 40 to 75 µg/kg/min if conversion is successful) can be used to treat ventricular tachycardia.\textsuperscript{24,26} Lidocaine should be used with caution in cats, which are sensitive to its adverse effects.\textsuperscript{26} Propranolol (0.02 to 0.06 mg/kg IV) is effective at controlling tachyarrhythmia but may slow renal excretion of methylxanthines.\textsuperscript{18,24,27} Metoprolol (0.04 to 0.06 mg/kg IV q8h) is as effective as propranolol and does not slow methylxanthine excretion.\textsuperscript{18,24} Patients should be monitored for hypotension after administration of β-blockers.\textsuperscript{18}

Intravenous fluid therapy promotes excretion of methylxanthines. A urinary catheter should be placed to prevent reabsorption of urinary methylxanthines through the bladder wall. Administration of corticosteroids and erythromycin should be avoided because these medications interfere with the excretion of methylxanthines.\textsuperscript{24} Therapy should be continued for 2 to 3 days. With supportive care, the prognosis is good to excellent.\textsuperscript{25}

**METALDEHYDE**

Metaldehyde is a polymer of acetaldehyde contained in liquid and granular molluscicide slug and snail baits. The LD\textsubscript{50} is 100 mg/kg in dogs, but severe effects can be seen at much lower doses.\textsuperscript{28} In the stomach, metaldehyde undergoes acid hydrolysis with conversion to acetaldehyde. Acetaldehyde and metaldehyde are rapidly absorbed, and metaldehyde readily crosses the blood–brain barrier.

**Clinical Signs**

Clinical signs develop within 30 minutes to 3 hours of ingestion.\textsuperscript{28} The exact mechanism of metaldehyde toxicity is incompletely understood but is thought to result from decreases in the concentrations of serotonin, γ-aminobutyric acid (GABA), and norepinephrine.\textsuperscript{28} Loss of GABA allows excitatory signals to predominate in the CNS, which results in seizure activity.\textsuperscript{28} Clinical signs of dogs and cats are similar, although feline toxicoses are less frequently reported. Early signs include anxiety and restlessness.\textsuperscript{29} Salivation, panting, mydriasis, tremors, ataxia, and incoordination subsequently develop.\textsuperscript{28} Muscle tremors are noted in 65% of dogs.\textsuperscript{28} Other signs include tachypnea, tachycardia, hyperthermia, vomiting, opisthotonus, convulsions, seizures, nystagmus, and cyanosis.\textsuperscript{28,29} Death can occur within 4 to 24 hours after exposure and usually results from respiratory failure. Delayed hepatic failure and blindness have been reported.\textsuperscript{28}

**Laboratory Findings**

Acidosis resulting from acetaldehyde production is a common laboratory finding. The definitive diagnosis may be made by submitting frozen stomach contents to a toxicology laboratory for measurement of acetaldehyde. Metaldehyde can also be detected in liver, urine, and plasma samples.\textsuperscript{28}

**Decontamination and Treatment**

If the patient presents acutely, is alert, and does not have excessive muscle tremors or seizures, an emetic should be given, followed by activated charcoal and a cathartic. Gastric lavage may be required if emesis is contraindicated.\textsuperscript{28,30} Seizure activity may be controlled with diazepam (2 to 5 mg/kg IV to effect or as a CRI at 0.1 to 0.5 mg/kg/hr).\textsuperscript{28} Methocarbamol may be used to manage muscle tremors and seizures. A dose of 55 to 220 mg/kg is recommended; half the dose is given quickly at a rate less than 2 mL/min, followed by the remaining amount to effect.\textsuperscript{28} Methocarbamol administration may be repeated, but a total dose of 330 mg/kg should not be exceeded within a 24-hour period.\textsuperscript{28} Barbiturates may compete with an enzyme that degrades acetaldehyde and should be avoided if possible.\textsuperscript{28,31} For seizures that are refractory to other therapies, propofol may be given as a bolus (5.0 to 6.9 mg/kg IV) or as a CRI (0.1 to 0.6 mg/kg/min).\textsuperscript{32,33}
Intravenous fluid therapy should be administered to aid in controlling dehydration and electrolyte imbalances. Oxygen therapy should be administered if the patient is tachypneic or dyspneic. Sodium bicarbonate may be required to correct metabolic acidosis, but it should be used with caution in patients with impaired ventilation. Hyperthermia generally resolves when the excessive muscle activity subsides, and cooling should be avoided. Therapy should be continued until the clinical signs resolve. In nonresponsive cases, euthanasia may be necessary. The prognosis depends on the amount of metaldehyde ingested and is guarded to poor in cases with severe signs. To detect delayed hepatotoxicity, liver values should be monitored in animals that recover.

**CONCLUSION**

GI absorption of ingested toxins should be minimized to decrease signs of toxicity and improve prognosis. Veterinarians must respond quickly to inhibit the absorption of toxins. Specific antidote administration and supportive care should then be instituted based on the toxin ingested.

**REFERENCES**


**ARTICLE #1 CE TEST**

The Auburn University College of Veterinary Medicine approves this article for 3 contact hours of continuing education credit. Subscribers may take individual CE tests or sign up for our annual CE program. Those who wish to apply this credit to fulfill state relicensure requirements should consult their respective state authorities regarding the applicability of this program. CE subscribers can take CE tests online and get real-time scores at CompendiumVet.com.

I. Induction of emesis is recommended for non-caustic toxins if the toxin was ingested in the past ______ hour(s).
   a. 1      b. 8      c. 12      d. 24   e. 48
2. The agent of choice to induce emesis in a feline patient in a veterinary hospital is
   a. apomorphine.
   b. xylazine.
   c. syrup of ipecac.
   d. yohimbine.
   e. naloxone.

3. Which of the following laboratory tests would have an abnormal result in a dog with early anticoagulant rodenticide toxicity?
   a. activated clotting time
   b. partial thromboplastin time
   c. prothrombin time
   d. thrombin time
   e. buccal mucosal bleeding time

4. Ethanol acts in the treatment of ethylene glycol toxicity by
   a. competitively inhibiting the uptake of ethylene glycol across the blood–brain barrier.
   b. promoting renal perfusion and increasing the glomerular filtration rate.
   c. competitively inhibiting the metabolism of ethylene glycol by the enzyme alcohol dehydrogenase.
   d. enhancing the degradation of ethylene glycol by activating the enzyme aldehyde dehydrogenase.
   e. all of the above

5. Which of the following signs are suggestive of marijuana toxicity?
   a. bradycardia, miosis, urinary incontinence
   b. bradycardia, mydriasis, urinary retention
   c. bradycardia, mydriasis, urinary incontinence
   d. tachycardia, miosis, urinary incontinence
   e. tachycardia, miosis, urinary retention

6. Repeated administration of activated charcoal can be beneficial in the management of which of the following toxicities?
   a. chocolate
   b. marijuana
   c. ethylene glycol
   d. a and b
   e. a and c

7. Metaldehyde is a
   a. first-generation anticoagulant rodenticide.
   b. competitive inhibitor of alcohol dehydrogenase.
   c. THC compound.
   d. theobromine.
   e. polymer of acetaldehyde.

8. The treatment of chocolate toxicosis involves
   a. administration of activated charcoal and a cathartic if clinical signs are not evident.
   b. administration of diazepam to control seizure activity.
   c. administration of β-blockers to control heart rate.
   d. placement of a urinary catheter.
   e. all of the above

9. In which of the following cases would emesis be indicated?
   a. a dog that presents with melena after ingesting warfarin
   b. a dog that presents 30 minutes after having a seizure caused by ingesting metaldehyde
   c. a dog that is asymptomatic after ingesting baking chocolate
   d. a dog that is azotemic and isosthenuric after ingesting ethylene glycol
   e. a dog that is stuporous after ingesting marijuana

10. Laboratory abnormalities associated with ethylene glycol toxicity do not include
    a. hyperglycemia.
    b. hypokalemia.
    c. increased anion gap.
    d. increased serum osmolality.
    e. isosthenuria.