Chapter 1

Decontamination and Detoxification of the Poisoned Patient

DEFINITION/OVERVIEW

- Decontamination and detoxification are essential processes in the management of an animal which has been poisoned. Poisoning can result from exposure to a variety of harmful substances, including chemicals, medications, and environmental toxicants.
- Decontamination and detoxification aim to remove or neutralize the toxic substance from the animal's body to prevent further harm and promote recovery.
- Decontamination involves the physical removal of the toxicant from the patient's body, while detoxification refers to the use of medications or other substances to neutralize the toxic effects of the poison. Decontamination may need to occur for the eyes, skin, or the gastrointestinal tract.
- Detoxification may involve the administration of antidotes or supportive therapies to manage the patient's symptoms and prevent further harm.
- The effectiveness of decontamination and detoxification depends on several factors, including the type of toxicant, the route of exposure, and the time elapsed since the poisoning occurred. Rapid and appropriate intervention is essential to minimize the potential for serious or life-threatening complications.

OCULAR DECONTAMINATION

- The goal of ocular decontamination is to reduce tissue damage by removing the offending product from the eye.
- This is accomplished by flushing the eye at home or in the veterinary clinic with sterile saline (e.g., contact lens solution) or warm water for 15–20 minutes. There may need to be a rest period for compliance of the animal to accomplish the total lavage time.
- High-pressure sprays should be avoided (e.g., detachable kitchen sink heads).
- Prevention of further iatrogenic trauma to the eye can be accomplished by placing an Elizabethan collar.
- If decontamination is carried out by the pet owner, the animal should be brought to a veterinarian and evaluated for corneal ulceration.

DERMAL DECONTAMINATION

- The goal of dermal decontamination is to prevent oral ingestion and transdermal absorption of a poison.
- Proper personal protective equipment should be used by pet owners and veterinary staff to prevent their exposure. This may include gloves, face shield or eye protection, facemask, apron, etc.

Blackwell's Five-Minute Veterinary Consult Clinical Companion: Small Animal Toxicology, Third Edition.
Edited by Lynn R. Hovda, Ahna G. Brutlag, Robert H. Poppenga, and Steven E. Epstein.

- When an oil-based toxicant is on the animal, they should be bathed with warm water and a liquid dish degreasing soap. The patient should be bathed and rinsed multiple times as soon after exposure as possible. Avoid pet or human shampoos, as they are typically insufficient to remove the majority of an oil-based product.
- When a dry substance is present, the animal may be vacuumed or brushed to remove prior to bathing.
- If an irritating or corrosive substance is on the skin, careful, gentle decontamination must occur. The skin should be thoroughly flushed with copious amounts of warm water for 15–20 minutes, making sure not to traumatize the area with abrasive scrubbing or high-pressure water sprays.

EMESIS

- Emesis is generally most effective if performed within 1–2 hours of ingestion.
- Exceptions to this are:
    - Acetaminophen and ethylene glycol, which are very rapidly and completely absorbed.
    - Many liquid medications are rapidly absorbed.
    - Situations where emesis may be effective after 1-2 hours.
        - Large blocks of toxicants (e.g., rodenticides), or ingestion of substances that can form concretions (e.g., xylitol-containing gum, fish oil capsules, etc.).
        - Chocolate as it increases pyloric sphincter tone.
        - Fruits (e.g., grapes or raisins) or eaten right after a meal.
        - Toxicants that delay gastric emptying (e.g., opioids, some antidepressants, some blood pressure medications, etc.).
- In a barium sulfate ingestion model in dogs, it has been reported that recovery rates of gastric contents following induction of emesis with apomorphine were 54-87%, while a mean estimated recovery was only 52% in a clinical study.
- Induction of emesis typically yields higher recovery rates than gastric lavage.
- Prior to induction of emesis, a history of what was ingested and screening for contraindications for emesis should be performed.
- Contraindications for emesis include:
    - Inability to protect their airway.
        - Altered mentation or unconsciousness patients.
        - Animals with laryngeal paralysis.
        - Megaesophagus/pharyngeal weakness.
    - Ingestion of caustic or corrosive substances (e.g., acids, alkalis, etc.).
    - Ingestion of petroleum products (e.g., gasoline, motor oil, etc.) can result in aspiration of the material into the lungs, which can lead to respiratory distress.
    - Ingestion of toxicants associated with sharp or pointed objects.
    - Actively seizuring, or a history of seizures (relative contraindication).

At-home Emesis

- Currently there are no over-the-counter emetic agents recommended for at-home use. Medications that have been used include 3% hydrogen peroxide, table salt, dish soap, 7% syrup of ipecac. Of these, the most acceptable is 3% hydrogen peroxide.
    - Induction of emesis with 3% hydrogen peroxide in dogs has been noted to induce gross esophageal and gastric lesions at appropriate doses, and a severe necroulcerative gastritis in a cat, necessitating euthanasia.
    - It should be noted that many animals have induction of emesis with 3% hydrogen peroxide with no clinical signs.

- Table salt should be avoided due to the risks of hypernatremia, persistent emesis, and hematemesis.
- Dish soap (e.g., Dawn®, Joy®) may be more benign and less efficacious than other methods of at-home emesis. It is dosed at 10 mL/kg of a mixture of three tablespoons of dish soap to 8 ounces of water. *Dish washer soap must be avoided* due to its caustic nature.
- 7% syrup of ipecac *is not recommended* in veterinary or human medicine. Potential complications from syrup of ipecac administration include:
  - Lack of effectiveness in approximately 50% of small animals.
  - Protracted emesis, severe hematemesis, lethargy, diarrhea, depression.
  - Potential cardiotoxic arrhythmogenic action.

- The decision on whether to induce emesis at home or wait until a patient can reach a veterinary office is multifactorial. Considerations include the time it takes to reach veterinary care, onset of action of potential toxicant, ability to administer 3% hydrogen peroxide (e.g., owner comfort in administering, availability in home, etc.) and if contraindications are present.
- For animals that have needed induction of emesis multiple times, ropinirole (Clevor®) can be prescribed for at-home use.

Emetic Agents

- 3% hydrogen peroxide.
  - Hydrogen peroxide is thought to act as an emetic by direct gastric irritation. Higher concentrations *should not* be used.
  - In cats, the use of hydrogen peroxide as an emetic *is not* recommended. It is not as effective in cats compared to dogs.
  - Dose: 1–2 mL/kg PO, maximum of two doses (1 tablespoon = 15 mL).
  - Emesis usually occurs within 10 minutes.
  - Care is needed to avoid aspiration during administration. Typically, it is administered with a turkey baster, syringe, or spoon.
- Apomorphine.
  - Apomorphine acts directly on the CTZ and works in dogs but not cats.
  - Dose: dogs 0.02–0.04 mg/kg IV or IM, or direct application of the tablet form onto the subconjunctival sac or gingival mucosa. If subconjunctival or gingival apomorphine is used, thorough flushing must be performed after the patient vomits.
  - Emesis typically occurs within 4–6 minutes.
  - If emesis does not occur, a second dose can be tried if given IV or IM. If emesis does not occur after a second dose, alternative medications should be used, or consider gastric lavage.
  - If a patient exhibits excessive CNS sedation or respiratory depression after apomorphine administration, naloxone can be used as a reversal (dose 0.01–0.04 mg/kg, IV, IM, SQ). However, naloxone will not reverse the emetic effect of apomorphine due to different receptor effects.
- Ropinirole.
  - Ropinirole is a dopamine agonist selectively affecting the D2 receptor and available as a topical eye drop (Clevor®) and can be used to induce emesis in dogs but not cats.
  - Dose administration in dogs is split between both eyes, 1–8 drops depending on body size.
  - Emesis usually occurs within 10–15 minutes and is effective on the first dose in 85–87% of dogs.
  - If emesis is not induced, a second dose can be used, or apomorphine tried if available.

  - No statistically significant difference has been found between it and IV/IM apomorphine, but studies have been underpowered to detect this.
- Alpha-2-adrenergic agonists.
  - Xylazine and dexmedetomidine have been used to induce emesis in cats.
  - Xylazine dose in cats is 0.22–0.44 mg/kg IM.
  - Dexmedetomidine dose in cats is 5.0–7.0 mcg/kg IM.
  - Xylazine has been reported to induce emesis in 43–60% of cats while dexmedetomidine is effective in 58–81% of cats and typically takes approximately 10 minutes.
  - Given availability and the suggestion for better efficacy, dexmedetomidine is more commonly administered.
  - Typically, emesis (if it occurs) is followed by sedation if the reversal agent is not administered. Cardiovascular and respiratory depression may also occur.
  - Xylazine should be reversed with yohimbine 0.05–0.1 mg/kg IM for doses of xylazine listed above.
  - Dexmedetomidine (0.5 mg/mL) should be reversed with equal volumes of atipamezole (5 mg/mL), or 0.05–0.07 mg/kg atipamezole for doses listed above.
- Tranexamic acid.
  - Tranexamic acid is an antifibrinolytic drug that when administered rapidly can induce emesis in dogs by stimulating a pathway involving tachykinin neurokinin 1.
  - Dose: dogs 50 mg/kg IV administered over 2–3 minutes induced emesis in approximately 85% of dogs within six minutes.
  - If emesis does not occur within 10 minutes, a second dose of 20–30 mg/kg IV can be administered.
  - Potential adverse effects reported include seizures.
  - Tranexamic acid has been used for its antifibrinolytic effects in cats at 10 mg/kg, but no reports on its use as an emetic have been published.

ADSORBENTS AND CATHARTICS

Activated Charcoal

- The goal of activated charcoal (AC) is to act as an adsorbent and to prevent systemic absorption of a toxicant. It is the primary treatment of choice for decontamination of the veterinary poisoned patient.
- AC contains carbon moieties that adsorb compounds with varying affinity, binding nonpolar compounds well.
- Heavy metals (e.g., zinc, iron, etc.) and alcohols (e.g., ethylene glycol, xylitol, methanol, isopropyl alcohol, ethanol) typically are not absorbed by AC.
- The interaction between the bound toxicant and AC could potentially undergo desorption (where the toxicant unbinds from the AC over time); hence, a cathartic is often added to help promote fecal expulsion and decrease GI tract transit time.
- Administration of AC with a cathartic as long as six hours past ingestion may still be beneficial with toxicosis, particularly if the product has delayed release (e.g., extended or sustained release) or undergoes enterohepatic recirculation.
- The use of AC with a magnesium-containing cathartic should be undertaken judiciously in cats.
- Dose: 1–2 g of AC per kg of body weight orally with the first dose containing a cathartic.
- Drugs undergoing enterohepatic recirculation (e.g., theobromine, bromethalin, etc.), with a long half-life (naproxen), or delayed-release products will require multidose administration of AC, with subsequent doses not containing a cathartic.

- Additional doses of AC should ideally not contain a cathartic, due to increased risks for dehydration via fluid losses from the GI tract.
- Adverse effects of AC administration include diarrhea (when contains a cathartic), electrolyte derangements, hyperlactatemia and hyperosmolality, and a report of small intestinal obstruction in dog with repeated doses.
- Few animals will ingest AC voluntarily without the addition of food. The addition of food causes a clinically insignificant reduction of the absorptive capacity. Alternatives for animals who will not voluntarily ingest AC include syringe feeding or large-bore nasogastric tube administration.
- To prevent dehydration and hypernatremia, the patient should be given free access to water.
- Administration of an antiemetic may help prevent emesis of the AC and allow for rapid return to oral water.
    - Maropitant 1 mg/kg, IV q 24 hours has been successfully used in this scenario.
- Activated charcoal should be used with care in patients with dehydration or electrolyte derangements and the need for fluid therapy should be evaluated in these patients.
- Contraindications for AC include a compromised airway (risk for aspiration pneumonia), known perforation of the GI tract, caustic substance ingestion, and hydrocarbon toxicosis (due to increased risk for aspiration pneumonia).

Cholestyramine

- Cholestyramine is a medication used to bind bile acids, lower cholesterol, and treat certain types of diarrhea.
- Cholestyramine can be dosed at 0.3–1 g/kg every 6–8 hours with toxicants that undergo enterohepatic recirculation or biliary elimination.
    - It is most likely to be helpful in vitamin D_3, microcystin, and bromethalin toxicosis.
- Little is known about the success of cholestyramine in veterinary medicine, and it should not routinely be used as a substitute for AC.

Cathartics

- Cathartics are designed to decrease the transit time of substances in the GI tract and promote fecal excretion of the toxicant.
- The two most common types of cathartics used in veterinary medicine are nonabsorbable saccharides (e.g., sorbitol), and nonabsorbable salts (e.g., magnesium sulfate).
- Dose: sorbitol 70% solution, 1–2 mL/kg, PO or 250 mg/kg magnesium sulfate diluted to a 20% solution PO.
- Adverse effects of sorbitol administration: vomiting, dehydration, secondary hypernatremia, abdominal cramping or pain, and possible hypotension.
- The use of cathartics alone is no longer recommended or beneficial.

GASTRIC LAVAGE

- Gastric lavage can be utilized if there is a contraindication to induction of emesis, or induction of emesis was unsuccessful.
- Recovery rates of toxicants are consistently lower than with emesis in people and dogs.
- Gastric lavage should be considered when:
    - Symptomatic patients need decontamination (e.g., metaldehyde toxicosis presenting with seizures).

  - Recent (<1–2 hours) ingestion of a life-threatening dose of toxicants that has no antidote.
  - Material is not easily absorbed (e.g., lily flower, oleander leaves, etc.).
  - Patient has a high risk of aspiration pneumonia with induction of emesis.
- Contraindications for gastric lavage include:
  - Corrosive agents.
  - Hydrocarbon ingestion.
- To perform gastric lavage, the patient must first be anesthetized and maintained on intravenous or inhalational anesthesia. An endotracheal tube should be placed and the cuff inflated and verified to not be leaking at 20 cmH_2O pressure in the anesthesia circuit. Frequently, an antiemetic is administered prior to induction of anesthesia to prevent vomiting at the time of induction, or in recovery.
- The orogastric tube of the largest diameter appropriate for the patient should be selected and premeasured to the 13th rib. A piece of tape can be used to mark this distance.
- The orogastric tube should be lubricated and inserted to the stomach. Its presence can be verified by direct external visualization, or auscultation of gas bubbles over the stomach as air is blown into the tube.
- Once the orogastric tube is properly placed and verified, the stomach is emptied (Figure 1.1a). Then a pump (Figure 1.1b) can be used, or gravity with a funnel to administer approximately

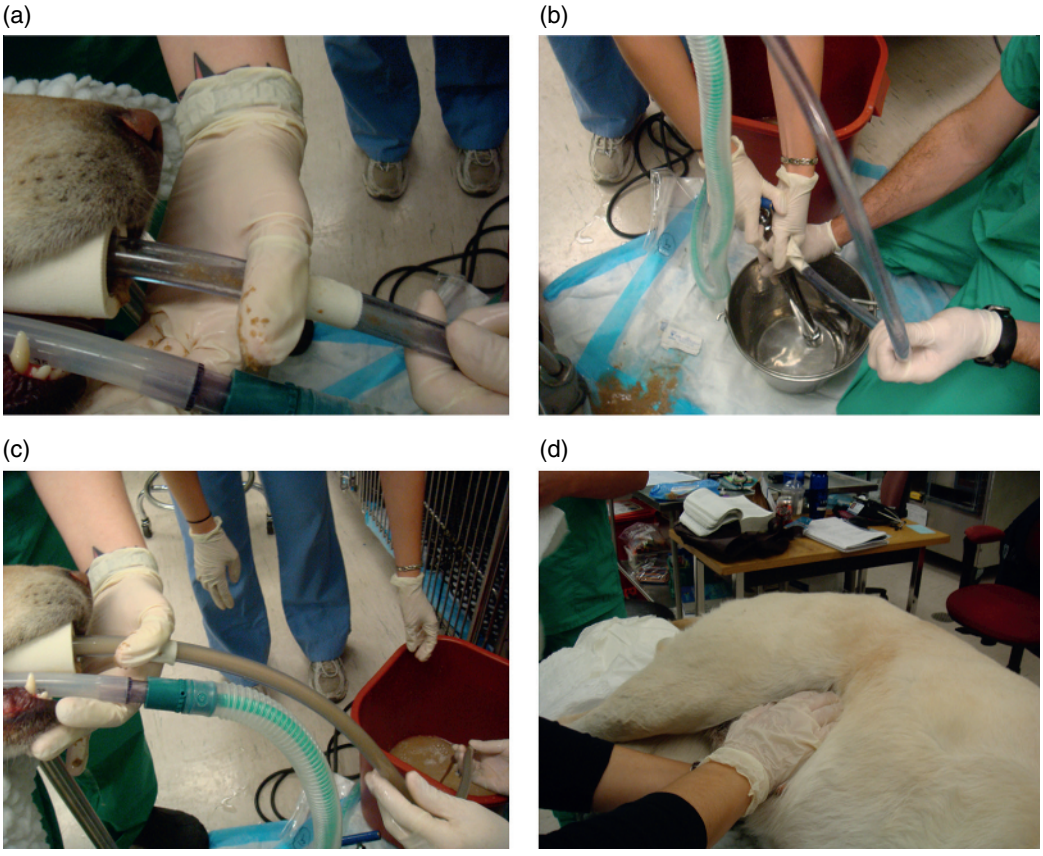

Figure 1.1 Gastric lavage in a dog. (a) Proper placement and marking of the orogastric tube. (b) Use of a pump to administer warm water into the stomach. (c) Siphon action of water to facilitate withdrawal of gastric contents. (d) Frequent palpation of stomach to ensure it is not overdistended.

20 mL/kg warm water into the stomach. The pump can be removed and the tube lowered below the patient to drain the water and contents from the stomach (Figure 1.1c). This process can be repeated multiple times until only clear water remains. During the process, the patient's stomach should be palpated frequently to ensure overdistention does not occur (Figure 1.1d).

- The gastric lavage fluid should be examined for the presence of toxicants (e.g., plant material, mushrooms, rodenticides, medications, etc.), and can be saved for toxicological testing if needed.
- Prior to removal of the orogastric tube, AC or cholestyramine can be administered.
- The orogastric tube should be kinked prior to removal to prevent contents from the tube from leaking into the esophagus during the removal process.
- The patient can then be recovered from anesthesia, ideally in sternal recumbency with their head elevated.

DIURESIS

- The main use of fluid diuresis in toxicities is to increase elimination of substances that are renally cleared from the body.
- Highly protein-bound substances (e.g., NSAIDs) do not benefit from fluid diuresis.
- Results of early studies have failed to show a benefit.
- Toxicants in which fluid diuresis is most likely to be beneficial include:
  - Amphetamines.
  - Lithium.
  - Bromide.
  - Phenobarbital.
  - Salicylates.
- If fluid diuresis is attempted, balanced electrolyte solutions (e.g., Lactated Ringer's solution, Plasma-Lyte-148®) are commonly used unless a high chloride concentration is indicated (bromide toxicosis) and then 0.9% saline may be utilized at 4–8 mL/kg/h IV.
- Furosemide at 1–2 mg/kg IV q 6–8 hours may be added to help prevent overhydration or treat it if it occurs.
- Adverse effects of fluid diuresis include:
  - Fluid overload.
  - Electrolyte and acid–base disturbances (hypokalemia, metabolic acidosis, etc.).

INTRAVENOUS LIPID EMULSION

- Intravenous lipid emulsion (ILE) therapy was first used to treat cardiac arrest from bupivacaine toxicosis in a human and has become the standard of care to treat local anesthetic systemic toxicity.
- ILE has been used to treat a multitude of veterinary toxicities with little evidence of efficacy or improving case outcomes.
  - Current veterinary evidence includes multiple case reports which garner the critique of selection bias (e.g., only cases in which therapy was perceived as successful are reported).
    - Some case reports do include pharmacokinetic evidence; however, often multiple therapies are utilized concurrently.
  - High-level evidence exists only as a randomized controlled trial in permethrin toxicosis in cats.

- ILE therapy in veterinary medicine, outside permethrin toxicosis, should be reserved for severe poisonings that are not responsive to standard medical therapy or where euthanasia is being considered because of poor prognosis or financial constraints.
- ILE is available in 10–30% solutions (20% is most widely used), and is composed of neutral, medium- to long-chain triglycerides derived from combinations of plant oils (e.g., soybean, safflower), egg phospholipids, and glycerin.
- The mechanism of action is not fully elucidated at this time, but two theories predominate.
    - The "lipid sink/shuttle" theory involves creating a lipid phase in the bloodstream sequestering lipophilic drugs, preventing them from reaching their target sites or shuttles them from target sites such as the brain or heart and transports toxicants to muscle or adipose tissue until they can be metabolized or excreted.
    - The other theory is that lipids can increase cardiac performance which likely plays a role in toxicants like the local anesthetics causing cardiovascular collapse.
- Initially ILE was thought to work better for toxicities with high lipid solubility as measured by the octanol/water partition coefficient (LogP), but an apparent benefit in nonlipophilic toxicities (e.g., baclofen, which has a negative LogP) indicates that other properties of the toxicant are important.
- A list of toxicants in which ILE have an apparent benefit is beyond the scope of this chapter and when thought to be of benefit is covered in individual chapters.
- The ideal dose of ILE has not been determined; however, a 20% solution is recommended for treatment of toxicities. Possible doses are:
    - 1.5 mL/kg IV fast bolus (if cardiac arrest or life-threatening situation) followed by 0.25 mL/kg/min IV for 30–60 minutes.
        - The clinician should recognize that this CRI rate delivers the initial bolus of 1.5 mL/kg over six minutes and the intent of the bolus is to rapidly achieve plasma levels.
    - If not in cardiac arrest, 0.25 mL/kg/min for 30–60 minutes IV.
        - If the patient is still experiencing severe clinical signs and the plasma is not lipemic, this dose can be repeated in 4–6 hours.
    - In humans, a 1.5 mL/kg intravenous bolus with an additional 0.25 mL/kg/min over three minutes, then 0.025 mL/kg/min up to 6.5 hours has been utilized as well.
- The use of an in-line filter might avoid lipid emboli creating adverse effects.
- Maximum dosing of 10–15 mL/kg/day of 20% lipid has been recommended as a nutritional supplement in parenteral nutrition; however, higher doses have been well tolerated on a single day for treatment of toxicosis.
- Generally, ILE therapy is well tolerated. Adverse effects include:
    - Pancreatitis.
    - Corneal lipidosis.
    - Facial pruritus and type I hypersensitivity.
    - Hemolysis.
    - Possible acute respiratory distress syndrome (ARDS).
    - Interference with laboratory tests.
    - Fat overload syndrome and death (accidental overdose of ILE).

EXTRACORPOREAL THERAPY

- Extracorporeal therapy (ECT) for toxicities consists of hemodialysis (HD), hemoperfusion (HP), and therapeutic plasma exchange (TPE).
- TPE can be performed manually or automated on a specialized machine, while other extracorporeal modalities can only be performed with a machine.

- There is little definitive evidence for the use of ECT in veterinary medicine; however, for many toxicants based on human literature, it is considered the standard of care when available (e.g., ethylene glycol).
    - Multiple case reports exist in veterinary medicine where ECT appeared to be beneficial. However, the effect on pharmacokinetic parameters other than simple plasma clearance measurements and the contribution of endogenous clearance in these cases is unknown. There is also likely selection bias similar to ILE therapy.
        - Propylene glycol.
        - Barbiturates.
        - Cannabinoids.
        - Methotrexate.
        - NSAIDs.
        - Vincristine.
- As during the treatment process, a portion of the blood is extracorporeal, a minimum patient size may be needed depending on the modality used (often >5 kg).
    - It is possible to treat smaller patients, but this will depend on the modality (primarily the extracorporeal circuit size), the experience of the operator, availability of blood products for priming, and the cardiovascular stability of the patient.
- Treatment with ECT for a toxicity should be considered for toxicants that are primarily limited to the vascular space and have low volumes of distribution (preferably <1 L/kg, but up to <2 L/kg).
    - If the volume of distribution is >2 L/kg, then prolonged treatment and processing of multiple blood volumes are necessary to achieve a significant decrease in total body drug concentration. This may not exceed endogenous clearance in which case ECT is unlikely to be of benefit.
- If the protein binding is >95% or the molecular weight (MW) of the toxicant is >50 kDa, TPE is the preferred methodology (e.g., vincristine). For effective TPE, a small volume of distribution (ideally <0.5 L/kg) is necessary.
- If the protein binding is >80–95% or the MW is 10–50 kDa, then hemoperfusion will likely be utilized (e.g., phenobarbital). The efficacy of hemoperfusion is dictated by the affinity of the toxicant for the adsorbent.
- If the protein binding is <80% or the MW is <500 Da to 1 kDa, then hemodialysis will likely be utilized. (e.g., ethylene glycol, baclofen).
- If the above criteria are met, consultation with a referral center capable of performing ECT is recommended.
- Conventional decontamination should be performed pending decision making regarding ECT.

Abbreviations

- AC = activated charcoal
- CTZ = chemoreactive trigger zone
- ECT = extrcorporeal therapy
- HD = hemodialysis
- HP = hemoperfusion
- ILE = intravenous lipid emulsion
- NSAID = nonsteroidal anti-inflammatory drug
- TPE = therapeutic plasma exchange

Suggested Reading

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