CHAPTER 5

TREATMENT PRINCIPLES

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Abstract

Management of toxic exposures follows systematic principles aimed at reducing further absorption, enhancing elimination, administering specific antidotes when available, and providing supportive care. Gastrointestinal decontamination methods include activated charcoal, which adsorbs many toxins but is contraindicated for caustic ingestions, hydrocarbons, and patients with unprotected airways. Once widely used, gastric lavage and induced emesis now have limited roles due to efficacy and safety concerns. Whole bowel irrigation may benefit in specific scenarios like sustained-release medication or body packer ingestions. Antidotal therapy directly counteracts toxic mechanisms through various actions including receptor antagonism, chelation, substrate competition, and metabolic interventions. Well-established antidotes include N-acetylcysteine for acetaminophen, naloxone for opioids, and various chelating agents for heavy metals, though many poisonings lack specific antidotes. Supportive care forms the cornerstone of management for most exposures, focusing on maintaining vital functions, treating symptoms, and preventing complications. Enhanced elimination techniques—including multiple-dose activated charcoal, urinary alkalinization, and extracorporeal methods like hemodialysis—can significantly reduce toxin burden for selected substances with appropriate pharmacokinetic properties. Treatment decisions must balance potential benefits against risks while considering individual patient factors including age, comorbidities, and exposure characteristics.

Keywords: *Decontamination, Antidotes, Activated Charcoal, Enhanced Elimination, Hemodialysis, Supportive Care*

Learning Objectives

After completion of the chapter, the learners should be able to:

- Evaluate the indications, contraindications, and efficacy of various gastrointestinal decontamination methods for different toxic exposures.
- Select appropriate antidotes for specific poisonings and explain their mechanisms of action, dosing, and administration routes.
- Implement comprehensive supportive care measures for toxic exposures lacking specific antidotes.
- Determine when enhanced elimination techniques are indicated based on toxin properties and patient factors.
- Compare the efficacy of different elimination methods including multiple-dose activated charcoal, urinary alkalinization, and extracorporeal techniques for specific toxins.
- Develop treatment plans that integrate decontamination, antidotal therapy, supportive care, and enhanced elimination based on specific poisoning scenarios and patient characteristics.

DECONTAMINATION METHODS

Decontamination procedures aim to reduce toxicant absorption and systemic burden through removal from exposure sites, with approach selection guided by route of exposure, toxicant properties, and time since exposure.

Gastrointestinal Decontamination

Gastric lavage, historically a mainstay of poisoning management, involves placement of a large-bore orogastric tube (36-40 French for adults) and sequential instillation and withdrawal of small aliquots (200-300 mL) of warm water or normal saline until returning fluid appears clear. This procedure demonstrates greatest efficacy when performed within one hour of ingestion, after which gastric emptying significantly reduces potential yield.

Modern practice has substantially restricted gastric lavage indications due to limited proven benefit and significant potential complications. Absolute contraindications include corrosive ingestion due to perforation risk, hydrocarbon ingestion due to aspiration concern, and unstable patient condition unless airway is secured. Potential complications include aspiration pneumonitis, hypoxemia,

laryngospasm, esophageal perforation, and fluid/electrolyte imbalances, particularly with repeated lavage attempts. Current positioning restricts lavage consideration to life-threatening poisonings presenting within one hour where no safer alternatives exist, and only by properly trained personnel with capacity for airway management.

Remember

Activated charcoal effectively adsorbs many toxins when administered within 1-2 hours of ingestion, but is contraindicated with caustic substances, hydrocarbons, and in patients with unprotected airways or gastrointestinal obstruction.

Activated charcoal administration represents the most widely employed gastrointestinal decontamination strategy, acting through adsorption of toxicants to its extensive internal surface area (1000-2000 m^2/g), preventing their absorption into systemic circulation. Standard adult dosing provides 1 g/kg (typically 50-100 g), administered as an aqueous slurry, ideally within one hour of ingestion, though potentially beneficial up to 4 hours post-ingestion for certain sustained-release preparations or drugs undergoing enterohepatic circulation. Activated charcoal demonstrates greatest efficacy for compounds with high charcoal affinity, including many pharmaceuticals, plant toxins, and mycotoxins. Important exceptions include alcohols, hydrocarbons, metals, corrosives, and lithium, which bind poorly to charcoal. Contraindications include unprotected airway in obtunded patients, gastrointestinal perforation risk, and corrosive ingestions where endoscopic evaluation may be compromised by charcoal presence. Complications include aspiration with subsequent pneumonitis, constipation, bowel obstruction with multiple-dose regimens, and reduced absorption of concurrently administered therapeutic medications.

Whole bowel irrigation employs large volumes of polyethylene glycol electrolyte solution (typically 1-2 L/hour in adults) administered orally or via nasogastric tube until rectal effluent becomes clear. This procedure mechanically flushes intestinal contents through the gastrointestinal tract, reducing toxicant absorption without relying on adsorptive binding. Primary indications include ingestions poorly adsorbed by activated charcoal, particularly sustained-release preparations, toxic metals including iron and lithium, and illicit drug packets in body packers. The isotonic, non-absorbable solution minimizes fluid and electrolyte disturbances compared to older cathartic approaches. Contraindications include gastrointestinal perforation or obstruction, significantly compromised hemodynamics, and uncontrolled vomiting. Absolute completion of the procedure requires

many hours, potentially delaying alternative interventions, though toxicant binding and movement through the gastrointestinal tract begins immediately upon solution administration.

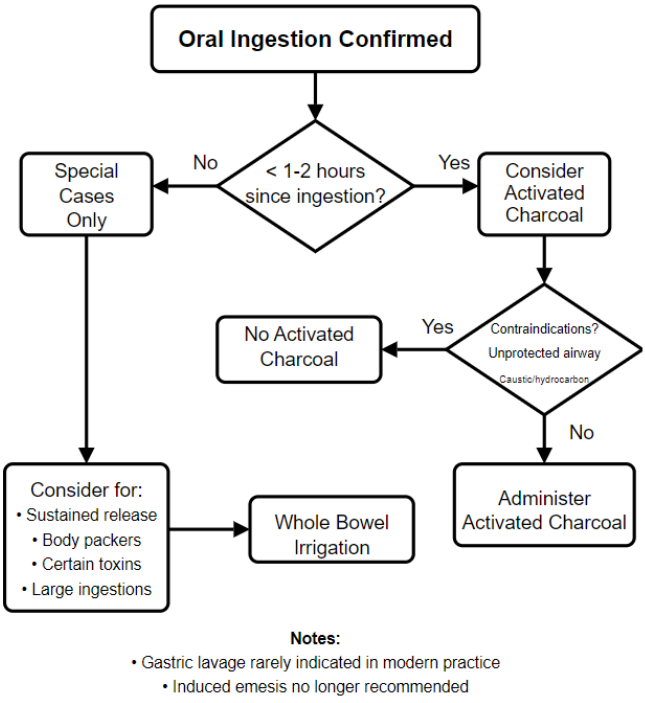

Figure 5.1: Gastrointestinal Decontamination Algorithm

Cathartics, including sorbitol, magnesium citrate, and magnesium sulfate, historically accompanied activated charcoal administration under the theoretical premise of accelerating gastrointestinal transit and reducing toxicant absorption time. Contemporary evidence indicates minimal benefit from this practice while introducing potential complications including fluid/electrolyte disturbances, excessive intestinal cramping, and hypotension from third-spacing of fluids. Current guidelines discourage routine cathartic use, particularly repeated doses or administration to pediatric or elderly patients. Syrup of ipecac, previously recommended for home use to induce emesis, has been abandoned in modern practice due to limited efficacy, potential for delayed administration of more effective interventions, aspiration risk, and persistent vomiting potentially interfering with oral antidote administration.

Table 5.1: Gastrointestinal Decontamination Methods

Method	Indications	Contraindications	Timing
Activated charcoal	Most oral poisonings	Caustics, hydrocarbons, altered mental status without airway protection	Most effective <1 hour, consider up to 4 hours for some toxins
Gastric lavage	Life-threatening ingestions when benefits outweigh risks	Caustics, hydrocarbons, absent gag reflex without intubation	<1 hour post-ingestion
Whole bowel irrigation	Sustained-release medications, body packers, heavy metals, iron	Bowel obstruction, perforation, ileus, hemodynamic instability	Effective for up to 12-24 hours for certain substances
Multiple-dose activated charcoal	Carbamazepine, phenobarbital, theophylline, salicylates	Same as single-dose charcoal	Can start later than single dose
Cathartics	No longer recommended as sole therapy	Bowel obstruction, diarrhea, electrolyte imbalances	N/A

Dermal Decontamination

Dermal decontamination procedures aim to remove toxicants from skin surfaces before significant absorption occurs, with effectiveness highly dependent on prompt initiation. Initial measures include removal of contaminated clothing, which may harbor substantial toxicant reservoirs, particularly with liquid exposures. Garments should be removed carefully to prevent secondary contamination of unaffected areas, with cutting rather than pulling over the head when feasible. Removed clothing requires proper containment and disposal according to hazardous materials protocols, particularly with pesticidal, chemical warfare, or radiological contamination.

Water lavage represents the principal dermal decontamination method, rapidly diluting and removing water-soluble toxicants while physically dislodging particulate matter. Irrigation should commence immediately and continue for 15-20 minutes with tepid, gentle-pressure water. Attention to irrigation runoff disposal prevents secondary contamination, particularly in mass casualty scenarios. High-pressure irrigation mechanisms may paradoxically enhance toxicant absorption by damaging skin barrier function or driving particulate matter deeper into tissues. Temperature extremes should be avoided, as hot water enhances percutaneous absorption through vasodilation and cold water may induce hypothermia with prolonged irrigation, particularly in pediatric patients.

Special considerations apply to specific toxicant classes. Oils, tars, and resins adherent to skin may require initial wiping with mineral oil or petroleum jelly before water irrigation, as these lipophilic substances resist water removal. Water-reactive compounds including elemental sodium, potassium, lithium, and certain metal hydrides necessitate initial dry brushing to remove visible material before cautious wet decontamination, as premature water application may generate exothermic reactions or caustic byproducts. Powdered caustic materials benefit from brushing before irrigation to prevent heat generation upon hydration. Hydrofluoric acid exposures require specialized decontamination with calcium gluconate gel (2.5-10%) to prevent fluoride ion penetration and subsequent tissue destruction through calcium sequestration.

Ocular decontamination follows similar principles but demands particular care given the eye's vulnerability to both toxicants and improper decontamination techniques. Initial irrigation should commence immediately using copious tepid water or saline, ideally through a Morgan lens or eyewash station allowing continuous flow while eyelids are manually held open. Irrigation should continue for at least 15-20 minutes, with pH testing of tears guiding prolonged irrigation needs after chemical exposures. Contact lenses must be removed early in decontamination to prevent trapping of toxicants against corneal surfaces. Particulate matter may require gentle saline lavage or careful removal with moistened cotton-tipped applicators. Petroleum-based products resistant to water irrigation may require special surfactant solutions. All significant ocular exposures warrant ophthalmological evaluation after initial decontamination to assess corneal damage and need for further intervention.

Inhalational Decontamination

Inhalational exposures require immediate removal from the contaminated environment to terminate ongoing toxicant absorption.

Rescuer safety remains paramount, with appropriate respiratory protection and hazardous materials protocols implemented before entry into contaminated areas, particularly with highly toxic gases including hydrogen sulfide, cyanide, or carbon monoxide. Patients capable of spontaneous respiration should be relocated to fresh air immediately, while those requiring rescue breathing or resuscitation should be removed from the contaminated area first to prevent rescuer exposure during airway management. Initial decontamination should occur outside healthcare facilities when feasible to prevent secondary contamination of hospital environments and staff.

Oxygen administration represents the primary intervention for most inhalational toxicants, addressing both hypoxemia from alveolar-capillary diffusion impairment and competitive displacement of toxicants from binding sites. High-flow oxygen (100% if available) should be administered immediately while avoiding positive pressure ventilation when possible with pulmonary irritants that may have caused alveolar damage. Carbon monoxide poisoning specifically requires high-flow oxygen to accelerate displacement from hemoglobin binding sites, with consideration of hyperbaric oxygen therapy for severe poisonings. Special oxygen delivery systems including Venturi masks and high-flow nasal cannulas provide precise oxygen titration capabilities for specific scenarios.

Removal of contaminated clothing and thorough skin decontamination remain essential complementary measures, as chemicals on clothing or skin surfaces may continue off-gassing, creating ongoing inhalational exposure. Particular attention to hair decontamination is warranted as the large surface area can trap significant toxicant quantities. Healthcare personnel should wear appropriate personal protective equipment during decontamination to prevent secondary contamination, with level of protection determined by toxicant properties and exposure risk.

Airway management considerations for inhalational exposures include recognition of potentially rapid progression of airway edema following irritant gas exposure. Early endotracheal intubation may be warranted with signs of impending airway compromise, including stridor, respiratory distress, or facial/oropharyngeal edema, particularly with exposures to highly water-soluble gases like ammonia or chlorine that create immediate upper airway injury. Bronchodilator therapy addresses bronchospasm common with irritant gas exposures, while corticosteroids may reduce inflammatory airway edema though evidence for their efficacy remains limited. Positive end-expiratory pressure may improve oxygenation in non-cardiogenic pulmonary edema resulting from less water-soluble irritants like phosgene or nitrogen dioxide that primarily affect distal airways and alveoli.

Special Decontamination Scenarios

Specific toxicant classes and exposure scenarios require specialized decontamination approaches extending beyond standard protocols. Chemical warfare agent exposures including nerve agents (sarin, VX), vesicants (sulfur mustard), and pulmonary agents (chlorine, phosgene) necessitate specialized decontamination procedures. Initial dry decontamination using absorbent materials removes gross contamination before wet decontamination to minimize spread of agent through runoff. Military decontamination kits containing specialized adsorbents and neutralizing solutions may provide superior efficacy compared to water alone. Rapid initiation is critical, particularly with nerve agents where minutes can significantly affect outcome. Mass casualty incidents require decontamination corridors with separate lanes for ambulatory and non-ambulatory patients to maximize throughput, with attention to wastewater containment and provider protection through appropriate personal protective equipment.

Radioactive contamination presents unique challenges requiring specialized approach. External contamination assessment utilizes radiation detectors (Geiger-Muller counters) to identify contaminated body regions requiring focused decontamination. Removal and contained disposal of clothing eliminates approximately 80-90% of external contamination in most scenarios. Gentle washing with tepid water and mild soap removes most remaining external contamination, with careful attention to skin folds, hair, and orifices where particulate matter may concentrate. Wound decontamination requires separate collection of irrigation fluid to prevent spread of contamination, with radiation monitoring between decontamination cycles. Internal contamination with radioisotopes may require specific decorporation agents including Prussian blue (cesium, thallium), calcium DTPA (plutonium, americium), or potassium iodide (radioactive iodine) to reduce systemic burden.

Body packing and body stuffing, involving ingestion of drug-filled packets for concealment or transportation, require specialized management. Body packers typically ingest professionally prepared, multiple-layer packages containing large quantities of illicit drugs intended for smuggling, while body stuffers hastily ingest poorly wrapped drugs to evade imminent law enforcement detection. Decontamination approaches vary based on package characteristics and clinical presentation. Asymptomatic body packers with professionally wrapped packages typically receive whole bowel irrigation without activated charcoal, which might obscure packet visualization. Surgical intervention becomes necessary with signs of packet rupture, bowel obstruction, or prolonged intestinal transit. Body stuffers with poorly wrapped packages face higher rupture risk, often warranting activated