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A Narrative Review of the Interdisciplinary Management of Acute Poisonings and Overdoses: From Bedside to Laboratory to Antidote

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Abstract

Background: Acute poisonings and overdoses represent a critical global public health challenge, characterized by evolving substance trends and complex presentations. Effective management necessitates a seamless, interdisciplinary approach integrating emergency medicine, nursing, laboratory toxicology, and clinical pharmacy.

Aim: This narrative review aims to synthesize contemporary evidence on the interdisciplinary management of acute poisonings, tracing the patient journey from initial bedside stabilization through laboratory diagnostics to specific antidotal therapy.

Methods: A comprehensive literature search was conducted across PubMed, Scopus, and Web of Science databases (2010-2024). Key search terms included "acute poisoning," "overdose," "toxicology," "antidote," "toxicology laboratory," "multidisciplinary," and specific agent and intervention names. Relevant articles, including reviews, clinical trials, and guidelines, were selected for analysis.

Results: Successful outcomes depend on a synergistic, protocol-driven response. Emergency medicine provides rapid stabilization and risk assessment, guided by toxidromes. Nursing ensures meticulous supportive care and monitoring for complications. The modern toxicology laboratory extends beyond basic screens to quantitative assays, pharmacokinetic modeling, and detection of novel substances, directly informing management. Clinical pharmacy specialists optimize antidote selection, dosing, and pharmacokinetic interventions, serving as a bridge to poison control center expertise.

Conclusion: The management of acute poisoning is a paradigm of time-sensitive, interdisciplinary care. Strengthening collaboration, communication pathways, and shared protocols between these four pillars—emergency medicine, nursing, laboratory science, and clinical pharmacy—is essential for improving patient outcomes amidst a changing toxicological landscape.

Keywords: Poisoning, Overdose, Interdisciplinary Care, Toxicology Laboratory, Antidote

Introduction

Acute poisonings and drug overdoses remain a leading cause of emergency department (ED) visits, morbidity, and mortality worldwide, constituting a persistent and dynamic public health crisis (Gummin et al., 2023; World Health Organization, 2021). The landscape of toxicological emergencies has shifted dramatically from primarily unintentional pediatric ingestions to complex adult exposures involving pharmaceuticals, illicit substances, and novel synthetic agents (Cole & Carmon, 2019; Zawilska & Wojcieszak, 2018). The proliferation of novel psychoactive substances (NPS), the ongoing opioid epidemic, and the rise in polypharmacy and intentional self-harm ingestions present clinicians with unprecedented diagnostic and therapeutic challenges (Revol et al., 2023; Mars et al., 2019). These complexities render a siloed approach to care obsolete.

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Optimal patient outcomes hinge on a highly coordinated, interdisciplinary framework that leverages the distinct yet overlapping expertise of emergency medicine, nursing, clinical toxicology laboratories, and clinical pharmacy, all underpinned by specialist consultation from poison control centers (PCCs) (Pannick et al., 2015; Greenwald et al., 2016). This narrative review synthesizes contemporary evidence from 2010 to 2024, delineating the integrated roles of these key disciplines along the continuum of care: from initial bedside stabilization and diagnostic dilemma, through the critical contributions of the laboratory, to the nuanced administration of specific antidotes and decontamination strategies.

Emergency Medicine and the Initial Stabilization

The management of any acutely poisoned patient begins with the emergency physician's application of the fundamental principles of resuscitation: Airway, Breathing, and Circulation (ABC). Rapid sequence intubation may be required for patients with a depressed Glasgow Coma Scale, inability to protect their airway, or respiratory failure from profound sedation or pulmonary complications (Brent et al., 2017; Getie & Belayneh, 2020). Hypotension is aggressively treated with crystalloid fluids, with vasopressors such as norepinephrine often necessary for refractory cases, particularly in overdoses of vasodilating agents (Gibbison et al., 2017; Corlade-Andrei et al., 2023). Concurrently, the emergency team initiates a focused assessment to identify a potential toxidrome—a constellation of clinical signs and symptoms suggestive of a class of toxins. Recognizing the sympathomimetic, anticholinergic, cholinergic, opioid, or sedative-hypnotic toxidrome provides immediate diagnostic and therapeutic direction (Morarasu et al., 2022; Nelson & Goldfrank, 2019). For example, the pinpoint pupils, respiratory depression, and coma of the opioid toxidrome mandate the prompt administration of naloxone, while the hyperthermia, agitation, and tachycardia of a sympathomimetic or anticholinergic syndrome guide cooling and sedation strategies (Darke et al., 2020; Apata et al., 2023). This initial phase is one of simultaneous stabilization and pattern recognition, where history (often limited or unreliable), physical exam, and point-of-care testing (e.g., glucose, lactate, anion gap) converge to form a preliminary management plan (Gardner et al., 2016; Weiss et al., 2022).

The Diagnostic Dilemma and the Role of Gastrointestinal Decontamination

Faced with an often-unknown exposure, the emergency physician must weigh the risks and benefits of gastrointestinal (GI) decontamination, a field where practice has evolved significantly. Single-dose activated charcoal (AC) may be considered within one hour of ingestion of a potentially toxic amount of a charcoal-adsorbable substance in a patient with a protected airway (Corcoran et al., 2016; Höjer et al., 2013). Its utility diminishes rapidly with time and is contraindicated in patients with an unprotected airway, bowel obstruction, or after ingestion of caustics or hydrocarbons. Whole bowel irrigation (WBI) with polyethylene glycol solutions is reserved for specific scenarios, such as ingestion of sustained-release preparations, enteric-coated drugs, or packets of illicit drugs ("body packers") (Thanacoody et al., 2015; Sandilands, 2023). Gastric lavage and syrup of ipecac are now considered obsolete in most clinical settings due to a lack of proven benefit and significant risk of complications (Benson et al., 2013; Juurlink et al., 2015). The decision to employ decontamination is increasingly nuanced and is best made in consultation with a PCC or clinical toxicologist, emphasizing the interdisciplinary nature of care from the earliest moments (Greenwald et al., 2016; Rege et al., 2021).

Nursing's Role in Continuous Monitoring and Supportive Care

Nursing is the linchpin of continuous, supportive care for the poisoned patient. Their role extends far beyond task completion to one of vigilant surveillance, proactive intervention, and holistic patient management. Nurses are responsible for the meticulous and frequent monitoring of vital signs, neurological status (often using structured tools like the Glasgow Coma Scale or Richmond Agitation Sedation Scale), cardiac rhythm, and urine output (Mohammed & Ahmed, 2019; Allam et al., 2021). They manage the practicalities of decontamination procedures, administer ordered antidotes and medications, and provide critical physical care to prevent complications of immobility, such as pressure injuries and ventilator-associated pneumonia (Abebe et al., 2019; Jones et al., 2016). Perhaps most importantly, nurses are the first to detect subtle clinical changes—a slight dip in respiratory rate, an emerging dysrhythmia, a temperature rise, or increasing agitation—that signal clinical deterioration or the onset of specific complications like serotonin syndrome, neuroleptic malignant syndrome, or withdrawal (Dunkley et al., 2003; Perry & Wilborn, 2012). Their detailed documentation creates a precise timeline of the patient's clinical course, which is invaluable for both ongoing management and subsequent review. Furthermore, nurses play a crucial role in providing psychosocial support to distressed patients and families, managing behavioral manifestations of toxidromes, and ensuring a safe care environment (Sharifi & Valiee, 2023; Vandewalle et al., 2019).

The Toxicology Laboratory from Screening to Quantitative Precision

The clinical toxicology laboratory serves as a vital diagnostic extension of the clinical team, transforming biological samples into actionable data. Its role can be conceptualized in three tiers: screening, confirmation/quantification, and specialized testing (Table 1). Initial immunoassay-based urine drug screens provide rapid results but are fraught with limitations, including cross-reactivities, variable

detection windows, and an inability to detect many NPS and pharmaceutical agents (Kwong et al., 2017; Maurer & Meyer, 2016). Therefore, a negative screen never rules out exposure. For critical management decisions, quantitative serum levels are paramount. Assays for acetaminophen and salicylate are considered standard in undifferentiated overdoses due to their ubiquity, potential for severe toxicity, and the availability of highly effective, level-directed antidotes (Heard & Dart, 2017; Orandi et al., 2023). Other quantitative assays (e.g., for lithium, valproic acid, carbamazepine, digoxin, iron, methanol, ethylene glycol) are guided by clinical suspicion and directly dictate specific interventions such as hemodialysis or the use of digoxin immune Fab (Brent et al., 2017; Orhan et al., 2023).

The most significant advancement in laboratory toxicology is the adoption of liquid chromatography-tandem mass spectrometry (LC-MS/MS) and high-resolution mass spectrometry (HRMS). These technologies enable comprehensive drug screening of hundreds of compounds in a single analysis, precise quantification, and, crucially, the identification of NPS and obscure metabolites that evade conventional testing (Jousselin et al., 2022; Zaami et al., 2019). The laboratory's role also extends to pharmacokinetic modeling (e.g., using the Rumack-Matthew nomogram for acetaminophen) and monitoring antidote levels or biomarkers of effect (e.g., monitoring coagulation factors during brodifacoum anticoagulant rodenticide poisoning) (Weiss et al., 2022; Rubinstein et al., 2018). Close communication between the clinician and the laboratory toxicologist is essential to interpret complex results in the clinical context and to guide appropriate test selection, thereby avoiding diagnostic delays and unnecessary costs (Pannick et al., 2015; Wu, 2020).

Table 1: Limitations and Advances in Toxicological Laboratory Analysis

Test Type	Common Examples	Turnaround Time	Key Advantages	Significant Limitations	Role in Interdisciplinary Care
Immunoassay Screen (Urine)	AMP, COC, OPI, BZO, BAR, PCP, THC	Minutes to 1-2 hours	Rapid, widely available, inexpensive.	High false +/-; limited panel; cross-reactivities; misses most NPS, fentanyl analogs, many synthetics.	Provides rapid, but **presumptive** data. Clinical correlation is essential. A negative result is **not** definitive.
Quantitative Serum Assays	Acetaminophen, Salicylate, Lithium, Valproate, Carbamazepine, Digoxin, Iron, Ethanol	1-3 hours (STAT)	Precise, reproducible. Directly guides specific, often antidotal, therapy (e.g., NAC, dialysis).	Targets specific drugs only. Must be clinically suspected and ordered.	**Cornerstone of targeted management.** Results require clinical interpretation (e.g., nomograms for acetaminophen).
Toxic Alcohol Panel (GC)	Methanol, Ethylene Glycol, Isopropanol	2-6 hours (often longer)	Definitive diagnosis for toxic alcohols. Essential for guiding fomepizole and dialysis.	Not available at all hospitals; significant send-out delay.	Initiate empiric fomepizole based on clinical/ABG findings **before** result returns. Lab provides confirmation.
Comprehensive Drug Screening (LC-MS/MS)	100+ pharmaceuticals, illicit drugs, and some NPS	4-24 hours	Broad, sensitive, specific. Can detect many agents missed by the immunoassay.	Slow TAT; expensive; requires expert interpretation; may not include the newest NPS.	**Retrospectively confirms exposure.** Informs prognosis, public health reporting, and follow-up. Useful in chronic poisoning/ Munchausen.
High-Resolution MS (HRMS)	Novel Psychoactive Substances (NPS), unknown metabolites	Hours to days	Unbiased screening can identify completely unknown compounds	Very slow; highly specialized; not routine; data	**Research and forensic tool.** Critical for identifying emerging threats and explaining atypical clinical presentations.

	based on exact mass.	interpretation complex.

Clinical Pharmacy and Antidote Management

Clinical pharmacists, particularly those specialized in emergency or toxicology care, are indispensable for optimizing pharmacotherapy in poisoning (Table 2). Their expertise encompasses three core domains: antidote stewardship, pharmacokinetic interventions, and PCC liaison. Pharmacists ensure the timely availability, correct preparation, and appropriate dosing of critical antidotes, which are often high-risk medications with narrow therapeutic indices or complex administration protocols (Panchal et al., 2020; Penm et al., 2019). They manage the intricacies of N-acetylcysteine (NAC) infusion for acetaminophen poisoning, including weight-based dosing, preparation to avoid errors, and management of anaphylactoid reactions (Heard & Dart, 2017; Yarema et al., 2018). Similarly, they oversee fomepizole or ethanol dosing for toxic alcohol ingestions, cyanide antidote kits, and the use of specific antibody therapies like digoxin immune Fab (Brent et al., 2017; McMartin et al., 2016).

Pharmacists also champion pharmacokinetic interventions aimed at enhancing toxin elimination. This includes advising on multi-dose activated charcoal for significant ingestions of carbamazepine, dapsone, phenobarbital, or theophylline, and coordinating with nephrology for hemodialysis in cases of severe poisoning with methanol, ethylene glycol, salicylates, or valproic acid (Ghannoum et al., 2014; Orhan et al., 2023). They act as a direct conduit to regional PCCs, facilitating case consultation, accessing specialized databases, and assisting in the procurement of rarely used antidotes (Greenwald et al., 2016; Rege et al., 2021). By integrating patient-specific factors with detailed pharmacological knowledge, the clinical pharmacist tailors the therapeutic plan, minimizes adverse drug events, and is a key educator for both the treating team and the patient upon discharge (Abebe et al., 2019; Pannick et al., 2015).

Table 2: Key Antidotes in Acute Poisoning: Indications and Interdisciplinary Considerations

Antidote	Primary Toxin(s)	Key Clinical Use	Emergency Medicine Role	Nursing Role	Pharmacy/Lab Role
Naloxone	Opioids (heroin, fentanyl, oxycodone, etc.)	Reverse respiratory depression, sedation.	Rapid IV/IM/IN administration; repeated dosing may be needed for long-acting opioids.	Monitor for re-sedation; administer subsequent doses per protocol; observe for acute withdrawal.	Ensure availability in ED/unit; educate on take-home naloxone kits for discharge.
N-Acetylcysteine (NAC)	Acetaminophen	Prevent/treat hepatic necrosis based on Rumack-Matthew nomogram.	Identify at-risk patients; order timely acetaminophen level; initiate loading dose.	Monitor for anaphylactoid reactions during loading dose; manage IV infusion.	Prepare weight-based dosing (IV or PO); manage reaction with antihistamines/slowing infusion; verify nomogram interpretation.
Fomepizole	Methanol, Ethylene Glycol	Inhibit alcohol dehydrogenase to prevent toxic metabolite formation.	Initiate based on high suspicion (osmolar gap, acidosis) prior to confirmatory level.	Administer loading/maintenance doses; monitor for CNS depression.	Calculate and prepare dosing; coordinate with lab for toxic alcohol levels; manage therapy during hemodialysis.
Sodium Bicarbonate	Sodium Channel Blockers (TCAs, cocaine, etc.), Salicylates	Treat QRS widening (>100ms) from TCAs; enhance elimination & correct acidosis in salicylate poisoning.	Administer bolus for wide-complex dysrhythmia; initiate infusion for	Monitor serial ECGs and ABGs; manage IV infusion.	Prepare concentrated infusions; advise on dosing to achieve target serum pH (7.45-7.55).

			salicylate poisoning.		
Digoxin Immune Fab	Digoxin, Digitoxin	Bind and neutralize cardiac glycosides in life-threatening toxicity (e.g., hyperkalemia, VT).	Identify indication (severe bradycardia, hyperkalemia, instability); order antidote.	Monitor for rapid reversal of dysrhythmias and hyperkalemia; assess for recurrent toxicity.	Calculate dose based on ingested amount or steady-state level; coordinate procurement (often costly).
Flumazenil	Benzodiazepines	Reverse sedation in known pure BZD overdose (diagnostic/therapeutic).	Use with extreme caution (seizure risk in mixed ingestions, chronic users). Contraindicated in unknown overdoses.	Monitor closely for immediate seizure activity post-administration; continuous EEG if available.	Restrict use per protocol; emphasize contraindications to team.
Cyproheptadine	Serotonin Syndrome	Antagonize serotonin receptors as adjunctive treatment for moderate-severe serotonin syndrome.	Initiate in conjunction with cessation of serotonergic agents and supportive care.	Administer loading dose and scheduled dosing; monitor for symptom resolution (clonus, agitation).	Ensure availability; advise on dosing regimen (e.g., 12 mg stat, then 4-8 mg q6h).

Case Studies of Interdisciplinary Management

The true value of this interdisciplinary model is best illustrated through clinical vignettes. Consider a patient with a delayed presentation of an unknown mixed ingestion, found with metabolic acidosis and an elevated osmolal gap. The emergency team stabilizes the airway, administers sodium bicarbonate for the acidosis, and initiates empiric therapy with fomepizole and folate/thiamine based on clinical suspicion for toxic alcohols, while nursing begins continuous cardiac monitoring and prepares for possible intubation. The laboratory rapidly processes an ethanol level, a basic metabolic panel (to calculate the anion and osmolal gaps), and sends stat tests for methanol and ethylene glycol via gas chromatography. The pharmacist ensures adequate fomepazole dosing, prepares a sodium bicarbonate infusion, and contacts the PCC to discuss the possibility of concomitant co-ingestants. When the laboratory confirms a lethal methanol level, the clinical pharmacist, nephrologist, and emergency physician collaboratively decide to initiate emergent hemodialysis, with the nursing team managing the patient during the procedure (Hoyte et al., 2021; McMartin et al., 2016).

In another case of a teenager with an altered mental status after using a "vape pen," the emergency team identifies a sympathomimetic toxidrome. Nursing implements aggressive cooling and sedation for hyperthermia and agitation. A standard urine drug screen is negative. Suspecting synthetic cannabinoids or cathinones, the clinician consults with the laboratory, which performs a broad-spectrum LC-MS/MS analysis on serum, identifying a potent synthetic cathinone. This information guides the clinical team away from unnecessary tests, confirms the need for continued supportive care, and provides critical data for public health surveillance. The pharmacist assists in managing benzodiazepine drips for agitation and provides counseling resources upon discharge (Jousselin et al., 2022; Zawilska & Wojcieszak, 2018). Figure 1 illustrates the coordinated, time-sensitive management of acute poisoning and overdose.

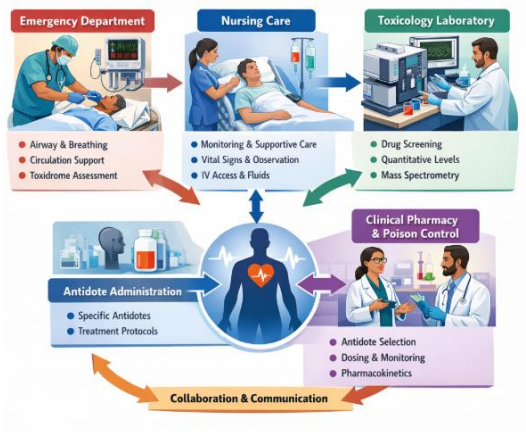

Figure 1. Interdisciplinary pathway in the management of acute poisoning: from bedside to laboratory to antidote

Challenges and Future Directions

Despite this integrated ideal, significant challenges persist. Access to advanced toxicology laboratory testing, particularly LC-MS/MS, is often limited to regional or academic centers, creating disparities in care (Kwong et al., 2017). The pace of NPS emergence outstrips the development of commercial assays, leading to diagnostic blind spots (Revol et al., 2023). Cost containment pressures can conflict with the need for comprehensive testing. Furthermore, interdisciplinary teamwork can falter due to poor communication, undefined roles, or a lack of institutional protocols (Mohammed & Ahmed, 2019; Jones et al., 2016).

Future directions must address these gaps. The development and validation of rapid, point-of-care tests for specific high-risk toxins (e.g., fentanyl, synthetic opioids) could revolutionize bedside decision-making (Scherer et al., 2017). Tele-toxicology consultations can extend specialist expertise to underserved areas (Greenwald et al., 2016). Enhanced informatics, including the integration of laboratory information systems with electronic health records and PCC databases, can streamline data sharing and clinical decision support (Pannick et al., 2015). Continued interdisciplinary education, simulation training, and the formalization of toxicology response teams within hospitals are essential to hardwire collaborative practice (Abebe et al., 2019; Allam et al., 2021).

Conclusion

The management of acute poisoning is a quintessential example of time-sensitive, interdependent medicine. No single discipline possesses all the knowledge or skills required for optimal patient care. From the emergency physician's initial resuscitation and toxidrome recognition, to the nurse's vigilant supportive care, to the laboratory toxicologist's precise analytical confirmation, to the clinical pharmacist's expert antidote and pharmacokinetic management, each pillar is essential. Success is predicated on strong, protocol-driven communication and mutual respect among these specialties, all supported by the remote expertise of poison control centers. As the toxicological landscape grows more complex, fostering and refining this interdisciplinary approach—from bedside to laboratory to antidote—is not merely beneficial but imperative for improving outcomes in this challenging patient population.

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