

# Toxicology News

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## Emergency Toxicology Labs Face Many New Challenges

By Tai C. Kwong

The traditional role of the emergency toxicology service has been to provide laboratory support to the emergency department for the diagnosis and management of patients suspected of a drug overdose. However, the modern clinical toxicology laboratory faces new challenges, including requests for service from other clinical areas, changing drug abuse patterns, and continued constraints on funding of laboratory services. This article focuses on clinical toxicology services supporting the emergency department (ED) for suspected drug overdoses and discusses several issues related to the provision of this service.

Ideally, all the toxicology tests that clinicians need to guide their decision-making would always be available. In reality, however, only a few selected tests are available and many have turnaround times (TATs) that are too long to be clinically useful. Moreover, the extent of service is limited by the laboratory's expertise and instrumentation. Finally, funding for hospital services is always limited and other clinical services may have a higher priority than the laboratory. It is in these contexts that both the clinical laboratory and the ED must focus on how best to use their resources to provide clinically useful toxicology services.

### Principles of effective toxicology services

The goal of the toxicology service is to support the needs of the ED with clinically useful tests. The emphasis is on offering tests that are "effective," meaning that their TAT provides results within a clinically relevant time interval.

A consensus has developed among many clinical laboratorians and medical toxicologists on this issue: A basic toxicology laboratory service should be available in all hospitals that have emergency de-

partments. The premises underlying this consensus are: 1) the simple, rapid, and economical laboratory tests that are essential for a basic clinical toxicology service can be easily made available to support the ED in even the smallest of clinical laboratories; 2) these basic tests are clinically useful for the most frequently encountered poisoning cases.

In addition to these basic tests, additional tests can be provided depending on the technical expertise, instrumentation, and financial resources of the laboratory. A laboratory capable of performing these advanced tests can take on the role of a regional or reference laboratory.

The National Academy of Clinical Biochemistry (NACB) has published guidelines for this two-tiered model of clinical toxicology service (1). The National Poisons Information Service and Association of Clinical Biochemists in the United Kingdom have jointly put forth a similar set of guidelines (2). Both guidelines recommend a basic service consisting of rapid, easy-to-perform tests in all acute hospitals, and an advanced service of analytically more challenging tests in referral laboratories with the expectation of less urgent TATs. The scope of this article is limited to the basic toxicology laboratory service, and is not intended to provide an in-depth discussion of emergency toxicology. Readers are encouraged to go to the documents noted above for details and discussions of the advanced toxicology service.

### Prerequisites for basic toxicology tests

The concept of the basic toxicology service is that there are essential tests that should be available at all times in acute hospitals, regardless of hospital

*Continued on page 5*

## Inside...

Pediatric Toxicology .....	2
Drugged Driving Update .....	4

## Distinguishing Children from Adults in Toxicology: Part 2

By Robert Middleberg

Children differ greatly from adults when it comes to pathological and toxicological issues. Unfortunately, this distinction is often ignored in post-mortem forensic investigations.

Part one of this article stressed some of the differences between adults and children. Part two deals with the challenges unique to the pediatric population and suggests ways to address some of the issues.

### Postmortem forensic issues

Like all postmortem cases involving toxicological findings, pediatric investigations ultimately need to address two questions:

1. What influence did the toxicological findings have on the cause of death?

2. Was the exposure accidental or intentional?

For the reasons outlined below, in pediatric cases, the answers to these questions are inherently more difficult to assess. At the center of the problem is the often remarkable surprise at significant post-mortem toxicological findings in cases involving children. However, given the statistical and historical data demonstrating the prevalence of poisonings of children highlighted in part one of this article, such surprise is unwarranted. Pre-analytical variables, the toxicological examination performed, and medicolegal/social issues all affect the ability to address these two questions.

### Pre-analytical variables

In general, postmortem toxicological findings should not be considered in isolation when assessing a case, and this principle is especially true in the pediatric population. All unexplained deaths of children *should* be treated as having a potential toxicological cause of death from the moment the body is discovered. Therefore, the scene investigation is of great significance to the toxicologist. Unfortunately, due to various social reasons, scene investigations involving the death of children, especially young children, are often delayed or incomplete. In this author's experience, when the scene investigation is delayed, toxicological evidence is often removed or destroyed. Proper scene investigation in these cases should include a detailed description of (1, 2):

1. the position of the body (location, description of the bedding and pillows, unusual findings such as vomitus and odors, photographs, videographs);

2. the environment (temperature, cleanliness, accessibility to ashtrays, recent use of pesticides,

perishable and non-perishable foods such as pepper);

3. the caretaker (appropriateness of response, intoxication);

4. history of terminal event (when found in relation to last being seen alive, found by whom, what child was doing proximate to death);

5. history of the child (birth history, illnesses, injuries, medications, immunizations, developmental progress, disposition, breast vs. bottle fed);

6. family history (previous deaths of children, history of in-born errors of metabolism, parental illnesses, parental vocations and hobbies, ages of siblings);

7. substances and products found throughout the facility where the body was discovered, including under-sink cabinets, medicine cabinets, garage, etc.

In addition, any information that can assist the toxicologist in reducing the infinite number of toxicological possibilities is helpful. The average home contains an estimated 60 or more products with chemicals capable of causing serious adverse effects, including at least a dozen cleaning products.

### Autopsy difficulties

Another significant factor in assessing the toxicological findings is the autopsy. Again, it is this author's experience that no autopsy or an incomplete autopsy of children is fairly common, especially in rural areas, for reasons that include a lack of recognition that poisoning or exposure to toxic agents may have occurred or a desire to not disturb the body appearance. Because of the hesitation to perform an autopsy, many cases of child poisoning are handled retrospectively after ancillary information is gathered, which can necessitate the examination of exhumed, embalmed, and decomposing specimens. The preferred action, of course, is that a complete external and internal examination occurs proximate to the time of death or when the body is found.

The autopsy itself can be difficult to perform because the small size of the child requires specialized equipment (2). As with adults, a detailed description of external, internal, and microscopic examination findings are of great significance to the toxicologist in narrowing down the possibilities. Any unusual odors, colors, and appearances should be noted and forwarded to the toxicologist.

It may be difficult to harvest proper specimens for testing. Peripheral blood is difficult to obtain in small children, thus leaving heart blood as the predominant blood specimen. Even with heart blood, the volume available may be limited in newborns and infants. All the same precautions with the interpretation of heart blood in adults certainly apply to children, perhaps even more so due to the potential

limited space for anatomic positioning of organs. Non-routine specimens are potentially of great importance, including intestinal and bowel contents (liquid diets in newborns and infants facilitate rapid clearance of gastric contents) and hair (to potentially differentiate in utero and chronic exposure). Samples of traditional autopsy specimens, such as visceral organs, should also be collected. Vitreous humor may be problematic to collect in very small infants (2).

### The toxicological examination

Experience has demonstrated that toxicological examinations of specimens from young children are often done perfunctorily. Routine tests often include only a screen for alcohol, common drugs of abuse, and some therapeutic agents.

The literature teems with examples of intoxications of children with other substances. This author has been involved in pediatric cases in which significant toxicological findings included propylene glycol, chloroform, mercury and other metals, emetine, chloral hydrate, methemoglobin-inducers, and sundry other substances. While in some of these cases a suspicion supporting such findings existed, many had no history to indicate such toxicological results. In these latter cases, further investigation often illuminated the cause of the presence of the detected compounds. While it may not be practical to analyze for all esoteric substances in every case, investigational and autopsy information should be used to carefully direct toxicological testing in pediatric cases.

For reasons noted above, the toxicology laboratory must be prepared to handle less than desirable quantities of autopsy materials. In addition, the laboratory needs methods to handle exhumed and embalmed tissues and a large armamentarium of testing protocols to deal with the large number of potential toxicants. While less than ideal, a shotgun approach is often warranted. Lastly, the toxicology laboratory may need to refer samples to laboratories capable of performing electrolyte testing, fluid cultures, in-born errors of metabolism examinations, and other cytogenetic testing.

The interpretation of postmortem toxicological findings in pediatric cases is difficult because of a relative dearth of comparative data. As noted above, individual cases of pediatric intoxication are often reported in the literature.

Attempts to organize such data into a central clearinghouse, such as the National Association of Medical Examiners' Pediatric Toxicology Registry, have met with limited success primarily due to a lack of consistent submissions and wide variations in opinions as to the role of the toxic agent in the cause of death. However, these shortcomings should not

detract from the potential value of such information, including trends and population distributions.

Other references, such as the yearly Poison Control Center Statistical reports (3), Poisindex (4), and some texts, may also be helpful. In addition to these sources, for the past five years, the toxicology section of the American Academy of Forensic Sciences has held a special session on interpretation of postmortem toxicological findings in pediatric cases. Toxicologists, pathologists, and other interested parties introduce cases, followed by open discussion. It is this author's intent to summarize these discussions in the near future.

Despite the lack of comparative data, postmortem toxicological findings in the pediatric population should not only be put into the perspective of the case, but must necessarily take into consideration the fundamental differences between children and adults.

### Medicolegal/social issues

Deaths involving children are especially painful in most cultures. For this reason, the poisoning deaths of children, whether accidental or intentional, are viewed with incredible emotion. Once a toxic agent has been implicated in the death of a child, the determination of whether the exposure was accidental or intentional becomes paramount. A number of factors make this determination difficult. While space limits a detailed discussion of these difficulties, a few points are noteworthy.

Accidental poisoning deaths of children can occur via the child itself, a parent, a caretaker, a sibling, or some passive means. As noted in Part 1 of this article, children less than six months old are not likely to self-administer toxic agents. Accidental exposures in this age group generally occur through a parent, sibling, or caretaker. The cause may range from an overdose of prescribed medications to the adult-perceived need to treat a cold or sedate the infant. Other common forms of exposure include breastfeeding and passive exposure to cigarette and other smoke. The likelihood of these latter exposures causing death may be regarded by some as controversial. Other esoteric means include the inability to properly dose an infant or the wrong medication being prescribed or delivered by a pharmacy.

Older children may play a more active role in their own exposure. Regardless, in some accidental poisoning cases, child endangerment or negligence charges may be appropriate.

Intentional poisoning deaths of children generally occur to kill or injure, to discipline, or to receive attention (Munchausen by proxy) (1).

History is filled with examples of all three rea-

sions. While it could be argued that, short of purposeful homicide, the other categories could be classified as accidental, this is a medicolegal issue. Factors that assist in the determination of homicide include the case presentation (claims of an accident or unknown illness; delay in seeking medical care; unexpected death) and the case history (inadequate, contradictory, and fluid explanations; previous poisonings; recurrent unexplained illnesses; blame placed on a third party; delay in seeking medical care) (1). Due to qualitative and quantitative differences in many of the previously discussed factors, many deaths of children that could be categorized as homicide may be called accidental, and vice versa.

Lastly, social issues may also affect a case. Prosecutors are often reticent to move forward with serious criminal charges based on unclear medical evidence, a feeling reinforced by the fear that juries won't believe someone could harm a child, especially one's own child (5). In Daytona Beach, Florida, only one in 14 child deaths over a five-year period determined to be from abuse or neglect resulted in successful criminal prosecution (6).

## Conclusions

Postmortem forensic pediatric toxicology and adult toxicology share many aspects. However, the many differences between them should cause all involved with these cases to pause before reaching conclusions and opinions about toxicological findings. Statistics demonstrate that children represent the preponderance of reported exposures to toxic substances. The history of childhood poisoning is both colorful and rueful and highlights the relative ease with which children can be targets of poisoning, both accidental and intentional. In addition, consideration of the toxicokinetic and toxicodynamic differences between children and adults can offer insight into the different effects and handling of toxic substances in the pediatric population.

By considering these differences in light of pre-analytical, analytical, interpretive, and medicolegal/social factors, conclusions about, and subsequent actions from, toxicological findings may be made easier in cases involving children. On the other hand, a failure to consider such differences may lead to misdiagnoses, lack of recognition of actual poisonings, or accusations where none are warranted. Whenever any of these latter conditions arise, the cause can often be attributed to a failure to recognize *that children are not small adults*.

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## New Publications Provide Updates on Drugged Driving

Since our last article on driving under the influence of drugs (DUID) in March 2002 ("Detection of Drug-Impaired Driving can be Difficult"), a number of new and important reports have become available. They are summarized below.

*Drugs and Human Performance Fact Sheets (DOT HS 809 725, National Highway and Traffic Safety Administration).*

These fact sheets are based on the deliberations of a panel of experts in psychopharmacology, behavioral psychology, drug chemistry, forensic toxicology, medicine, and drug recognition. They summarize the conclusions of the panel and provide a practical guide for toxicologists, pharmacologists, law enforcement personnel, attorneys, and the general public on issues relating to drug-impaired driving. Sixteen substances are reviewed, including over-the-counter medications such as dextromethorphan and diphenhydramine; prescription medications such as carisoprodol, diazepam, and zolpidem; and abused and/or illegal drugs such as cocaine, gamma-hydroxybutyrate (GHB), marijuana, ketamine, methadone, and morphine.

Available on the web at <http://nhtsa.gov/people/injury/research/job185drugs/index.htm>.

*State of Knowledge of Drug-Impaired Driving* (DOT HS 809 642, National Highway and Traffic Safety Administration).

This publication examines the current state of knowledge about drug-impaired driving. The review covers a broad range of research, including the detection and measurement of drugs in drivers, experimental research on the effect of drugs on the performance of driving-related tasks, drug prevalence in various populations of drivers, drug-crash risk, and countermeasures for drug-impaired driving. The review covers scientific literature published since 1980.

Available on the web at <http://nhtsa.gov/people/injury/research/StateofKnowledgeDrugs/StateofKnowledgeDrugs/index.html>.

*The Feasibility of Per-Se Drugged Driving Legislation* (The Walsh Group, Substance Abuse Policy Research Group).

This report discusses the feasibility of per se drugged-driving legislation as a strategy to improve traffic safety and deter illegal drug use by drivers. The report examines how these laws might function as a trigger for court-ordered drug treatment and education programs. Current DUID laws are reviewed in the context of legal and legislative issues as well as substance abuse treatment issues.

Available on the web at <http://walshgroup.org>.

*Driving Under the Influence of Drugs (DUID) Legislation in the United States* (The Walsh Group and The American Bar Association's Standing Committee on Substance Abuse).

This publication summarizes DUID laws in 50 states and the District of Columbia. It describes the types of drugs that are prohibited, defenses allowed by statute, specimens to be tested, and sanctions and contestable issues for each state.

Available on the web at <http://walshgroup.org>.

*Developing Global Strategies for Identifying, Prosecuting, and Treating Drug-Impaired Drivers* (Symposium Report, The Walsh Group).

This report summarizes the consensus of experts following the symposium, "Developing Global Strategies for Identifying, Prosecuting, and Treating Drug-Impaired Drivers," held in Florida in February 2004. Nearly 125 experts on DUID from 14 nations gathered to discuss how drug-detection technology can be used with driving-under-the-influence laws to support strategies to reduce drugged driving. The report focuses on three main issues: identification of drugged drivers; enforcement and prosecution; and treatment, education, and prevention.

Available on the web at <http://walshgroup.org>.

## Emergency Toxicology Challenges

*Continued from page 1*

size. The list of these tests, taken from the NACB consensus document, is comprised of quantitative serum and qualitative urine tests (see Tables 1 and 2). For a test to be included on this list, it must have clinical relevance in the following ways: The drug tested for must have a high prevalence in the local area; if misused or abused, it can result in significant toxicity; and the test results must have immediate impact on management decisions. In addition, the analytical method must be easy and have a short TAT so results can contribute to the clinical decision-making process.

It is important that the lab and the ED agree on the definition of TAT. Often, the clinician thinks of TAT as the time interval between ordering the test and receiving the results, whereas the lab usually calculates the TAT from the moment the specimen arrives at the laboratory to the time when the result is reported. Since TAT depends on both laboratory and ED protocols, the laboratory and the ED must jointly decide on a realistic goal for a toxicology test TAT and then organize their protocols to meet it.

### Tests to exclude

Some tests may not be included if the drug causes no significant toxicological sequelae (such as marijuana) or if the local prevalence of abuse of the drug is low (such as phencyclidine or methamphetamine). Unfortunately, there are no easy, rapid assays for drugs such as fentanyl, ketamine, or gamma-hydroxybutyrate (GHB).

### Quantitative serum tests

For a quantitative serum test to be included, a serum drug concentration–drug effect relationship must exist, which is the same requirement as for a therapeutic drug monitoring test. The lab and the ED should develop this list jointly. The typical list, which can vary depending on local prevalence, is shown in Table 1.

The list is less daunting than it appears because

**Table 1. Basic Toxicology Service Serum Quantitative Tests**

Acetaminophen, salicylate
Carbamazepine, valproate, phenobarbital
Theophylline
Digoxin
Lithium
Iron, transferrin (or unsaturated iron-binding capacity)
Ethanol (methanol, ethylene glycol, if available)
Carboxyhemoglobin, methemoglobin by co-oximetry

many of these tests are available in most clinical chemistry laboratories. Tests for methanol and ethylene glycol are more difficult to perform and are generally not available in most clinical toxicology labs; they are prime candidates for being included in the service of a reference or regional toxicology center.

### Screening for acetaminophen overdose

The NACB recommends that all patients suspected of accidental or intentional drug overdose be screened for acetaminophen using a quantitative serum assay (1). The rationale is that specific symptoms are absent during the critical period when intervention with the antidote, N-acetylcysteine, can effectively prevent liver damage. Some experts disagree with this recommendation because of the low prevalence of acetaminophen detection in patients with suicidal intent or altered mental status, or in those who deny acetaminophen ingestion. The issue can be framed in terms of the cost of screening vs. the cost of treating a missed acetaminophen overdose that progresses to fulminant liver failure, but the NACB recommends use of the screening.

### Ethanol measurement and interpretation

A patient's blood or serum ethanol concentration does not necessarily correlate with clinical symptoms because of tolerance and co-ingestion of other toxic substances. Still, a high result can be helpful in assessing the cause of presenting signs and symptoms. Importantly, a negative result leads to a search for other etiologies to explain a patient's clinical presentation. Forensic cutoffs such as those used in driving-under-the-influence tests are not related to clinical intoxication, so tests for legal sobriety should not substitute for clinical decision-making.

Ethanol can be measured in blood, serum, plasma, saliva, or breath, and analysis can be laboratory-based or in a near-patient setting. Ethanol concentrations measured in these different matrices are not the same, but these differences have no clinical significance. Therefore, point-of-care testing and alternate specimen types should be considered for better TAT and lower cost. The lab report should clearly indicate the specimen type used for analysis. The laboratory, moreover, should provide the support for a quality assurance/quality control program to ensure the reliability of point-of-care tests (1, 3).

### Methanol and ethylene glycol

Methanol and ethylene glycol poisoning are associated with significant morbidity and mortality. Fortunately, effective treatments are available, including ethanol infusion and hemodialysis, or administration of fomepizol, a new antidote that is a

specific inhibitor of hepatic alcohol dehydrogenase. Early detection and quantitative monitoring of therapeutic treatment is important, but quantitative tests for these two toxins are generally not available.

Gas chromatography is the preferred method for methanol and ethylene glycol measurements. These direct chromatographic assays are generally not available in clinical laboratories, and due to the low incidence of these poisonings, there are no commercial reagent packs available. "Home-brew" enzymatic assays for methanol and ethylene glycol measurement, performed on automated clinical chemistry instrumentation, have been reported (4, 5).

The enzymatic assay for methanol is based on the coupling of alcohol oxidase (International Union of Biochemistry and Molecular Biology method EC 1.1.3.13) with formaldehyde dehydrogenase (EC 1.2.2.46). Alcohol oxidase converts methanol to formaldehyde (and other lower alcohols to their corresponding aldehydes), but the formaldehyde dehydrogenase makes the overall reaction specific for methanol.

The enzymatic assay for ethylene glycol is based on the action of glycerol dehydrogenase (EC 1.1.1.6). Glycerol dehydrogenase is not specific for ethylene glycol; triglycerides, glycerol, propylene glycol, elevated lactate, and lactate dehydrogenase can contribute to a falsely elevated ethylene glycol concentration (6, 7). Therefore, an elevated ethylene glycol result, particularly one that is slightly elevated, should be interpreted with caution. A negative result, however, has very high negative predictive value for ethylene glycol poisoning. The clinical utility of this enzymatic assay lies in its usefulness as a screening test for eliminating ethylene glycol as the cause of the presenting metabolic acidosis in a suspected drug overdose.

For many clinicians, the "osmolality gap" (the difference between measured and calculated serum osmolality) is a useful alternative (8). At best, this gap is a qualitative indicator of the presence of a large amount of osmotically active particles and its limitations must be understood (9).

### Qualitative urine tests (immunoassays)

The basic level of toxicology service also includes urine tests. Unlike serum quantitative tests, urine tests are qualitative and results do not correlate with drug effects. The urine tests typically are for drugs of abuse (Table 2). The list of tests may vary with the local prevalence of drug abuse and requires periodic evaluation by the ED and the lab. Since these tests are almost exclusively immunoassays, the list is limited to those available in pre-packaged kits.

Several issues are particularly pertinent to the

**Table 2. Basic Toxicology Service Urine Qualitative Tests**

Amphetamines	Opiates
Barbiturates	Phencyclidine
Benzodiazepines	Propoxyphene
Cocaine	Tricyclic antidepressants

use of immunoassays, including immunospecificity, cutoffs, and confirmation testing.

### Immunospecificity

The specificity of an immunoassay helps determine its accuracy; a lack of specificity can lead to false-positive results. For example, phencyclidine false positives can be caused by ingestion of dextromethorphan or diphenhydramine (10, 11), and tricyclic antidepressant false positives can be caused by phenothiazines (12).

An immunoassay with too much specificity can generate false negatives. An example is an amphetamines assay designed to detect amphetamine and/or methamphetamine with a high degree of specificity. This specificity is welcomed by workplace drug testing laboratories because their analytes of interest are amphetamine and methamphetamine only. For these laboratories, an amphetamines immunoassay that does not detect sympathomimetic amines can reduce the number of costly mass spectrometry confirmation tests. In the clinical setting, though, it is preferable to have an amphetamines immunoassay with broader specificity to avoid missing patients suspected of an overdose or abuse of other members of the amphetamines family, such as ephedrine or methylenedioxy-methamphetamine.

Another issue is whether the assay specificity is adequate. Many drugs are excreted into the urine mainly as metabolites; for example, benzodiazepines are excreted as glucuronides. Many benzodiazepines assays have specificity targeted toward the parent drugs rather than their metabolites and record a positive result only if there is a prior hydrolysis step to convert glucuronide metabolites back to the parent compounds. An immunoassay with specificity toward the major metabolite(s) would be preferable.

The specificity of the opiates immunoassay is also a limiting factor. Typical opiate immunoassays target morphine and codeine but usually has sufficient cross-reactivity to detect other semi-synthetic narcotics such as hydrocodone and hydromorphone; oxycodone may not be detected and may require a separate assay. A clinically more appropriate assay would be one that detects "opioids" rather than "opiates." Such an assay would detect not only the opiates but also the non-opiate opioids, such as methadone, meperidine, pentazocine, propoxyphene,

buprenorphine, tramadol, and fentanyl. Due to the lack of structural similarity among these synthetic analogs, however, the development of such an immunoassay is unlikely.

Laboratories should make sure that physicians are aware of the specificity limitations of the assays in use. If the laboratory does not perform confirmation testing and the initial immunoassay result is the final result, the laboratory report should clearly indicate that these positive results are "not confirmed." Laboratories might even consider listing major cross-reacting substances in reports for positive results.

### Immunoassay cutoffs

The immunoassays for drugs of abuse are qualitative assays with assigned cutoffs or threshold concentrations to designate results as positive or negative. Most of the assay manufacturers have adopted the cutoffs used in workplace drug testing, which may be inappropriately high for clinical toxicology. For example, the workplace drug testing cutoff for opiates has been raised from 300 to 2000 ng/mL to reduce the number of positive results due to poppy seed exposure. The lower cutoff may be more desirable for clinical toxicology for determining if the presence of opiates explains the clinical presentation.

Lowering the cutoff increases the detection rate (provides higher sensitivity) of drug exposure among ED patients, but increases the number of cases of clinical false positives, those in which the drugs are not contributing to clinical symptoms (and thus, lowers specificity).

### Confirmation of presumptive positive results

Given the lack of absolute specificity of immunoassays, the standard of practice in forensic toxicology is to perform confirmation testing of positive immunoassay results. In emergency toxicology, the issue involved in confirming presumptive positive immunoassay results is essentially the conflicting need for a stat result vs. the value of a confirmed, but delayed, result. Because interpretation of toxicology results by the ED physician is in the clinical context of patient history, presentation, physical examination, and other clinical and laboratory information, a rapid TAT of an unconfirmed result has more clinical value for managing a suspected drug overdose than a delayed confirmed result. Thus, routine confirmation testing is not necessary in most circumstances. The laboratory report, however, should indicate that the positive result is "not confirmed."

### Conclusion

The basic toxicology service consisting of carefully selected serum and urine tests can be invaluable

to the ED for most poisoning encounters. A better understanding of the issues related to test selection and the limitations of the tests can improve the quality of this essential laboratory service.

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