Chapter 12

Toxicology in the Crime Laboratory

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1. Introduction

Toxicology is the science of poisons and their effect on the human body. To paraphrase Paracelsus (1493–1541), all substances are poisons. The only difference between a remedy and a poison is the size of the dose. Toxicologists, therefore, deal with those substances that may cause bodily harm if taken in sufficient quantity. They deal with substances ranging from illicit street drugs to rat poison to prescription drugs, and everything in between.

Poisons rarely leave unique marks on the body. When searching for a cause of death, the medical examiner cannot determine from an autopsy whether or not drugs were involved. Samples of body fluids are collected and sent to the toxicology laboratory for study by the toxicology staff.

Similarly, erratic driving may be caused by any number of medical conditions, as well as drugs or alcohol. Although police officers are well trained in evaluating individuals in these situations, only the toxicology exam can tell for sure whether a drug is involved.

Most of the work of toxicologists involves the identification and quantitation of poisons in biological fluids and tissues, e.g., blood, urine, and liver. It is the toxicologist who measures the amount of drug or poison in the blood and determines if that amount was sufficient to cause death or impairment.

The scope of the toxicology aspect of a modern crime laboratory largely depends on the organization of the local criminal investigation apparatus. Traditionally, the crime laboratory has been a function of the police department

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and the investigations undertaken by the crime laboratory have focused on crime scene investigation, firearms, tool marks, trace evidence, arson investigation, fingerprints, questioned documents, and similar fields. Most of these traditional crime laboratories also have a forensic chemistry section, the function of which is to identify unknown chemical substances in bulk form, e.g., powders, liquids, pills, and plant material. Toxicology in these laboratories is usually restricted to blood alcohol determinations and the investigation of "under the influence" situations.

In these traditional organizations, investigations involving death fall under the jurisdiction of the medical examiner's office, and any toxicological investigation in these cases is performed by a toxicology laboratory selected by the coroner or medical examiner (ME). In most large cities, the toxicology laboratory is located in the ME's facility and is a permanent fixture of that office. In smaller jurisdictions, there is little need for a full-time toxicology laboratory (or ME for that matter) so any toxicology work is sent to an off-site reference laboratory.

As a result, the toxicology laboratory in many crime laboratories is a rather small unit with limited capabilities. Because many deaths involve criminal activity or criminal investigations, the toxicology aspect requires close coordination between the crime scene investigators, the medical investigators from the ME's office, the investigating police officers, and the ME. Because these entities are generally located at different sites, proper coordination can sometimes be difficult.

Several large jurisdictions in the United States (e.g., Bexar County [San Antonio] and Harris County [Houston] in Texas and Sedgwick County [Wichita] in Kansas) have addressed this problem by creating centralized forensic science centers. These centers contain most of the laboratories involved in criminal investigations thereby allowing consolidation of physical plant requirements, as well as the regular close interaction of the personnel investigating the crime. Thus, in a death case involving drugs or poisons, the autopsy, the firearms examination, the trace evidence from the body, and the toxicology can all be performed in a central location with minimization of chain of custody requirements and the chance for evidence to be lost or mishandled.

No matter which type of organizational structure is in place, the toxicological aspect of the crime laboratory involves two fundamental types of investigation: antemortem and postmortem. Depending on the organization, drug identification may also be performed in the toxicology laboratory, but this is generally not good practice because the possibility of contamination is always present.

In toxicology, as in every other aspect of forensics, a good rule that must always be remembered is that *every time a forensic examination is performed, no matter how simple, someone's life is at stake.*

2. INSTRUMENTATION

As any viewer of the popular television series CSI knows, the modern crime laboratory is packed with highly complex instruments. In toxicology, the primary function of these instruments is twofold: first, to separate the drugs and poisons from blood or tissue and from each other and, second, to identify those drugs and poisons.

2.1. Separation Technology

Modern toxicology laboratories rely extensively on the technique of chromatography and most of the analytical instrumentation found in the laboratory is based, at least in part, on this principal. Chromatography is a separation technique capable of separating minute quantities of chemicals from similar substances. Gas chromatography is performed on a gas chromatograph (GC), employing a tube (column) up to 30 m (100 ft) or more in length. The tube has a very small diameter and the entire 100 ft can fit into an oven the size of a shoebox. The GC is attached to an injector for the introduction of the sample and a detector for the identification of the components of the sample after separation by the column. The sample is dissolved in an organic solvent like hexane or methanol and injected into the GC injector with a small syringe. The injector is quite hot and the solvent and sample are immediately vaporized. The sample is carried through the column by a stream of gas, usually helium, and by the time it reaches the end of the column the components of the sample are separated from each other. Using identical conditions for each injection, the time required for a compound to move through the GC (called the retention time) should be the same each time. Modern GCs are capable of reproducing retention times within a few hundredths of a second. Figure 1 is a chromatogram from an actual urine specimen. The largest peak was identified as metoprolol, a heart medication.

The second most common type of chromatography seen in the toxicology laboratory is high-performance liquid chromatography (HPLC, or sometimes just LC). The principles are the same as for GC, except in HPLC the column is much shorter (usually about 15–30 cm in length), the separation takes place at much lower temperatures (usually employs at least some water as a solvent), and it does not require vaporization of the sample. This low temperature separation is used for compounds that decompose under the high temperature injections of GC or for compounds that dissolve in water but not in organic solvents (e.g., sugars).

Some toxicology laboratories still use thin layer chromatography (TLC), although it is not seen as frequently today as it once was. TLC is similar to HPLC except that instead of a column, a glass plate coated with silica is used. Separation is less efficient than with GC or HPLC and sensitivities are lower.

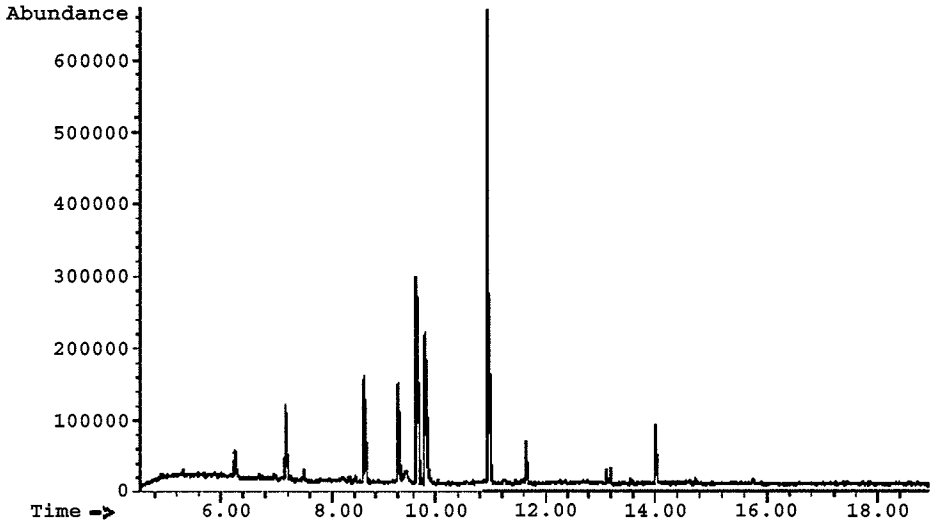

Fig. 1. Gas chromatogram of urine sample containing metoprolol.

2.2. Detectors

No matter which chromatographic technique is used, once the separation is complete, the components must be identified. This identification may be accomplished by a number of different techniques, all of which have their strengths and weaknesses. In principle, any detector may be attached to any chromatographic device. The pairing is usually identified by combining the acronym for each technique employed. The combination of a GC (separation device) and a mass spectrometer (MS, detector) is referred to as a GC/MS or GC-MS. An HPLC using an MS detector is called HPLC/MS or an LC/MS.

Detectors commonly seen in the toxicology laboratory include the flame ionization detector (FID), the nitrogen-phosphorus detector (NPD), the Ultraviolet detector (UV) and the MS. The FID and NPD are used on the GC to provide GC/FID and GC/NPD techniques, whereas the UV detector is employed on the HPLC to give HPLC/UV. The MS detector is seen on both the GC (GC/MS) and the HPLC (LC/MS) instruments. It is even possible to "piggyback" detectors to create hybrids like LC/MS/MS or GC/MS/MS.

The FID responds only to substances that burn. The NPD responds only to substances containing either phosphorus or nitrogen. The MS is the most versatile of the three, providing a "mass spectrum" containing a wealth of information about the unknown substance. As practiced in most toxicology laboratories, the mass spectrum is compared (by computer) to a vast library containing the known

mass spectra of hundreds of thousands of substances and identification is made based on that comparison.

Most toxicology laboratories use the GC/FID for the determination of blood alcohol. There are only a few substances that may be present in the human body that are vapors and that burn, so the GC/FID is a good choice for routine samples. Methanol, ethanol, isopropanol, and acetone (the most commonly encountered "volatiles" in the human body) are easily detected and quantified using this technique. GC/FID can also be used to detect organic solvents such as toluene and xylene.

The major drawback of the GC/FID is the fact that the only information it imparts is that the detected substance burns. The presence of unusual substances has caused laboratories to erroneously report the presence of ethylene glycol *(1,2)*. Although this can lead to inappropriate legal action being taken against the individual, a false identification also may cause a delay in seeking medical help if the misidentified substance is a toxin or an indicator of a metabolic disorder.

Because the vast majority of drugs and poisons contain either nitrogen or phosphorus, the GC/NPD is a good choice for the general screening of toxicological samples. The NPD has excellent sensitivity down to the nanogram level (billionths of a gram), the range in which most drugs and poisons are found in the body.

The disadvantages of the NPD are (1) that it is restricted to compounds containing nitrogen or phosphorus, so it will not detect substances like aspirin or tetrahydrocannabinol (THC, the active ingredient in marijuana) and (2) that there are many nondrug substances that contain nitrogen that may make correct identification difficult. For this reason, GC/NPD is widely used as a "screening" instrument and any identification made by NPD is confirmed by a more precise method.

MSs are the best all-around detectors available today. The amount of information available from a mass spectrum is at least 10 times greater than with any other detector. In routine operation by a trained operator, an MS is capable of definitively identifying thousands of drugs, poisons, and other substances. A good mass spectroscopist can extend that capability multifold and can frequently identify a new, unknown substance even though it has never been seen before. Figure 2 is the mass spectrum of the largest peak visible in Fig. 1. The sample has been treated with a chemical (a derivatizing agent) to enhance its detectability, so the mass spectrum is of the methaneboronate of metoprolol.

Chromatographs, both GC and LC, can handle only one sample at a time. A typical run time for a single sample is on the order of 10–30 min (note that the run time in Fig. 1 is about 19 min) not including sample preparation time which,

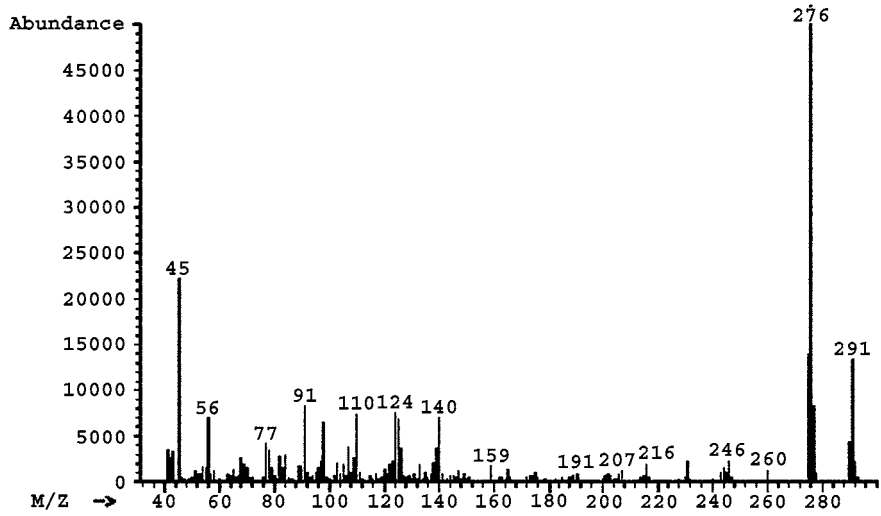

Fig. 2. Mass spectrum of metoprolol methaneboronate.

coupled with interpretation and data analysis, may add several more hours to the analysis. We are not yet to the Star Trek "tricorder" stage, where answers are instantaneously available. As good as the technology and instrumentation is, it must also be remembered that quality control, interpretation, and common sense all play a critical role in the final outcome of a toxicological analysis.

3. Analytical Procedures

One of the fundamental principles of toxicology is that the identification of a drug or poison should be by two separate techniques in order to minimize the chance of error. A common means of accomplishing this is to perform a *screening* test and a *confirmatory* test. A screening test is generally designed to allow rapid, inexpensive testing of large numbers of samples for the *probable* presence of drugs or toxins. Confirmatory testing focuses on those samples which the screening test identified as probables (called *presumptive positives*) and uses an analytical procedure based on a different chemical principle and that is more specific than the screening test.

3.1. Screening Tests

There are two fundamental types of screening test widely used in modern forensic toxicology labs. The first is a chromatographic method utilizing GC/NPD (described under Section 2). The GC/NPD is useful as a broad spectrum

screen, detecting substances that contain phosphorus or nitrogen atoms, including most drugs and poisons.

The second widely utilized screening test is based on the principle of *immunoassay* (IA). Immunoassay tests are based on the antibody–antigen reaction. Basically, the kit contains an antibody to the drug(s) in question and an indicator. If the sample contains the drug, the indicator will change. Some manufacturers use an indicator that results in a color change, others a change in the UV range, and still others use a radioactive tracer. The basic principle is the same in all IAs. IA kits are commercially available for most of the common drugs, such as amphetamines, opiates, barbiturates, benzodiazepines, cocaine, marijuana, phencyclidine (PCP), methadone, fentanyl, LSD, and many more.

One major drawback to IA kits is that they only detect the targeted drugs or drug classes and the sensitivity to specific drugs in a given class varies considerably. For instance, the Syva EMIT (a brand name) opiate assay detects morphine and codeine quite well, but is some 50 times less sensitive to oxycodone (Oxycontin®) even though all three drugs are opiates.

Another potential problem with immunoassays is that the antibodies are not 100% specific. The antibody will frequently detect substances that have similar chemical structures to the target compound. The amphetamine assays sometimes detect pseudoephedrine (Sudafed®) and similar drugs. The PCP assay sometimes reacts to large amounts of dextromethorphan, a cough suppressant.

Overall, because of the cost effectiveness and the ease of automation, IAs are a mainstay in the toxicology laboratory. Owing to the limitations cited previously, it is standard practice that all IA results are verified by GC/MS or a similar specific technique.

4. Premortem Toxicology

Premortem toxicology in the forensic toxicology laboratories is focused on three general areas:

1. Driving under the influence (DUI) of alcohol or of other substances (driving under the influence of drugs [DUID]).
2. Erratic or unusual behavior in nondrivers.
3. Drug testing in probation and pretrial cases.

4.1. Driving Under the Influence

The most frequently performed tests in the modern crime laboratory toxicology department are breath alcohol or blood alcohol concentration (BAC) determinations. Most states have a legal BAC limit for driving of 0.080 g%.

Years of research have shown that there is a good correlation between the amount of alcohol in breath and the BAC. When a Breathalyzer® or similar instrument is used, the instrument automatically converts the breath alcohol level to BAC.

Breathalyzer examinations must conform to specific standard operating procedures, including a 15-min wait prior to the analysis, removal of dentures and other objects in the mouth, certification of the operators and regular calibration of the instrument. The Breathalyzer exams are routinely administered by trained personnel outside of a laboratory with the procedure being fully documented or videotaped.

When blood is used to determine BAC, the toxicology laboratory performs the analysis. There are several techniques used for this analysis, but the most common and one of the most reliable when properly performed is GC/FID.

The proper determination of a BAC begins at the collection site. The individual responsible for drawing the blood must sterilize the venipuncture site with a nonalcohol-containing substance such as iodine or Betadine®. The blood must be collected in a tube containing fluoride preservative. The commercially available gray top Vacutainers® used in many hospitals are appropriate for BAC blood collections. The blood should be stored in a refrigerator after collection with only minimal time at room temperature.

After arrival at the laboratory, storage should again be in a refrigerator until analysis. At that time, a small amount of blood is taken from the tube and placed in a vial, which is then sealed. A small amount of the vapor above the blood is then introduced into the GC. The volatile components are separated from each other and the ethanol identified by the FID and quantitated.

Quality control for DUI analyses should include a minimum of the following:

1. A standard containing all of the common volatiles (methanol, ethanol, isopropanol, and acetone) should be run to show that the instrument is capable of distinguishing between them.
2. A standard curve should be constructed by injecting ethanol standards of known concentration to show that accurate BACs can be determined by the method.
3. A blank should be run to show that the instrument can distinguish between no alcohol and alcohol and also to show that no alcohol was introduced into the samples during preparation.
4. A proper control should be injected to monitor the analysis.

4.2. Driving Under the Influence of Drugs

This analysis is generally performed only when the arresting officer suspects the presence of a substance other than alcohol or when alcohol is suspected but the

GC/FID analysis fails to detect any alcohol. The procedures followed are a simplified version of those employed by the ME's office when investigating the cause of death. In short, the specimen may be analyzed by IA. Alternatively, the blood or urine is subjected to an extraction procedure that removes any drugs from the blood into an organic solvent. The resulting solution is then analyzed by GC/NPD or GC/MS.

If the analysis is by GC/NPD or IA, the sample should be reanalyzed by GC/MS to provide definitive identification of any suspected substances. Once the substance is identified, a known sample of that drug should then be injected to verify that the proper identification was made.

Quality control for DUID analyses is similar to that for DUI cases:

1. A standard containing several common drugs should be injected to show that the instrument is capable of separating the components.
2. A standard curve should be constructed by injecting drug standards of known concentration to show that accurate concentrations can be determined by the method.
3. A blank should be run to show that no drug was introduced into the samples during preparation.
4. It is good laboratory practice to run positive samples in duplicate to show that no errors were made during the measurement of the sample.
5. A proper control should be injected to monitor the analysis.

It must be remembered that many prescription or over-the-counter (OTC) drugs may cause erratic behavior in some situations and any quality analysis will search for and identify those drugs, as well as the common drugs of abuse. For instance, the common OTC allergy medication diphenhydramine (Benadryl®) may cause drowsiness in moderate doses and hallucinations in excessive doses. In some cases, it may be necessary to search for the *absence* of a drug. An individual with epilepsy may have permission to drive when taking the proper medication. Erratic driving or accidents may result from seizures owing to the absence of the appropriate medication.

4.3. Nondriving Situations

A number of situations involving erratic behavior but not involving driving may require toxicological examination. Many jurisdictions have laws against public intoxication or being "under the influence" of drugs. Frequently a crime will involve the use of a drug to incapacitate a victim. The classic example of this is the old "Mickey Finn" used to Shanghai sailors in the 1800s and has evolved to "trick rolls," where wealthy individuals are rendered helpless by the addition of drugs to a drink so that they can be robbed. Drug-facilitated sexual assault uses the same approach with the purpose being rape rather than robbery.

All of these situations require the analysis of blood and/or other body fluids for the presence of drugs. The procedures used are identical to those used in DUID cases.

4.4. Other Premortem Situations

Poisoning by other substances, such as household products, rodenticides, or insecticides, intentional poisoning by prescription medications, and similar situations are investigated by law enforcement officials, but the actual analysis is rarely performed by a crime laboratory. In many cases, the point of first contact is with the emergency department at the hospital and the initial toxicology is done at the hospital laboratory. These hospital laboratories are generally not equipped to perform full forensic toxicology screens, so it is conceivable that many potential poisonings are misdiagnosed. Unfortunately, in many cases the best samples for full-screen toxicological testing from the initial hospital admission are either of insufficient quantity, are destroyed, or are never collected by hospital personnel, so follow-up testing is difficult.

4.5. Interpretation of Results

In any situation involving toxicological analysis, interpretation is critical. The information available from a toxicological analysis depends to some extent on the sample. Blood samples provide more information about which drugs might currently be affecting the individual, whereas urine samples are better at revealing what drugs the individual has been exposed to in the past several days. When interpreted by a forensic toxicologist, blood levels of drugs can be instrumental in determining impairment or even cause of death.

5. Postmortem Toxicology

As a general rule, the most thorough toxicological analyses are performed by toxicology laboratories involved in the investigation of death. The *cause* of death may be almost anything, e.g., blunt trauma, gunshot wound, or heart attack. The *manner* of death may only be natural, homicide, suicide, accidental, or undetermined. Because the purpose of a postmortem examination is to determine the cause and manner of death, the contribution of foreign agents must be evaluated.

Autopsies are performed by forensic pathologists in an effort to unravel the circumstances surrounding a death. During the autopsy, specimens are collected for toxicological analysis. Because of the untidy nature of death, the type of specimens that are available may vary from case to case, so the toxicologist must be able to adapt the analysis to the available specimens. Routinely, the autopsy team will collect vitreous fluid (from inside the eyeball), liver, heart blood,

femoral blood (from the femoral artery in the upper leg), gastric (stomach) contents, and urine. In some cases other tissue specimens are also collected, including kidney and brain.

The specimens collected at autopsy are processed in the laboratory using a variety of extraction procedures designed to separate the drugs and poisons from the body fluids. Once the extractions are complete, any drugs are contained in a relatively clean solution that can be analyzed by one of the methods outlined previously in this chapter. Rare or unusual poisons (ricin, aconitine, tetrodotoxin) or new illegal synthetic drugs may be more difficult to detect and may require specialized methods or instrumentation.

The presence or absence of drugs or poisons can never be determined without performing a complete toxicology screen. The purpose of the screen is to determine whether the death was caused by drug overdose or whether a particular drug was present (or absent, in some cases) in sufficient amounts to alter behavior and thereby contribute to the death. A few examples will help to make the possibilities more clear.

5.1. Example Cases

The cases outlined in the next few paragraphs are fictionalized accounts of the type of situations encountered by forensic toxicologists.

5.1.1. Case 1

A deceased 23-yr-old male is found in a tenement with a tourniquet around his left arm and a syringe in his right hand. Toxicological analysis finds that his blood contains morphine and 6-monoacetylmorphine, both metabolites of heroin. Based on these results coupled with the autopsy findings, the medical examiner determines:

Cause of death:	Drug overdose
Manner of death:	Accidental, suicide or homicide, depending on the remainder of the investigation

5.1.2. Case 2

A fight between two construction workers results in one of the men being killed by blunt trauma to the head by a piece of lumber. Toxicological analysis reveals a significant amount of PCP in the blood of the deceased man. Further investigation reveals that the victim was behaving in a bizarre, aggressive manner and attacked the other man, who defended himself. Based on these results coupled with the autopsy findings the medical examiner determines:

Cause of death:	Blunt trauma of the head
Manner of death:	Accidental

5.1.3. Case 3

A 43-yr-old female with a history of epilepsy is involved in a fatal single car accident, with the automobile hitting a tree. Toxicological analysis reveals no drugs in the blood even though the victim's physician reports that she is supposed to be taking daily doses of phenytoin and carbamazepine to control her seizures. Based on these results coupled with the autopsy findings the medical examiner determines:

Cause of death: Blunt trauma
Manner of death: Accidental

5.2. Limits on Interpretation

Forensic toxicology is not an exact science. The techniques used to detect and quantitate drugs are often accurate, but the exact meaning of those findings is subject to the experience and interpretation of the forensic toxicologist. For many drugs, the amount of drug seen in the blood in one person when the subs-tance is taken as prescribed may be the same as the level in another who suffers severe toxicity or even death. For example, in 13 individuals who were determined to have died from methamphetamine overdose, the blood levels ranged from 90–18,000 ng/mL. However, when methamphetamine is taken for the treatment of obesity, blood levels in 10 volunteers ranged from 62–291 ng/mL *(3)*. An example of a task faced by the toxicologist is the determination of whether a level of 200 ng/mL is lethal or not because it falls in the ranges seen in therapeutic use and in reported fatal overdoses.

Another example of the interpretation of results is seen in the extrapolation of BACs. Almost a century of research on blood alcohol levels has established several well-founded principles. Alcohol is absorbed from the gut in about 0.5–2.0 h. One standard drink will raise the blood alcohol about 0.017 g% (the legal limit for driving in most states is 0.080 g%). The average human will eliminate alcohol from the blood at a rate of about 0.017 g% every hour.

Because these principles are so well established, it is not uncommon for the toxicologist to be asked to extrapolate results.

5.2.1. Case 4

An individual is arrested at the scene of an automobile accident 30 mi from the nearest hospital. The officer responding to the scene suspects that the individual is intoxicated, so he requests that blood be drawn at the hospital for a blood alcohol determination. The accident occurred at 1:00 AM, the officer arrived at 1:45 AM, the ambulance arrived at 1:55 AM, and the individual arrived at the hospital at 2:45 AM. The individual was stabilized and blood was

drawn for the alcohol determination at 3:00 AM. The BAC on the 3:00 AM sample was 0.070 g%. The toxicologist is asked to estimate the BAC at 1:00 AM based on established alcohol metabolic parameters.

The forensic toxicologist uses his or her knowledge of the principles of alcohol metabolism to determine that the BAC was near 0.104 g% and, thus, the individual was probably driving with a BAC above the legal limit. The toxicologist also considers other parameters that may affect that interpretation such as:

- Is the individual average?
- Does he/she absorb and eliminate alcohol at the average rate?
- Was there food in the stomach?

Interpretation of toxicology results is a complex problem. The true meaning of those results should be taken in context with all of the other information obtained from a thorough investigation and should be interpreted only by a competent, trained forensic toxicologist.

6. *Conclusion*

As demonstrated by the cases outlined in this chapter, toxicology is a complex science even in the simple cases. Each case must be approached with a trained, experienced eye. The forensic toxicologist must look at all possibilities, examine each piece of evidence with objectivity, "stand on the shoulders of the giants" who have provided the mountains of pertinent research and to process the bulk of the findings into a logical, coherent explanation. The process is an arduous one, but the search for the truth is never easy and is always fulfilling.

Glossary

BAC: Blood alcohol concentration. Usually reported in gram percent (g%). The legal limit for driving in most states is 0.080 g%.

DUI: Driving under the influence, usually restricted to situations involving driving under the influence of alcohol.

DUID: Driving under the influence of drugs. Usually used for situations involving driving under the influence of any drug other than alcohol.

FID: Flame ionization detector. A device used to detect compounds that have been isolated by a gas chromatograph. An FID essentially detects anything that burns.

GC: Gas chromatography. A separation technique that is used to separate mixtures of chemical compounds. A GC is usually run at relatively high temperatures (100–300°C) and uses helium to help move the unknown

compounds through the system. A GC is coupled to any one of a number of different detectors, including NPD, FID, and MS detectors.

GC/MS: A GC coupled to an MS detector.

HPLC: High-pressure (or high-performance) liquid chromatography. A separation technique that is used to separate mixtures of chemical compounds. An HPLC is usually run at relatively low temperatures and frequently uses aqueous solutions so that the analysis of temperature sensitive and water-soluble substances may be detected. An HPLC is coupled to any one of a number of different detectors, including UV and MS detectors.

IA: Immunoassay. A detection technique relying on the interaction of an antibody with a drug or poison.

LC/MS: Also called HPLC/MS. An HPLC coupled to an MS detector.

ME: Medical examiner.

MS: Mass spectrometer. A device used to detect compounds which have been isolated by a gas chromatograph, a liquid chromatograph (HPLC), or can be used alone to identify pure substances. A mass spectrometer provides a great deal of information to help identify unknown substances, information which may include the molecular weight, a unique mass spectral fingerprint, presence of nitrogen or other halogens, and some information on how the molecule is structured.

NPD: Nitrogen-phosphorus detector. A device used to detect compounds that have been isolated by a gas chromatograph. An NPD essentially detects anything that contains nitrogen or phosphorus and is useful for detecting drugs, poisons, and explosives.

OTC: Over the counter. Drugs that are available without a prescription.

Toxicology: The science of poisons.

UV: Ultraviolet detector. A device used to detect compounds that have been isolated by a liquid chromatograph. A UV detector detects anything that absorbs ultraviolet light.

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