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Forensic Toxicology and Poisoning

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ABSTRACT

Forensic toxicology is a scientific discipline which studies the medical and legal aspects of the harmful effects of a substance on organisms, and by chemical and analytical methods helps to establish facts in forensic investigations. Forensic practice is particularly significant for fatal poisoning, as well as those that may be related to the commission of criminal acts.

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Introduction

Toxicology is the science dealing with properties, actions, toxicity, fatal dose, detection and estimation of, interpretation of the results of toxicological analysis and treatment of poisons [1]. Forensic toxicology deals with the medical and legal aspects of the harmful effects of chemicals on human beings. Poison is a substance (solid, liquid or gaseous), which if introduced in the living body, or brought into contact with any part thereof, will produce ill-health or death, by its constitutional or local effects or both. The definition of poison is vague and unsatisfactory for (1) a substance which is harmless in small quantities may act as poison, and cause death when taken in large amount, and (2) bacterial toxins are not regarded as poisons in ordinary sense of the term. Clinical toxicology deals with human diseases caused by, or associated with abnormal exposure to chemical substances. Toxinology refers to toxins produced by living organisms which are dangerous to man, e.g. poiso-nous plants, the venom of snakes, spiders, bees, etc. and bacterial and fungal toxins.

When considering the criminal act of poisoning from a forensic perspective, it should be noted that the criminal investigation is conducted in two directions [2]. In the first case, it is necessary to find out what kind of damage has been caused and what the poison is doing, and in the other it is necessary to find out who is the perpetrator and which are his or her motives. Poisoning does not always end with death, but a victim of poisoning can have permanent health consequences. This means that criminal investigation of poisoning is a very complex procedure involving experts from different profiles. The surviving victim of poisoning has to resort to medical treatment within which the therapy will depend on the damage to the organism. Depending on the degree of damage to the organism, recovery may take some time.

Suspicion

The following conditions hould arouse suspicion of poisoning [1].

1. The symptoms appear suddenly in a healthy person.
2. The symptoms appear immediately or within a short period after food or drink.
3. The symptoms are uniform in character, and rapidly increase in severity.
4. When several persons eat or drink from the same source of poison in the food or drink at the same time, all suffer from similar symptoms at or about the same time.
5. The discovery of poison in food taken, in the vomit or in the excreta is strong proof of poisoning.

Symptoms

The following groups of symptoms are suggestive of poisoning [1].

1. The sudden onset of abdominal pain, nausea, vomiting, diarrhoea and collapse.
2. The sudden onset of coma with constriction of pupils.
3. The sudden onset of convulsions.
4. Delirium with dilated pupils.
5. Paralysis, especially oflower motor neurone type.
6. Jaundice and hepatocellular failure.
7. Oliguria with proteinuria and haematuria.
8. Persistent cyanosis.
9. Rapid onset of the neurological or gastrointestinal illness in persons known to be occupationally exposed to chemicals.

Poison

There are several definitions of what makes a poison a poison [3]. We already know that a poison is something that causes illness and death. As stated earlier, any substance can be a poison if taken in the right amount. This concept is at the very core of toxicology: The dose is the key to determining the outcome of exposure to a chemical.

Certainly, there are quantitative differences between substances in toxic potential. Cyanide is more toxic than aspirin, but large quantities of aspirin can also be fatal. Some chemicals are more potent when it comes to toxicity and potential as poisons, so we can make judgments about their relative safety or hazardous nature. In addition, people differ widely in their susceptibility to many drugs and poisons, depending on time of usage, genetic predisposition, individual metabolism, preexisting medical conditions, and so on. What is fatal to one person may be much less dangerous to another.

What makes a poison an efficient and deadly instrument of murder? A poison used as a weapon needs to be toxic enough that small

quantities are effective; it should be easily disguised (in water or food); if it is to be administered orally, the taste or odor should be easily masked; it should cause symptoms that are delayed and nonspecific or appear to be due to natural illness; it must be readily obtainable and relatively easy to work with.

Among the killers, poisons and drugs occupy a special place [4]. The role is played by the type of agent, the amount given, the time of entry of the agent into the victim's organism, the pharmacological and pharmaco-dynamic properties of the agent etc. Often poisoning occurs gradually, so death occurs after a shorter or longer period. It is a chronic poisoning. In this way, the clinical picture of a natural disease is better simulated. These agents can be administered openly, without concealment, sometimes by force or threat, but also in an insidious and covert manner, for example by placing them in a favorite dish, replacing the prescribed medicine with poison etc. Putting in food "kills" unpleasant aromas and flavors, especially with the use of strong flavored spices.

Poisoners

Poisons and poisoners can be traced to antiquity and undoubtedly go back to pre-history [5]. Although conceptualising poisons and poisoning is not straightforward, there are accepted definitions. Also, classifications can assist in understanding toxic substances. Certainly, poisons used in homicides in the past and in the present are wide ranging and include: plant, animal and bacterial poisons, drugs, elements their compounds and derivatives, and 'other poisons' such as antifreeze.

This variety and the ubiquitous nature of some poisons such as salt and antifreeze pose challenges for controlling the use of poisons and for detection. For example, lacking odour and taste make certain poisons less detectable. Also, a poisoner's choices are widened by the various routes via which poisons can be administered, and the different ways that they act on the body including mimicking some diseases and illnesses. Such is the nature of poisoning that in comparison with other forms of homicide, it may not even be apparent that any crime has taken place.

Yet such complexities can be reduced by the systematic consideration of poisons such as their characteristics, action, estimated fatal dose, and the treatment of poisoning. The distinction between acute and chronic poisoning can be relevant to understanding the motives of poisoners. Trends suggest that in the past, poisons such as arsenic and cyanide were frequently used while today, narcotics are more commonly detected in poison victims.

There is a difference between motivation and criminal intent [6]. Motivation speaks to the purpose behind an offender's desire to poison someone, which may relate to underlying psychological needs of which the offender may or may not be aware. Intent refers to one's willingness to carry out the deed. There are many ways to find evidence to prove intent, but the best way to start is for the investigating officer to avoid rushing to judgment and to keep an open mind while interviewing witnesses and conducting searches.

Intent can be established by demonstrating the suspect had prior knowledge that a substance was potentially lethal. This information is sometimes provided by witnesses who recall sinister comments made by an offender, or it may be found in poisoning literature the offender accessed or ordered on the Internet. Suspects who decide to procure poisons covertly may unintentionally reveal their identity when they purchase the poison, or they may try to conceal their identity, a sure sign of guilty knowledge.

Establishing the motive for a criminal poisoning can help investigators determine the extent of how many victims an offender has poisoned and where evidence of these crimes may be found. Understanding what drives an offender can help police formulate investigative strategies and guide the search for relevant evidence. Prosecutors may use this information when deciding how to present their case in court. Investigators should be careful to avoid rushing to judgment about motivation. Sometimes, the motivation for a poisoning may appear obvious, but investigation is needed to ascertain the true reason(s) the crime was committed. Investigators should be careful not to accept at face value explanations provided by a suspect regarding his or her motivation, as this might be an attempt to mislead the investigation.

Crime Scene

It may seem redundant, but crime scenes exist whenever a crime has been committed [7]. It could be at the location of the "boiler room" telephone scam artist or at the home or office of a person sending threatening hate mail or e-mail, but more than likely the professional investigator will encounter crime scenes where a violent act or financially significant theft has occurred.

Investigations at crime scenes can generally be broken down into five areas:

1. Security and safety,
2. Documentation and collection of evidence,
3. Detention, segregation and interview of witnesses, suspects, or persons already under arrest,
4. canvass for additional witnesses, and
5. Exiting.

It is clear from the preceding cases that the crime scene must be conceptualized [8]. Once its position and boundaries are defined, the scene must then be made secure, the physical evidence discovered and collected, and the crime reconstructed (if needed). Had the correct procedure been followed in the ambush investigation-boundaries defined and protected, and the area within them recorded-there would not have been a question of whether there were one or three sites or perpetrators. In this case, ensuring that the boundaries were "properly protected" would have meant cordoning it off until daylight, when the cursory search in the dark turned up little evidence. In all cases it means excluding reporters, government officials, even superior police officers who are not directly involved in the investigation; not to mention local residents and curiosity seekers. In any ambush investigation it is important to establish where the perpetrator was concealed and to record details of activity within that area. Afterward, it can be searched for other physical evidence, such as spent cartridges, food containers, or discarded cigarettes and matches. In this ambush, a thorough search conducted the next morning led to the discovery of a spent shell casing (from a 30.06 rifle) that had been overlooked.

An offender brings physical evidence to the crime scene: in burglary cases, tools needed to break into the premises or a safe; in robbery or homicide cases, a weapon used to threaten, assault, or kill; in arson cases, a container of flammable fluid; in technology-related cases, a hard drive or the messages on a cell phone. During the commission of a crime, an offender may inadvertently leave evidence behind (in situ): fingerprints, tool marks, shoe prints, blood-spatter patterns, spent bullets, fired cartridge casings.

When searching the crime scene (and afterward), an investigator's observations and interviews might develop intangible evidence. For example, the emotional factors involved in motivating and carrying out a homicide become manifest as intangible evidence through an assessment of such observations as: grossly excessive stab wounds, bones unnecessarily broken, parts of the body cut

out or cut off, or the choice and kind of lethal weapon employed. A shrewd appraisal of intangible evidence (as in psychological profiling) can provide leads to possible perpetrators. Interviewing also can be used to develop intangible evidence. Witnesses or victims may report on the language used during the commission of the crime. How exactly did the robber convey intentions and demands? What did the rapist say, before, during, and after the assault? Because such commands and comments are elements of the perpetrator's modus operandi, they have investigative and probative value.

Evidence

Evidence can be defined as anything legally submitted to a tribunal or trier of fact (judge or jury) that tends to prove or disprove a fact in question [9]. In a very practical sense, the two fundamental questions to be answered in any criminal investigation are what happened and who did it? Many specifics must absolutely be deduced to ultimately answer these questions with a reasonable degree of certainty, but anything that assists the investigator and, in turn, the trier of fact in answering these questions can be considered evidence. The term anything is, of course, very broad, but as we will discuss, the word evidence encompasses a broad range of objects, information, and observations.

Evidence is generally categorized as one of four types: testimonial, documentary, demonstrative or physical [10]. Testimonial evidence is information obtained through interviewing and interrogating individuals about what they saw (eyewitness evidence), heard (hearsay evidence) or know (character evidence). Documentary evidence typically includes written material, audio recordings and videos. Demonstrative evidence includes mockups and scale models of objects or places related to the crime scene and helps juries visualize more clearly what they are unable to view personally. Occasionally, however, juries are taken to the crime scene if the judge deems it vital to the fair processing of the case, but this is expensive and time-consuming. Most commonly, investigators deal with physical evidence. Physical evidence is anything real-that is, which has substance-that helps to establish the facts of a case. It can be seen, touched, smelled or tasted; is solid, semisolid or liquid; and can be large or tiny. It may be at an immediate crime scene or miles away; it may also be on a suspect or a victim.

Some evidence ties one crime to a similar crime or connects one suspect with another. Evidence can also provide new leads when a case appears to be unsolvable. Further, evidence corroborates statements from witnesses to or victims of a crime. Convictions are not achieved from statements, admissions or confessions alone. A crime must be proven by independent investigation and physical evidence.

Forensic Toxicology

Forensic toxicology is a discipline that involves the identification and quantification of drugs and other poisons or toxins in body tissues, including blood [11]. "Screening tests" are said to be "qualitative," where a test is either positive (indicating that the drug/toxin is present) or negative (indicating that the drug/toxin is not present). When specific levels of drugs or toxins are determined, the tests are said to be "quantitative." For a result to have forensic significance, two separate methodologies are required, an initial (screening) test, and a confirmatory (quantitative) test. Another function of some toxicology laboratories is drug identification.

Forensics is the application of many different fields of science to the legal system [3]. This may involve criminal activity or civil actions. Forensic toxicology is a field of forensics that applies the principles of toxicology to legal purposes. It includes three major categories: postmortem toxicology, human performance toxicology, and forensic drug testing. Early forensic toxicology dealt with only postmortem investigations, but today forensic toxicologists are involved in a variety of cases. All work or opinions of the toxicologist must withstand the scrutiny of a court of law. Reports and findings may be introduced as evidence and the toxicologist is often asked to testify. A forensic toxicologist must consider all aspects of an investigation, such as any possible symptoms, evidence found at a crime scene, or any relevant information related to the history of a case. Armed with this information and samples for analysis, the forensic toxicologist determines what toxic substances may be related to the case and at what concentrations they are present. He or she must then interpret the probable role that a drug or poison played in the case.

The term 'forensic toxicology' covers any application of the science and study of poisons to the elucidation of questions that occur in judicial proceedings [12]. The subject is usually associated with work for the police, the coroner and the criminal law courts. However, the analysis and identification of medicines and the maintenance of agricultural, industrial and public health legislation (to ensure clean air, pure water and safe food supplies) are also aspects of forensic toxicology, although usually associated with civil courts rather than criminal courts. Like the forensic toxicologist in criminal cases, analysts employed in these civil areas may at times find their work subject to severe public scrutiny in a law court, and both groups should be aware of the strengths and limitations of each other's methodology.

Accidental self-poisoning and attempted suicide cases are generally the responsibility of the clinical toxicologist or the hospital biochemist, who may work in conjunction with a poison control centre. A small proportion of these cases is referred to the forensic toxicologist, either because of an allegation of malicious poisoning or because the patient dies and a coroner's inquest is ordered.

The toxicologist is concerned with the identification and recognition of poisons, with their physiological effects on humans and animals, and with their antidotes [13]. Crime laboratories usually provide some toxicological support but vary considerably in the amount and type that they can furnish. However, full toxicological support is always available through a combination of hospital, medical examiner, coroner, and criminalistics laboratories. Crime laboratories can direct police to local facilities.

Because the uncontrolled use of drugs has become a worldwide problem affecting all segments of society, the role of the toxicologist has taken on new and added significance [14]. Toxicologists detect and identify drugs and poisons in body fluids, tissues, and organs. Their services are required not only in such legal institutions as crime laboratories and medical examiners' offices; they also reach into hospital laboratories—where the possibility of identifying a drug overdose may represent the difference between life and death—and into various health facilities responsible for monitoring the intake of drugs and other toxic substances. Primary examples include performing blood tests on children exposed to leaded paints or analyzing the urine of addicts enrolled in methadone maintenance programs.

Testing

Analytical methodologies used by forensic laboratories vary, but most use a combination of immunoassay and chromatographic methods to identify and quantify drugs and poisons [15]. Alcohol is routinely analyzed in forensic laboratories by gas chromatography. Enzymatic and colorimetric methods are occasionally used as an initial or screening test. Carbon monoxide testing can be tested

by spectrophotometric differentiation between oxyhemoglobin, reduced hemoglobin, methemoglobin, and carboxyhemoglobin. Carbon monoxide analysis is also done by a diffusion and colorimetric method, and by gas chromatography. Cyanide testing is done by diffusion and by colorimetric quantitation. Immunoassay testing can be used for screening both blood and urine specimens for a variety of drugs and drug classes. Opiates, amphetamines, barbiturates, benzodiazepines, and cocaine metabolites are examples of immunoassay testing. Chromatographic methods such as thin layer chromatography (TLC), gas chromatography (GC), high performance liquid chromatography (HPLC), and chromatography interfaced with mass spectrometry (GC/MS, GC/MS/MS, LC/MS, LC/MS/MS) are used for qualitative analysis and quantitative testing of specimens for drugs and poisons. For heavy metal poisoning, specimens of arsenic, mercury, cadmium, lead, and so on can be analyzed by atomic absorption spectrophotometry.

For the results of toxicology testing to be scientifically valid, the methods and procedures used for analyzing specimens must be validated to ensure the accuracy, precision, and specificity of the method. The process includes identifying limits of detection and lower and upper limits of quantitation. The method of validation tests for possible interfering substances, evaluates carryover from previously tested samples. The method must be able to provide accurate results for reference specimens. The forensic toxicologist must understand the importance of validation and be able to evaluate the effectiveness of the process. Results from scientifically valid methods are necessary to support medico-legal circumstances of criminal or civil cases.

Conclusion

Forensic scientists collect, store and analyze scientific evidence during an investigation. While some forensics travel to the crime scene to collect the evidence themselves, others take on a laboratory role, performing analyzes on cases brought to them by other individuals. In addition to their laboratory role, forensic scientists testify as expert witnesses in criminal and civil cases and they can work for the prosecution or for defense. Although any area could technically be forensic, certain sections have evolved over time to cover most forensically related cases.

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