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Forensic Toxicology and Legal Investigation of Death, Poisoning, and Drug Use

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Abstract

Forensic toxicology is a branch of pharmacology, the study of the effects of carious concentrations of drugs and poisons on human bodies. Today, forensic scientists have become better appreciated in their role of determining whether a certain death was caused by the use of a certain drug. Forensic medicine serves as the basis for the connection between forensic toxicology and the legal system. There is a high prevalence of drug-related deaths all over the world as drugs and poisons have been proven to be among the top ten causes of death in the world. Approximately 275 million people were estimated to have used an illicit drug at least once in 2016. Drugs and poisons affect body organs and thus these organs are extracted by the forensic toxicologists for tests to determine the actual cause of death or poisoning in cases where the affected individual has not yet died. The most important samples that the forensic toxicologist should collect for proper examination include gastric contents, oral fluid, exhaled air, nails, hair, urine, plasma or serum, and blood. Forensic toxicologists should look for procedures that will make the investigation process as reliable as possible.

Keywords: forensic toxicology; drug-related deaths; postmortem; drugs; poisons.

1. Introduction

Forensic toxicology is a branch of pharmacology, the study of the effects of carious concentrations of drugs and poisons on human bodies [1]. A poison is defined as any substance that causes negative effects to the body when administered, either by design or accident, to any living organism [2].

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For a long time, there has been confusion concerning what forensic toxicology should entail and most forensic toxicologists were referred to as “postmortem chemists”. However, today, forensic scientists have become better appreciated in their role of determining whether a certain death was caused by the use of a certain drug [3]. Pharmacology is a wide field and involves many disciplines while forensic toxicology is mainly concerned with the role of drugs and poisons as causes of death and/or impairment [1]. Forensic toxicology also has branches that involve the detection and interpretation of poisons and drugs in body fluids and tissues.Most importantly, the analysis and interpretation of the effects of toxins and drugs must be done in way that it can be presented in a court of law as evidence.There are several scientific procedures that are applied in the detection and interpretation of drugs and poisons on the body such as Tandem Mass Spectrometry Methods and advanced immunoassays.Moreover, recent advancements in pharmacogenomics and genetic autopsy will improve the interpretation of lethal and therapeutic doses of substances based on the interplay of genotypes and phenotypes on the metabolic processes of an individual [4].

2. Connection between Forensic Toxicology and the Legal Investigation of Death, Poisoning, and Drug Use

Forensic medicine serves as the basis for the connection between forensic toxicology and the legal system.Reports from postmortem toxicological investigations that indicate the possibility of poisoning can be used as evidence in a court of law [5].Therefore, forensic toxicology is an important branch of the legal system especially in the investigations of homicides and other deaths due to poisoning.Toxicological analysis is integral to death investigations and forensic toxicologists seek to solve cases where there are deaths after a sudden and unexpected change in the condition of a subject after the administration of a chemical substance or poison [6].

Forensic toxicologists should understand the effect of various substances and poisons on body organs and fluids.Most forensic toxicologists are drawn from the fields of medicine, pharmacy, biochemistry, and chemistry because these fields involve the study of chemical substances and/or the human body [5].However, when called upon to testify, the forensic toxicologist should refrain from using complicated jargon, and testify concerning the findings in a way that is understandable to a lay person with no special training in toxicology.Forensic toxicologists should retain the specimens until the termination of a case in court because the importance of a toxicological investigation is revealed days or weeks after a death due to poisoning.Forensic toxicologists should also collect the proper specimens because poisons and drugs have different effects on different body organs and body fluids [6].

A research by Gruszecki and his colleagues revealed that individuals whose cause of death was unknown had a 5.3 likelihood to have a history of drug abuse than to be cholecystitis patients [7].Another study by Gruszecki and his colleagues revealed that chronic drug abuse is responsible for sudden deaths [8].The results of the study indicate that undetermined sudden deaths have a higher probability (4.2 times) of being due to chronic drug abuse than due to automobile collisions.Forensic toxicologists are thus required to testify in cases where sudden and unexplained deaths are suspected to have been caused by drug abuse.This is because decedents that have a history of drug abuse have a higher risk of dying because of their chronic deaths even in the absence of toxicological and anatomical data from autopsies to account for the cause of death [7].

Ellis, McGwin, Davis, and Dye proved deaths caused by drug poisoning even in the absence of evidence from autopsies. These scholars investigated whether heroine toxicity could be responsible for deaths in which 6-acetylmorphine (6-AM) is not detected during toxicological analysis.In the study, M/C ratio in drug users is used as the evidence of death due to heroin toxicity.The study concluded that heroin toxicity is responsible for deaths even in cases where 6-AM is not detected in the blood provided that the M/C ratio in the IV is greater than one [9].

3. Drug Related Deaths

There is a high prevalence of drug-related deaths all over the world as drugs and poisons have been proven to be among the top ten causes of death in the world. According to United Nations Office on Drugs and Crime, approximately 275 million people were estimated to have used an illicit drug at least once in 2016 [10].On average, each individual in the world above 15 years of age drinks 6.2 liters of absolute alcohol every year. Every year, 3.3 million deaths are caused by the use of alcohol [11].Cannabis is the most abused drug according to estimates of the World Health Organization. In 2016, approximately 192 million people used cannabis throughout the world[12]. Other drugs that have been linked with deaths include cocaine, heroin, and other narcotics. Each drug will be considered individually as a potential cause of drug related deaths.

3.1 Alcohol

Alcohol consumptions is one of the leading causes of death throughout the world. In the United States, approximately 88,000 people (26,000 women and 62,000 men) die from alcohol-related conditions. This makes alcohol the third most potent preventable causes of disease in the United States [13].It is estimated that the average alcohol consumer in the United States shortens their life by up to 30 years [14].In 2015, 47% of the 78,529 liver disease deaths of persons above the age of 12 years in the United States were caused by alcohol [13].Alcohol consumption has been linked with higher risks of contracting cardiovascular diseases [15]. However, this study by Xi and his colleagues also revealed that light and moderate consumption of alcohol can reduce the risk of contracting cardiovascular diseases. The cardiovascular diseases only arise when there is excessive consumption of alcohol [15].Consumption of alcohol also increases the risk of contracting some types of cancer such as breast, liver, larynx, pharynx, esophagus, and the mouth [13].Therefore, it is important to understand how alcohol consumption becomes a leading cause of death by investigating the substances in alcohol that are poisonous at higher concentrations and their effect on different body organs. This will be covered later in the article.

3.2 Cannabis

Cannabis use has also been linked to deaths though there is insufficient data to prove this hypothesis [16]. Between 1993 and 2017, cannabis use has been responsible for 391 deaths, with 29 of these deaths occurring in 2017 [17].However, cannabis use does not cause as many deaths as some other substances such as alcohol and tobacco. There is insufficient data to link cannabis smoking and lung cancer [16]. Also, the use of cannabis as a secondary drug is not linked with higher risk of deaths among patients with alcohol, cocaine, or opiate

dependence. The people with alcohol, cocaine, and opiate dependence who also use marijuana will not die faster because of their dependence of marijuana as a secondary drug [18].Therefore, it is necessary to understand some of the substances contained in cannabis for people who use marijuana as a primary drug. It is also necessary to ascertain the effects of substances in marijuana on the human body to ascertain the actual effects of substances in marijuana on the human body to determine accurately whether cannabis use is a cause of death.

3.3 Cocaine

Cocaine is an addictive stimulant drug that is extracted from the Coca plant that is native to the South American continent.Cocaine is used both for medicinal purposes and as a drug though recreational use of the drug is illegal in the United States [19]. A study by the Center for Disease Control and Preventioncarried out between 2015 and 2016 across 31 states and Washington D.C. revealed that the death rate because of cocaine-related overdose increased by 52.4% in the period [14].

Lucena and his colleagues investigated the role of Cocaine in causing sudden deaths in South-West Spain. There are approximately 12 million consumers of cocaine in Europe and cocaine accounts for the most emergency department visits in European hospitals among illicit substances.The study focused on the prevalence, toxicological traits, and causes of death in cocaine-related deaths. This study revealed that cocaine related deaths were rampant indicating that abuse of cocaine is a cause of death [20].A study by Qureshi, Chaudhry, andSuri explored the relationship between cocaine abuse and the probability of contracting cardiovascular diseases that lead to death.The study revealed that cocaine abuse is not linked to higher risks of contracting cardiovascular diseases. However, the study still established that cocaine overdoses are still a leading cause of drug related deaths [21].

Another study by McGallJones, Baldwin, and Compton revealed that synthetic opioids, opioids, and heroin have increased the numbers of cocaine-related deaths. The results of this study imply that people who abuse cocaine alongside heroin and fentanyl are at a higher risk of dying from cocaine overdoses.These scholars attributed the increased death rate due to using cocaine alongside heroin to the growing demand and supply for heroin and illegally manufactured fentanyl in the U.S. [22].Therefore, the study of the effects of cocaine on the body and the dosages that are considered lethal is important to the forensic scientist. This is due to the huge number of deaths that occur each year because of cocaine related causes.

4. Body Fluids and Body Organs Important to the Forensic Toxicology Process

Drugs and poisons affect body organs and thus these organs are extracted by the forensic toxicologists for tests to determine the actual cause of death or poisoning in cases where the affected individual has not yet died. The most important samples that the forensic toxicologist should collect for proper examination include gastric contents, oral fluid, exhaled air, nails, hair, urine, plasma or serum, and blood.Relevant quantitative analysis is only possible in tests that involve blood, serum, or plasma that has been obtained from the specific body organ that is undergoing toxicological tests to ascertain the cause of death or poisoning.There are several procedures that can be used to collect relevant samples from corpses to enable the investigation process to begin [23]. These

methods either involve collection of in vivo or postmortem samples.

4.1 Collection of In Vivo Samples

In vivo samples are collected while the person is still alive. Therefore, in vivo samples are collected on living people to ascertain the cause and extent of poisoning to determine the best treatment plan to implement [23].The collection of some of the in vivo samples shall be discussed in this article.

4.1.1 Exhaled Air

Exhaled air is useful for both qualitative and quantitative analysis especially for volatile compound analysis for substances such as ethanol and in cases of carbon monoxide poisoning [24].

4.1.2 Oral Fluid

The forensic toxicologist collects 1-2 ml of oral fluid in a plastic container with a preservative. The sample should be diluted because of the presence of preservatives, buffers, and other reagents in the collection container. To reduce contamination, the donor should be observed for a 10-15 period in which they will not be allowed to eat, drink, or smoke. Rinsing the mouth is unnecessary because collection of samples does not lower the concentration [25].

4.1.3 Breast Milk

30 ml of breast milk is collected in a container with no preservative. It is usually available in large amounts but there is a problem with collecting samples of breast milk because many women consider it to be an invasion of their privacy. Breast milk is mostly used to estimate the amount of contaminants in the adipose tissue. Samples normally contain high concentrations of lipids and proteins[26].

4.2 Collection of Post-Mortem Samples

Postmortem samples are collected on a dead body. Therefore, these samples are drawn to ascertain the cause of death as forensic toxicologists attempt to find the poison responsible for the death [23]. Various organs and fluids are extracted for the postmortem toxicological investigations and some of them include cardiac blood, blood clots from epidural, subarachnoid, and subdural spaces, blood collected from abdominal and thoracic cavities, pleural effusions, lung, liver, kidney, and heart. The extraction of samples from cardiac blood, liver, and kidney shall be described in this article.

4.2.1 Cardiac Blood

Cardiac blood is always collected for forensic toxicological investigations. 30ml of cardiac blood is collected and stored in a plastic container with screw cap. The plastic container may or may not contain a preservative. Mostly used for qualitative analysis and quantitative analysis should only be used in cases where it is absolutely necessary. Most experts prefer to collect cardiac blood from the right chamber [23].

4.2.2 Liver

The liver is always collected for postmortem toxicological investigations. Normally, 30g of the liver is collected and stored in a plastic container with a screw cap that lacks a preservative. The deep right lobe is preferably collected because it lacks contaminants from gastric contents that are present in the left lobe. Also, the forensic toxicologist should ensure that the gall bladder is separated from the liver during collection. High protein and lipid content of liver tissue may interfere with toxicological investigations [23].

4.2.3 Kidney

The kidney is normally collected for ethylene glycol analysis or for the investigation of the presence of heavy metals that are concentrated in the kidney during excretion. The kidney is only useful for qualitative analysis. Normally, 30g of the kidney is collected in a plastic container with a screw cap without preservatives. The capsule is removed before the kidney is stored in the plastic container. The kidney is important in toxicological investigations that lack urine as a specimen [23].

5. Constraints/Limitations of the Study

The main limitation of the study was that it was dependent on the findings from other studies. The researchers did not ascertain whether the results and findings of the researches that are described within the article are true as they did not conduct the procedures outlined. Therefore, the study is a reflection of the work of the previous researchers.

6. Conclusion

Forensic toxicology is a wide field that encompasses many disciplines. Most importantly, all these fields converge at the intersection of drugs and poisons and their effects on the human body. Drugs and alcohol cause millions of deaths every year throughout the world. It is therefore necessary to understand the effect of drugs on the body, especially the effect of these substances on body fluids and organs. However, there are defined procedures for the extraction of in vivo and postmortem samples before the toxicological examination begins. Forensic toxicologists should adhere to these rules to ensure the reliability of their findings. With the rise in the number of people that use recreational drugs and alcohol, the number of deaths related to alcohol and drugs is also likely to increase. Therefore, forensic toxicologists have a more important role today because they will be called upon to ascertain deaths caused by alcohol and drug use.

7. Recommendations

The article recommends forensic toxicologists to gather more data concerning the analysis of poisons and toxins in internal organs. There are many classes of poisons that are continuously being invented. Therefore, there should be more research on the effect of toxic substances that can be ingested together with the drugs that have been associated with different levels of poisoning.

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