

EDITORIAL

FORENSIC TOXICOLOGY: A RETROSPECTIVE

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Forensic toxicology is the science of determining poisons and xenobiotics in mainly, but not limited to, biological matrices. It has been a crucial component of criminal justice systems for centuries, assisting in the analysis and interpretation of drugs, poisons, and other chemicals in biological samples to determine their role in injury, death, or criminal activity.

Its evolution from rudimentary practice to the sophisticated, highly specialised discipline it is today is a testament to advances in science and technology, as well as an increased understanding of biology, pharmacology, and drug science. This retrospective aims to explore the historical development, key advancements, challenges, and future directions of forensic toxicology.

The roots of forensic toxicology can be traced back to antiquity, where the use of poisons for both medical and criminal purposes was well-documented. In ancient Rome, poisoning was a common method of assassination and political intrigue, and the early practices of poisoning detection were basic but nonetheless important. However, the scientific discipline of forensic toxicology emerged during the 19th century, coinciding with the rise of modern chemistry and advances in analytical techniques. One of the earliest milestones in the field was the development of chemical assays for the identification of poisons. In 1813, chemist Mathieu Orfila, often considered the father of forensic toxicology, published '*Traité des Poisons*' (or '*Treatise on Poisons*'). This laid the groundwork for systematic toxicological analysis in criminal investigations through laboratory experimentation. It also emphasised the importance of scientific rigor in forensic investigations and ensured that chemical

analyses became a routine part of forensic medicine.

However, it is Paracelsus who is considered the founder of modern toxicology. It was Paracelsus who claimed "*sola dosis facit venenum*" ("only the dose makes the poison"). This has possibly had the biggest impact on the interpretation of toxicological findings.

Today, toxicological investigations serve several purposes in criminal investigations, which can be summarised in two main categories: ante-mortem and post-mortem investigations. Ante-mortem investigations involve criminal investigations of cases involving drug-facilitated crime and investigations of workplace- or driving-impairment. Investigating driving under the influence, whether under the influence of alcohol or drugs, remains a challenge with the continued decriminalisation and legalisation of substances, e.g., cannabis, in several countries. For the investigation of ante-mortem cases, a toxicologist's work will focus on determining the presence of substances that may have had a psychological effect on the individual involved. In post-mortem settings, the toxicologist's role is to aid the forensic pathologist and inform the inquiry into an individual's death. Determining the drug, often also the concentration of the drug present in the system at the time of death, may aid the forensic pathologist in determining the cause and category of death.

When it comes to the interpretation of toxicological results, antemortem interpretation poses an added challenge as outcomes will have an impact on an individual's life, which is not necessarily pertinent to post-mortem investigations. Conversely, post-mortem toxicology is based on several assumptions and has an added layer

of difficulty as the biological samples available for analysis are not always 'clean' and representative. These post-mortem challenges may include drug concentration variability based on the sampling site, post-mortem redistribution, and *in-vitro/in-vivo* drug changes.

Understanding the challenges that are associated with the interpretation of drug concentrations, along with reporting the results, leads us to consider some of the other factors that will influence the workings of a forensic toxicologist.

One very clear contest, which the field has seen increase steadily over the past years, is the increase of poly-drug use in the drug-using communities. This leads to an increase in the complexity of the cases presented, as a toxicologist must consider drug interactions and the pharmacokinetic and pharmacodynamic effects of the multitude of drugs present.

This is further complicated by the emergence and continued influx of new, primarily synthetic, drugs. These new psychoactive substances present unique challenges to the laboratory and toxicologists as they are not often well-documented, and methods for detecting them may not be readily available. In the past, forensic toxicology has relied on pharmacokinetic models to understand how substances are absorbed, distributed, metabolised, and eliminated in the body. With further synthetic compounds inundating the market, it is, therefore, vital to study these at a pharmacological level. We should further consider integrating molecular biology into forensic toxicology to uncover new avenues for research and understanding. The field of toxicogenomics, studying the genetic response to toxic substances, holds the potential to improve the understanding of individual susceptibility to toxins. Additionally, the further use of biomarkers of exposure and effect can be increasingly useful for detecting and quantifying substances in forensic investigations. Finally, the constantly evolving landscape of drug use requires toxicologists to stay up to date with published literature on new substances and expand current or

develop new detection methods. Associated with this is the potency of these new substances, which may be much greater than that of the "classical" drugs of abuse, which require sensitive instruments to determine very low concentrations of drugs within a biological matrix.

So, what does this then mean for the future of forensic toxicology? Forensic toxicology is poised for continued innovation. We monitor advances in molecular biology, genomics, and machine learning to further enhance the precision and scope of toxicological analyses. Additionally, as global awareness of new psychoactive substances and their potential harms grows, the field will need to continually adapt rapidly, developing methods to detect and understand these substances. We hope to work more closely with law enforcement and public health, as there is a growing emphasis on collaborative approaches to preventing and addressing toxicological issues in society. This should also include research on the social and psychological impacts of drug and alcohol use, improving the education and training of toxicologists to ensure they are equipped to handle the increasing complexity of modern forensic investigations.

We can see that the field of forensic toxicology has come a long way from its origin to its present role as an integral part of criminal investigations. The evolution of analytical techniques, alongside a deeper understanding of pharmacology, has enriched the field's capacity to detect, analyse, and interpret toxic substances with extraordinary accuracy. Whilst challenges remain, such as the rapid influx of new drugs of a fleeting nature and the complexities of interpretation, future advancements in technology and research promise to further refine the field, making forensic toxicology an even more indispensable tool in forensic investigations.

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