



The Importance of Analytical Chemistry and Instrumental Developments for Medico-Legal and Forensic Applications

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The pivotal role of analytical chemistry in the medico-legal and forensic applications is explored in this article.

Forensic medicine is the branch of medicine that deals with applying medical knowledge to the widest legal fields. Currently, more attention is paid to the medico-legal field in the realm of crime reporting. Crime news is commonly read every day, from violent

crimes committed under the influence of psychoactive substances to family feuds ending in tragedy. The medico-legal field also includes unexpected deaths where the causes are difficult to identify, and deaths in road accidents where substance abuse



is investigated. The role of the medical examiner is central to the investigations that are performed to evaluate and identify responsibilities in criminal acts.

It is important to highlight that the work of the medical examiner must be integrated and supported by many other professionals. Medico-legal and forensic investigations require a high-level of collaboration between medical examiners and other specialists, including analytical chemists, to maintain and improve the investigation techniques.

The analytical chemist plays an important role in providing precise and exact data (1) regarding both targeted and untargeted quantitative analyses in complex matrices (2) to support medico-legal assessments. Additionally, as a result of the strict legal limits and requirements, it is mandatory to have methods that can quantify with accuracy drugs, substances of abuse, legal and illicit analytes, markers and metabolites, as well as new psychoactive substances (NPS) that are increasingly found in circulation, not easily detected, or not detectable at all, with a traditional screening method.

In this scenario, all the technologies necessary to respond to the needs of the forensic and medico-legal fields are currently available and well-known by analytical chemists. While new methods, new protocols, new materials, and above all, new sample

preparation-instrumental configurations, are increasingly necessary and essential (3–5).

Therefore, the possibility of fully exploiting the potential and flexibility of analysis of the current instrumentation (and software) is central. In this context, those who develop the analysis methods should always consider the possibility of implementing their procedures with new analytes to “keep pace” with the discovery of new substances found during seizures and during police operations.

The increase in biological matrices used in the forensic field allows for the analysis of bodies in a state of decomposition and at risk of contamination. For example, the vitreous humour is not affected by external pathogens in many cases. Additionally, in criminal proceedings, the judge often requires analysis of the defendant to ensure the presence or absence of psychoactive substances. For this reason, it is simpler using matrices such as saliva, which is easy to sample and matches with patient’s compliance (2,3,6).

Another element to highlight is how often in the forensic medical field it is necessary to be able to evaluate in situ the numerous elements that can clarify the dynamics of the event using portable analysis procedures. This represents an additional challenge for analytical chemistry to respond to continuous technological and methodological developments. Additionally, the quality of the

data is also important in this field because the measurement is often not repeatable. The analytical panorama is developing increasingly accurate procedures. Additionally, the analysis of increasingly smaller quantities of a sample to obtain valuable information, and above all, not consuming the entire available sample, is important.

Using different matrices can reduce sample volume, while maintaining the performance of the analysis. Reducing volume, sample and hazardous solvent, the principles required to decrease environmental impact, are also important (7). Similarly, it is also interesting to search for new materials to extract desired analytes from complex matrices: Fabric phase sorptive extraction (FPSE), magnetic nanoparticles, solid phase micro-extraction (SPME), sensor-assisted extraction (1,4–9), are novel techniques which have recently been discussed in a review (10).

The role of the analytical chemist also includes the development of methods and procedures with reduced environmental impact (8), while trying to respond to the needs and questions posed by the forensic and medico-legal fields (6). Analytical chemistry can provide accurate and detailed information, as required by law. Additionally, one of the major goals of analytical chemistry is to validate a method in complex matrices including conventional matrices, such as blood, plasma, and urine, but

also unconventional ones, including vitreous humor, teeth, bones, and hair, based on the type of analysis and analytes that are being investigated.

As a result of the increase in pollution, green chemistry (GC) principles were born. In 2000 green analytical chemistry (GAC) principles were introduced (8). One of the major goals of analytical chemists is trying to match GAC principles with the selectivity and sensitivity of a method. In this way, analytical chemists can be helpful in legal-medicine, because law ranges are restrictive. For example, Italian law regarding driving under the influence of alcohol provides a limit of 0.5 g/L, but this value is highly influenced by health, sex, age, for the person tested. For this reason, the medical examiner needs sensitive method, which permits quantitative values that are affordable.

Certainly, one of the major problems in this type of analysis is the first phase of analytical chemistry: sample preparation. This is because the sampling procedure must be made by the medical examiner, but sample preparation is performed by analytical chemists. The continuous research for methods, materials, and protocols is essential to optimize the sampling phase by making it easier and operator-independent to obtain valid samples.

We can say that for medico-legal and forensic applications a full multidisciplinary



collaboration between various professionals involved is a winning solution to arrive at standardized, operator-independent procedures that can be easily implemented (and modulated) to respond to the continuous updates of new substances, while always maintaining a rigorous chain of custody.

It is our opinion that to respond simultaneously to all these needs, the creation of “specialized centers” would certainly provide a service to the various police forces, but also catalyze in a coordinated manner the research interests to develop specific programs and projects in the forensic and medico-legal fields.

Based on the structure of the center, a multidisciplinary reality could be created (based on the specific needs of the region) where the know-how of the different sectors is applied to obtain a all-round analysis of the body, the time, means, and causes that led to death and to provide a complete picture to the investigators. In addition, the high specialization of the various application fields and the coordinated multidisciplinary approach on cadavers would allow for the synergistic implementation of multi-parametric studies, as well as the organization of specific post-graduate and highly specialized/training courses on the same topics that would allow for the training of future generations.

Disclaimer

The opinions expressed are solely our own and do not express the views or opinions of other scientists which are not included in this document.

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