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RESEARCH PAPER

Forensic Toxicology: Unveiling the Secrets in Crime Investigation and Trial in Pakistan

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ABSTRACT

Forensic toxicology, expanding its outdated boundaries. In context of autopsy, to identify cause of death and finding drugs in blood, new refined techniques are helpful. Object of conducting research was mainly to identify weaknesses and suggesting possible solutions. Forensic toxicology stands as a pivotal discipline within the realm of forensic science, weaving together chemistry, pharmacology, and medicine to unravel the mysteries concealed within crime scenes. This research employs methods, qualitative analytical techniques, and novel applications shaping the discipline. Researcher used descriptive method to present results. Modern tools work with specificity in detecting drugs, even in trace amounts and including new psychoactive substances (NPS). In Pakistan still outdated tools used for detection. It is recommended that collaboration among pharmacology with forensic toxicology and medico-legal for knowledge exchange and boosting progress in this domain and use of nano technology to improve its working.

Keywords: Biological Material, Chemical Testing, Homicidal, Poison, Suicidal, Suspicious Death, Toxicology

Introduction

Forensic toxicology primarily concerns the identification and quantification of toxic substances, such as drugs, poisons, and alcohol, within biological specimens collected from individuals involved in criminal activities. These specimens can range from blood and urine to hair and tissue samples. By employing sophisticated analytical techniques, such as chromatography and mass spectrometry, toxicologists can detect even minute traces of toxic substances, crucial for establishing links between suspects, victims, and crime scenes. Forensic toxicology stands as a pivotal discipline within the realm of forensic science, weaving together chemistry, pharmacology, and medicine to unravel the mysteries concealed within crime scenes. This specialized field delves into the examination of sample taken from biological substance to spot/detect and measure the presence of drugs, poisons, and other toxic substances in the human body. Its significance in crime investigation and trial cannot be overstated, as it provides crucial evidence to determine the cause of death, unveil foul play, and bring perpetrators to justice (Drummer, 2004).

Toxicology: Toxicology is the scientific discipline concerned with the study of poisons, encompassing their origins, characteristics, mechanisms of action, resulting symptoms, lethal dosage, fatal outcomes, treatment approaches, detection methods, quantitative assessment, and autopsy observations.

Forensic Toxicology: forensic toxicology is sub type of toxicology which is about the medico-legal aspects of poisons and toxic substances in human body. In Asian countries certain poisons (easy detection) and on other hand in west - Pharmaceutical products are difficult to detect.

The Crucial Role of Forensic Toxicology: In the intricate web of crime investigation, forensic toxicology serves as a beacon of truth, shedding light on the circumstances surrounding suspicious deaths and intoxications. By meticulously examining bodily fluids, tissues, and organs, toxicologists can identify substances ingested or administered, assess their concentrations, and ascertain their potential contribution to the demise of an individual (Jones, 2003).

Moreover, forensic toxicology plays a multifaceted role in legal proceedings, offering invaluable insights to law enforcement agencies, medical examiners, and judicial bodies. Through meticulous analysis and expert testimony, toxicologists aid in establishing causality, determining the manner of death, and corroborating or refuting witness testimonies, thus fortifying the pillars of justice (Peterson, 2007).

Applications of toxicology in Crime Investigation: Forensic toxicology finds diverse applications in the investigation of various types of crimes, ranging from homicides and assaults to drug-related offenses and driving under the influence (DUI) incidents. In cases of suspected poisoning or overdose, toxicological analysis of biological specimens such as blood, urine, and hair can unravel the presence of lethal substances and provide critical clues regarding the mode of administration and timeline of events (Peterson, 2007).

Furthermore, toxicological findings can corroborate circumstantial evidence and unravel complex scenarios, enabling investigators to reconstruct the sequence of events leading to an individual's demise. By discerning between therapeutic doses and toxic levels of drugs, toxicologists can differentiate between accidental overdoses, suicides, and deliberate homicides, thereby aiding law enforcement agencies in apprehending suspects and securing convictions. Forensic toxicology plays a multifaceted role in crime investigation, offering insights into various aspects of criminal activities:

1. **Cause of Death Determination**: Toxicological analysis helps determine whether the presence of toxic substances contributed to the cause of death, especially in cases of suspected poisoning or drug overdose.
2. **Impairment Assessment**: Toxicologists assess the influence of substances on an individual's cognitive and motor functions, crucial for understanding behaviors leading to accidents or crimes, such as impaired driving.
3. **Linking Suspects to Crimes**: Analysis of biological samples from suspects can establish their involvement in criminal activities by identifying traces of substances found at crime scenes or within victims' bodies.
4. **Victim Identification**: Toxicological analysis aids in identifying victims of poisoning or drug-related incidents, especially in cases involving unidentified or decomposed remains.
5. **Evidence in Court**: Toxicological findings serve as key evidence in legal proceedings, providing objective data to support prosecution or defense arguments and assisting juries and judges in making informed decisions.

Contributions to Legal Proceedings

Forensic toxicologists serve as expert witnesses in court proceedings, presenting their findings in a clear and comprehensible manner to legal professionals and jurors. Their testimony helps elucidate complex scientific concepts, such as drug metabolism and toxicokinetic, ensuring that the significance of toxicological evidence is accurately understood and weighed in the context of the case.

Challenges and Ethical Considerations

In the courtroom arena, forensic toxicology plays a significant role in elucidating the intricacies of toxicological evidence and translating scientific findings into comprehensible narratives for judges and jurors. Expert witnesses, typically forensic toxicologists, elucidate the significance of toxicological findings, highlight discrepancies in witness testimonies, and offer professional opinions on the cause and manner of death. Moreover, toxicological evidence can sway the outcome of trials, serving as a cornerstone for both the prosecution and defence. Despite its invaluable contributions, forensic toxicology faces several challenges and ethical considerations:

Interpretation Complexity: Interpreting toxicological findings requires expertise and caution, as substances may have different effects depending on factors such as dosage, individual tolerance, and co-ingestion of other substances.

Sample Integrity: Ensuring the integrity of biological samples is crucial to prevent contamination or degradation, which could compromise the accuracy and reliability of toxicological analysis.

Literature Review: In biological contexts, poisons refer to substances that induce mortality, injury, or deleterious effects on organs following their absorption in adequate quantities, typically through chemical reactions or molecular interactions at the cellular level. Within the realms of medicine, especially veterinary science, and zoology, there exists a nuanced differentiation between poisons, toxins, and venoms.

A poison is defined as a substance capable of causing destruction, illness, or fatality, or anything that poses a threat to well-being. For instance, cyanide serves as an exemplar of a poison. Additionally, a poison can manifest in non-chemical forms, such as a negative attitude that disrupts a positive environment. Poison could be entering into the human body by many methods such as, by inhaling through mouth and nose during taking breath, by IV injection, by touching or skin and from exposure to radiation or by snake bite Venom or insect bite etc (Shannon, 2012).

Pakistan Penal Code Sec 337- J (Qisas and Diyat): Anyone who administers or induces any person to ingest poison, stupefying substances, intoxicants, or harmful drugs with the intention to cause harm to that individual, facilitate the commission of an offense, or with the knowledge that such action is likely to cause harm, may, in addition to the punishment prescribed for the type of harm caused, be subjected to imprisonment for a period of up to 10 years, depending on the severity of the harm inflicted.

Suicidal Poisons: In suicidal cases, various substances such as KCN, HCN, opium, barbiturates, organophosphorus compounds, oleander, etc., have been commonly observed. It's noted that poisons used in such cases are often easy to obtain (readily available), inexpensive, easily administered by adding to food or drink, possessing a pleasant taste, odorless, having a small lethal dose, and inducing a short and painless lethal period. Examples of such substances include arsenic, mercury, antimony, aconite, thallium, maddar, strychnine, powdered glass, insulin, etc.

Perfect Homicidal Poison: An ideal homicidal poison would possess the following characteristics are economical, readily accessible, lacking color, scent, and flavor, administrable via food or drink.

Homicidal poisoning: Symptoms should mimic those of a common illness, lethal dosage should be minimal, fatal onset should be prolonged, no known antidote should exist, post-mortem examination should not readily detect its presence, stupefying poisoning can involve substances such as alcohol, dhatura, cannabis (typically found in organic material like cigarettes), and specific narcotics.

Accidental Poisoning: it is not common and takes place due to negligence and carelessness. Its quick remedy is only available with hospitals. Cases are of animal bites and food poisoning.

Classification: According to the mode of action classification, substances can be grouped into six categories:

1. Corrosives: This category comprises potent acids and alkalis.

2. Irritants: a. Inorganic: i. Non-metallic irritants like chlorine (Cl), bromine (Br), and iodine (I). ii. Metallic irritants such as arsenic, mercury, lead, copper, etc. b. Organic: i. Derived from plants, like castor oil, croton oil, and Abrus. ii. Derived from animals, such as Cantharides, venom from snakes, scorpions, spiders, etc. c. Mechanical irritants, including powdered glass, chopped hair, dried sponge, and diamond dust. d. Spinal irritants, like Nux vomica and selenium. e. Peripheral irritants, examples include Curare and conium.

3. Cardiac: This group includes substances like Digitalis, oleander, and aconite.

4. Asphyxiants: These substances cause asphyxiation, such as carbon monoxide (CO), carbon dioxide (CO2), sewer gas, and war gases.

Miscellaneous: This group encompasses various pharmacological products like analgesics, antipyretics, antihistamines, antidepressants, etc (Shannon, M. W., & Borron, S. W.2012)..

Route Of Administration: Includes oral, rectal, parenteral, injection (intradermal, intramuscular, intravenous, subcutaneous), inhalation, external application, and natural orifices.

Method of Administration: a. Inhaled: Rapid administration through inhalation. b. Intravenous, Subcutaneous, Intramuscular: Various injection methods.

Chronic poisoning: Exacerbation of symptoms occurs following ingestion of suspected food, medication, or fluids. Symptoms improve or disappear entirely upon removing the patient from the source. Poison can be detected in routine samples and items used by the patient. Common symptoms include fatigue, generalized weakness, declining health, and recurrent undiagnosed gastrointestinal issues. Typically associated with homicidal intent.

Poisoning in deceased individuals: Detecting poisoning relies on post-mortem examination, chemical analysis, experimentation on appropriate animal models, as well as moral and circumstantial evidence. Poison can impede normal decomposition processes.

Post-mortem examination: Standard procedures should be followed, with attention given to olfactory cues from clothing and the body, frothing at the nose and mouth, stains on the lips and chin, skin colour and lividity patterns, injection marks, and gastrointestinal abnormalities like congestion, softening, ulceration, and perforation.

Chemical Analysis: This involves the detection of poison in the parenchyma of organs, providing concrete evidence. Additionally, the presence of poison can be identified in food items. Experiments on Animals: This may include experiments such as observing the dilation of pupils in cats administered with Datura.

Moral and Circumstantial Evidence: This encompasses clues related to recent purchases, the behavior of the victim or suspect, the presence of a suicidal note, any history of conflicts or financial problems, and the hurried disposal of the deceased's body. These methods are commonly employed in investigations involving suspected poisoning cases.

Responsibilities of a doctor in cases of poisoning: Record essential details including the patient's name, age, gender, occupation, address, arrival time, accompanying individuals, medical history, and any dying declarations. Provide necessary medical treatment to the patient. In private practice, reporting is not mandatory unless summoned by law enforcement or the court. Accidental poisonings, such as those occurring in hotels or from contaminated water sources, should be reported.

If suspicion of homicide arises, it is the doctor's duty to inform the police, especially in government healthcare facilities where all cases must be reported.

Maintain meticulous records, including collecting samples such as stomach washings, vomit, urine, and blood for analysis, as well as any suspicious articles or clothing near the patient.

If the patient's condition is critical, arrangements should be made for a dying declaration. I case of death of victim refrain MLO from issuing death certificate until informing and arrival of police. Any opinions regarding the nature of the poison should be provided after receiving the chemical examiner's report. If performing an autopsy, preserve the viscera for further examination.

Treatment of poisoning: If the specific poison is identified, administer targeted treatment. Otherwise, adopt general management principles aimed at sustaining the patient's respiration and circulation. Focus on eliminating unabsorbed poison, using antidotes if available, and promoting the body's natural processes of metabolism and excretion to rid it of absorbed toxins.

The primary objectives are to remove unabsorbed poison, administer antidotes to enhance survival, eliminate absorbed poison, address general symptoms, and maintain the patient's overall condition.

Poisoning symptoms: vary widely and can differ from case to case, as each poison has its own unique set of manifestations. For instance, some poisons may cause pupils to dilate, while others may cause them to constrict. Certain toxins may induce excessive salivation, while others can result in dryness of the hands and skin. Some toxins accelerate heart rate, while others decelerate it. Similarly, certain substances may increase breathing rate, while others may depress it. Moreover, some poisons can induce pain, while others may be painless, and some may lead to hyperactivity while others induce lethargy. Confusion often accompanies could be one symptom.

Antidotes are substances that neutralize the effects of poisons without causing significant harm to the body. They are administered when the poison may not have been entirely removed, when the poison is already absorbed, or when the poison has been administered through routes other than ingestion.

Classification of antidotes includes

1. Mechanical or Physical: These methods impede the absorption of poison, such as demulcents, bulky food, and activated charcoal.

2. Chemical: These antidotes utilize direct chemical reactions to neutralize poisons.

3. Physiological or Pharmacological: These antidotes produce effects opposite to those of the poison.

Chelating agents are universal antidotes that form firm, non-ionized cyclic complexes to eliminate absorbed poison.

Methods for the elimination of absorbed poison include excretion through urine (achieved via excessive water intake or urine alkalinization), peritoneal dialysis, hemodialysis, and exchange transfusion.

Maintenance of Victim Conditions If Alive: Ensure the victim is warm and comfortable, avoiding the risk of infection. Administer antibiotics as necessary. Provide psychiatric counseling if needed. Common Household Poisons: Various household items contain toxic substances, such as shoe polish, kerosene oil, talcum powders, shampoo, drain cleaners baking powder etc

W.H.O Toxicity Chart: Toxicity levels are graded based on substance amount:

Extremely toxic: 1mg/kg or less.

Highly toxic: 1.5mg/kg. Moderately toxic: 50-500mg/kg.

Slightly toxic: 0.5-5.0gm/kg. Non-toxic: 5-10gm/kg. Harmless: more than 10gm/kg

Toxi-domes: Certain toxic substances are associated with what toxicologists' term toxidromes, which are a combination of the words "lethal" and "syndrome." Toxidromes consist of clusters of signs and symptoms that are typically found together in a specific type of poisoning. For instance, Jimson weed, a plant consumed or smoked for its hallucinogenic effects, triggers the anticholinergic toxidrome. This toxidrome is characterized by a rapid pulse, dilated pupils, dry and warm skin, urinary retention, mental confusion, hallucinations, and severe lethargy. While many toxins do not have associated toxidromes, some may exhibit only some of the typical features of a toxidrome.

Fatal Types of Poison: Arsenic Poison, Mustard Gas Poison, Ricin Poison, Cyanide Poison, Sarin Poison, Polonium Poison, botulinum Poison.

Arsenic Poisoning: Arsenic poisoning occurs when the body is exposed to high levels of arsenic, leading to various medical complications. If arsenic poisoning occurs suddenly, symptoms may include vomiting, abdominal pain, encephalopathy, and bloody diarrhoea. Diagnosis typically involves testing urine, blood, or hair samples. Arsenic is naturally present in soil and is also used in fertilizers. It is widely distributed in the environment, including groundwater. Symptoms of arsenic poisoning may encompass a metallic taste in the mouth, breath odor resembling garlic, excessive saliva production, difficulty swallowing, presence of blood in the urine, muscle cramps, hair loss, stomach cramps, sweating, vomiting, and diarrhoea. In severe cases, the condition may advance to convulsions, alterations in nail pigmentation, seizures, shock, coma, or even death.

Causes and Risk Factors: Arsenic poisoning can result from ingestion, absorption, or inhalation of the chemical. It can lead to severe health problems and even death if left untreated. While deliberate poisoning is a concern, exposure to arsenic can also occur through contaminated water, soil, rocks, and arsenic-treated wood. However, environmental arsenic is not inherently dangerous and is naturally regulated, making toxic levels of arsenic rare.

Complications: Long-term exposure to arsenic can lead to various complications, including cancer (skin, lung, bladder, kidney), liver disease, diabetes, nervous system disorders (loss of limb sensation, hearing problems), and digestive issues.

Diagnosis: Arsenic poisoning can be detected through blood or urine tests, or through a toxicology screen. Symptoms often affect the skin, liver, lungs, and kidneys. In advanced stages, symptoms may include seizures and shock, potentially leading to coma or death.

Mustard Gas Poison

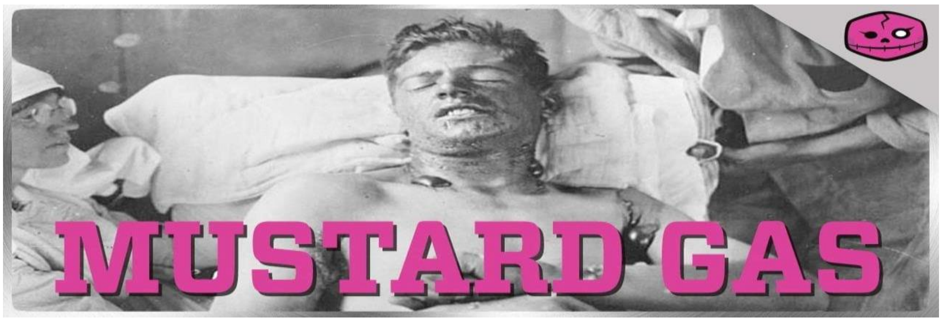

Figure. 1. patient of mustard gas poisoning

Mustard gas, also known as sulphur mustard (SM) or bis-[2-chloroethyl] sulphide, is a blistering agent employed in warfare and recognized as a potential weapon of chemical terrorism. Exposure to SM leads to the formation of debilitating skin blisters (vesication) and causes damage to the eyes and respiratory tract, with severe respiratory injury that can result in death. Developing an effective medical strategy to mitigate SM-induced respiratory injury is crucial for both military and civilian anti-terrorism agencies, such as Homeland Security. Various therapeutic approaches have been explored for this purpose, including the use of anti-inflammatory agents, antioxidants, protease inhibitors, and anti-apoptotic compounds. While this review examines all these options, it suggests that preventing cell death by inhibiting apoptosis represents a promising strategy. This approach could potentially be complemented by adjunct therapies utilizing other drugs such as anti-inflammatory agents, antioxidants, and protease inhibitor compounds. Sulphur mustard, the primary blistering agent used as a chemical weapon causing numerous casualties during World War I and still considered a significant chemical threat, remains a cause for concern due to its ease of production and existing stockpiles. Since its initial use, mustard gas has been deployed in various isolated incidents since World War I. Its toxic effects on metabolism and tissue injury affect nearly every system in the body, potentially leading to permanent disability or death. The care of injured patients requires a comprehensive understanding of the physiological aspects of this type of injury, necessitating a multidisciplinary approach. In the event of mustard gas use, medical personnel must be prepared to manage large numbers of casualties, requiring long-term care.

Ricin Poison

Figure 2

Ricin Poisoning: A Lethal Threat

Ricin, a potent toxin derived from the castor plant (Ricinus communis), has garnered attention as a potential biological warfare agent or weapon of mass destruction (WMD). This deadly substance, found in the waste material known as "white mash" left over from castor bean processing, can be fatal even in small quantities. Ricin exposure can occur through inhalation, ingestion, or injection.

Symptoms of Ricin Poisoning: Symptoms of ricin poisoning vary depending on the amount of toxin and the method of exposure. They may include fever, vomiting, nausea, severe cough, abdominal pain, diarrhoea, dehydration, and flu-like symptoms. The onset of symptoms depends on the route of exposure and the amount ingested. Inhalation of airborne ricin can affect multiple individuals simultaneously, with symptoms typically appearing within 8 hours. These symptoms may include fever, nausea, vomiting, a persistent cough, and nasal and throat congestion. Severe exposure can lead to breathing difficulties and chest tightness within 12-24 hours.

Ingestion: Ingesting contaminated food or drinks can lead to symptoms resembling food poisoning, usually occurring within 6 hours. Individuals may experience stomach pain, vomiting, diarrhoea, and dehydration. In severe cases, ingestion of significant amounts of ricin can result in more severe symptoms, including bloody vomiting or diarrhoea.

Injection and diagnosis: Injection of ricin, whether in pellet form or dissolved in a liquid, can result in pain and swelling at the injection site. Individuals may also experience flu-like symptoms such as nausea, vomiting, and body aches. Severe symptoms may manifest later, leading to critical illness. Diagnosing ricin poisoning can be challenging, especially in cases of isolated injection, as there are no widely available tests to confirm exposure to the toxin. Diagnosis often relies on symptoms and the likelihood of exposure.

Time of death: In cases of ricin injection, death can occur within 36 to 72 hours after exposure. The speed and severity of symptoms depend on the type of exposure.

Cyanide Poisoning: Cyanide harming is those outcomes from introduction to various types of cyanide. Early manifestations incorporate cerebral pain, dazedness, quick pulse, shortness of breath, and retching. It further could be led to seizures, slow pulse, low circulatory strain, loss of awareness, and heart failure. Beginning of manifestations is for the most part inside a couple of moments. In the event that an individual makes due, there might be long haul neurological issues. Dangerous cyanide-containing mixes incorporate hydrogen cyanide gas and various cyanide salts. Harming is moderately basic due to smoke of house-fire. Other potential courses of introduction incorporate working environments engaged with metal cleaning, certain bug sprays, the prescription nitro-preside, and certain seeds, for example, those of apples and apricots. Fluid form of cyanide easily could be retained by skin. Particles of cyanide meddle in cell breath, bringing about the body's tissues being not able to utilize oxygen. On the off chance that presentation is suspected, the individual ought to be expelled from the wellspring of introduction and disinfected. Treatment includes steady consideration and giving the individual 100% oxygen. Symptoms are confusion, bizarre conduct, excessive lethargy, coma, shortness of breath, headache, dizziness, vomiting, abdominal pain and seizures. Early symptoms include headaches, dizziness, rapid heartbeat, shortness of breath, and vomiting. Severe cases can lead to seizures, slow heart rate, low blood pressure, loss of consciousness, and even heart failure. Symptoms typically manifest within moments of exposure, and survivors may experience long-term neurological issues.

Sources of Cyanide: Cyanide poisoning can result from exposure to hydrogen cyanide gas, cyanide salts, and other toxic compounds. Common sources include smoke inhalation from house fires, workplaces involved in metal processing, certain pesticides, medications like nitroprusside, and certain seeds such as those found in apples and apricots. Liquid cyanide can also be absorbed through the skin, exacerbating the risk of poisoning. Cyanide interferes with cellular respiration, preventing tissues from utilizing oxygen effectively (Wax, 2016). Cyanide exposure commonly occurs through smoke inhalation during fires involving rubber, plastic, or silk. Industries utilizing hydrogen cyanide, such as photography, chemical research, metal processing, and fumigation, also pose a risk. Certain plants, including apricot, bitter almond, and cassava, contain cyanogenic glycosides, while laetrile, a cancer treatment containing amygdalin, can cause cyanide poisoning. Chemicals like artificial nail polish removers and solvents may also be converted into cyanide in the body. Cigarette smoke is a prevalent source of cyanide exposure (Wax, 2016).

Cyanide Diagnosis: Diagnosis of cyanide poisoning relies on clinical evaluation, patient history, and laboratory tests, including blood tests and X-rays. A rapid diagnostic test for cyanide detection, developed at South Dakota State University, shows promising results, with detection possible within 70 seconds. Prognosis depends on the severity of the poisoning and the timeliness of medical intervention. Patients who receive prompt treatment and remain conscious generally have a favourable prognosis, although delayed neurological complications may occur.

Sarin Poison: Understanding its Lethal Nature

Sarin is an extremely toxic chemical compound that disrupts signalling within the nervous system, leading to its deadly effects. It is an engineered organophosphorus compound, typically appearing as a colourless, odourless liquid. Due to its potency as a nerve agent, sarin is utilized as a chemical weapon, posing a severe threat to human life. Exposure to even minute concentrations of sarin can be fatal, causing death within minutes to hours, primarily due to respiratory muscle paralysis leading to suffocation. Individuals surviving non-lethal doses may suffer from permanent neurological damage if not promptly treated.

Regulation and Prohibition: Recognized as a weapon of mass destruction, sarin production and stockpiling were banned by the Chemical Weapons Convention of 1993 as of April 1997. Classified as a Schedule 1 substance, sarin is subject to strict regulations. International efforts, such as those by the UN Special Commission on Iraqi Disarmament, have aimed to eradicate existing stockpiles of sarin.

Toxicity and Mechanism of Action: Sarin exhibits high volatility, facilitating rapid absorption through inhalation and skin contact. Its toxicity surpasses that of cyanide, with a lethal dose estimated to be significantly lower. The mode of action involves inhibition of acetylcholinesterase, resulting in excessive accumulation of acetylcholine and subsequent nerve signal disruption.

Exposure Symptoms: Exposure to sarin manifests in various symptoms, including confusion, headache, watery eyes, coughing, salivation, and gastrointestinal distress. Lethal exposure induces convulsions, loss of consciousness, paralysis, and respiratory failure. Victims often describe the sensation of breathing sarin as akin to a burning blade ravaging their lungs.

Treatment and Management: Timely intervention is critical in sarin poisoning. Immediate evacuation from the contaminated area and administration of fresh air are paramount. Decontamination involves removing contaminated clothing and thorough washing with soap and water. Medical attention should be sought urgently, with supportive care aimed at alleviating symptoms and mitigating further exposure.

Polonium Poison: A Radioactive Threat: Polonium is a highly radioactive element with lethal toxicity. Discovered by Marie Curie in 1898, polonium-210 is the most prevalent radioactive isotope of polonium. While naturally occurring, it poses significant health risks, particularly through inhalation, ingestion, or skin contact.

Biological Effects: Polonium exerts its toxic effects by irradiating DNA, leading to cell death and carcinogenesis. Inhalation of polonium causes lung cancer, while ingestion results in systemic distribution to organs such as the liver, kidneys, bone marrow, and gastrointestinal tract, culminating in tissue damage and malignancy.

Symptoms of Exposure: Exposure to polonium elicits symptoms such as nausea, vomiting, hair loss, diarrhea, and bone marrow suppression. The severity and speed of symptom onset correlate with the dose received, with higher doses leading to rapid deterioration and potentially irreversible damage.

Chelation Therapy: Chelating agents, such as dimercaprol and penicillamine, are employed to reduce heavy metal toxicity by binding and facilitating elimination. These agents have shown efficacy in mitigating poisoning from metals like mercury, lead, and polonium, aiding in symptom management and recovery.

Environmental Concerns: While naturally occurring in trace amounts, polonium levels can escalate in certain environments, posing health hazards. Increased industrial activities, including fracking, may elevate polonium concentrations, necessitating monitoring and regulation by authorities like the Environmental Protection Agency.

Botulinum Toxin: A Double-Edged Sword: Botulinum toxin, derived from Clostridium botulinum bacteria, is renowned for its muscle-paralyzing effects. Initially feared as a potent poison, it has found widespread use in medical and cosmetic applications, offering temporary muscle relaxation and anti-aging benefits.

Botulinum Poison

Figure 3

Botulinum Toxin: A Potent Neurotoxin Botulinum toxin, produced by the bacterium Clostridium botulinum, is recognized as one of the most potent organic substances known to humanity. C. botulinum secretes eight distinct exotoxins (A, B, C1, C2, D, E, F, and G), all of which disrupt neural transmission by inhibiting the release of acetylcholine, the primary neurotransmitter at neuromuscular junctions. This inhibition leads to muscle paralysis. The weakness induced by botulinum toxin A injection typically lasts for approximately three to six months. Botulinum toxins now play a crucial role in managing a wide range of conditions, including strabismus, central dystonias, hemifacial spasms, various spastic movement disorders, headaches, hypersalivation, hyperhidrosis, and certain chronic conditions that show only partial response to conventional treatments. The list of potential new indications is rapidly expanding.

Cosmetic Applications: Cosmetic applications of botulinum toxin involve the correction of lines, wrinkles, and creases across the face, jawline, neck, and décolletage. Additionally, dermatological applications such as hyperhidrosis are common. Botulinum toxin injections are generally well-tolerated, with few adverse effects. A precise understanding of the functional anatomy of the mimic muscles is crucial for the accurate use of botulinum toxins in clinical practice.

Therapeutic Use of Botulinum Toxin: Botulinum toxin is a neurotoxic protein produced by the bacterium Clostridium botulinum, ranking as one of the most toxic naturally occurring substances globally. Despite its high toxicity, it is used in minute doses to treat painful muscle spasms and as a cosmetic treatment in certain regions worldwide. Commercially, it is sold under the brand names Botox and Dysport for these purposes. The terms Botox and Dysport are proprietary names and are not used generically to describe the neurotoxins produced by Clostridia species. Researchers discovered in the 1950s that injecting overactive muscles with minute amounts of botulinum toxin type A reduced muscle activity by blocking the release of acetylcholine at the neuromuscular junction, rendering the muscle incapable of contracting for a period of four to six months.

Methodology: Clinical and qualitative method is applied for recent data collection in research in hand. Descriptive method is use for data presentation and compilation of results and findings. Forensic toxicology is pure scientific and legal topic therefore data is collected carefully from authentic sources.

Research outcome/Results and Discussion:

1. **Autopsy in Cases of Suspicious Death:** In all cases of suspicious death, autopsy emerges as crucial evidence for initiating investigations. If the cause of death remains undisclosed following autopsy, various tissue samples in small quantities are collected and subjected to chemical analysis to determine the cause and manner of death.
2. **Demographics:** the research revealed that majority cases fall in category of young peoples of age group 26.57 ± 11.82 years. The majority patients belonged to the 20–40-year age group. There was no statistically significant difference between the genders of the patients. Referrals were predominantly made from within the city or the province.
3. **Rate of mortality and survival:** The overall mortality rate was low. Unsurprisingly, the highest number of deaths were attributed to organophosphate (OP) poisoning. Similarly, OP ingestion mortality) was also correlated with longer hospital stays (Khan, 2016).

Table 1
Demographics and epidemiological characteristics

	N=2546
Gender	
Male	1311 (51.45%)
Female	1235 (48.55%)
Location	
Karachi	2357 (92.61%)
Sindh	151 (5.89%)
Baluchistan	33 (1.33%)
Punjab	5 (0.15%)
Age groups	

≤12 years	20 (0.78%)
13-19 years	755 (29.69%)
20-40 years	1527 (59.93%)
41-59 years	156 (6.12%)
60≥ years	94 (3.69%)
Overall age (mean)	26.57±11.82 years

Poisoning types Organophosphate (OP) ingestion was hands down the most common type of poisoning seen. Off-label products and rat killer poison were the most common OP ingested. Types of poisoning are summarized in Table 2.

Table 2
Different types of poisoning analyzed during the study.

	N=2546
Organophosphates	1174 (46.11%)
Off-label products	458 (17.98%)
Rat killer	282 (11.07%)
Insecticides	194 (7.61%)
Typhoon	190 (7.46%)
Phenyle	50 (1.96%)
Snake bite(s)	231 (9.07%)
Over the counter pills	225 (8.80%)
Bleach ingestion	194 (7.61%)
Sleeping pills	86 (3.37%)
Heroin/opoids overdose	58 (2.27%)
Insect bite(s)	53 (2.07%)
Kerosene/Diesel ingestion	46 (1.86%)
Acid ingestion	32 (1.25%)
Scorpion sting	21 (0.82%)
Alcohol	12 (0.47%)
Methanol	10 (0.39%)
Ethanol	2 (0.07%)
Blackstone	12 (0.47%)
Copper sulphate	9 (0.35%)
Indeterminate poisoning	393 (15.43%)

Table 3
Overall mortality, discharge frequency, and length of stay at the hospital.

	N=2546	Length of stay (mean in days)
Discharged	2331 (91.51%)	1.87±1.59
Expired	92 (3.61%)	2.48±3.40
Left against medical advise	123 (4.88%)	1.46±0.95

Table 4
Absolute and relative mortality rates for specific poisons.

	Mortality N (%)	Relative mortality within the poisoning type group (%)
Organophosphates (all)	70 (2.7%)	5.96%
Off-label products	38 (1.49%)	8.29%
Typhoon	16 (0.62%)	8.42%
Rat killer	11 (0.43%)	3.90%
Insecticide	5 (0.19%)	2.57%
Blackstone (paraphenylene-diamine)	8 (0.31%)	66.66%
Methanol overdose	5 (0.19%)	41.66%

Snake bite	3 (0.11%)	1.29%
Acid ingestion	2 (0.07%)	6.25%
Kerosene ingestion	2 (0.07%)	4.34%
Heroin overdose	2 (0.07%)	3.44%
Overall	92 (3.61%)	

Discussion

The incidence of poisoning cases has seen a significant increase over the past three decades. Comparative analysis of data from the same unit indicates a rise from one patient every two days to more than 20 patients per day, marking a more than 40-fold increase. This surge can be attributed to factors such as population growth, improved hospital accessibility, enhanced intercity transportation, and rapid urbanization in Karachi.

Both men and women were equally affected, with a median age of 23 years, a trend that has remained consistent over the past thirty years. Approximately 80% of patients were under 40 years old, with teenagers constituting almost one-third of the cases. Deliberate self-harm emerged as the primary motive, in line with previous studies.

While the percentage of organophosphate (OP) poisoning aligns with Pakistani and international data, there is a noticeable shift in the type of OP poisoning observed. Most patients ingested off-label products, which lack regulatory oversight and clear labeling instructions. These multipurpose and inexpensive products are widely used. Other OP compounds, such as rat killers and insecticides, also contributed to the cases.

Snakebites, including scorpion and insect bites, emerged as the second most common cause of admission and the leading cause of unintentional harm. The prevalence of these cases is attributed to the geographical features surrounding Karachi and the interior province of Sindh, characterized by flat terrain, wild shrubs, lakes, and marshes. The lack of taxonomic markers often complicates the identification of venomous creatures.

Although alcohol poisoning incidence was low, occasional outbreaks during public holidays were linked to local moonshine businesses. These outbreaks are associated with severe methanol overdoses and exceptionally high mortality rates. Mortality rate is 2/3 in cases reported in rural areas. Mostly in Pakistan fertilizer chemicals and DDT is used in rural areas for poisoning and specially in suicidal cases.

Deaths from acid and kerosene ingestion were linked to a high volume of intake and the development of aspiration pneumonia. Heroin overdose fatalities occurred predominantly in addicts with poor nutritional status and unaddressed comorbidities. Discharged patients had relatively short lengths of stay.

There was some disparity in the length of stay (mean) for deceased patients. While most international data suggest a median of seven days, our study showed a mean of three days. This could be attributed to late presentations of patients with multi-system poisoning, leading to early mortality and consequently reducing the mean length of stay.

Conclusion

It is observed that out of 2546 overall 2/3 cases victims succumbed remaining survived and majority case were of suicidal. Understanding the toxicological properties and effects of substances like sarin, polonium, and botulinum toxin is crucial for safeguarding public health and implementing effective preventive measures and treatment protocols. Vigilance, regulation, and prompt intervention are essential in mitigating the risks associated with these hazardous substances. The incidence of poisoning cases in Pakistan has alarmingly increased, primarily affecting young adults and teenagers. Most poisons are readily accessible and available in households or shops, especially organophosphates. Considering the age groups involved, the mortality rate is high. A comprehensive effort from both the social and medical sectors is required to mitigate its adverse effects.

Recommendations

Researcher recommends that Integrating nanotechnology into forensic toxicology could revolutionize the field by enhancing the sensitivity, specificity, and speed of toxicological analyses. Nanoparticles offer unique properties such as high surface area-to-volume ratio and tunable surface chemistry, making them ideal candidates for various forensic applications.

1. **Nanoparticle-based Sensors**: Develop nano-sensors capable of detecting trace amounts of toxins in biological samples with unprecedented sensitivity. These sensors could target specific toxic compounds or classes of compounds, enabling rapid and accurate identification in forensic investigations.

2. **Nanoparticle-assisted Sample Preparation**: Utilize nanoparticles for sample preparation techniques such as solid-phase extraction or microextraction, enhancing the efficiency of toxin extraction from complex matrices like blood, urine, or tissue samples. This could streamline the analysis process and improve detection limits.

3. **Nanoparticle-enabled Imaging Techniques**: Leverage nanomaterials for advanced imaging modalities such as nanoparticle-enhanced mass spectrometry or nanoparticle-based imaging probes. These techniques could provide detailed spatial information about toxin distribution within tissues, aiding in the reconstruction of poisoning events.

4. **Nanoparticle-based Drug Delivery for Antidotes**: Design nanocarriers capable of delivering antidotes or therapeutic agents specifically to affected tissues or organs in cases of acute toxicity. This targeted drug delivery approach could mitigate the adverse effects of toxins and improve patient outcomes.

5. **Nanoparticle-based Forensic Markers**: Develop unique nanoparticle-based markers that can be added to toxicological samples for traceability and authentication purposes. These markers could serve as molecular signatures, helping to prevent sample tampering or contamination during forensic analysis.

6. **Nanoparticle-based Rapid Screening Kits**: Create portable and user-friendly rapid screening kits based on nanoparticle technology for on-site detection of common toxins or drugs of abuse. Such kits could be invaluable for law enforcement agencies, emergency responders, and forensic investigators in the field.

Integrating nanotechnology into forensic toxicology holds immense potential for enhancing analytical capabilities, improving forensic investigations, and ultimately contributing to more accurate determination of toxicological causes of death or injury. However, it's crucial to address concerns regarding the safety, reliability, and ethical implications of deploying nanomaterials in forensic settings.

In end I must say that, the future of forensic toxicology holds promise for innovation and advancement. By embracing emerging technologies, fostering collaboration, and upholding ethical principles, forensic toxicologists can continue to play a vital role in unraveling the mysteries of drug use, ensuring justice, and promoting public health.

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