

Oral-toxicology

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Abstract

Forensic toxicology deals with the investigation of toxic substances, poisonous products or with the environmental chemicals. This field of science helps to identify poison substance and hazardous chemicals. Forensic toxicology deals with the way that substances are absorbed, distributed or eliminated in the body – the metabolism of substances. This paper reviews the manifestations that each poisonous substance presents concentrating toward the commonly used poisonous substance especially in India. It also explains the Indian Penal Code, which is main criminal code intended to cover all substantive aspects of criminal law regarding poison.

Key words: Aluminum phosphide, barbiturates, organophosphates, poison, toxicology

Introduction

Toxicology is derived from Greek word “toxicos” means “poisonous logos” means “study.” It is a branch of biology, chemistry, and medicine, which deals with the study of the adverse effects of chemicals on living organisms. It is the study of symptoms, mechanisms, treatments, and detection of poisoning, especially the poisoning of people.^[1]

Forensic toxicology is a branch of forensic medicine concerned with medical and legal aspects of the harmful effect of chemical on a human being. It aids in medical or legal investigation of death, poisoning, and drug use.^[2]

Poisons are substances that can cause disturbances to the organisms, by chemical reaction or other activity on the molecular scale, when a sufficient quantity is absorbed by an organism. A Poison is defined as any substance, which when administered in a living body through any route (inhalation, ingestion, surface absorption, etc.) will produce ill-health

or death by its action, which is due to its physical chemical or physiological properties.^[3]

Epithelia of the body surface and mucosa are in continuous contact with the external environment. The stratified epithelia of the oral cavity and skin form a physical barrier. Cell promotes the diffusion of gases, liquids, and nutrients. Absorption, in chemistry, is a physical or chemical phenomenon or a process in which atoms, molecules or ions enter some bulk phase gas, liquid or solid material.^[4]

Chemicals such as foods, medicines, drugs of abuse, industrial chemicals can enter the human body by various mean including ingestion, inhalation, injection (intravenous, subcutaneous, intramuscular), skin application, use of a suppository, and application to mucous membranes (eye, oral and nasal cavities). Except for injection directly into the blood stream, the chemical must pass through a complex system of living cell membrane before it can enter the blood stream.^[5] Chemicals to enter or exit from the cell they must cross the cell membrane. It is the membrane that keeps all of the cell contents securely inside, but which allows some materials to pass in and out of the cell through several different mechanisms. Some of the mechanisms for moving chemicals through the cell membrane are active transport, passive diffusion, facilitated diffusion, pinocytosis or phagocytosis. Once the chemical has entered the bloodstream, it is available for distribution to distant organs. Chemical concentration in blood will be at a higher concentration initially, finally they tend to leave the blood

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and enter in to surrounding cells. Blood in order to bring their effects they must enter cells of the various organs by passing through a complex cell membrane.^[5]

Sources of Poisons in India

1. Domestic or household sources here poisoning commonly occur from detergents, disinfectants, cleaning agents, antiseptics, insecticides, rodenticides, etc.
2. Agricultural and horticultural sources: Different insecticides, pesticides, fungicides, and weed killers.
3. Industrial sources: In factories, where poisons are manufactured or poisons are produced as by products.
4. Commercial sources: From store-houses, distribution centers, and selling shops.
5. From uses as drugs and medicines: Due to wrong medication, overmedication, and abuse of drugs.
6. Food and drink: Contamination in a way of use of preservatives of food grains or other food material, additives such as coloring and odoring agents or other ways of accidental contamination of food and drink.
7. Miscellaneous sources: Snakes bite poisoning, city smoke, sewer gas poisoning, etc.^[2]

Classification of Poisons

Poison can be classified in many way, following are two types in which poison can be classified:^[6]

I)

Chemical

Gaseous e.g., carbon monoxide

Inorganic

- (a) Corrosives
- (b) Metallic and non-metallic salts

Organic

- (a) Volatile
- (b) Non-volatile, non-alkaloidal
- (c) Alkaloidal

Miscellaneous, e.g., botulism

II)

Physiological/pharmacological

Corrosive

- (a) Strong mineral/organic acids
- (b) Strong alkalis

Irritant

- (a) Metallic, e.g., mercury
- (b) Vegetable, e.g., castor oil
- (c) Gas, e.g., ammonia

Hypnotic/narcotic, e.g., barbiturate, morphine

Deliriant/convulsant, e.g., cocaine, strychnine

Paralytic/anti-cholinesterase, e.g., curare, nicotine

Abortifacient, e.g., ergot, quinine

Poisonous gases, e.g., carbon monoxide, prussic acid

Commonly Used Poisons in India

Suicidal (KCN, HCL, opium, barbiturates, organophosphorus (OP), oxalic acid oleander, etc.), homicidal (arsenic, aconite, thallium, oleander, madar, carbamates, OP, etc.) and accidental poisoning are seen in India. Pesticides have been commonly used for self-poisoning.^[7] Pesticides are highly toxic and pesticide poisoning is a significant problem in India. Acute pesticide poisoning is now an important cause of morbidity and mortality world-wide.^[8] OP compounds cause most self-poisoning deaths in southern and central India. In parts of Northern India, aluminum phosphide (AIP) causes most deaths.

Organophosphorus

Within word iq.com OPs are the general name for any organic compound containing phosphorus. OP compounds have been widely used for a few decades in agriculture for crop protection and pest control. In addition, OP compounds are also used in veterinary, and medical uses and "nerve gases" in chemical warfare. They are also been used as plasticizers, stabilizers in lubricating and hydraulic oils, flame retardants, and gasoline additives.^[9] They are highly toxic substances, which harm the brain and nervous systems. These chemical substances inhibit the activity of cholinesterase within the nervous system. They are used as used as solvents, plasticizers, and extreme pressure additives.^[9]

Classification of organophosphorus compounds

According to their toxicity and clinical use OP compounds are classified as:^[9]

1. Highly toxic OPs (e.g., parathion): Used as agricultural insecticides.
2. Intermediately toxic OPs (e.g., coumaphos, trichlorfon): Used as animal insecticides.
3. Low toxicity (e.g., diazinon, malathion): Used for household application and also field applications.

Mechanism of action

Most OPs are highly lipid-soluble agents and are well absorbed from the skin, oral mucous membranes, conjunctiva and gastrointestinal and respiratory routes. OP that is absorbed cutaneously, ingested, inhaled or injected inhibits an enzyme acetylcholine esterase (AChE) an enzyme that degrades the neurotransmitter acetylcholine (ACh) into choline and acetic acid. Symptoms of toxicity generally occur within 4 hour. Usually, lipid soluble OP (e.g., fenthion and dichlofenthion) taken into fat stores and subsequently slowly and intermittently released and metabolized to more active compounds. In this situation, the symptoms of toxicity may not occur for up to 48 hour and may continue for weeks.^[10] OPs inactivate AChE by phosphorylating the serine hydroxyl group located at the active site of AChE. The phosphorylation occurs by loss of an OP leaving group and

establishment of a covalent bond with AChE. Once AChE has been inactivated, Ach accumulates throughout the nervous system, resulting in overstimulation of muscarinic and nicotinic receptors.^[11]

Once an OP binds to AChE, the enzyme can undergo either endogenous hydrolysis of the phosphorylated enzyme by esterases or paraoxonases, Reactivation by a strong nucleophile such as pralidoxime, Irreversible binding and permanent enzyme inactivation (aging).^[12]

Clinical Manifestation

Generally oral or respiratory exposures result in signs or symptoms within four hrs. The onset and severity of symptoms of organophosphate depend on the specific compound, amount, route of exposure, and rate of metabolic degradation. Deaths from dermal or occupational exposure are very rare. Oral ingestion of OPs most frequently involves high concentrations, which are at a higher risk. Clinical features of OP poisoning are characterized by a triphasic response involving an initial acute cholinergic phase, an intermediate syndrome (both associated with high mortality) and a disabling, but non-lethal delayed polyneuropathy.^[13]

A human can come in contact with OP by various means such as ingestion, eating or drinking, inhalation or dermal contact. If a human gets sick of these OP it can manifest in various manner such as runny nose, chest tightness, shortness of breath, sweating, nausea, vomiting, stomach cramps, muscle twitching and confusion in case of mild OP poisoning. Whereas, in severe OP poisoning individual may develop seizures, paralysis or coma; some may die.^[12]

Oral Manifestation of OP Poisoning

Most OPs are highly lipid soluble compounds and well absorbed from intact skin, oral mucous membranes, conjunctiva and the gastrointestinal and respiratory tracts. Most OPs predominantly presents with parasympathetic over-activity and characteristic garlic smell from the oral cavity.

Manifestation includes, Bronchorrhea (production of more than 100 ml per day of watery sputum), Rhinorrhea (runny nose consists of increased amount of nasal fluid), Laryngospasm (uncontrolled/involuntary muscular contraction (spasm) of the laryngeal cords). Vomiting commonly occurs after oral ingestion of OP compound.

AIP (Phostoxin, Fumitoxin)

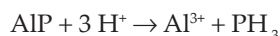
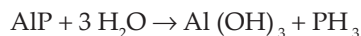
AIP is an inorganic compound, which is commonly used as a fumigant since 1940. It is utilized for control of pests in buildings (structural fumigation), soil, grain, and produce and it is also used during processing of goods to be imported or exported to prevent transfer of exotic organisms.

Aluminum phosphide poisoning (ALP) is available as tablets (3 g) or as pellets (0.6 g, quickphos, alphos, cellphos). The fatal dose for a 70 kg adult is 0.5 g.

Aluminum phosphide are not absorbed dermally, main routes of exposure are through ingestion and inhalation. They are highly toxic via both these routes.^[14]

Mechanism of Action

AIP when ingested, liberates of Phosphine gas in the stomach, which has a very pungent smell.^[15] phosphine is a strong reducing agent which inhibit cellular enzymes, which is involved in several metabolic process. Phosphine generated in the gastrointestinal tract is readily absorbed into the bloodstream, and it is readily absorbed through the lung epithelium. Phosphine cause denaturing of oxyhemoglobin (the carrier for systemic distribution of oxygen) as well as enzymes important for respiration and metabolism, and may also have effects on cellular membranes.



Uses

Pesticide: It can be used as a rodenticide, insecticide, and also fumigant.

Semi conductor applications: It can be used as a semiconductor material that is usually alloyed with other binary materials, which can be used in certain devices like light emitting bodies.

Signs and Symptoms

Symptoms of mild to moderate acute aluminum phosphide toxicity includes, nausea, abdominal pain, tightness in chest, excitement, restlessness, agitation, and chills.

Symptoms of more severe toxicity includes:^[16,17]

Diarrhea, cyanosis, difficulty breathing, pulmonary edema, respiratory failure, tachycardia (rapid pulse) and hypotension (low blood pressure), dizziness and/or death.

Individuals after death consuming ALP on external examination during autopsy, face when observed appears to be livid or distinct bluish discoloration. Garlicky pungent odor can be noted in many cases. Froth can be noted around the mouth and/or nose.^[18,19]

Lead Poisoning

Lead (Pb) is a soft, ductile, heavy, bluish-gray metallic element that is extracted chiefly from galena. It is very durable and resistant to corrosion and is a poor conductor of electricity. It

is used in a variety of products such as paint, ceramics, pipes, solders, gasoline, batteries, and cosmetics. When the lead level increases in the body it results in lead poisoning (plumbism, saturnism, painter's colic). Lead poisoning can result when a person swallows, absorbs, or inhales lead in any form.

Lead poisoning or lead intoxication occurs due to exposure of high levels of lead, which result in severe health effects. The severity of lead poisoning effects depends on the amount of lead in the blood and tissues, as well as the time course of exposure, determine toxicity. Organic lead compound is known to be more toxic than inorganic lead compounds. Acute lead poisoning, results when a relatively large amount of lead is taken into the body over a short period of time. It results in pain, muscle weakness, paresthesia, abdominal pain, nausea; vomiting, diarrhea, and constipation are other acute symptoms. In addition on mouth, it causes astringency and metallic taste. Chronic lead poisoning results when small amounts of lead are taken in over a longer period. It presents with symptoms affecting multiple systems, which includes of short-term memory or concentration, depression, nausea, abdominal pain, loss of coordination, and numbness and tingling in the extremities. Fatigue, problem with sleep, headaches, stupor, slurred speech, and anemia are also found in chronic lead poisoning. A "lead hue" of the skin with pallor is another feature. A blue line along the gum, with bluish black edging to the teeth is another indication of chronic lead poisoning.^[19,20]

Arsenic is a chemical element that occurs in many minerals, mainly combined with sulfur and metals, and also naturally in the native (elemental) state. Mainly metallic arsenic is used for strengthening alloy of copper like lead, also it is commonly used as a semiconductor.^[20]

Inorganic arsenic compounds (trivalent forms) in drinking water have a much higher acute toxicity than organic arsenics. In the literature, most of the arsenic poisoning is because of arsenic compound found in drinking water, arsenic trioxide, which is 500 times more toxic than pure arsenic. Arsenic poisoning can affect various organ such as lungs, skin, and kidneys, liver, and finally it may lead to coma and death. Symptoms of arsenic poisoning begin with headaches, confusion drowsiness, convulsions, and changes in fingernail pigmentation. In addition symptoms such as diarrhea, vomiting, blood in the urine, cramping muscles, hair loss, and stomach pain can be noted. Long-term exposure to arsenic can lead to vitamin A deficiency, which can lead to heart problems and night blindness.^[21,22]

Barbiturate Poisoning

Barbiturates are central nervous system depressants, which cause mild sedation to total anesthesia. They are effective also as anxiolytics as hypnotics, and as

anticonvulsants. Barbiturates can be classified as long acting barbiturates, intermediate acting barbiturates and short acting barbiturates. Short acting barbiturate can cause more dangerous effect than long acting barbiturate.^[23,24]

Barbiturate poisoning will lead to central nervous system (CNS) depression; patient will be confused and lethargic with poor coordination, ataxia, dysarthria, deep unremitting coma, total areflexia and unresponsiveness. Conjugate doll's eye movements are absent. Pupils are usually constricted, but may dilate in terminal phases. Pupillary response to light is minimal. Later respiration is feeble, shallow and irregular and hypotension occurs. Apnea and cardiac arrest may result.

Indian Penal Code Related to Poison and Drugs

Indian Penal Code (IPC) is the main criminal code of India. It is a comprehensive code, intended to cover all substantive aspects of criminal law. It is a document that covers almost all the crime happening in the society. The code applies to any offence committed by an Indian Citizen anywhere and on any Indian registered ship or aircraft. The IPC came into force in 1862. IPC was prepared by the First Law Commission, which was chaired by Lord Macaulay.^[25,26]

Section 85 of IPC 1860: Act of a person incapable of judgment by reason of intoxication caused against his will

Nothing is an offence, which is done by a person who, at the time of doing it, is, by reason of intoxication, incapable of knowing the nature of the act or that he is doing what is either wrong, or contrary to law; provided that the thing, which intoxicated him was administered to him without his knowledge or an against his will.

Section 86 of IPC 1860: Offence requiring a particular intent or knowledge committed by one who is intoxicated

In cases where an act carried out is not an offence unless carried out with a particular knowledge or intent, a person who does the act in a state of intoxication shall be liable to be dealt with as if he had the same knowledge as he would have had if he had not been intoxicated unless the thing which intoxicated him was administered to him without his knowledge or against his will.

Section 148 of IPC 1860: Rioting, armed with deadly weapon

Whoever is guilty of rioting, being armed with a deadly weapon or with anything which, used as a weapon of offence, is likely to cause death, shall be punished with imprisonment of either description for a term, which may extend to 3 years or with fine, or with both.

Section 270 of IPC 1860: Malignant act likely to spread infection of disease dangerous to life

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 2 years or with fine or with both.

Section 272 of IPC 1860: Adulteration of food or drink intended for sale

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to 1000 rupees or with both.

Section 273 of IPC 1860: Sale of noxious food or drink

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 274 of IPC 1860: Adulteration of drugs

Whoever does so shall be punished with imprisonment of either description for a term, which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 275 of IPC 1860: Sale of adulterated drugs

Whoever does so shall be punished with imprisonment of either description for a term, which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 276 of IPC 1860: Sale of drug as a different drug or preparation

Whoever does so shall be punished with imprisonment of either description for a term, which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

(Note: in state amendments some state like UP, West Bengal in Sections 272, 273, 274, 275, and 276 for the words “of either description for a term which may extend to 6 month or with fine which may extend to one thousand rupees or with both” the following shall be substituted, with imprisonment for life and shall also be liable to fine.)

Section 277 of IPC 1860: Fouling water of public spring or reservoir

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 278 of IPC 1860: Making atmosphere noxious to health

Whoever does so shall be punished with imprisonment of either description for a term, which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 279 of IPC 1860: Rash driving or riding on a public way

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 282 of IPC 1860: Conveying person by water for hire in unsafe or overloaded vessel

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 284 of IPC 1860: Negligent conduct with respect to poisonous substance

Whoever does so shall be punished with imprisonment of either description for a term which may extend to 6 months or with fine, which may extend to one thousand rupees or with both.

Section 306 of IPC 1860: Abetment of suicide

Whoever commits suicide, whoever abets the commission of such suicide, shall be punished with imprisonment of either description for a term, which may extend to 10 years, and shall also be liable to fine.

Section 324 of IPC 1860: Voluntarily causing hurt by dangerous weapons or means

Whoever voluntarily causes hurt by means of any instrument for shooting, stabbing or cutting, or any instrument, which used as weapon of offence, is likely to cause death or by means of fire or any heated substance or by mean of any poison or any corrosive substance, or by mean of any explosive substance or by mean of any substance, which it is deleterious to the human body to inhale, to swallow, or to receive into the blood or by mean of any animal, shall be punished with imprisonment of either description for a term which may extend to 3 years or with fine, or with both.

Section 326 of IPC 1860: Voluntarily causing grievous hurt by dangerous weapons or means

Whoever voluntarily causes grievous hurt by means of any instrument for shooting, stabbing or cutting, or any instrument which, used as a weapon of offence, is likely to cause death or by means of fire or any heated substance or by means of any poison or any corrosive substance or by means of any explosive substance or by means of any substance, which it is deleterious to the human body inhale, to swallow or to receive into the blood or by means of any animal, shall be punished with 1 (imprisonment for life) or with imprisonment of either description for a term, which may extend to 10 years, and shall also be liable to fine. Whoever voluntarily causes grievous hurt by means of any instrument for shooting, stabbing or cutting or any instrument which, used as a weapon of offence, is likely to cause death or by means of fire or any heated substance

or by means of any poison or any corrosive substance or by means of any explosive substance or by means of any substance, which it is deleterious to the human body inhale, to swallow or to receive into the blood or by means of any animal, shall be punished with 1 (imprisonment for life) or with imprisonment of either description for a term, which may extend to 10 years, and shall also be liable to fine.

Section 328 of IPC 1860: Causing hurt by means of poison, etc. - with intent to commit an offence

Whoever administers to or causes to be taken by any person any poison or any stupefying, intoxicating or unwholesome drug, or other thing with intent to cause hurt such person, or with intent to commit or to facilitate the commission of an offence or knowing in to be likely that he will there by cause hurt, shall be punished with imprisonment of either description for a term which may extend to 10 years, and shall also be liable to fine.

Section 430 of IPC 1860: Mischief by injury to works of irrigation or by wrongfully diverting water

Whoever does so shall be punished with imprisonment of either description for a term, which may extend to 5 years or with fine or with both.

Section 510 of IPC 1860: Misconduct in public by a drunken person

Whoever does so shall be punished with simple imprisonment for a term which may extend to 24 h, or with fine, which may extend to ten rupees or with both.

Conclusion

Forensic toxicology is the use of toxicology and few other disciplines such as analytical, pharmacology, chemistry, and clinical chemistry in medico-legal investigations of death, poisoning, and drug use. The main aim of forensic toxicology is the technology and the techniques that are used in obtaining and interpreting the results. Determining the substance ingested is often complicated by the bodies natural processes. Toxins have different affinities for body tissues. It is a known fact that anything that has been consumed or inhaled will be absorbed by different cells and later transported into blood, which finally transported to different tissue. Further, study on large scale sample is necessary to know whether histological study of oral tissue sample helps to identify the poisonous substance that is consumed.

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