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Guidelines for students and interns

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Методичні вказівки
для студентів та лікарів інтернів

МІНІСТЕРСТВО ОХОРОНИ ЗДОРОВ'Я УКРАЇНИ
Харківський національний медичний університет

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Substantiation of the Topic. Toxicology is a science dealing with properties, actions, toxicity, fatal dose, detection, estimation, and treatment of poisonings. Forensic toxicology studies medical, legal features of poisonous effects of chemical substances on humans.

Duration of practical classes: 2 academic hours

Purpose of the Practical Class: To study forensic medical methods which are used to determine the poisoning, to learn characteristic signs of poisoning and peculiarities of forensic medical autopsy when a poisoning is suspected.

Direct purposes of study:

1. To be able to determine the harm from the action of poisons and make an appropriate description of that harm.
2. To be able to determine the cause of violent death.
3. To write out the "Medical Certificate of Death".
4. To be able to withdraw objects for conducting forensic toxicological analysis.
5. To interpret results of forensic toxicology analysis.
6. To determine the degree of alcohol intoxication.

Basic level of knowledge and skills (before the practical class):

1. Peculiarities of drug action on organism and its excretion from the organism (pharmacodynamics and pharmacokinetics);
2. Principles of drug administration;
3. General information on poisons.

Visual Aids and Material Tools

1. Different natural specimens and some autopsy reports; additional case materials;
2. Studying tables, photos, and videos.

Technological card of carrying out the practical classes

№	Level	Time, min	Manuals	Place
1	Control of the initial level of knowledge on the topic	10	Oral answering	Classroom
2	Analysis of the forensic medical classification of poisons	10	Tables with scheme	Classroom
3	Study methods of forensic medical diagnostics of death from poisoning	25	Photos, video	Classroom
4	Analysis of peculiar poison's action	25	Autopsy reports, Death certificate	Classroom
5	The examination – situational tasks	15	Situational tasks	Classroom
6	Class summarizing	5	–	Classroom

BLOCK OF INFORMATION

General Aspects of Forensic Toxicology

Terminology

Toxicology is a science dealing with properties, actions, toxicity, fatal dose, detection, estimation, and treatment of poisonings.

Forensic toxicology studies medical, legal features of poisonous effects of chemical substances on humans.

A poison is a solid, gaseous or liquid chemical substance which if introduced in a living body in minimal quantity, or during the contact with a part of a living body, will produce health impairment or death by its physical-chemical or chemical effects.

Epidemiology

Poisoning, both accidental and intentional, strongly influences mortality and morbidity throughout the world. According to WHO, 3 000 000 acute poisoning cases with 220000 deaths occur yearly. Among those, 90 % of fatal poisonings occur in developing countries, particularly among agricultural workers.

Classification

In forensic medicine classification of poisonings based on pathophysiologic action of poisons is accepted. According to this classification, poisoning is considered as a disease with morbid affection of the whole organism, but with primary selective action on individual tissues, organs or systems of the organism.

Forensic medical classification of poisons according to mechanism of action

1. **Local, corrosive poisons:**
   - Alkalis (NaOH, $Ca(OH)_2$, etc.);
   - Organic and mineral acids, H_2O_2, $KMnO_4$, preparations of iodine, phenol.
2. **Resorptive poisons:**

а) Blood poisons:
- Carbon monoxide;
- Methaemoglobin-forming (nitrites, nitrates, aniline, nitrobenzene, etc.);
- Haemolytic poisons (mushrooms, snakes, insects, organic acids).

б)Destructive poisons (heavy metals):
- Mercurial preparations (Sulema, Calomel, etc.);
- Preparations of zinc;
- Preparations of arsenic;
- Other preparations with destructive action.

в) Functional poisons:
- General functional;
- Cerebrospinal;
- General narcotic;

- Alkaloid narcotic group;
- Convulsive and hallucinogenic;
- Encephalopathic and motor-paralytic;
- Cardiac nervous poisons.

Methods of Forensic Medical Diagnostics of Death from Poisoning

1. Study of data of the case.
2. Study of clinical symptoms.
3. Forensic examination of the Scene of death.
4. Post-mortem examination of the corpse.
5. Laboratory investigations.

Action of Poisons

Local action is a poison's direct effect on an organ or a system of organs and it may cause corrosion as in the case of strong mineral acids or congestion and inflammation as in the case of irritants. Such poisons generally produce gross changes seen with a naked eye at post-mortem examination.

Remote action is due to absorption of the poison into the system. It may be either specific or non-specific. Specific action depends on the effect of the poison on certain organs with which it has special affinity, e.g., opioids effect the cerebral cortex; strychnine effects the spinal cord, digitalis effects the heart muscle. Remote action may be localized in a certain organ, e.g., in the liver during detoxication, or in the kidney during excretion. Certain poisons, such as corrosives, are capable of producing a remote non-specific action, such as shock, similar to that which often results from severe mechanical injury.

Certain poisons, e.g., oxalic acid, carbolic acid, produce both local and remote actions.

General action results when the absorbed poison evokes response from a wide variety of tissues beyond the limits of one or two systems, e.g., arsenic, mercury, lead, barbiturates, etc.

The Factors Which Specify the Action of Poisons

1. Dose.
2. Form of poison.
3. Method of administration.
4. State of the organism.

Dose: As a general rule, small doses produce therapeutic action; large doses produce toxic effects; and lethal doses produce death. However, there are certain exceptions to this general rule:

1. Some individuals have an idiosyncrasy (inherent intolerance) towards certain drugs and foods resulting in intense symptoms. This is seen with drugs such as morphine, cocaine, quinine, aspirin, and many others, and certain articles of food, e.g., mushrooms, eggs, milk, and shellfish.

2. Some individuals are allergic towards certain drugs. Allergy means hypersensitivity acquired as a result of previous administration of the toxic agent or induced by the simultaneous presence of another poison. Penicillin is the most important modern example of acquired hypersensitivity. Many protective sera are other examples.

3. Habit diminishes the effects of certain poisons, since a tolerance toward them is gradually developed. Such tolerance is common in the case of alcohol, opioids, pethidine, and tobacco. It should not be confused with addiction.

4. Two poisons, as for example, alcohol and barbiturates in non-toxic doses, when administered simultaneously may cause toxic symptoms due to synergism which means that the final response is greater than the sum of their individual actions. The effect is called additive if the final response is equal to the sum of their individual actions.

5. If a poison exerts an emetic effect, a large dose may induce violent vomiting and mitigate the evil effect of a poison. Occasionally, a large dose acts differently from a small dose of the same poison. As for example, a large dose of arsenic may produce death by shock while a small dose results in gastrointestinal irritation.

6. Some poisons such as arsenic, mercury, lead, barbiturates, digitalis and carbon monoxide are eliminated slowly and may accumulate in the body (cumulative poisons). Their repeated administration even in small doses may result in chronic poisoning.

Form of poison:

1. Physical state: Gases and vapours act more rapidly than fluid poisons. Fluid poisons act more rapidly than solid ones, of which fine powders act more quickly than coarse ones. Synthetically coated pills soluble in the alkaline contents of the small intestine might have their action delayed for several hours.

2. Chemical combination: The toxic effects of substances may vary greatly from chemical combination. Some substances become inert, e. g, acids with alkalis, and strychnine with tannic acid. Some substances become poisonous, such as lead carbonate and copper arsenite which are insoluble in water but are rendered sufficiently soluble by the hydrochloric acid in the stomach, to make their poisonous effects felt. Some substances, such as alcohol and barbiturate, in nontoxic doses may prove toxic due to synergism.

3. Mechanical combination: The action of a poison is considerably altered when combined mechanically with inert substances. Alkaloids when taken with animal charcoal fail to act. Corrosive acids or concentrated alkalis, when sufficiently diluted with water, act as irritants.

Method of administration:

Poisons may gain entry into the body by several ways:

1. **Enteral route**, e.g., by mouth or by rectum, to be absorbed across the enteral mucous membrane.

2. **Parenteral route**, e.g., by injection either intradermal, subcutaneous, intramuscular, intravenous, intra-arterial, intraperitoneal, intrathecal or into the bone marrow.

3. **Inhalation** through the air passages.

4. **Introduction into natural orifices** such as rectum, vagina, urethra, nose, eyes, and by sublingual route.

5. **External application** on wounds, serous surface, unbroken skin.

Organic phosphates, nicotine, insecticides, some organic solvents and lewisite gas can penetrate the skin and produce death. Other substances which are absorbed through the skin are: phenol and its derivatives, endrin, methyl salicylate, mercury, tetraethyl lead, cantharidin, hydrocyanic acid.

State of the organism

1. **Age**: Poisons have greater effect at the two extremes of age.

2. **State of health**: Persons in poor health are more susceptible to poisons, e.g., a 30 % concentration of carbon monoxide in blood may kill a person suffering from coronary heart disease. In certain diseases, the tolerance of the body to certain drugs is increased, as for example, hypnotics and opiates in mania or delirium tremens, and strychnine in paralysis.

3. **Sleep and intoxication**: The bodily functions are at low metabolic level during sleep and intoxication. The action of a poison is therefore delayed if a person goes to sleep after taking it or if a person is intoxicated when he takes a poison.

Fate of Poisons in the Body

Unless the poison is given in a small amount and in a liquid state, the greater part of it may be lost by vomiting or diarrhea. Once it is absorbed, the body may deal with it in one of several ways. It may be excreted unchanged. Commonly, it will be partly or completely metabolized or converted to another active compound prior to further metabolism (biotransformation). When not completely metabolized, it may be detected in the original form or in the form of intermediate products in the tissues (e.g., liver, bile) or the excreta (e.g., urine). Certain tissues, such as the epidermis, nails, hair, and bones, may retain inorganic poisons, such as arsenic, after it is eliminated from the rest of the body, and the bony skeleton may hold such poisons as arsenic, lead, and radioactive isotopes for long periods.

Routes of Elimination

The absorbed portion of poison is mainly excreted by the kidneys and to some extent by the skin. Other routes are bile, milk, saliva, and mucous and serous secretions. The unabsorbed portion is excreted in the vomit and faeces.

Scene of Death

If a death from poisoning is suspected, first the routine examination of the corpse is produced on the Scene of death (the condition of the clothes, position and pose of the corpse, time of death, degree of development of post-mortem changes, injuries). Only after that the corpse on the Scene of death is examined with reference to evidences of death from acute poisoning. At examination, attention is paid to material evidences, signs of poisons and solutes; foods and drinks, human secretions.

Particularities of Technology of Forensic Autopsy

At suspicion on death from poisoning, in order not to contribute and not to stand any poisons during autopsy, following precautions are provided:

1) instruments, table, gloves, laboratory glassware must be clean;

2) water must be used in minimum quantity; disinfecting solutions must not be used;

3) autopsy room must be aerated and free of any smelling materials.

External post-mortem signs

1. Spots or marks of vomit, feces or the poison itself could be seen on the body and clothes.

2. Smell about the mouth and nose: Substances which may be recognized by their odour are: Garlic-like: phosphorus, arsine gas, arsenic (breath and perspiration), thallium, selenium, dimethylsulfoxide, tellurium, parathion, malathion, Sweet or fruity: ethanol, chloroform, and nitrites, Acrid: paraldehyde, chloral hydrate, Rotten(spoiled) eggs: mercaptans, hydrogen sulphide, disulfiram, Fishy or musty: zinc phosphide.

Other substances, which have specific smell: phenol, opium, cyanides, ether, camphor, etc.

3. The color of the skin and mucous membranes is changed under the influence of following substances: Nitric acid – yellow color. Hydrofluoric acid – reddish-brown color. Sulphuric, hydrochloric acids – grey, darkened because of blood. Carbolic acid – light grey color. Oxalic acid – grey, darkened because of blood. Cresols – leather-like, brownish-colored. Caustic alkalis – light grey color. Mercuric chloride – light blue color. Zinc chloride – whitish. Chromic acid and potassium chromate – carroty color, leather-like.

Skin should be examined for lesions, e.g. hyperkeratosis and pigmentation may be found in chronic arsenical poisoning. Jaundice may occur in poisoning from senecio, phosphorus and in susceptible persons by potassium chlorate.

4. Colour of livores mortis: The colour may be yellow or dark brown in poisoning by copper (acute poisoning), phosphoric compounds. Color could become cherry red in cases of carbon monoxide poisoning, chocolate-coloured or brown in death from by nitrobenzene, nitrites, acetanilide, bromates, aniline, chlorates poisonings, due to the formation of methaemoglobin.

5. Development of rigor mortis: with convulsive poisoning (by strychnine), rigor mortis is acutely developed, but with mushrooms poisoning (pale toadstool) it is absent or weakly developed).

6. The natural orifices, e.g., mouth, nostrils, rectum and vagina may contain traces of poisonous substance or signs of its appliance.

7. Sizes of pupils of the eyes, particularly their narrowing in case of pilo- carpinum, muskarinum poisonings.

8. Expert should look for injection marks very attentively.

9. Any marks of violence, such as bruises, or wounds of any nature may suggest some manner of death other than poison.

Internal Post-Mortem Appearances

The Sequence of medico-legal autopsy: Initially, the breast cavity is opened. It is extracted and the heart is researched. The blood is taken from the cavities of heart for laboratory analysis. Then the abdominal cavity is opened and the stomach is bandaged beside the entry and the output. The intestine must be bandaged. Then the organs of the oral cavity and neck, organs of breast and abdominal cavities, and the cavity of skull are investigated. If the external study shows that the poison did not enter the organism through the mouth but, for example, through sexual organs, then these organs are investigated after the study of the heart.

Smell: On opening the body, note any peculiar smell. This is useful in cases of poisoning by alcohol, ether, phenol, cyanide, chloroform cresol, camphor.

Mouth and throat: Forensic medical expert should look at the tongue and mouth to see if there are: erosion, inflammation, staining.

Oesophagus: In cases of poisoning by corrosive alkalis a mucous membrane becomes soft, regions of its desquamation could be seen.

Upper part of a respiratory tract: Forensic medical expert should inspect the larynx, trachea, bronchi to see traces of inhaled poisonous substances' action, as well as volatile irritants' action. Glottis' congestion, trachea's mucous membrane of the and bronchi desquamation, edema, of the may be seen in corrosive acid or alkali poisoning when it enters the respiratory tract.

Stomach:

a) **Hyperaemia**: irritant poisons lead to hyperaemia of mucous membranes which is seen at the heart apex, greater stomach curvature, seldom at pyloric part. It looks spotted, deep dark red colored. Also, mucous membrane could be covered by the sticky secrete, tiny haemorrhagic spots could be observed.

b) **Softening**: the immediate contraction of the muscles is produced by irritants as well as corrosives, which damages the superficial epithelium, while the depths of the glands are protected by compression of their necks by the spasm. Excessive secretion of mucus by the glands due to the neighboring irritation could be seen. If life holds, the poison passes deeper and deeper.

Spasm of the pylorus holds a poison at this point; this site is involved most often. Corrosive poisons, especially the alkaline corrosive cause the softening of the mucous membrane of stomach, particularly of its cardiac part and the greater curvature. It is also seen in the mouth, throat and oesophagus. In a disease, it is confined in the stomach and is usually found at its cardiac end.

c) **Ulcers**: Ulcerations due to corrosive or irritant poisons are found, typically, on the greater stomach curvature. It looks like an erosion with small, crumbly margins. The surrounding mucosa is softened due to inflammation, and there is diffuse hyperaemia. An ulcer from a disease is usually seen on the lesser curvature and the margins are well defined, thickened and indurated.

d) **Perforation**: Perforation is occasionally observed when the strong mineral acids have been taken, especially sulphuric acid; it is much less common with the other acids. The stomach is blackened and extensively destroyed, the opening is irregular, the edges are sloughing, and the adjacent tissues can be easily torn. The acid escapes into the abdomen and causes peritonitis. Perforation by irritant poisons is rare. In chronic gastric ulcer it is oval or rounded, has a punched-out appearance, and may show chronic adhesion to neighbouring organs.

The contents of the Stomach: The stomach is opened along its greater curvature in a clean porcelain dish. The wall is examined for fragments of poisons adhered to it, such as powdered poisons, fragments of capsules, starch from tablets, fragments of leaves or fruits, cantharides, etc. The contents are observed regarding the volume, colour, etc., including food. The presence of seeds, leaves, capsules and foreign bodies, such as nails, pins, glass, etc., are noted.

Duodenum and Intestines: strongly acid reaction is of greater significance than in the stomach contents. The only characteristic change, occurring in the intestine, could be seen in poisoning by mercury. This change, which usually involves the ascending and transverse colons, is a colitis, which may look same as enteritis in cases of acute dysentery.

Liver: Substances, like trinitrotoluene, carbon tetrachloride, chloroform, senecio produce the necrosis of liver. Death cap mushroom (Amanita phalloides), yellow phosphorus, arsenic carbon tetrachloride, iodine, ferrous sulphate (rarely) could result in a fatty liver. Jaundice may be caused by phosphorus, potassium chlorate, senecio, because of acute hemolytic anemia.

Kidneys: Parenchymatous degenerative changes are commonly found in irritant metal poisoning and in cantharidin poisoning. Extensive necrosis of proximal convoluted tubules may be found in deaths from poisoning by mercuric chloride, phenol, lysol and carbon tetrachloride.

Heart: Subendocardial haemorrhages in the left ventricle occur in the most cases of acute arsenic poisoning.

Bladder and in females, the vagina and uterus should be particularly examined for poison occasionally introduced into the body.

Laboratorial Examination
Toxicological Analysis

At suspicion on death from poisoning or in case of a poisoning with unknown poison the organs are removed from the corpse and placed into separate banks for toxicological investigations:

No.1 – stomach with contents, with one meter of small intestine and one meter of large intestine;

No.2 – 1/3 of liver and gall bladder with bile;

No.3 – kidney and urine;

No.4 – 1/ 3 of brain;

No.5 – heart with blood, spleen, 1/4 of lung.

In some cases, it is necessary to also take:

1. Blood and urine - at suspicion on alcohol poisoning,
2. Blood - at suspicion on carbon monoxide poisoning;
3. Hair, nails, flat bones - at suspicion on chronic arsenic poisoning;
4. The contents of large intestine - in case of suspecting a poisoning by mercury or other heavy metals.

Forensic Medical Medical Estimation of Forensic Toxicological Analysis Results

Positive result of chemical analysis (finding the poison) indicates to death from poisoning, with exclusion of the following:

1. Administration of the poison to the organism in the lifetime as a medicine.
2. Administration of the poison to the corpse when opening or preserving the organs of the corpse for delivery for Forensic-toxicological study.
3. Administration of the poison to the corpse at finding it in the soil (at exhumation) and withdrawal of parts of the corpse for Forensic-toxicological study.
4. Sudden death from chronic poisoning with minimum clinical signs.

Negative result of chemical study excludes the death from poisoning, but this result is false in the following cases:

The poison has a metatoxic action: Metatoxic action of poison is present in more or less long-term consequences of poisoning; it is not directly associated with the influence of most poisons and shows mainly after removal of the poison from the organism. The poison may have been eliminated by vomiting and diarrhoea, this happens, e.g., with irritant poisons. After absorption the poison may be detoxified, conjugated and eliminated from the system. Some organic poisons, especially alkaloids and glucosides, may deteriorate by oxidation in the lifetime or due to faulty preservation over a long interval, or from decomposition of the body and cannot be detected chemically.

Poison is not established by chemical methods: Some vegetable alkaloidal poisons cannot be definitely detected by chemical analysis. Some drugs are rapidly metabolized, making extraction difficult. Biological toxins and venoms which may be protein in nature cannot be separated from the body

tissues. Many drugs may be present in very small amount, and this may require considerable amount of viscera for their identification. A wrong or insufficient material may have been sent for analysis.

Consequently, the forensic medical expert must compare the chemical analyses data and sectional data of the toxicological investigation for final estimation of the results.

Other Laboratory Methods of Examination of Organs and Parts of a Corpse

- Histological;
- Spectral;
- Botanical;
- Experimental-toxicological (experiments on animals).

The suspected food, medicine or fluid, or the poison extracted from the viscera can be fed to domestic animals, such as the dog, cat and rat. These animals are affected by the poison in the same way as human beings. Such a procedure is not acceptable in some countries.

- Pharmacological tests;
- Bacteriological (at bacterial food poisoning). In case of death from bacterial food poisoning, the contents of the intestine, bile and blood are directed for a bacteriological investigation.

SEPARATE TYPE OF POISONINGS

Forensic Medical Examination of Poisonings by Carbon Monoxide

This is a colourless, odourless, non-irritant gas which cannot be perceived by the senses. It is formed by incomplete combustion of carbon and organic matter. The principal sources are: water gas, and illuminating gas; gases resulting from explosion in mines, from dynamite and other high explosives; from improperly regulated oil heaters, large oil lamps, and gas heaters without efficient flues; and from gases formed in crank cases, exhaust of vehicular engines, cycle engines, and in burning houses.

Action: CO is readily absorbed across the alveolus and combines with haemoglobin. Normal blood contains 20 % of oxygen, with 18 % bound to haemoglobin and 2% dissolved in plasma. About 10 to 20 % CO is present in extracellular tissues that combined with myoglobin and haemoproteins. CO affinity to myoglobin is about 40 times greater than oxygen, which may cause direct myocardial depression.

The affinity of carbon monoxide for haemoglobin is about 200–300 times greater than that of oxygen. It displaces oxygen and combines with haemoglobin to form carboxyhaemoglobin which is a relatively stable compound. It acts as a chemical asphyxiant and produces death due to anaemic anoxia. CO is a potent cellular toxin. It effectively and firmly binds to haemoglobin and myoglobin. It inhibits the electron transport by blocking cytochromeoxidase and cytochrome P-450, and therefore intracellular respiration.

Fatal Dose: Death usually occurs when more 60 % of haemoglobin is saturated with CO.

Senility, or the co-existence of any respiratory or circulatory deficiency, or of anaemia or in association with depressive drugs like barbiturates, and alcohol result in a significant reduction of maximum lethal saturation, and death can occur from as little as 30 % saturation.

Post-Mortem Appearances: A cherry-red colouration of areas of livores mortis, the skin, mucous membranes, conjunctivae, nail-beds, blood, tissues all internal organs is seen. The blood is fluid, hyperaemia is general and serous effusions are common. Congestion of the lungs with pink fluid blood, and if the victim survived for some time, pulmonary oedema with congestion are found. The lungs may show bronchopneumonic consolidation. Necrobiosis of the heart muscle and pleural and pericardial anoxial haemorrhages are common. Bilateral symmetrical necrosis of the basal ganglia in the brain, especially the putamen and globus pallidus is the most characteristic lesion, though the cerebral cortex, hippocampus, cerebellum and substantia nigra may be affected. Punctiform haemorrhages in the white matter of the brain with widespread oedema are common. Haemorrhages in the meninges and cortex, and selective cellular necrobiosis of ganglion cells in the cortex may be seen.

Laboratory tests:

1. Kunkel's test or tannic acid test: If tannic acid is added to blood it remains cherry-red in CO poisoning, while oxyhaemoglobin turns deep brown.

2. Hoppe-Seyler's test: Few drops of blood are added to a solution of 10 % sodium hydroxide. Normal blood turns brownish-green, but if CO is present, the colour will remain pink.

3. Spectroscopic examination of blood shows characteristic bands of carboxyhaemoglobin.

4. If vapour or gas intoxication is suspected as the cause of death, 10 ml. of heart blood should be collected prior to autopsy.

Forensic medical examination of ethyl alcohol's deadly poisonings

Alcohol is a drug of addiction and is responsible for many socio-economic problems, crimes, morbidity and mortality. It is a contributory factor in many deaths. The ethyl alcohol (or ethanol) is usually referred to as "Alcohol". Various distilled, fermented drinks contain the ethyl alcohol. It has a "burning" taste and a specific odor; it is a colorless, transparent, volatile (easily evaporates at room temperatures) liquid. It is present in many different drinks, such as: beer, wine, brandy, whiskey.

Rectified spirit contains 95 % of alcohol. In absolute alcohol, the remaining water content is removed by special technique, bringing it down to not more than 0.2 % water.

It is easy to calculate an alcohol consumption in alcohol units:

1 unit is equal to **a standard-sized drink** which is **approximately 10 g of the pure(non-diluted) alcohol.**

So that, the one unit corresponds to a glass of wine or to a semi-pint of beer.

The alcohol content should be written down on the tag of alcohol-containing drink as % (percentage) of alcohol in the total drink volume.

4 % by volume = 4 ml of an alcohol (per 100 ml of drink).

The metabolism of ethyl alcohol

After consuming one alcoholic beverage, the joint effect of multiple factors that affect absorption as well as metabolism, excretion, leads to a specific "curve" of alcohol concentration over the time:

1. In an absorption phase, the alcohol level increases abruptly to its maximum.

2. During a period of diffusion, there is an irregular fall of alcohol concentration, till the balance of an alcohol concentration in tissues is reached (from 15 to 30 minutes). The highest alcohol concentration is observed between 45 and 90 minutes after the drink intake, the peak is usually seen after 60 minutes.

3. Then, during the elimination phase, the alcohol level is decreased linearly. At high concentration levels, i.e. above 200 mg %, there is a non-linear decrease of alcohol, because of its bigger excretion by breath and by urine.

Blood alcohol concentration or blood alcohol content is the alcohol concentration in blood. It could be measured both in percentage of body weight, or by alcohol quantity in certain volume, or as a combination. For instance, if the alcohol content in blood is 0.30 %, or 3.0 ‰, that could denote 3 grams (of alcohol) per 1 000 grams of one's blood, or it can mean 0.3 grams (of alcohol) per 100 milliliters of one's blood.

In most countries there is a measurement of the blood alcohol content in grams per 1 000 milliliters (or grams per 1 liter of blood).

A permille or per mille is a tenth part of a percent or one per a thousand. It is written with the sign ‰: l ‰ = 10 – 3. For instance, 5 ‰ = 5 / 1 000 = = 0.005 = 0.5 %.

First phase of a metabolism of alcohol in an organism is absorption. Ethyl alcohol is quickly absorbed from organs of gastrointestinal tract. In usual conditions about 20 % of the drunken alcohol it is absorbs in the stomach, the others 80 % – in the upper small intestine. Following absorption, the alcohol concentration in the blood reaches a maximum in approximately 45–90 minutes after its intake. Absorption is generally complete in 1 to 3 hours.

In second phase (distribution - equilibrium phase) after the absorption, alcohol is dissolved in blood and is spread throughout the organism by bloodstream. Tissues containing water the most, for instance, muscles, absorb more alcohol from the bloodstream than others. Even concentrations of alcohol in tissues and blood are achieved in 1–2 hours.

In third phase (phase of elimination) approximately 90–92 % of absorbed alcohol is oxidized mostly in the liver, the remaining 8–10 % being excreted mainly by the lungs, kidneys. Small alcohol amounts could be eliminated by feces, sweat.

There is a convention of ethyl alcohol into the acetaldehyde by enzyme called the alcohol dehydrogenase. The initial product of ethanol metabolism, Acetaldehyde, is more toxic than ethanol itself. Acetaldehyde is converted to Acetate by the enzyme Aldehyde Dehydrogenase. Acetate is converted to carbon dioxide and water.

In a healthy person, the rate of clearance of alcohol from the blood by liver is 15–18 mg alcohol per 100 ml blood per hour (the equivalent of one unit per hour). However, the range is from 10–40 mg per 100 ml per hour. Liver disease may reduce metabolism.

Some people, especially those of East Asian descent, have a genetic mutation in their acetaldehyde dehydrogenase gene, resulting in less potent acetaldehyde dehydrogenase. This leads to a buildup of acetaldehyde after alcohol consumption, causing the alcohol flush reaction with hangover-like symptoms such as flushing, nausea, and dizziness. These people are unable to drink much alcohol before feeling sick, and are therefore less susceptible to alcoholism.

Mechanism and Symptoms

Ethyl alcohol depresses the central nervous system (CNS) irregularly in descending order from cortex to medulla. It first depresses the higher centres which control judgment and behaviour (stage of excitement), then the motor centres (stage of incoordination), and finally the vital centres in the medulla (stage of narcosis).

The approximate relationship between the alcoholic content of blood and clinical manifestations see table below.

Stages of an Alcoholic Intoxication

The Blood Alcohol Concentration, ‰	Stages of an Alcoholic Intoxication	Clinical semiology
< 0.4	There is no influence	There are no manifestations
0.4–0.5	Insignificant influence of alcohol	Slight physiological disturbances, light euphoria, self-confidence
0.5–1.5	Slight intoxication	Undue fatigability, emotional lability, impairment of reactions and visual acuity, sensory-motor coordination, logical thinking, hyperaemia of face
1.5–2.5	Moderate alcoholic intoxication	The emotional lability, the unsteady gait, rambling speech, drowsiness
2.5–3.5	Severe alcoholic intoxication	Decrease of reflexes, animosities and aggression, decrease of painful sensitivity up to full analgesia, hypothermia, delay of pulse and breath, cyanosis of faces are possible
3.5–5.0	Grave alcoholic intoxication	Dream, stupor, disturbances of consciousness, function of breath, alcoholic coma of I degree
More then 5.0	Fatal alcoholic poisoning	Alcoholic coma of II–III degree, lethal outcome without rendering medical aid

Causes of Death in Alcoholic Intoxications

Fatal Doze changes individually, on the average make about 6–8 g of pure alcohol on 1 kg of body weight. According to Methodical recommendations "Forensic medical diagnostic of lethal poisonings by ethyl alcohol" (Kiev, 2004) the fatal concentration of alcohol in blood usually is 5 ‰ and more. At the same time, death can occur at lower concentrations of alcohol in the blood, within 3 ‰.

There is a list of pathological processes and diseases which are caused by acute alcoholic intoxication and can be the immediate cause of death:

- Alcoholic cardiomyopathy results in cardiovascular insufficiency.
- Blockade of heart conducting system as a result of oedema and haemorrhages, in connection with the increased permeability of a vascular wall. The immediate cause of death – cardiac arrest.
- Bronchopneumonia and lobar pneumonia are the commonest.
- Acute forms of a pancreatitis, hemorrhagic pancreatonecrosis.
- Alcoholic hepatitis (acute and chronic), caused hepatotoxic action of alcohol on hepatic cells, results to necrosis with the subsequent infiltration of necrotic zones by cellular elements, should finish with toxic hepatic dystrophy, hepatic insufficiency or complicated by an alcoholic (portal) cirrhosis of the liver.
- Fatty hepatosis as the result of acute alcoholic intoxication results in hepatic insufficiency.
- Haemoglobinurinal nephronecrosis can result to acute renal insufficiency in connection with that haemosiderin slags promote development of epithelium's necrosis of renal tubules.
- Paralysis and oppression of the respiratory centre.
- Mechanical asphyxia from aspirate of respiratory ways by food (vomit) masses as complication of a poisoning.

Collection of Samples and Laboratorial Analysis

Blood and urine. Blood for definition of ethyl spirit take from peripheral venous vessels (femoral, brachial veins) or sinuses of dura mater of a corpse. Samples of blood and urine on 10–20 ml place in clean sterile bottles.

Gas chromatography: A measured microlitre quantity of sample containing alcohol is put into a previously heated chamber. The vaporised alcohol is carried by an inert carrier gas, usually nitrogen, through a column packed with a suitable adsorbent material. The various constituents of the sample are separated due to differences in adsorption, etc., land detected by a sensitive detector. A record on a moving chart (chromatogram) provides the qualitative and quantitative analysis.

ADH method: This biochemical method is based on the principle that the enzyme ADH (alcohol dehydrogenase) converts alcohol into acetaldehyde with co-enzyme NAD (nicotinamide adenine dinucleotide, previously called DPN,

diphosphopyridine nucleotide or co-enzyme-1). The reaction is driven to completion by maintaining a high pH and removing acetaldehyde with semicarbazide. The increase in absorbance at 340 nm (NADH) is monitored on a spectrophotometer.

Section signs of lethal ethanol poisoning

Section signs of deadly poisoning by alcohol are nonspecific and can be used in forensic medical diagnostics only in combination with histological, toxicological, biochemical and other laboratory data.

External and internal investigation of the corpse show typical signs of rapid onset of death, acute violations of blood circulation. It is a common, spread, saturated, blue-purplish livores mortis, often with multiple small and large-colored hemorrhages; cyanosis of the skin and swelling of the face, oedema of the eyelids, protrusion of eyeballs, pronounced injection of vessels of the conjunctiva; sometimes striped hemorrhages in the neck muscles; liquid condition of the blood, common venous congestion; small and large hemorrhages under the serous membranes of internal organs; blood overflow and edema pia mater, substance of the brain, vascular plexus of the ventricles of the brain; hyperemia of the vessels of the mucous membranes of the larynx and trachea, focal hemorrhage in the lung tissue. Edema of the gallbladder bed in the form of a lacquer-like lining; hyperemia of the mucous membrane of the stomach, sometimes hemorrhages of different size and shape in the area of its bottom and in large curvature, in some places - small erosions, hyperemia of the mucous membrane of the proximal small intestine. Sometimes presence there viscous light gray mucus; focal hemorrhages in the pancreas tissue; small-pointed hemorrhages in the kidney tissue and larger in the adrenal gland; The urinary bladder is often stretched, overflow urine. On the abdominal surface of the diaphragm sometimes there are well-defined burrow-reddish focal hemorrhages.

QUESTIONS FOR STUDENT'S INDEPENDENT WORK

1. Peculiarities of forensic medical examination of a corpse on the scene of incident at suspicion on death from poisoning.
2. Additional and laboratory methods of poisoning investigation.
3. Estimation of carboxyhaemoglobin and methaemoglobin preliminary tests results in blood.
4. Morphological changes in organs and tissues at different kinds of poisoning.

TESTS AND SITUATIONAL TASKS FOR SELF-ASSESSMENT

1. On forensic autopsy of K., 43, the expert suspected his poisoning with unknown poison. He took the 2 kg of internal organs in total mass for examination. What department of forensic medical laboratory should these organs be sent to:

A. Forensic histological.

B. Forensic toxicological.

C. Forensic immunological.
D. Forensic cytological.
E. Forensic medical criminalistics.

2. What is the main principle of poisons' classification in forensic medicine?
A. Based on the origin of the poison.
B. Based on the using of the poison in the medicine and other sciences.
C. Based on the pharmacological formula of the poison.
D. Based on the level of danger to organism.
E. Based on the pathophysiological action on organism.

3. Which of abovementioned poisons is a functional poison:
A. Carbon Monoxide.
B. Pesticides.
C. Alcohol.
D. Haemolytic poisons.
E. Organic and mineral acids.

4. What concentration of alcohol conforms the severe alcohol intoxication?
A. 0,5–1,5 ‰.
B. 1,5–2,5 ‰.
C. 2,5–3,5 ‰.
D. 3,5–5,0 ‰.
E. 5,0–6,0 ‰.

5. What concentration of HbCO in blood conforms its lethal concentration?
A. 20–30 %.
B. 30–40 %.
C. 40–50 %.
D. 60–80%.
E. 100 %.

ANSWERS

1 – B; **2** – E; **3** – C; **4** – C; **5** – D/

After the practical class every student should know:

1. Forensic medical classification of poisons.
2. Methods of forensic medical diagnostics of death from poisoning.
3. Peculiar poison's action on organism.
4. Particularities of the forensic medical autopsy when poisoning is suspected.

Should be able to:

1. To make an expert evaluation of preliminary findings when poisoning is suspected.
2. To reveal and estimate morphological signs of various poisonings.
3. To estimate results of toxicology tests on poisons' concentration.

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Навчальне видання

Судова медицина.
Розділ 2. Судово-медична експертиза ушкоджень внаслідок дії факторів зовнішнього середовища. Судово-медична експертиза речових доказів

Тема 10. Судово-медична токсикологія

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