YU. A. SOKOLOV

TOXICOLOGICAL CHARACTERISTICS OF HAZARDOUS CHEMICALS AND TOXIC TECHNICAL LIQUIDS COMMON IN THE NATIONAL ECONOMY

Minsk BSMU 2024

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ УНИВЕРСИТЕТ
КАФЕДРА ОБЩЕСТВЕННОГО ЗДОРОВЬЯ И ЗДРАВООХРАНЕНИЯ

Ю. А. Соколов

ТОКСИКОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА РАСПРОСТРАНЕННЫХ В НАРОДНОМ ХОЗЯЙСТВЕ АВАРИЙНО-ОПАСНЫХ ХИМИЧЕСКИХ ВЕЩЕСТВ И ЯДОВИТЫХ ТЕХНИЧЕСКИХ ЖИДКОСТЕЙ

TOXICOLOGICAL CHARACTERISTICS OF HAZARDOUS CHEMICALS AND TOXIC TECHNICAL LIQUIDS COMMON IN THE NATIONAL ECONOMY

Рекомендовано Учебно-методическим объединением
по высшему медицинскому, фармацевтическому образованию
в качестве учебно-методического пособия для студентов
учреждений высшего образования, обучающихся по специальностям
7-07-0911-01 «Лечебное дело», 7-07-0911-03 «Стоматология»

Минск БГМУ 2024

УДК 615.099:614.75(075.8)
ББК 52.84я73
С59

Р е ц е н з е н т ы: канд. мед. наук, доц., полковник м/с, нач. военной кафедры Витебского государственного ордена Дружбы народов медицинского университета И. А. Лятос; военная кафедра Гомельского государственного медицинского университета

Соколов, Ю. А.

С59 Токсикологическая характеристика распространенных в народном хозяйстве аварийно-опасных химических веществ и ядовитых технических жидкостей = Toxicological characteristics of hazardous chemicals and toxic technical liquids common in the national economy : учебно-методическое пособие / Ю. А. Соколов. – Минск : БГМУ, 2024. – 76 с.

ISBN 978-985-21-1575-9.

Приведена краткая токсикологическая характеристика некоторых аварийно-опасных химических веществ и высокотоксичных технических жидкостей, их физико-химические свойства, механизмы токсического действия, клинические проявления острой экзогенной интоксикации, а также порядок оказания первой, скорой медицинской помощи на догоспитальном этапе и основные направления лечения в стационарных условиях.

Предназначено для студентов 3-го курса медицинского факультета иностранных учащихся, обучающихся на английском языке по специальностям «Лечебное дело», «Стоматология».

УДК 615.099:614.75(075.8)
ББК 52.84я73

ISBN 978-985-21-1575-9

MOTIVATIONAL CHARACTERISTICS OF THE TOPIC

Methodological recommendations are developed for the purpose of optimization of educational process and are recommended for training students in practical classes on the topic "Toxicological characteristics of technical liquids common in the national economy". This topic is considered in the section "Military toxicology and toxicology of extreme situations" of the educational discipline "Disaster Medicine".

Teaching Purpose: to consider major specific features of the toxic process caused by the damage to the human body by some hazardous chemicals and highly toxic technical liquids, as well as clinical signs and symptoms that allow making an initial toxicological diagnosis.

Teaching objectives. The student should:

1. Know:

– brief toxicological characteristics of the studied toxic substances;

– classification of the studied toxic substances according to the degree of toxicity based on the predominant syndrome;

– medical and tactical characteristics of the foci of chemical contamination formed by the studied toxic substances;

– routes of exposure, mechanisms of toxic action;

– clinical signs and symptoms of acute severe poisoning;

– approaches to first aid and emergency medical care.

2. Be able:

– to make a preliminary toxicological diagnosis on the spot of a chemical accident;

– to provide first aid and emergency medical care at the prehospital stage.

3. Be familiar with:

– physical, chemical and organoleptic properties of the studied toxic substances that can help to identify contamination of the environment and sanitary treatment of affected persons.

Requirements for the initial level of knowledge. For better mastering of the topic a student must revise the following notions from:

– First aid: personal safety on the spot of an accident; the procedure of initial assessment of victims.

– Anesthesiology and Reanimatology: airway management; clinical manifestations and principles of correction of acid-base and water-electrolyte balance disorders; signs and symptoms of hypovolemic shock; pulmonary edema.

The checking questions from related disciplines:

1. The main sources of threats to the rescuer on the spot.
2. The concept of "isolation of body tissues".
3. The algorithm of the initial assessment of the affected persons on the spot.
4. Methods of providing airway patency.
5. Methods of evaluation of the level of consciousness.

6. Methods of evaluation of the functions of the cardiovascular system.

7. Pathophysiology, principles of diagnostics and intensive therapy of hypovolemic shock.

8. Principles of diagnostics and intensive therapy of pulmonary edema.

9. The basic forms of acid-base balance disorders, pathophysiology. Clinical manifestations, correction principles.

10. The main types of acid-base and water-electrolyte balance disorders, pathophysiology. Clinical signs, intensive therapy.

Self-check questions:

1. Classification of hazardous chemicals according to the degree of toxicity.

2. Classification of hazardous chemicals based on the predominant syndrome.

3. Brief syndromological characteristics of lesions with hazardous chemicals.

4. Approaches to intensive therapy of the main syndromes caused by hazardous chemicals.

5. Ammonia: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

6. Chlorine: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

7. Trichloroethylene: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

8. Hydrogen sulfide: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

9. Hydrogen peroxide: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

10. Carbon disulfide: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

11. Acrylonitrile: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

12. Sulfuric and hydrochloric acids: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

13. Methyl alcohol: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

14. Ethyl alcohol: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

15. Ethylene glycol: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

16. Organochlorine solvents: physical and chemical properties; toxicity; routes of exposure; mechanisms of toxic action; clinical signs and symptoms of acute poisoning; first aid and emergency medical care.

INTRODUCTION

Nowadays, mankind has knowledge of more than 10 million chemical substances and compounds. Of these, according to WHO, about 60 thousand are used in industry and agriculture, and annually this amount increases by 200–1000 new substances. About 500 chemical compounds, representing the greatest danger to humans, are among the most important emergency-hazardous chemicals (EHC).

Cases of emergency situations in industry and chemical pollution of the environment are mainly associated with:

– untimely maintenance of machinery and equipment and violation of the rules of their operation;

– shortcomings in the construction of enterprises;

– violation of the technological process.

The reasons leading to chemical contamination of the surrounding environment are: leakage of toxic substances from storage tanks; spillage of such compounds as a result of destruction of the container storage in emergency situations (road accidents with tank trucks and accidents on railways with tank cars), accidents on product pipelines, as a result of an explosion (in peacetime or wartime), terrorist acts, etc.; fires in chemical storage facilities and in large public buildings (hotels, etc., in which furniture and various coverings are made mainly of synthetic materials, since their combustion products are toxic).

Main features of EHC:

– the ability to be transferred over long distances in the direction of the wind, their toxicological characteristics being preserved;

– volumetric action, i.e. the ability of the contaminated air to penetrate into non-pressurized premises;

– a wide variety of EHC makes it difficult to identify the agent, as well as to establish individual and collective protective equipment;

– the ability of many EHC to have not only a direct damaging effect, but also a mediated one by penetration into the body through contaminated water, food, as well as by contact with surrounding objects;

– a number of EHC (acrolein, carbon disulfide, etc.) are flammable liquids, and their vapors and gaseous state (ammonia, methylamine, etc.) form explosive mixtures with air.

CLASSIFICATION OF EMERGENCY-HAZARDOUS CHEMICALS AND TECHNICAL LIQUIDS

By their chemical structure, physical, chemical and toxic properties EHC are heterogenic and can be classified in a number of ways (Fig. 1).

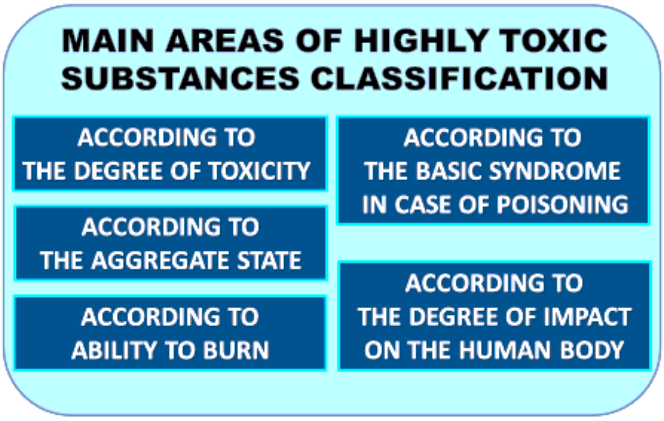


Fig. 1. Approaches to classification of highly toxic substances

According to the degree of toxicity there are 6 groups of EHC (Table 1).

The most dangerous (extremely and highly toxic) **poisons** include:

– organic and inorganic compounds of some metals (arsenic, mercury, lead, zinc, etc.);

– carbonyls of metals (nickel, iron, etc.);

– hydrocyanic acid and cyanides, nitriles, isocyanates;

– phosphorus compounds (organophosphates and others);

– organofluorine compounds;

– organochlorine compounds (ethylene chlorohydrin, ethyl chlorohydrin);

– halogens (chlorine, bromine);

– other compounds (ethylene oxide, allyl alcohol, methyl bromide, phosgene).

Table 1

Classification of EHC according to the degree of toxicity

Group of toxicity	Route of administration	
	Inhalation — LC, mg/l	Ingestion — LD, mg/kg
Extremely toxic	Less then 1	Less then 1
Highly toxic	1–5	1–50
Very toxic	6–20	51–500
Moderately toxic	21–80	501–5000
Low-toxic	81–160	5001–15 000
Practically non-toxic	Higher then 160	Higher then 15 000

Less dangerous (very and moderately toxic) **poisons include**:

– mineral and organic acids;

– sulfur compounds (dimethyl sulfate, carbon disulfide, sulfur chloride and fluoride, etc.);

– alkalis (ammonia, sodium lime, caustic potassium, etc.);

– chlorine and bromine-substituted hydrocarbon derivatives (methyl chloride, methyl bromide);

– some alcohols and acid aldehydes;

– organic and inorganic nitro- and amino compounds (hydroxylamine, hydrazine, aniline, toluidine, amyl nitrite, nitrobenzene, nitrotoluene, dinitrophenol);

– phenols, cresols and their derivatives;

– heterocyclic compounds.

Based on the predominant syndrome, developing in acute poisoning, the following groups of EHC are distinguished:

I. Toxic substances with predominantly ***suffocating effect***: compounds, for which main areas of negative influence in the body are the upper and lower respiratory tract, with the possible development of toxic tracheitis, bronchitis, pneumonia, toxic pulmonary edema (phosphorus trichloride, sulfur chloride, chloropicrin, chlorine, phosgene, methylisocyanide).

Under the action of vapors of a number of suffocating substances in high concentrations, a rapid lethal outcome due to the shock state caused by chemical burns of the skin, mucous membranes of the upper respiratory tract and lungs is possible.

According to the rate of development of the toxic process in the lungs toxic substances of this group are divided into:

– fast-acting suffocating agents: chlorine, chloropicrin, ammonia;

– slow-acting suffocating agents: phosgene, diphosgene, nitrogen oxides.

II. Toxic substances of predominantly ***all-poisoning action***: compounds, capable to provoke acute impairment of bioenergetic exchange, which in severe cases causes a lethal outcome. Conventionally, they can be divided into blood and tissue poisons (Fig. 2).

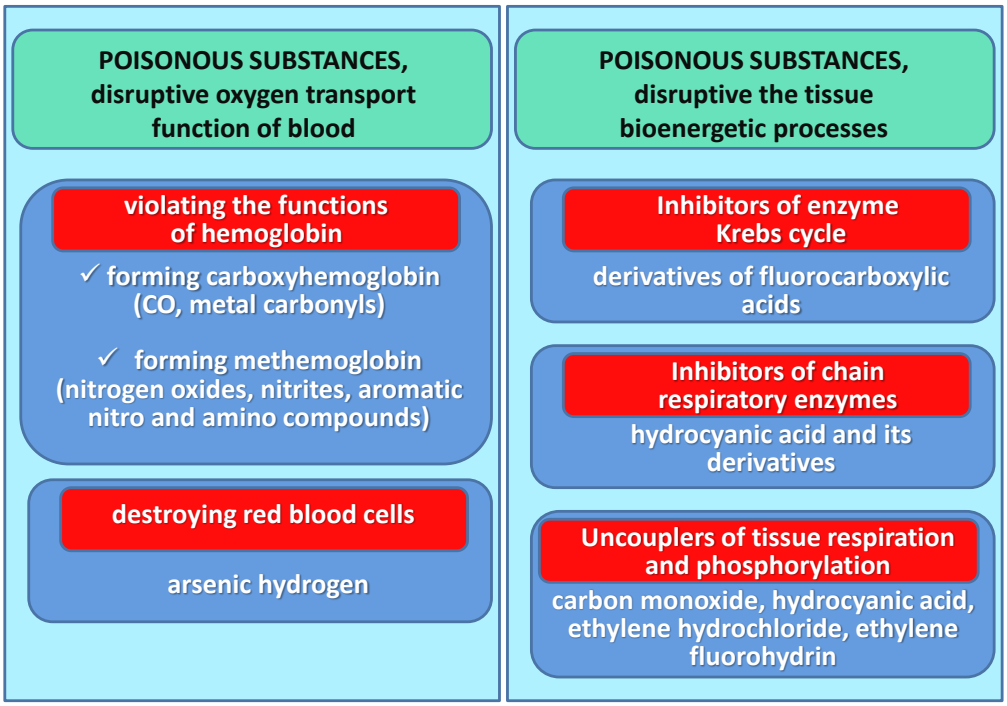


Fig. 2. Classification of poisonous substances of all-poisoning action

III. Substances that have ***suffocating and all-poisonous effects*** (acrylonitrile, nitrogen oxides, sulfurous anhydride, hydrogen sulfide).

A significant amount of EHC, capable of causing toxic pulmonary edema during inhalation exposure, and disrupting energy metabolism after resorption. Many chemical compounds of this group have the expressed cauterizing effect, which makes it difficult to provide medical care.

IV. Substances affecting the generation and transmission of nerve impulses (***neurotropic poisons***) and damaging the mechanisms of central and peripheral nervous regulation: nerve agents, carbon disulfide, ammonia.

The main principles of the effect of the above toxic substances on the body:

– impairment of the processes of synthesis, storage, release, interaction with receptors, inactivation and reuptake of the decomposition products of neurotransmitters;

– competitive interaction with target receptors;

– change in the permeability of ion channels of excitable membranes.

V. ***Metabolic poisons with alkylating activity*** have a damaging effect on body tissues by creating deep structural and functional changes in cells, leading to their death.

Alkylation in organic chemistry refers to reactions associated with the introduction of an alkyl radical into the structure of nucleophilic reagents. The latter include mercaptans, amines, alcohols, nucleic bases and other compounds.

Among the most toxic representatives of this group of agents are:

1. Halide alkyls:

– methyl iodide, methyl bromide, etc.

The reaction of the above compounds with nucleophilic reagents is described by the equations:

$$\mathbf{RX + HRS6' \rightarrow RSR + XH}$$

$$\mathbf{RX + H_2NR' \rightarrow RNH\text{-}R + XH},$$

where R stands for CH_3; C_2H_5 or other alkyl radicals, X is a halide, R' is an alkyl radical in the substrate molecule with which the alkylating agent reacts.

2. Substituted halide alkyls and their derivatives (organoelement compounds):

– organosulfur compounds (halogenated thioesters: sulfur mustard);

– organonitric compounds (halogenated aliphatic amines and some amino compounds of the fatty series: nitrogenous mustard gas, ethylenamine);

– organoarsenic compounds (halogenated aliphatic arsines: lewisite);

– organic oxides and peroxides (ethylene oxide), etc.

3. Alkyl (methyl, etc.) esters of sulfonic acids and phosphorus acids, as well as other mineral acids:

$$\mathbf{CH_3OSO_2OCH_3 + H_2NR \rightarrow CH_3NR + HOSO_2OCH}.$$

4. Chemical compounds containing activated multiple bonds, the disclosure of which occurs during reactions with nucleophilic reagents (olefins and their

derivatives: butene-2, isobutylene, perfluoroisobutylene; acrolein, chloroacetophenone, CS, CR).

Main targets of alkylating compounds are aminoacids, peptides, proteins, nucleic acids, lipids and other biologically significant compounds.

Main effects inherent in alkylating compounds are:

A) **Cytotoxic** — direct damaging effect upon contact with tissues:

– impairment of the structure and function of the active centers of enzymes (alkylation of hexokinase, which provides glucose phosphorylation, thereby disrupting carbohydrate metabolism, inhibition of nicotinamide adenine dinucleotide with subsequent disruption of tissue respiration, etc.);

– change in the activity of receptors;

– impairment of the conformation of biologically important macromolecules.

B) **Cytostatic** ("radiomimetic"):

– alkylation of nucleic (usually purine) bases with the formation of onium compounds (formation of a "point mutation" — breaking of the N-glycoside bond with depurinization of the nucleotide, which manifests itself during subsequent replication and transcription of nucleic acids);

– impairment of cell division (primarily organs and tissues with high mitotic activity — red bone marrow, reticuloendothelial system, the skin, mucous membranes, sex glands): loss of the ability to mitosis or non-viability of daughter cells due to chromosome mutations.

C) **Sensitizing:** inhibition of diamine oxidase inactivating histamine, which leads to the impaired metabolism of the latter.

D) Pronounced **cumulative** effect due to lipophilicity.

5. Substances cause metabolic disorders — toxic compounds of the dioxin group. Dibenzodioxins and polychlorinated benzofurans are particularly biologically active.

These substances are characterized by:

– the ability to penetrate through the lungs, digestive tract, intact skin;

– the ability to cause diseases with an extremely prolonged course.

When intoxicated with dioxins, almost all organs and systems of the body are involved in the pathological process. A characteristic feature of the action of these substances are pronounced metabolic disorders.

Major characteristics of dioxins as superecotoxicants:

– extraordinary persistence and ability to accumulate on objects of the environment;

– ability to be transmitted along the food chain without loss of toxic properties;

– high ability to accumulate in humans and animals;

– long half-life (5–7 years).

6. Substances with ***suffocating and neurotropic effects*** (ammonia).

This group includes toxic compounds that cause toxic pulmonary edema during inhalation; moreover, their systemic action leads to severe lesions of the nervous system.

The action on the brain is based on the impairment of the generation, conduction or transmission of a nerve impulse, which is aggravated by a state of severe hypoxia caused by the impaired external respiration.

According to the degree of impact on the human body, EHC are divided into 4 hazard classes:

Class 1: the coefficient of possibility of inhalation poisoning (CPIP) is more than 300;

Class 2: CPIP = 299–30;

Class 3: CPIP = 29–3;

Class 4: CPIP less than 3 (Table 2).

Table 2

Hazard Classes for EHC

Parameters	The norm for the hazard class			
	1st	2nd	3d	4th
Maximum permissible concentration (MPC) of EHC in the air of the working area, mg/m^3	< 0.1	0.1–1.0	1.1–10.0	> 10.0
Average lethal dose when administered into the stomach, mg/kg	< 15	15–150	150–5000	> 5000
Average lethal dose upon application on the skin, mg/kg	< 100	100–500	501–2500	> 2500
Average lethal concentration in the air, mg/m^3	< 500	500–5000	5001–50 000	> 50 000
CPIP	> 300	300–30	29–3	< 3
Acute action zone, m	< 6.0	6.0–18.0	18.1–54.0	> 54
Chronic action zone, m	> 10.0	10.0–5.0	4.9–2.5	< 2.5

Medical and tactical characteristics of the foci of chemical contamination with some EHC is presented in Table 3.

Table 3

Medical and tactical characteristics of the foci of chemical contamination with EHC

Focus Type	Substance	Aggregate state	Route of exposure	Resistance
Unstable fast-acting	HCN	liquid	Inhalation	sec.-min.
	Chlorine	gas	Inhalation	min.
	Chloropicrin	liquid	Inhalation	min.
	Ammonia	gas	Inhalation	min.
	Carbon monoxide	gas	Inhalation	sec.-min.
Unstable slow-acting	Phosgene	gas	Inhalation	
	Methyl bromide	gas	Inhalation Intact skin	min.-hours
	Chloromethyl	gas	Inhalation Intact skin	min.-hours
Persistent fast-acting	Organophosphates	liquid	Inhalation Intact skin	hours-days
	Dinitrophenol	crystalline	Inhalation Intact skin	days-weeks

End of the Table 3

Focus Type	Substance	Aggregate state	Route of exposure	Resistance
Persistent slow-acting	Dioxin	solid	Inhalation Intact skin	months
	Tetrachlorodibenzofuran	solid	Inhalation Intact skin	months
Semi-resistant fast-acting	Acrylonitrile	liquid	Inhalation	hours
	Carbon disulfide	liquid	Inhalation Intact skin	hours
	Phosphorus chloride	liquid	Inhalation Intact skin	hours
Semi-resistant slow-acting	Dimethyl sulfate	liquid	Inhalation Intact skin	hours
	Ethylene oxide	liquid	Inhalation Intact skin	hours
	Ethylene chlorohydrin	liquid	Inhalation	hours

SYNDROMOLOGICAL CHARACTERISTICS OF EMERGENCY-HAZARDOUS CHEMICALS

In the focus of chemical contamination scarcity of methods for primary toxicological diagnosis takes place, that is why the correct and timely assessment of clinical symptoms and syndromes is of paramount importance. It serves as a basis for rapid decision-making on the priority, scope and certain actions of first aid and emergency medical care. The syndromological principle (from the leading syndrome to the nosological diagnosis) in such a situation may become the only and most appropriate approach.

Visceral changes in case of exogenous intoxication may be pathogenetically associated with the action of a toxic agent, or may not have this correlation, i.e., be pathogenetically unrelated to toxic agents. First, there are general syndromes and organopathological changes (primary and secondary). Changes pathogenically unrelated to the action of a toxic agent are divided into prior and intercurrent, developing simultaneously with acute poisoning.

It should be emphasized that in most cases the differentiation of variants of the formation of pathological syndromes by clinical signs is very difficult. Let’s consider the main syndromes that develop under the influence of EHC.

a) Nervous system dysfunction syndromes

Practically in cases of poisoning with any EHC, either fragmentary or syndromologically delineated disorders of the nervous system develop. Most often these are disorders of consciousness (sopor, coma, acute psychosis), less often — convulsive syndrome, naturally occurring in the patients poisoned with the substances of resorptive and mixed action. Impairment of consciousness and convulsions are often observed in the same victim, replacing each other. Thus, acute psychosis often precedes the development of coma and (or) occurs when

coming out of it. For some types of intoxication the above-mentioned functional disorders of the Central Nervous System (CNS) are the leading ones and make up the main component of clinical manifestations. Convulsive syndrome is characteristic of intoxications with poisons with mediatory action, as well as with all-poisoning substances that cause tissue hypoxia. Rapid development of coma is characteristic of poisons having narcotic properties and disrupting the transport of oxygen by hemoglobin, etc.

Acute intoxication psychosis is often observed in cases of poisoning with haloid organic and some metallic organic compounds (toxic substances of cytotoxic action). In case of poisoning with substances of irritating and cauterizing action, these disorders are also possible, but their development is almost always caused by severe respiratory insufficiency or reflex apnea, and toxic pulmonary edema. Very often upon poisoning with EHC, various somatovegetative disorders develop. They are caused by a disruption of the regulatory functions of CNS, reflex effects, the direct action of poisons on the transmission of nerve impulses in the synapses of the autonomic nervous system. The example can be observed in comatose states of various natures, hypersecretion of the bronchial glands (bronchorrhea), as well as bradycardia, bradypnea and then tachypnea with irritation of the respiratory tract. Manifestations of somatovegetative syndrome are of the greatest diagnostic importance in cases of poisoning with substances that damage the nerve impulse (organothosphates) and lead to such symptoms as myosis, hypersalivation, bronchoconstriction, bronchorrhea, etc.

Quite often, upon acute poisoning with EHC in the early period of intoxication, subfebrile fever may be observed, not associated with infectious complications (pulmonary edema, hemolysis, etc.). Upon poisoning with all-poisoning toxic substances, due to the separation of biological oxidation and phosphorylation processes (dinitroortocresol, dinitrophenol, pentachlorophenol), rapidly developing toxic hyperthermia (“thermal explosion”) can occur.

b) Syndromes of impaired external respiration

Respiratory function disorders are extremely important for the accurate diagnosis and prognosis of poisoning with EHC. First of all, it is necessary to pay attention to the syndrome of irritation of the respiratory tract and eyes — a typical sign of intoxication with toxic substances of irritating and mixed effects. Irritation of airways refers to the early manifestations of the lesion that occur at the moment of contact with a poisonous agent. It is also expedient to gradate EHC according to the severity of the irritating action. Thus, the irritating effect of substances such as phosgene is insignificant, and the vapors of acids, halogens are very expressed. Poisons with toxic substances having expressed cauterizing properties can cause reflex apnea when inhaling high concentrations of these substances, as well as chemical burns of the respiratory tract and skin accompanied by pronounced reflex reactions, pain syndrome, and shock.

Aspiration-obturation syndrome — the most common form of ventilation disorders in inhalation poisonings — often poses the immediate threat to

the victim's life, but its specificity for intoxication with poisons of a certain type of action is low.

Respiratory mechanics disorder syndrome (neurogenic form) occurs in two main variants — in the form of central and peripheral respiratory paralysis. Paralysis of the respiratory center usually develops in association with pronounced depression of the central nervous system (III and IV degree coma), and is characterized by "pathological rhythms" (the appearance of Cheyne-Stokes, Biot's breathing,) or delayed aperiodic breathing with the outcome in apnea. It is observed mainly in persons affected by all-poisoning and neurotropic poisonous substances. Periodic respiratory paralysis is much less common. It is caused by the impaired conduction of excitation in the neuromuscular junction, and develops gradually, often with preserved consciousness. It is characterized by tachypnea with a progressive decrease of chest excursions and, as a rule, indicates poisoning with anticholinesterase poisons (organophosphates, carbamates).

Restrictive syndrome (a pulmonary form of acute respiratory failure) at the early stage of poisoning with EHC is mainly caused by toxic edema or chemical burn of the lungs due to the exposure to toxic substances of irritating and mixed action.

c) Syndromes of oxygen transport disorders and oxygen utilization disorders

In contrast to pulmonary ventilation disorders, impairment of blood oxygen transport is rare in case of poisoning with EHC. However, the detection of these disorders is extremely important, as it indicates poisoning with representatives of the group of all-poisoning agents — hemolytic poisons, carboxy- or methemoglobin-forming agents. Acute intravascular hemolysis is clinically manifested by chills, fever, muscle pain, lower back pain, changes in urine color (from red-brown to black), and later — anemia, jaundice, anuria. Impairment of oxygen utilization by tissues is observed in case of poisoning with EHC blocking tissue respiratory enzymes (prussic acid, nitriles, hydrogen sulfide). The most characteristic sign of poisoning with the representatives of the above groups of poisons is a change in the color of the skin and mucous membranes associated with pronounced brain disorders. A crimson shade is known to be typical of carbon monoxide poisoning, chocolate-brown — of methemoglobin-forming agents, and bright scarlet — of cytochrome inhibitors.

d) Syndromes of dysfunction of the cardiovascular system

Disorders of the functions of the cardiovascular system, which are very often observed upon intoxication with EHC, are, at the same time, the least specific in cases of poisoning by substances of various types of action, so we can only talk about the more or less hourly development of certain syndromes. Nosologically, they are expressed by hypertension, acute cardiovascular failure, toxic myocardial dystrophy.

e) Syndromes of dysfunction of parenchymal organs

Liver and kidney damage in acute poisoning is commonly referred to as toxic hepatopathy or nephropathy. This pathology is observed during intoxication with

various poisons, however, its severe forms with the development of renal-hepatic failure are more often caused by the effects of hemolytic, hepato- and nephrotropic poisons and manifest themselves at a relatively late stage of poisoning.

f) Syndromes of gastrointestinal disorders

Gastrointestinal disorders are also frequent manifestations of inhalation poisoning. In most cases functional disorders of the stomach with moderately pronounced dyspepsia and vomiting (mostly repeated) are observed, less often, mainly in poisoning with anticholinesterase poisons, intestinal disorders occur.

Thus, it can be stated that the clinical picture of poisoning is characterized by a complex multisyndromic structure, which significantly complicates the problem of nosological diagnosis.

PRINCIPLES OF TREATMENT OF PATIENTS AFFECTED BY EMERGENCY-HAZARDOUS CHEMICALS

The above considered approaches to classification of EHC and the characteristics of the most common syndromes upon poisoning with them, to a certain extent, determine the strategy and tactics of providing emergency medical care and further specialized treatment of affected persons.

Elimination of manifestations of intoxication and associated homeostasis disorders is carried out by restoration of various levels of its regulation by means and methods of etiotropic, pathogenic and symptomatic therapy at both toxicogenic and somatogenic stages of poisoning.

It should be noted that emergency medical care should be focused on the following measures: reduction of the local action of the poison and its further absorption, stimulation of elimination of the absorbed poison from the organism, use of specific antidotes, maintenance of vital functions of the body, stability of the internal conditions, correction of pathological changes of internal organs and systems, prevention and treatment of complications.

Priority measures should be aimed at stopping the local action of the poison and its resorption by using personal protective equipment, leaving the contaminated area, sanitary processing.

It is especially important to quickly remove substances with a strong cauterizing effect from the skin and mucous membranes, which is achieved by prolonged (10–15 min) washing of the affected areas with water. As a rule, the use of special solutions of neutralizing agents in this case has no advantages. The use of broad-spectrum pathogenetic medicines is indicated for severe pain syndrome, acute respiratory and cardiovascular failure, coma, psychomotor agitation, convulsions, often observed directly in the focus of lesion.

EHC can be removed from the blood by stimulating natural excretory processes (forced diuresis, hyperventilation) or creating artificial elimination pathways based on the principles of dialysis (hemodialysis using the artificial kidney apparatus, peritoneal dialysis), adsorption (hemo-, lymphosorption) or substitution (blood replacement surgery, plasmapheresis).

Forced diuresis is advisable in cases where toxic agents or their active metabolites are highly soluble in water and are removed from the body mainly through the kidneys (some alcohol surrogates, organophosphates, organic acids, etc.) Forced diuresis with alkalinization is also a very effective method of preventing acute renal failure in cases of poisoning with hemolytic poisons.

Since many EHC are mainly volatile and eliminated from the body with exhaled air, hyperventilation is theoretically justified in case of poisoning with them. The higher the elimination ability of hyperventilation is, the lower the coefficient of solubility of substances in the blood and the lower their ratio in the blood-alveolar air system. Hyperventilation is achieved by inhalation of a mixture of oxygen with CO_2 (carbogen) during spontaneous breathing or by artificial ventilation of the lungs. Clinical experience of using this method is available only for intoxications with halogenated hydrocarbons, carbon monoxide and carbon disulfide. Its application is also promising in case of poisoning with certain EHC.

Among the "artificial" methods of detoxification, the greatest interest presents hemodialysis (HD) using the "artificial kidney", hemosorption (HS) and blood replacement surgery (BRS).

The therapeutic effect of HD in case of exogenous intoxication with "dialyzable" poisons has been confirmed by long-term practice. However, the complexity of the equipment and laboratory control reduces the possibilities of clinical use of this method, especially in case of mass casualty chemical accidents. Among the negative aspects, it should also be noted that during dialysis, fat-soluble poisons and substances associated with proteins are not sufficiently eliminated from the blood.

These disadvantages are largely devoid of HS, which in terms of detoxification ability is not inferior to HD, and in some cases significantly exceeds it. High therapeutic effectiveness of HS is noted in cases of poisoning with organophosphates, halogenated and aromatic hydrocarbons, some alcohols, organoelement compounds, etc. In the presence of relatively simple equipment and trained medical staff HS can be carried out not only in hospital conditions, but also at the pre-hospital stage, which makes it possible to consider this method one of the most promising for a wide clinical application.

The use of BRS is limited, as a rule, it is used in cases of severe poisoning with hemolytic and hemoglobin-inactivating poisons (arsenic hydrogen, aniline, nitrobenzene); in case of carbon monoxide poisoning, hyperbaric oxygenation (HBO) is preferred. In addition, BRS is used when it is impossible to carry out HD and HS in combination with dialysis methods.

Undoubtedly, the use of specific antidotes, especially in the early stages of poisoning, significantly increases the effectiveness of subsequent treatment. At the same time, the arsenal of such tools is very limited today and in case of severe poisoning, the possibilities of antidotes are limited, and it is impossible to stop the toxic process only with applying this method of intensive treatment. Under these conditions, pathogenetic and symptomatic therapy, techniques for

eliminating the main clinical manifestations of intoxication, maintaining the functions of vital organs, and the stability of the internal conditions are of particular importance.

In the syndromological characteristics of EHC, we should, first of all, take into account the fact that in the foci of chemical accidents the most likely is the development of inhalation lesions. At the same time, it is impossible to completely exclude the alimentary route of exposure (due to the contamination of water, food), which should also be kept in mind when differentiating the leading syndromes of intoxication.

The approaches to the therapeutic management of the leading syndromes of acute poisoning with EHC are presented in Table 4.

Table 4

Therapy for the main syndromes of acute poisoning with EHC

Poisoning syndrome	Therapeutic measures
I. Psychoneurological disorders	
Acute psychotic state	Fixation. Supervision. Sedative medicines: phenazepam, seduxen, haloperidol, γ-hydroxybutyric acid, aminazine (2.5 % solution 2–3 ml) intramuscularly in combination with antihypoxants (aminalon, pyrroxane, etc.). If indicated — immobilization (muscle relaxants). Antidote therapy. Detoxification therapy. Symptomatic treatment
Toxic coma	Airway patency control (mouth expander, tongue fixation with oropharyngeal tube). If indicated — intubation of the trachea, suction of the contents of the respiratory tract. Artificial lung ventilation (ALV). Oxygen therapy. Forced diuresis, hemo-, peritoneal dialysis, hemosorption. At cerebral edema — dehydration therapy. Analeptics are contraindicated. Cardio-, vasotonic agents (camphor, cordiamine, caffeine). Prevention and treatment of bronchopulmonary infection. Correction of electrolyte imbalance. Symptomatic treatment. According to indications — antidotes
Convulsive reaction	Fixation. Ensuring the patency of the respiratory tract. Relief of seizures (diazepam or phenazepam, 0.5 % solution, 2 ml of 1–2 ampoules, intravenously, intramuscularly, γ-aminobutyric acid 100–150 mg per 1 kg of body weight in 20–40 % glucose solution, barbiturates (hexenal) intramuscularly or intravenously. In severe cases, ether-oxygen anesthesia with muscle relaxants. ALV. Antidote and detoxification therapy
Hyperthermic syndrome	Ice on the head and groin areas; wet wraps; blowing with a fan. Intramuscularly: lytic mixture (2 ml of 2.5 % solution of aminazine or diprazine, 50 % analgin) or intravenously 4 ml of 50 % analgin solution. Craniocerebral hypothermia
Muscarine-like syndrome	Cholinolytics: 1 ml of 0.1 % solution of atropine sulfate repeatedly. According to indications: bronchodilators, ALV. Detoxification and antidote therapy
II. Respiratory disorders	
Toxic pharyngitis, laryngotracheitis, tracheobronchitis, bronchopneumonia	Voice rest. Bronchodilators intravenously or by inhalation (2.4 % solution of aminophylline 10.0 ml, 5 % solution of ephedrine 1.0). Diphenhydramine 1 % — 1.0 ml, steroid hormones (prednisone 30–60 mg, hydrocortisone 125 mg). Oil inhalations. Antitussive remedies. Analgesics. Antibiotics

Continuation of the Table 4

Poisoning syndrome	Therapeutic measures
Aspiration-obstruction breathing disorders	Giving a drainage position. Ensuring the patency of the respiratory tract. Intubation, with laryngeal edema — cricothyroidotomy. Aspiration of the secret of the airways. Intramuscularly 1–2 ml of 0.1 % atropine sulfate solution. Hydrocortisone hemisuccinate 125–250 mg intravenously. With hypoventilation or lack of breathing — ALV, oxygen therapy. Antidote therapy
Toxic lung edema	Semi-sitting position. Physical peace. Warming up. Maintenance of airway patency. Aspiration of edematous fluid. Oxygen therapy. Inhalation of defoaming agents. Bronchodilators. Dehydration therapy: 100–150 ml of 30 % urea solution intravenously (1–2 g/kg body weight) or 200 mg of furosemide with 20 ml of 40 % glucose solution, or mannitol 10–20 % solution in injection water, or in isotonic sodium chloride solution, or in 5 % glucose solution (at the rate of 0.5–1.5 g of dry matter per 1 kg of body weight). Glucocorticoids (prednisone 160–300 mg per day); diprazine, diphenhydramine. Heparin (average daily dose of 30,000 units). Intravenous calcium chloride. Ganglioblockers, antioxidants (tocopherol acetate). Antibiotics. Sedative therapy (lithium mixture, neuroleptics). Correction of acidosis and brain edema. Cervical vagosympathetic blockade. Vitamins. Symptomatic therapy. At the prehospital stage — tourniquets on all limbs for 20–30 minutes
Neurogenic form of respiratory disorders	Toilet of the respiratory tract. Intubation or tracheostomy for ventilation. Inhalation of oxygen or injection of oxygen through a nasopharyngeal catheter. Detoxification therapy. According to indications — antidotes
III. Cardio-vascular disorders	
Exotoxic shock	Intensive supportive multicomponent infusion therapy: 0.9 % of sodium chloride; 5 % glucose solution with insulin and novocaine; 4–8 % sodium bicarbonate solution intravenously. Respiratory care. Correction of metabolic changes. Antidote therapy. Symptomatic treatment. At low arterial pressure — vasoconstrictors and glucocorticoids. With high blood pressure — droperidol. Heparin once, and then with a drip infusion. Nicotinic acid, trental. Correction of electrolyte balance. Methods of accelerated detoxification, symptomatic therapy
Primary toxicogenic and secondary somatogenic collapse	In case of toxicogenic collapse — correction of acute respiratory failure, antidote therapy; resuscitation measures (chest compressions, defibrillation, ALV). With flickering, fluttering of the ventricles and extracorporeal cardiac arrest — electro-pulse therapy. Antidote therapy. In case of somatogenic collapse — complex therapy: intravenously drip 400–800 ml of polyglucine, infusion of 5 % glucose solution or isotonic sodium chloride solution with 1–2 ml of 0.2 % solution of norepinephrine hydrotartrate. With low diastolic pressure — ephedrine, sulfocamphocaine. Vitamins of B-group, cocarboxylase, ATP, anabolic substances. Heparin. Antiarrhythmic medicines (anapriline). In case of cardiac arrhythmia, coronary dilators are used. Measures to stop pulmonary edema. Treatment of complications of the somatogenic phase, which were the cause of the collapse

End of the Table 4

Poisoning syndrome	Therapeutic measures
IV. Acute hepatic-renal failure	
Toxic hepato- and nephropathy	In the toxicogenic phase — emergency detoxification (hemodialysis, hemosorption, hemofiltration). Forced diuresis (urea, mannitol, furosemide in combination with aminophylline). Treatment of exotoxic shock. Antidote therapy. Intensive infusion therapy (intraportal infusions). Heparin. Proteolysis inhibitors (kontrical). Antioxidants. Vitamins of B-group, cocarboxylase (200 mg in 0.5 % solution of lipoic acid). Restoration of hemodynamics. In the somatogenic phase — correction of endotoxicosis (hemodialysis, peritoneal dialysis, hemosorption; drainage of thoracic lymph flow, lymph sorption, lymphodialysis). With hyperhydration — hemofiltration. Restoration of hemodynamics. Correction of acid-base and water-electrolyte balance. Prevention of intestinal auto-intoxication (antibiotics; intestinal lavage, enterosorbents)

CHARACTERISTICS OF POISONING WITH THE MOST COMMON EMERGENCY HAZARDOUS CHEMICALS

AMMONIA

Ammonia was first obtained by the English scientist D. Priestley in 1774 under the action of slaked lime on ammonium chloride.

Physical and chemical properties. Toxicity. Ammonia (***NH_3***) is a colorless gas with a suffocating pungent smell of ammonia. It tastes pungent. Ammonia is 2 times lighter than air, but the resulting cloud of air-ammonia mixture is heavier than the surrounding air. The boiling point is –33.4 °C, the melting point is –77.7 °C. It dissolves well in water, forming ammonia hydrate (NH_4OH). A 10 % aqueous solution of ammonia is used in medicine.

Ammonia is very active in substitution, addition and oxidation reactions. With the moisture of the air it forms liquid ammonia. In the air, it quickly turns into ammonium carbonate. It burns in oxygen with the formation of water and nitrogen.

In the presence of catalysts, it is oxidized to nitric oxide. It reacts with acids and metals.

Application of ammonia:

– for the production of nitric acid and its salts, ammonium nitrate and sulfate, hydrogen cyanide, urea, sodium carbonate;

– in organic synthesis;

– when dyeing fabrics;

– in medicine (in the form of liquid ammonia);

– as a refrigerant in refrigerators;

– when silvering mirrors;

– for the production of fertilizers.

The maximum concentration of ammonia is 0.2 mg/l. The lethal dose for humans at 0.5–1 h exposure is 1500–2700 mg/m^3.

Routes of exposure. Inhalation. Ingestion. When acting in high concentrations, ammonia causes damage to the skin. Chemical burns of the eyes are possible.

Mechanisms of toxic action. Ammonia is a convulsive poison. It leads to the development of pronounced muscle weakness with increased reflex excitability, impaired coordination of movements. The victim is excited, is in a state of violent delirium. Sharp sounds lead to the formation of a convulsive attack. Death occurs from acute heart failure. These changes are based on the polysynaptic activity of ammonia, its ability to disrupt the exchange of certain inhibitory neurotransmitters. The ability of brain tissue to retain oxygen is sharply reduced.

Consequences of severe intoxication: personality change, decrease in intellectual level with memory loss, neurological symptoms.

Clinical signs and symptoms of intoxication. Acute ammonia poisoning in industrial conditions occurs only in emergency situations.

Ammonia has an irritating effect, mainly on the mucous membranes of the upper respiratory tract. In high concentrations it causes CNS excitation. In the case of exposure to low concentrations of ammonia symptoms are limited to irritation of the mucous membranes of the eyes and nasopharynx. At the same time, there is dryness in the eyes and throat, sneezing and coughing, hoarseness of the voice, soreness in the chest area.

If the lesion is more severe, then there is burning pain in the throat, swelling of the larynx and lung tissue. Bronchitis and pneumonia may develop. When a highly concentrated ammonia solution penetrates into the cavity of the stomach or intestines, foci of tissue necrosis appear, which, when aggravated, can cause the development of pain shock.

When exposed to a cloud with high concentrations, there is a sharp irritation of the mucous membrane of the mouth, upper respiratory tract and eye membranes, coughing attacks, a feeling of suffocation, anxiety, dizziness, pain in the stomach, vomiting. In addition, severe ammonia poisoning can lead to gastrointestinal bleeding, laryngeal edema and asphyxia, reactive peritonitis. Subsequently, stenosis of the esophagus and other parts of the gastrointestinal tract develops.

Death may be caused by a painful shock. In the later stages of the development of ammonia poisoning, the cause of death may be associated with burn disease and complications on its background — extensive bleeding, pneumonia and perforation of acute ulcers of the stomach and intestines, mediastinitis.

When liquid ammonia gets on the skin, a skin burn develops with erythema, blisters. Ammonia vapors cause erythema more often. When the eyes are affected, lacrimation, photophobia, eyelid spasm, conjunctivitis are noted.

With prolonged contact with subtoxic doses of ammonia, chronic catarrh of the upper respiratory tract and conjunctivitis may occur.

Ammonia in the body is quickly neutralized, so its cumulative effect is unlikely.

Emergency medical care.

I. Stabilization of the patient's condition.

Acute respiratory failure. With increasing laryngeal stenosis due to edema or chemical burn, obstruction of the respiratory tract or bronchorrhea with signs of hypoxia, emergency intubation of the trachea is necessary, if it is impossible, cricothyroidotomy or tracheostomy, ventilation, aspiration of the tracheobronchial tree content, oxygenotherapy may be used.

Acute cardiovascular failure. Chest compressions in the absence of pulse on the carotid arteries. With hypotension, intravenous infusion of colloidal fluids 10–20 ml/kg, titration of dopamine 3–15 mcg/kg/min.

With convulsions and agitation, seduxen (0.5 % — 2.0) — 10–20 mg (or other benzodiazepines), hexenal, sodium thiopental may be used before the effect is obtained.

II. Cleansing of the gastrointestinal tract. Gastric lavage with a thick probe lubricated with vaseline oil, lidocaine paste or oil with an anesthetic agent. Rinsing with cold water — it reduces hyperemia and thus limits absorption. The presence of blood in the flushing waters is not a contraindication for gastric lavage. Gastroenterosorption is carried out.

III. Artificial detoxification of the body. With the development of oligoanuria, azotemia, hyperkalemia — hemodialysis or plasmodialysis.

IV. Infusion therapy. Intravenous infusion of plasma, albumin and plasma substitutes (rheopoliglucin, polyglucin, neorondex), reamberin 10–15 ml/kg, 5–20 % glucose, isotonic sodium chloride 40–100 ml/kg/day (up to 3–15 l/day). Intensive fluid administration continues until the hemodynamic parameters are stabilized, then drip infusion of the solution is performed.

With the development of bleeding: hunger, local hypothermia of the stomach, blood components and fresh frozen plasma transfusion. Parenteral nutrition.

V. Syndrome therapy. Relief of pain syndrome: promedol (2 % — 1.0 ml) intramuscularly (IM) or intravenously (IV) 20 mg after 4–6 hours, omnopone (2 % — 1.0 ml) IM 20 mg after 6–8 hours, tramadol (5 % — 1.0) IV 50–100 mg after 6–8 hours. Removal of smooth muscle spasm: atropine (0.1 % — 1.0) IM or IV 1–2 mg, papaverine, drotaverine IM or IV 2–4 ml after 4–6 hours. Decongestant therapy: prednisone 25–125 mg IV, atropine 1–2 mg IV, dimedrol (1 % — 1.0) in 10–20 mg, aminophylline (2.4 % — 10.0) in 5–10 ml, furosemide (1 % — 2.0) in 20–40 mg only after infusion therapy. Solcoseryl IV 3–5 ampoules in 250 ml of 5 % glucose solution or isotonic sodium chloride solution. To suppress the secretion of chlorides and hydrogen ions, almagel A is prescribed orally 1 tablespoon 6–8 times a day. A mixture of 200 ml of sunflower oil with the addition of an antibacterial agent (for example, ampicillin) and an anesthetic medicine of 2.0 g every hour for 20 ml.

In case of burns of the esophagus with damage to the pharynx and larynx, inhalations of a mixture consisting of 5 ml of 4 % sodium bicarbonate solution, 75–125 mg of hydrocortisone, 5 ml of 3 % ephedrine solution are indicated. Treatment includes antibiotics — IM or IV ampicillin, ampiox 1 g 4 times a day.

Vitamins: E (30 % — 1.0 ml) IM 300–600 mg after 12 h, C (5 % — 1.0 ml) IV 5–10 ml after 8–12 h, B_6 (5 % — 1.0 ml) IM 2–4 ml after 12 h.

VI. Prevention of inflammation and subsequent development of esophagus strictures: corticosteroids (hydrocortisone, prednisone) IM or IV 2–7 mg/kg and antibacterial agents. To eliminate early secondary bleeding from the esophagus and stomach, local hypothermia is used. For this purpose, one- or two-channel probes are used, feeding water cooled with ice up to 2–4 °C through them. Water is supplied at a rate of 0.5 l/min. within 2 hours. With a chemical burn of the upper respiratory tract, manifested by "asphyxia syndrome", tracheostomy is indicated, washing of the respiratory tract with 1 % sodium bicarbonate solution with antibacterial agents. Prevention: Acute renal failure — antispasmodics, diuretics, hepatoprotectors, vitamins, antihypoxants; pancreatitis — antiprotease medicines; pneumonia — antibacterial therapy.

VII. It is contraindicated to induce vomiting and non-probe gastric lavage. Laxatives are not prescribed. Surgical methods of treatment for early bleeding are contraindicated.

CHLORINE

Chlorine was the first substance used for military purposes as warfare toxic agent. On April 22, 1915, near the city of Ypres, German troops released it from cylinders (about 70 tons), directing a stream of gas driven by wind to the positions of French troops. This chemical attack caused damage in more than 7,000 people. Later, the substance was widely used in the fronts of the World War I and, therefore, the clinical picture of the damage was well studied.

Currently, chlorine is not considered as warfare toxic agent. Nevertheless, millions of tons of the substance are obtained annually and used for technical needs — water purification (2–6 %), bleaching of cellulose and tissues (up to 15 %), chemical synthesis (about 65 %), etc. Chlorine is the most common cause of industrial accidents.

Physical and chemical properties. Toxicity. Chlorine (Cl_2) is a yellowish — green gas with a characteristic suffocating odor, about 2.5 times heavier than air. Spreading in the contaminated atmosphere, it follows the terrain, flowing into pits and shelters. It is well adsorbed by activated carbon. It is chemically very active. When dissolved in water, it interacts with it, forming hydrochloric and hypochlorous acids. It is a strong oxidizer. Chlorine is neutralized with an aqueous solution of hyposulfite. It is stored and transported in liquefied form under high pressure. In case of accidents at production sites, storage, transportation and use facilities, mass destruction of people is possible. It accumulates in basements and lowlands of the area. It is stored and transported in a liquefied state.

It is explosive in a mixture with hydrogen. It is not flammable, but it is a fire hazard. Containers can explode when heated. It supports combustion of many organic substances.

Even in minimal concentrations (0.01 g/m^3) chlorine irritates the respiratory tract, acting in higher concentrations (more than 0.1 g/m^3) it causes severe damage.

Staying in an atmosphere containing chlorine at concentrations of 1.5–2 g/m^3 is accompanied by rapid (after 2–4 hours) development of pulmonary edema.

Routes of exposure. Chlorine acts mainly as a suffocating agent entering by inhalation. Ingestion is also possible. High concentrations of this gas can cause damage to the skin and mucous membranes.

Mechanisms of toxic action. The mechanism of the damaging effect of chlorine on the cells of the respiratory system is associated with its high oxidative activity, the ability to form hydrochloric acid (a sharp change in the pH of the medium and denaturation of macromolecules) and hypochlorous acid when interacting with water. Hypochlorous acid forms chloramines in the cytosol of cells that have a sufficiently high biological activity, can interact with unsaturated fatty acid bonds of phospholipids and form peroxides, block sulfhydryl groups of oligopeptides and proteins. Data have been obtained that in the reactions of hypochlorous acid with biomolecules, a superoxide radical is formed — the initiator of the process of free radical oxidation in cells.

Data on the effect of chlorine on the state of the biochemical system of the lungs are scarce. It has been shown that when the substance is inhaled in an average lethal toxic dose, there is a decrease in the content of reduced glutathione and ascorbic acid in the lungs, as well as the activity of glucose-6-phosphate dehydrogenase, glutathione reductase, glutathione peroxidase and catalase.

Clinical signs and symptoms. Most often, at the time of initial contact, the victim notes a marked burning sensation in the eyes and upper respiratory tract, as well as difficulty breathing. At the same time, severe weakness develops, practically depriving the victim of the possibility to run out of the contaminated area. Almost from the beginning of intoxication, a painful dry cough appears, and later severe shortness of breath develops with the involvement of auxiliary muscles in the act of breathing. The affected person takes a forced position, facilitating breathing. After the cessation of chlorine exposure, significant relief occurs (a latent period), but symptoms of respiratory tract irritation often persist: cough, scratching pain along the trachea, soreness in the diaphragm area. The respiratory rate gradually increases against the background of a slight drop in systolic pressure, the ratio of respiratory rate to heart rate changes to 1 : 2.

Percussion reveals dull pulmonary sound, the expansion of the boundaries of cardiac dullness, the mobility of the pulmonary edge decreases against the background of low position of the diaphragm. Single moist wheezes (rales) are heard in the lungs. After some time (from several hours to one day), the condition worsens again: cough and shortness of breath (up to 40 respiratory movements per minute) increases. Various moist rales are heard in the lungs, foamy yellowish or pinkish liquid is discharged from the mouth (up to 1 liter per day). Hypothermia, arterial hypotension and bradycardia are noted. The main causes of death in case of chlorine damage:

1. Reflex arrest of breathing and heartbeat already during the first breaths of infected air.

2. Chemical burn of the lungs (death occurs after 20–30 minutes of staying in the area with a high concentration of chlorine). At the same time, the autopsy reveals dry, collapsed lungs of a greenish-gray color. There is an empty left half of the heart against the background of pronounced dilatation and fullness of its right parts.

3. Progressive respiratory failure in the alveolar phase of toxic pulmonary edema. If death has not occurred within 24 hours after the initial exposure, the prognosis improves. After 48 hours, the condition gradually improves, the edematous fluid resolves. There comes a period of complications, the principal manifestation of which is pneumonia. In the vast majority of cases, with lesions of mild and moderate severity, complete recovery occurs, however, in some cases, pneumosclerosis and emphysema of the lungs develop in the long term with the formation of chronic cardiopulmonary insufficiency. In some cases, the development of bronchial asthma is possible.

Emergency medical care.

I. Stabilization of the patient's condition.

Acute respiratory failure. When the tongue is retracted, an air duct insertion is applied, oxygen therapy is carried out. In the absence of pharyngeal and laryngeal reflexes — intubation of the trachea, ventilation and aspiration of the tracheobronchial tree content.

Acute cardiovascular failure. ECG analysis of rhythm disorders is performed. According to the indications — medical correction, defibrillation, electrocardiostimulation. With hypotension — glucocorticoids (5–20 mg/kg/day of prednisone IV) or titration of dopamine 5–20 mcg/kg/min.

With convulsions and agitation — 2 ml of 0.5 % seduxene (10–20 mg) IV or other benzodiazepines, hexenal IV, sodium thiopental until the effect is obtained.

II. Inhalation of aerosols: sodium bicarbonate, antibiotics.

III. Infusion therapy: intravenous infusion of plasma, albumin and plasma substitutes: (rheopolyglucin, polyglucin) 5–20 % glucose, isotonic sodium chloride solution up to 30–50 ml/kg per day.

IV. Syndrome therapy: 1 ml of 1 % morphine, 1 ml of 1 % atropine, 20 ml of 10 % calcium gluconate, 10 ml of 2.4 % aminophylline, 2 ml of 1 % dimedrol, hydrocortisone — up to 300 mg per day IM, antibacterial medicines.

V. Prevention and treatment of complications. Treatment of toxic pulmonary edema and toxic shock. Treatment of conjunctivitis.

TRICHLOROETHYLENE

Physical and chemical properties. Toxicity. Colorless liquid, slightly aromatic odor, reminiscent of chloroform, insoluble in water, volatile, low resistance to light and air, decomposes in heat, forming hydrochloric acid, carbon dioxide, dichloromethane and phosgene. It is used as a degreasing agent, for dry cleaning of clothing, fur, fabrics, work wear, as well as in the process of extracting oils, glue. It is used in industry and as a raw material. The widespread use of this chloride solvent explains the large number of acute accidental poisoning by ingestion or inhalation.

Trichloroethylene has a strong narcotic and weak irritating effects.

The narcotic effect develops quickly and ends in 2–3 minutes after exposure. It differs from other narcotic substances in that it produces strong analgesia in small concentrations in the first stage of anesthesia. Trichloroethylene is used for anesthesia in a semi-closed system using special anesthesia devices with a calibrated evaporator without an absorber. For anesthesia and long-term analgesia, trichloroethylene is used in a concentration of 0.6–1.2 vol.%.

The lethal dose when ingested is about 100 ml. A concentration of 5.6 mg/l leads to severe poisoning. MPC — 200 mg/m^3.

Routes of exposure. Inhalation. Ingestion. Possible lesions of the skin.

Mechanisms of toxic action. The mechanism of action consists in the adsorption of toxicant molecules on the surface of cell membranes and organelles in many organs, in particular in the brain, which leads to reversible inhibition of spontaneous activity of neurons and manifests itself in the form of anesthesia. With an increase in concentration, a deep disorganization of biochemical processes in cells occurs and the transition to a state of first paranecrosis, and then necrosis. In fact, death occurs earlier due to paralysis of the respiratory center or acute heart failure as a result of pronounced arrhythmia and collapse.

When inhaling trichloroethylene vapors, 60–70 % of the substance passes into the blood and is retained in adipose tissue, brain, adrenal glands, liver and kidneys. Its maximum concentration in the blood is observed after 30 minutes – 1 hour and in acute oral poisoning is detected in the blood within 10–15 hours.

Regardless of the absorption pathways, 80 % of the trichloroethylene entering the body is metabolized in hepatic microsomes and red blood cells. The biological transformation of trichloroethylene consists in its transformation into trichloroethanol, monochloroacetic and trichloroacetic acids by means of an oxidation and reduction reaction in the presence of reduced NADP.

When the source of trichloroethylene intake is eliminated, stage I anesthesia is stopped after 2–3 minutes. Even the first stage of anesthesia, in fact, is poisoning, since during this period sensitivity to adrenergic influence increases, which can cause arrhythmia of heart contractions. With deeper anesthesia, especially when reaching stage IV (overdose), the exit from anesthesia is delayed. In the case of ingestion of trichloroethylene, absorption and manifestation of toxic effects occur much later and depend on the dose taken.

Clinical signs and symptoms. Acute poisoning with trichloroethylene causes nervous, respiratory, cardiovascular, gastrointestinal and renal-hepatic symptomatology. On the part of the CNS visual impairment, uncoordinated movements, mental disorders, depression of consciousness, sopor and coma are observed; peripheral nervous system — inflammation of the trigeminal and other nerves, optic nerve damage are noted.

Cardiovascular manifestations — shock and cardiac arrhythmia (up to ventricular fibrillation). When the gastrointestinal tract is affected, nausea, vomiting, abdominal pain are the main characteristics, in rare cases — bleeding from the gastrointestinal tract, protective tension of the abdominal muscles,

intestinal obstruction and even perforated ulcer are noted. Hepatic-renal disorders are manifested by jaundice and microscopic hematuria.

In severe poisoning as a result of massive exposure to trichloroethylene, the clinical picture is associated with narcotic and rapidly advancing comatose state, toxic shock, bloody diarrhea and signs of acute toxic inflammation of the liver.

In acute poisoning with trichloroethylene, fatal cases account for 10 %.

Trichloroethylene also causes skin lesions in the form of eczema-like dermatitis and burns with blisters — in cases of prolonged contact of the toxic substance with the skin.

There are two types of dermatitis with local action of trichloroethylene: contact dermatitis, accompanied by eczema and generalized form, leading to erythematous-papular skin lesions with muscle changes, necrotoxic effects, pulmonary disorders, progressive systemic sclerosis.

Emergency medical care.

I. Stabilization of the patient's condition.

Acute respiratory failure. When the tongue is retracted — an air duct insertion is applied, oxygen therapy is carried out. In the absence of pharyngeal and laryngeal reflexes — intubation of the trachea, ventilation, aspiration of the tracheobronchial tree content.

Acute cardiovascular failure. ECG analysis of rhythm disorders. According to the indications — medical correction, defibrillation, electrocardiostimulation. With hypotension — glucocorticoids (5–20 mg/kg/day of prednisone IV).

II. Cleansing of the gastrointestinal tract: when ingested, probe gastric lavage (in a coma state — after intubation of the trachea). Gastroenterosorption with activated charcoal (other sorbent) 0.5–1 g/kg every 8 hours for 1–3 days. Intestinal stimulation: saline laxative. Cleansing enema. In case of inhalation damage — oxygen therapy. In case of skin exposure — washing with soap and water.

III. Methods of artificial detoxification: early hemodialysis.

IV. Infusion therapy: forced diuresis with the introduction of 4 % sodium bicarbonate solution, intravenous infusion of plasma, albumin and plasma substitutes (rheopolyglucin, polyglucin), 5–20 % glucose solution, isotonic sodium chloride solution from 40 to 100 ml/kg/day. Intensive fluid administration continues until hemodynamic parameters are stabilized, then drip infusion may be used.

V. Syndrome therapy: vitamins B_1, B_6, C, B_{12}; relief of psychomotor agitation, convulsive syndrome — 2 ml of 0.5 % seduxen (10–20 mg) or other benzodiazepines, hexenal IV, sodium thiopental until the effect is obtained.

VI. Prevention of the primary cardiotoxic effects (correction of rhythm disturbances, conduction), brain edema, toxic encephalopathy, toxic nephropathy, acute renal failure. With aspiration — treatment of aspiration pneumonia.

VII. Contraindicated: adrenaline, norepinephrine.

HYDROGEN SULFIDE

Physical and chemical properties. Toxicity. It is a colorless gas with a pungent smell of rotten eggs, noticeable even at insignificant concentrations of 1 : 100 000. There is no direct proportionality between the concentration of hydrogen sulfide and the intensity of the odor. On the contrary, at a high, very dangerous concentration, the sensation of the smell of hydrogen sulfide weakens, up to the point of disappearance, apparently due to paralysis of the olfactory nerve endings.

The chemical formula is H_2S. The boiling point is 60.28 °C. The density of the substance is 1.363 g/l (g/cm^3). Solubility — 0.25 (40 °C) g/100 ml.

It occurs naturally in the composition of oil, natural gas, volcanic gas and in hot springs. Thermally unstable (at temperatures above 400 °C decomposes into simple substances — S and H_2). Saturated aqueous solution of H_2S is hydrogen sulfide acid.

Hydrogen sulfide is of limited use due to its toxicity.

In analytical chemistry, hydrogen sulfide and hydrogen sulfide water are used as reagents for the deposition of heavy metals, whose sulfides are very slightly soluble, in medicine — as part of hydrogen sulfide baths. Hydrogen sulfide is used to produce sulfuric acid, elemental sulfur, sulfides, and is also used in organic synthesis to produce thiophene and mercaptans.

In recent years, the possibility of using hydrogen sulfide accumulated in the depths of the Black Sea as energy and chemical raw materials has been considered.

It has both local irritant and general neurotoxic effects due to tissue hypoxia. At hydrogen sulfide concentrations of 0.02–0.2 mg/l, symptoms of intoxication already appear; at a concentration of 1.2 mg/l, a lightning form of poisoning is observed.

Routes of exposure. Hydrogen sulfide enters the body mainly through the respiratory organs and in small quantities through the skin and stomach.

Mechanisms of toxic action. When inhaled, hydrogen sulfide is retained mainly in the upper respiratory tract. When in contact with the moist surface of the mucous membranes, H_2S reacts with alkalis with formation of sodium sulfide, which has an irritating and cauterizing effect. But it should be noted that the main toxic effect of hydrogen sulfide is manifested not in local irritation of the mucous membranes, but in its general resorptive effect on the organism. Currently, it is considered that there are three mechanisms of hydrogen sulfide toxicodynamics — the effect on the central nervous system, oxidative processes and blood functions.

In small amounts, hydrogen sulfide depresses the CNS, in moderate amounts it excites, and in large amounts it causes paralysis, in particular of the respiratory and vascular centers. These changes are in many cases functional and reversible.

Hydrogen sulfide has a toxic effect on the mechanisms of oxidative processes in tissues: like cyanides, it causes tissue hypoxia due to the ability to interact with iron cytochromes B, C, A, inhibit cytochrome oxidase. In addition, the metabolism

of hydrogen sulfide is associated with the formation of peroxide compounds in tissues, which inhibit glycolysis, further increase the “energy hunger”.

The ability of the blood to be saturated with oxygen decreases. With chronic hydrogen sulfide poisoning, the ability of hemoglobin to absorb oxygen decreases to 80–85 %, with acute — up to 15 %. There is also a decrease in the oxidative capacity of tissues.

The effect of hydrogen sulfide on the blood occurs in two phases: first, the number of red blood cells increases, then decreases, the hemoglobin content decreases, blood clotting and viscosity increases.

The risk of poisoning at high concentrations of hydrogen sulfide increases due to the loss of smell feeling.

The oxidation of hydrogen sulfide in the body occurs very quickly: up to 99 % of hydrogen sulfide is removed from the body within 3–4 minutes, so it is detected in the blood only if the rate of hydrogen sulfide intake is equal to the rate of oxidation or exceeds the latter. H_2S is oxidized to sulfur and sulfates, which are excreted by the kidneys; about 7 % of hydrogen sulfide is excreted unchanged through the lungs.

Clinical signs and symptoms. Clinical manifestations when inhaling hydrogen sulfide for several hours at a concentration of 0.006 g/m^3 — burning in the eyes, headache, lacrimation, photophobia, runny nose, decreased air and bone conduction; at 0.2–0.3 g/m^3 — pain in the eyes, fullness of the conjunctiva, irritation of the nasopharyngeal mucosa, metallic taste in the mouth, fatigue, headache, chest tightness, nausea; at higher concentrations (0.3–0.5 g/m^3) — painful irritation of the conjunctiva, nausea, vomiting, cold sweat, appearing within 15–30 minutes. Later, headache, dizziness, sudden weakness, fainting or excitement with clouding of consciousness occur. The respiratory rate slows down at first, then — rapid shallow breathing, cough and chest pain occur. Continued inhalation leads to the formation of toxic pulmonary edema. When inhaling hydrogen sulfide at a concentration of 0.6 g/m^3 or more, clinical manifestations of general resorptive effects of the poison develop.

There are two possible variants of the intoxication course: *apoplectic* and *convulsive-comatose forms*. In the first case, almost instantaneous convulsions, loss of consciousness take place. Death occurs from respiratory and cardiac arrest within a few minutes.

Convulsive-comatose form develops slowly. After a convulsive period, a prolonged coma occurs, which is sometimes replaced by motor excitement, hallucinations, apathy, drowsiness, retrograde amnesia after coming out of the coma.

Complications: decreased intelligence up to dementia, psychosis, paralysis, gastrointestinal diseases, pneumonia, myocardial dystrophy.

Emergency medical care.

I. Stabilization of the patient's condition.

Acute respiratory failure. When the tongue is retracted, an air duct insertion is applied, oxygen therapy is carried out. In the absence of pharyngeal and

laryngeal reflexes — intubation of the trachea, ventilation and aspiration of the tracheobronchial tree content are performed.

Acute cardiovascular failure. ECG analysis of rhythm disorders. According to the indications — medical correction, defibrillation, electrocardiostimulation. With hypotension, dopamine titration is 3–15 mcg/kg/min. With convulsions and agitation — 2 ml of 0.5 % seduxen (10–20 mg) IV or other benzodiazepines, hexenal IV, sodium thiopental until the effect is obtained.

II. Infusion therapy: intravenous infusion of plasma, albumin and plasma substitutes (rheopolyglucin, polyglucin), 5–20 % glucose, isotonic sodium chloride solution up to 30 ml/kg/day.

III. Syndrome therapy: in case of damage to the upper respiratory tract: inhalation of a mixture consisting of 5 ml of 4 % sodium bicarbonate solution, 125 mg of hydrocortisone, 5 ml of 3 % ephedrine solution, antibacterial medicines IV or IM (ampicillin, ampiox 1 g 4 times per day), 10 ml of 2.4 % aminophylline, 10–20 ml of 5 % vitamin C and then repeatedly up to 5 g/day, vitamins B_1, B_6.

IV. Prevention of complications. With severe respiratory insufficiency — ALV, treatment of tracheobronchitis, pneumonia, pulmonary edema. Treatment of cerebral edema: craniocerebral hypothermia, glucocorticoids (up to 300 mg of methylprednisolone), osmodiuretics. Treatment of toxic encephalopathy: 20 ml of piracetam after 6–8 hours. Rehabilitation in the neurological department.

HYDROGEN PEROXIDE

Physical and chemical properties. Toxicity. It is a colorless liquid with a faint smell of ozone. The boiling point is +151.4 °C. Hydrogen Peroxide (H_2O_2) is a low-volatile compound, so poisoning most often occurs when it comes into contact with a liquid product or aerosol. It is used as a bleaching agent in the textile and paper industry, antiseptic and disinfectant (3 % aqueous solution), in organic synthesis. Concentrated hydrogen peroxide (80–90 %) is also used as fuel in engines for submarines, airplanes, torpedoes, etc.

Routes of exposure. Under the action of hydrogen peroxide in an aerosol or liquid state, chemical burns of the skin and eyes occur with loss of vision. The greatest toxicological danger is oral intake into the body, a toxic effect is possible with inhalation exposure: hydrogen peroxide in an aerosol state can cause inflammatory and necrotic changes in the respiratory organs up to toxic pulmonary edema.

Mechanisms of toxic action. Local action leads to chemical burns of different degree of severity. With the penetration of hydrogen peroxide into the blood, the development of a gas embolism is possible. The mechanism of action of hydrogen peroxide is also associated with its ability to cause hemolysis and the formation of methemoglobin. When intoxicated with hydrogen peroxide, the activity of peroxidase and catalase decreases, and the content of reduced glutathione necessary to maintain the integrity of erythrocyte membranes decreases, as a result of which hemolysis develops. The methemoglobin-forming effect of hydrogen peroxide is explained by the ability to oxidize hemoglobin iron

to a trivalent state and inhibit enzymes that regulate the content of methemoglobin (glutathione peroxidase, glutathione reductase and methemoglobin reductase).

Clinical signs and symptoms.

1. In case of local action chemical burns of different degrees of severity develop, the skin of the face, neck and hands are most frequently affected, the eyes are damaged. Burn shock with extensive lesions may also develop.

2. General resorptive effects. Hydrogen peroxide causes pronounced destructive changes in the wall of the digestive tract, which by nature approach the action of alkalis. Deep damage to the mucous, submucosal and sometimes muscular layers with disruption of the integrity of the vascular wall create conditions for the penetration of gaseous oxygen into the vascular bed with the subsequent development of gas embolism of the vessels of the brain and heart.

In case of poisoning with hydrogen peroxide, burn disease develops with its characteristic pathological syndromes. A serious complication of this pathology is gas embolism of the cerebral vessels. In patients, there is impairment of consciousness, the appearance of focal neurological symptoms, respiratory disorders of the central type, which may present certain diagnostic difficulties.

Emergency medical care.

I. Stabilization of the patient's condition.

Acute respiratory failure. With increasing laryngeal stenosis due to edema or chemical burn, obstruction of the respiratory tract or bronchorrhea with signs of hypoxia, emergency intubation of the trachea is necessary, if it is impossible, cricothyroidotomy or tracheostomy, ventilation, aspiration of the tracheobronchial tree content. Oxygen therapy. Hyperbaric therapy.

Acute cardiovascular failure. In the absence of pulse on carotid arteries CPR is performed. With hypotension — intravenous infusion of colloidal fluids 10–20 ml/kg, titration of norepinephrine 2 mcg/min or dopamine 3–15 mcg/kg/min.

With convulsions and agitation — 2 ml of 0.5 % seduxene (10–20 mg) IV or other benzodiazepines, hexenal, sodium thiopental IV until the effect is obtained.

II. Cleansing of the gastrointestinal tract. Gastric lavage with a thick probe lubricated with vaseline oil, lidocaine paste, or oil with other anesthetic medicine. Washing with cold water — it reduces hyperemia and thereby limits absorption. The presence of blood in the flushing water is not a contraindication for gastric lavage procedure.

III. Artificial detoxification of the body. With the development of oligoanuria, azotemia, hyperkalemia — hemodialysis or plasmodialysis is indicated.

IV. Infusion therapy. Intravenous infusion of plasma, albumin and plasma substitutes (rheopolyglucin, polyglucin, neorondex), reamberin 10–15 ml/kg, 5–20 % glucose, isotonic sodium chloride 40–100 ml/kg/day (up to 3–15 l/day). Intensive fluid administration continues until the hemodynamic parameters are stabilized, then drip infusion of solutions is used. With the development of bleeding: hunger, local hypothermia of the stomach, blood components transfusion.

V. Syndrome therapy: relief of agitation and anesthesia — 1 ml of 0.005 % fentanyl + 1–3 ml of 0.25 % droperidol after 4–6 hours IV, 1 ml of 2 % promedol

(20 mg) after 4–6 hours IV or IM, 1 ml of 2 % of omnopone (20 mg) IM after 6–8 hours, 1 ml of 5 % tramadol IV (50–100 mg) after 6–8 hours, 200–300 mg ketoprofen (ketonal) IV.

In case of pulmonary embolism — 10–15 000 U of heparin IV, 10 ml of 2.4 % aminophylline (120–240 mg), 60–120 mg prednisone IV.

In case of embolism of cerebral blood vessels — 2 ml of 0.5 % cavinton (20–40 mg) in 400 ml of 5 % glucose solution or 4 mg of sermion in 250 ml of isotonic sodium chloride solution IV.

With hypercoagulation — heparin of 10 000 U every 4–6 hours.

Decongestant therapy: 25–125 mg of prednisone, 1–2 mg of atropine, 1 ml of 1 % dimedrol (10–20 mg) IV, 10 ml of 2.4 % aminophylline IV, 2 ml of 1 % furosemide (20–40 mg) IV only after infusion therapy. Solcoseryl IV drip of 3–5 ampoules in 250 ml of 5 % glucose solution or isotonic sodium chloride solution. A mixture of 200 ml of sunflower oil with the addition of an antibacterial agent (for example, ampicillin) and anesthetic agent 2 g every hour for 20 ml. Vitamins: E — 1 ml of 30 % IM (300–600 mg) after 12 hours, C — 1 ml of 5 % (5–10 ml) IV after 8–12 hours, B_6 — 1 ml of 5 % IM (2–4 ml) after 12 hours.

For burns of the esophagus with damage to the pharynx and larynx, inhalations of a mixture consisting of 5 ml of 4 % sodium bicarbonate solution, 75–125 mg of hydrocortisone, 5 ml of 3 % ephedrine are indicated. Antibacterial medicines — ampicillin, ampiox 1 g 4 times a day IV or IM.

VI. Prevention of inflammation and subsequent development of strictures of esophagus — corticosteroids (hydrocortisone, prednisone) 2–7 mg/kg IV or IM; for correction of acute renal failure — antispasmodics, diuretics, hepatoprotectors, vitamins, antihypoxants.

CARBON DISULFIDE

Physical and chemical properties. Toxicity. Carbon disulfide (CS_2) is a colorless, highly volatile liquid with a density of 1.263 and a boiling point of +46.24 °C. In its pure form, it has a pleasant smell, is easily ignited, vapors are 2.6 times heavier than air, almost insoluble in water, soluble in alcohol and ether. It is a good solvent of fats, oils, rubber.

It is used in the viscose industry, during the cold vulcanization of rubber, as a solvent for rubber products, phosphorus, fats, for pest control of agriculture. In production conditions, carbon disulfide vapors rarely reach high concentrations and therefore acute intoxication is possible only in case of accidents, when descending into inspection wells of sewer systems. Chronic poisoning is more common.

Until relatively recently, carbon disulfide was one of the most dangerous industrial poisons in a number of industries, mainly in the chemical industry, and gave a large number of very serious poisoning. For the last 30 years, due to the elimination of it from some industries or the restriction of its use, as well as the adoption of precaution measures, the number of carbon disulfide poisoning cases has significantly decreased. MPC — 10 mg/m^3. Toxic concentration of carbon disulfide is 100–127 mg/l.

Routes of exposure. Being highly soluble in lipids, carbon disulfide easily penetrates into the blood through the respiratory tract and the skin. It should be noted that with the inhalation route of exposure, about 90 % of the toxicant is exhaled back. In the process of metabolism, about 50 % of it is excreted unchanged with exhaled air, partially oxidized to inorganic sulfate, excreted in urine, feces and sweat.

Mechanisms of toxic action. CS_2 is a polytropic poison that causes acute and chronic poisoning. In acute poisoning, it has a pre-narcotic effect. It affects the central and peripheral nervous system, causing functional disorders of the type of neurasthenia and organic disorders of the type of encephalopolyneuritis. It causes disorders in the cardiovascular system with direct effects on the heart (dystrophic changes), as well as extracardial angiodistonic disorders. It has a damaging effect on the organs of the gastrointestinal tract, causing chronic gastritis, peptic ulcer of the stomach and duodenum, toxic hepatitis. It disrupts the biotransformation of cholesterol and steroids. It has an atherogenic effect, disrupts the ovarian-menstrual cycle, can lead to spontaneous abortions, premature birth. It causes neuroendocrine disorders, disrupts the metabolism of histamine, serotonin, vitamin B_6, nicotinic acid; disrupts the processes of oxidative deamination, inhibits the activity of cytochrome oxidase, ATP-ase.

Clinical signs and symptoms. In severe poisoning, the phenomena of anesthesia are most often prevailed. After several minutes of inhalation at a concentration of 10 mg/l, a person loses consciousness, then coma develops, death occurs from cardiac arrest. With a successful outcome, coming out of a comatose state is often accompanied by psychomotor agitation, vomiting, ataxia, memory disorders, obsessive thoughts of a suicidal nature, sexual disorders up to impotence may occur.

In acute poisoning of moderate severity, the state of anesthesia is characterized by the presence of an excitation phase. Redness of the skin of the face, constant euphoria, unreasonable laughter, ataxia, headache, nausea, vomiting, convulsions, hearing disorders are observed; sometimes unmotivated actions and behavior, delusional state, hallucinations may develop. The phase of excitation is usually replaced by depression, accompanied by sweating, general inhibition, apathy. Pronounced acute and subacute intoxication can lead to persistent organic damage to the central nervous system by the type of encephalomyelitis with significant intellectual insufficiency, Parkinsonism phenomena, oculomotor disorders are noted. With mild degrees of poisoning, headache, dizziness, nausea, irritation of the upper respiratory tract, a feeling of intoxication, paresthesia, a decrease in the skin sensitivity occur. There is a marked decrease in alcohol tolerance. After taking alcohol, paroxysmal vomiting, mucous diarrhea with blood occurs.

Emergency medical care.

I. Stabilization of the patient’s condition.

Acute respiratory failure. When the tongue is retracted, an air duct insertion and oxygen therapy are applied. In the absence of pharyngeal and laryngeal reflexes — intubation of the trachea, ventilation, aspiration of the tracheobronchial tree content.

Acute cardiovascular failure. ECG analysis of rhythm disorders. According to the indications — medical correction, defibrillation, electrocardiostimulation. With hypotension — dopamine titration is 3–15 mcg/kg/min.

With convulsions and agitation — 2 ml of 0.5 % seduxene (10–20 mg) or other benzodiazepines IV, hexenal IV, sodium thiopental until the effect is obtained.

II. Infusion therapy: intravenous infusion of plasma, albumin and plasma substitutes (rheopolyglucin, polyglucin), 5–20 % glucose solution, isotonic sodium chloride solution up to 30 ml/kg/day.

III. Syndrome therapy: in case of damage to the upper respiratory tract: inhalation of a mixture consisting of 5 ml of 4 % sodium bicarbonate solution, 125 mg of hydrocortisone, 5 ml of 3 % ephedrine solution; antibiotics — ampicillin, ampiox 1 g 4 times per day IV or IM. 2,4 % of aminophylline — 10 ml. Vitamin C — 10–20 ml of 5 % and then repeatedly up to 5 g/day, vitamins B_1, B_6.

IV. Prevention of complications. With severe respiratory insufficiency — ALV, treatment of tracheobronchitis, pneumonia, pulmonary edema, treatment of cerebral edema (craniocerebral hypothermia, glucocorticoids — up to 300 mg of methylprednisolone, osmodiuretics). Treatment of toxic encephalopathy: pyracetam 20 ml after 6–8 hours. Rehabilitation in the neurological department.

ACRYLONITRILE

Acrylonitrile (CH_2=CH–C≡N) is used as a monomer in the production of artificial fibers, polymers and rubber, as well as in the organic synthetics industry. In addition, it is used as a powerful insecticide. Despite the fact that the toxicant is prohibited for use on food products, it continues to be used in the cultivation of cereals, dried fruits, tobacco, and is used as a "point insecticide" in mills and bakeries to destroy those in flour.

In addition to direct emissions into the atmosphere during production and industrial use, release of acrylonitrile is possible due to accidents, equipment failures and non-compliance with technology and operating rules. The main source of supply of acrylonitrile with air is its production.

Physical and chemical properties. Toxicity. Acrylonitrile under normal conditions is a colorless liquid with an easily distinguishable smell of mustard. Volatile. The saturating concentration of vapors at +20 °C is 249 g/m^3. Vapors are heavier than air.

The MPC of acrylonitrile is 0.5 mg/m^3. In the latter case, the development of toxic pulmonary edema is possible.

Acrylonitrile has both a local and a strong general toxic effect. Skin irritation also develops under the action of acrylonitrile vapors at a concentration of 0.3–0.5 g/m^3 or higher. The effect of the substance in such concentrations is also accompanied by the phenomena of irritation of the eyes and mucous membranes of the upper respiratory tract. The smell of acrylonitrile is felt with a vapor content in the amount of 0.008–0.04 g/m^3.

When the concentration of poison in the air is 0.035–0.22 g/m^3, symptoms of intoxication develop within 15–20 minutes.

Routes of exposure. The half-life in water is 5–7 days, however, the emergency entry of acrylonitrile into groundwater can lead to long-term contamination. Despite the decontaminating measures, acrylonitrile can get into food products (especially butter, margarine) from polymer containers and packaging materials consisting of acrylonitrile copolymers. Acrylonitrile is easily absorbed through the intact skin. Thereby poisoning with acrylonitrile can take place through the gastrointestinal tract, intact skin and lungs.

Mechanisms of toxic action. Like many other representatives of the nitrile group, the substance is destroyed in the body with the formation of the CN-ion, which inhibits the activity of cytochrome oxidase. This is due to the general poisonous effect of acrylonitrile. The mechanisms of the suffocating and cauterizing effects of the poison have not been studied.

Clinical signs and symptoms. Acrylonitrile has both local and strong general resorptive toxic effect. If drops of the substance are not immediately removed from the surface of the skin or poorly treated after removal of the poison, bulbous dermatitis usually develops within 10–24 hours at the site of application, less often ulceration, healing with scar formation is noted.

Headache, nausea, vomiting, dizziness, shortness of breath, sweating, diarrhea appear; in more severe cases severe shortness of breath, tachycardia, decrease in body temperature, convulsions with a predominance of the tonic component develop, then — coma, muscle relaxation, death from respiratory and cardiac arrest. Consciousness is lost even in the period preceding the development of convulsive syndrome.

With prolonged exposure to acrylonitrile vapors in moderate concentrations toxic pulmonary edema develops.

Victims who have undergone acrylonitrile intoxication frequently have long-lasting pain and weakness in the legs, muscle twitching, shaky gait, emotional instability, memory loss, reduced blood pressure, lack of pulse in the extremities.

Emergency medical care. The treatment consists of three points:

1. Treatment of lesions of the skin and eyes (developed as a result of the cauterizing effect of the poison) according to the general principles of treatment of chemical burns.

2. Prevention and therapy of toxic pulmonary edema.

3. The correction of the phenomena of the general poisonous effect of the poison, for which the same antidotes are used as in case of cyanide poisoning.

SULFURIC ACID

Physical and chemical properties. Toxicity. Sulfuric acid (H_2SO_4) is colorless oily liquid. Non-volatile compound (0.022 mg/l). At 50 °C and higher, vapors of sulfuric anhydride appear — a product more toxic than sulfuric acid. Solubility in water is good. With water vapor of the air it forms a thick stable fog (density 1,7). Strong oxidizer. Ignites organic solvents and oils.

Oleum — technical sulfuric acid — a solution of sulfuric anhydride (about 20 %) in sulfuric acid, contains toxic arsenic hydrogen. A colorless heavy liquid.

Slowly evaporates, forms smoke in the air. It forms persistent foci of chemical contamination. Aggregate state: vapor, aerosol, drip-liquid. The aerosol is more dangerous, concentrated in the surface layer of the atmosphere. Contaminates water sources.

Routes of exposure. Poisoning is possible as a result of droplets (aerosol) on the skin and mucous membranes, as well as inhalation. Sulfuric acid has an irritating and cauterizing effect on the mucous membranes of the respiratory tract and lungs.

Mechanisms of toxic action. Sulfuric acid is a strong oxidizing agent. In contact with tissues, it causes coagulation necrosis, denaturation of proteins.

Clinical signs and symptoms. Upon contact with the skin, sulfuric acid causes severe burns, manifested by severe burning, with the formation of a brown-black scab, under which there is ulceration. Scarring is long (1–1.5 months). Burn shock and collapse are possible.

If sulfuric acid is immediately washed off with water, its effect may be limited to hyperemia of the skin.

Acute poisoning with sulfuric acid is manifested by sharp irritation of the upper respiratory tract, difficulty breathing, spasm of the glottis, burning in the eyes. At high concentrations of sulfuric acid in the air, severe bronchitis or pneumonia can develop. After a long latent period (90 days), toxic pulmonary edema is observed, accompanied by deep respiratory and hemodynamic disorders, pronounced acidosis. With severe intoxication, toxic hepatopathy and nephropathy often develop.

Usually, along with an aerosol of sulfuric acid, there is a large amount of sulfur dioxide in the air, so poisoning is aggravated by the effect of this strong poison on the body.

HYDROCHLORIC ACID

Physical and chemical properties. Toxicity. Hydrochloric acid (HCl) is a colorless liquid containing 35–38 % hydrogen chloride. It easily evaporates in the air, smokes, is not flammable. It dissolves well in water.

Routes of exposure. The lesion occurs by inhalation, as well as a result of direct exposure to the skin and mucous membranes.

Mechanisms of toxic action. Hydrochloric acid is a corrosive agent. It is one of the most powerful acids. It destroys paper and wood. In contact with tissues it causes coagulation necrosis, denaturation of proteins.

Clinical signs and symptoms. There is bullous dermatitis on the skin (gray inflammation with blisters), the affected areas have a gray-whitish color; burns are insignificant. On the mucous membranes of the eyes it causes conjunctivitis, chemical burn, corneal opacity. Acute rhinitis with ulceration is characteristic. When inhaling vapors, the typical irritating effect of the upper respiratory tract is manifested by hoarseness, cough, chest pain, laryngeal edema, asphyxia. In severe cases, toxic pulmonary edema develops after 3–4 hours. With resorptive action, hemolysis, acidosis, toxic hepatopathy and nephropathy are possible.

The zone of chemical contamination is local, short-term. The toxic cloud is heavy, concentrates in low places, contaminates water sources. The lesion is fast-acting. The spilled substance is fenced with an earthen rampart, covered with sand, decontaminated with lime mortar, caustic solutions. Vapors are deposited remotely with water or lime solution. The danger zone is isolated.

Personal protective equipment: industrial anti-gas filter grade B; RPG-67V respirator; protective suit; rubberized raincoats; gloves; boots made of resistant rubber; safety glasses; after leaving the focus of chemical contamination sanitary processing is necessary — washing in the shower with soap.

Common approaches to carrying out emergency medical care for acid poisonings.

I. Stabilization of the patient's condition.

Acute respiratory failure. With increasing laryngeal stenosis due to edema or chemical burn, obstruction of the respiratory tract or bronchorrhea with signs of hypoxia, emergency intubation of the trachea is necessary, if it is impossible — cricothyroidotomy or tracheostomy, ALV, aspiration of the tracheobronchial tree content, oxygenotherapy.

Acute cardiovascular failure. CPR is performed in the absence of pulse on the carotid arteries. With hypotension — intravenous infusion of colloidal fluids 10–20 ml/kg, titration of dopamine 3–15 mcg/kg/min.

With convulsions and agitation — 2 ml of 0.5 % seduxene (10–20 mg) or other benzodiazepines IV, hexenal, sodium thiopental IV until the effect is obtained.

II. Cleansing of the gastrointestinal tract. Gastric lavage with a thick probe lubricated with vaseline oil, lidocaine or another anesthetic medicine. Washing with cold water — it reduces hyperemia and thus limits absorption. The presence of blood in the flushing waters is not a contraindication for the gastric lavage. It is good to wash the stomach with water with the addition of egg protein (it can help to neutralize acids (4 egg proteins per 1 liter of water). Gastroenterosorption is indicated.

III. Artificial detoxification of the body. With the development of oligoanuria, azotemia, hyperkalemia — hemodialysis or plasmodialysis.

IV. Infusion therapy: intravenous infusion of plasma, albumin and plasma substitutes (rheopolyglucin, polyglucin), reamberin 10–15 ml/kg, 5–20 % glucose solution, isotonic sodium chloride 40–100 ml/kg/day (up to 3–15 l/day). Intensive fluid administration should be continued until the hemodynamic parameters increase by 45–50 % compared to the baseline level, then it is possible to switch to a drip infusion of the solutions. For elimination of acidosis, alkalinization of blood and urine (prevents the precipitation of hemoglobin in the renal tubules) is indicated — intravenous infusion of 4 % sodium bicarbonate solution of 5–15 ml/kg.

To prevent hemolysis, hemoglobinuria, hemoglobinuria nephrosis, acute renal failure: intravenous forced diuresis with 4 % sodium bicarbonate 5–15 ml/kg using urea, mannitol (1–2 g per 1 kg of body weight) or lasix 60–240 mg simultaneously, hypertonic (10–20 %) glucose solution is administered.

With the development of gastrointestinal bleeding: hunger, local hypothermia of the stomach, transfusion of blood and freshly frozen plasma.

III. Syndrome therapy: Relief of pain syndrome: 1 ml 2 % promedol IM or IV (20 mg) after 4–6 hours, 1 ml of 2 % omnopone IM (20 mg) after 6–8 hours, 1 ml of 5 % tramadol IV (50–100 mg) after 6–8 hours. Removal of smooth muscle spasm: 1 ml of 0.1 % atropine IM or IV (1–2 mg), drotaverine, No-spa IM or IV 2–4 ml after 4–6 hours. Decongestant therapy: 25–125 mg of prednisolone IV, 1–2 mg of atropine IV, 1 ml of 1 % dimedrol IV (10–20 mg), 10 ml of 2.4 % aminophylline IV (5–10 ml), 2 ml of 1 % lasix IV (20–40 mg) only after infusion therapy. Solcoseryl — IV of 3–5 ampoules in 250 ml of 5 % glucose solution or isotonic sodium chloride solution. To suppress the secretion of chlorides and hydrogen ions, Almagel A is prescribed orally 1 tablespoon 6–8 times a day, H_2-blockers — 450–600 mg/day of ranitidine in 2–3 doses, 20 mg of famotidine 3–4 times a day. A mixture of 200 ml of sunflower oil with the addition of an antibiotic agent (for example, ampicillin) and 20 ml anesthetic agents every hour.

For burns of the esophagus with damage to the pharynx and larynx, inhalations of a mixture consisting of 5 ml of 4 % sodium bicarbonate solution, 75–125 mg of hydrocortisone, 5 ml of 3 % ephedrine solution are indicated. Treatment includes antibiotics — ampicillin, ampiox 1 g 4 times a day IM or IV. Vitamins: E — 1 ml of 30 % IM (300–600 mg) after 12 hours, C — 1 ml of 5 % IV (5–10 ml) after 8–12 hours, B_6 — 1 ml 5 % IM (2–4 ml) after 12 hours.

VI. Prevention of inflammation and subsequent development of strictures of the esophagus — corticosteroids (hydrocortisone, prednisone) IM or IV 2–7 mg/kg and antibiotics.

To eliminate early secondary bleeding from the esophagus and stomach, local hypothermia is indicated. For this purpose, one- or two-channel probes are used, feeding water cooled with ice to 2–4 °C through them. Water is supplied at a rate of 0.5 l/min. for 1–2 hours. In case of a chemical burn of the upper respiratory tract, manifested by asphyxia syndrome, tracheostomy, aspiration of the respiratory tract content with a 1 % solution of sodium hydrocarbonate with an antibiotic is indicated. Prevention of acute renal and liver failure — antispasmodics, urine, hepatoprotectors, vitamins, antihypoxants; pancreatitis — antienzyme medicines; pneumonia — antibacterial therapy.

VII. Vomiting induction and non-probe gastric lavage with sodium bicarbonate solution, laxatives and surgical methods of treatment for early bleeding are contraindicated.

Table 5 shows the schemes of antidote therapy for the most common poisoning with emergency hazardous chemicals.

Table 5

Antidote therapy of poisoning with EHC

Substances	Antidotes	Mechanism of antitoxic action	Methods of antidote therapy
Halogenated hydrocarbons (tetrachloromethane, methyl bromide, etc.)	Acetylcysteine	Binding of active metabolites, increasing the level of endogenous glutathione	Intravenously 10 % solution in 5 % glucose (up to 250–300 mg/kg of body weight per day) for 1–2 days
Hydrazine and its derivatives	Vitamins of group B (pyridoxine hydrochloride)	Restoration of the activity of pyridoxal enzymes	IV or IM 5–10 ml of 5 % solution 2–3 times a day. In severe cases, 25 mg/kg of body weight ($^1/_4$ dose IV and $^3/_4$ dose intramuscularly). With prolonged convulsions, they are re-administered after 2–3 hours
Methemoglobin-forming agents (aniline, nitro benzene, etc.)	Ascorbic acid	Conversion of methemoglobin into hemoglobin	10–20 ml of 5 % solution repeatedly (up to 60 ml on the first day) IV
	Methylene blue	The same mechanism	1 % solution 5–10 ml IV, in severe cases, injections are repeated after 3–4 hours
	Cystamine dihydrochloride	Prevention of formation of methemoglobin and hemolysis of erythrocytes	Orally 0.4 g 2–3 times with an interval of 2–3 hours
Arsenic Hydrogen	Mercaptide	Oxidation of arsenic hydrogen to form non-toxic cyclic thioarsenites	Intramuscularly, 1 ml of 40 % oily solution. In case of severe swelling, 2 ml after 4–6 hours. On the 2nd – 3rd day — after 8–12 hours
Carbon monoxide	Oxygen	Elimination of hemic hypoxia, acceleration of carboxyhemoglobin dissociation	First, inhalations of 80–100 %, and then 40–60 % oxygen. The most effective hyperbaric oxygenation sessions are 1–1.5 hours at an excess pressure of 1.5–2 atm.
	Tetacin-calcium	Binds poisons with the formation of complex compounds excreted in urine	20 ml of 10 % solution in 250–300 ml of 5 % glucose IV 1–2 times a day (with a break of at least 3 hours) within 3–4 days
Organophosphorus insecticides, carbamates	Atropine sulfate	M-cholinolytic action	Intramuscularly 1–3 ml of 0.1 % solution repeatedly after 20–30 min (in severe cases, IV 5–7 ml every 10–15 minutes) until signs of mild overatropinization appear. Maintenance atropinization for 2–7 days

End of the Table 5

Substances	Antidotes	Mechanism of antitoxic action	Methods of antidote therapy
	Dipyroxime	Reactivation of cholinesterase, binding with a poison, reduction of sensitivity of cholinergic receptors	Intravenously or intramuscularly 1–2 ml of 15 % solution 2–4 times a day for 2 days
	Isonitrosine	The same action	IV or IM 3 ml of 40 % solution repeatedly (daily dose 8–10 ml)
Cyanides (prussic acid, its salts, etc.)	Anticyan	Formation of methemoglobin binding cyanides	IM 1 ml or IM 0.75 ml of 20 % sol. in 10–20 ml 40 % sol. glucose. In severe cases, 1 mg IM after 30 and 60 minutes after the first injection
	Amylnitrite	The same action	Inhalation of vapors from a crushed ampoule
	Methylene blue or chromosome	Formation of methemoglobin, binding of excess protons	Intravenously 1 % solution of 1–2 ml/kg of body weight
	Sodium thiosulfate	Formation of non-toxic rhodanides	Intravenously slowly 50 ml of preheated 30 % solution
	Glucose	Formation of non-toxic cyanhydrins	Intravenously, 20–40 ml of 40 % solution

TOXICOLOGICAL CHARACTERISTICS OF WIDESPREAD TECHNICAL LIQUIDS: METHYL ALCOHOL, ETHYLENE GLYCOL, CARBON TETRACHLORIDE, DICHLOROETHANE

Toxic technical liquids used in the national economy and the Armed Forces are divided into seven groups:

1. Alcohols and alcohol-based liquids: methanol — synthetic poison (methyl alcohol), tetrahydrofurfuryl alcohol, denatured ethyl alcohol, brake fluids.

2. Glycol-based liquids: ethylene glycol, cooling low-freezing liquids, high-temperature low-freezing cooling liquid, brake fluids, anti-icing liquids.

3. Organochlorine solvents: technical carbon tetrachloride, dichloroethane, technical trichloroethylene, perchloroethylene.

4. Ethyl liquid and leaded gasoline: ethyl liquid, aviation gasoline some types of automobile gasoline.

5. Solvents of the aromatic hydrocarbons: benzene, toluene, xylene, petroleum solvent for the varnish-paint industry.

6. Liquids based on fluorinated hydrocarbons.

7. Oils and liquids with toxic additives.

One of the most numerous groups of technical and household toxic liquids is represented by alcohols or alcohol-containing mixtures; their toxicity is

determined by presence of alcohol in their composition. Poisoning with substances of this group in clinical practice is interpreted as poisoning with alcohol surrogates. Alcohol surrogates are divided into ethyl alcohol-based liquids, containing various impurities and non-ethyl alcohol liquids, containing other monatomic or polyatomic alcohols.

The first group includes hydrolysis and sulfite alcohols (obtained from wood by hydrolysis), denaturates (technical alcohol with a slight admixture of methyl alcohol and aldehydes), colognes and lotions, glue based on phenolic-formaldehyde resin dissolved in ethyl alcohol, polishing agents (technical ethyl alcohol with acetone, butyl and amyl alcohol), "nigrozin" (stain for wood, which contains ethyl alcohol and coloring substances that cause intense and prolonged staining of the skin and mucous membranes in blue).

The second group includes other monatomic alcohols of the fatty series (methanol, propanol, butanol, etc.), individual diatomic alcohols and their esters (ethylene glycol, its methyl and ethyl esters — "Cellosolve"), as well as some heterocyclic compounds (tetrahydrofurfuryl alcohol).

Alcohols can be consumed in different ways, however, acute poisoning occurs only after ingestion. Alcohols are rapidly absorbed into the blood, relatively evenly distributed in the tissues. The metabolism of alcohols is carried out mainly in the liver according to the scheme: alcohol → aldehyde → acid. The first stage of the process is catalyzed by alcoholdehydrogenase (ADG) and to a much lesser extent by other enzymes. Propanol is oxidized the fastest in the body, while methanol is oxidized slower than others. The excretion of alcohols from the body occurs with urine and exhaled by air. The lowest aliphatic alcohols are not concentrated in urine, as for diatomic alcohols, the ratio of their concentration in urine to concentration in blood reaches 3–5 : 1.

All alcohols have a narcotic (neurotoxic) effect of different degrees. In monatomic alcohols, the strength of the narcotic effect initially increases, and after C_6–C_7 decreases due to a reduction of solubility in water. The narcotic effects of diatomic alcohols are less pronounced. In the process of biotransformation of alcohols, more toxic metabolites are often formed, which determines the clinical features of poisoning with a specific toxin. For example, toxic lesions of the vision organ are caused by some normal primary alcohols — methyl, hexyl and others; methanol has a particularly strong effect. Some alcohols have a pronounced damaging effect on parenchymal organs (liver, kidneys).

METHANOL

Physical and chemical properties. Toxicity. Methyl alcohol (wood alcohol) in its pure form is a colorless, transparent, easily volatile liquid with an odor resembling ethyl alcohol. It is used as a component of fuel for engines and as a solvent in the production of varnishes, organic paints, mastics, drying oils, polishes, etc., for denaturing purposes ethyl alcohol is used as part of a number of antifreezes. Crude methanol has an unpleasant odor, caused by the content of impurities. It mixes well with water, ether, ethyl and other alcohols, as well as all

organic solvents. Density — 0.81 g/cm^3, boiling point — +66 °C. The chemical formula is CH_3OH.

Lethal doses for adults when ingested are subject to significant fluctuations. In some cases, the death of the victims occurred after taking 10–30 ml of poison, while in other cases, deaths did not occur even after ingestion of 250–300 ml. On average, 100 ml is considered to be a lethal dose of methyl alcohol. In case of group poisoning, the lethality reaches 30–40 %. The maximum permissible concentration of methanol vapor is 50 mg/m^3.

Methyl alcohol is rapidly absorbed from the gastrointestinal tract, but it is slowly oxidized and removed from the body within 5–8 days. With repeated doses, the poison can be accumulated. Methanol oxidation occurs with the formation of formaldehyde and formic acid.

About 70 % of methanol entered into the body is removed unchanged with the exhaled air. The remaining 30 % are oxidized to formaldehyde and formic acid and excreted with urine. Absorbed methanol and the products of its oxidation in the body are released by the mucous membrane of the stomach and reabsorbed in the intestine. Therefore, a number of authors recommend repeated gastric or continuous gastric lavage through a 2-lumen probe.

Routes of exposure. Acute alcohol poisoning in the vast majority of cases occurs due to ingestion of the poison. Inhalation and mixed intoxication are possible only under special conditions (pouring over a significant body surface without rapid degassing, prolonged stay in the atmosphere, containing significant concentrations of poison). Severe percutaneous poisoning of infants occurs when methanol is used for alcohol compresses.

Mechanisms of toxic effect. After ingestion, methanol is rapidly absorbed and distributed in biological fluids and tissues. The average values of lethal concentrations of this poison in plasma in adults are 1 g/l, in children — 0.4 g/l. Methanol is mainly metabolized in the liver (94 %), 5 % is excreted in unchanged state by the kidneys, 1 % — with exhaled air. The half-life of methanol ($T_{0.5}$) taken in low doses is 14–27 hours and increases up to 30 hours when taken in high doses.

Metabolism of methanol has been studied in sufficient detail. Main metabolites of methanol are formaldehyde and formic acid, and the transformation of formaldehyde into formate occurs rapidly, and the cleavage of formic acid to carbon dioxide and water is very slow. This leads to the fact that significant amounts of formate accumulate in the biological fluids and tissues. The biological effect of the unchanged methanol molecule is limited by the narcotic effect. Toxicity of methyl alcohol is almost completely defined by formaldehyde and formic acid. These metabolites have multiple and pronged effect on the biochemical systems of the body. The main directions of their effect are the following:

– suppression of oxidative phosphorylation with the development of ATP deficiency;

– metabolic acidosis (both due to impaired oxidation and as a result of formate accumulation);

– diminished levels of reduced glutathione, deficiency of sulfhydryl groups;

– formation of conjugates with biologically active substances — amines, vasoactive compounds, neurotransmitters, nucleotides etc.

Methanol is a strong neurovascular poison. The main objects of its impact are the most sensitive ATP structures (brain, retina and optic nerve). Oculotoxic effect manifests itself at various times after poison ingestion (from 40 min to 72 h). During ophthalmoscopy, edema of the optic nerve is observed, developing as a result of its demyelination (Fig. 3).

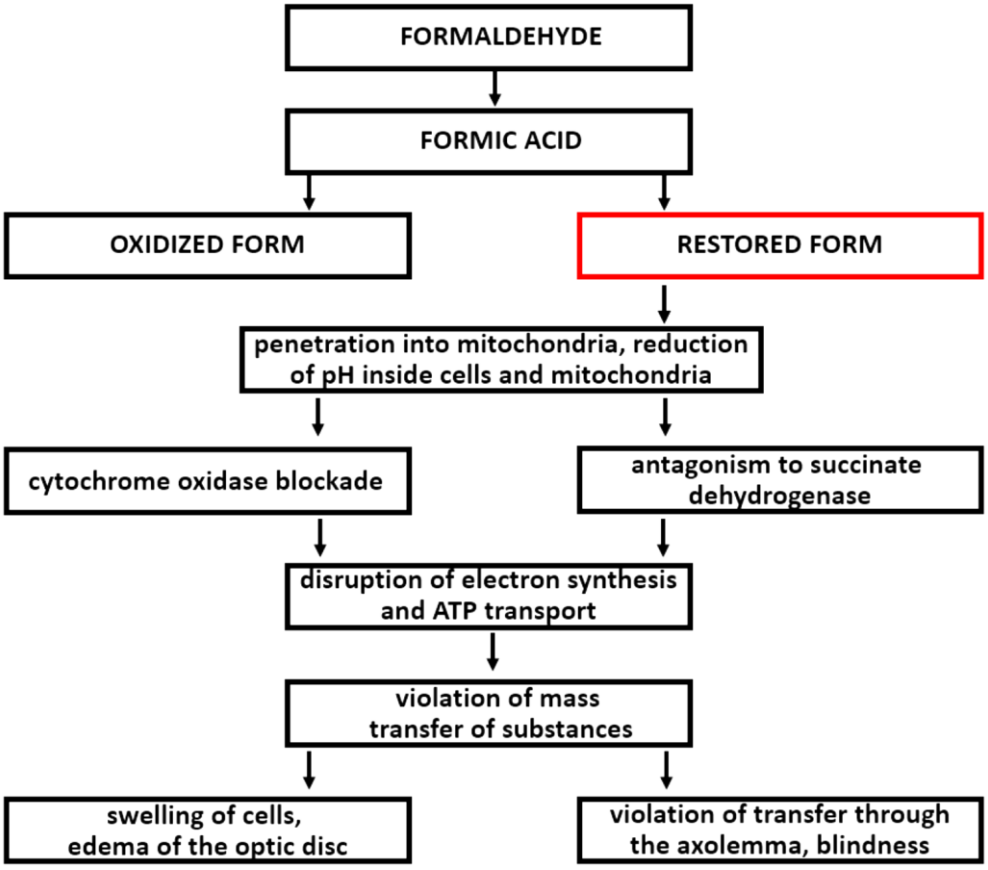


Fig. 3. Mechanisms of methanol oculotoxic effect

The damage to the visual organs is based on the damage of phosphorylating processes in the cytochrome oxidase system (cytochrome A_3).

As a result, energy formation is disrupted, and as a consequence — a change in the mass transfer the substances through axolemma, leading to demyelination and subsequent atrophy of the optic nerve as a whole.

The lesions are aggravated by metabolic acidosis, vasoactive substances and neurotransmitters metabolism pathology, general and cerebral hemodynamics disorders, increased biomembrane permeability and fluid redistribution with the development of cerebral edema.

General cerebral disorders with the impairment of the vital functions are the main cause of death in methanol poisoning.

Clinical signs and symptoms. Development of methanol poisoning is characterized by the following periods: initial, latent, pronounced manifestations, recovery and consequences.

According to the severity of poisoning, they are divided into mild, moderate (ophthalmic) and severe (generalized) forms.

Soon after taking the poison, a state of intoxication is observed lasting up to several hours. It is a characteristic sign of the fact that the degree of intoxication is usually less than one would expect from taking the same amount of ethanol. The euphoric component is less pronounced, often already at this stage, lethargy, headache, nausea are noted. Inebriation, if it is caused only by methanol, is usually doesn't reach a pronounced degree with the rapid development of the narcotic phase, although drowsiness is very characteristic for such patients.

After inebriation comes a latent period, the duration of which is on average 12–16 hours, but it can be reduced to 2–5 hours and increased to 1–2 or even 3–4 days. A long latent period does not indicate mild poisoning. The severity of intoxication is determined by the severity of symptoms at the next stage, characterized by general brain disorders, visual disturbances and gastrointestinal syndrome.

Patients with a ***mild degree of poisoning*** complain of general weakness, headache, dizziness, feeling of fog, mesh, flashing in the eyes, abdominal pain, nausea, vomiting. On medical examination a moderate dilation of the pupils with a decrease in reaction to light is determined. The duration of these symptoms usually does not exceed 3–4 days, during a week the phenomena of asthenization may persist. Usually vision is restored completely without any long-lasting consequences.

Poisoning of moderate severity is manifested at the beginning by the same symptoms as in mild intoxication, expressed, however, to a greater extent. Later eye symptoms come to the first plan — a progressive decrease in visual acuity up to complete blindness. In some cases, after a sharp decrease, vision is restored in 3–4 days, but after 1–2 weeks a new deterioration is possible, usually irreversible. Methanol poisoning is characterized by a combination of these disorders with pupil dilation and absence of their reaction to light.

Edema of the retina and the nipple of the optic nerve, dilation of veins, sometimes small blood outpourings are detected at the early stages with ophthalmoscopy; subsequently, pallor of the nipple, narrowing of the arteries, signs of optic neuritis are observed.

At the acute stage of moderate poisoning, the following complications may develop — myocardial dystrophy, pneumonia, pancreatitis, peripheral neuritis. Severe abdominal pain, observed in some patients can serve as a reason for erroneous laparotomy. After intoxication, asthenization persists for 2–3 weeks. The most serious consequence is loss of sweat or a decrease in visual acuity of varying degrees not corrected by optics.

For the ***severe (generalized) form of intoxication***, the rapid development of symptoms is characteristic. After the latent period, sharp weakness, headache, abdominal pain, calf muscles, repeated vomiting, visual disturbances appear. Psychomotor agitation, then — sopor and coma may appear. The face skin and the collar zone are purplish-cyanotic. The pupils are sharply dilated and do not

react to light. Breathing is frequent, noisy (acidotic). There is muscle rigidity, symptoms of irritation of meninges, central respiratory and circulatory disorders. At the acute stage the following complications appear, including myocardial dystrophy with heart rhythm disorders, pneumonia and pulmonary edema, pancreatitis, hepatopathy and nephropathy. The liver and kidney lesions, even with severe methanol poisoning, are moderately pronounced, acute hepatic and renal insufficiency does not develop. The death of the victims usually occurs on the 1st–2nd day as a result of respiratory and circulatory disorders of central genesis. With a more favorable course, consciousness gradually disappear, visual disturbances and symptoms of complications come to the fore. In the sequel asthenization persists for a long time, often in combination with signs of micro organic brain damage and persistent visual disorders.

When diagnosing methanol poisoning the following factors are taken into account: the disease stage, methanol smell in the exhaled air, early visual impairment in combination with dilation of the pupils and a decrease in their reaction to light, the symptoms of metabolic acidosis, presence of methanol in biological fluids and the residues of the ingested liquid.

As an express analysis of the poison residues, a sample with a red-hot copper wire can be used, when immersed in methanol, a characteristic smell of formaldehyde is felt. The main method of chemical and toxicological research is gas-liquid chromatography. Determination of methyl alcohol in biological fluids and tissues is possible within 3–5 and even 7 days from the moment of poison intake.

It is important to establish the following facts:

– less pronounced inebriation compared with taking the same amount of ethyl alcohol;

– clinical manifestations of intoxication, including visual impairment.

Emergency medical care. In acute methanol oral poisoning, it is necessary to remove the newly formed poison from the gastrointestinal tract as soon as possible. For this purpose, vomiting is induced, a probe-free, and then a probe gastric lavage is performed, a saline laxative is administered and intestine cleansing is performed. Gastric lavage is carried out with 1–2 % sodium bicarbonate solution or low concentrated solution of potassium permanganate. Per oral activated charcoal is useless, since methanol is not absorbed by it. For 2–3 days, repeated gastric lavage or prolonged irrigation of the stomach with sodium bicarbonate is indicated to remove methanol eliminated by the mucous membrane.

The antidote of methyl alcohol is ethanol, which competes with methanol for alcohol dehydrogenase and other enzymes of alcohol metabolism and prevents the formation of formaldehyde. Ethanol is prescribed orally, the first single dose is 100–150 ml of a 30 % solution, later ethyl alcohol is administered every 3–4 hours (50–100 ml of the specified solution) for 3–4 days. The daily dose of ethanol is 1.5–2 ml per 1 kg of the body weight. In addition to oral administration, ethanol is administered intravenously (into the peripheral vein — 5–10 % solution in 5 % glucose, 30 % solution into the central vein) in a daily dose of 1–1.5 ml/kg. The regularity of repeated injections of ethyl alcohol is very important to maintain

its concentration in the blood at the level of 1 g/l (corresponds to a mild degree of intoxication), providing effective competition with methanol. With a decrease in the ethanol content in the biological fluids below the specified level, toxicity of methyl alcohol resumes. It should be noted that antidote therapy should be started no later than 18 hours from the moment of poisoning.

Neutralization of the poison metabolites is facilitated by large doses of folic acid. Folic acid is used in a daily dose of 1–1.5 mg/kg for 2–3 days.

Pyrazole derivatives (4-methyl, 4-brompyrazole) — alcohol dehydrogenase inhibitors can be used as antidotes.

Forced diuresis with alkalinization, hemodialysis and peritoneal dialysis are used to remove the absorbed poison and its metabolites from the body. Hemodialysis is the most effective measure, providing blood clearance by methanol up to 140 ml/min. During hemodialysis, the ethanol dose should be increased by 2 times. The optimal timing of these procedures is 1–2 days. Hemosorption in methanol poisoning is ineffective.

Pathogenetic and symptomatic therapy includes, first of all, correction of metabolic acidosis. For this purpose, sodium bicarbonate is used (3–5 g orally every 2–3 hours or 1000–1500 ml of 3–5 % solution intravenously) under the control of the acid-base status or until the alkaline reaction of urine onset. With cerebral edema, often observed in severe methanol poisoning, dehydration is carried out (glycerin inside, 40 % glucose, diuretics intravenously, cranio-cerebral hypothermia, discharge lumbar puncture). To eliminate hypoxia, circulatory disorders, metabolic patholoc, oxygen therapy, infusions of substitutes, glucocorticoids, solutions of novocain, piracetam, aminophylline are applied and a complex of vitamins (C, B_1, B_6, PP, B_{12}), ATP, cardiovascular agents, antibiotics are administered.

With progressive visual impairment, retrobulbar injections of atropine, prednisone, etc. are indicated. Treatment of patients, poisoned with methanol must be carried out with the mandatory participation of an ophthalmologist and a neuropathologist. All patients should be hospitalized to the specialized toxicological centers or departments.

ETHYL ALCOHOL

Ethanol (C_2H_5OH, ethanol) is used as a solvent, a component of special fuels. It is used for synthesis of other compounds and as a part of some antifreezes, cosmetics, polishes, adhesives, etc. The so-called hydrolysis, sulfite alcohols, denaturation, along with ethanol, contains impurities of methanol, aldehydes, medium alcohols.

Currently the increase in alcohol consumption by the population should be viewed not only as a medical and biological problem. There are all prerequisites to consider the abuse of ethanol as a serious threat to the genetic fund and national security of many countries. The share of acute poisoning by ethanol and its surrogates is 20 % of all acute poisonings, whereas a decade earlier this figure did not exceed 10 %; in some years the “contribution” of ethanol to the total mortality rate from acute poisoning may reach 50 % or more.

Acute alcohol poisoning is usually associated with the intake of ethyl alcohol or beverages containing more than 12 % of ethanol. The maximum single dose of ethanol largely depends on individual sensitivity and amounts 4–12 g/kg of body weight (on average 300 ml of 96 % ethanol in case of acquired tolerance absence). Alcoholic coma develops when the concentration of ethanol in the blood is higher than 3 g/l (3 %).

Various impurities being parts of alcoholic beverages deserve separate consideration. They can affect the toxic properties of ethanol.

Aldehydes (acetic, propionic, oil, etc.). They are intensively formed during distillation of wine into cognac alcohol, as well as during the sherry of wines. Unsaturated aldehydes (acrolein, crotonic aldehyde) give alcoholic beverages a burning taste and bitterness. At the same time, their combination forms a unique bouquet of wines and cognacs. The toxicity of aldehydes is low. They are actively destroyed in the lumen of the small intestine and in contact with the mucous membrane. Their content in purified alcohol does not exceed 8 mg/l, in cognacs — 30–50 mg/l, in wines — 10–50 mg/l, in sherry — up to 250 mg/l or more.

Fusel oils are a mixture of higher (C_3–C_5) monatomic aliphatic alcohols, esters, etc. (about 40 compounds) formed during purification of raw alcohol. By toxicity fusel oils are significantly higher than ethanol and have the potential for its negative effects. The content of fusel oils ranges from 250–650 mg/l in wines to 1000–4000 mg/l in rum, brandy, whiskey.

Methanol is one of the most toxic components of alcoholic beverages. Its separation during purification is a significant difficulty. The lowest concentration of methanol is in white grape wine (up to 240 mg/l), in red wine — up to 3000 mg/l, cognac — 1000 mg/l, fruit and berry wines — up to 6000 mg/l.

Complex esters (diethyl, formic-ethyl, acetic ethyl, etc.) are formed during interaction of alcohols with organic acids. Esters have low effect on the toxicity of ethanol, but at the same time they are able to change its organoleptic properties. For example, diethyl ether enhances the smell of ethanol, and ethyl vinegar weakens it.

As a rule in case of lethal alcohol poisoning the total dose of the above-listed impurities does not exceed 0.01 of their LD_{50}. It is also applied to low-grade samples of alcoholic beverages. Hence, the cause of death is more often the toxic effect of ethanol itself.

Physical and chemical properties. Toxicity. Ethyl alcohol is a colorless liquid with characteristic odor. It mixes with water in any ratio, dissolves well in organic solvents. It burns with a blue flame. Relative density is 0.816 g/cm^3 and the boiling point is +78.6 °C.

Routes of exposure. Practical meaning has the most common route of alcohol intake — through the gastrointestinal tract. Alcohol enters the bloodstream most quickly with intravenous administration of its solution. In such a case, the maximum alcohol concentration in the blood occurs almost simultaneously with the getting the last drop of the solution. According to the rate of alcohol getting into the bloodstream, the second place after intravenous administration

belongs to inhalation of alcohol vapors, especially in high concentrations. In case when alcohol concentration reaches 15 mg/l of air, the alcohol concentration in the blood can be 0.45 vol. %, but it can only occur in experiments. Alcohol concentrations in premises (pubs, restaurants, wine shops and cellars, etc.) do not give a concentration in the blood above 0.10 vol. %. In case of low alcohol concentrations in the air, small amounts of it are immediately oxidized in the body. With chronic inhalation of low concentration alcohol vapors in non-drinkers, the characteristic signs of chronic alcoholism are observed. Alcohol is absorbed very quickly when it is infused into the rectum. Most often, alcohol is introduced in this way accidently or by mistake, rather than with medication. Cases of lethal outcomes with such erroneous alcohol injections are described. With subcutaneous administration of alcohol solutions, its absorption is much slower than when ingested.

Alcohol can enter the bloodstream either through damaged or undamaged skin while applying alcohol compresses to a significant surface of the body or when treating areas of damaged skin with alcohol. In such cases, the rate of alcohol entering the bloodstream is insignificant and the amount of alcohol is negligible. Such routes of alcohol entering the organism are of low practical importance. Also, the practical importance of alcohol intake via intraperitoneal and intrapleural route is not essential.

Mechanisms of toxic effect. In toxicokinetics of ethanol, two phases of distribution are distinguished: resorption (absorption) and elimination (excretion). During the first phase, ethanol saturation of organs and tissues occurs much faster than biotransformation and excretion, which results in increase of its concentration in blood. Ethanol is rapidly absorbed into the bile (20 %) and small intestine (80 %), on average after 1–1.5 hours its concentration in blood reaches its maximum level. Alcoholic beverages with strength less than 30 % absorbed faster. Effervescent (sparkling) drinks containing carbon dioxide also considerably accelerate the absorption of alcohol. Food masses in the stomach slow down the absorption of alcohol due to their adsorption properties. The rate of resorption is much higher when taken on an empty stomach repeatedly or in people with stomach diseases (gastritis, peptic ulcer). Up to 10 % of ethanol is excreted from the body within 12 hours with exhaled air and urine. The main part of alcohol undergoes metabolism with an average speed of 4–12 g/h (0.1 g/kg per 1 hour). Definition of the ethanol distribution phase is of great diagnostic and forensic importance. To define this, the ratio of its concentrations in urine and blood is calculated. During the resorption phase, it is less than one, while during the elimination phase, this ratio is always more than one.

Ethanol belongs to the neurotropic substances of the alcoholic barbituric group. There are several leading factors in the pathogenesis of poisoning. Its action is carried out at the level of brain cells membranes. It was found that under the influence of ethanol, the fluidity of the lipid matrix of membrane formations increases, leading to the disturbance of their functions, which is expressed in ion fluxes changes, biophysical characteristics of receptors, activity of membrane-

bound enzyme systems, capture of certain substances, etc. The membrane-toxic effects of ethanol are also facilitated by the lipid peroxidation induced by it. A significant role in ethanol poisoning is assigned to the processes associated with its metabolism.

At least 80 % of ethanol is oxidized in the liver with the participation of alcohol dehydrogenase. Both enzymes use oxidized nicotinamide dinucleotide (NAD) as a hydrogen acceptor. As a result of ethanol oxidation, reduced NAD accumulates and, accordingly, the concentration of its oxidized form decreases. Considering that many oxidative processes in the liver occur with the participation of NAD+ (metabolism of triglycerides, fatty acids, hormones, etc.), we can observe serious impaiment of the hepatocytes function. In addition, the resulting acetaldehyde has the ability to bind with biomolecules (amino acids, proteins, catecholamines, etc.), disrupting their function and enhancing metabolic disorders in organs.

Much less amount of ethanol is required when the liver microsomal ethanol-oxidizing system is involved. The importance of the last two ways of ethanol biotransformation increases gradually in case of chronic alcoholism.

To characterize ethanol completely toxicological data should be provided connected with the fact that its oxidation is accompanied by the release of a significant amount of energy (7.1 kcal/g). This energy is actively utilized by tissues. At the same time, the processes of energy supply due to fats and carbohydrates are disrupted, since ethanol successfully competes with them, surpassing the criterion of bioavailability. People suffering from chronic alcoholism, caused by ethanol, can receive up to 50 % of the daily caloric content of the diet. A similar action is called a “calorific” effect.

Thus, the toxic effect of ethanol is realized due to the following mechanisms:

– damage to biological membranes;

– depletion of the pool (stock) of oxidized nicotinamide adenine dinucleotide;

– formation of acetaldehyde;

– “calorific” effect.

Narcotic effect of ethanol is associated at the initial stage with impaired inhibition processes in the higher parts of the CNS and disinhibition of subcortical formations, manifested as euphoria, excitement, impaired coordination of movements, etc. After taking large doses of poison, general depression of brain functions develops, accompanied by loss of consciousness, suppression of the respiratory center function, thermoregulation center, etc. (Fig. 4).

Respiratory disorders in case of ethanol poisoning are caused by both respiratory depression and aspiration-obturation complications. Genesis of hemodynamic disorders in ethanol-poisoned patients is complicated. In their development, along with the general poison effect, the direct vasodilating effect of acetaldehyde plays an essential role, including the ability to weaken the contractions of the heart muscle. Clinically, these disorders are manifested by a collaptoid condition, heart rhythm disorders, pulmonary edema. Prolonged comatose state, developing in patients poisoned with ethanol and its surrogates,

may, under certain conditions, lead to compression of large muscle masses with the development of positional compression syndrome; at low temperatures it may cause hypothermia. Metabolic disorders, hypoxia , acidosis and circulatory disorders, which naturally develop with severe ethanol poisoning, can lead to brain edema and contribute to the formation of diffuse dystrophic changes in organs and tissues with violation of their functions.

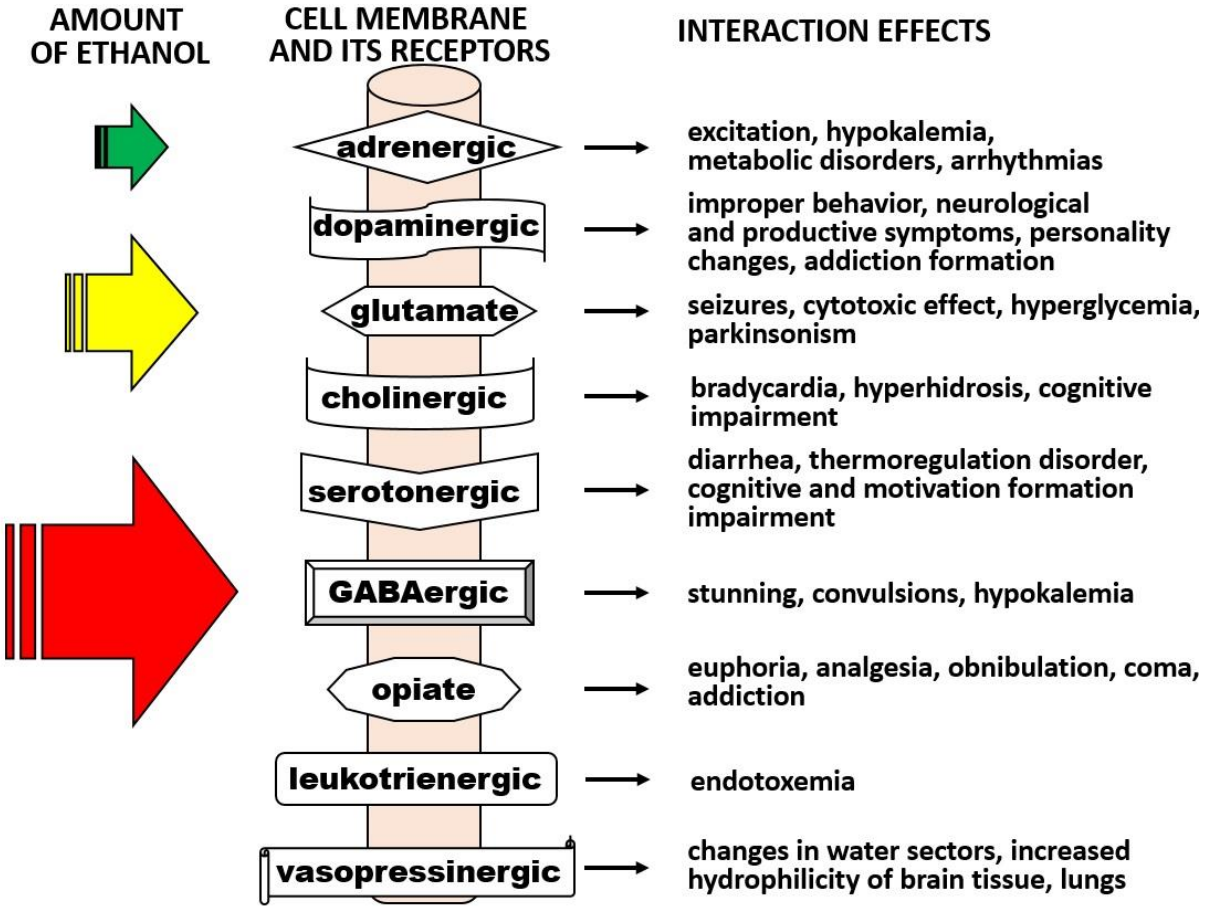


Fig. 4. Pathogenesis of ethanol intoxication

Clinical signs and symptoms. It is necessary to distinguish alcoholic inebriation and alcoholic coma. The state of alcoholic inebriation is temporary impairment of the body functions, and the victim can cope with it without any medical assistance. The external manifestations of alcohol inebriation depend on the characteristic features of the individual, his reaction to alcohol (presence of acquired tolerance). Clinical manifestations of inebriation leads to two effects of alcohol: euphoric and narcotic.

Alcoholic coma has two stages: superficial and deep, each of them can occur in complicated and uncomplicated variants. Superficial coma is manifested by loss of consciousness, reduction of corneal and pupillary reflexes, pain sensitivity. It may have the following neurological symptoms: preservation or increase of tendon reflexes, trism of masticatory muscles, muscle rigidity, myofibrillation; motor excitation, appearance of meningeal symptoms, convulsions. Many ocular characteristic symptoms may appear, including “pupil play”, manifested mainly by

myosis, less often by mydriasis in response to pain or medical manipulations; floating movements of the eyeballs and transient anisocoria. Purple coloring of the face skin, tachypnea, tachycardia, hypertension are also observed. In some cases, asphyxia develops due to the tongue falling down or aspiration of vomit. A deep coma is characterized by a sharp suppression of all types of reflex activity, ophthalmoplegia, symptoms of meninges irritation and appearance of pathological reflexes. The skin is pale cyanotic, cold, covered with sticky sweat. The temperature is decreased to 36–35 °C.

Respiratory disorders are caused by various obstructive aspiration complications in the form of retracted tongue, hyperventilation and bronchorrhea, laryngospasm, aspiration of vomit, leading to the development of lung atelectasis or Mendelson syndrome. Respiratory disorders of the central type are a rarer complication that occurs only in deep coma.

Disorders of the cardiovascular system are not specific. They are manifested by tachycardia, and as the depth of coma increases, the tendency of vascular tone and blood pressure decrease up to collapse. Microcirculation pathology with such clinical manifestations as pallor, marbling of the skin, acrocyanosis and sclera capillaries hyperemia are revealed.

Recovery from alcoholic coma occurs gradually with restoration of reflexes, muscle tone, appearance of myofibrillation, chills-like hyperkinesis. In most poisoned patients, regaining of consciousness is preceded by psychomotor agitation with illusory and hallucinatory episodes alternating with periods of sleep. Epileptiform seizures are possible. Less often the outcome of alcoholic coma passes without psychomotor agitation and is characterized by drowsiness and adynamia.

Clinical manifestations of intoxication with ethyl alcohol poisoning, depending on the concentration of ethanol in the blood are presented in Table 6.

Table 6

The concentration of ethanol in the blood and the corresponding manifestations of intoxication (in adults)

Ethanol concentration in the blood (g/l)	Clinical manifestations
0,20–0,99	Mild changes in mood and perception, progressive movement coordination disorders, sensory function disorders, behavior disorders (increased talkativeness), etc.
1,00–1,99	Distinct mental activity disorders, coordination disorders up to ataxia
2,00–2,99	Deepening of ataxia, nausea, vomiting, diplopia
3,00–3,99	Hypothermia, stage I anesthesia, followed by amnesia
4,00–7,00	Coma, respiratory failure, death

The diagnosis of alcohol intoxication in most cases is not difficult. However, alcohol intoxication is often combined with other conditions that can significantly worsen the prognosis: traumatic brain injury, hypothermia, taking hypnotic narcotic drugs, stroke, diabetes mellitus, etc. The dynamics of the patient's

condition is of great diagnostic importance. Absence of noticeable improvement against the background of intensive treatment of alcohol intoxication for 3–5 hours indicates unrecognized complications, mainly cerebral, or non-alcoholic coma.

It is generally considered that there is a certain dependence between the concentration of ethanol in the blood and the degree of intoxication: alcohol concentration up to 1 g/l corresponds to mild intoxication, 2 g/l is a pronounced degree of intoxication, more than 2 g/l is observed in comas, and 3 g/l corresponds to a deep coma. It should be noted that these figures are very approximate and the degree of intoxication largely depends on the acquired tolerance to alcohol. It is more reliable to assess the correlation of ethanol concentration in urine and blood. Deep loss of consciousness with a coefficient of 1.5 indicates either severe complications, or the non-alcoholic coma.

Emergency medical care. First aid and medical assistance to patients in an alcoholic coma should be started with restoration of adequate pulmonary ventilation. In case of aspiration-obturation disorders, an oropharyngeal cleansing is carried out and oropharingeal air duct is inserted. To reduce salivation and bronchorrhea, atropine (0.5–1.0 ml of 0.1 % solution) is administered parenterally or intratracheally. In case of respiratory disorders of the central type, intubation of the trachea is recommended, followed by aspiration of the respiratory tract content. Subsequently, oxygen inhalations, postural drainage are carried out. Transportation of patients, if tracheal intubation is not conducted, is performed in a fixed side (recovery) position.

Elimination of severe hemodynamic disorders is provided prior to making gastric lavage. For this purpose, infusion therapy is performed — the administration of 5 % glucose, isotonic solution of sodium chloride and polyionic solutions, sodium bicarbonate solution, cardiac glycosides, analeptics in normal therapeutic doses and glucocorticoids are prescribed. Intake of analeptics (caffeine, cordiamine) in high doses in cases of deep coma is not recommended, since they increase brain ischemia and provoke generalized seizures.

After elimination of acute respiratory and hemodynamic disorders in deep coma, tracheal intubation is performed, followed by gastric lavage.

Gastric lavage is carried out through a probe in a side position with water, solutions of sodium bicarbonate or potassium permanganate (500–700 ml) till clean flushing waters appearance. Particular attention should be paid to more complete removal of the last portion of the flushing water, which is achieved by inserting a probe to different depths with moderate pressure applied to the epigastric region.

Activated charcoal does not absorb ethanol well. Its prescription is recommended when ethanol intoxication is combined with other poisons.

Forced diuresis is used to remove the absorbed poison. In severe cases, especially with combined poisoning, hemodialysis is indicated.

In order to correct metabolic acidosis, a 4 % sodium bicarbonate solution is administered intravenously. To accelerate the oxidation of alcohol, glucose

solutions with insulin, sodium thiosulfate and a complex of vitamins (C, B_1, B_6, nicotinic acid) are administrated intravenously.

With psychomotor agitation, convulsions, withdrawal syndrome, sodium oxybutyrate, benzodiazepines, barbiturates, magnesium sulfate are used. Introduction of barbiturates requires caution due to their depressing effect on the respiratory center.

ETHYLENE GLYCOL

Physical and chemical properties. Toxicity. Ethylene glycol (glycol 1,2-ethanediol) (CH_2OHC_2OH) is a colorless, syrupy, sweet, odorless liquid, well soluble in water and alcohols. The relative density is 1.11 g/cm^3. It boils at a temperature of +194 °C and freezes at a temperature of –12 °C. Its aqueous solutions freeze at significantly lower temperatures. Ethylene glycol is mainly used as an antifreeze, cooler and preserving agent (e.g. fuel antifreeze contains 99–100 % ethylene glycol, wipers — 60–100 %, paint solvents — 4–42 %, varnish solvents — 5–15 %) and is an industrial substitute for making glycerin.

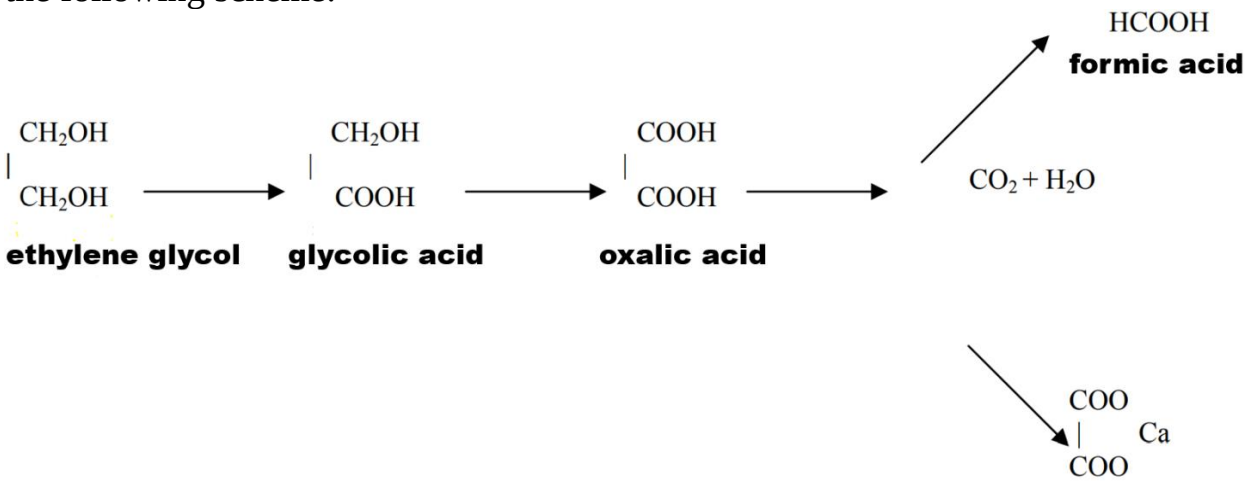
There is a group of ethers, derivatives of ethylene glycol (monomethyl, monoethyl, monobutyl, etc.) with the common name "cellosolves". The most interesting are monomethyl and monoethyl esters. These are liquids that have an indistinct odor. Their boiling point is lower than ethylene glycol, and their volatility is noticeably higher. They are well soluble in water and organic solvents. Cellosolves are used as solvents.

The minimum toxic dose for humans is 50 ml, the lethal dose is 100–300 ml. There are differences in individual sensitivity to ethylene glycol, the lethal dose can range from 50 to 500 ml. The mortality rate in case of ethylene glycol poisoning reaches 60–63 %. A group of toxic glycol-based industrial liquids is the most common cause of acute poisoning with a fatal outcome due to the fact that the taste and smell of ethylene glycol are close to that of alcohol.

Ethylene glycol and its esters are rapidly absorbed into the blood, relatively evenly distributed in biological fluids and tissues. The highest concentrations in the blood are determined within 6–12 hours, the level of 0.4–0.6 g/l and above is typical for severe poisoning. Ethylene glycol is excreted from the body with urine, up to 70 % of the injected poison is removed within 1–2 days. The concentration of ethylene glycol in urine is usually higher than in blood. Cellosolves are excreted not only with urine, but also with exhaled air.

Ethylene glycol is metabolized mainly by liver enzyme systems. The first stage — conversion to glycolic aldehyde — is catalyzed by alcohol dehydrogenase. Then, glycolic aldehyde is transformed into glycolic and glyoxylic acids. A small part (3–5 %) of the administrated ethylene glycol is converted into oxalic acid. Metabolism of cellosolves differs significantly from that of ethylene glycol. It is carried out in two ways, the main of which is the oxidation of the alcohol group to the corresponding hydroxyacetic acid, and the second is hydrolysis of the ether bond with the formation of ethylene glycol and aliphatic alcohol.

Transformation of ethylene glycol in the body occurs according to the following scheme:



Routes of exposure. Acute poisoning with ethylene glycol and liquids containing it occurs almost always as a result of the poison ingestion. Vaporization (due to low volatility) has not been described. Inhalation poisoning by aerosols is possible, but extremely rare.

In addition to alimentary route, cellosolves can cause inhalation poisoning, producing general toxic and irritating effect.

Mechanisms of toxic effect. As it was noted above, ethylene glycol is oxidized in the body to carbon dioxide and water with the formation of toxic intermediate substances — glycolic aldehyde, glycolic acid, oxalic, acetic, formic and other acids, which leads to acidosis, severe metabolic disorders, hypoxia. Oxalic acid interacts with calcium ions to form an insoluble oxalic acid calcium salt. The main way to remove ethylene glycol and its metabolic products from the body is through the kidneys (up to 50 % of the poison). At the same time, oxalates are deposited in the walls of capillaries, tubules and pelvis of the kidneys, and, acting directly and reflexively, disrupting renal blood flow, contribute to the development of toxic nephropathy.

Hypocalcemia caused by binding of ionized calcium may be one of the causes of the CNS and heart function disruption. Ethylene glycol acts as a vascular and protoplasmic poison, suppresses oxidative processes, causes edema, swelling and necrosis of small vessels leading to tissue circulation pathology, shifting the acid-base balance towards metabolic acidosis, disrupting the water-electrolyte balance.

In the mechanism of ethylene glycol toxic action, a certain role is assigned to both unchanged glycol and its biotransformation products. A moderately pronounced narcotic effect of the poison is associated with the whole molecule, as well as high osmotic activity, possibly leading to water degeneration of renal epithelial cells and brain edema. Ethylene glycol metabolites play the main role in the development of poisoning. For a long time, the main attention was paid to oxalic acid capable of binding calcium to form poorly soluble oxalate. However, it turned out that only an insignificant fraction of ethylene glycol is transformed into

oxalate, and hypocalcemia does not develop in all cases of severe poisoning. On the other hand, calcium oxalate crystals are formed in the kidneys, brain and lungs, which impairs the function of these organs.

Currently, it is considered that glycolic acid and its metabolite, glyoxylic acid, being the most toxic, play a major role in the formation of the cytotoxic effect of ethylene glycol. It separates oxidation and phosphorylation. Thus, the products of ethylene glycol biotransformation cause serious and diverse pathologies of enzymatic processes. These disorders are intensified due to the osmotic effect of the poison, as well as metabolic acidosis, which develops as a result of endogenous products and acids accumulation formed during of ethylene glycol metabolism.

Metabolic disorders are a trigger in the development of lesions, most pronounced in the brain, kidneys and liver. Severe metabolic disorders, hypoxia, increased membrane permeability contribute to the formation of exotoxic shock.

Significant hemodynamic disorders in ethylene glycol poisoning are observed in the kidneys. It is known that when the volume of circulating blood decreases by 2 times, the renal blood flow decreases by 20–30 times slowing down the renal blood flow, stasis; increased permeability of membranes leading to ischemia of kidney tissue, interstitial edema, increased intra-organ pressure, filtration and reabsorption processes impairment, progression of hemo- and lymph flow disorders. Reflex spasm of the cortex arteries, opening of arteriovenous anastomoses with the discharge of blood via juxtamedullary veins further strengthen the lesions of the renal parenchyma. These disorders, combined with the direct damaging effect of ethylene glycol metabolism products, lead to the development of total two-sided cortical necrosis of the kidneys, which is very characteristic of such kind of intoxication.

Clinical signs and symptoms.

Periods. In the clinical picture of ethylene glycol poisoning, the following periods are distinguished: initial, latent, pronounced manifestations (***a*** — mainly brain disorders, ***b*** — liver and kidney damage), recovery and consequences.

The *initial period* is characterized by intoxication, resembling the one after taking ethanol. Intoxication with ethylene glycol poisoning, as a rule, is expressed moderately. Unlike poisoning with ethanol and its surrogates, the exhaled air of those poisoned with ethylene glycol has no smell. The initial period of intoxication gradually turns into a latent one, during which the victims feel satisfactory.

The *latent period*, on average is equal to 4–6 hours, can last from 1–2 to 12–16 hours, and in the most severe cases, intoxication is directly replaced by pronounced clinical manifestations of poisoning.

The *period of expressed manifestations of poisoning* is characterized by several main signs, including encephalopathy, exotoxic shock, gastrointestinal disorders, hepato-nephropathy, metabolic acidosis. At the beginning of this period, the manifestations of encephalopathy, shock and gastroenteritis prevail, further — the symptoms of parenchymal organs damage, including the most serious complication — acute renal failure occur. After the latent period, the victims

develop general weakness, headache, movement coordination disorders, nausea, vomiting, abdominal pain, sometimes so severe that patients undergo laparotomy on suspicion of acute surgical disease of the abdominal organs. Excitement often develops with euphoria, emotional hyperesthesia, delirium, hallucinations, followed by depression, drowsiness, sopor or coma. An objective examination determines hyperemia and puffiness of the face, cyanosis of the mucous membranes. The skin is cold and moist.

The pupils are moderately dilated; the reaction to light is weakened. Breathing is deep, noisy (acidotic). There is lability of pulse and blood pressure, symptoms of microcirculation disorders (marbling of the skin of the extremities, a positive symptom of a white spot), a decrease in diuresis, etc. In some patients, against the background of coma, signs of irritation of the meninges, pathological foot reflexes (Oppenheim, Gordon, Babinsky) appear.

With further coma deepening, hemodynamic and respiratory disorders progress, which are the direct causes of death. Deaths from ethylene glycol poisoning occur most often at the end of the 1^{st}–2^{nd} day after taking the poison.

With a more favorable course after 2–3 days consciousness is restored, often through the stage of psychomotor agitation.

During this period, symptoms of kidney and liver damage come to the fore. Patients complain of lower back pain, thirst, lack of appetite, nausea, vomiting, pain in the epigastric region and in the right hypochondrium. An objective examination determines jaundice of the skin, enlargement and soreness of the liver, soreness when beating on the lower back, increased arterial pressure; oligo- and anuria develops. Later, a different picture of renal or renal-hepatic failure is formed, complications develop (myocardial dystrophy, pneumonia, pancreatitis, etc.). The outcome of poisoning is mainly determined by the degree of kidney damage. Severe liver damage is not mandatory in severe forms of poisoning. They develop in about 50 % of cases, especially when a person is intoxicated with some technical liquids containing ethylene glycol.

Depending on the nature of the pathological process in the kidneys, and their functional state, three degrees of toxic nephropathy: mild, moderate and severe are defined. Severe nephropathy is characterized by acute renal failure syndrome (ARF).

The clinical course distinguishes the following stages of ARF:

1. Initial.
2. Oligoanuric.
3. The stage of restoration of diuresis or polyuric (early, late).
4. The stage of recovery.

1. The initial stage (or shock). It is limited by the time from the moment of exposure to the poison (or the occurrence of shock, hemolysis, burn, etc.) to the first signs of ARF. At this stage, the clinical picture of the main process that causes nephropathy (poisoning with ethylene glycol, chlorinated hydrocarbons, etc.) comes to the fore. This stage is also called shock. The duration of the initial period ranges from several hours to 3–5 days.

2. The oligoanuric stage. It most clearly reflects the clinical picture of ARF.

After a short-term improvement in the patient's condition (2–5–7 days), a significant deterioration occurs. Diuresis gradually or suddenly decreases, reaching in some cases the degree of anuria. During this period, general weakness, drowsiness, headache increase. Nausea, vomiting, pain in the lumbar region and abdomen, shortness of breath appear. Blood pressure often rises up to 160–200 / 90–120 mm Hg; though in some cases, blood pressure does not change significantly.

Despite the small amount of urine, its specific gravity becomes low early (1,008–1,012).

The increase in the level of nitrogenous metabolites and, above all, creatinine and urea, as well as a decrease in its index (the ratio of the concentration of urine urea to blood urea) are considered to be the most objective features of functional insufficiency. A decrease in the urea index below 10 indicates a significant impairment of the kidney function. Azotemia in acute renal failure is associated not only with impaired renal excretory function, but also with the increased breakdown of tissue protein.

As a consequence of the ARF, the electrolyte composition of the blood is significantly disrupted: the content of K^+ and Mg^{2+} ions, as well as sulfate and phosphoric anions ($(SO_4)^{2-}$ and $(HPO_4)^{2-}$). Initially developed alkalosis is quickly replaced by acidosis, caused by hyperphosphatemia, hypersulfatemia and the accumulation of intermediate under-oxidized metabolic products.

Hemorrhagic diathesis and anemia soon join these disorders. Electrolyte pathology (hyperkalemia), acidosis, anemia, exo- and endointoxication lead to myocardiodystrophy, accompanied by cardiac, mainly left ventricular, insufficiency (hypertension in the system of a large circle of blood circulation and increased load on the left ventricle are important). The extreme degree of heart failure manifests itself in the form of pulmonary edema. Edema often acquires a prolonged subacute course and does not respond well to therapy.

In the development of the pathological process in acute kidney injury, water metabolism impairment, leading to tissue hyperhydration, is of great importance. Hyperhydration is both a consequence of the kidney excretory function impairment and the intake of excess fluid; decrease in the protein content in the blood due to its release into the interstitial fluid (because of vessel walls increased permeability), as well as liver damage. Hyperhydration significantly worsens the course of ARF. Especially noticeable its influence is manifested in the system of the small circle of blood circulation. Edema of the interstitial lung tissue significantly worsens their ventilation capacity; respiratory failure is joined to heart failure. Such a pathological process is called the syndrome of a “watery”, “moist” or “hyperhydrated” lung. Most objectively, the syndrome of a “watery” lung can be established by radiography.

3. The stage of diuresis restoration is polyuric. On the 5^{th}–7^{th} day, diuresis gradually (sometimes quickly) increases and reaches 1500–2000 ml. The Zimnitsky test reveals hypo- and isostenuria. The specific gravity of urine ranges from 1,008–1,010. In the early period, despite the increase in diuresis, the content of residual nitrogen in the blood does not change significantly, since the functional

ability of the kidneys is still low. They can excrete from the body only products of endogenous decay. The patient's condition improves to a certain degree. Consciousness clears up, vomiting stops or becomes less frequent. Blood pressure begins to decrease.

After 5–7 days from the beginning of the restoration of diuresis, the functional ability of the kidney increases significantly. This moment can be considered a transition from the early polyuric stage to the late one.

The daily diuresis reaches 3000–5000 ml. Despite the low specific gravity of urine, the kidneys manage to remove a large amount of nitrogenous metabolites from the body along with the liquid.

The residual nitrogen in the blood decreases. The signs of uremia are gradually disappearing. The duration of the polyuric stage ranges from at least from 3 weeks to 2–3 months.

It should be kept in mind that due to the large loss of water by the body, and with it Mg^{2+} and K^{+} salts (with simultaneous retention of NaCl), the general condition may deteriorate again. Headache, insomnia, heart failure, general weakness, mental disorders, coma, etc. appear. Within the same period, infectious complications are often observed — pneumonia, sore throat, parotitis, etc.

4. Recovery after poisoning is slow. The transition to this stage occurs gradually 1–2 months after poisoning. By this time, the daily diuresis decreases to 1500–2000 ml, the specific gravity of urine reaches 1.016–1.018.

However, the Zimnitsky test still shows large fluctuations in the specific gravity of urine (1.010–1.016). Asthenization, dyspepsia, liver and kidney dysfunction, anemia persist for a long time. Complete restoration of kidney function occurs much later, in 3–5 months after poisoning. Recovery may also be incomplete due to the development of focal nephrosclerosis. These foci occur in areas where tubule necrosis was deep and accompanied by destruction of the basement membrane. In this case, we should consider "recovery with damage". However, in most cases, even after severe acute renal failure, kidney and liver functions recover after a few months.

***Degrees of severity*.** Acute poisoning with ethylene glycol is divided into mild, moderate and severe.

Mild intoxication is characterized by shallow and short-term intoxication, a prolonged latent period (up to 12 hours or more), mild manifestations of encephalopathy (general weakness, headache, mild ataxia) and dyspepsia; kidney lesions are limited to grade I nephropathy (changes in urine composition without impaired diuresis, nitrogen metabolism and electrolyte balance). With poisoning of *moderate severity*, intoxication is more pronounced, a latent period is up to 6–8 hours, encephalopathy is manifested by arousal, emotional lability, ataxia, drowsiness, a short temporary soporotic state. The gastrointestinal syndrome is clearly expressed. Development of hepatopathy of I–II degree is possible.

Kidney lesions are manifested by oliguria (within 2–3 days) and moderate azotemia (up to 0.8–1 g/l of urea). There is no need for hemodialysis.

In *severe poisoning*, intoxication is clearly pronounced, the latent period is shortened to 1–4 hours, or it may be absent altogether. At the expanded stage, all the main intoxication syndromes are sharply expressed. Only in some cases, the cerebral and gastrointestinal manifestations of intoxication are insignificant, and the disease manifests symptoms of ARF.

In clinical investigation of blood, neutrophilic leukocytosis with a shift to the left, lymphopenia, and aneosinophilia are determined at the early stages. The number of red blood cells is either unchanged or increased due to hemoconcentration; the erythrocyte sedimentation rate (ESR) is normal. Against the background of ARF, normochromic anemia develops, ESR increases, toxic changes in neutrophils appear.

When examining urine, low relative density is determined against the background of a decrease in diuresis, acid reaction, various degrees of proteinuria severity, hyaline, granular, less often waxy cylinders, the increased number of leukocytes and erythrocytes, calcium oxalate crystals are revealed in the sediment. Minor proteinuria and isohypostenuria persist for a long time during the recovery stage.

Biochemical blood tests at the early stages reveal moderate hyperglycemia, in some cases hypocalcemia; metabolic acidosis is naturally observed. Later, changes in biochemical parameters characteristic of renal insufficiency (increased creatinine, urea nitrogen, hyponatremia, hyperkalemia, etc.) and liver damage (hyperenzymemia, hyperbilirubinemia, decreased procoagulants, cholesterol, pathological sedimentary reactions, etc.) may be determined.

The diagnosis of poisoning is determined by the fact of glycol-based technical liquids ingestion, typical frequency and characteristic clinical picture of intoxication, significant changes in urine (indicating serious kidney damage), presence of calcium oxalate crystals and an increased amount of hippuric acid in the urine, chemical and toxicological examination of the biological fluids and tissues and the remnants of the administrated poison.

When determining ethylene glycol in biological fluids, positive results can be obtained no later than 2–3 days after taking the poison.

ORGANOCHLORINE SOLVENTS

Among organochlorine compounds of the greatest interest for clinical toxicology are fatty acid compounds — 1,2-dichloroethane (DHE), carbon tetrachloride (CTC).

Compounds of this series are widely used as organic solvents and extractants. DHE is also used for dry cleaning, for skin treatment before tanning, in the production of plastics, in agriculture as an insecticide and fungicide, a fumigant of soil and granaries, it is an integral part of adhesives. CTC is a part of stain removers, it is widely used in industry as a solvent of oils, fats, rubber, for degreasing metal products.

Regardless of the chemical structure, chlorinated carbohydrates have similar physical and chemical properties. All these compounds, being liquids with

a characteristic odor, “sweet” taste, poorly soluble in water, are highly lipophilic volatile substances. When heated, almost all chlorinated hydrocarbons can form phosgene. The generality of chemical and physical properties ultimately determines the similarity of the toxic effects of these toxic liquids.

Physical and chemical properties. ***Dichloroethane*** (ethylene chloride, ethylene dichloride) is a transparent, colorless or slightly yellowish, slightly mobile liquid with an odor reminiscent of chloroform or ethyl alcohol. Specific gravity at 20 °C — 1,249–1,258. Flammable. Poorly soluble in water, well — in alcohol, ether, acetone. DHE vapors are 3.5 times heavier than air and therefore can accumulate in the lower part of the building. It is well sorbed by clothing fabrics, especially cloth. It is used as a solvent of paints and varnishes, as a means for degassing military equipment, uniforms, workwear in case of contamination with chemical warfare agents, for the extraction of fats, oils, resins, refined petroleum products, for dry cleaning and for other purposes.

Technical ***carbon tetrachloride*** is a transparent colorless, easily mobile, evaporating, non-flammable liquid with a characteristic sweet smell. The specific gravity is 1.5–1.6. A good solvent, used for cleaning uniforms and overalls, as a solvent of varnishes, fats, rubber, sulfur, resins, for degreasing the surfaces of metal parts and elements, in the production of fire extinguishers, for special purposes and as a chemical reagent. Decomposes (when extinguishing fires) with the formation of phosgene, which can cause severe poisoning.

Toxicity. Routes of exposure. Poisoning can occur due to alimentary, percutaneous and inhalation exposure, as well as their combination. It should be noted that among poisoning with chlorinated hydrocarbons, acute intoxication takes the first place, which occurs mainly when these substances are ingested as alcohol surrogates, and in some cases with a suicidal purpose. Inhalation and percutaneous exposures are only met in 5 %. The percutaneous route of administration is more significant for CTC, significantly less for DHE.

When ingested, CTC is rapidly absorbed, while about a third of it is absorbed from the stomach, the rest from the small intestine. In the blood, its maximum concentration is determined after 2–4 hours, after 6–8 hours there is a sharp decrease in it due to deposition in tissues rich in lipids. In the future, within a few days, it disappears from the blood. Up to 80 % of CTC is excreted unchanged from the body through the kidneys and lungs. The poison is found the longest in exhaled air and adipose tissue.

The maximum resorption of DHE when ingested occurs within 3–4 hours from the moment of ingestion of the poison, and after 6–8 hours most of it (about 70 %) is deposited in lipid-rich tissues. Trace amounts of DHE are detected in the blood until the end of the first or beginning of the second day. The main ways of excretion of DHE and its metabolites are the lungs and kidneys. 10–42 % of DHE is released with exhaled air, 51–73 % with urine, an insignificant part is excreted through the intestine.

When ingested, the lethal dose of DHE and CTC averages 20–40 ml.

The toxic concentration of DHE in the air is 0.3–0.6 mg/l when inhaled for 2–3 hours, the concentration of 1.25–2.75 mg/l when working without a gas mask is fatal. The lethal concentration of CTC is 50 mg/l when inhaled for 1 hour.

Mechanisms of toxic action. The peculiarity of chlorinated hydrocarbons is that with any routes of exposure, especially inhalation, chlorinated hydrocarbons are rapidly absorbed into the blood. After 6 hours, 70 % of the poison is no longer detected in the bloodstream, it is fixed in the tissues.

Chlorinated hydrocarbons are distributed unevenly in the body, the accumulation of toxicants occurs in tissues rich in lipids (brain, adrenal glands, subcutaneous fat, omentum, liver, kidneys, etc.). The maximum concentration of the toxicant in the liver is observed for 24 hours.

Biotransformation of chlorinated hydrocarbons occurs mainly in the liver and is carried out due to the functioning of monooxygenase systems of the smooth endoplasmic reticulum and conjugation reactions associated with them, mainly with reduced glutathione. When taking high doses of chlorinated hydrocarbons, glutathione reserves are rapidly depleted.

A common pattern is the formation of water-soluble products in the process of biotransformation, which are subsequently excreted in the urine. Unchanged fractions of xenobiotics are excreted mainly through the lungs and gastrointestinal tract.

Chlorinated hydrocarbons realize their toxic potential by various mechanisms in various target organs.

Simplistically, these mechanisms can be divided into the direct action of the starting substance on target organs (*non-specific*, *non-electrolytic action*) and the action of molecules that have arisen during biotransformation (*specific action*).

The nonspecific effect is characteristic of all representatives of this group and is due to the action of the whole molecule of the substance, which is realized due to the lipophilic properties of xenobiotics.

These properties determine the narcotic effect of the poison, a decrease in the contractility of the myocardium, hemolysis. The cause of the disorder of cardiac activity may be not only a direct toxic effect, but also an increase in sensitivity to adrenaline and norepinephrine. When poisoning with substances with a predominantly non-electrolytic effect, disorders of the CNS, and external respiration come out on top in the pathogenesis and clinical picture of intoxication. Kidney and liver lesions are rare.

The specific (electrolyte) effect of poisons is associated with the lethal decomposition of the initial compounds in the process of biotransformation with the formation of more toxic water-soluble products. Thus, CTC in liver cells under the action of enzymatic systems of the endoplasmic reticulum (with the participation of cytochrome P-450) undergoes reductive dechlorination with the formation of free radicals, of which the trichloromethyl radical has the highest activity. The latter has not only a direct damaging property, but also stimulates lipid peroxidation, thereby disrupting the structure and function of membranes. In addition, during the oxidative decomposition of CTC, phosgene is formed, which has alkylating properties.

The toxic effect of DHE is also associated with the products of its biotransformation. Thus, in the process of dechlorination, 1-chloroethanol is formed, which, with the participation of alcohol and aldehyde dehydrogenase, is oxidized to chloroacetoaldehyde and monochloroacetic acid. The natural way of detoxification of DHE in the body, as well as other hydrocarbons under consideration, is a reaction with reduced glutathione in the liver; as a result, low-toxic mercapturic acids are formed, but one of the intermediate products — semi-mustard gas — is able to have an alkylating effect. Metabolites of DHE have high activity and, interacting with sulfhydryl groups of enzymes, disrupt their structure and function. Apparently, monochloroacetic acid has the greatest toxicity, which, by blocking aconite transferase, disorganizes the work of the tricarboxylic acid cycle.

Toxic metabolites of organochlorine compounds by alkylation and (or) stimulation of lipid peroxidation damage plasma and intracellular membranes and trigger, apparently, the calcium mechanism of cell death. Inside the cell, calcium accumulation blocks mitochondrial oxidative phosphorylation, destabilizes lysosomal membranes, activates endoproteases located in lysosomes that have autoproteolytic properties. The consequence of these changes, as well as disorders of lipid metabolism (an increase in the amount of lipids entering the cell and inhibition of their excretion), are dystrophic (mainly fatty dystrophy) and necrotic cell lesions.

These mechanisms (non-electrolyte and electrolyte action of the toxicant) are primary, realized already in the toxicogenic phase of intoxication. They cause changes in various organs and tissues, lead to serious homeostasis disorders (metabolic acidosis, water-electrolyte, hemocoagulation shifts, etc.), the formation of a number of secondary syndromes (central and aspiration-obturation respiratory disorders, acute insufficiency of parenchymal organs, etc.).

Hemodynamic disorders, especially exotoxic shock, play an important role in the pathogenesis of organochlorine compounds intoxication, as a consequence of a sharp increase in the permeability of the vascular wall with the release of the liquid part of the blood into the interstitial space, the development of true hypovolemia, centralization of blood circulation, peripheral vasoconstriction, hemoconcentration, aggregation of blood cells, significant microcirculation disorders, deepening tissue hypoxia and homeostasis disorders.

The disorders described above at a certain stage of the formation of exotoxic shock lead to pronounced changes in the rheological properties of blood with the further development of consumption coagulopathy (disseminated intravascular coagulation (DIC) syndrome).

In the somatogenic phase of intoxication, the main place is occupied by lesions of parenchymal organs — the liver and kidneys. Dystrophic and necrotic changes in the cells of these organs are accompanied by the impairment of all the main functions of the liver — synthetic, detoxifying, regulating all the main types of intermediate metabolism, and kidneys — the release of water, electrolytes, nitrogenous components, regulation of hematopoiesis, blood pressure. These metabolic disorders, as well as the products of destruction of parenchymal

organs themselves, are the basis for the formation of secondary endogenous intoxication, often with manifestations of multiple organ failure, which in itself leads to an increase in degenerative-dystrophic changes in tissues, contributes to the development of complications, including infectious.

Clinical signs and symptoms. Organochlorine poisoning is characterized by damage to the CNS, cardiovascular, respiratory systems, gastrointestinal tract, liver and kidneys, therefore, in the clinical picture of acute intoxication with these poisons, it is customary to distinguish the following major syndromes: toxic encephalopathy, respiratory and circulatory disorders, toxic hepatopathy and nephropathy, gastrointestinal disorders.

The presence of certain syndromes and their severity depend on the physical and chemical characteristics of the poison, the route of exposure, dose, and the initial state of the poisoned person. For example, acute inhalation (and inhalation-percutaneous) poisoning with chlorinated hydrocarbons is somewhat easier than oral. They are characterized by a more pronounced narcotic effect and less severe lesions of the liver, gastrointestinal tract, exotoxic shock and coagulopathy develop less often.

In the clinical course of acute oral poisoning with chlorinated hydrocarbons, the following periods are defined: ***initial manifestations*** (mainly cerebral and gastrointestinal disorders), ***relative clinical wellbeing***, ***damage to parenchymal organs*** and ***outcome***.

The clinical picture of ***the initial period*** of intoxication with chlorinated hydrocarbons is associated with the phenomena of acute gastroenterocolitis and the narcotic effect of the toxicant. When ingesting the poison, after a short latent period lasting from several minutes to 1–2 hours, depending on the severity of intoxication, victims develop salivation, nausea, vomiting, pain in the epigastric region, dizziness. After a few hours, the symptoms of acute enteritis (enterocolitis) appear, characterized by pain in meso- and hypogastric area, repeated liquid flocculent stools, often with an admixture of blood (and in combination with DIC-syndrome — bleeding), dehydration phenomena.

Manifestations of toxic encephalopathy develop in all patients poisoned with chlorinated hydrocarbons and begin to progress almost simultaneously with the symptoms of damage to the organs of the gastrointestinal tract. Disorders of consciousness and mental functions are most clearly manifested in the clinical picture of intoxication, which are characterized by both symptoms of CNS excitation (psychomotor agitation with euphoria, hallucinations, delirium) and depression by stun, up to sopor and coma in severe poisoning). One of the frequent complications of severe intoxication is convulsive syndrome.

In the initial period of poisoning with organochlorine compounds, a *primary coma* is isolated, due to the narcotic effect of the poison (in the first minutes and hours), and a *secondary one*, developing at the height of exotoxic shock. The duration of the primary coma usually does not exceed several hours. It is characterized by pupils dilation, lack of pain sensitivity with preserved reflexes, muscle hypertonicity, respiratory and circulatory disorders, the smell of poison in the exhaled air.

The narcotic effect of chlorinated hydrocarbons, which leads to depression of consciousness, is the cause of respiratory disorders in the initial period of intoxication, in severe cases manifested by acute respiratory failure of the central type due to respiratory depression (rare breathing, pathological rhythms, apnea). In addition, the cause of respiratory disorders may be aspiration-obturation processes (the fallen down tongue, aspiration of vomit, nasopharyngeal mucus, etc.).

Against the background of exotoxic shock, it is possible to form respiratory distress syndrome in adults with a clinical picture of pulmonary edema and a typical X-ray picture.

Primary toxicogenic collapse develops in the first hours of intoxication after administration of extra-large doses of the toxic substance due to the impairment of the regulation of the vasomotor center, manifested by a sharp decrease in blood pressure and poorly amenable to therapy. Chlorinated hydrocarbons also have a direct cardiotoxic effect, which can cause sudden death due to ventricular fibrillation.

The development of exotoxic shock may be accompanied by *DIC-syndrome*. Its first, hypercoagulation phase, characteristic of the initial period of intoxication, is usually short-term, masked by a picture of shock and is often not diagnosed. The development of this phase indicates rapid thrombosis of vascular catheters, needles, blood in vitro, hypercoagulation detected by coagulation tests, a decrease in platelet levels, and paracoagulation tests (ethanol, protamine sulfate, etc.) are poorly positive.

With a favorable course of intoxication, the narcotic effect of the poison decreases over time, which manifests itself in recovering consciousness, as a rule, through a phase of pronounced psychomotor agitation with clonic-tonic convulsions or chills-like hyperkinesis. A decrease in the degree of depression of consciousness indicates the onset of a period of “imaginary well-being”, which in some cases is replaced by a general deterioration and the development of a secondary coma, which usually has an unfavorable prognosis.

However, even in this phase, the phenomena of toxic gastritis (nausea, repeated vomiting, pain in the epigastrium) and enteritis (frequent liquid, fetid stools) persist. Against this background, the phenomena of exotoxic shock, consumption coagulopathy, and then fibrinolysis are the main causes of death of victims on the 1^{st}–2^{nd} day of poisoning.

The second stage of coagulopathy (progressive) is characterized by an apparent normalization of coagulation, however, the results of studies reveal multidirectional changes characteristic of both hypo- and hypercoagulation. Thrombocytopenia is more pronounced. The indicators of paracoagulation tests are distinctly positive, the fibrinogen content is reduced, fibrinolysis is activated.

In the third stage (pronounced hypocoagulation) there are symptoms of hemorrhagic diathesis (blood seepage around vascular catheters, hematomas at injection sites, bleeding of various localization). Platelet count, fibrinogen level, prothrombin complex indicators, antithrombin III level are progressively decreasing; fibrinolysis is pronounced, the concentration of fibrinogen degradation

products (PDF) is increased. Paracoagulation tests are poorly positive or negative. In this phase, profuse bleeding is often the cause of death.

If the patient does not die in the early stages of poisoning, then on the 2–3 day intoxication enters the somatogenic stage, when manifestations of hepatic and renal failure, myocardiodystrophy, gastrointestinal disorders, infectious complications come to the fore.

The severity of the condition in the somatogenic period of intoxication is determined by damage to parenchymal organs — the liver and kidneys.

Toxic hepatopathy — a typical manifestation of intoxication with chlorinated hydrocarbons — usually develops 2–3 days after exposure to the poison (in the early somatogenic period) and is a consequence of the hepatotoxic effect of the metabolic products of the initial toxicants.

According to the ability to cause liver damage, chlorinated hydrocarbons can be arranged in a row in order of decreasing their hepatotoxic potential: carbon tetrachloride → dichloroethane → trichloroethylene. The morphological substrate of toxic hepatopathy is fatty degeneration with centrilobular necrosis, which later spreads to the entire lobule.

Hepatopathy as a result of exposure to chlorinated hydrocarbons is characterized by the development of cytolysis, cholestasis and acute hepatic cell insufficiency syndromes. Clinically, liver damage is manifested by its enlargement and soreness, icteric sclera, jaundice, general intoxication, fever, hemorrhagic syndrome and in severe cases — ascites, hepatic odor and hepatic encephalopathy. The above clinical changes are not specific to hepatic cell insufficiency, cholestasis or cytolysis and they can only be evaluated in relation to biochemical disorders.

Acute hepatic cell insufficiency is characterized by synthetic and detoxifying liver dysfunction. Biochemical parameters indicating the impairment of synthetic function are a decrease in the concentration of albumin, cholesterol, coagulation factors (especially prothrombin), plasma cholinesterase activity.

An increase in the concentration of bilirubin, short-chain fatty acids, acetone, and ammonia in the blood serum indicates a metabolic disorder, detoxification processes with damage to liver tissue. As hepatic cell insufficiency increases, hemorrhagic syndrome and jaundice progress, and hepatic coma may develop.

Cholestatic syndrome is manifested by an increase in the activity of alkaline phosphatase, bilirubin concentration and is noted in approximately 50 % of cases of poisoning.

Jaundice is hepatic-cellular by the mechanism of its formation and develops rapidly. The rate of increase of bilirubinemia (due to its direct fraction) usually reflects both the rate of progression of liver damage and a decrease in biliary function.

Cytolytic syndrome is characterized by an increase in the activity of aminotransferases — aspartate aminotransferase (AST), alanine aminotransferase (ALT), fructose-1-phosphataldolase of the 4^{th} and 5^{th} fractions of lactate dehydrogenase (LDH). Cytolysis indicators can significantly outpace clinical manifestations of hepatopathy, changing already in the first hours of intoxication.

In the development of acute toxic liver damage in poisoning with chlorinated hydrocarbons, the stages of the course can be traced. The first phase (24–72 h) is characterized by the appearance of cytolytic syndrome, jaundice and clinical signs of liver damage (hepatomegaly, soreness in the right hypochondrium), and for the second (48–72 h) — liver failure, severe jaundice, hemorrhagic manifestations and the addition of acute renal failure.

Toxic nephropathy at poisoning with chlorinated hydrocarbons develops simultaneously with liver damage or after a few days, which leads to the development of the hepatic-renal failure and significantly aggravates the course of intoxication. Renal dysfunction usually develops on the 1st–3rd day of poisoning, but in some cases it is observed already in the first hours and is a consequence of hypoperfusion of the organ due to exotoxic shock.

CTC has the most pronounced nephrotropic effect among chlorinated hydrocarbons. Kidney lesions are characterized mainly by hydropic dystrophy of the proximal sections of the convoluted tubules, in severe cases with nephronecrosis. When intoxications with DHE, the phenomena of protein and fatty degeneration prevail. The changes described above are due to the direct action of poisons or their metabolites on the renal parenchyma, exotoxic shock, and also a secondary impairment of perfusion, temporary hypoxia of the organ, disorders of acid-base and water-electrolyte state, increased intrarenal pressure.

Depending on the severity of clinical manifestations, biochemical and functional changes, toxic nephropathy is divided into mild, moderate and severe, manifested by acute renal failure. Mild nephropathy is characterized by a slight and short-term urinary syndrome, a slight decrease in glomerular filtration, with preserved concentration and nitrogen excretion function.

With moderate nephropathy, there are more pronounced changes in the composition of urine lasting up to 2–3 weeks, a moderate decrease in the glomerular filtration rate and concentration function of the kidneys. There is a slight increase in creatinine levels in the blood with unchanged other indicators of nitrogen metabolism.

Severe nephropathy is manifested by the syndrome of acute renal failure due to acute tubular or cortical necrosis. In all patients with a pronounced clinical picture of poisoning with chlorinated hydrocarbons, changes in the acid-base state of the blood are noted — metabolic acidosis develops. In case of the impairment of external respiration, its combination with respiratory acidosis is possible.

The severity and prognosis of poisoning is also influenced by the damage to other organs and systems. In particular, parenchymal respiratory insufficiency in this phase of intoxication may be a consequence of the “wet lung” syndrome in the oligoanuric stage of acute respiratory failure, hemodynamic pulmonary edema against the background of myocardial dystrophy, drain pneumonia.

The development of myocardiodystrophy is associated with non-specific processes (hypoxia, decreased coronary blood flow, shock, etc.) and may manifest as conduction disorders, contractility and rhythm. In some cases, acute heart

failure may develop mainly in the left ventricular type, which may be facilitated by excessive infusion therapy.

It is also possible to develop acute pancreatitis, neuritis of peripheral nerves.

Infectious complications pose a great danger to the poisoned person during this period. The most frequent of them is pneumonia, which develops in almost all seriously ill patients.

Its development is promoted by aspiration-obturation syndrome, circulatory disorders, suppression of immunity. This causes frequent bilateral localization and the draining nature of the process.

Poisoning with chlorinated hydrocarbons is divided into mild, medium and severe according to the degree of severity.

Mild degree is characterized by minor and short-term dyspeptic disorders (nausea, vomiting), moderately pronounced cerebral disorders (ataxia, euphoria, lethargy), grade I hepatopathy.

With poisoning of ***moderate severity***, acute gastritis or gastroenteritis, more pronounced cerebral disorders (ataxia, lethargy or psychomotor agitation), toxic hepatopathy and nephropathy of the I–II degree develop.

Severe poisoning is manifested by pronounced psychoneurological disorders (acute intoxication psychosis, stupor, sopor, coma), respiratory disorders, exotoxic shock, acute gastroenteritis, coagulopathy, hepato-nephropathy II–III degree.

The main causes of unfavorable outcomes in the somatogenic period of intoxication are acute hepatic or hepatic-renal failure and infectious complications.

Diagnosis of acute poisoning with chlorinated hydrocarbons. Diagnosis of poisoning with organochlorine compounds is based on anamnesis data, features of the clinical picture of intoxication, data from clinical-instrumental and chemical-toxicological examinations and does not present any particular difficulties if the fact of contact with the poison is known. The greatest difficulties arise in the diagnosis of inhalation and percutaneous CTC poisoning caused by exposure to low concentrations of poison, when the manifestations of narcotic action may not be expressed, and catarrhal phenomena, gastrointestinal disorders, signs of general intoxication, mental disorders, which are quite often mistaken for acute food toxic infection. Acute gastroenteritis, hepatic colic, cholecystitis, pancreatitis, angina pectoris with glomerulonephritis, infectious hepatitis, internal bleeding, acute psychosis take the first place in the clinical picture after the latent period.

In the early stages of intoxication, the presence of a specific aromatic odor in the exhaled air, from vomit masses, flushing water and the results of chemical and toxicological examination of biological fluids (blood, urine), as well as the remains of the liquid taken, are of great diagnostic importance. The timing of the detection of poisons in biological fluids depends on the characteristics of the toxicokinetics of a particular poison. Usually DHE is identified in biological liquids during the first, sometimes at the beginning of the second day, CTC and trichloroethylene — 2–3 days. At a later date, chlorinated hydrocarbons can be identified in subcutaneous fat biopsies. Approximate information can be obtained by applying the simplest methods to assess the remains of the poison: the presence

of a characteristic odor, insolubility and high relative density (a drop sinks in a test tube with water).

Preliminary information about the etiology of poisoning can also be obtained using a simple test with a copper wire. When copper wire pre-etched with nitric acid and moistened with urine containing chlorinated hydrocarbons is introduced into the flame of an alcohol lamp, the flame turns green.

Today, the most reliable among chemical and toxicological methods is gas chromatography, which allows not only qualitative, but also quantitative determination of a toxic agent in biological fluids and tissues of the patient.

Treatment of acute poisoning with chlorinated hydrocarbons. The treatment of poisoning traditionally begins with the prevention of further introduction and removal of the non-absorbed portions of poison. To do this, in case of inhalation poisoning, it is necessary to take the victim out into the fresh air, change clothes and decontaminate the affected skin and mucous membranes with water.

In case of oral poisoning, a probe gastric lavage is performed using 12–15 liters or more of room temperature water till the appearance of clean flushing water. At the end, up to 50–70 g of activated charcoal is administrated, the procedure is repeated 2–3 times at intervals of 1–2 hours. In the future, enterosorbent is used for 7–10 days for 10–15 g 3–4 times a day.

Non-absorbable (vaseline) oils are advisable to use only when enterosorbents on the bases of activated charcoal, which fix the poisonous agent much more firmly, are not available. It is also impractical to use sorption agent and oil at the same time, since their sorbing properties are mutually neutralized. Gastric lavage with milk is categorically contraindicated, as well as ingestion of it or other absorbed fats. To speed up the passage of poison through the intestine saline laxatives and siphon enemas are used.

Removal of the absorbed poison is achieved by using elimination methods of extracorporeal detoxification — hemosorption, peritoneal dialysis. Elimination methods are most effective in the first hours of intoxication, when there is high concentration of toxicant. The optimal timing is 2–4 hours from the moment of exposure to the poison and is usually limited to 6–12 hours. The most effective is hemosorption using modern sorbents, the perfusion rate is 150–200 ml/min, its volume is at least 3 volumes of circulating blood. The clearance of DHE is high and reaches 100 ml/min. Peritoneal dialysis is also used, which makes it possible to “wash” from chlorinated hydrocarbons the fatty tissue of the abdominal cavity containing high concentrations of poison, especially in oral poisoning. The second mechanism of therapeutic action of dialysis methods is dialysis through the peritoneum, which is a semipermeable membrane, of exotoxins and their metabolites. It is recommended to use this method as an independent one at a later time (6–12–24 hours after exposure to the poison), as well as with the development of pronounced hemodynamic disorders that make hemosorption impossible. It is carried out for a long time (during the day) with the shift of 20–25 volumes of dialysis fluid. According to experimental data, the effectiveness of peritoneal dialysis increases significantly when adding oils or fat emulsions to the dialysis fluid.

The stimulation of the excretion of volatile chlorinated hydrocarbons with exhaled air is theoretically justified, but the method of artificial hyperventilation is not sufficiently developed for practical use. However, if a patient in the early stage of poisoning is performed ALV, against the background of a deep coma, central respiratory failure, it is advisable to carry it out in the mode of moderate hyperventilation.

Forced diuresis in poisoning with chlorinated hydrocarbons has no independent significance, however, it is usually used as a component of complex therapy.

Indications for the use of hemosorption and peritoneal dialysis are anamnestic information about the intake of a toxic dose of chlorinated hydrocarbons, a clinical picture of severe intoxication, a distinct smell of poison in the exhaled air, data from a chemical-toxicological analysis of biological fluids and tissues.

Using elimination methods in poisoned patients, it is necessary to understand that these methods are the main ones, their timely and high-quality use largely determines the intoxication outcome, severe poisoning with DHE, CTC requires the complex use of detoxification measures — gastrointestinal cleansing, early hemosorption and, according to indications, peritoneal dialysis.

A specific antidote therapy for poisoning with chlorinated hydrocarbons is currently under research. The following methods of this group are used in practice:

1. Inhibitor of microsomal enzyme systems and cytochrome P-450 — levomycetin-succinate, capable of slowing down the rate of DHE metabolism and the formation of more toxic products.

The use of this medicine begins in the early stages of intoxication with simultaneous intravenous and intramuscular administration of 1 g, and later intramuscularly 1 g every 4–6 hours during the first day. There is evidence that levomycetin-succinate has a beneficial effect on the course of CTC intoxication. In experimental poisoning with DHE, encouraging results were obtained from the introduction of an alcohol dehydrogenase inhibitor — isovaleric acid amide, however, clinical research of this substance has not yet been carried out.

2. Binding of active metabolites of DHE and an increase in the content of glutathione in the liver is achieved by the introduction of acetylcysteine in the first 2 days of intoxication. Acetylcysteine is administered intravenously as a 5 % solution on the first day up to 500 mg/kg (the first injection is 100 ml, then after 3 hours 40–60 ml), on the second — up to 300 mg/kg (60 ml after 6 hours). To avoid collapse, acetylcysteine is administered slowly, especially to children.

3. Suppression of lipid peroxidation processes activated by poisoning with DHE and CTC is achieved by the introduction of antioxidants. The most commonly used is α-tocopherol (vitamin E), which is administered intramuscularly 2 ml 3–4 times a day for 3 days, with severe intoxication, the use of the medicine is continued for up to 7–18 days in smaller doses. It is recommended to administer unithiol intramuscularly for the first 3 days after 4 hours at a dose of 5 mg/kg, for 2–3 days after 6 hours.

Pathogenetic and symptomatic therapy of poisoning with chlorinated hydrocarbons is carried out in several directions. Respiratory disorders of aspiration-obturation genesis require restoration and maintenance of airway patency, central respiratory paralysis — AVL.

Treatment of pulmonary edema, disorders of the water-electrolyte balance and acid-base state is carried out according to general rules.

Measures for the prevention and therapy of exotoxic shock are of great importance. They include infusion therapy to replenish the circulating blood volume (low molecular weight blood substitutes, albumin, glucose-salt solutions with a colloid: crystalloid ratio = 1 : 2 or 1 : 3). The total amount of infusion during the day can reach 8–10 liters, the treatment is carried out under the control of the main hemodynamic parameters (pulse, blood pressure, central venous pressure, cardiac output), hematocrit number.

As a means of stabilizing hemodynamics, reducing membrane permeability, suppressing the "proteolytic explosion", activation of the coagulation system, polyvalent proteolysis inhibitors are used (up to 100 000–300 000 units/day for 2–3 days intravenously or other medicines in equivalent doses) in combination with heparin (20 000–30 000 units/day) and glucocorticoids (up to 1000 mg of prednisone for 1–2 days). In the absence of the effect of infusion therapy, inotropic medicines are used — dopamine in a dose of 5–20 micrograms/kg/min. with the mandatory ECG-monitoring (risk of ventricular arrhythmia).

For the prevention of DIC syndrome, early administration of antiplatelet agents is indicated — curantil (0.5 % solution, 2–4 ml), pentoxifylline (2 % solution, 5–10 ml) slowly intravenously in glucose solution, etc. In the initial and progressive phases of this syndrome, the administration of heparin, antiplatelet agents, glucocorticoids, proteolysis inhibitors is indicated. With severe coagulopathy (at the stage of fibrinolysis), the use of heparin requires caution; preparations containing antithrombin III (freshly frozen plasma) are absolutely indicated in amount of 1–2 liters/day), proteolysis inhibitors; antifibrinolytic agents (aminocaproic acid) are used topically, as well as intravenously (with hyperfibrinolysis). Intravenous administration of fibrinogen is permissible in cases occurring with a sharp decrease (up to 0.3 g/l and below) in the concentration of this compound in the blood.

Basic measures for liver damage include infusions of glucose solutions, the use of vitamins (B_1, B_6, B_{12}, B_{15}, essentiale 20–30 ml/day, lipoic acid 20–30 mg/kg per day). Means that increase the metabolic load on the liver (sleeping pills, narcotic analgesics, phenothiazines, hepatotoxic antibiotics, etc.) are excluded. The effectiveness of therapy increases with intraportal administration of medicines (through the awakened umbilical vein), as well as in combination with various methods of liver arterialization.

Hyperbaric oxygenation (HBO) contributes to the acceleration of liver regeneration and improvement of its detoxification function from 3–5 days (excess pressure of 0.7–1 atm. for 60 minutes, up to 10–12 sessions). HBO is especially indicated in combination with sorption detoxification and plasma exchange in

the initial manifistations of hepatic encephalopathy. In these cases, protein intake is limited, solutions containing cyclic amino acids are infused, glucose solutions, vitamins, essentiale, ornicetil are continued (2–4 g intravenously 2 times a day), portalak is prescribed orally (50 ml 3–4 times a day).

Elimination measures, antishock therapy, and medicines that improve microcirculation (trental, curantil, low molecular weight heparin) play a major role in the prevention of acute kidney injury.

With the developed acute renal failure, therapy is carried out according to the general principles of treatment of this condition. It shows the purpose of a diet with a restriction of energy value, protein up to 20 g/day, foods rich in potassium are excluded from the diet, compliance with a strict water regime, which requires daily monitoring of body weight and excreted fluid. Antihypertensive agents are indicated with a pronounced increase in blood pressure. Early detection and treatment of infectious complications using antibiotics that do not have nephrotoxicity is important. An increase in water and uremic intoxication (increased levels of urea and creatinine in the blood), hyperkalemia are indications for hemodialysis or similar methods.

SITUATIONAL CASES

Case 1. The victim N. was delivered to the admission department of the central district hospital 12 hours after poisoning. He complains of a headache, dizziness, nausea, "fog" in front of the eyes, periodic darkening in the eyes. According to the patient, he drank about 40 ml of a clear transparent liquid that smells and tastes like ethyl alcohol. In about 30 min. he felt intoxicated, pronounced drowsiness. He fell asleep and slept for about 8 hours. After waking up, he was disturbed by the above-mentioned changes in well-being, which continued to increase. On medical examination: the patient is apathetic, the skin is hyperemic, the pupils are dilated, they react sluggishly to light. Pulse is 110 beats/min, soft, weak filling, single extrasystoles are detected, heart tones are muted, blood pressure is 100/60 mm Hg, the number of breaths is 22 per minute, breathing is weakened.

Tasks:

1. Formulate and justify a preliminary diagnosis.
2. Make an emergency medical care plan.

Case 2. Patient M. was taken to the admission department of the central district hospital by an ambulance team. According to the medical staff, the patient was in a state of psychomotor agitation, complained of a severe abdominal pain, a headache, there was double vomiting on the way to the hospital, then the patient lost his consciousness.

On medical examination: the patient is unconscious, pupils are sharply dilated, do not react to light, breathing is frequent, deep, "noisy", breathing rate is 28 per minute; blood pressure is 90/50 mm Hg, heart rate is 124 per minute, heart tones are muted, arrhythmic. The skin of the face, neck-collar area is purplish-cyanotic; there is a smell of alcohol in the exhaled air.

Tasks:

1. Formulate and justify a preliminary diagnosis.
2. Make an emergency medical care plan.

Case 3. The patient D. was taken to the admission department of the central district hospital 1 hour and 20 minutes after poisoning. He complains of pain and burning sensation along the esophagus and in the epigastric area, weakness, dizziness, vomiting with streaks of blood. The above symptoms appeared about 20 minutes after accidentally drinking a few sips of an oily liquid with a sweet smell (according to the description of the victim, "some kind of solvent"). On examination the patient is excited, the skin and visible mucous membranes are pale, the pulse is 120 beats/min, rhythmic, heart tones are weakened, blood pressure is 90/50 mm Hg. Breathing is vesicular. The abdomen is slightly swollen, painful in the epigastrium.

Tasks:

1. Formulate and justify a preliminary diagnosis.
2 Make an emergency medical care plan.

Case 4. The victim was taken to the admission department of the hospital by an ambulance team in an unconscious state. According to the patient's wife, about 5 hours ago he was engaged in car body repair in a poorly ventilated garage, used "some paints and solvents". There she also found the victim unconscious and called an ambulance team. During the initial examination: consciousness is absent, but the reaction to pain stimuli is preserved. The skin and visible mucous membranes are pale, an aromatic smell is felt in the exhaled air. Pulse is 80 beats/min, rhythmic, heart tones are muted, arrhythmic, blood pressure is 80/50 mm Hg. Breathing rate is 20 per minute, vesicular sounds are heard, abdomen is soft, painful.

Tasks:

1. Formulate and justify a preliminary diagnosis.
2. Make an emergency medical care plan.

ANSWERS FOR SITUATIONAL CASES

Case 1

1. The combination of narcotic action with subsequent damage to the cardiovascular system (toxic cardiomyopathy) and the organ of vision is characteristic of methyl alcohol poisoning. The described clinical picture corresponds to a mild degree of severity.

2. If there are contents in the stomach, a test with a red-hot copper wire should be carried out to clarify the diagnosis, when immersed in methanol, a characteristic smell of formaldehyde is felt. It is necessary to carry out a probe gastric lavage, followed by the introduction through the probe of 1–2 % sodium bicarbonate solution (5–6 g) and saline laxative (200 ml of 25 % magnesium sulfate), 150 ml of 30 % ethyl alcohol solution orally, folic acid 20–30 mg, oxygen inhalation, intramuscularly metazone (1 ml of 1 % solution). It is the indication to urgent evacuation to a specialized healthcare facility where hemodialysis is available.

Case 2

1. Based on the rate of increase and severity of clinical symptoms, a combination of early manifestations of toxic cardiomyopathy, a pathological type of respiration characteristic of metabolic acidosis, severe pain and dyspeptic syndromes, as well as the early development of toxic coma. Maximum pupil dilation and the absence of their reaction to light may indicate severe methanol poisoning.

2. Ensuring the patency of the respiratory tract, aspiration of tracheobronchial content. Tracheal intubation.

Probe gastric lavage, test with red-hot copper wire: put the contents of the stomach into the first portion. The smell of formaldehyde will confirm or refute the preliminary toxicological diagnosis. After the appearance of clean flushing waters, a 1–2 % solution of sodium bicarbonate (5–6 g) and a saline

laxative (200 ml of a 25 % solution of magnesium sulfate) are administered through a probe.

Intravenous administration of ethanol: 5–10 % (into the central vein — 30 %) 1–1.5 ml/kg of body weight/day.

Folic acid 1–1.5 mg/kg body weight/day.

Sodium bicarbonate 4 % — 400 ml intravenously.

If severe methanol poisoning is confirmed, hospitalization to a specialized medical facility is necessary, where hemodialysis is possible.

Case 3

The rapid development of clinical manifestations, the appearance of pain along the esophagus and in the epigastrium, vomiting with streaks of blood, weakness, dizziness, signs of exotoxic shock are characteristic of poisoning with chlorinated carbohydrates. Taking into account the amount of poison taken, it is possible to assume the development of severe poisoning in the patient. Intramuscular administration of prednisolone (150–300 mg), probe gastric lavage followed by administration of 1 g per 1 kg of body mass of enterosorbent (activated charcoal), intestinal lavage is indicated too. 10 ml of 5 % unithiol solution, 50 ml of 30 % sodium thiosulfate solution, 1 g of levomycetin sodium succinate (20 ml of 5 % glucose solution) are administered intravenously, 2 ml of cordiamine are administered intramuscularly. Urgent evacuation to a specialized medical institution where hemodialysis or hemosorption is possible is indicated for this patient. If urgent evacuation is impossible, forced diuresis should be started.

Case 4

The circumstances of the incident, the presence of an aromatic odor in the inhaled air, the pronounced narcotic effect of the poison and the absence of gastrointestinal manifestations, indicate inhalation poisoning with chlorinated hydrocarbons. Emergency care consists in intramuscular administration of prednisolone (90–120 mg), cordiamine (2 ml), intravenously — unithiol (10 ml of 5 % solution), sodium thiosulfate (50 ml of 30 % solution), levomycetin sodium succinate (1 g in 20 ml of 5 % glucose solution). It is indicated an urgent evacuation to a specialized medical institution in which hemosorption, peritoneal dialysis are possible. In the absence of the possibility of immediate evacuation, forced diuresis should be started.

TEST TASKS

1. Specify the effects of ammonia on the human body:

A. Irritating effect.

B. Suffocating effect.

C. Narcotic effect.

D. Psychodisleptic effect.

2. Indicate the most likely causes of adverse outcomes in case of chlorine poisoning:

A. Reflex respiratory and circulatory arrest at high concentration of chlorine in the inhaled air.

B. Paralysis of the respiratory muscles due to the disorder of nerve impulse conduction.

C. Acute hepatic-renal insufficiency.

D. Progressive acute respiratory failure in the alveolar phase of toxic pulmonary edema.

3. Specify the statements fair for hydrogen sulfide:

A. It has a long half-life from the human body.

B. In the atmosphere with a high concentration, the smell is practically not felt.

C. In small amounts, hydrogen sulfide depresses the central nervous system, in moderate amounts it excites.

D. The main route of exposure is inhalation; ingestion and administration through the intact skin are also possible.

4. Specify mechanisms of toxic action of hydrogen peroxide:

A. Chemical burns of the skin and mucous membranes.

B. Hemolysis of erythrocytes.

C. Paralysis of the respiratory muscles.

D. Formation of methemoglobin.

5. Specify the statements that are fair for carbon disulfide:

A. It is a yellowish gas with a characteristic garlic smell.

B. The only route of administration is inhalation.

C. In the process of metabolism, about 50 % is released unchanged with the exhaled air.

D. Almost insoluble in water, soluble in alcohol and ether.

6. Specify the intermediate metabolites that determine the clinical manifestations of severe methanol intoxication:

A. Acetaldehyde.

B. Formaldehyde.

C. Formic acid.

D. Oxalic acid.

7. Antidote used for methanol intoxication:

A. Ethylene Glycol.
B. Ethyl alcohol.
C. Methylene Blue.
D. Atropine.

8. What syndromes are most characteristic for ethylene glycol intoxication?

A. Toxic coma.
B. Acute renal failure.
C. Hemolytic anemia.
D. Convulsive syndrome.

9. Specify the antidotes used for ethylene glycol intoxication:

A. Ethyl alcohol.
B. 4-methylpyrazole.
C. Calcium Gluconate.
D. Ficilin.

10. What detoxification methods are used for poisoning with chlorinated hydrocarbons?

A. Probe gastric lavage followed by the enterosorbent given through the probe.

B. Probe gastric lavage without the enterosorbent due to poor sorption of chlorinated hydrocarbons.

C. Hemosorption.
D. Peritoneal dialysis.

Keys for test tasks: 1 — A, B; **2** — A, D; **3** — B, C, D; **4** — A, B, D; **5** — C, D; **6** — B, C; **7** — B; **8** — A, B; **9** — A, B, C; **10** — A, C, D.

SUMMARY

Учебное издание

Соколов Юрий Анатольевич

ТОКСИКОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА РАСПРОСТРАНЕННЫХ В НАРОДНОМ ХОЗЯЙСТВЕ АВАРИЙНО-ОПАСНЫХ ХИМИЧЕСКИХ ВЕЩЕСТВ И ЯДОВИТЫХ ТЕХНИЧЕСКИХ ЖИДКОСТЕЙ

TOXICOLOGICAL CHARACTERISTICS OF HAZARDOUS CHEMICALS AND TOXIC TECHNICAL LIQUIDS COMMON IN THE NATIONAL ECONOMY

Учебно-методическое пособие

На английском языке

Ответственная за выпуск Т. П. Павлович
Переводчик Ю. А. Соколов
Компьютерный набор Ю. А. Соколова
Компьютерная вёрстка Н. М. Федорцовой

Подписано в печать 15.05.24. Формат 60×84/16. Бумага писчая «Xerox Марафон Бизнес».
Ризография. Гарнитура «Times».
Усл. печ. л. 4,42. Уч.-изд. л. 5,23. Тираж 50 экз. Заказ 319.

Издатель и полиграфическое исполнение: учреждение образования
«Белорусский государственный медицинский университет».
Свидетельство о государственной регистрации издателя, изготовителя,
распространителя печатных изданий № 1/187 от 24.11.2023.
Ул. Ленинградская, 6, 220006, Минск.