**Extreme States**

**Overview of extreme states**

Pathological states accompanied by profound disturbance of vital unctions and metabolin. characterized by overstrain and breakdown of adaptive mechanisms of the organism and causing in threatening conditions, are called extreme states (ES). The most important and clinically significant com are collapse, shock and coma.

The extreme states differ from the terminal states. The terminal state is the final stage of life or he process of dying; it is a state bordering between life and death. Adverse development of an extreme state may lead to the development of a terminal state. In this state, the effectiveness of treatment is low, and if not carry out intensive emergency measures, irreversible processes may lead to death. In the terminal state, the manifestation of the specificity of the causative factor and pathogenetic links is very low or absent, and extremely complicated state of the body is observed. Therefore, emergency measures must be done immediately to prevent the development and transition of extreme state to a terminal state.

***General etiology of extreme states***. Exposure of extremely strong and intensive physical, chemical o biological *exogenous* factors within certain conditions may lead to extreme states. For example, the damaging effect of mechanical factors (various traumas), high and low temperature, electric current, radiation excessively high or low atmospheric pressure, etc. Moreover, decreased oxygen content of the air, the effect of chemicals (industrial poisons, acids, alkalis) and biological factors (toxins of microbes, parasites or fungi or toxic products of metabolism) may cause ES.

The endogenous causes of ES may be severe forms of diseases and pathological processes. For example, the loss of a large amount of blood during internal bleeding, cardiovascular failure, respiratory insufficieng, renal and liver failure, hemorrhages in vital organs or their ischemia, tumors, pathological immune reactions, etc.

*General pathogenesis of extreme states*. There are several stages in the development of ES. As with other pathological processes, adaptation mechanisms are first turned on. At this time, due to the activation of the sympathoadrenal system, several *non-specific protective and adaptive reactions* ("stress reactions") are observed. Furthermore, specific adaptive mechanisms develop to a specific factor that causes ES. nengalid.n

The exhaustion of adaptive mechanisms and increasing of the action of damaging factors lead to the development of the subsequent stage of ES. At this stage, all metabolic and physico-chemical processes, physiological functions of the body are severely disrupted, and the structural elements of tissues and cels are destroyed. The pathogenesis of extreme states has common and similar features. One of the main causes of severe disorders that occur during ES is hypoxia. Acute hypoxia of various origins may lead to an extens state. However, at a certain stage of ES of a different origin, secondary hypoxia occurs. Usually, sud hypoxia is mixed, and develops due to disorders that have developed in various organs and tissues.

Hypoxia plays the role of causative and initiating factor in the occurrence of metabolic disorders. First of all, the synthesis of macroergic compounds is disrupted; the ATP content in the cells decreases and the content of its products of hydrolysis increases, *metabolic acidosis* develops. The disturbances in electrolyte and salt metabolism - an accumulation of Na+, Ca2+ and other ions inside the cell, and K+, Mg2+,H+ and others outside the cell are observed. An increase in the content of Na+ ions in the cells leads to theirhyperhydration and swelling.

The synthesis and secretion of biologically active substances (histamine, kinins, serotonin, lysosomal enzymes, etc.) increase during extreme states.

In most ES similar changes are observed in the blood and circulatory system. Disturbances of the blood microcirculation causing severe changes in the activity of many organs may lead to a decrease in gas diffusion in the pulmonary alveoli, renal and liver failure, and various pathologies of the nervous system.

Moreover, the volume of circulating blood and the rate of blood flow are reduced, aggregation of blood cells, hypercoagulation and thrombosis are observed. In addition, arrhythmias develop and signs of heart and coronary insufficiency appear.

In extreme states, various disorders of external respiration develop. Hyperventilation observed at the stage of adaptation is replaced by impaired rhythm, depth and frequency of respiration, a changed ratio between the phases of inspiration and exhalation. Kussmaul breathing, Biot, Cheyne-Stokes types of respiration appear and in severe cases complete respiratory arrest is observed.

During ES disorders in the nervous system include sensory and motor disturbances, disorders in autonomic (vegetative) nervous system, the changes in consciousness of varying severity. The signs of various types of extreme states only at the initial stage of their development differ from each other. So, in shock, the general state of excitation in the nervous system lasts a long time, then, despite the preservation of consciousness, the inhibition, decreased contact with others are observed and only at the terminal stage consciousness is lost. Coma begins with drowsiness, difficulty in contact, partial loss of consciousness, further development of the process leads to complete loss of consciousness, hyporeflexia and then total areflexia. In collapse, if consciousness is preserved at the beginning, apathy and an indifferent attitude to the environment are observed.

***The severity of coma according to the Glazko scale.***

|  |  |  |
| --- | --- | --- |
| Signs | Degree of dysfunction | Scores |
| Opening of eyes | Confused  Upon request  In response to pain irritation  Is absent | 4  3  2  1 |
| Verbal reactions | Oriented  Confused consciousness  Single word  Soporous state  No consciousness | 5  4  3  2  1 |
| Motor response to irritation | Follows the requirements  In response to pain irritation  Unfocused reactions in response to pain  Flexion synergy  Extensor synergyzm  Is absent | 6  5  4  3  2  1 |
| Maximum score  Minimum score |  | 15  3 |

The renal changes in extreme states are manifested by proteinuria, impaired filtration, oliguria or anuria, uremia to varying degrees. Dysfunction of the liver is manifested by a weakening of detoxification processes, impaired metabolism of proteins, carbohydrates, lipids and bile pigments. Changes in the digestive system are accompanied by disturbances in the motor and secretor functions of the stomach and intestines.

The characteristic sign of extreme states is the development of *vicious circles*. An example of a vicious circle in shock, collapse and coma may be the changes in blood circulation: most of the blood is accumulated in the organs of the abdominal cavity, lungs and in the dilated arteries and veins of the subcutaneous tissue, resulting in a decrease in the volume of circulating blood returning to the heart, and this leads to a decrease in stroke heart volume and an even more significant decrease in circulating blood volume and worsening of the patient's status.

***General principles for the correction of extreme states.*** Emergency therapeutic measures carried out in ES include etiotropic, pathogenetic, symptomatic therapy, as well as measures aimed at strengthening the protective and compensatory-adaptive mechanisms of the body. *Etiotropic therapy* is aimed at reducing the intensity or complete cessation of the pathogenetic action of the factor that caused the extreme state.*Pathogenetic therapy* is aimed at preventing the development of an extreme state. This includes measures against pathogenetic changes (circulatory and respiratory disorders, hypoxia, acid-base and ionic balance disorders. *Symptomatic therapy* is aimed at eliminating the symptoms and signs that complicate the state of the patient in each case. Therapeutic measures aimed at enhancing of protective and compensatory-adaptive mechanisms include stimulating the activity of the heart, respiration, liver, kidneys, other organs and tissues, activating of detoxification and recovery systems, eliminating the excess of reactive oxygen species and lipid radicals, enhancing of the plastic processes, etc.

**Collapse.**

*Collapse* is an acute vascular insufficiency characterized by decreasing of arterial and venous pressures, a mismatch between the level of circulating blood and the volume of the vascular bed. Several factors are involved in the onset of collapse: a decrease in the volume of circulating blood and stroke volume of the heart, a decrease in peripheral vascular resistance, and increasing of the vascular lumen.  
 ***Pathogenesis and manifestation of collapse.*** The primary and the main pathogenetic factors in the development of collapse are disorders in the cardiovascular system that lead to the inadequate blood supply to organs and tissues. Circulatory changes are manifested: by a decrease in stroke volume of the heart, an acute decrease in blood pressure (60-70 mm Hg and below), venous hyperemia, tachycardia, and disturbance of microcirculation. Changes in the nervous system are characterized by general inhibition, apathy, indifferent attitude to events, tremor of the fingers, hyporeflexia, and sometimes convulsions. In collapse, consciousness is mainly preserved, but during the critical decrease in blood supply to the brain a short-term loss of consciousness is observed. Patients have acute weakness, pallor of the skin, cold sweat, decreased temperature, chills, thirst, reduced vision, and sometimes nausea and vomiting. Microcirculatory disorders lead to capillary-trophic insufficiency, a decrease in gas exchange in the lungs. As a result of acute arterial hypotension, a disturbance of the excretory function of the kidneys (oliguria, hyperazotemia) and renal failure develop. Hemodynamic disorders - hypovolemia, increased viscosity of blood can lead to increased aggregation of red blood cells and platelets, as well as the formation of blood clots. In the course of the process, firstly circulatory, and then a mixed type of hypoxia is observed. Deepening hypoxia leads to lite-threatening disorders.  
 ***Pathogenetic classification of collapse***. Cardiogenic, hypovolemic and vasodilation types are the pathogenetic types of collapse. Decreasing of the volume of blood ejected by the heart into the vascular system leads to cardiogenic collapse. This condition is observed with myocardial infarction, cardiac tamponade, some arrhythmias, as well as with heart failure that occurs with severe infections and intoxications, pathologies that impede the flow of blood into the heart or the pumping of blood from the left ventricle into the aorta.  
 A decrease in the volume of circulating blood leads to hypovolemic collapse. This condition occurs during acute blood loss, dehydration for various reasons (profuse diarrhea, uncontrollable vomiting, excessive sweating, prolonged refusal to take water, etc.), burns of a large area, as a result of the loss of a large amount of plasma. Relative insufficiency of the volume of circulating blood is observed with the accumulation of a significant part of the blood in the dilated veins and capillaries (mainly in the organs of the abdominal  
cavity).  
 An acute decrease in the total peripheral vascular resistance is the cause of vasodilation collapse. Severe infections and intoxications, hypoxia, endocrine disorders (adrenal and pituitary insufficiency), increased blood levels of biologically active substances (adenosine, histamine, serotonin, kinins), hyperthermia, radiation, improper use of certain drugs (for example, adrenergic blockers, sympatholytics, calcium blockers) can cause this condition.  
 ***Classification of collapse according to the etiological principle.*** There are the following etiological types of collapse: orthostatic, hemorrhagic, pancreatic, toxic-infectious, etc.  
 *Orthostatic collapse* can occur in a sharply transition to a vertical position of the body after prolonged inactivity and bed rest. Moreover, the cause of the development of orthostatic collapse is general vasodilation as a result of a sharply decrease in the tone of arterioles and large-caliber vessels. During this time, vascular tone decreases, and when the body position changes to a vertical state, blood accumulates in the lower part of body. As a result, the volume of blood entering the brain decreases. During a sharp rise from the bed, orthostatic collapse can be observed in persons with hypotension, the cause of which is irritation of the neurons of the vestibular center and an increase in cholinergic effect on the walls of blood vessels.  
 One of the main pattogenetic factors of orthostatic collapse is a decreased sensitivity of the vessel wall to the action diency, functional ditances (catecholamines, angiotensin, etc). The reason for this may be yarenal insuficiency, unctional disorders of the vasomotor center and hypothalamus, en.  
 *Hemorrhagic collapse*. the pathogenetic cause of the hemorrhagic collapse is an acute and significant decrease in the volume of circulating blood as a result of massive blood loss. Despite the fact that this increases the tone of the vessels, this does not eliminate the discrepancy between the volume of circulating blood and the capacity of the vascular bed. As a result, the blood supply to organs and tissues decreases, firstly circulatory,and then a mixed type of hipoxia develops.In hemorrhagic collapse,acute posthemorrhagic anemia occurs. Therefore, treatment should be aimed not only at restoring the volume of lost blood, at the same time, the patient needs to transfuse blood and red blood cells, to stimulate  
hematopoiesis.  
 *Pancreatic collapse* occurs in severe trauma to the abdominal cavity, acute pancreatitis leading to damage to the pancreatic tissue. In both cases, activated proteolytic pancreatic enzymes enter the blood vessels and damage their walls. As a result of this, the overall vascular tone decreases and collapse develops. Since this type of collapse is associated with the occurrence of degenerative changes and irreversible damage in the vascular walls, its treatment is very difficult.  
 *Toxic-infectious collapse.* Its cause is the pathogenic effect of exogenous and endogenous toxins (toxins of microbes, parasites or fungi, toxins of microbes that died during antibiotic therapy, products of impaired metabolism). Toxins directly upset the regulation of vascular tonicity and cardiac activity. As a result, there is a decrease in vascular tone, systolic volume of the heart, volume of circulating blood.  
 ***General principles of collapse correction.*** The etiotropic treatment of collapse is aimed at eliminating the cause of the development of collapse. Depending on the type of collapse, these measures include stopping bleeding, administering an antidote and antitoxins, carrying out detoxitication measures, prescribing antibacterial drugs, giving the patient a horizontal position and etc.  
 Pathogenetic treatment includes measures aimed at eliminating the discrepancy between the volume of circulating blood and the capacity of the vascular bed. At the same time, normalization of central, local and microcirculatory circulation is of great importance. Plasma and blood substitutes are transtused to restore the volume of circulating blood, dehydration is eliminated. Drugs that increase vascular tonicity, the activity of the heart and respiratory center are used. In case of insufficiency of adrenal hormones, corticosteroids are prescribed, if it is necessary, artificial ventilation of the lungs and also hyperbaric oxygen therapy are performed.

**Shock**

*Shock* is an acute developing syndrome characterizing by disturbances in the neuro-humoral regulating mechanisms of organism, which arises under the influence of extraordinary stimuli. It is accompanied by a sharp decrease in capillary blood flow in various organs, insufficient oxygen supply, inadequate elimination of metabolic products from the tissue, and manifested by severe disorders of the body. Like all typical pathological processes, shock is a complex of reactions of an adaptation, aimed at protecting a biological

species.

It is necessary to carry out the correct differentiation between shock and collapse. It should be noted that in case of collapse, the process begins with a disturbance of hemodynamic, but in case of shock, circulatory disorders develop a secondary, mainly as a result of a disorder of the central nervous system.

The main differentiating feature of shock is the development of severe damage to the structural elements of tissues and organs as a result of the action of an extreme factor.

Based on etiological and pathogenetic signs, the following types of shock are distinguished : shock associated with exogenous pain (traumatic shock, burn shock, etc.);

* ﻿﻿shock associated with endogenous pain (cardiogenic, nephrogenic, abdominal shock, etc.);
* ﻿shock associated with humoral factors (blood transfusion, anaphylactic, hemolytic, etc.);
* ﻿psychoemotional shock.

In practical medicine, shock is divided according to severity: I degree (mild), II degree (moderate), III degree (severe). The allgower index is used to assess the severity of shock by determining the ratio of heart rate to systolic blood pressure. Normally, this coefficient is 0.5-0.6; in a shock of I degree - 0.7-0.8; in II degree - 0.9-1.2; and in III degree - 1.3 or more.

***Pathogenesis and stages of shock.*** Regardless of the causes and clinical signs, the severity in the pathogenetic development of shock, two stages are distinguished. As with other pathologies, at the first stage, adaptive-compensatory mechanisms of the body are turned on. This stage, accompanied by a general excitation of CNS neurons, is called the erectile stage. If the adaptation processes are not sufficient, the next stage of shock develops - the stage of decompensation. At this time, there is a general inhibition of neuronal activity. This stage is called the torpid stage. At both stages of shock, consciousness is preserved, but certain changes can be observed in mind (especially at the torpid stage). But its complete disappearance is not

*At the erectile stage*, which lasts for a relatively short time, afferent impulse, intensively entering the central nervous system from extra-, intra-, and proprioreceptors, leads to changes in neuroendoctine regulation. At this time, the activity of the sympathoadrenal and hypothalamic-pituitary-adrenal system is significantly enhanced, catecholamines and corticosteroids are released into the blood in a large amount, metabolism and a number of physiological systems are activated. As a result, hyperfunction of the cardiovascular and respiratory systems, kidneys, liver and other systems and organs is observed. During the erectile stage, tachycardia, hypertension, centralization of blood circulation, an increase in the frequency and depth of breathing, blood outflow from the depot, mental and motor excitement, an increase in the intensity of the response to various stimuli (hyperreflection) are observed.

*At the torpid stage*, which is considered as a complication of the shock, depletion of adaptive mechanisms and general inhibition in the central nervous system develop. Firstly, at this stage, the content of catecholamines and corticosteroids is high, but the intensity of their action on various organs is reduced.

Then the sympathoadrenal and pituitary-adrenal systems are depleted and their activity decreases, and the content of neurohormones and corticosteroids in the blood decreases. Weakening of hemodynamic indices - a decrease in blood pressure, arrhythmias, a decrease in volume of circulated blood and pulse pressure are observed. Ventilation is reduced and pathological forms of breathing are common for this stage. Mental and motor inhibition, hyporeflexia are noted.

*Hypoxia*, which plays one of the main roles in the pathogenesis of shock, firstly occurs in connection with a disturbance of general blood circulation (circulatory type of hypoxia). Later, disorders that occurred in the respiratory system, changes in the blood and microcirculation disorders lead to the transition of hypoxia into a mixed type. A severe form of hypoxia leads to metabolic disorders, damage to the structural elements of cells, impaired membrane permeability and other consequences.

*Toxemia* is one of the important pathogenetic factors of the shock of various etiologies. Depending on the type of shock, the rate of toxemia, its nature and significance can be different. In some cases, the extreme factor that caused the shock becomes the cause of toxemia (in toxic-infectious shock, anaphylactic shock, burn and other types of shock). During shock physiologically active substances (histamine, serotonin, kinins, acetylcholine, catecholamines, etc.) entering the bloodstream and other body fluids also have a toxic effect on the body. Disrupted metabolic products (lactic and pyruvic acids, denatured proteins, etc.), lysosomal enzymes are found in the blood. Due to impaired detoxification and excretion functions of the liver and kidneys, substances such as phenol, skatol, indole, urea, uric acid and others pass into the blood.

The pathogenesis of shock is characterized by impaired microcirculation. As a result of disturbance of neuro-humoral regulation, the post-capillary vessels narrow, and this leads to an increase in pressure and congestion in the capillary network. At the same time, the permeability of the vascular wall increases and this leads to the transition of plasma into the tissue. As a result, the volume of circulated blood decreases, blood viscosity increases, stasis develops, hypercoagulation and aggregation of blood cells occur.

During Shock, hypoperfusion of organs and tissues develops, as a result of disorders in the microcirculation, all internal organs are damaged. However, the "shock lung" and "shock kidney" should be noted separately. In shock, damage to these organs leads to a certain symptom complex and triggering of pathogenetic mechanisms that complicate the course of shock.

During shock, angiospasm occurs in the pulmonary circulation and the permeability of the capillary wall increases, which leads to the transition of plasma into the alveoli and the development of pulmonary edema. Bronchospasm and edema of the wall of the bronchi associated with an imbalance of biologically active substances lead to obstruction of bronchioles and lung atelectasis. Disturbed blood circulation in the lungs causes a weakening of gas exchange in the alveoli.

During shock, as a result of impaired general circulation, hypovolemia, postcapillary angiospasm of the renal vessels, hypercatecholaminemia, hypoxia and other factors, ischemia of the kidneys and death of nephrons occur. In the renal glomeruli, the filtration pressure decreases and the juxtaglomerular apparatus is damaged.

***Traumatic shock***. The cause of traumatic shock is large and severe damage to organs, soft tissues, bones and muscles as a result of mechanical factors. In this case, nerve ends, roots, plexuses are damaged and very strong pain afferentation occurs. A mechanical injury causing traumatic shock is usually accompanied by blood loss and infection of the wound and further, this worsens the patient's condition.

***Cardiogenic shock***. Severe damage to the myocardium (up to 50%) during its infarction becomes the cause of cardiogenic shock. In this case, the appearance of a very strong pain afferentation plays the main role in the development of cardiogenic shock. Unlike other types of shock, a significant increase in blood pressure is not observed at the erectile stage of cardiogenic shock. The reason for this is an acute decrease in stroke volume of the heart. In this case, an increase in the tone of the walls of the peripheral vessels is not sufficient to raise blood pressure. Only in some cases, in the background of motor excitement, short-term arterial hypertension can be observed.

***Anaphylactic shock*** is one of the severe forms of an immediate type of allergic reaction that occurs during the parenteral administration of an allergen to a sensitized body. Anaphylactic shock can develop during the administration of vaccines, certain medications (antibiotics, sulfanyl-amides, analgesics, hormones, vitamins, etc.), an insect bite and other conditions. Anaphylactic shock usually develops very quickly, within a few seconds.

The reason for the development of ***transfusion shock*** is the mismatch between the donor's and the recipient's blood group, Rh-factor and individual antigens. The use of Low-quality blood during transfusion of whole blood or its components (as a result of hemolysis, protein denaturation, bacterial contamination) can lead to the development of shock. During a mismatch of blood groups, the first signs of shock appear during blood transfusion and in a mismatch of Rh-factor or individual antigens, these signs can occur within a few hours after blood transfusion.

In the pathogenesis of blood transfusion shock, the main mechanism is an agglutination of a large part of red blood cells and the formation of conglomerates as a result of the formation of antigen-antibody complexes, which then undergo hemolysis. In this case, as a result of excessive excitation of vascular interoreceptors, strong afferent impulses are sent to the nerve centers. Intravascular hemolysis sharply worsens the transport function of the blood to carry oxygen and leads to hemic hypoxia. And the disturbances that occur in the circulatory system lead to the fact that hypoxia takes on a mixed character and is even more aggravated.

During blood transfusion shock, blood coagulation decreases and many hemorrhages are formed. This type of shock is characterized by impaired renal function and often, the severity of the condition is determined by this factor.

The occurrence of oliguria or anuria, hyperazotemia or uremia, are characteristic of acute renal failure.

***Burn shock***. The cause of burn shock is burns of the II or III degree, damaging more than 25% of the body surface (in children and the elderly, more than 10% of the body surface).

Strong pain impulse coming from the receptors of burned skin and soft tissues leads to a general excitation of the nervous and endocrine systems. Usually, the erectile stage in burn shock is short, it quickly (often before first aid transit into the decompensation and the torpid phase develops.

One of the important factors in the pathogenesis of burn shock is the dehydration of the body as a result of the intense loss of plasma from the burn surface. At the same time, due to an increase in the permeability of the vascular wall, there is a transition of plasma into tissues and a decrease in circulated blood volume, there is also an increase in blood viscosity, impaired microcirculation and the formation of blood clots.

Burn shock is characterized by short-term severe intoxication. The cause of intoxication is protein denaturation, which occurs under the influence of high temperature, proteolysis products, biologically active substances released as a result of damage to cells and tissues (histamine, kinins, catecholamines, acetylcholine, etc.), microbial toxins formed during the development of an infectious process on a burn surface. The impaired barrier function of the skin, an acute increase in vascular permeability in the area of the burn and around it create the conditions for the absorption of a large number of toxic compounds into the blood.

As a result of disturbances in the physicochemical properties of the blood, the red blood cells undergo hemolysis. This leads to deterioration in the blood supply to the kidneys and their damage.

***General principles for the treatment of shock.*** First of all, it is necessary to eliminate the cause of the shock for reduction the pathological pain afferentation from pain receptors, as well as from extra; intra- and proprio-receptors. Surgical and conservative methods of treatment can be used for this. At the same time it is necessary to use various analgetics.

It is necessary to take measures aimed at normalizing central and peripheral circulation and also nicrocirculation. Blood, plasma or their substitutes are transfused to eliminate hypovolemia; medicinal jibstances are prescribed that increase the contractility of the heart and vascular tone; drugs that reduce vascular wall permeability are used (corticosteroids, vitamins, calcium preparations); solutions of sodium bicarbonate and potassium chloride are introduced to regulate electrolyte and acid-base balance.

Along with this, therapeutic measures should be taken to eliminate or reduce toxemia. For this purpose, antidotes, antitoxins, blockers of biologically active substances (histamine, kinins, etc.), glucocorticoids, and colloidal solutions (for absorption of toxic substances) are prescribed; hemosorption and plasmapheresis are carried out.

In case of respiratory failure, artificial lung ventilation is performed using gas mixtures with high oxygen content. In some cases, hyperbaric oxygenation is used.

Measures are taken to improve the blood supply to the kidneys; if signs of renal failure and uremia develop, hemodialysis is used.

**Coma**

*Coma* is an extreme state characterized by loss of consciousness, a serious weakening of the activity of CNS, lack of reactions to irritations, metabolic disorders, and insufficiencies of respiratory, circulatory and other systems. The main difference between coma and other extreme states is a complete and prolonged loss of consciousness. However, the complication of shock and collapse can also lead to a coma.

***The etiological reasons*** causing coma are divided into exogenous and endogenous groups. *Exogenous* causes include environmental factors that have very strong toxic or damaging effects. The following are exogenous causes of coma:

* damaging of the brain as a result of mechanical injury or the action of an electric current;
* neurotropic exotoxins: alcohol poisoning, a high dose of drugs, sedatives or barbiturates, industrial poisons, poisonous mushrooms, etc.;
* sun or heat shock, excessive hypothermia of the body;
* ﻿﻿reduction of the partial pressure of oxygen in the inhaled air;
* ﻿﻿prolonged starvation;
  + toxins of infectious origin: neurotropic viruses, botulism and tetanus toxins, pathogens of malaria, cholera, etc.;
  + high dose of ionizing radiation.

Coma of *endogenous origin* arises as a result of the development of a severe form of various diseases and pathological conditions, disruption of the activity of individual organs and systems. At the same time, changes occur in vital parameters and indicators. Endogenous coma causes include:

* pathological processes in the brain (ischemic or hemorrhagic stroke, tumor, abscess, edema, etc.);
* local and general circulatory disorders leading to cerebral hypoxia;
* respiratory failure (asthmatic status, cerebral hypoxia with asphyxiation and pulmonary edema);
* disorders in the blood system (hemolysis of the majority ot red blood cells, severe anemia);
* disorders of the endocrine system (hypo- and hyperinsulinism, hyper- and hypothyroid states, adrenal insufficiency);
* ﻿﻿renal failure;
* ﻿﻿liver failure.

***Stages and pathogenesis of coma.*** In some cases, coma can develop very quickly ("fulminant" coma), while in a short time, consciousness is completely lost and signs of a severe coma appear. However, often a coma develops gradually and passes through several stages, including a precomatous state. The separation of the development of coma at the stage is determined according to the severity of the disorders that occur in the mind and central nervous system.

*At the I (initial) stage*, mental anxiety, impaired coordination of movements, primary changes in the electroencephalogram (EEG) are noted.

*At stage II,* drowsiness, blurred consciousness are observed (despite the preservation of consciousness, the sequence, logic and clarity of thinking are disturbed), hypodynamia, decreased sensitivity to external stimuli, including pain irritants.

*At stage III,* a soporous state occurs, with a general slowdown, weakening or partial loss of consciousness, a certain response to strong sound, light or pain stimuli is noted. At this stage, gross changes occur on the EEG, sometimes spastic contractions of individual muscles are observed.

*Stage IV* (deep coma) is characterized by complete loss of consciousness and areflexia (at the same time, corneal and pupil reflexes are not determined. As a result of severe disorders in the central nervous system, arterial hypotension, cardiac arrhythmias, respiratory disorders, lowering body temperature, etc. occur, sometimes central paralysis develops.

Coma can last a long time. An unfavorable course of coma can lead to the occurrence of a terminal (agonal) state and death.

*Disturbance of electrolyte balance plays* an important role in the pathogenesis of coma. K+ ions exit the cell, and Na+ and H+ ions accumulate inside the cell (hyperkalemia and hyponatremia). Associated disturbances in water metabolism also play an important role in the development of coma. In some types of coma, intracellular hyperosmia and hyperhydration lead to the occurrence of cerebral and pulmonary edema. And sometimes, on the contrary, as a result of diarrhea, vomiting, polyuria, intracellular and then total hypohydration develops first.

The most common forms of coma include *apoplexy, traumatic, hepatic, diabetic, hypoglycemic coma.*

***Apoplexy coma*** develops as a result of cerebral hemorrhages or acute local cerebral ischemia. Such conditions associated with the acute development of disorders in the brain and vital functions of the body are called a stroke. The main pathogenetic factors for the occurrence of apoplectic coma include ischemia and hypoxia, resulting from a restriction or extensive circulatory disturbance in the brain, a significant increase in microvascular permeability and accelerated development of cerebral edema. And in ischemic stroke also occur secondary circulatory disorders around the area of cerebral ischemia.

Apoplexy coma resulting from cerebral hemorrhage (hemorrhagic stroke), the patient suddenly loses consciousness, visible vessels are dilated (the face often acquires a dark red color) and their pulsation is

disorders, hypertension and bradycardia occur.

observed, the pupils do not respond to light, hypo- or areflexia is observed, pathological reflexes, respiratory.

*The coma that occurs during ischemic stroke* develops gradually; dizziness, impaired movement, speech, sensitivity, and loss of consciousness are observed. Then there are disturbances or complete loss of consciousness, a decrease in blood pressure, cardiac arrhythmias, a decrease in the respiratory rate and superficial breathing, blanching and cooling of the skin and visible mucous membranes and neuropathological signs are revealed.

***Traumatic coma*** develops as a result of a concussion, contusion of brain tissue and focal hemorrhage. Loss of consciousness can last from a few minutes to several days. At the same time, hypo- or areflexia, to an extreme degree weakening or complete loss of reactions to pain stimuli, respiratory and heart rhythm disturbances, lowering of blood pressure and blood volume, frequent vomiting, involuntary urination, a number of neuropathological signs are observed - paralysis, pathological reflexes, and convulsions can develop. In this case, blood is usually detected in the cerebrospinal fluid.

***Hepatic coma***, or ***hepatocellular coma***, develops as a result of severe damage to most of the liver cells. This condition occurs in severe forms of viral hepatitis, intoxication with various poisons and poisonous mushrooms, sepsis, the decay of malignant tumors, etc. In some conditions, autoimmune mechanisms play a large role in damage to the liver cells. Another type of hepatic coma develops during cirrhosis as a result of blood flow from the portal vein to the inferior vena cava ("bypass") through portocaval anastomoses.

The main link in the pathogenesis of hepatic coma is the intoxication of the body with ammonium ampounds; in addition, hypostycemia, changes in the protein composition of the blood and other istrbances of homeostasis develop. During cirrhosis of the liver in the occurrence of intoxication, the anstion of toxic products from the large intestine into the blood and directly into the general bloodstream plays the main role.

Usually, signs of hepatic coma develop gradually, precomatous state can last for a long time, confused consciousness and drowsiness are suddenly replaced by psychomotor agitation. There may be signs of ritation of the cerebral cortex, edema of the brain and lungs. There are respiratory disorders and types of pathological breathing, tremors. As a result of the excretion of mercaptan, absorbed from the large intestine, through the lungs, a specific "liver odor" is felt in the exhaled air. In some cases, jaundice occurs.

***Diabetic coma*** develops as a complication of severe diabetes. Due to the development of diabetic coma on the background of elevated glucose levels, it is sometimes mistakenly called hyperglycemic coma. However, hyperglycemia is not a direct cause of coma, but an indicator of the severity of diabetes.

The occurrence of intoxication in diabetic coma is associated with the formation of a large number of ketone bodies as a result of impaired fat metabolism (ketoacidotic coma). Among them, acetylacetic acid has a particularly strong toxic effect. Sometimes a diabetic coma can develop with a relatively low level of ketonemia. In this case, the disturbance of the water-electrolyte balance plays a more significant role (hyperosmolar coma).

In a diabetic coma, the patient faints, severe dehydration (sagging dry skin, soft eyeballs), decreased Dood pressure, pathological breathing such as Kussmaul respiration are observed. There are severe disturbances in reflex activity, and exhalation is accompanied by the acetone smell.

The onset of ***hypoglycemic coma*** is associated with an acute decrease in blood glucose. Hypoglycemic coma develops as a result of the administration of a high dose of insulin, used to treat diabetes, it hypersecretion of insulin by insulinoma, a pancreatic tumor, in other endocrine disorders and liver failure. The basis of the mechanism of the pathogenetic development of hypoglycemic coma is acute energy failure of brain cells. Glucose is the main source of energy for brain cells and hypoglycemia is the cause of substrate hypoxia.

Hypoglycemic coma is characterized by general weakness, dizziness, confusion, hunger. At the same time, tremor of the fingers, cold sweat, dilated pupils are observed. As coma develops, consciousness is lost, conic convulsions appear, blood pressure decreases, breathing weakens. As a result of complications of the process, cardiac and breathing arrest may be developed.

***General principles for the correction of coma.*** The basic principle of treating of coma is carrying out measures aimed at reducing or eliminating the pathogenic effect of an etiological factor that caused it.

*Pathogenetic therapy* is aimed at eliminating hypoxia and intoxication, normalizing electrolyte and water balance. In the treatment of coma, an important condition is the elimination of disorders that arise in various physiological systems, in particular the circulatory and respiratory systems, and measures aimed at combating dangerous states such as pulmonary edema and brain edema.