REACTION OF THE BODY

Reactivity of the body (from Latin "reactio" -opposition) - is ability to react to the exogenous influence by changing of vital activity. This property is developed in the course of evolution as the highest form of irritability and has a mainly protective and adaptive nature. Reactivity - a manifestation of a biological reflection of matter, socially mediated in humans.

A well – known pathophysiologist N.Sirotinin studied the problem of the body’s reactivity for over 30 years.

Reactivity is a characteristic of all living beings. The ability of a human being or an animal to adapt to the environment, to maintain homeostasis largely depends on the reactivity. It is the reactivity that determines the occurrence and the progress of an illness. Therefore, the study of reactivity and its mechanisms is so important for understanding a disease pathogenesis and its purposeful prevention and treatment.

Different species of animals change their vital activity under endogenous influence differently; different groups of people react to the same influence in different ways, and every individual has his own peculiar ways of reacting.

The types of reactivity:

1. Species (biological).
2. Group.
3. Individual: (physiological, pathological, non-specific, specific).

Species (biological) reactivity

Species (biological) reactivity is the reactivity typical of particular species of animals. Species reactivity is aimed at preserving the species in general, and has an adaptive character.

We can cite animals’ seasonal behaviour as an example of the species’ reactivity (hibernation, migration of birds and fish, etc.), specific features of pathologic processes in different species (inflammation, fever, allergy, the response of an acute stage, etc.)

Vertebrates’ reactivity is manifested stronger and more varied than invertebrates’ reactivity. All warm–blooded species can produce special antibodies, and this ability of different species is expressed differently. In an experiment one can easily reveal the specific features of the reactions of different species to mechanic, chemical and thermal exposures, ionic radiation (dogs, guinea-pigs and people are the most sensitive, and unicellulars and worms are the least sensitive), hypoxia.

Susceptibility or unresponsiveness to infection is a vivid symptom of the species’ reactivity and resistance: dogs’ distemper and foot – and – mouth disease are not dangerous for people; tetanus is dangerous for people, monkeys and horses and it is not dangerous for cats, dogs, hedgehogs, tortoises, crocodiles; sharks are never ill with this disease and their wounds never fester; rats and mice can’t have diphtheria, dogs and cats – botulism.

Group reactivity

Group reactivity is the reactivity of separate groups of people (or animals) sharing a common sign which determines the reaction specifics of all the representatives of this group to external exposure.

Group reactivity is property of a specific group of animals or humans to react by change of vital activity to response of environmental factors. This reactivity is aimed at preserving certain group of people or animals due to protective and adaptive responses. The group was formed in the process of evolution, and during the life of animals or humans of a certain group.

Such signs are: age, sex, constitution type, race, blood group, higher nervous activity type, group of people with the same illness, etc.

E. g.: Men are often affected by such diseases as gout, spondylarthritis; pyloric stenosis, ulcer, cancer of the head of pancreas, coronarosclerosis, alcoholism; and women rather have
rheumatoid arthritis, cholelithiasis, cancer of cholecyst, myxedema, hyperthyreosis, purpura hemorrhagica; dark-skinned people are not very sensitive to ultraviolet rays. The risk of getting a peptic ulcer is as much as 35% as high for people sharing the 1st blood group, these people died more often in time of epidemics of plague; and people sharing the 2nd blood group more often get stomach cancer, a coronary disease, they are more sensitive to grippe, but they are more resistant to enteric fever.

Individuals of phlegmatic, sanguine, melancholic and choleric types respond differently to a social and emotional stress (their reactivity depends on their temperament).

Children and old people have special reactivity. This fact has resulted in the development of special branches in medicine – pediatrics and geriatrics. Any age is characterized by certain morphological and functional characteristics which determine the character of a body response to external exposures. Children under 1 month never suffer from mumps, scarlet fever, since they have received their mothers’ antibodies; newborn babies are very sensitive both to over-cooling and overheating as a result of their imperfect mechanisms of thermoregulation. They need a special diet because of morphofunctional specifics of their gastrointestinal tract and digestive glands, a special water intake schedule, due to the high intensity of their water metabolism. The period of involution is characterized by weakened protective mechanisms, limited adaptability to the environment, weakened regeneration and immune protection, hormonal reorganization. Such people are more subjected to oncological and infectious diseases.

**Individual Reactivity**

*Individual reactivity is the property of the individual to react by change of vital activity to response of adequate or extreme stimuli of the environment. Individual reactivity is aimed to preserve or restore of homeostasis and to maintain the health and save the life of the individual.*

Every human being or animal possesses a range of reactions typical of a certain group or species. Therefore, they respond to external agents changing their vital activity, in their own, particular way.

For example, some people have low resistibility to influenza, others have higher resistibility, and there are people who don’t get this disease at all, however, the virus can be found in their body (they can be virus carriers).

Individual reactivity of every organism accounts for this fact. The diseases may advance individually for every particular patient. Every case should be treated individually. A particular disease has to be treated (etiologically, pathogenetically, and symptomatically) in a particular patient considering their individual reactivity.

**Individual physiological reactivity**

*Physiological reactivity is the property of the individual to react by change of vital activity to response of adequate stimuli of the environment. This reactivity is aimed to preserve of homeostasis and maintain of the health of the individual.*

Physiological reactivity means a change of the bodily vital activities, definite forms of reaction to the influence of external agents that don’t disturb its homeostasis; it is the reactivity of a healthy person (or an animal) to non-pathogenic stimulants (e. g. adaptation to moderate physical strain, processes of thermoregulation, secretion of hormones and peptic enzymes, natural emigration of leucocytes, etc.).

**Individual pathological reactivity**

*Pathologic reactivity is the property of the individual to react by change of vital activity to response of extreme stimuli of the environment. This reactivity is aimed to restore of homeostasis and save the life of the individual.*

Pathologic reactivity manifests itself when an organism is exposed to pathogenic factors causing lesions of the body and disturbing its homeostasis.
Individual non-specific and specific reactivity

Specific reactivity is related to certain factor. Specific reactivity is the ability of an organism to respond to the influence of an antigen by producing antibodies or with a complex of cell reactions, that are specific to this antigen, i.e. it is the reactivity of the immune system (immune reactivity).

Its types are as follows: active specific immunity, allergy, autoimmune diseases, immunodeficiency and immunosuppressive conditions, immunoproliferative diseases.

Immunological tolerance is a condition of a specific immunological non-reactivity to a particular antigen caused by the previous contact with this antigen. Immune reactivity to other antigens is preserved.

Immunological tolerance is an active process when the contact with an antigen (tollerogen) causes specific elimination or inactivation of the antigen-reactive clones of lymphocytes (e.g. by means of antibody complexes) or formation of suppressor-cells inhibiting immunocompetent lymphocytes. The types of immunological tolerance are as follows: congenital or natural, acquired (immunological paralysis or high doses, small doses, drug-induced).

Runt disease (homologous disease) is conditioned by the immunological reaction of a transplant to a host. It is usually observed in case of transplanting allogenic immunocompetent lymphocytes of a donor to an adult recipient whose immune system is considerably impaired as a result of earlier roentgeno- or chemotherapy.

Non-specific reactivity.

Non-specific reactivity is related to many factors. All changes in the body occurring in response to the influence of external agents and not associated with the immune reaction, are the signs of nonspecific reactivity. For example, the changes in the body in response to the hypovolemic or traumatic shock, hypoxia, acceleration or overstrain are the signs of nonspecific reactivity. In infectious, allergic, autoimmune diseases the mechanisms of both specific (production of antibodies) and nonspecific reactivity (inflammation, fever, hypercytosis, changes of function of damaged organs and systems, etc.) are involved.

Both the whole organism and its separate systems, organs, cells may have reactivity. When an environmental agent affects the whole organism, its main regulatory systems – nervous and endocrine – get involved in response to it, when metabolism, blood circulation and respiration change, we can witness the reactivity of the whole organism. If a patient with an ischemic heart disease develops a stenocardial attack as a result of physical exertion, in this case we mainly deal with cardiac reactivity with affected coronary vessels.

Criteria of individual reactivity in disease (criteria of pathological individual reactivity):
1. Quantitative (rate of occurrence of the reaction, the amplitude, the duration of the reaction).
2. Qualitative (protective potential of the organism, its passive and active resistance).

Quantitatively is distinguished forms of reactivity:
- normergy;
- hyperergy;
- hypoergy;
- disergy.

Normal reactivity – normergy, increased – hypergy (hyper – more, ergon – act), decreased – hypoergy; perverted – disergy. The lack of reaction to any influence is called anergy. If a disease (pneumonia, tuberculosis, dysentery, etc) takes an intensive, rapid course, with clearly marked symptoms, high fever, sharp acceleration of erythrosedimentation rate, high leucocytosis, etc., the course of this disease is considered to be hyperergic. On the contrary, if the symptoms of a disease are poorly marked and the course of the disease is inactive without manifestations of the acute phase, they speak about the hypoergic course of the disease. A perverse (atypical) reaction of the
patient to a drug, vasodilation and excessive sweating at low temperatures in patients with disorders of the vegetative nervous system are the examples of disergy. Anergy is a condition when the body doesn’t respond to the presence of pathogenic microorganisms in it (carriers), or when the central nervous system is either deeply depressed or inhibited (coma, shock, anesthesia, inhibitory stage of parabiosis). The condition of immunological tolerance to an antigenic stimulus can be also classified as anergy.

Reactivity should be estimated in relation to a particular intervention. Quite often high reactivity to one agent is coupled with low reactivity to another (for example, reactivity to hypoxia and acceleration, overheating and over-cooling, to physical overstrain and starvation, reactivity to different infective agents, etc.). During prenatal development an embryo doesn’t respond to enteric fever and jail fever infection but responds to diphtheria, staphylococcus and streptococcus.

A newborn has low reactivity to hypoxia but high reactivity to overheating. Sometimes when two or several agents affect the body, it can respond only to one of them ignoring the others.

**Qualitative characteristics of reactivity:**

1. **Resistance** – basic qualitative indicator.
2. **Irritability** - a general property of all living things, defines the most basic reaction.
3. **Lability** (functional mobility) - the rate of elementary reactions.
4. **Excitability** - ability of the nervous, muscular, glandular tissues to respond to stimulation by occurrence of the excitement.
5. **Sensitivity** - The ability of the whole organism to determine the location, strength and quality of the stimulus.

**The Resistance**

Resistence is the body insusceptibility to pathogenic effects.

**Forms of resistance:**

1. Primary resistance:
   - active;
   - passive;
2. Secondary resistance;
3. Passive resistance;
4. Active resistance;
5. Specific resistance;
6. Non-specific resistance;
7. Local resistance;
8. General resistance;

The resistance of the body to pathogenic effects manifests itself in different forms: for example, skin and mucous membranes are the structures preventing the penetration of microorganisms and many poisonous agents into the body. They perform the so-called barrier function. Subcutaneous fat tissue has poor thermal conductivity, while bones and other tissues of the locomotor apparatus are characterized by high resistance to deformation under the influence of mechanical agents. These examples testify to the resistance of tissues and the whole body depending on their inherited structure and properties. This is the so-called primary resistance.

**Primary and Secondary resistance**

Primary resistance is hereditary. It is based on the morphofunctional specifics of the body owing to which an organism is resistant to the action of extreme factors (unicellular organisms and worms are resistant to radiation, cold-blooded animals – to hypothermia, etc.).

Due to hereditary immunity people are not subjected to many infections typical of animals, and in the period of epidemics of smallpox and plague some people who were directly in contact with sick people didn’t catch the infection.

Hereditary resistance (immunity in particular) may be absolute and relative.
Gonorrhea is a human disease. Animals cannot be infected with gonococcus. It is possible to infect hens with anthrax only by exposing them to cold, however, they are resistant to it in ordinary conditions.

Secondary resistance is acquired (for example, immunity develops after some infectious diseases, after the administration of vaccines and sera). Resistance to non-infectious interventions can be acquired through exercising resistance to physical exertion, to acceleration and overstrain, hypoxia, low and high temperatures, etc.

**Passive and Active resistance**

Passive resistance of the body is provided by its barrier systems (skin, mucous membranes, hematoencephalic barrier, etc.), the present bactericidal agents (hydrochloric acid in the stomach, lysozyme in the saliva) and hereditary immunity.

Active resistance is provided by the activation of its protective-adapting and compensatory mechanisms, such as production of leukocytes, phagocytosis, production of antibodies, neutralization and excretion of toxins, secretion of stress hormones, changes of blood circulation and breathing, fever, synthesis of acute phase proteins by the liver, increase of leuco- and erythropoiesis, etc.

**Reactivity and resistance relationship**

Reactivity and resistance are interrelated but not always unidirectional. For example, reactivity in breast-fed babies under 3 months is low but resistance to some infections is high as they have received some antibodies from their mothers. A newborn animal has low reactivity and high resistance to hypoxia, while in a mature animal it is opposite. In surgery anesthesia is used to reduce the patient’s reactivity and at the same time to boost their resistance to trauma. In animals which are dormant in winter reactivity is low but the resistance to many external agents is high. At the same time old people have a hypoergic course of most diseases and their resistance is low.

**Factors of individual reactivity of organism:**

1. Heredity.
2. Age.
3. Sex.
4. Life story.
5. Constitution type of the body.

Role of heredity factor in the individual reactivity: Heredity - individual reactivity factor. Human genotype determines how to respond to environmental factors - its norm of reaction. Reaction norm - is determined by genotype range of adaptive reactions of the organism - its adaptation in time and space.

Role of the age factor in the individual reactivity of organism: in process of development man from the state of infancy to adulthood - reactivity is improved (its resistance increases to various environmental factors). Persons at any age have their own morphological and functional peculiarities and the body response to external intervention depends on them. The adaptability to environmental temperature changes is weaker in newborns than in adults as a result of immaturity of their thermoregulatory system. Children aged 1 – 3 years are highly susceptible to different infections (measles, scarlet fever, whooping-cough, diphtheria) due to functional immaturity of their immune system (inability to produce the required amount of their own antibodies) and the exhaustion of antibodies received from their mothers through placenta and breast milk as well as as a result of immaturity of their barrier systems. The incidence of malignant tumors, atherosclerosis, ischemic heart disease increases in elderly people. It may be conditioned by age-specific peculiarities of the activity of regulatory systems, their rearrangement in the process of individual development. Owing to decreased function of the nervous system, weakened barrier systems as
well as ability to develop an immune reaction in senile people, the susceptibility to infections, especially to coccal bacteria, increases again.

Role of the sex factor in the individual reactivity of organism: the norm of reaction of the female body as a result of homozygosity for 23 pair of chromosomes is wider. Wide norm of reaction leads to greater life expectancy of women. Men are often affected by such diseases as myocardium infarction, coronarosclerosis, spondylarthritis, pyloric stenosis, ulcer, cancer of the head of pancreas, alcoholism. Women are often affected by such diseases as autoimmune disorders, cholelithiasis, myxedema, hyperthyroidism, purpura hemorrhagica.

History of life - individual reactivity factor of human: history of life may leave trails former biologically important stimuli of the environment. This can affect the body's reactions to a given stimulus (including the aggressor).

Constitution type of the body - individual reactivity factor. The constitution type of the body - a combination of structural, biochemical, functional characteristics of the organism of hereditary and acquired genesis affecting on its individual reactivity. This is an important internal condition that promote or hinder the emergence of the disease (with the causes of disease).

Classification of constitution type by Chernorutskii:
1. normosthenic
2. asthenic
3. hypersthenic.

Index of Pine (IP): growth (cm) - chest circumference (cm) + weight (kgs)/

IP = 10-30 - normosthenik
IP >30 - asthenik
IP < 10 – hypersthenic.

Asthenic characterized by slender body, weak development of the muscular system, dominated (as compared to normostenic) longitudinal body size and the size of the chest over the size of the stomach. High level of metabolical processes. The tendency to ptosis of the organs, stomach ulcer, severity of pulmonary tuberculosis, hypotension, pathological amenorrhea.

Normosthenic characterized by proportional body size and harmonious development of the musculoskeletal system. Predisposition to diseases of the upper respiratory tract and musculoskeletal system.

Hypersthenic characterized by long body and short limbs, a relative predominance of the transverse dimensions of the body, the size of the stomach over the size of the chest. Low metabolism. Tendency to hyperlipidemia, hyperglycemia. Predisposition to diseases of the cardiovascular system (atherosclerosis, myocardial infarction, hypertension), diabetes mellitus, obesity, gallstones.

Mechanisms of physiological reactivity:
1. Humoral mechanism.
2. Reflex mechanism (more often).
3. Neurohumoral mechanism.

Mechanisms of physiological reactivity is characterized by the formation of negative feedback.

Mechanisms of pathological reactivity:
1. Humoral mechanism.
2. Reflex mechanism.
3. Neurohumoral mechanism (more often).

Mechanisms of pathological reactivity may with negative feedback, without negative feedback, with the positive feedback.
The mechanisms of nonspecific protection:
1. The cellular: Phagocytosis is phylogenetically oldest and most stable protective and adaptive cellular response of the organism.

Phagocytic cells are:
- macrophages (alveolar, peritoneal macrophages of the liver, etc.);
- monocytes (macrophage precursors);
- neutrophil granulocytes and macrophages.

2. Humoral:
- Inhibitors of viral activity (heat-labile, thermostable);
- Complement system - heat-labile enzyme system;
- Lysozyme (muramidase);
- Properdin - high molecular weight protein that provides antibacterial, hemolytic, antiviral property of serum;
- Leukins - thermostable antibacterial factors which are able to inactivate gram (+) bacteria;
- Interferons - having antiviral activity.

American psychophysiologist and physiologist Walter Cannon (1871-1942) emphasized the importance of sympathetic nervous system in the development of protective and compensatory mechanisms.

L.A. Orbeli in 1935 formulated the theory about the adaptive-trophic role of the sympathetic nervous system. It has been shown that the damaging effects it is through the sympathetic nervous system activates the higher parts of the central nervous system, there is a mobilization of energy, stimulates the cardiovascular system, increasing efficiency of muscles are activated immunological mechanisms and other processes.

Great contribution to the study of stress brought Canadian pathologist Hans Selye. Selye merit is that he investigated in detail and showed a critical role in the development of the general adaptation syndrome, pituitary-adrenal axis.

Damaging factors when acting on the body caused by two types of reactions: specific, related to the quality of the factors and non-specific, general. This set of characteristics, stereotypical general response of the body to the action of stimuli of various nature is called "stress" or "general adaptation syndrome." Such reactions are primarily the protective and aimed at adaptation of the body to the new conditions, the alignment of the changes that are caused by damaging factors.

Stress is the nonspecific response of the body that occurs under the influence of various extreme factors that threaten the disruption of homeostasis, and is characterized by stereotypical changes in the nervous and endocrine systems.

Irritant causing a stressful situation, called a stressor.

Stressor in origin may be of any factor.

The damaging effect of a stressor depends on the intensity (power), and the duration or frequency of its impact.

Selye noted that despite the variety of stressors, they all lead to the same changes in the thymus, adrenal glands, lymph nodes, blood composition and metabolism. In experiments on rats, he observed the typical triad:
1. Hypertrophy of the adrenal cortex.
2. Involution lymphoid system (thymus).
3. Hemorrhage in the mucosa of the stomach and duodenum.

General adaptation syndrome, according to Selye, in its development goes through three stages:
1. First stage - "alarm reaction".
2. Second stage - stage of resistance.
3. Third stage of the adaptation syndrome - the stage of exhaustion.

First stage: Antihock phase is characterized by changes in the opposite direction (increased blood pressure, muscle tone, blood glucose), leading to the development of the next stage - the stage
of resistance. The main pathogenetic link of antyshok phase - is a persistent increased secretion of corticotropin and corticosteroids.

**Second stage.** In the second stage, the stage of resistance - developed hypertrophy of the adrenal cortex with a steady increase in the formation and secretion of corticosteroids. They increase the amount of circulating blood, increases blood pressure, have an antihistamine effect, increase gluconeogenesis. These effects are related both to the direct action of corticosteroids, and to a large extent with the ability to activate the effects of the sympathetic nervous system and its adaptive-trophic influence. At this stage usually increases the body's resistance to the action of some of extraordinary stimuli, although there are cases increase of sensitivity. If the action of the stressor stops or it is insignificantly, the changes caused by them, gradually normalized.

**Third stage.** If the effect of the pathogenic factor is extremely strong and lengthy develop depletion of adrenocortical function and death of the organism occurs. This third stage of the adaptation syndrome - the stage of exhaustion.

**Pathogenesis of stress**

The impact of the stressor

Central and peripheral nervous system

Hypothalamus

Pituitary

Adrenal cortex

Thyroid gland

catecholamines, glucocorticoid, thyroxine, glucagon, TSH, stress limiting factors and others

- ↑ blood pressure, metabolism stimulation, CNS stimulation;
- Gluconeogenesis, the involution of the thymus, lymph nodes, inhibition of inflammation, immune responses, development of gastrointestinal ulcers;
- limit the damaging effects of glucocorticoids and catecholamines.

**Adaptive effects of glucocorticoids to the stress exposure:**
- Mobilization of energy resources.
- The delay Na (↑ blood volume) - ↑ blood pressure.
- ↑ sympathetic influences (↑ blood pressure, ↑ cardiac output, ↓ blood flow to the kidneys, ↓ peripheral blood flow).
- A powerful anti-inflammatory effect.
- Activate erythropoiesis neutropoiesis, thrombocytopenia, ↓ eosinophils and lymphocytes (on the periphery).

**Adaptive effects of catecholamines to the stress exposure:**
- Acceleration and increased of cardiac activity.
- Regulation of blood pressure (noradrenaline).
- Centralization of blood flow.
- Dilation of coronary vessels (epinephrine).
- ↑ rate and depth of breathing, bronchodilation.
- Stimulation of lipolysis.
- Mobilization of psychic activity.
- Blunting of pain.

**Functional system of preservation of life (FSPL)** is set of all hereditary and acquired adaptive reactions (protective, compensatory, homeostatic), emerging in response to the emergency
(damaging) stimulus (the aggressor) of the environment - causes of the disease. Formation of FSPL goes through the individual reactivity factors (heredity, age, sex, history of life, the constitution). They create the initial functional state of regulatory and executive body systems.

**Example embodiments of forming the results of the response FSPL:**

1. Absolutely optimal functional system of preservation of life with negative feedback (favorable outcome of the general stress, the favorable outcome of the meeting with the pathogens) - the disease does not occur.
2. Optimal functional system of preservation of life with negative feedback (illness with complete recovery).
3. Relatively optimal functional system of preservation of life with negative feedback (a disease with a chronic course, with incomplete recovery).
4. Nonoptimal functional system of preservation of life without negative feedback (sudden death in acute pneumonia, acute myocardial infarction, etc.).
5. Nonoptimal functional system of preservation of life with positive feedback (severe course of the disease with complications - infections sepsis, severe mechanical trauma with traumatic shock of II - III stages, etc.). Possible death.