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Causes of Cell Damage

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Abstract: This paper examines cell damage resulting from pathogenic factors, including physical, chemical, and biological damage. It also examines factors in immune and allergic processes related to antigen similarity. The origins of all cell damage factors, including exogenous and endogenous factors, as well as infectious and non-infectious origins, are explored.

Key words: pathogenic factor, cell, immune, allergic, process, antigen, exogen, endogen, infectious, non-infectious, genesis, organ, tissue, function.

The cell is the structural and functional unit of tissues and organs. It is within the cell that processes occur that underlie the energy and plasticity of tissue structure and function.

Various pathogenic factors acting on a cell can cause damage. Cell damage refers to changes in its structure, metabolism, physicochemical properties, and functions that lead to disruption of vital functions.

Often the process of damage is described by the term alteration, which is not entirely accurate, since alteratio is translated as change, deviation and is thus a broader concept.

Cell damage can result from exposure to a variety of pathogenic factors. These are conventionally divided into three main groups: physical, chemical, and biological. Among physical factors, the most common causes of cell damage are the following [1-2]:

- mechanical effects. They cause disruption of the structure of the plasma membrane and the membranes of subcellular structures;
- Temperature fluctuations. Elevated cell temperatures, up to 45-50 °°C or more, can lead to protein and nucleic acid denaturation, decomposition of lipoprotein complexes, increased membrane permeability, and other changes. A significant decrease in temperature can cause a significant slowdown or irreversible cessation of metabolic processes in the cell, crystallization of intracellular fluid, and membrane rupture.
- changes in osmotic pressure within the cell, particularly due to the accumulation of products of incomplete oxidation of organic substrates, as well as excess ions. The latter is typically accompanied by a flow of fluid into the cell along the osmotic pressure gradient, swelling, and stretching (even to the point of rupture) of its plasma membrane and organelle membranes. A decrease in intracellular osmotic pressure or an increase in it in the extracellular environment leads to fluid loss by the cell, its shrinkage (pyknosis), and often death;
- exposure to ionizing radiation, which causes the formation of free radicals and the activation of peroxidative free-radical processes, the products of which damage membranes and denature cellular enzymes. Gravitational, electromagnetic, and other physical factors can also have a pathogenic effect on cells.

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Cell damage is often caused by chemical factors. These include a variety of substances of exogenous and endogenous origin, including organic acids, alkalis, heavy metal salts, and metabolic waste products.

Thus, cyanides suppress cytochrome oxidase activity . Ethanol and its metabolites inhibit many cellular enzymes. Substances containing arsenic salts inhibit pyruvate oxidase . Incorrect use of medications can also lead to cell damage.

For example, an overdose of strophanthin significantly suppresses the activity of the K +-Na + -ATPase in the sarcolemma of myocardial cells, leading to an imbalance in intracellular ion and fluid levels. Importantly, cellular damage can be caused by both an excess and a deficiency of the same factor. For example, excess oxygen in tissues activates lipid peroxidation (LP), the products of which damage enzymes and cell membranes.

On the other hand, a decrease in oxygen levels leads to a disruption of oxidative processes, a decrease in ATP production, and, consequently, to cellular dysfunction. Biological factors, such as viruses, rickettsia, microbes, parasites, and fungi, are common causes of cell damage. Their metabolic products disrupt cellular function, impair metabolic reactions, membrane permeability , or even integrity, and inhibit the activity of cellular enzymes.

Cell damage is often caused by factors of immune and allergic processes. These can be caused, in particular, by the similarity of antigens, for example, between microbes and the body's cells. Damage can also result from the formation of antibodies or T-lymphocytes acting against the body's normal cells due to mutations in the heme. B or T lymphocytes of the immune system.

Substances entering the cell from neuronal endings, particularly neurotransmitters , trophogens , and neuropeptides , play an important role in maintaining metabolic processes in the cell. A reduction or cessation of their transport causes metabolic disorders in cells , disruption of their vital functions, and the development of pathological conditions known as neurodystrophies .

In addition to the factors mentioned above, cell damage is often caused by significantly increased organ and tissue function. For example, prolonged excessive physical exertion can lead to heart failure due to impaired cardiomyocyte function .

Cell damage can result not only from pathogenic factors but also from genetically programmed processes. Examples include the death of the epidermis, intestinal epithelium, red blood cells, and other cells as a result of their aging process. The mechanisms of aging and cell death include gradual, irreversible changes in the structure of membranes, enzymes, and nucleic acids, depletion of metabolic substrates, and decreased cellular resistance to pathogenic influences.

By origin, all causal factors of cell damage are divided into :

1) exogenous and endogenous;

2) infectious and non-infectious genesis.

Damaging factors act on cells either directly or indirectly. In the latter case, a chain of secondary reactions is initiated, producing intermediary substances that mediate the damaging effect.

The action of a damaging agent can be mediated through :

- changes in nervous or endocrine effects on cells (for example, during stress, shock);
- systemic circulatory disorder (in case of heart failure);
- deviation of physicochemical parameters (in conditions accompanied by acidosis, alkalosis, formation of free radicals, PSO products, imbalance of ions and fluid);
- immunoallergic reactions in autoallergic diseases;
- formation of excess or deficiency of biologically active substances (histamine, kinins , prostaclandins).

Many of these and other compounds involved in the development of pathological processes are called intermediaries (for example, mediators of inflammation, allergies, carcinogenesis, etc.).

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