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MINERAL BALANCE AND ITS ROLE IN THE DEVELOPMENT OF ONCOLOGICAL DISEASES

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Abstract
Oncological diseases represent one of the most complex problems in modern medicine and genetic, environmental, lifestyle, dietary factors play an important role in their development. In recent years, the role of mineral metabolism in the body regarding the development and course of oncological diseases has been widely studied. Minerals participate in cellular metabolism, enzyme activity, DNA synthesis and repair, immune system functioning, and antioxidant defense mechanisms. Their deficiency or excessive accumulation can lead to disruption of cellular function and an increase in oxidative stress. Based on scientific data, this article is discussed about the biological mechanisms of essential minerals, such as calcium, magnesium, zinc, selenium, iron, copper, and iodine, in the emergence and development of oncological diseases.

Keywords: Oncological diseases, minerals, trace elements, oxidative stress, DNA repair, immunity, zinc, selenium, magnesium, iron.

Introduction

Oncological diseases belong to a group of illnesses that pose a serious threat to human health worldwide. Every year, millions of new oncological cases are recorded, making oncological diseases a major cause of death in many countries. The development of oncological diseases is a complex, multi-stage process where

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damage to the cellular genetic apparatus, uncontrolled proliferation, disruption of the process, and weakening of immune control serve as the primary mechanisms. Although hereditary factors are important in the etiology of oncological diseases, environmental and dietary factors also carry great significance. The body's supply of nutrients, especially the amount of vitamins and minerals, is one of the necessary conditions for the normal functioning of cells. Although minerals are required in small amounts, they participate in vitally important biological processes.

Mineral substances participate in the body as the active center of enzymes, in transmitting intracellular signals, regulating energy metabolism, and forming the antioxidant system. Therefore, their deficiency can diminish the protective capabilities of cells and create favorable conditions for the development of oncological diseases.

Oxidative stress is considered one of the primary mechanisms of the development of oncological diseases. Free radicals damage DNA molecules, inducing gene mutations. Minerals such as selenium, zinc, and magnesium contribute to preventing these processes by participating in the activity of antioxidant enzymes. At the same time, excessive amounts of elements like iron and copper can exacerbate oxidative stress.

Currently, the disruption of mineral metabolism is viewed as a factor affecting not only the development of oncological diseases but also their treatment process and the patient's general condition. Therefore, studying mineral levels remains one of the directions for prevention and supportive therapy in oncology.

Mineral substances participate in numerous physiological and biochemical processes in the body. They are essential for cell growth, division, differentiation, energy metabolism, and maintaining the stability of genetic material. Changes in the amount of mineral elements affect intracellular metabolic processes, which can accelerate or slow down certain stages of tumor development.

One of the primary pathogenic factors in the development of oncological diseases is increased oxidative stress in cells. Free radicals damage DNA, proteins, and cell membranes. As a result, genetic mutations accumulate, increasing the

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likelihood of normal cells transforming into tumor cells. Minerals with antioxidant properties play an important role in limiting these processes.

In the human body, magnesium is one of the most important macroelements, participating in more than 300 enzymatic reactions. It plays a vital role in regulating energy metabolism, protein synthesis, DNA replication, and cell division. Magnesium is involved in ensuring the stability of the DNA molecule. Its deficiency can disrupt DNA repair processes, leading to the accumulation of genetic errors. Furthermore, magnesium deficiency exacerbates inflammatory processes and weakens immune system activity.

Epidemiological studies have shown that individuals with low magnesium levels face an increased risk of developing certain types of oncological diseases, especially colorectal cancer. Adequate levels of magnesium help maintain normal cell cycle regulation and can limit uncontrolled cell proliferation.

Another essential trace element for the body is zinc (Zn), which is crucial for regulating the immune system, antioxidant defense, and gene expression. Zinc is a component of many enzymes and proteins. One of the primary biological functions of zinc is participating in DNA protection and repair processes. As a result of zinc deficiency, oxidative stress increases, DNA damage escalates, and normal cellular functioning is disrupted.

Patients with oncological diseases often exhibit decreased levels of zinc in their blood. Studies have detected reduced zinc levels in patients suffering from prostate, breast, gastric, and lung cancers. Zinc also regulates the functioning of the immune system. It supports the activity of T-lymphocytes and natural killer cells, which are involved in detecting and destroying malignant cells that emerge in the body.

The next trace element with powerful antioxidant properties is selenium (Se). It is a structural component of antioxidant enzymes such as glutathione peroxidase, protecting cells from the harmful effects of free radicals. The anti-oncogenic effect of selenium is realized through several mechanisms:

- Decreasing oxidative stress
- Preventing DNA damage
- Enhancing the immune response

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- Stimulating apoptosis in tumor cells
- Limiting angiogenesis

Some studies have observed that individuals with higher selenium levels have a relatively lower risk of prostate, lung, and colorectal cancers. However, taking high doses of selenium supplements is not always beneficial. Therefore, the use of selenium preparations requires an individual approach.

Iron is also an essential element for the body, participating in hemoglobin formation, oxygen transport, and cellular respiration processes. At the same time, excessive accumulation of iron can adversely affect the development of oncological diseases. Iron ions enhance the formation of free radicals, which leads to DNA damage and the emergence of mutations. Disruption of iron metabolism can be linked to tumor development in the liver, intestines, and other organs.

In oncology patients, conversely, iron deficiency is commonly observed. This condition can be associated with chronic inflammation, blood loss, dietary disruptions, and therapeutic modalities. Iron deficiency causes anemia, thereby reducing the patient's quality of life.

Copper (Cu) participates in cellular metabolism, enzyme activity, and the process of blood vessel formation. Angiogenesis is a critical stage in tumor progression because new blood vessels supply the tumor with oxygen and nutrients. Elevated copper levels are observed in many malignant tumors. High copper levels can support tumor cell proliferation and metastatic processes. Currently, therapeutic approaches aimed at controlling copper metabolism are being investigated in scientific research. Copper-depleting agents represent a promising direction as adjuvant therapy in certain tumor types.

Iodine is a trace element essential for the production of thyroid hormones. These hormones regulate body metabolism, growth, and development processes. Iodine deficiency can lead to thyroid dysfunction, goiter development, and, in some cases, an increased risk of thyroid tumors. The utilization of iodized table salt is one of the effective preventive methods to reduce iodine deficiency and prevent thyroid diseases among the population.

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During the progression of an oncological disease, the general metabolic status of the body changes significantly. Tumor cells require large amounts of energy and nutrients to proliferate rapidly. Therefore, the oncological process also influences mineral metabolism. The duration of the disease, tumor localization, the patient's nutritional status, and the applied treatment methods can cause changes in mineral element levels.

During chemotherapy and radiotherapy, patients experience nausea, decreased appetite, intestinal dysfunction, and reduced nutrient absorption. Consequently, deficiencies in essential elements such as magnesium, zinc, selenium, and iron can develop. This condition leads to a decline in immune system function, exacerbation of fatigue syndrome, and a slowdown in the patient's recovery process. Mineral deficiency also adversely affects the function of immune cells that fight oncological diseases. For instance, zinc and selenium are necessary for the normal functioning of the immune system, and their reduction can lower the body's protective capabilities against tumor cells.

Therefore, evaluating the nutritional status of patients and controlling mineral balance is an important component of comprehensive treatment in modern oncology. However, recommending mineral supplements equally to all patients is not scientifically justified. The mineral level in each patient must be evaluated based on laboratory tests.

To evaluate the mineral status in oncology patients, blood biochemical analyses, methods for determining the amount of trace elements, and studying the patient's nutritional status are utilized. In certain cases, the following conditions may be observed:

- **Magnesium deficiency** – can lead to muscle weakness, cardiac dysfunction, and general lethargy.
- **Zinc deficiency** – reduces immunity, slows wound healing, and increases susceptibility to infections.
- **Selenium deficiency** – causes a weakening of antioxidant defense.
- **Iron deficiency** – induces anemia and chronic fatigue.
- **Copper excess** – can enhance angiogenesis and metastatic processes in certain tumors.

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Therefore, controlling the level of mineral substances is of great importance not only in the prevention of oncological diseases but also during the treatment process.

Studying the relationship between minerals and oncological diseases is one of the promising directions in modern medicine.

Mineral substances are among the key components regulating vital biological processes in the human body. They play an important role in cellular metabolism, DNA stability, antioxidant defense, immune system functioning, and normal cellular development.

Scientific research demonstrates that disruptions in mineral balance can be one of the factors influencing the development and course of oncological diseases. Adequate amounts of elements such as zinc, selenium, and magnesium help protect cells from oxidative stress. At the same time, the excessive accumulation of elements like iron and copper can activate mechanisms that stimulate tumor development. Controlling mineral metabolism, eliminating identified deficiencies, and improving nutritional status in oncology patients represent important supportive directions that help increase treatment efficacy. However, the uncontrolled intake of mineral preparations is not recommended. Mineral supplements should be prescribed only based on clinical indications and laboratory test results.

In general, a deep study of the correlation between mineral levels and oncological diseases holds significant scientific value in improving prevention, early diagnosis, and comprehensive treatment strategies for oncological diseases.

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