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In-depth analysis and outlook on the effect of selenium on cancer

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Abstract:

This study focuses on the relationship between selenium and cancer, and analyzes the mechanism of selenium in the occurrence, development, prevention and treatment of cancer, including its antioxidant, immunomodulatory and other functions on cancer, through the existing literature research and rational thinking. It is found that selenium deficiency increases the risk of cancer, and moderate selenium supplementation has positive significance in cancer prevention and treatment, but the effects of long-term supplementation with different doses of selenium have yet to be clarified. The study aims to provide a theoretical basis for cancer prevention and treatment, help optimize clinical intervention strategies, and promote the development of selenium in cancer research.

Keywords: Selenium, Cancer, Antioxidant, Preventive therapy, Dose effect, Mechanism of action

1. Background of the study

Cancer, as a major disease that poses a serious threat to human health, has always been the focus of research in the fields of medicine and life sciences. In recent years, more and more studies have shown that trace elements play an important role in the occurrence, development and prevention of cancer.

As an essential trace element, selenium plays an indispensable role in life activities. Since its discovery in 1817, its research in the field of health and disease has been expanding [5]. Selenium has an atomic number of 34 and is located in the oxygen group of the periodic table, between sulfur (S) and tellurium (Te), and this unique position gives it special chemical properties . In the human body, selenium is involved in numerous physiological processes and is significant in maintaining normal body functions.

A large number of experimental studies have confirmed that selenium is closely related to the occurrence of many types of cancer. Selenium has a protective effect on many types of cancer, including lung cancer and liver cancer, and has demonstrated strong anti-cancer effects in a number of clinical trials. At the same time, selenium also has a good preventive and therapeutic effect on more than forty diseases such as heart disease, age-related and pancreatic diseases, hypertension, diabetes and anemia [10].

Domestic research on selenium has been increasingly emphasized. Studies have shown that selenium is an important component of most enzymes and proteins in biological organisms, and has biological functions such as improving detoxification and detoxification, boosting immunity, preventing cancer, protecting and repairing nutrient cells, anti-aging, and increasing the oxygen-carrying capacity of red blood cells . Selenium has a strong influence on the development

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of cancer risk, which is mainly related to the limitation of antioxidant protection (glutathione peroxidase GSH-PX) and redox regulation (TRS) in the organism. For example, animal skin GSH - PX activity is negatively correlated with skin carcinogenesis due to UV irradiation or fopperolipids [11]. In addition, when the organism is deficient in selenium, it may lead to oxidative damage to the viral genome, which in turn induces mutations that enhance viral pathogenicity. On the contrary, the replication of certain viruses may be effectively prevented by selenium supplementation, thus modulating the pathological process of viral diseases [1].

Foreign scholars have also been fruitful in selenium research. In recent years, the correlation between bottom selenium levels and cancer occurrence has attracted widespread attention. According to Schrauzer's statistics, populations in 27 countries around the world have shown that selenium is inversely related to cancer incidence [2]. At the same time the same conclusion has been reached in other countries and the parameters of selenium levels are negatively level correlated with risk factors for cancer of the brain, ovary, bladder, lung, head and neck, stomach, cancer of the pancreas, thyroid, esophagus, melanoma, prostate, and colon, and pre-cancerous damage. Mechanistically, selenium supplementation not only antagonizes PAF activation but also restores selenium binding protein 1 (SELENBP1) levels, and the selenium - SELENBP1 axis becomes a potentially important target for the prevention of related diseases [3].

However, existing research on selenium remains problematic. Research suggests that there may be a "U-shaped" association between selenium levels and health effects, i.e., either high or low blood selenium levels may trigger adverse health outcomes. Currently, most studies on selenium supplementation have focused on higher doses (≥ 200 μg/d), and fewer studies have examined the relationship between long-term selenium supplementation at different doses and the risk of death [9]. An in-depth exploration of these issues is important for a comprehensive understanding of the relationship between selenium and cancer, and for promoting cancer prevention and treatment research.

2. Significance of the study

2.1 Theoretical implications

In-depth study of the effects of selenium on cancer can help to reveal the complex mechanisms of selenium's role in human physiological processes, especially in cancer-related cell signaling pathways, redox balance regulation, and gene expression regulation [11]. Studying the association of PTMs (post-translational modifications of proteins) of Sp1 with selenium can provide further insight into the mechanisms by which cell signaling pathways regulate the stability of Sp1 and the regulatory mechanisms by which Sp1 affects cancer progression [12]. This not only enriches the theoretical system of the relationship between trace elements and cancer, but also provides a new perspective for the study of the molecular mechanism of cancer development and promotes the continuous improvement of theories in related fields.

2.2 Practical implications

The results of this study can provide a scientific basis for cancer prevention and treatment, and guide people to consume appropriate amount of selenium through rational diet or nutritional supplements to reduce the risk of cancer incidence. For cancer patients, it can help doctors formulate more accurate comprehensive treatment plans, such as reasonable supplementation of selenium during chemotherapy and radiotherapy, to enhance the therapeutic effect, reduce the side effects of treatment, and improve the quality of life and survival rate of patients. In addition, the research results can also provide reference for the development of new anti-cancer drugs and biomarkers, and promote the innovation and development of cancer prevention and treatment technologies.

3. Research methodology

3.1 Research ideas

Based on the literature study, this study extensively collects research literature on the relationship between selenium and cancer at home and abroad, comprehensively combs through the current research status, and analyzes the strengths and weaknesses of the existing research. Using the rational thinking method, the specific role of selenium on the pathological mechanism of cancer is explored in depth based on the literature, and the effects of existing interventions and treatment measures are summarized systematically. Through comprehensive analysis, research conclusions are drawn and future research directions are envisioned to provide reference for subsequent research.

3.2 Research process

The study is expected to last five months. In the first two months, we will focus on literature review and collect relevant research materials through academic databases and websites of professional journals. While reviewing the literature, the preface of the paper was written simultaneously to describe the background, purpose and significance of the study. In the next month, the collected literature was

systematically organized and thoroughly analyzed to sort out the relationship between selenium and cancer and extract the key information. During the process of organizing and analyzing, the results section of the paper will be written to present the research findings. After the analysis is completed, we will integrate the completed parts of the paper, write the discussion, conclusion and other remaining contents to complete the overall creation of the paper.

3.3 Research methodology

Using domestic and international academic databases such as Web of Science, PubMed, and China Knowledge, we collected relevant literature in the past 20 years, including journal articles, dissertations, research reports, etc., using the keywords of "selenium", "cancer", "selenium deficiency", "selenium supplementation", and so on. "selenium supplementation" as the keywords, we collected relevant literature in the past 20 years, including journal articles, dissertations, research reports, and so on. The collected literature was screened and sorted according to research topics, research methods, and research conclusions to systematically analyze the current status, progress, and problems of research on the relationship between selenium and cancer. Using the rational thinking method, based on the findings of the literature, in-depth consideration was given to the mechanism of selenium's role in the process of cancer occurrence, development, prevention and treatment [4-8]. To explore how selenium affects cancer development through antioxidant protection, redox regulation, immunomodulation and other pathways from multidisciplinary perspectives such as molecular biology, cell biology, immunology, etc. [11]. Logical reasoning and theoretical analysis of the differences in the effects of different doses of selenium supplementation and the synergistic effects of selenium applied in combination with other therapeutic means were carried out to construct a theoretical framework for the relationship between selenium and cancer .

4. Findings

4.1 Selenium deficiency and cancer risk

Selenium deficiency significantly increases the risk of cancer development. In terms of antioxidant protection, selenium is an important component of GSH - PX, and when selenium is deficient it affects GSH - PX activity, making it ineffective in scavenging excess free radicals in cells [6]. A large accumulation of free radicals attacks intracellular biomolecules such as DNA, proteins, and lipids, leading to DNA damage, gene mutations, and abnormal cellular function, which in turn increases the likelihood of cancer development. It was found that skin carcinogenesis induced by UV irradiation or fopperolipids was negatively correlated with animal skin GSH - PX activity, which fully demonstrates the key role of selenium in the antioxidant defense system .

Imbalanced redox regulation is also an important mechanism by which selenium deficiency increases cancer risk [11]. Selenium is involved in the regulation of several redox reactions in the body and helps maintain intracellular redox homeostasis. When selenium is deficient, redox regulatory mechanisms are impaired, leading to increased levels of intracellular oxidative stress, which in turn interferes with normal cellular metabolism, proliferation and apoptotic processes. Oxidative stress also activates a series of cell signaling pathways, such as NF-κB pathway and MAPK pathway, which are closely related to the development of cancer. In addition, selenium deficiency induces oxidative damage to viral genomes, contributing to pathogenic mutations in viruses, thereby increasing the risk of virus-induced cellular carcinogenesis.

4.2 Role of selenium in cancer prevention

Selenium plays an important role in cancer prevention. On the one hand, selenium can activate immune cells and enhance the body's immunity, such as T-lymphocytes and B-lymphocytes, to enhance the body's ability to recognize and remove cancer cells. Selenium is also able to influence the function of immune cells, promote the secretion of cytokines, and enhance the immune response, thus effectively preventing the occurrence of cancer [6]. On the other hand, the antioxidant properties of selenium enable it to protect cells from free radical damage and maintain normal cell structure and function . Selenium can reduce the oxidative damage of free radicals to cell membranes, DNA and proteins by directly scavenging free radicals or participating in the synthesis of antioxidant enzymes, reducing the risk of cellular carcinogenesis .

Selenium may also play a role in cancer prevention through mechanisms such as regulating the cell cycle and inducing apoptosis in cancer cells [2]. Studies have shown that selenium has the ability to modulate the expression of related proteins (cell cycle protein-dependent kinase CDK) and (cell cycle protein Cyclin), thereby inducing cancer cells to arrest at specific cell cycle stages and thus inhibiting their proliferation. In addition, selenium can activate apoptosis-related signaling pathways in cells, including the mitochondrial pathway and the death receptor pathway, thereby inducing apoptosis in cancer cells and achieving cancer prevention.

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4.3 Selenium and cancer treatment

Selenium has potential application value in cancer treatment. Adequate supplementation of selenium can not only change the efficacy and toxic side effects of chemotherapeutic drugs, but also improve the sensitivity of the body to chemotherapeutic drugs, making cancer cells more susceptible to attack by chemotherapeutic drugs. It has been found that selenium can regulate the expression of drug resistance-related proteins in cancer cells, reduce the drug resistance of cancer cells and improve the effect of chemotherapy. Selenium can also protect normal cells from damage caused by chemotherapeutic drugs, reduce chemotherapy-induced side effects such as bone marrow suppression and gastrointestinal reactions, and improve the quality of life of patients .

However, there is a lack of clarity regarding the optimal regimen for different doses of selenium in cancer treatment . Most of the available studies have used larger doses of selenium (≥ 200μg/d) for supplementation, and there is a lack of in-depth research on the safety and efficacy of long-term selenium supplementation at different doses. Selenium levels have a “U-shaped” relationship with health effects, and excessive doses of selenium may have toxic effects and pose a risk to human health. Therefore, determining the appropriate dose and duration of selenium supplementation is a key issue in the application of selenium in cancer treatment.

4.4 Current status of research on different doses of selenium supplementation

Currently, most studies have examined high doses (≥ 200 μg/d) of selenium, and fewer have examined the relationship between long-term selenium supplementation at different doses and the risk of death [9]. Studies related to selenium levels have shown that either high or low blood selenium levels may lead to adverse health effects [8]. Low selenium status increases the risk of many diseases such as cancer, while high selenium status may cause selenotoxicity with symptoms such as hair loss, nail deformities, nausea, and vomiting .

The requirement and tolerance of selenium varies in different populations, such as age, gender, genetic factors, and health status, which affect the metabolism and utilization of selenium in the human body [8]. Therefore, it is crucial to develop a personalized selenium supplementation program . More large-scale, long-term clinical studies are needed in the future to thoroughly investigate the safety and efficacy of long-term selenium supplementation at different doses, and to determine the optimal selenium supplementation doses and modalities suitable for different populations.

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