EPIGENETIC MECHANISMS OF BREASTFEEDING IN IMMUNE SYSTEM DEVELOPMENT

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ABSTRACT:

The immune system undergoes a crucial developmental stage in the early stages of life. In this process, breast milk plays a particularly significant role not only with its nutritional and protective functions but also with its epigenetic effects. Our research analyzes how bioactive components in breast milk (microRNAs, molecules affecting DNA methylation, factors controlling histone modification) perform epigenetic regulation through the differentiation and expression of immune cells. This article focuses on analyzing the impact of breast milk on immunogenesis from an epigenetic perspective, proposing new scientific approaches that prove the importance of early feeding in the development of the immune system.

Keywords: breast milk, epigenetics, immune system, DNA methylation, histone modification, microRNA, neonatal development

INTRODUCTION

The development of the immune system occurs intensively in the postpartum period. A newborn cannot fully respond to external microbiological factors. Therefore, immunologically active components in breast milk (immunoglobulins, cytokines, lactoferrin, oligosaccharides, microRNAs) are the main means of strengthening the immune status of the child's body.

Recent epigenetic studies show that breast milk not only delivers immunocomponents but also regulates the immune system through epigenetic modifications. These include changes in DNA methylation, histone modification, and microRNA expression. This article examines the role of epigenetic mechanisms in immune development through breast milk in a deep scientific way.

METHODOLOGY

This article was prepared on the basis of a theoretical and analytical approach, which includes the following steps:

1. Analytical Literature Review - The epigenetic mechanisms of breast milk were studied based on scientific articles and meta-analyses related to epigenetics, immunology, and neonatology published between 2010 and 2024.

2. Types of Epigenetic Mechanisms - DNA methylation, histone modification, and microRNA regulation were studied separately, and their effect on immune system genes was clarified.

3. Role of Biomolecules - The epigenetic activating potential of microRNAs, SCFA (short-chain fatty acids), vitamins, and oligosaccharides in breast milk was evaluated.

4. Development of Immune System Cells - The epigenetic effect of components in breast milk on the formation of T- and B-lymphocytes, macrophages, and NK-cells was analyzed.

5. Clinical Observations and Experimental Evidence - Epigenetic factors were evaluated based on immune responses observed in infants, reduced allergies, and the level of resistance to infectious diseases.

RESULTS AND ANALYSIS

1. DNA Methylation and Immune Gene Expression

DNA methylation is the main epigenetic mechanism that suppresses gene expression. Vitamin B9 (folate) and methyl donors in breast milk regulate the expression of immune genes (e.g., FOXP3, IL-10) by increasing the activity of DNA methyltransferase enzymes. This, in turn, promotes the formation of T-regulatory cells and prevents allergic diseases.

2. Nuclear Control through Histone Modification

Short-chain fatty acids such as butyrate in breast milk promote histone acetylation, keeping genes in an active state. This is especially important in controlling the expression of inflammation-related genes such as IL-6, TNF-α, helping to maintain an anti-inflammatory balance.

3. MicroRNAs and Cellular Differentiation

More than 1400 types of microRNAs have been identified in breast milk, most of which are involved in the regulation of genes related to the immune system. For example, miR-155 and miR-146a affect the function and differentiation of T lymphocytes. These microRNAs ensure the formation of immune memory in the infant's body and a stable response against infections.

4. Immunological Plasticity and Programming

The epigenetic signal transmitted through breast milk at an early stage creates a permanent "epigenetic programming" in the infant's immune system. As a result, the child's immune system becomes adaptable and resistant to various diseases (asthma, diabetes, allergies).

CONCLUSION

Studies show that breastfeeding has a profound effect on the development of the infant's immune system, not only physiologically but also molecularly and epigenetically. Through DNA methylation, histone modification, and microRNAs, the gene expression and differentiation of immune cells are controlled. These

processes ensure the stable and effective formation of immunogenesis, protecting the infant from infections and preventing autoimmune and allergic diseases that may occur in the future.

Therefore, breastfeeding should be seen not only as a process that meets nutritional needs but also as a natural mechanism of epigenetic programming. This approach creates an important scientific and practical basis for raising a healthy generation.

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