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Role of Nutrition in Developing Immunity in Infants

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Abstract

Every newborn has an immature immune system at birth. However, in utero, the passive transfer of immunity from the mother provides some protection. The nutrition that is provided to the infant plays a vital role in the development of active immunity. The neutrophilic responses, T and B lymphocytic maturation, and other peptides that are required to protect against any disease can be altered based on the nutritional consumption. Every nutrient plays a specific role in aiding maturation of the various aspects involved in the immune response. Hence, it is extremely important to understand and provide all the required nutrients, so that optimal immune system development can occur.

Key Words: Nutrition, immunity, antibodies, antimicrobial peptides, T and B lymphocytes, immune function, protection

Introduction

At birth, the immune system is quite immature, despite the neonate having over 1600 genes that support the innate and acquired immunity.[1] Maternal immunity is naturally transferred to the neonate to protect him/her in the initial stages of life. Immunity obtained from the mother is referred to as passive immunity, which is generally adequate to protect the neonate during the early days of life. However, as the neonate grows, his/her body develops immune mechanisms that protect the body throughout the life. It is essential to understand various factors that affect the development and response of the immune system.

Immunity at Birth

During the last trimester of pregnancy, the fetus receives maternal nutrients as well as antibodies through the placenta. The functioning of innate immune cells, neutrophils, macrophages, and dendritic cells is weak at birth, although they develop in the later stages of fetal development.[1] By 2 to 3 months of age, the levels of the antibodies begin to drop and the neonate's immune system starts to develop.[2] Newborns, especially preterms, tend to have poorer neutrophilic responses, making them prone to various infections in early infancy.[1]

Changes in the Immune System in the Earlier Days of Life

Neonates are prone to infections during their initial days because of the inactive innate immune system at birth.[1,2] As the neonate grows, all the immune systems in the body continue to mature and reach a significantly well-developed phase by the end of 1 year.[3] Both host genetics and environmental factors affect the development of the immune systems.[2] In humans, the immune system reaches maturation level by the age of 12 to 14 years.[3] Hence, any deleterious factors that affect the maturation and functioning of the neonate's immunity can have long-lasting effects.

Effect of Nutrition on a Neonate's Immunity

Neonate's immune system is affected by the nutrition and external environmental factors. Hence, breast milk, the sole nutrition in the early days of life, has a vital role in modeling the immune status.[4] Breast milk contains several biologically active antimicrobial peptides (AMPs), such as defensins and cathelicidin and immunomodulatory compounds that support the development of passive immunity.[4] Studies have shown that casein and α-lactalbumin accelerate the lymphocytic functions.[5] Alpha-lactalbumin and whey protein concentrate have been shown to increase antibody production to foreign antigens.[5]

As a neonate grows, all these nutrients must be provided through the diet, especially foods containing ω-3 and ω-6 fatty acids.

Micronutrients and Immunity

Effect of deficiency of water-soluble vitamins on immunity

Vitamins B complex and C are water soluble. The B complex vitamins are essential for various enzymatic actions and production and maintenance of the normal milieu interior of the cells.

Besides, vitamin B_6 deficiency impairs growth, maturation, and proliferation of lymphocytes and antibody production and suppresses Th1 responses and proliferation of Th2 cells, thus favoring the development of allergic responses in the body.[5]

Vitamin B_{12} deficiency impairs response to bacterial and viral infections.[5] Neutropenia, lymphopenia, and other white cell abnormalities are also caused by vitamin B_{12} deficiency.

Vitamin B_9 (folate) is another micronutrient essential for the normal immune mechanisms. Deficiency of this vitamin impairs neutrophil maturation.[5] Low level of vitamin C is associated with decreased bactericidal activity and locomotion of neutrophils and macrophages, in turn affecting resistance to infections.[5]

Effect of deficiency of fat-soluble vitamins on immunity

The fat-soluble vitamin A affects mucosal integrity, protects phagocytic cells, and stimulates effector T cell functions.[5] Hence, vitamin A deficiency increases the likelihood of infections.

Vitamin C is a free radical scavenger, the level of which reduces during infections.[6] It has been shown that supplementation of this vitamin improves immune response to streptococcal infections and *Helicobacter pylori* infections.[6]

Effect of deficiency of minerals and trace elements on immunity

Copper is another important micronutrient for immune development, the deficiency of which affects T cell functioning, resulting in impaired humoral, cellular, and nonspecific immune responses.[4]

Chromium affects the production of T and B lymphocytes, macrophages, and cytokines and alters the immunostimulatory mechanism, favoring the development of hypersensitivity.[4]

Zinc plays an important role in the development of T cells, B cells, and NK cells. Deficiency of this trace element impairs the immune response, reduces hematopoiesis and antioxidant enzyme activity, and suppresses the bone marrow.[6] Zinc is also essential for normal thymic activity. Zinc deficiency also causes lymphopenia and alters immune function by lowering levels of CD4 T cell receptor expression and salivary IgA. Studies have shown that breast milk alone is an insufficient source of zinc for a newborn and hence supplementation may be indicated, especially in preterm neonates.[7] In low-birth-weight neonates, supplementation of zinc reduces morbidity from pneumonia and the duration of diarrhea and protects against malaria, thus reducing mortality.[7]

Selenium is required for the development of monocytic, NK cell, as well as T cell functions. The deficiency affects development of these cell lines and suppresses the antigen presentation. Selenium deficiency is associated with higher predisposition to infections by certain viruses such as coxsackie B and influenza.

Fatty Acids and Immunity

Effect of deficiency of LCPUFAs on immunity

Long-chain polyunsaturated fatty acids (LCPUFAs) act as gatekeepers of the immune system; the ratio of n-3 to n-6 fatty acids influences the development and function of the immune system. The deficiency of these causes atopic disease.[8] The LCPUFAs, especially arachidonic acid and docosahexaenoic acid, are preferably found in cell membrane phospholipids, wherein they regulate signal transduction, gene expression, and membrane fluidity, and these are important for maintaining the immune functions. Alteration in n-3 and n-6 LCPUFAs ratio could increase the likelihood of allergy.[8]

Conclusion

Neonates should be provided adequate healthy nutrients to ensure proper development of the immune system. Deficiency of any one of the nutrients is also associated with the development of infections during early days in life. Hence, age-appropriate doses of trace elements and micronutrients are indispensable for maintaining health along with the normal functioning of the immune system.

References

1. Simon AK, Hollander GA, McMichael A. Evolution of the human immune system from infancy to old age. *Proc Biol Sci.* 2015;282(1821):20143085.
2. Goenka A, Kollmann TR. Development of immunity in early life. *J Infect.* 2015;71(Suppl 1):S112–S120.
3. Indian Academy of Pediatrics. The key role of nutrition in developing your baby's immunity. https://www.iapvaani.org.in/the-key-role-nutrition-plays-in-developing-your-babys-immunity. Accessed March 21, 2019.
4. Pai UA, et al. The role of nutrition in immunity in infants and toddlers: an expert panel view. *Clin Epidemiol Global Health.* 2018;6:155–159.
5. Ibrahim KS, El-Sayed EM. Potential role of nutrients on immunity. *Int Food Res J.* 2016;23(2):464–474.
6. Cunningham-Rundles S, et al. Role of nutrients in development of neonatal immune response. *Nutr Rev.* 2009; 67(Suppl 2):S152–S163.
7. Maggini S, Pierre A, Calder PC. Immune function and micronutrient requirements change over the life course. *Nutrients.* 2018;10(10):E1531.
8. Calder P, Prescott S, Caplan M. Scientific review: the role of nutrition in immune function of infants and young children. https://www.meadjohnson.com/pediatrics/us-en/sites/hcp-usa/files/Sci-Rev-LCPUF-AImmMono_0.pdf. Accessed April 5, 2019.

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