

Role of Vitamin C in Immune Function of Human Body

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Abstract

Vitamin C is an important micronutrient for humans with pleiotropic function associated with its ability to donate electrons. It is a potent antioxidant and a cofactor for a family of biosynthetic and gene regulatory enzymes. Vitamin C contributes to immune system defense by supporting various cellular functions of both the innate and adaptive immune system. Vitamin C supports epithelial barrier function against environmental oxidative stress. Vitamin C accumulates in phagocytic cells like neutrophils, and may enhance chemotaxis, phagocytosis, generation of reactive oxygen species and ultimately microbial killing. It is also needed for apoptosis and clearance of the spent neutrophils from sites of infection by macrophages. Vitamin C deficiency leads to impaired immunity and better susceptibility to infections. In turn infections significantly impact on Vitamin C levels thanks to enhanced inflammation and metabolic requirements. In contrast treatment of established infections requires a significantly higher dose of vitamin to catch up on the increased inflammatory response and metabolic demand. One of the most reasons people take vitamin C supplements is to spice up their immunity as vitamin C is involved in many parts of the immune system. First, vitamin C helps encourage the assembly of white blood cells known as lymphocytes and phagocytes which helps to protect the body against various infections. Vitamin C is a strong antioxidant that can boost blood antioxidant levels and vitamin C rich foods and supplements have been linked to reduce blood uric acid levels. Many studies show vitamin C intake lower risk of several cancers and also reduced risks of eye diseases. Vitamin C is an essential nutrient for healthy immune function. The main aim of the paper is to know the role of Vitamin C in immune function of the human body.

Key Words: Immune system, Vitamin C, ascorbic acid, Lymphocytes.

Introduction

The immune system may be a multifaceted and complicated network of specialised organs, tissues, cells, proteins and chemicals, which has evolved so as to guard the host from a variety of pathogens such as bacteria, viruses, fungi and parasites as well as cancer cells^{1,2}.

It can be divided into epithelial barriers and cellular and humoral constituents if either innate and acquired immunity³. These constituents are intact in multiple and highly complex ways⁴. More than half a century of research has shown Vitamin C to be a crucial player in various aspects of the immune system, particularly immune cell function. Vitamin C is an essential nutrient which cannot be synthesized by humans due to loss of a key enzyme in the biosynthetic pathway⁵. Severe Vitamin C deficiency leads to the doubtless fatal disease scurvy. Scurvy is characterized by weakening of collagenous structure resulting in poor wound healing and impaired immunity. Individuals with scurvy are highly susceptible to potentially fatal disease such as pneumonia. In turn infections can significantly impact on Vitamin C levels due to enhanced inflammation and metabolic requirements⁶. Early on it was noted that scurvy often

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followed infectious epidemics in population epidemics in population and cases of scurvy have been reported following respiratory infection⁷⁻⁹. This is particularly for individuals who are already malnourished. Although the amount of Vitamin C required to prevent scurvy is relatively low (i.e. 10mg/day)¹⁰. The recommended dietary intake for Vitamin C is up to one hundred fold higher than other vitamins¹¹. A diet that supplies 100-200mg/day of Vitamin C provides adequate intake is required to prevent hypervitaminosis. Vitamin C has a number of activities that could conceivably contribute to the immune modulating effects. It is a highly effective antioxidant, thanks to its ability to readily donate electrons, thus protecting important biomolecules [proteins, lipids, carbohydrates and nucleic acids] from damage by oxidants generated during normal cell metabolism and through exposure to toxins and population. Vitamin C is also a cofactor for a family biosynthetic and the gene regulatory monooxygenase and dioxygenase enzymes. The vitamin has long been known as a cofactor for the lysyl and prolyl hydroxylase required for stabilization of the tertiary structure of collagen and is a cofactor for two hydrolysis involved in carnitine biosynthesis, a molecule required for transport of fatty acid into mitochondria for generation of metabolic energy. Vitamin C in the regulations of gene transcription¹². And cell signaling pathway through regulation of transcription factor activity and epigenetic marks. Our review explores various roles of Vitamin C in the immune system including barrier integrity and wound healing and leucocyte function and modulating effects of Vitamin C in the context of infection conditions leading to Vitamin C insufficiency¹³.

A Review type of study is to understand the significant role of Vitamin C in immune function of the human body by retrieving related articles. The sampling

data collection search engines are pub med, google scholar, research gateway and so on. Inclusion Criteria included are articles related to vitamins, Vitamin C, human body, immune function and exclusion criteria are articles not related to human body and immune functions.

VITAMIN C IN HUMAN IMMUNE FUNCTIONS

Functions of Immune System

The function of the precise immune response is aimed towards a lively removal of foreign antigen. In the case of cellular immunity, T helper effector cells function in the active requirement of cells, such as macrophages which phagocytize and remove foreign substances. Cytotoxic cells bind foreign antigen bearing cells and kill them¹⁴. This is especially an advantage in the case of replicating agents such as viruses because it can limit the spread of the virus. The function of B cells is to produce antibodies which binds antigen and facilitates its removal from the body¹⁵. An antibody / antigen complex can initiate a spread of various processes aimed toward antigen elimination including facilitative, phagocytosis complement activation, antibody dependent cellular cytotoxicity and mastocyte degranulation. The entire process is finely turned. There are a variety of regulatory mechanisms involved in its control of immune responses including T suppressor cells, anti-idiotypic regulation and antigen elimination¹⁶. This regulatory control is critical in avoiding lymphoproliferative disease and immunopathologic response. When immune responses result in disease they are formed hypersensitivities. The ultimate function of the response is to provide protection from foreign substances. Since there are a variety of important steps and regulations in the immune system¹⁷.

Table 1: Role of Vitamin C in Immune mechanisms.

Immune system	Function of Vitamin C
Epithelial barriers	Enhances collagen synthesis and stabilization Protect against ROS induced damage Shortens time to wound healing in patients
Phagocytes	Act as an antioxidant Enhance motility/chemotaxis Enhance phagocytosis Facilitate Apoptosis Decrease Necrosis
B and T lymphocyte	Enhance differentiation and proliferation Enhance antibody levels
Inflammatory mediators	Modulate cytokine production Decrease histamine levels

Barrier Integrity and Wound Healing

The skin has numerous essential functions, the primary of which is to act as a barrier against external insults including pathogens¹⁸. Skin contains kill molar concentrations of Vitamin C with higher levels found in the epidermis than the dermis (Table 1)¹⁹. Vitamin C is actively accumulated into the epidermal and dermal cells^{20,21} via the two sodium dependent Vitamin C transporter²². Clues to the role of Vitamin C in skin come from the symptoms of Vitamin C deficiency scurvy which is characterized by bleeding gums, brushing and impaired wound healing²³. These symptoms are thought to be a result of the role of vitamin C as a cofactor for the prolyl and lysyl hydroxylase enzymes that stabilize tertiary structure of collagen²⁴. Cell culture and preclinical studies have indicated that Vitamin C enhances epithelial barrier function via number of different mechanisms^{25,26}.

Vitamin C Insufficiency Conditions

Numerous environmental healthy conditions can have an impact on Vitamin C status. Tobacco smoke is an underestimated pollutant in many parts of the world.

Both smokers and passive smokers have lower plasma and leukocyte Vitamin C levels than non-smokers. The antioxidant property of vitamin c enables it to protect lung cells exposed to oxidants and oxidant mediated damage caused by various pollutants, heavy metals, pesticides and xenobiotics²⁷. Individuals with diabetes are of greater risk of common infections. A decrease in plasma vitamin C reading has been observed in studies of type 2 diabetes and a major cause for increased Vitamin C in type 2 diabetes is thought to be the high level of oxidation stress caused by hyperglycemia²⁸. Elderly people are particularly susceptible to infections due to immunosenescence and decreased immune cell function²⁹.

Vitamin C and Leukocyte Function

Leukocytes like neutrophils and monocytes actively accumulate vitamin C against a degree gradient, leading to values that are 50-100 fold above plasma concentration³⁰. These cells accumulate Vitamin C concentration at a dietary intake of 0-100mg/day]. DHA is then rapidly reduced to ascorbate intra cellularly to give levels of about 10mm. It is believed that the accumulation of such high Vitamin C concentrations

indicates function within these cells³¹. Thus Vitamin C could modulate redox-sensitive cell signaling pathways or by directly protecting important cell structural components^{32,33}.

Vitamin C and Infection

A major symptom of the Vitamin C deficiency disease scurvy is the marked susceptibility to infections, particularly of the respiratory tract with pneumonia of the respiratory tract with pneumonia being one of the most frequent complications of scurvy and a major cause of death^{34,35}. Cases of acute lung infection have shown rapid clearance of chest x-rays following administration of intravenous Vitamin C³⁶. Beneficial effects of Vitamin C on recovery are noted in pneumonia. An elderly person hospitalized because of pneumonia, who was determined to have very low Vitamin C levels³⁷. Administration of Vitamin C reduced the respiratory symptom score in the more severe patients. It is likely that the low Vitamin C levels observed during respiratory infections are both a cause and consequence of the diseases³⁸.

Some others Benefits of Vitamin C

Cardiovascular health: Vitamin C may widen the blood vessels and this could help protect against heart disease and hypertension or high blood pressure.
Cholesterol levels: There are found to be lower in individuals with adequate levels of Vitamin C³⁹.
Cataract: Vitamin C may help lower the risk of cataracts as well as age related macular degeneration.
Anemia: Vitamin C enhances the absorption of iron.
Lead levels may be reduced if there is an adequate intake of Vitamin C⁴⁰.
 In dental disorders the role of Vitamin C in stabilizing the collagen and prevents gum bleeding⁴¹. As an antioxidant Vitamin C acts as an anticancer agent also⁴².

Vitamin C is a key for a strong and well-functioning immune system. Vitamin C supports the production of interferons. Interferons are produced when the presence of pathogens is detected. They facilitate the ability of cells to initiate protection of cellular defenses^{43,44}. Vitamin C enhances the function of phagocytes. Phagocytes are a kind of white cells that surround pathogens and other dangerous particles; once the intruders are captured they are digested and neutralized enzymatically⁴⁵. Some of the primary cells of the immune system have levels of Vitamin C upto 80 times higher than levels found in

plasma. Vitamin C inhibits apoptosis of various forms of T lymphocytes. Vitamin C increases the assembly of 13 lymphocytes. Vitamin C increases the assembly and activity of antibodies. Good antibody function is vital for a healthy immune system⁴⁶. Vitamin C supports the activity of natural killer cells. Natural killer cells are small lymphocytes which will attack directly cells such as cancer cells and kill them⁴⁷. Vitamin C can make bacterial membranes more permeable to some antibiotics. Vitamin C is a fanatical supporter of healthy immune function^{46,47}.

Conclusion

Overall Vitamin C appears to exert a mass of beneficial effects on cellular functions of both the innate and adaptive immune system. Although Vitamin C may be a potent antioxidant protecting the body against endogenous exogenous oxidative challenges. It's likely that its action as a cofactor for varied biosynthetic and gene regulatory enzymes plays a key role in immune-modulating effects. It's apparent that Vitamin C is important for the immune system to mount and sustain an adequate response against pathogens, while avoiding excessive damage to the host. Epidemiological studies indicate that hypovitaminosis C remains relatively common worldwide and Vitamin C deficiency is the fourth leading deficiency. Ensuring adequate intake of vitamin through the diet or via supplements especially in groups such as the elderly or in individuals exposed to risk factors for Vitamin C insufficiency is required for proper immune function and resistance to infections.

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