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Antiviral Mechanisms of Vitamin C

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Abstract
There isn't a COVID-19 vaccination or particular antiviral drug available yet. In order to preserve lives and stop the disease's spread, a readily available, efficient, and secure therapy is desperately needed. Acute respiratory distress syndrome plays a major role in COVID-19 death rates. The characteristic of acute respiratory distress syndrome is markedly elevated oxidative stress brought on by a fast release of free radicals and cytokines (cytokine storm), which can result in organ failure, cellular damage, and even death. We describe a case where the patient responded well to early administration of high dose intravenous vitamin C in addition to other nutrients and drugs.
Keywords: vitamin C; upper respiratory tract infection; iviral; mechanism; COVID-19

Introduction

Since it can give electrons, vitamin C is a micronutrient that is vital to human health and has a wide range of pleiotropic physiological effects. Many biosynthetic and gene-regulating enzymes require it as a cofactor.[1] Vitamin C has a considerable reducing potential, which makes it an important component of many metabolic processes. By assisting the innate and adaptive immune systems' numerous cellular processes, vitamin C strengthens the immune system.

The immune system is a complex and multidimensional network that defends the host against various pathogens, including viruses, bacteria, fungus, parasites, and cancer cells. It is possible to classify the immune system as innate and adaptive. Physical and chemical barriers, as well as natural killer cells, phagocytic leukocytes, dendritic cells, and plasma proteins, make up the innate immune system. The humoral immune response, which is regulated by activated B cells and antibodies, and the cell-mediated immune response, which is executed by T cells, are the two categories of adaptive responses that comprise the adaptive immune system (also known as the acquired immune system).

Increased susceptibility to infections, especially of the respiratory system, is a major symptom of the vitamin C deficient disease scurvy. One of the most common consequences of scurvy and a leading cause of death is pneumonia. When patients with acute respiratory infections get vitamin C, the intensity of their respiratory symptoms is lessened and their plasma vitamin C levels return to normal. [2]

After receiving intravenous vitamin C, cases of acute lung infections have showed quick resolution on chest X-rays. [3] It is possible that increased apoptosis and subsequent phagocytosis and clearance of the spent neutrophils by macrophages are the cause of this vitamin C-dependent neutrophil clearance from diseased lungs. [4]

When used in high amounts, either by intravenous injection or well timed oral doses, vitamin C has shown strong antiviral action. [5] There is clinical data demonstrating the powerful antiviral properties of vitamin C. There are published studies where very large quantities of vitamin C are used to cure various viral infections. [5] For most persons, antiviral therapy consists of frequent oral dosages of vitamin C that are high enough to exceed a gastrointestinal tolerance limit. [6] In the most severe situations, intravenous vitamin C is recommended.

We and others have found that the more ill a person was, the more ascorbic acid they could take orally without experiencing diarrhea. Oral ascorbic acid dosages of 5 to 15 grams are safe for healthy individuals with normal GI tract function and no diarrhea. A person with a moderate cold can handle 30 to 60 grams; someone with a severe cold, 75 grams; and someone with influenza, nearly 100 grams. With viral pneumonia, mononucleosis, etc. Oral ascorbic acid in the range of 150–200 grams would be tolerated without causing diarrhea. [6] Cathcart was the first to explain the technique of titrating to bowel tolerability to identify the appropriate dose—that is, the dose that will relieve acute symptoms without inducing diarrhea. When oral ascorbic acid is taken to a level of 90% or higher of intestinal tolerance, symptoms are often neutralized.

Hickey's dynamic flow model is another intriguing idea. [7] According to the dynamic flow model, the body maintains a constant electron flow when an excess of oral ascorbate is consumed. According to the dynamic flow paradigm, human physiology should be restored to resemble that of animals that can make vitamin C on their own. You can accomplish this by ingesting more ascorbate than what is typically absorbed. Spreading out this intake throughout the course of the day ensures a steady supply. Glucose transporters and the sodium-dependent vitamin C transporter (SVCT) are responsible for moving vitamin C across cellular membranes (GLUT). A diverse class of membrane proteins known as glucose transporters helps move glucose across the plasma membrane. These transporters become more active the sicker you get.

Vitamin C as a regulator of metabolism

Peripheral hypoxia, insulin resistance, elevated oxidative stress, and systemic inflammation are characteristics of sepsis. A potentially fatal systemic inflammatory response that can cause multiple organ failure is sepsis. One medical condition known as sepsis is characterized by a severe deficiency of vitamin C and other antioxidants. Lung epithelial cells get their energy from mitochondrial oxidative phosphorylation, whereas immune effector cells get their energy from glycolysis. Treatment with high-dose vitamin C functions as an antioxidant for lung epithelial cells as well as a pro-oxidant for immune cells. [8] Vitamin C's pro-oxidant function necessitates pharmacological (millimolar) concentrations as opposed to physiological (micromolar) ones. A potential issue with administering high-dose vitamin C for pneumonia treatment is that it causes osmotic cell death of immune cells instead of apoptosis, which may cause localized inflammation in the alveoli. Therefore, in order to mitigate the potential inflammatory side effects of high-dose vitamin C treatment, IV glucocorticoid therapy needs to be added. Infusions of at least 5 g of vitamin C per day will be considered high-dose intravenous treatment for the purposes of this article. To combat inflammation brought on by vitamin C therapy, adding hydrocortisone 50 mg IV every six hours for seven days should be taken into consideration. The oxidation of the cortisol receptors is attempted to be compensated for by this activity, despite the fact that endogenous cortisol levels in sepsis are already very high. Vitamin C may lessen the receptors' oxidation, allowing endogenous cortisol to take effect. When administered intravenously in large doses, vitamin C may function as an antioxidant to enhance the functions of epithelial lung cells while also acting pleiotropically as a pro-oxidant to reduce the expression of pro-inflammatory mediators. [9] When vitamin C is taken in large quantities, it functions as an antioxidant or pro-oxidant depending on the kind of cell and the surrounding conditions. [8] This illustrates vitamin C's versatility as a diverse, multifunctional metabolic regulator.

Ascorbic Acid's Antiviral Mechanisms of Action

Direct systems:

When taken in medicinal levels, ascorbic acid's redox capacity damages the viral capsid. Strong reducing agents include ascorbic acid. [10]

When administered at therapeutic levels, the viral capsid sugar moiety of its glycoprotein envelope is disrupted. [11] In addition to directly blocking viral replication enzymes, therapeutic concentrations of this substance also limit viral replication by establishing an unfavorable environment for this activity to take place. [5] Ascorbic acid degrades the single- and double-stranded genomes of DNA and RNA viruses, making replication more vulnerable to damage from ascorbate. [12] This lowers the amount of viral proteins that are produced.

Mechanisms that operate indirectly:

enhances cellular immunity by boosting the quantity, vigor, and aggressiveness of immune cells such macrophages, NK cells, leukocytes, and lymphocytes. Vitamin C concentrations affect lymphocyte formation and function. [13] Chemotaxis, chemokinesis, and phagocytosis are all improved by vitamin C accumulation in the lysosomes of phagocytic cells. When exposed to oxygen, vitamin C promotes the production of reactive oxygen species such H2O2. [14] It has been demonstrated that vitamin C increases phagocyte motility and chemotaxis (Murata & Uike, 1976). Vitamin C values that are 50–100 times higher than plasma concentrations are obtained by white blood cells as they accumulate the vitamin against a gradient in concentration. [15]

produces more antibodies, which boosts humoral immunity. [1]

boosts the synthesis of pro-inflammatory cytokines TNF-α and IL-6 while decreasing the production of antiviral proteins such α/β interferons. [5]

Boosts energy by supplying the electrons that are needed and by moving electrons across the mitochondria to increase the electron flow needed to produce ATP. [16]

Restricts the ability of pathogenic organisms to use glucose as their primary energy source when given in therapeutic quantities. [17] Viruses that carry DNA and RNA can cause glycolysis. Viruses can enhance a host cell's reliance on extracellular glucose and diminish its oxidative phosphorylation.

When vitamin C is given in the right amounts, antioxidant action is evoked to stop the cytokine storm, which is a severe and hazardous pathological cascade. [1] reduces the cytokine storm: Vitamin C seems to regulate systemic and leukocyte-derived cytokines. Cytokines can cause pro- or anti-inflammatory reactions. The oxidants generated by phagocytes are countered by vitamin C, which shields the host cells. According to Chen et al. (2014), vitamin C reduces the production of the pro-inflammatory cytokines TNF-α and IL-6. [18]

Acute lung injury (ALI)/acute respiratory syndrome (ARDS) caused by cytokine storm or markedly increased oxidative stress is the deadly disease that underlies COVID-19. These pathologies have also been linked to

respiratory viral infections like SARS and MERS, as well as viruses that attack other body parts and cause multi-organ failure. The antioxidant, antiviral, and immune-stimulating properties of vitamin C are supported by clinical evidence that it can alleviate pneumonia, ARDS, and sepsis.
Encourages the production of collagen, which preserves the structural integrity of cells. [19] Endothelial barrier function is shielded by vitamin C from the damage caused by sepsis. [20]
alters the expression of genes. When vitamin C is administered, it increases the expression of NF-κB and decreases the expression of susceptibility genes such as interferon regulatory factor 3 (IRF3) and mitochondrial antiviral signaling (MAVS). Together, these trigger an innate antiviral response and cause type I interferons (IFNs). [21]

When taken in large quantities, vitamin C can fight any kind of infection; but, even at moderate supplemental levels, it can be beneficial. For those with limited medical options and poor incomes, this is crucial. For instance, a well-controlled, randomized research found that giving elderly patients 200 mg/day of vitamin C improved their respiratory symptoms, even in the most critically sick hospitalized patients; the vitamin C group also had an 80% reduction in mortality. [2]
As an acute infection, the coronavirus, SARS-coV-2, should be anticipated to be as sensitive to vitamin C as all the other viruses that it has been shown to be highly successful against. No known circumstance has seen sufficiently large concentrations of vitamin C fail to neutralize any virus that it has been tested against. [22]
High dosages of Vitamin C are seen by many doctors to be an effective antiviral drug, capable of acting as a functional vaccine against a range of influenza strains. [23]

Conclusions

If administered in high dosages as continuous infusions, vitamin C can be utilized as a stand-alone therapeutic agent to eradicate a bacterial or viral illness (Zabet et al. 2016). We conclude that high-dose vitamin C supplementation appears to be able to both prevent and aid treat respiratory and systemic infections based on this mechanistic explanation of the therapeutic use of vitamin C to prevent inflammatory hyperactivation in myeloid and lymphoid cells. When taken in high enough levels, ascorbate can both prevent viral illness and significantly accelerate the healing process after an acute infection.

References

1. A.C. Carr and S. Maggini *Vitamin C and immune function.* Nutrients **9**(11): p. 1211 (2017).
2. C. Hunt, N. Chakravorty, G. Annan, et al. *The clinical effects of vitamin C supplementation in elderly hospitalised patients with acute respiratory infections.* International journal for vitamin and nutrition research **64**(3): p. 212-219 (1994).
3. A. Bharara, C. Grossman, D. Grinnan, et al. *Intravenous vitamin C administered as adjunctive therapy for recurrent acute respiratory distress syndrome.* Case reports in critical care **2016** (2016).
4. M.C. Vissers and R.P. Wilkie *Ascorbate deficiency results in impaired neutrophil apoptosis and clearance and is associated with up-regulation of hypoxia-inducible factor 1α.* Journal of Leucocyte Biology **81**(5): p. 1236-1244 (2007).
5. R.M.L. Colunga Biancatelli, M. Berrill, and P.E. Marik *The antiviral properties of vitamin C.* Expert review of anti-infective therapy **18**(2): p. 99-101 (2020).
6. R.F. Cathcart III *The method of determining proper doses of vitamin C for the treatment of disease by titrating to bowel tolerance.* cancer **15**(100): p. 4 (1981).
7. D. Hickey, H. Roberts, and R. Cathcart *Dynamic flow: A new model for ascorbate.* Journal of Orthomolecular Medicine **20**(4): p. 237-244 (2005).
8. A. Erol *High-dose intravenous vitamin C treatment for COVID-19.* OSF Preprints **26** (2020).
9. W.J. Lee, S.L. Kim, Y.S. Choe, et al. *Magnesium ascorbyl phosphate regulates the expression of inflammatory biomarkers in cultured sebocytes.* Annals of dermatology **27**(4): p. 376 (2015).
10. L. Cheng, Y. Liu, B. Li, et al. *An in vitro study on the pharmacological ascorbate treatment of influenza virus.* Zhonghua jie he he hu xi za zhi= Zhonghua Jiehe he Huxi Zazhi= Chinese Journal of Tuberculosis and Respiratory Diseases **35**(7): p. 520-523 (2012).
11. A.K. Debnath, H. Zhang, and F. Curreli, *Small molecule inhibitors of retroviral assembly and maturation*, Google Patents.(2013).
12. S. Murad, D. Grove, K. Lindberg, et al. *Regulation of collagen synthesis by ascorbic acid.* Proceedings of the National Academy of Sciences **78**(5): p. 2879-2882 (1981).
13. A. Sorice, E. Guerriero, F. Capone, et al. *Ascorbic acid: its role in immune system and chronic inflammation diseases.* Mini reviews in medicinal chemistry **14**(5): p. 444-452 (2014).
14. B. Frei and S. Lawson *Vitamin C and cancer revisited.* Proceedings of the National Academy of Sciences **105**(32): p. 11037-11038 (2008).
15. M.C. Goldschmidt *Reduced bactericidal activity in neutrophils from scorbutic animals and the effect of ascorbic acid on these target bacteria in vivo and in vitro.* The American journal of clinical nutrition **54**(6): p. 1214S-1220S (1991).
16. M.J. González, J.R. Miranda, and H.D. Riordan *Vitamin C as an Ergogenic Aid.* Journal of Orthomolecular Medicine **20**(2) (2005).

17. G.N. Dakhale, H.V. Chaudhari, and M. Shrivastava *Supplementation of vitamin C reduces blood glucose and improves glycosylated hemoglobin in type 2 diabetes mellitus: a randomized, double-blind study.* Advances in Pharmacological and Pharmaceutical Sciences **2011** (2011).
18. Y. Chen, G. Luo, J. Yuan, et al. *Vitamin C mitigates oxidative stress and tumor necrosis factor-alpha in severe community-acquired pneumonia and LPS-induced macrophages.* Mediators of inflammation **2014** (2014).
19. S. Englard and S. Seifter *The biochemical functions of ascorbic acid.* Annual review of nutrition **6**(1): p. 365-406 (1986).
20. M. Han, S. Pendem, S.L. Teh, et al. *Ascorbate protects endothelial barrier function during septic insult: Role of protein phosphatase type 2A.* Free Radical Biology and Medicine **48**(1): p. 128-135 (2010).
21. Y. Cai, Y.-F. Li, L.-P. Tang, et al. *A new mechanism of vitamin C effects on A/FM/1/47 (H1N1) virus-induced pneumonia in restraint-stressed mice.* BioMed Research International **2015** (2015).
22. K. FR *Massive doses of vitamin C and the virus diseases.* Southern Medicine and Surgery **113**(4): p. 101-107 (1951).
23. A.W. Saul *Nutritional treatment of coronavirus.* Orthomolecular Medicine News Service **16**(6): p. 22 (2020).