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Journal of Antivirals & Antiretrovirals

ISSN: 1948-5964

Commentary

Harnessing the Strength of Cell-Mediated Immunity

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DESCRIPTION

Cell-mediated immunity is a type of immune response that involves the activation of T cells to defend the body against intracellular pathogens, cancerous cells, and foreign substances. In contrast to antibody-mediated immunity, which is mainly involved in fighting extracellular pathogens, cell-mediated immunity plays a critical role in the recognition and elimination of infected or abnormal cells within the body. The process of cell-mediated immunity begins when an Antigen-Presenting Cell (APC) encounters an antigen and processes it into small peptide fragments. The APC then presents the peptide fragments on its surface, bound to Major Histocompatibility Complex (MHC) molecules, to activate T cells. This process is known as antigen presentation and is critical for the initiation of cell-mediated immune responses. Once the T cell recognizes its specific antigen presented on the APC, it undergoes activation and differentiation into different types of effector T cells, such as Cytotoxic T Cells (CTLs) and T Helper Cells (Th cells). CTLs are responsible for directly attacking and killing infected or abnormal cells, whereas Th cells help coordinate and regulate the immune response.

CTLs are activated by recognition of their specific antigen on MHC class I molecules. Once activated, they migrate to the site of infection or tumor and release cytotoxic molecules such as perforin and granzymes, which cause cell death. CTLs also express the Fas ligand, which binds to the Fas receptor on the target cell, inducing apoptosis. Th cells, on the other hand, are activated by recognition of their specific antigen on MHC class II molecules. They secrete cytokines that stimulate the proliferation and activation of other immune cells, including B cells, macrophages, and CTLs. Th cells also differentiate into subsets, such as Th1 and Th2 cells, that have different functions in the immune response. Th1 cells secrete cytokines such as Interferon-Gamma (IFN-γ) and Tumor Necrosis Factor-Alpha (TNF-α), which activate macrophages and promote the development of CTLs. Th1 cells are involved in the defense against intracellular pathogens, such as viruses and bacteria. Th2 cells secrete cytokines such as Interleukin-4 (IL-4) and Interleukin-5 (IL-5), which stimulate B cell proliferation and antibody production. Th2 cells are important in the defense against extracellular pathogens, such as parasites and allergens.

When a foreign organ is transplanted into a recipient, the recipient's immune system recognizes the foreign MHC molecules on the transplanted cells as non-self and mounts an immune response against them. This process is known as allo-immunity and is mediated by T cells. In addition to its role in defense against pathogens and cancer cells, cell-mediated immunity is also involved in autoimmune diseases, where the immune system mistakenly attacks healthy cells and tissues. In autoimmune diseases, T cells recognize self-antigens as foreign and mount an immune response against them. Examples of autoimmune diseases include multiple sclerosis, type 1 diabetes, and rheumatoid arthritis.

Overall, cell-mediated immunity plays a critical role in protecting the body against intracellular pathogens, cancer cells, and foreign substances. The process of cell-mediated immunity involves the activation of T cells through antigen presentation, the differentiation of effector T cells, such as CTLs and Th cells, and the release of cytokines that stimulate the immune response. A better understanding of cell-mediated immunity has led to the development of new therapies for cancer and autoimmune diseases, and ongoing research in this area is expected to lead to further advances in the field of immunology. There are several subtypes of T cells involved in cell-mediated immunity, including cytotoxic T cells, helper T cells, and regulatory T cells. Cytotoxic T cells (also known as CD8+ T cells) are the primary effector cells of cell-mediated immunity. They recognize and kill infected cells or cancer cells by releasing cytotoxic molecules such as perforin and granzyme, which induce apoptosis (cell death). Helper T cells (also known as CD4+ T cells) play a critical role in coordinating the immune response by activating and directing other immune cells such as B cells and cytotoxic T cells. Regulatory T cells (also known as Tregs) are responsible for suppressing the immune response to prevent excessive or harmful reactions to self-antigens or innocuous environmental antigens.

The activation of T cells also involves the secretion of cytokines, which are small signaling molecules that regulate the immune response. Cytokines are produced by both T cells and APCs and

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Received: 28-Feb-2023, Manuscript No. JAA-23-23254; **Editor assigned:** 03-Mar-2023, PreQC No. JAA-23-23254 (PQ); **Reviewed:** 17-Mar-2023, QC No. JAA-23-23254; **Revised:** 24-Mar-2023, Manuscript No. JAA-23-23254 (R); **Published:** 03-Apr-2023, DsOI: 10.35248/1948-5964.23.15.264

Citation: Cecelio J (2023) Harnessing the Strength of Cell-Mediated Immunity. J Antivir Antiretrovir. 15:264.

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play a critical role in coordinating the immune response. Cytokines can stimulate the proliferation and differentiation of T cells, enhance the activity of cytotoxic T cells and natural killer cells, and activate macrophages to phagocytose and destroy pathogens. The cell-mediated immune response also involves the formation of memory T cells, which are long-lived T cells that are specific for a particular antigen. Memory T cells are critical for providing long-term immunity to infections and are responsible for the rapid and robust immune response upon re-exposure to the same antigen. Memory T cells can quickly proliferate and differentiate into effector T cells upon re-exposure to the antigen, leading to the rapid clearance of the pathogen. Several factors can influence cell-mediated immunity, including age, genetics, nutrition, and environmental factors.

Age-related changes in the immune system can affect the function of T cells, leading to a decline in immune function and an increased susceptibility to infections and cancer. Genetic factors can influence the development and function of T cells, leading to differences in immune response between individuals.

Nutritional deficiencies, such as vitamin D or zinc deficiency, can impair T cell function and increase the risk of infections.