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Opinion Article

Immune Cell Function and Interaction in Disease Pathogenesis

Buwei Roybal*

Department of Evolutionary Biology, University of Vienna, Vienna, Austria

DESCRIPTION

The immune system plays a central role in maintaining the body's health by defending against pathogens, eliminating damaged or abnormal cells, and regulating inflammation. Immune cells such as T cells, B cells, macrophages, dendritic cells, and natural killer cells are essential for recognizing and responding to threats, while also ensuring that the immune response does not become too destructive or prolonged.

Immune cells

The functions and interactions of immune cells in disease pathogenesis is critical for developing new therapeutic strategies. This immune cells function in disease and how their interactions can either protect or promote disease progression. Both play pivotal roles in maintaining immune homeostasis and responding to infection, but their functions and mechanisms of action differ.

These are phagocytic cells that play a vital role in the detection and elimination of pathogens, as well as the clearance of dead cells. They also release cytokines to initiate and regulate inflammation. Macrophages can polarize into different phenotypes, such as pro-inflammatory M1 macrophages, which promote tissue damage, and anti-inflammatory M2 macrophages, which aid in tissue repair. NK cells recognize cells that exhibit abnormal "self" markers, such as the loss of Major Histocompatibility Complex (MHC) class I molecules, which are often downregulated in cancer cells or virus-infected cells. These lymphocytes are key players in the adaptive immune response. $CD4^+$ helper T cells, which coordinate the immune response by secreting cytokines, and $CD8^+$ cytotoxic T cells, which directly kill infected or tumor cells. T cells are activated by Antigen-Presenting Cells (APCs), like dendritic cells, and undergo clonal expansion to target specific pathogens or tumor cells.

Immune cell interactions

Immune cell interactions are essential for maintaining immune balance. This dysregulation often involves both innate and adaptive immune cells. In diseases like Rheumatoid Arthritis (RA) and Multiple Sclerosis (MS), $CD4^+$ T cells are activated inappropriately, often due to genetic predisposition or environmental triggers. In RA, T cells contribute to the chronic inflammation of joints by promoting the activation of macrophages and neutrophils, leading to tissue damage. In MS, autoreactive T cells attack the myelin sheath surrounding nerve fibers, causing neurological damage. In Systemic Lupus Erythematosus (SLE), B cells produce autoantibodies that target self-antigens, forming immune complexes that deposit in tissues, leading to inflammation and organ damage. The activation of autoreactive B cells can be exacerbated by helper T cells that secrete cytokines promoting B cell proliferation and antibody production.

In autoimmune diseases, regulatory T cells (Tregs), which normally suppress immune responses and prevent autoimmunity, are often dysfunctional or insufficient in number, further promoting disease progression. In IBD, macrophages in the gut mucosa become persistently activated, producing pro-inflammatory cytokines such as TNF-α, which contribute to mucosal damage. In cancer, immune cells can play a dual role they can either inhibit tumor growth or, conversely, facilitate tumor progression. Cancer cells often develop mechanisms to evade immune detection and create a tumor microenvironment that supports their growth. TILs, particularly $CD8^+$ cytotoxic T cells, are capable of recognizing and killing cancer cells. However, tumors can develop strategies to inhibit T cell activity. For instance, cancer cells often express checkpoint proteins like PD-L1, which bind to PD-1 on T cells and inhibit their function, a mechanism that tumors use to escape immune surveillance.

CONCLUSION

Immune cells are central to the pathogenesis of various diseases, with their functions and interactions shaping disease outcomes. In autoimmune disorders, dysregulated T and B cells drive tissue damage. In chronic inflammatory conditions, persistent immune activation causes ongoing tissue destruction. In cancer, immune cells can either inhibit or promote tumor progression, depending on the tumor microenvironment.

Correspondence to: Buwei Roybal, Department of Evolutionary Biology, University of Vienna, Vienna, Austria, E-mail: roybal.buwei@yale.at

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