OPEN ACCESS Freely available online

ISSN: 2155-6121
Journal of
Allergy & Therapy

Perspective

Role of the Immune System in Allergic Reactions

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DESCRIPTION

Allergic reactions are hypersensitive responses of the immune system to otherwise harmless substances, known as allergens. These reactions are orchestrated by complex interactions between various components of the immune system, involving both innate and adaptive immunity. Understanding the role of the immune system in allergic reactions is essential for developing effective strategies for diagnosis, treatment, and prevention of allergic diseases.

Immune system recognition of allergens

The immune system recognizes allergens as immune response to eliminate them. Allergens can be proteins from pollen, dust mites, animal dander, foods, or drugs. Upon exposure to an allergen, Antigen-Presenting Cells (APCs), such as dendritic cells, macrophages, B cells and process the allergen. The processed allergen is then presented to T lymphocytes, leading to their activation.

Activation of T lymphocytes

T lymphocytes play a major role in orchestrating allergic reactions. Allergen presentation by APCs to naive T cells leads to their differentiation into allergen-specific T helper 2 (Th2) cells. Th2 cells produce cytokines such as interleukin-4 (IL-4), interleukin-5 (IL-5), and interleukin-13 (IL-13), which drive the allergic response. IL-4 promotes B cell class switching to produce allergen-specific IgE antibodies, while IL-5 stimulates eosinophil recruitment and activation. IL-13 enhances mucus production and airway hyperresponsiveness.

IgE-mediated hypersensitivity

The production of allergen-specific IgE antibodies is a significance of allergic reactions. IgE antibodies bind to high-affinity receptors (FcεRI) on the surface of mast cells and basophils, sensitizing these cells to subsequent allergen exposure. Upon re-exposure to the allergen, cross-linking of IgE antibodies on mast cells and basophils triggers the release of inflammatory mediators, including histamine, leukotrienes, and cytokines. These mediators cause vasodilation, increased vascular permeability, smooth muscle contraction, and recruitment of inflammatory cells, leading to the characteristic symptoms of allergic reactions, such as itching, swelling, bronchoconstriction, and mucus production.

Activation of eosinophils and other effector cells

Eosinophils are effector cells implicated in the pathogenesis of allergic diseases, particularly asthma and allergic rhinitis. IL-5 produced by Th2 cells stimulates the recruitment and activation of eosinophils in target tissues. Eosinophils release cytotoxic granule proteins, lipid mediators, and cytokines, contributing to tissue damage, inflammation, and remodeling. Additionally, other immune cells, such as neutrophils, macrophages, and dendritic cells, participate in the allergic response by producing pro-inflammatory cytokines and chemokines, amplifying the inflammatory cascade.

Regulation of allergic reactions

The immune system employs various mechanisms to regulate allergic reactions and maintain immune homeostasis. Regulatory T cells (Tregs) play a major role in suppressing excessive immune responses and preventing autoimmunity and allergy. Tregs produce anti-inflammatory cytokines such as Interleukin-10 (IL-10) and Transforming Growth Factor-beta (TGF-β), which inhibit the activation and function of effector cells, including Th2 cells, mast cells, and eosinophils. Dysfunction of Tregs is associated with the development and exacerbation of allergic diseases.

Therapeutic interventions

Understanding the immune mechanisms underlying allergic reactions has led to the development of targeted therapeutic interventions for allergic diseases. Pharmacological agents such as antihistamines, corticosteroids, leukotriene receptor antagonists, and biologics target specific components of the allergic cascade to alleviate symptoms and suppress

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Received: 26-Feb-2024, Manuscript No. JAT-24-25223; **Editor assigned:** 29-Feb-2024, Pre QC No. JAT-24-25223 (PQ); **Reviewed:** 14-Mar-2024, QC No JAT-24-25223; **Revised:** 21-Mar-2024, Manuscript No. JAT-24-25223 (R); **Published:** 29-Mar-2024, DOI: 10.35248/2156-6121.24.15.379

Citation: Kulesza S (2024) Role of the Immune System in Allergic Reactions. J Allergy Ther. 15:379.

inflammation. Allergen Immunotherapy (AIT) aims to induce immune tolerance by administering gradually increasing doses of allergen extracts, modulating immune responses, and providing long-term benefits in reducing symptoms and medication use.

CONCLUSION

The immune system plays a central role in mediating allergic reactions through a complex interplay of innate and adaptive immune mechanisms. Allergic reactions involve the activation of Th2 cells, production of allergen-specific IgE antibodies, release of inflammatory mediators from mast cells and basophils, recruitment and activation of eosinophils, and modulation by regulatory T cells. Understanding the immune pathways involved in allergic reactions is essential for developing targeted therapies and interventions to effectively manage allergic diseases and improve patient outcomes.