THE INTERPLAY BETWEEN GUT MICROBIOTA, IMMUNE TOLERANCE, AND REGULATORY T-CELLS IN ALLERGIC DISEASES

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Introduction. Allergic diseases, including atopic dermatitis, allergic rhinitis, food allergy, and bronchial asthma, are characterized by inappropriate immune responses to otherwise harmless environmental antigens. The development of these conditions involves genetic predisposition, environmental exposures, epithelial barrier dysfunction, and alterations in immune regulation. Increasing evidence suggests that the gut microbiota contributes to immune system maturation and the establishment of immune tolerance, particularly during early childhood.

Materials and Methods. This thesis is based on a narrative review of scientific literature addressing the role of gut microbiota in immune regulation, the mechanisms of regulatory T-cell differentiation, and the relationship between intestinal dysbiosis and allergic diseases.

Results and Discussion. The gut microbiota contributes to immune homeostasis through interactions with intestinal epithelial cells, antigen-presenting cells, and lymphocytes. Certain commensal bacteria stimulate the production of short-chain fatty acids, including acetate, propionate, and butyrate, through the fermentation of dietary fibers. These metabolites can promote regulatory T-cell differentiation and activity by influencing histone deacetylases, G-protein-coupled receptors, and the expression of immunoregulatory molecules.

Regulatory T cells, characterized by the expression of CD4, CD25, and the transcription factor FOXP3, are essential for maintaining peripheral immune tolerance. They suppress excessive immune responses through mechanisms involving interleukin-10 (IL-10), transforming growth factor-beta (TGF-β), and direct interactions with other immune cells. Adequate Treg activity may limit type 2 helper T-cell (Th2)-mediated responses, which are central to many allergic conditions.

In contrast, intestinal dysbiosis may disrupt microbial metabolite production, weaken epithelial barrier integrity, and alter antigen-presenting cell

function. These changes may reduce regulatory immune responses and favor Th2-associated inflammation, immunoglobulin E (IgE) production, and mast-cell activation. However, the effects of individual microorganisms vary according to the host, microbial strain, developmental stage, diet, and environmental conditions.

Although experimental studies support a mechanistic relationship between microbiota-derived metabolites and Treg function, human evidence remains heterogeneous. Probiotics, prebiotics, and dietary interventions may influence immune responses, but their clinical efficacy varies across allergic diseases and populations. Therefore, microbiota-targeted interventions require further investigation before they can be recommended as universal strategies for allergy prevention or treatment.

Conclusion. The gut microbiota, immune tolerance, and regulatory T cells form an interconnected system that contributes to the maintenance of immune homeostasis. Microbial dysbiosis may impair Treg-mediated regulation and facilitate allergic inflammation. A better understanding of microbiota-derived metabolites and their effects on regulatory immune pathways could support the development of targeted approaches to allergic disease management. Further longitudinal and mechanistic studies are needed to establish causality and identify effective, disease-specific interventions.

REFERENCES

1. Arpaia N., Campbell C., Fan X., et al. Metabolites produced by commensal bacteria promote peripheral regulatory T-cell generation. Nature. 2013;504:451–455.
2. Furusawa Y., Obata Y., Fukuda S., et al. Commensal microbe-derived butyrate induces the differentiation of colonic regulatory T cells. Nature. 2013;504:446–450.
3. Honda K., Littman D.R. The microbiota in adaptive immune homeostasis and disease. Nature. 2016;535:75–84.
4. Renz H., Allen K.J., Sicherer S.H., et al. Food allergy. Nature Reviews Disease Primers. 2018;4:17098.