THE ROLE OF CELLULAR IMMUNITY IN OBESITY

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Abstract. Obesity has become one of the most prevalent non-communicable diseases worldwide and is recognized as a major risk factor for numerous metabolic, cardiovascular, and endocrine disorders. Traditionally considered a consequence of excessive energy intake and reduced physical activity, obesity is now increasingly viewed as a chronic low-grade inflammatory condition characterized by profound alterations in immune system function. In recent years, growing evidence has highlighted the critical role of cellular immunity in the development, progression, and complications of obesity. Understanding the interactions between immune cells and adipose tissue is essential for elucidating the pathogenesis of obesity and identifying novel therapeutic targets.

Keywords: Obesity, cellular immunity, T lymphocytes, macrophages, chronic inflammation, adipokines, insulin resistance, immunometabolism.

Adipose tissue is no longer regarded solely as an energy storage organ but rather as a dynamic endocrine and immunologically active tissue. Under physiological conditions, adipose tissue contains a variety of immune cells, including macrophages, T lymphocytes, B lymphocytes, dendritic cells, neutrophils, eosinophils, and natural killer cells. These cells contribute to tissue homeostasis and metabolic regulation. However, excessive accumulation of adipose tissue results in significant changes in the immune microenvironment, leading to chronic inflammation and metabolic dysfunction.

One of the earliest immunological events observed in obesity is the infiltration of adipose tissue by pro-inflammatory immune cells. Studies have demonstrated an increased accumulation of CD8+ T lymphocytes and T helper 1 (Th1) cells within visceral adipose tissue. These cells produce inflammatory cytokines such as interferon-gamma (IFN-γ) and tumor necrosis factor-alpha (TNF-α), which stimulate macrophage recruitment and activation. As obesity progresses, macrophages become one of the predominant immune cell populations within adipose tissue. The number of macrophages may increase from approximately 10% of total cells in lean individuals to more than 50% in obese individuals.

Macrophages in obese adipose tissue predominantly exhibit the M1 pro-inflammatory phenotype. These activated macrophages secrete a variety of inflammatory mediators, including TNF-α, interleukin-1β (IL-1β), and interleukin-6 (IL-6). The sustained production of these cytokines contributes to systemic inflammation and interferes with insulin signaling pathways, thereby promoting insulin resistance and increasing the risk of type 2 diabetes mellitus. In addition, inflammatory cytokines can influence lipid metabolism, endothelial function, and cardiovascular health.

Regulatory T cells (Tregs) play a crucial role in maintaining immune tolerance and controlling excessive inflammatory responses. In healthy adipose tissue, Tregs contribute to the preservation of metabolic homeostasis by suppressing pro-inflammatory immune activity. Obesity is associated with a significant reduction in both the number and function of Treg cells, resulting in an imbalance between inflammatory and anti-inflammatory mechanisms. This shift favors chronic inflammation and accelerates the progression of metabolic disturbances.

Another important aspect of cellular immunity in obesity involves T helper 17 (Th17) cells. Increased differentiation and activation of Th17 cells have been observed in obese individuals. These

cells produce interleukin-17 (IL-17), a cytokine associated with inflammation, autoimmune responses, and metabolic dysfunction. The imbalance between Th17 cells and Treg cells is considered a key mechanism linking obesity to chronic inflammatory diseases.

Natural killer (NK) cells and dendritic cells also participate in obesity-associated inflammation. NK cells contribute to macrophage activation through cytokine production, while dendritic cells facilitate antigen presentation and T-cell activation. Furthermore, obesity affects the function of B lymphocytes, which can produce pro-inflammatory cytokines and pathogenic antibodies that exacerbate tissue inflammation.

Recent research has introduced the concept of "metaflammation," a form of chronic metabolic inflammation driven by excess nutrient availability and adipose tissue expansion. Unlike classical acute inflammation, metaflammation develops gradually and persists over long periods. Cellular immune responses play a central role in maintaining this inflammatory state, thereby contributing to the development of obesity-related complications, including type 2 diabetes mellitus, atherosclerosis, hypertension, non-alcoholic fatty liver disease, and certain cancers.

The interaction between adipocytes and immune cells is mediated by numerous adipokines, including leptin, adiponectin, resistin, and visfatin. Leptin, whose levels are elevated in obesity, exerts significant immunomodulatory effects by promoting T-cell activation and pro-inflammatory cytokine production. In contrast, adiponectin possesses anti-inflammatory properties and is typically reduced in obese individuals. These alterations further contribute to immune dysregulation and chronic inflammation.

Current evidence suggests that targeting immune pathways may represent a promising strategy for obesity treatment. Modulation of macrophage polarization, restoration of Treg function, inhibition of pro-inflammatory cytokines, and regulation of adipokine signaling are being actively investigated as potential therapeutic approaches. Such strategies may complement traditional interventions focused on diet, physical activity, and pharmacological management.

Conclusion

Cellular immunity plays a fundamental role in the pathogenesis of obesity and its associated metabolic complications. The infiltration of adipose tissue by immune cells, the activation of pro-inflammatory pathways, and the disruption of immune homeostasis contribute significantly to chronic inflammation and metabolic dysfunction. Advances in immunometabolic research have improved our understanding of the complex relationship between the immune system and obesity. Further studies are required to identify novel biomarkers and therapeutic targets that may help reduce the global burden of obesity and its complications.

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