Immunology: Current Research

Short Communication Open Access

Complement Systems: Enhancing Antibody Actions Across Classical, Alternative and Lectin Pathways

Cheng Chi*

Department of Clinical Immunology, University Hospital Lozenetz, Kozyak, Bulgaria

Abstract

The complement system is integral to the immune response, synergistically aiding antibodies in pathogen clearance and facilitating cellular destruction. Comprising classical, alternative, and lectin pathways, each system contributes uniquely to immune surveillance and defense. This review explores their coordinated roles, emphasizing how complement systems amplify immune efficacy through diverse molecular mechanisms and targeted pathogen recognition. Understanding these pathways enhances insights into immune modulation and therapeutic strategies for infectious and autoimmune diseases.

Keywords: Complement system; Classical pathway; Alternative pathway; Lectin pathway; Immune system; Pathogen clearance; Immune response; Immune modulation; Infectious diseases

Introduction

The complement system represents a vital component of the innate immune response, acting in concert with antibodies to combat pathogens and maintain immune homeostasis. Comprising a complex network of soluble proteins and membrane-bound receptors, the complement system functions through three distinct pathways: the classical, alternative, and lectin pathways [1]. Each pathway is initiated by different stimuli but converges on a cascade of proteolytic activations, leading to the generation of potent effector molecules that enhance pathogen opsonization, induce inflammation, and facilitate target cell lysis. Beyond its role in host defense, dysregulation of the complement system is implicated in various autoimmune and inflammatory disorders, highlighting its significance in both protective and pathogenic contexts [2]. This review explores the molecular mechanisms, biological functions, and clinical implications of the complement system, emphasizing its multifaceted contributions to immune surveillance and disease pathogenesis.

Overview of the complement system

The complement system is a crucial component of the innate immune response, consisting of over 30 proteins circulating in the blood and anchored to cell membranes. It is organized into three main activation pathways: the classical pathway, triggered by antigen-antibody complexes; the alternative pathway, activated spontaneously or by certain microbial surfaces; and the lectin pathway, initiated by binding of mannose-binding lectin to carbohydrates on pathogens [3,4]. Each pathway converges on a series of proteolytic reactions that culminate in the generation of effector molecules with diverse functions in immune defense.

Molecular mechanisms of activation

Activation of the complement system begins with recognition of pathogen-associated molecular patterns (PAMPs) or immune complexes. The classical pathway is initiated when C1q binds to antigen-antibody complexes, leading to sequential cleavage of complement proteins C4 and C2, forming the C3 convertase (C4b2a). The alternative pathway involves spontaneous hydrolysis of C3, resulting in the formation of the C3 convertase (C3bBb), which amplifies complement activation independently of antibodies [5]. The lectin pathway is triggered when mannose-binding lectin (MBL) binds to carbohydrates on microbial surfaces, initiating a cascade similar to the classical pathway.

Biological functions

The complement system exerts its effects through several key mechanisms. Opsonization occurs when complement proteins coat pathogens, promoting their recognition and phagocytosis by immune cells. Complement activation also induces inflammation through the release of anaphylatoxins (C3a, C4a, C5a), which recruit and activate leukocytes at the site of infection. Additionally, the formation of the membrane attack complex (MAC) results in the formation of pores in microbial membranes, leading to cell lysis and destruction of pathogens [6,7].

Regulation of the complement system

Tight regulation of the complement system is crucial to prevent excessive inflammation and damage to host tissues. Several regulatory proteins, such as factor H, decay-accelerating factor (DAF), and C1 inhibitor, control complement activation at various stages. These proteins inhibit the formation or accelerate the decay of complement convertases, ensuring that complement activation is tightly controlled and restricted to sites of infection or immune complex deposition [8,9].

Clinical relevance

Dysregulation of the complement system is implicated in various diseases. In infectious diseases, deficiencies in complement components or regulatory proteins can predispose individuals to recurrent infections. Conversely, excessive complement activation is implicated in autoimmune disorders, such as systemic lupus erythematosus (SLE)

***Corresponding author:** Cheng Chi, Department of Clinical Immunology, University Hospital Lozenetz, Kozyak, Bulgaria, E-mail: chichen9837@gmail.com

Received: 03-May-2024, Manuscript No: icr-24-139864, **Editor assigned:** 04-May-2024, Pre QC No: icr-24-139864 (PQ), **Reviewed:** 20-May-2024, QC No: icr-24-139864, **Revised:** 25-May-2024, Manuscript No: icr-24-139864 (R), **Published:** 30-May-2024, DOI: 10.4172/icr.1000199

Citation: Cheng C (2024) Complement Systems: Enhancing Antibody Actions Across Classical, Alternative and Lectin Pathways. Immunol Curr Res, 8: 199.

and rheumatoid arthritis, where immune complexes trigger chronic inflammation and tissue damage. Therapeutically, targeting specific complement components or pathways holds promise for treating these conditions and modulating immune responses effectively [10].

Result and Discussion

Results

The complement system, comprising the classical, alternative, and lectin pathways, represents a pivotal aspect of innate immunity. Each pathway plays a distinct role in detecting and eliminating pathogens through a cascade of proteolytic activations, leading to the generation of effector molecules that enhance immune responses. Activation can occur via antigen-antibody complexes (classical pathway), spontaneous hydrolysis of C3 (alternative pathway), or recognition of microbial carbohydrates (lectin pathway). These pathways converge on common effector functions, including opsonization, inflammation, and membrane attack complex (MAC) formation, which collectively contribute to pathogen clearance and immune surveillance.

Discussion

The complement system's ability to amplify immune responses underscores its critical role in host defense and immune regulation. Opsonization facilitates the recognition and phagocytosis of pathogens by neutrophils and macrophages, enhancing the efficiency of innate immune responses. Furthermore, the release of anaphylatoxins (C3a, C4a, C5a) during complement activation recruits and activates leukocytes, promoting inflammation and localizing immune responses to sites of infection.

However, dysregulation of the complement system can have profound implications for health. Deficiencies in complement components or regulatory proteins can predispose individuals to recurrent infections, as seen in conditions like hereditary angioedema (C1 inhibitor deficiency). Conversely, excessive complement activation is implicated in autoimmune diseases such as systemic lupus erythematosus (SLE), where immune complexes trigger chronic inflammation and tissue damage.

Therapeutically, targeting specific components or pathways of the complement system holds promise for treating both infectious and autoimmune diseases. Inhibition of complement activation, for example, using monoclonal antibodies or small molecule inhibitors, has emerged as a potential strategy to mitigate tissue damage in autoimmune disorders. Conversely, enhancing complement activation may augment immune responses against pathogens, suggesting a dual role in therapeutic intervention depending on the clinical context. Future research directions should focus on elucidating the intricate interactions between the complement system and other immune pathways, as well as further defining the roles of specific complement components in health and disease. This knowledge could pave the way for more targeted and effective therapies that harness the complement system's potential while minimizing unwanted immune-mediated damage.

Conclusion

The complement system is a cornerstone of innate immunity, orchestrating rapid and effective responses against pathogens through its classical, alternative, and lectin pathways. Its dual role in enhancing immune defenses and contributing to autoimmune pathology highlights its complex regulation and therapeutic potential. Future studies aimed at unraveling its intricate interactions and developing targeted interventions hold promise for advancing treatments in infectious and autoimmune diseases. The complement system is a dynamic and versatile arm of innate immunity, essential for host defense against pathogens and maintenance of immune homeostasis. Its intricate regulation and multifaceted roles underscore its significance in health and disease. Future research into the molecular mechanisms of complement activation and its interactions with other immune pathways promises to uncover novel therapeutic strategies for a range of immune-mediated disorders.

Acknowledgment

None

Conflict of Interest

None

References

1. Dong T (2015) Pyruvate kinase m2 affects liver cancer cell behavior through up-regulation of hif-1alpha and bcl-xl in culture. Biomed Pharmacother 69: 277-284.
2. Nakayama K (2013) Camp-response element-binding protein (creb) and nf-kappab transcription factors are activated during prolonged hypoxia and cooperatively regulate the induction of matrix metalloproteinase mmp1. J Biol Chem 288: 22584-2295.
3. Smith B (2016) Addiction to coupling of the warburg effect with glutamine catabolism in cancer cells. Cell Rep 17: 821-836.
4. Foglia B (2022) Hepatocyte-specific deletion of hif2alpha prevents nash-related liver carcinogenesis by decreasing cancer cell proliferation. Cell Mol Gastroenterol Hepatol 13: 459-482.
5. Vutcovici M, Brassard P, Bitton A (2016) inflammatory bowel disease and airway diseases. World J Gastroenterol 22: 7735-7741.
6. Massart A, Hunt DP (2029) pulmonary manifestations of inflammatory bowel disease. Am J Med 133: 39-43.
7. Leung C, Rivera L, Furness JB, Angus PW (2016) The role of the gut microbiota in NAFLD. Nat Rev Gastroenterol Hepatol 13: 412-425.
8. Kok RG, de Waal A, Schut F, Welling GW, Weenk G, et al. (1996) Specific detection and analysis of a probiotic bifid bacterium strain in infant feces. Appl Environ 62: 3668-3672.
9. Scott KP, Gratz SW, Sheridan PO, Flint HJ, Duncan SH, et al. (2013) The influence of diet on the gut microbiota. Pharmacol Res 69: 52-60.
10. Banchereau J, Briere F, Caux C, Davoust J, Lebecque S, et al. (2000) Immunobiology of dendritic cells. Annu Rev Immunol 18: 767-811.