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Review of the immunology: the innate and adaptive immunity in Animals

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***Abstract*— The immune system is a complex network of organs containing cells that identify the foreign object in the body. The immune system function is simple yet challenging to eliminate pathogenic agents. Every animal has a rudimentary defensive mechanism against the infections to which they are susceptible. This defense is called innate or natural immunity. No pathogen can infiltrate or attack every organism, even if there are many that have the potential to be harmful. This is because a pathogen can only inflict harm on a susceptible host, and not all species are susceptible to the same pathogens. This review highlights our current understanding of the various immune system components and how they work together to defend the host against pathogens.**

***Keywords* — Innate Immunity, Adaptive Immunity, Immune System, Pathogens, Antimicrobial Peptides, Antimicrobial Peptides, Complement System, T Cells, B Cells.**

I. INTRODUCTION

ANIMALS are constantly in danger of being invaded by microbes. Usually, the colon, respiratory system, and skin are the entry points for these invaders into the body. The gut's vast and varied microbiota fills a niche that prevents other species from colonizing, protecting the intestine from infectious invaders. Animal-transmitted infectious pathogens are among the other possible invaders. The body employs a variety of tactics that when combined provide an extremely potent defense to stop this microbial invasion (1). Every animal has a rudimentary defensive mechanism against the infections to which they are susceptible. It is known as innate immunity, or natural immunity (2). One of the two primary immunologic processes present in animals is innate immunity. The innate immune subsystem's primary roles include inflammation, anatomic defenses against infectious pathogens, chemical defenses such complement cascade activation, and nonspecific immune cells. (3,4). The innate immune system responds quickly to infections or signs of danger. It is precisely triggered to prevent excessive inflammation and tissue damage in addition to effectively eliminating infections (5). An innate immune system generally has short-term memory and offers immediate, if insufficient, defense against invaders. It begins slowly from scratch every time it encounters a known trespasser, as opposed to mounting a quicker and more efficient response. Furthermore, innate immunity has drawbacks. Innate cell-used receptors, like the TLR, are skilled at differentiating between self and non-self (6). Innate immunity consists of various components, including physical barriers (tight junctions in the skin, epithelial and mucous membrane surfaces, and mucus), anatomical barriers, enzymes from epithelial and phagocytic cells (such as lysozyme), phagocytes (including neutrophils, monocytes, and macrophages), inflammation-related serum proteins (such as complement, C-reactive protein, mannose-binding lectin, and ficolins), surface and phagocyte granule antimicrobial peptides (such as defensins and cathelicidin), cell receptors that detect microorganisms and initiate a defensive response (such as Toll-like receptors), and cells that secrete cytokines and inflammatory mediators (including macrophages, mast cells, and natural killer cells). A signaling cascade that enhances the immune response and activates certain mechanisms is initiated immediately upon the interaction between host and pathogen. (7,8).

II. CHEMICAL BARRIER IN THE INNATE IMMUNITY

An essential function of antimicrobial peptides (AMPs) is to support cutaneous innate immunity. Numerous animals, including mammals, have them in their skin. They are both constitutively present and can be induced by damage or infection (9). Depending on their peptide structure, antimicrobial peptides have varying degrees of antimicrobial activity against bacteria, viruses, fungi, and parasites. Additionally, they function as multipurpose effector molecules that affect a variety of biological functions, such as cell motility, proliferation, and differentiation (10). Numerous antimicrobial peptides are found in tissues. Among them are the following:

detergent-like proteins that have the ability to lyse bacterial cell walls, such as cathelicidins and defensins. enzymes that destroy a lot of gr am-positive bacteria, including lysozyme. Hepcidin and haptoglobin are examples of iron-binding

proteins that stop bacteria from growing by depriving them of vital iron (11).

III. Complement System

An important component of humoral immunity as well as innate immunity is the complement system. It is made up of about thirty proteins that work together to eliminate invasive bacteria. The proteins are numbered in the order of their action and are identified alphanumerically (C1, C2, C3, C4,..etc). The complement system's main function is to bind C3 and C4 to microbial surfaces covalently, which makes the binding irreversible (12,13). Degradative enzymes and harmful oxygen metabolites are produced when the complement cascade is activated by one of several paths. Complement proteins (C4b, C3b) are deposited and recognized by WBC receptors (14). The classical mechanism of complement activation is initiated when antibodies attach to bacteria surfaces. A secondary complement-activating pathway is initiated when bacterial surface carbohydrates interact with a mannose-binding protein in serum. The alternative pathway, a third mechanism of the activation of complement, is initiated by bacterial surfaces that bind C3 (15).

IV. Cells of the innate immunity

Rapid cellular response and early detection of invasion are essential components of a successful innate immune response. Numerous cell types serve as sentinel cells. (16,17). cells (e.g., dendritic cells, innate lymphoid cells, monocytes or macrophages, and neutrophils). The first line of defense for a host is innate immunity, which is crucial for avoiding infection while allowing for normal host flora (18).

- Neutrophils are very adept at eliminating pathogenic microorganisms. They engulf the invaders, initiate the respiratory burst, and produce fatal oxidizing agents such as hydrogen peroxide and hypochlorite ions that eliminate most ingested bacteria.
- Eosinophils are specialized effector cells that target and eliminate invading parasites. They comprise enzyme combinations specifically formulated to eliminate migratory helminth larvae.Macrophages are the third principal population of cytotoxic cells. These cells travel to regions of microbial invasion at a slower rate than granulocytes. Nonetheless, they possess the ability for prolonged and efficient phagocytosis. They possess the potent antibacterial agent nitric oxide, enabling them to eliminate pathogens resistant to neutrophil-mediated destruction.
- Natural killer (NK) cells constitute a subset of innate lymphoid cells specialized in the elimination of virus-infected cells. (19,20).

V. Adaptive immunity

Innate immunity and adaptive immunity combine to give vertebrates a stronger defense against pathogens, parasites, and other foreign objects. Nevertheless, adaptive immunity is also in responsible for allergy responses and transplanted tissue rejection since it may confuse it for a dangerous foreign invader. (21). The binding of pathogen-associated molecular patterns (PAMP) to Toll-like receptors (TLR) stimulates the generation of reactive oxygen and nitrogen intermediates (ROI and RNI), pro-inflammatory cytokines, and enhances the expression of co-stimulatory molecules, thereby starting adaptive immunity (22). The adaptive immune system assumes control. The adaptive immune system precisely identifies the specific pathogen responsible for the infection. However, it must first identify the germ as such. This indicates that it responds more slowly than the innate immune system, yet it is more precise upon activation (23,24). Besides specificity, a key characteristic of adaptive immunity is the formation of immunologic memory. Upon initial exposure to an antigen (pathogen), populations of enduring memory T and B lymphocytes are formed. Upon subsequent exposure to the identical pathogen, the memory cells are promptly triggered to produce a swifter and more vigorous defensive response (25). T and B cells constitute the principal elements of the adaptive immune system, both exhibiting highly specialized antigen receptors on their surfaces(26).

VI. T-cell development

The T cell serves as a conduit between the innate and adaptive immune systems (27). T cells originate in the thymus from common lymphoid progenitors derived from the bone marrow. The seeding of the thymus is facilitated by the contact between platelet selectin glycoprotein on progenitors and the adhesion molecule P-selectin on thymic epithelium. Recently arrived cells swiftly proliferate in response to IL-7, which receptor transmits signals via the common γ chain, encoded on the X chromosome, and utilized by several other cytokine receptors (28). The majority of T cells generate a multimeric T cell receptor (TCR) including α (alpha) and β (beta) chains, but a minority express γ (gamma) and δ (delta) chains (29).

VII. B-cell development

B cells perform several critical activities in the adaptive immune system, including antibody synthesis, antigen presentation, cytokine release, and the establishment of appropriate lymphoid architecture (30). B cells begin in the bone marrow, where they grow and generate an initial varied array of non-self-reactive B-cell receptors. Upon relocation to the periphery, naïve B lymphocytes encounter antigens presented by dendritic and other antigen-presenting cells. B cells that encounter and recognize an antigen become activated, proliferate, and then modify the B-cell receptor to enhance antigen specificity via somatic hypermutation and affinity maturation. The B-cell receptor is then released as an active, mature antibody. Antibodies may identify and attach to bacteria, viruses, and other antigens, triggering a series of reactions that eliminate pathogens from the body (31). B cells generate particular antibodies that kill infections, enhance phagocytosis by opsonization, and activate the complement system. The T cell response is facilitated by the T cell receptor (TCR). The T cell receptor (TCR) recognizes antigenic peptides displayed on macrophages after the phagocytosis of pathogens, including bacteria, as well as peptides from cytosolic pathogens, such as viruses, presented on infected cells (32).

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