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The Role of Natural Physical, Mechanical, and Biochemical Barriers as Innate Immunity: A Narrative Literature Review

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A B S T R A C T

The specialized epithelial outer layer, including the skin and mucosal surfaces, is relatively resistant to most environmental hazards and resistant to infection by disease-causing microorganisms. This literature review aimed to describe the role of natural physical, mechanical, and biochemical barriers in innate immunity. The physical barrier that protects against damage and infection consists of closely related epithelial cells, including the skin and the sheet membranes that line the digestive tract, genitourinary, and breathing. The epithelial surface also provides a biochemical barrier by synthesizing and secreting substances intended to trap or destroy microorganisms (chemicals derived from the epithelium). Mucus, sweat, saliva, tears, and earwax are examples of biochemical secretions that can trap and kill potential disease-causing microorganisms. Microorganisms in the microbiome do not usually cause disease, although some are opportunistic in that they can cause disease if the integrity of the body surface is compromised or the individual's immune or inflammatory systems are damaged. In conclusion, natural barriers include physical, mechanical, and biochemical on the surface of the body and are present from birth to prevent damage by substances in the environment and prevent infection by pathogenic microorganisms.

1. Introduction

The immune system is the body's defense mechanism that is owned by each individual as the body's defense system against various disturbances from the outside environment. Without this defense system, our body will be very vulnerable to attacks by various microorganisms from outside. The body has two immune systems, namely innate immunity and adaptive immunity. Innate immunity is a natural body defense system that is always present and ready to block various disturbances from outside the body.[1,2]

The specialized epithelial outer layer, including the skin and mucosal surfaces, is relatively resistant to most environmental hazards and resistant to infection by disease-causing microorganisms. If the epithelial barrier is damaged, highly efficient local and systemic responses (inflammatory) are mobilized to limit the extent of damage, protect against infection, and initiate the repair of damaged tissue. The natural epithelial barrier and inflammation provide resistance and innate immunity.[3,4] This review aimed to outline the role of natural physical, mechanical, and biochemical barriers in innate immunity.

Physical and mechanical barriers

The physical barrier that protects against damage and infection consists of closely related epithelial cells, including the skin and the sheet membranes that line the digestive tract, genitourinary, and breathing. Mucosal epithelial cells are highly interconnected

junctions that prohibit the entry of microorganisms into the underlying tissues. Normal turnover of cells at these sites as well as mechanisms for mechanical cleaning of surfaces, can eliminate many infectious microorganisms and prevent their establishment on the epithelial surface. For example, regular peeling and replacement of Dead skin cells also remove attached bacteria. Mechanical cleaning of surfaces, including vomiting and urination. Upper respiratory goblet cells produce mucus which coats the surface of the epithelium and traps microorganisms that are secreted by hairlike cilia, which mechanically move mucus upwards to be expelled by coughing or sneezing. In addition, low skin temperature and low skin and stomach pH generally inhibit microorganisms, most of which prefer temperatures closer to 37°C (98.6°F) and closer to neutral pH for more efficient growth.[5-9]

Biochemical barriers

The epithelial surface also provides a biochemical barrier by synthesizing and secreting substances intended to trap or destroy microorganisms (chemicals derived from the epithelium). Mucus, sweat, saliva, tears, and earwax are examples of biochemical secretions that can trap and kill potential disease-causing microorganisms. The sebaceous glands in the skin secrete antibacterial and antifungal fatty acids and lactic acid. Sweat, tears, and saliva contain enzymes (lysozymes) that attack the cell walls of gram-positive bacteria. The secretions of these glands produce an acidic skin surface (pH 3 to 5), which is an inhospitable environment for most bacteria.[10-12]

Epithelial cells secrete complex arrays of proteins that destroy potential pathogens. Small molecular weight antimicrobial peptides are generally positively charged polypeptides consisting of about 15 to 95 amino acids and can be divided into two classes—cathelicidins and defensins—on the basis of their three-dimensional chemical structure. Both classes exist in very high local concentrations and are toxic to some bacteria, fungi, and viruses. The cathelicidins-helixes have a linear shape, and only one is currently known to function in humans. In contrast, about 50 different defensins have been identified so far. All of them are three-stranded -sheet structures. Defensin molecules contain 3 intrachain disulfide bonds and can be subdivided into α (at least 6 identified in humans) and β types (at least 10 identified, but possibly up to 40 different molecules), depending on how the cysteine residues are connected during the formation of the disulfide bonds. α-defensins often require activation by proteolytic enzymes, whereas β-defensins are synthesized in an active form. Bacteria have cell membranes free of cholesterol, which allows cathelicidins to enter and disrupt their membranes. Given the similarity in chemical charge, defensins can kill bacteria in a similar way. These same chemicals can also contribute to other modes of protection because they are also produced by monocytes, macrophages, and neutrophils, which are components of the inflammatory response. Cathelicidins are stored in neutrophils, mast cells, and various epithelial cells. α-defensins are very rich in neutrophil granules and may contribute to the killing of bacteria by these cells. They are also found in Paneth cells lining the small intestine, where they protect against various disease-causing microorganisms. β-Defensins are found in the epithelial cells lining the respiratory, urinary, and intestinal tracts, as well as in the skin. In addition to its antibacterial properties, β-defensins can also help protect epithelial surfaces from human immunodeficiency virus (HIV) infection. Both classes of antimicrobial peptides can also activate innate and adaptive immune cells.[13-15]

The lungs also produce and secrete a family of glycoproteins, the collectors, which include surfactant proteins A through D and mannose-binding lectins. Collectins react with different affinities to carbohydrates and lipids on the surfaces of various pathogenic microorganisms. Collector binding facilitates the recognition of microorganisms by macrophages, enhancing macrophage attachment, phagocytosis, and killing. Mannose-binding lectin (MBL) recognizes sugars commonly found on microbial surfaces and is a potent activator of the plasma protein

(complementary) system resulting in bacterial damage or increased recognition by macrophages.[16]

Other epithelial antimicrobials include resistin-like molecules, bactericidal/permeability-inducing proteins, and antimicrobial lectins. The resistin-like molecule is found in intestinal goblet cells, where it appears to protect against helminth infections. Bactericidal/permeability-inducing protein (BPI) is stored in neutrophils and intestinal epithelium. The BPI protein specifically reacts with lipopolysaccharides on the surface of gram-negative bacteria, causing bacterial lysis. Antimicrobial lectins are carbohydrates found in the intestinal epithelium and have activity against gram-positive bacteria.[14]

Normal microbiome

The body's surface is colonized by a spectrum of microorganisms. The microbiome is normal. Every surface, including the skin and mucous membranes of the eyes, upper and lower digestive tract, urethra, and vagina, is colonized by combinations of bacteria and fungi that are unique to the particular location and individual. Microorganisms in the microbiome do not usually cause disease, although some are opportunistic in that they can cause disease if the integrity of the body surface is compromised or the individual's immune or inflammatory systems are damaged. The microbiome's relationship with humans is referred to as commensal (benefit one organism without affecting another); however, the connection may be more mutual (to the benefit of both organisms). Using the large intestine as an example, at birth, the lower intestine is relatively sterile, but colonization with bacteria begins rapidly, with number, diversity, and concentration increasing progressively during the first year of life. For the benefit of humans, many of these microorganisms help digest fatty acids, large polysaccharides, and other food substances; produce biotin and vitamin K; and aid in the absorption of ions, such as calcium, iron, and magnesium.[17]

These bacteria contribute to the innate protection of the human body against pathogenic microorganisms in the large intestine. They compete with pathogens for nutrition and block attachment to the epithelium. Members of the normal microbiome also produce chemicals (ammonia, phenols, indoles, and other toxic materials) and toxic proteins. *(bacteriocin)* which inhibit colonization by pathogenic microorganisms. Long-term treatment with broad-spectrum antibiotics may alter the normal gut microbiome, decrease its protective activity, and lead to the overgrowth of opportunistic pathogenic microorganisms, such as yeast. *Candida albicans* or bacteria *clostridium difficile* (overgrowth can cause pseudomembranous colitis, infection). From the large intestine). In addition, the normal gut microbiome helps train the adaptive immune system by inducing the growth of gut-associated lymphoid tissue (where adaptive immune system cells reside) and the development of local and systemic adaptive immune systems.[18]

*Lactobacillus b*acteria are major constituents of the normal vaginal microbiome in healthy women: at least 22 distinct species of *Lactobacillus have* been identified in the vaginal microbiome, with 4 among them dominantly represented. These microorganisms produce various chemicals (e.g., hydrogen peroxide, lactic acid, bacteriocins) that help prevent vaginal and urinary tract infections by other bacteria and yeast. Long-term antibiotic treatment may reduce the colonization of *Lactobacillus* and increase the risk of urological or vaginal infections, such as vaginosis.[19]

Opportunistic microorganisms are usually controlled by the innate and adaptive immune systems and contribute to the defense of the human body. For example, *Pseudomonas aeruginosa* are members of the normal skin microbiome and produce toxins that protect against staphylococcal and other bacterial infections. However, severe burns compromise the integrity of the skin and can lead to life-threatening systemic pseudomonal infections.[20]

2. Conclusion

Natural barriers include physical, mechanical, and biochemical on the surface of the body and are present from birth to prevent damage by substances in the

environment and prevent infection by pathogenic microorganisms.

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