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Sears's Anatomy & Physiology for NURSES

As per INC Syllabus



7th Edition

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CHAPTER

3 Immunity

The body has a variety of defenses against microbial invaders. Some of these immune mechanisms are innate and are present from birth; they are non-specific in that they counteract a wide variety of infective agents. In contrast, acquired immune mechanisms are specific, each being directed against a particular microorganism.

INNATE IMMUNITY

There are major differences between species, and between strains within species, in susceptibility to infection. A dog, for example, stands no risk whatever of catching a cold from its master. Lesser determinants of innate immunity are individual genetic factors, age, sex, nutritional status and hormonal balance.

The intact skin, and particularly its outer horny layer, affords an effective mechanical barrier to the entry of microorganisms into the body. The mucous membranes, not having a horny layer, afford less protection but have mechanical mechanisms of their own. For example, the mucosa of the respiratory tract traps particles in its moisture and they are swept upwards, by the hair-like processes or cilia (performing mechanical cleansing), to reach the oropharynx, from which they are swallowed or expectorated. Unfortunately the cilia may be disabled by a variety of agents, including viruses which infect the respiratory tract. In the gastrointestinal tract, a layer of mucus traps organisms and peristaltic movement prevents stagnation and bacterial overgrowth. A high flow rate of secretions, as in the urinary and biliary tracts, discourages bacterial proliferation; such regions are usually sterile but may become infected if flow is impeded, by calculi or by prostatic obstruction of the bladder neck, for example. Temperature is also a factor in the innate immunity of an animal to some infective agents. Whilst warm blooded animals are susceptible to tuberculosis, for example, cold-blooded animals are immune because the tubercle bacillus is temperature dependent.

Chemical factors also protect against infection. Among these, the fatty acids on the surface of the skin have an antiseptic action. These are present in the secretions of the sebaceous glands and are also produced by Proprionobacterium acnes, which is a member of the normal microflora of the skin. The normal microflora also provides protection from pathogens in other ways. Large numbers of microorganisms live in a close harmonious relationship with humans and are known as commensals. The acidity of sweat (pH 5.5) also has a microbiocidal effect.

Lysozyme, an enzyme secreted by macrophages, is found in large quantities in human tears and helps to prevent bacterial conjunctivitis. It is found in relatively high concentration in most tissue fluids and in polymorphonuclear leukocytes, although it is nor synthesized by these cells. Lysozyme disables or destroys many Gram-positive bacteria by chemically attacking their cell

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walls, breaking them up, a process known as lysis. The macrophages then remove damaged cells and bacteria from the tissues. Macrophages are large cells which are derived from the bone marrow but are distributed widely throughout the body and congregate at the site of an inflammatory response.

In the course of infection and inflammation, a variety of basic polypeptides released from damaged cells have a destructive effect on certain bacteria. The levels of a number of other 'acute phase' substances are increased in the blood in the inflammatory response but the roles of many of them are unclear.

A major defense mechanism is provided by a complex group of proteins, all of large molecular size, collectively known as complement. They form a series of enzymes which can be activated directly by some bacteria and indirectly, with the help of antibody, in other cases. Activated products of the complement system help in the first-line host defence against microorganisms, destroying them by lysis, and they mediate inflammatory changes. Complement can also lyse red cells (hemolysis) and indeed much of our knowledge of the complement system comes from studies of immune hemolysis.

The complement system is a triggered enzyme cascade system in which circulating inactive forms (proenzymes) are converted into active forms by their predecessors in the cascade. The complement system can be activated in two ways, known as the classical pathway and the alternate pathway. Tile classical pathway is typically initiated by complexes of antibody and antigen whereas the alternate pathway can be activated in the absence of antibody. Three stages are involved in the activation of the system, namely the recognition stage, the activation stage and the membrane attack stage.

The components of the complement system are known by their numbers, C1 to C9 and, of these components, C3 is the most abundant. The main sources of complement components are the intestinal epithelium, the macrophages, the liver and the spleen.

When attacked by a virus, many cells rapidly respond by producing interferon. This is a family of proteins which block the replication (multiplication) of viruses, both in the cells which produce the interferon and in other cells. Expressed simply, it interferes with the synthesis of new virus by the cells of the host. Interferons have two important actions:

(a) They alter the properties of the cell membrane against accessibility by viruses; and
(b) They activate cellular genes to produce intracellular enzymes which interact with double-stranded RNA to inhibit protein synthesis in the virus.

Because of their protective properties, lysozyme and interferons have been described as 'natural antibiotics.' They provide rapid protection against invaders, lysozyme against bacteria and interferon against viruses.

Phagocytes

Certain cells in the body have the power of engulfing bacteria and other foreign materials. They are known as phagocytic cells and are of two types, the circulating polymorphonuclear leukocytes of the blood and the mononuclear phagocytic cells known as macrophages. The latter are distributed throughout the body and are themselves of two kinds, namely those which circulate in the blood (monocytes) and those which are fixed in the tissues (e.g. histiocytes in the connective tissues). These actively phagocytic cells are collectively referred to as the mononuclear phagocytic system. The phagocytes either digest the material which they engulf or store it out of

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harm's way so that it can no longer act as an irritant. They quickly clear the blood of bacteria and other particulate matter.

The macrophages form an important link between the innate and acquired immune systems. They pass on to the lymphoid cells some of the antigens, or their products, but at the same time retain some of them so that the lymphoid cells are not overwhelmed.

The normal function of phagocytes depends upon their ability to *recognize, bind* and *ingest* microorganisms and other particles. This is, in part, non-specific but, in addition, bacteria coated with antibody and complement adhere to the phagocyte because the phagocyte cell membrane has receptors for a part of the antibody molecule and a component of the complement system. Antibodies can greatly enhance the phagocytosis and even the intracellular digestion of bacteria. An antibody which coats the surface of a bacterium or other particle (antigen), and makes it more susceptible to phagocytosis, is known as an opsonizing antibody or opsonin. IgM antibodies are particularly effective opsonizing agents. Clearly, the complement also acts as an opsonic in this situation.

Generally, polymorph nuclear neutrophils are more effective than monocytes or macrophages in the rapid killing of bacteria. However, macrophages are more versatile than neutrophils and are essential for the elimination of various chronic infusive agents.

Immunity refers to resistance exhibited by the host towards injury caused by microorganism, or its products.

Immune response is reaction of body against foreign antigen.

Antigen is a substance which when introduced into the body can generate immune response, and is usually a protein. The antibody formed reacts specifically and in an observable manner. Antigenicity depends on the presence of an antigenic determinant or epitope on the surface of the antigen, represented by a small area on the surface of antigen.

Immunity → Natural (innate)
Immunity → Acquired

Natural immunity refers to resistance to infection which an individual possess because of his genetic and constitutional make up. It does not require prior exposure to antigen, or immunization, e.g. phagocytosis of bacteria by neutrophil.

ACQUIRED IMMUNITY

It is the resistance an individual acquire during life can be active or passive.

Active immunity is the resistance developed by an individual as a result of antigenic stimulation. It involves active functioning of the immune system.

Active immunity → Natural
Active immunity → Artificial

Natural: Infections produce natural active immunity.
Artificial: Vaccines provide artificial active immunity.

Passive immunity → Natural
Passive immunity → Artificial

Passive immunity: Body's immune system plays no role in its development.
Natural passive immunity: From mother to fetus through placenta or breast milk.
Artificial passive immunity: Introducing preformed antibody.

Acquired immunity → ***Humoral:*** Mediated by B lymphocytes
Acquired immunity → ***Cell mediated:*** T- lymphocytes

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Humoral Immunity

Mediated by circulating antibodies which are carried by globulin fraction of plasma proteins produced by plasma cells derived from lymphocytes.

In early neonatal life committed stem cells give rise to pre-B lymphocytes which mature in red bone marrow (RBM). They escape from RBM enter the peripheral lymphoid tissue like lymph node—peyer's patch, tonsil, white pulp of spleen and circulate back and forth between circulation and peripheral lymphoid organs. B lymphocytes produce 5 classes of immunoglobulins (Ig) (Fig. 3.1):

1. IgG
2. IgA
3. IgM
4. IgD
5. IgE

Complement System

Consisting of several enzymes also interact with immune system.

Cellular Immunity

Mediated by sensitized T lymphocytes constitute major defense against infection by viruses, fungi, and few intracellular bacteria, e.g. tubercle bacillus also defense against malignant tumors. Cells of both these systems interact in many ways.

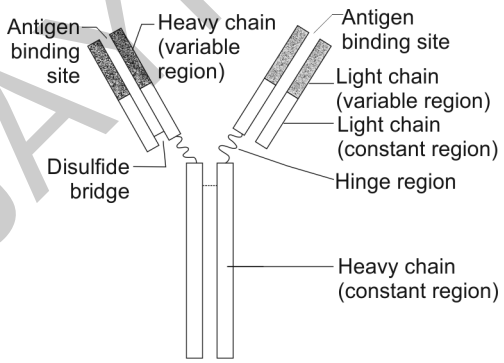


Fig. 3.1: An immunoglobulin molecule

Development of Immune System

In the thymus the lymphocytes proliferate and develop extreme diversity for reacting against specific antigens. This proliferation in the thymus is not dependent on antigenic stimulus. In the thymus lymphocytes are educated so that they become capable of mounting cell mediated immune response against appropriate antigens. They acquire surface receptors and become immunologically competent cells. These cells have antigen recognition sites on their surface which enables each cell to recognize only one antigen specifically. T lymphocytes are also taught not to react against proteins or other antigens that are present on bodies own tissues. These cells migrate to peripheral lymphoid tissue, spleen lymph node etc. They circulate through blood, lymph node and tissues so that they can reach any site immediately following introductions of antigen into any part of body. These cells are capable of:

- Recognizing antigens
- Storage of immunological memory
- Immune response to specific antigens

T cells can be classified to:

- Helper T cells
- Suppressor T cells
- Memory T cells
- Cytotoxic T cells

Helper T cells

2 Types → Helper I, Helper II

Helper I: Recreates interleukin 2, interferone and is involved in cell mediated immunity.
Helper II: Secretes interleukin 4, 5 and interact with B lymphocytes in bringing about humoral immunity.

Suppressor T Cells

Inhibit antibody production by B cells and immune response of cytotoxic T cells. Thus they regulate the activities of other cells.

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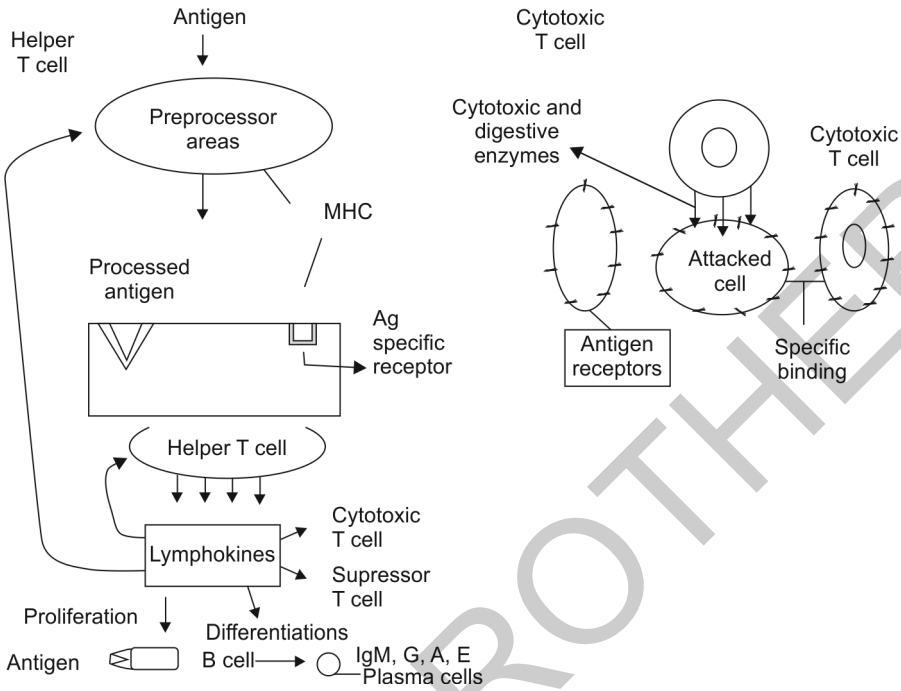


Fig. 3.2: Mechanism of action of helper T cells, cytotoxic T cell mediated lysis

It prevent them from causing excessive immune reaction damaging to the tissues.

Helper and Suppressor T cells together are called regulatory cells. Normal balance between helper and suppressor is registered for normal immune response.

T cells can be differentiated into subsets depending on presence of certain antigenic determinants on the surface. Most cytotoxic T cells have a CD_8 antigenic determinant (Fig. 3.2).

Antigenic determinant in helper T cell is CD_4 antigen.

Memory Cells

When stimulated, both B cell and T cell undergo clonal selection and proliferation so that the antigen is eliminated. After elimination of antigen lymphocytes of this particular clone die, but a few lymphocytes of this clone survive with in the lymph node in a dorment state. Memory cells can be either Bor T memeory cell. Memory cells retain the memory of the particular antigen. If a second attack by same antigen occurs, memory cells begin to proliferate and lymphocytes of that particular clone are released with in few days.

Cytotoxic T Cell

Individed accurate and pinpoint destruction of the antigen together with the macrophage which have engulfed the antigen occurs with the help of cytotoxic T cells.

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This book is presented in a simplified form to make nursing students understand Anatomy and Physiology in an easier way. The contents will help students understand applications in anatomy correlate to clinical aspects. The book will also helpful to know the importance of learning basic science of anatomy and physiology during practice as nurses in hospitals.

Indira CK is currently working as an Associate Professor of Anatomy at Government Medical College, Konni, Kerala, India. She has done MBBS from Government Medical College, Thrissur (1992) and MD (Anatomy) 2005 from Government Medical College, Calicut. She started teaching medical students from 1999 onwards.



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