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Research Article

Cells and tissues involved in immune system

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Abstract: A. Introduction and objective: Chronic physical illnesses are directly associated with malfunctions of the immune system. This research aims to study the cells and tissues involved in the immune system.
B. Materials and methodology: This is a library research which uses valid internet websites in order to access related articles and studies.
C. Conclusion: There are various cells and tissues involved in the immune system from among which we can refer to B and T cells as well as thymus and lymph nodes in the lymph tissues

Keywords: immune cells, thymus, lymph nodes

1. Introduction

Immune system cells are naturally found in blood and lymph in the form of circulating cells and anatomic complexes, respectively, and are also scattered in all tissues except the central neuro system. These cells enjoy particular characteristics. Firstly, they are concentrated in places that are the best location for growth and distinctions of the lymphocytes which have been stimulated by antigen. Secondly, the exchange and immigration of lymphocytes between blood and tissues is a continuous process and they can find a position for homing at the point where they coincide with the antigen. When the foetus is 17 to 19 days old, the blood cells concentrate in omentum where they are generated from the first cell that is the origin of all blood cells in brain and bones and is called pluripotent stem cells, also called the colony forming unite-spleen (CFU-S) or the hematopoietic stem cell. When the foetus is 19 days old, hematopoiesis and division of stem cells accelerate in the yolk sac. The other organ is the fetal liver which starts making blood when the fetus is 1 and half months old and continues its operation for some time after the birth. Its maximum activity happens between the 4th and 5th months of fatal formation. Thus, when the foetus is about 70 days old, the spleen starts hematopoiesis and continues its operation until the foetus is 6 or 7 months old. Eventually, the main blood- making starts in the bone marrow when the foetus is 4 months old. This trend gains momentum and the bone marrow becomes the main hematopoiesis organ at the time of the birth. It should be mentioned that when the foetus is 4 months old, some other blood extracts are also being produced and this process continues sometime after the birth.

The pluripotent stem cell generates two progenitor cells namely;

1- The multi potential lymphoid stem cell which is also cold as the common lymphoid progenitor in some resources.

2- Multi potential myeloid progenitor stem cells which are also called common myeloid progenitor in some resources.

Immune cells can be divided into two categories; the myeloid category which plays an important role in creation of innate immune responses and the lymphoid category which are very important in producing adaptive immune responses. It should also be mentioned that CMP produces four subcategories of which the red blood cells (erythrocytes) and platelets are related to hematology.

2. Phagocytes

A. Polymorphonuclear cells (PMN)

Based on the colours of cytoplasmic granules (hematoxylin-Eosin), the mature cells in this group are divided into neutrophil, eosinophil, and basophil. Due to their cytoplasmic granules (granulocytes) and their role in innate inflammation and immune processes, these cells are also called inflammatory cells. They are produced at a rate of 80 million per minute; however, they last only a few days.

1- Neutrophil

This is the main cellular group in myeloid category which is produced in the bone marrow and, then, enters the blood to move to body tissues after 12 hours. These cells have a life cycle of a few days and constitute about 65-70% of human white blood cells (leukocytes).

Neutrophils are circular with a diameter of 12-15 micron and contain two types of granules in there cytoplasm.

1-1 Primary granules or Esophils which are concentrated and contain bacteria-killer enzymes such as myeloperoxidase, lysozyme, neutral protease like elastase, acidic hydrolases like glucuronidase and cathepsin

1-2 Secondary granules which contain enzymes like collagenase and iron-binding protein. Secondary granules are three times more in number than primary ones. The main duty of neutrophils is phagocytosis that includes destroying harmful foreign particles. Phagocytosis contains four stages of chemotaxis, adherence, ingestion and digestion.

Chemotaxis includes the movement of neutrophils and phagocytes as influenced by foreign chemical stimulants called chemotactic factors. When phagocytes come into contact with invaders, their receptors will bind to the invaders and direct them into their own cytoplasm through creating phagosome. Later, lysozyme binds with phagosome to make phagolysosome. The lysozyme membrane tears apart while the cytoplasmic granules and other enzymes are sucked into phagocytic vacuoles to complete the ingestion and digestion processes. Neutrophils have receptors for IgE antibody and complementary proteins.

2- Eosinophils

The name comes from the ability of these cells to absorb the red colour of eosin by their cytoplasmic granules. Eosinophil is produced in the bone marrow and then moves to spleen to grow and mature. Mature eosinophils flow in blood for 30 minutes and eventually enter the body tissues. They have a lifespan of 12 days; therefore, there exist 500 reserves in tissues per each eosinophil in blood. In a healthy body, the eosinophils constitute 2-5 percent of blood leukocytes and their number increases in cases of parasitic infections or allergies. Eosinophils belong to phagocyte type though their granules lack lysozyme and they include a substantial amount of phosphatase and peroxidase acid.

The main biological duty of eosinophils is to destroy invading parasites. These cells have IgE receptors and bind better with particles covered by IgE. That is why they are more efficient in destroying parasites and worms that create IgE.

Colony-stimulating factors (CSF) are effective in hematopoiesis as well as growth and proliferation of both neutrophils and eosinophils. Materials such as M-CSF and GM-CFS together with cytokines like interleukin 3 and 5 produced by T-cells are among the main factors contributing to EO synthesis. Eosinophils are attracted by substances such as chemotactic eosinophil in anaphylaxis (ECE-A) which are produced by T-cells and basophils. They emit a toxic substance called major basic protein (MBP) which can destroy cells of many worms and parasites.

3- Basophile

Their name originates from the cytoplasmic granules' ability to absorb basic colours of hematoxylin. Basophils constitute about 0.5 per cent of blood leukocytes and are normally found in out-of-vessel tissues. These cells have granules containing vasoactive amines like histamine and serotonin. They also have receptors for IgE. They are recognised as similar to MAST-cells since the latter contains histamine granules as well as IgE receptors. The difference lies in the existence of Charcot-Leyden crystals and major basic proteins which are absent in MAST-cells. Both types of cells contain heparin and ECF-A.

B) Mononuclear System (MNS)

This is the second major cell category in the immune system and includes cells with similar origins whose main job is phagocytosis. Monocytes and macrophages are the main cells in mononuclear system.

Numerous stimulants activate macrophages and cause their various shapes. In some cases, the cytoplasm of macrophages expands and stimulates skin cells. That is why they are also called quasi epithelioid cells. They can also merge into multinuclear giant cells. Macrophages perform various functions including phagocytosis. They engulf foreign particles, microbes, macromolecules, dead tissues and even exhausted red blood cells and destroy the waste.

Phagocytosis occurs in immunologic and non-immunologic ways. In the former, phagocytosis is conducted using immune products and antibody molecules that exist in macrophage receptors. The latter includes binding, ingestion and digestion of foreign particles without contribution of antibodies or complement factors. In addition, macrophages release active oxygen radicals, enzymes and chemical moderators such as prostaglandin to destroy microbes and prevent the spread of infection.

The second main function of macrophages is to process antigen into T-cells. Not all macrophages are able to process antigens for immune responses; the capable ones include those which bear MHC on their surface. The lymphocytes stimulated by antigens emit cytokine during the operation. The cytokine activates macrophages and enhances their efficiency.

Besides, macrophages are among the efficient and active elements in inflammation. They move towards the infection site to help eradicate the invaders and emit the required factors including complement system components like C2,C3,C4,C5, lysozyme enzymes, collagenase, elastase, plasminogen activators, prostaglandin, leukotriene, as well as alpha, beta,... interferons. Moreover, macrophage interleukin-1 (IL-1) which is a general response to infection raises the temperature and stimulates neutrophils. Lastly, macrophages secrete growth factors for fibroblasts and endothelium and repair the damaged tissues.

Monocytes and macrophages have numerous receptors on their surface for antibodies like IgE; components of the complement system; factors for growth and hematopoiesis like GM-CSF and M-CSF; cytokines like interleukin II & IV; interferon gamma (IFN-γ); and macrophage inhibiting factor.

They also have surface molecules or markers like CD13, CD14 and CD15.

3- Dendritic cells

Since macrophages destroy a large part of the antigen they are unable to process it. There exist other auxiliary immune cells called dendritic cells (DS) which play a crucial role in immune responses. These cells feature bar or membrane shape axons as well as a large number of cytoplasmic axons in the form of long filaments with multi-part nucleus. These macrophage-like cells are scattered throughout body and, in particular, in lymph organs and the skin. There are two types of dendritic cells with different features and functions.

3-1 Interdigitating Dendritic Cells (IDC)

These cells can be observed in most in-between-organ tissues; rich T-lymphocyte sites in lymph nodes and the spleen; and are also scattered in skin epidermis called Langerhans cells. They contain cytoplasmic organs called Birbeck granules whose functions are still unknown. They originate from progenitors in bone marrow and provide Th-cells with antigens. Langerhans cells ingest the antigens that they take from skin and carry them to lymph nodes. Such cells are known as veiled cells.

3-2 Follicular Dendritic Cells (FDC)

These cells owe their name to their existence in generative centres of lymph follicles, spleen and lymph tissues containing mucus. They do not originate from bone marrow and have no relation with IDCs. These cells trap antigen, antibody or complement components and send them to B-lymphocytes for identification. These cells lack MHC molecules; but contain a lot of FCγR and receptors for complement components of CRI & CR II.

4- Lymphocytes

Lymphocytes provide specific immune responses. They are the only body cells that are able to distinguish various antigens and respond specifically to each one. An average person has about 10^{12} lymphocytes and 10^{9} new lymphocytes are produced daily by bone marrow and thymus.

Lymphocytes are small circular cells with a diameter of 7-15 micron and a large spherical nucleus which takes colours like hematoxylin. Their function cannot be understood by their appearance. They can be observed in two forms in peripheral blood smear (PBS).

A. Small lymphocytes which are relaxing and contain a little cytoplasm. They constitute a large percentage of lymphocyte population.

B. Large lymphocytes which are active and contain more cytoplasm and a more concentrated nucleus. Due to lack of enzyme granules, these lymphocytes cannot involve in phagocytosis.

Lymphocytes are sub-categorized into groups that are totally distinct with regard to their functions and protein products. In general, lymphocytes are divided based on four criteria.

- Antigen receptor
- Specific surface antigen
- Ontogeny
- Responses to mitogens

4-1 B-lymphocyte

This lymphocyte appears in humans and most mammals together with superficial immunoglobulin. The name comes from its origin that is bone marrow in mammals and bursa of fabricius in birds. This is the only cell that produces antibodies and its antigen receptor consists of antibody molecules present on its surface. The interaction between antigen and antibody on the surface of B-cell activates the cell and transforms it into a cell that secretes antibody (plasma cell). B-lymphocyte constitutes about 5-15 percent of the circulating lymphocytes and has a lifespan of 5-7 weeks. There exist some receptors on the surface of a B-cell as described below;

A. antigenic receptor

This is an immunoglobulin receptor mostly of IgM and IgD types which is observed at the surface of B-cell. A few B-cells in certain sites contain a little IgE, IgA and IgG antibody.

B. FCR receptors

This receptor binds to fixed areas of antibody and is of RII γ FC type in B cells. It includes a polypeptide chain with a molecular weight of 40,000 Dalton.

C. Complement receptors (CR)

B-lymphocytes contain receptors for activated complement components. About 50-70% of mature B lymphocytes contain complement receptors type 1 (CR1) which are ready to bind with complement components of C3b and C4b. In addition, B cell includes CR II which can bind with the other complement components. This receptor is a receiver for Epstein Barr virus (EBV).

D. Receptors for differentiation antigens

Each cell category is distinguished by molecules and certain antigens that represent the amount of maturation, certain cellular lineage, or the degree of cell activity. These cell surface antigens are also known as markers and include three types, namely, lineage markers that represent a certain cell generation; maturation markers which temporarily appear during cell differentiation and maturation; and, activation markers that emerge during cell activities.

These three cell surface markers were first named on the basis of the antibodies to which they react. Yet, it led to a lot of complexity. Therefore, a unified naming system was presented and agreed for human leucocyte to resolve the issue. In this system, each surface marker which represents a cell category or an evolution process will have a known structure and is identified by a set of certain monoclonal antibodies. In this way, we can unravel the lineage or evolution. It is not always possible to categorise markers in these the groups mentioned above since it is possible that a maturation marker in one cell lineage may act as an activation marker in another and vice versa. However, each marker should be reviewed in its own cell category.

As mentioned earlier, it is the function of surface

immunoglobulin of B-lymphocytes to play the role of antigenic receptors and send the message into the cells. If the immature lymphocytes containing just superficial IgM contacts antigen, that cell discontinues its evolution process and becomes intolerant against antigen. This phenomenon is called clonal energy and contributes to tolerance against large amounts of self-antigen. Conversely, the contact between mature B lymphocytes containing both superficial IgM, and IgD and antigen activates the lymphocyte and changes it into plasma cell with memory B-cell.

Antibody production in blood starts in embryonic development when IgM is produced at the 10th week of homing followed by production of IgG a short time later. Production of serum and secreted IgA is delayed until the 30th week, however.

Surface receptors of T-cells can recognise antigenic peptides bound with MHC while surface antibodies of T-cells can directly bind with various antigens such as glycoproteins, glycolipids, polysaccharide, peptides and other immunogens. Studies reveal that B-lymphocytes not only produce antibodies but also secrete some cytokines that interfere in differentiation and the growth of other cells and lymphocytes. There are about 1.5 x 10^5 antibody molecules on the surface of each B-lymphocyte that act as antigen receptors. Marker CD5 used to be observed only on T-cells. This means that these cells can potentially produce autoantibody. As observed in rats' peritoneal cavity, these cells - also called B1 α- have a way of differentiation as distinct from that of normal B cells. In addition, some human B cells combine with red blood cells of rats to form rosettes. This ability together with the CD5 molecules features a new subcategory of which the antibodies tend to bond with self- antigens like DNA, FC, Rγ, self- phospholipid and components of cellular skeleton.

4-2 T-lymphocyte

This is the second main type of lymphocytes whose progenitor originates in bone marrow and then enters thymus for maturation; hence known as T. They have a relatively long life span and live about 6-10 months in human body. The main circulating lymphocytes constitute about 80% of peripheral blood. Based on their function, they are divided into two distinct groups of T-helpers and T-cytotoxic. The two groups differ in their surface antigens. T-helpers have CD4 marker and can distinguish antigens with the presence of MHC-II molecules whereas TCs have CD8 marker and they distinguish the antigen in adjacency with MHC-1 molecules. In response to antigenic stimulation, T-helpers secrete a protein hormone called cytokine which causes proliferation, evolution or differentiation of T cells, B cells and macrophages.

Based on cytokine secretion, T-helper cells are divided into subgroups. There are two clones of Th cells in human body. Th1 secretes cytokines like interleukin 2 (IL-2) as well as interferon gamma (IFN-γ), and causes various events in cytotoxicity and inflammatory responses. They play an important role in combating intercellular pathogens such as viruses, bacteria and parasites. In general, they strengthen the cell immune conditions. The second sub group is called Th2 which secretes cytokines like IL-4, IL-5, IL-6 and IL-10 in human body and is vital for stimulation of B cells and production of antibodies. Their main function is to destroy out-of-cell microorganisms. IL-12 can transform Th cells to Th1.

TC lymphocytes destroy cells that produce foreign antigens and, like virus infected cells or intercellular microbes, are immune against antibodies. T-Cells are divided into two groups according to their functions. One group secretes IL-2 in response to stimulation; however, the other group is not able to secrete and just responds.

A. T-Lymphocyte antigenic receptor

T cell receptor (TCR) is the antigenic receptor in T-cells which appears in two forms. TCR-1 consists of two polypeptide chains (gamma and delta) and exists in 5-7% of real T cells in epithelium. TCR-2 which is a mature form of TCR consists of two polypeptide chains (alpha and beta) and appears in 93-95% of T cells. Both forms of antigenic receptors are connected to a polypeptide set called CD3 complex and constitute the T-cell acceptor together.

B- Antibody FC Receptors (FCR)

Some T-lymphocytes have FCR though they are much fewer in number compared to B-cells. About 60% of T lymphocytes in human peripheral blood contain FC receptors (for IgM molecules) and act as Th cells.

About 25% have γFCR for IgG molecules and act as either TC or TS (suppressor). Some T-cells contain a few receptors for other antibodies. TS may be considered as the third group of T cells though their existence has not been confirmed yet. General belief holds that both Th and TC cells can curb immune responses through toxic and cytotoxicity secretion or apoptosis.

C- Complement receptors

T lymphocytes have CR-I for active complement components such as C4b and C3b. Complement receptors may appear only when T-lymphocytes have been activated by antigens.

D- Receptors for differentiation antigens

T cells containing CD-(1, 2, 3, 4, 5, 7, 8) are family markers. We already know that primary T lymphocytes contain CD9 and CD10 to both lose CD9 during maturation and get CD- (4, 7, 8). Mature thymocytes are divided into two main subgroups. The first one keeps CD4 and loses CD8 to transform into (CD4+, CD8-) cells called Th cells, while the second subgroup loses CD4 and keeps CD8 to change into (CD4-, CD8+) cells called TC. Th and TC cells constitute 55-65 and 20-30 percent of lymphocytes in peripheral blood, respectively. Two other small subgroups called positive dual (CD4+, CD8+) and negative dual (CD4-, CD8-) constitute 5% of T cells that emit thymus. This contribution is negligible, however. It is said that negative dual cells contain TCR-1 (gamma and delta), though their target antigens that have not

been identified well yet. Having been activated, these cells are able to generate IL-2, 4 and IFNγ.

E- Tissues and limbs of the body immune system (lymph system)

Although mononuclear phagocytic macrophages trap and process the antigen, creation of an immune response is the duty of lymphocytes which are abundant in spleen, lymph nodes, and thymus. Immune responses occur in lymph organs. In fact, the immune system tissues and organs are a suitable site not only for birth, maturation and qualification of the necessary cells, but also for efficient contact between these cells and antigens.

In addition, the body needs control systems to regulate the immune responses. This regulation takes place in two phases. At first, the production of lymphocytes is set in a way that their number is proportionate to their functions. The produced lymphocytes are also regulated to ensure that they only react to foreign antigens not the self-ones. In the second stage, the response power of each lymphocyte is set in a way that both meets the body needs and remains within a moderate limit. Lymphoid system tissues are divided into two groups based on their duties.

- Primary or generative lymph organs

Birth and maturation of lymphocytes occur in lymph organs while self-antigen identifying lymphocytes get omitted or inactive. Lymphocytes are differentiated from lymphoid stem cells and proliferate into mature functional cells. T cells and B cells mature in thymus and fetal liver, respectively, in mammals whereas birds have a special site called bursa of fabricius for generation and maturation of B cells. Lymphocytes gain in the lymph organs their specific antigen receptors which are necessary for dealing with antigenic contacts during their life cycle. The cells are selected based on their tolerance of immunity against autoantigens. Therefore, when these cells are in the environment, they can only identify outsider antigens.

- Secondary or peripheral lymph organs

These organs provide the setting in which mature lymphocytes respond to antigens and where lymphocytes can interact with each other, helpers, and antigens. In addition, these organs spread the immune response. Such responses which are created in secondary lymph organs require phagocytic macrophages, antigen suppliers, as well as mature T and B cells. Lymph nodes, spleen, payers patches, mucous lymph tissues and sub-skin tissues are among the main peripheral lymphoid organs.

Primary lymphoid organs (PLO)

A. Bone marrow

Lymphocyte progenitor cells are first produced by omentum in the early embryonic development and later in the yolk sac and fetal liver; however, in later stages of embryonic development and also in grown-ups, the bone marrow is the main origin of lymphocytes and various blood cells. Hematopoiesis in a mature person mostly occurs in the marrow of sternum, vertebras, iliac bones and ribs. Bone marrow consists of two hematopoietic and vascular parts which are in alternate positions like pieces of cake and make triangular sites in long bones.

Hematopoietic parts contain progenitors of all blood cells surrounded by a layer of adventitial cells whereas the vascular parts include a large number of blood sinuses that are covered by endothelial cells and contain reticular cells as well as macrophages. The adventitial cells in old people are filled with fat and cover the hematopoietic tissues in a way that the bone marrow turns into a yellowish greasy substance. Various cytokines in bone marrow cause stimulation, proliferation and maturation of progenitor cells. Some of these cytokines are known as colony stimulating factors (CSF). Macrophages and T lymphocytes stimulated by antigens produce cytokines that are effective in hematopoiesis. For example, stimulated t cells produce interleukin 4 (IL-4) which has already been named B cell growth factor (BCGF). IL-4 helps both B cells and other progenitor cells to grow. Bone marrow performs three functions in adults. It is not only the origin of all blood cells, but also uses its mono nucleus phagocytes to depart antigen particles from blood flow. This function is similar to that of spleen, liver and lymph nodes. Moreover, it stimulates B cells by antigens to transform them into plasma cell to generate antibody. Bone marrow counts as one of the main sources of antibody and a secondary lymph organ. All stem cells in bone marrow lack differentiation blood cell markers; instead, they contain CD34, CD38, CD10 and stem cell antigen Sca-1.

B- Bursa of Fabricius

This is a small epithelial organ in birds located right above cloaca which reaches its largest size 1 or 2 weeks after hatching and then suffers from atrophy. This organ is produced by the lymph in the connection site of ectoderm and endoderm or is produced directly by endoderm in the early stages of embryogenesis. Bursa is covered by pseudostratified epithelium tissues and contains lymphoid follicles. Each molecule consists of a membrane and a centre called cortex and medulla, respectively.

Cortex contains lymphocyte cells, plasma-cell and macrophage. There exists a basement membrane with a capillary network at the connection site of cortex and medulla which is covered by epithelial cells. These medulla epithelial cells divide rapidly and are replaced by lymphocytes as they move towards the centre. Consequently, the centre of follicles includes just lymphocytes. Bursa is responsible for creation of a suitable environment for evolution and differentiation of antibody-producing or B lymphocytes. Besides, bursa acts as a secondary lymph organ since it can trap antigens and synthesize antibodies.

C- Thymus

Thymus is a pale double-lobe organ located in the chest in mediastinum between lungs. Each lobe is divided into several lobules separated by thin septa walls. Lobules consist of central and membrane parts. Thymus changes in size and

reaches its largest relative and absolute sizes in babyhood and puberty, respectively. Then it enters atrophy and its cortex is replaced by fatty tissues. From an embryological perspective, thymus originates from the endoderm of the third and fourth bronchitis cavities. It is the first organ in vertebrates that produces lymphocyte. The membrane of each lobule contains a lot of T cells called thymocytes which divide frequently and penetrate the thymus cortex. The central part called medulla contains fewer thymocytes and more epithelial cells. It should be mentioned that epithelial cells with abundant cytoplasm, phagocyte, and dendritic cells are scattered throughout thymus. Hassall's Corpuscles exist in the centre. These special structures consist of compressed epithelial loops and, probably, dead cell debris together with keratin protein. This may be an indication of unsuccessful keratinization by epithelial cells. Thymus has a lot of blood vessels as well as efferent lymph vessels to convey cells to lymph nodes in the chest. Each lobule is surrounded by a capsule made of connective tissues. At least three types of epithelial cells can be distinguished in thymus according to their structure, function and phenotype. They include nurse cells in the outer cortex, cortical epithelial cells and medulla epithelial cells located in the central part. Interdigitating dendritic cells (IDC) and macrophages are located in thymus lobules between cortex and medulla. High endothelial Venules (HEV) in this organ allows the cells to move in and out of thymus.

Thymus is responsible for creating an appropriate environment for maturation and qualification of T cells. For this purpose, thymus epithelial cells secrete a humoral factor to absorb lymphocyte progenitor cells into thymus from the bone marrow. The newcomers move from cortex to medulla while they are being differentiated, assigned new duties and again new surface antigens. Most T-lymphocytes in the central part are mature T cells which contain only one of CD4 or CD6 markers to change into either Th or Tc. This process seems to include a kind of selection of T cells which is conducted in thymus during evolution of T cells and inside nurse cells and macrophages. It is in this environment that T cells lose the ability to identify self-antigen and are only capable of recognizing outsiders. Cell selection processes are vital for recognition of self and non-self in an immune system.

Besides the above-mentioned tasks, thymus epithelial cells secrete many types of polypeptide hormones.

A. Thymosins

These polypeptide hormones are divided into α, β, and γ categories based on electrophoresis movement. Their functions include maturation and differentiation of primary T-cells.

B. Thymopoietins

These are polypeptide hormones and regulators of immune responses. They increase the number of Ts cells and exert blocking effect on muscular-nervous system. They are also effective in pathogenesis of myasthenia gravis.

C. Thymic humoral factor (THF)

This is a peptide hormone that recovers the immune response in animals whose thymus has been removed after birth. It also causes differentiation and maturation of T cells.

D. Facteur Thymique Serique (FTS) or thymulin

Peptide hormones contain 9 types of amino acid that are separated from thymus epithelial cells and found in serum. They contribute to emergence of mature T-cell antigens on immature T cells. Their various quantities impose different effects on the functions of suppressors.

Removing thymus (thymectomy) at birth in various species affects the immune system deeply. It stops the growth of baby rats and makes them prone to infections. In this way, the number of lymphocytes declines and the rats cannot reject transplantation. Besides, their humoral immunity weakens.

Since human immune cells qualify in early stages of embryonic development, thymectomy at birth leaves no serious effect on reduction of B and T cells. However, inadequate thymus growth during embryonic development causes inefficiencies of immune system and diseases such as Di George syndrome which happens as a result of disruption in completion of embryonic bronchitis cavities. This syndrome leads to various degrees of hyperplasia, inefficiency of the immune system, heart deficiency at birth, abnormal face and weakness of parathyroid gland. Mature T cells of medulla contain CD44 marker which is absent in cortex thymocytes. This receptor exists in all moving cells and connect them to hyaluronic and connective tissues; however, it is absent on stationery lymphocytes. T cells also mature in a skin; for instance, a population of T cells resides in skin and links with keratinocyte cells. They spend a part of the evolutionary process in the epidermis.

5. Conclusion

The immune system is a precise and complex system which includes various organs with different but interrelated functions. Any interference or lack of coordination in their responsibilities may result in disruption and severe, and sometimes, irrecoverable consequences. The main primary and secondary organs of the immune system include cells (e.g. lymphocytes, monocytes, macrophages, special cells and the like); tissues (lymph and cover tissues, etc.); and molecules solved in blood such as antibodies, complement, cytokines, etc.).

In addition to macrophages, some white blood cells called lymphocytes contribute to this mechanism. They originate from the stem cells of bone marrow. Lymphocytes perform an adaptive function meaning that they recognise and destroy a certain type of invaders.

Lymphocytes are immature after production and need to evolve to gain the required qualification and combat microbes. Based on their evolution location, lymphocytes are divided into B and T categories which are qualified in bone marrow and thymus, respectively.

Mature lymphocytes gain the ability to identify molecules and distinguish self and foreign cells as well as the capability to combat invaders. Lymphocytes carry receptors on their surface whose geometrical shape compliments the certain antigen located on the surface of foreign particles. In this way, each lymphocyte involves a certain kind of receptor to discover and destroy a specific antigen, hence their specific function. Some lymphocytes move between lymph and blood while others populate in lymph nodes, spleen, tonsils and appendix.

Innate immunity is the first defence line against microbes and foreign particles. The innate mechanism is formed before any contact with microbes and formation of adventitious immune responses. Due to its evolution, the innate immunity is the oldest defence mechanism against microbes. It has developed vis-a-vis microbes to defend all multicellular organisms like plants and insects against infection. The significance of the innate immune system lies in its primary response to microbes which either prevents infection in the host or controls and removes it. Its significant defensive role has been proved in studies which show that restriction or reduction of functions of any innate immune mechanism will substantially increase vulnerability to infections even though the adaptive immune system works immaculately.

Many pathogens have found new ways to resist against the innate immune system and enhance their ability to cause diseases. The innate immune system curbs the infection in such conditions until the adaptive immune system is activated. The adaptive responses are much more effective and can destroy resistant microbes. The innate immune system includes epithelial buffers, circulating cells, tissue cells, plasma proteins, neutrophils, mononuclear phagocytes and natural killer (NK) cells. NKs attack the foreign particles that cross epithelial buffers and enter the tissues or blood circulation. A vast spectrum of a plasma proteins attack those microbes that enter blood flow. The main innate immune proteins, complement system proteins, and other plasma proteins identify microbes structures.

In all treatments including radiotherapy, chemotherapy, and amputation, weakened immune system brings about negative consequences such as hair fall, sickness, vomiting, itching and more vulnerability to infection. Biological treatments are non-invasive and more efficient. For instance, immunotherapy in cancer treatment is an effective approach that focuses on empowerment of immune system so as to restrict the growth and spread of cancer cells. Natural killers are among effective cells in the immune system that play a crucial role in cancer treatment.

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