

How immune system impact the nervous system

Bohan Huang *

Oaks Christian High School, California, US

* Corresponding Author Email: BHuang@student.oakschristian.org

Abstract. Immune system and nervous system are both important. Adaptive immune system and innate immune system are two categories of the immune system. Both types of system have a lot of organs that has different types of function. Both the CNS and the PNS share this characteristic. The nervous system disorders have some relationship with the immune cells being too activated. The T-cells, B-cells, macrophages, and glial cells will become to activate and accidentally kill some cells in the nervous systems to cause the diseases. However, these types of disorders will have a varying cause and the scientists have to spend more studying on that. Autoimmune encephalitis (AE), Acute disseminated encephalomyelitis (ADEM) and Multiple sclerosis (MS) are both common disease with a huge prevalence around the world. This research paper has found out the treatment and pathogenesis of these diseases. The main cause of these types of diseases are the disorders of immune cells.

Keywords: Immune system; nervous system; autoimmune encephalitis.

1. Introduction

The immune system contains many types of organs such as, spleen, thymus, lymphatic vessels, and lymph nodes. Spleen is located at the bottom part of the rib. Spleen controls the level of the WBC, RBC, and platelets by removing different types of blood cells. Thymus locates between the lungs in the chest. Thymus could generate the WBC. WBC have B-cells and T-cells. Those cells could generate antibody with the help of Thymus. Lymphatic vessels located all over the body just like the blood vessels. The lymphatic vessels help transport the fluids from the tissue cells and also the lymphocytes. Lymph nodes spread all over your body. The macrophage will send the bacteria to the lymph nodes. The lymphocytes will increase and kill the bacteria.

Neurons are the basic unit of the nervous system, and it has cell body, dendrites and axons. Dendrites and axons could be called as neural fibers. The main function of neural fibers is to stimulus and transport the information. The main function of cell bodies is to deal with the information from the dendrites and send the signals through the axon.

Both immune system and nervous system contribute a lot of crucial things on maintaining the homeostasis of human body. The immune system helps us protect our body from diseases. Nervous system guides our moving, emotions, thinking and remembering. The human body cannot be alive without any of the systems. The immune system has innate immunity and adaptive immunity to protect our life. The innate immunity could protect us physically by providing some physical barrier. Mucosa, skin and cilia are some examples of the physical barrier. Those organs are essential to our body to maintain the homeostasis. Without these physical barriers, the bacteria and viruses can attack humans easily. That many bacteria and viruses will be too many for the immune system to handle. The adaptive immunity could protect our body by generating antibodies to some specific viruses or bacteria. Here is a perfect example about how to explain this. Covid vaccination will inject the ineffective viruses that could be easily killed by the lymphocytes. The B cells could report the antibody to avoid Covid for the next time. The brain and the rest of the nervous system are also significant. The brain guides with all your vision for people to be able to see. It also guides your hearing by dealing with the signals from ears. The nervous system controls all parts of human body. The brain helps people to think and stores the memory in the hippocampus

The things above are the introductory information about Nervous system and immune system. The rest of the essay is going to talk about some relative diseases and functions about detailed organs. Also, the ways to deal with diseases and how it works.

2. Function and explanation of two types of immunity

In order to maintain the homeostasis in body. There are two types of immunity, the innate immunity and adaptive immunity. The innate immunity is a type of immunity that we have it since we've born. The innate immune system is the first body protection line. The innate immune system provides a physical barrier to the foreign body and bacteria. The human skin could provide a physical barrier against pathogen, ultraviolet light, chemicals, and mechanical injuries. Epidermis is a part of human skin that contains no blood. If a mechanical cut does not go farther than Epidermis, it will not start bleeding which the blood vessels will not explode to the foreign body area. However, the people will start to feel hurt because the nerve will still sense the cut since there are neurons in the epidermis layer in human skin. Dermis is the area where the sweat gland and capillaries located. As a part of innate immune system, the capillaries will transfer the pathogen and some wastes to the sweat gland. Then, the sweat gland will start sweating to bring these bacteria and germs out.

The respiratory and digestive systems are both protected by mucosal tissues. Similar to the epidermis of the skin, the oral mucosa creates the first layer of defense in the mouth, shielding the epithelium from potential dangers including bacteria and antigens from food and the environment. However, due to the powerful action of stomach acid, the gastric mucosa in the stomach is vital in the elimination of the majority of bacteria and viruses from ingested food, with the exception of *Helicobacter pylori*. With the help of its cilia and mucus secretion, the nasal mucosa effectively removes dust and bacteria from the air, protecting the body from injury. The trachea mucosa serves as the second line of defense in the respiratory system in the event that the nasal mucosa is insufficient, absorbing dust and germs and expelling them as phlegm from the mouth [1].

The adaptive immune system will be activated if the immune system does not stop the bacteria and germs from entering the body. The adaptive immune system is also called lymphatic system. The lymphatic system will maintain the fluids level in cardiovascular system. It will remove the extra fluids in the blood which can help human to maintain homeostasis. The lymphatic vessels will transfer the wastes from capillaries to lymph capillaries. It is located every organ in human body just like blood vessels. The lymphatic vessels could also carry the wastes from tissue cells. The lymph vessels will carry these lymph fluids to lymph node. The lymph node contains macrophages (also called white blood cells), the macrophages will kill the bacteria, viruses, even the cancer cells. These pathogens will spread through the body by using cardiovascular system which shows that the lymphatic system is super important to our body's immunity. The lymphatic nodes swelling is also an example of filtration. The macrophages will become crowded in the lymph nodes as there are more pathogens occurred in lymph fluids. The kidneys or liver are responsible for waste disposal, and the spleen and lymph nodes also serve to identify and filter out undesired microorganisms. Lymph fluids return to capillaries after bacterial clearance. The removal of damaged red blood cells and the provision of emergency blood supply in circumstances of considerable blood loss are other functions of the spleen. The thymus, a key lymphatic organ, on the other hand, recognizes pathogens and produces antibodies to protect the body. During illness, powerful lymphocytes called killer T cells that carry these antibodies successfully fight off viruses and bacteria, demonstrating the adaptive immune system's capacity to manufacture particular antibodies for targeted disease protection. Together, these interdependent systems and organs support the body's immune system and maintenance of general health.

Cytotoxic T cells, which are generated from the thymus, separate themselves from NK cells by selectively attacking infected cells by relying on CD8 receptors and necessitating antigen activation. Helper T cells promote immunological activation by identifying antigens and prompting B cells to produce antibodies, whereas regulatory T cells control the immune response and minimize damage to healthy tissue after infection. Vaccines take use of this technique by delivering weaker antigens to activate memory T cells, improving antibody production, and boosting immunity. Memory T cells, with a longer lifespan, retain antigen "memory," allowing for a swifter immune response upon re-exposure [2].

B cells could generate the antibody when it is activated. The plasma b cells can be triggered in two different ways. It can first be triggered by helper or memory T cells. Second, the helper b cells have the ability to activate it. B cells absorb antigen and exhibit it on their surface while t cells are activating them. The helper t cells will then begin communicating risky signals to the B cells. Finally, the plasma B cells, also known as activated B cells, can produce antibodies against that antigen type. Some B cells will, however, develop into assistance B cells, which serve the same purpose as memory T cells.

In the adaptive immunity, macrophages play important roles in homeostasis and other physiological processes, such as metabolism, cellular debris removal, and tissue remodeling. In order to coordinate an immune response in pathogenic circumstances, TRMs can be replaced and joined by enrolled monocyte-derived macrophages. In the nervous system, the glial cell also plays an important role to maintain the homeostasis. A vital nervous system function is supported by a large number of glial cells. In addition to supporting neurons, glial cells also contribute to maintain homeostasis and generate myelin. The majority of the cells in the central nervous system are glial cells [3].

3. Autoimmune encephalitis(AE)

3.1. Morbidity, Mortality, and economical burden of the AE

T cells are always the main cause of the Nervous system disorders that are related to the immune system. If the regulatory T cells do not work well, the cytotoxic t cells will start to kill a lot of tissue cells that may damage the nervous system. The generation of autoantibodies by B cells is the method of CNS injury induction that is most frequently examined. This is seen in NMO, where the removal of astrocyte end feet by antibodies causes astrocyte mortality and the loss of CNS barriers [4]. The Morbidity of this disease is just like the other types of disease around the world. It is about 13.7/100,000 and it is not special around the prevalence of all the encephalitis which is about 11.6/100,000 [5]. However, the mortality of the AE is about 8-18.45% [6].

It has a slightly higher morbidity than all types of encephalitis which is about 10% [7]. The cost of the AE also has a higher cost. According to an article that talks about the economic burden of the AE, of the 208 patients reviewed, the average cost of AE is 94129 RMB which is about 14219 USD. The cost of the AE is unaffordable to most of the family. The symptoms may come over a few days or weeks. The early-phase symptom is just like the flu such as headache, fever, running nose. As it gets worse, the patient will have some psychiatric symptoms. It will appear, disappear and reappear again. It is kind of like an unstable symptom that will appear in a period people will not recognize. Common symptoms include weakening, seizures, uncharacteristic and uncontrollable movements, difficulty with balance, speech, or eyesight [8].

3.2. Pathogenesis of autoimmune encephalitis

The CNS has the highest privilege for the immune system. The only cell that can get into the CNS is the T cell. T cells will be actively survey in the CNS even a person is healthy. Recent evidence has also confirmed the presence of T cells while a person is healthy [9]. They find out the T cells all come together in the lymphatic node. Scientists believe that when virus causes the immune cells absorb the protein. Then, the immune system starts to kill a lot of neurons or other cells in the CNS to get rid of the virus. There is no problem if the immune system kills some tissue cells in the body, because they are not as important as the neurons. If the brain structure has been damaged, it will cause the psychiatric problem. The brain is the main organ to control human body. Without the brain, human might not maintain their homeostasis.

If the antigen from the outside, the antibodies will also have a strong role to produce AE symptoms [10]. The antibodies will form as a reaction to the virus, it will bind with the receptor and cause the disorder of the virus. However, the receptor will also be pulled from the outside of the neurons to the inside, which the immune system cannot detect the virus in the neurons. While the neurons are infected by the virus, this will also cause AE by the neurons disorder.

The current study's findings suggest that the course of EAE can be dramatically changed by providing macrophage/microglial modulators at points during the disease's development. Better EAE clinical scores were obtained using three of the four techniques we investigated to change macrophage/microglial activation in wild-type mice injected with MOG. Tuftsin administration before or at the time of the onset of EAE symptoms was efficacious, whereas pre-treatment with MIF was of only marginal benefit [11].

3.3. Treatment

The first step to treat the AE is to check the antibody. If the antibody is diagnosed, the initial treatment should start by using steroids or IVIG. This will make the lymphocytes become inactivated. The AE will start to reduce after the T cells cool down. If first-line therapy has not been tried and if a synaptic/cell-surface antibody is discovered, it should be given to the patient if they display any severe symptoms. In general, higher outcomes are associated with early treatment and more aggressive treatment for sicker patients. Anti-AE treatments have been devised and used to treat additional cell-surface/synaptic autoantibody diseases, despite the absence of randomized therapeutic studies. According to the ncbi, their group often us IV solumedrol and IVIG. The main function of IV solumedrol is to reduce inflammation around lesions and closing the blood-brain barrier. IVIG will provide extra antibodies if the human body cannot make on their own.

4. Acute disseminated encephalomyelitis (ADEM)

4.1. Morbidity and Mortality of the ADEM

ADEM is a monophasic demyelinating disease of central nervous system. According to the JAMA neurology, ADEM affected commonly in the young and adolescent children. The estimated morbidity is 0.8 per a million people per year. The incidence in adult and elderly patients is lower than the morbidity of children. The mortality of the ADEM is much higher than the morbidity which is about 5% [12]. ADEM will be presented after 3-6 weeks, it might also be activated instantly. ADEM could damage every part of neuraxis. That will cause different types of clinical features. According to NCBI, the common features are altered mental status, pyramidal dysfunction and cerebellar ataxia. Altered mental status is a changing in awareness, movement and behaviors. Pyramidal dysfunction causes the decrease of fine motor coordination. Cerebellar ataxia will cause the clumsy voluntary movements [13].

4.2. The reason of the appearance of ADEM

There are now 2 concepts that have been developed as a result of extensive research using these animal models. According to the idea of an inflammatory cascade, neurotropic pathogens directly infect the CNS, leading to tissue destruction in the CNS, and systemic leakage of CNS-restricted self-antigens into the bloodstream through the damaged blood-brain barrier. Once these autoantigens have been digested by the systemic lymphatic organs, they will break down tolerance and trigger an encephalitogenic and self-reactive T-cell response. Such activated T cells have the capacity to invade the CNS and prolong CNS inflammation [12].

4.3. Treatment

For the treatment, the FDA has not expressly approved any drugs to treat ADEM because it is a rare condition. The usual course of treatment for ADEM is high-dose steroids administered intravenously (via a vein). They are administered over a number of days to lessen spinal cord, brain, and optic nerve inflammation. According to the MDPI, high-dose intravenous CSs are used as the first line of treatment before oral tapering. In individuals who are steroid-resistant or who have steroid contraindications, IVIGs and PE are regarded as second-line therapy. Early on in fulminant situations,

PE should be taken into account. Some critically ill patients require supportive care in addition to specific therapy. To lessen long-term effects, rehabilitation therapy should be taken into consideration.

5. Multiple sclerosis (MS)

5.1. Morbidity, Mortality and Economic burden of MS.

MS is a chronic CNS condition. It is believed to be an autoimmune disease in which the body accidentally attacks itself. As a sudden illness, it affects everyone differently. According to the National MS Society, the morbidity of MS is about 1 in 333. It is a common disease as a result of the morbidity. And the NCBI also claims that 120 of the 23,053 persons in this sample who had received a medical diagnosis of MS did so, with females having a higher prevalence (0.85%) than males (0.31%) [14]. NCBI also provides the data that MS increases the mortality of a person for 80% than a person doesn't have MS. The sciencedirect states that the cost of the MS has increased every year. They discovered that the price for MS care climbed at rates of \$40 million and \$8 million annually, respectively. We researcher found that the inflation of medical bills increased by 1.6 times over the previous ten years, and that this inflation was negatively connected with cost-to-charge ratios. The economic burden of US government has increased annually. It also gives a big changeling on the American health care system [15].

5.2. Pathogenesis of multiple sclerosis

The CNS is mostly damaged in MS due to inflammation. We still don't know what exactly triggers this inflammation. Numerous immunological studies have focused on the EAE, an animal model of human multiple sclerosis [16]. To start the adaptive response, antigen presentation cells (APCs) expose a specific antigen to T lymphocytes. Dendritic cells, macrophages, microglia, and B cells are other antigen-presenting cells [16]. Regulatory T cells (T reg) are a different CD4+ T cell subgroup involved in the pathogenesis of MS. T regulatory cells control effector Th1, Th2, and Th17 cells. Despite having the same number of T reg cells as controls, MS patients have lowered T reg function [17]. In MS lesions, CD8+ T cells have been shown to destroy glial cells, harm axons, increase vascular permeability, and cause oligodendrocyte death in addition to suppressing CD4+ T cell proliferation by secreting perforin [18].

5.3. Treatment of MS

There are now 8 drugs that the FDA has approved for relapsing forms of MS. For the primary progressive form of MS, the FDA has not yet approved any medicines [19]. Four different forms of interferon-beta (Avonex, Extavia Rebif), natalizumab (Tysabri), glatiramer acetate (Copaxone), and the most recent oral drug, fingolimod (Gilenya), have all received FDA approval [19]. Numerous more immunologically active drugs are used outside of their approved uses, and others are almost ready for FDA approval after completing their studies. The complexity and potential hazards of future MS treatment will rise due to the different types and lengths of these medicines' immunologic effects.

6. Conclusion

Although the cause of the AE, ADEM, and MS are varied, the research still finds the main cause of these disease. Therefore, the main cause of the inflammation of neural disorders is the immune cells disorder. Moreover, disorders of the neurological system and excessively active immune cells may be related in some way. To create disorders, the T-cells, B-cells, macrophages, and glial cells will activate and unintentionally kill some cells in the neurological systems. This research will help the people recognize the importance of the aspirin that is against the inflammation. The advice from this research paper is to seek more opportunity to explain the function of the medicines in the treatment.

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