Immune System: An Overview

Introduction

Immunology, the study of the immune system, is the fastest growing field in medical research. With the HIV epidemic and the spread of new infectious diseases, the medical community is realizing the importance of studying the mechanisms of the immune system. There is a vast amount of information on the immune system, light years beyond the scope of this material. I will touch on some of the basic concepts and relate them to diseases and issues currently affecting the immune system.

The immune system is the human body's defense against unwelcome intruders: the many potentially dangerous viruses, bacteria, and other pathogens we encounter in the air, food, and water. The immune system is also responsible for handling abnormal cell growth, which if not dealt with properly, may develop into cancer.

Through evolution, the body has developed two cooperative defense systems that counter these threats. The first system is **nonspecific** in nature, meaning that the immune system is working without the direction of attacking a specific bacteria, virus or infectious disease. There are two types of nonspecific immunity, external and internal defense. The external defense consists of the skin and mucous membranes that cover the body. The second line of defense is internal, consisting of antimicrobial proteins and phagocytic cells that indiscriminately attack any invader that penetrates the body's outer barriers, engulfing and recycling them.

The second defense system is **specific** in nature, meaning that the immune system responds only to a particular type of invader. A specific response includes the production of special proteins called antibodies and the participation of white blood cells. The 'specific defense' is what we associate with the immune system.

Specific Defense- The Immune System

The specific defense, or the immune system, is distinguished from the nonspecific defenses by four features:

- **Specificity**: This refers to the immune system's ability to recognize and eliminate a particular foreign molecule or infectious disease-causing pathogen. The foreign molecule is recognized by the immune system because it elicits an immune response from a substance produced by b-lymphocytes called **antigens**. Every type of microorganism, such as a virus, bacteria, fungi, protozoan, and parasitic worm, has its own unique antigen. The immune system recognizes this antigen and responds by producing specialized white blood cells (lymphocytes) and antibodies. Each antigen stimulates the production of a very specific type of antibody that defends only against that particular antigen. Specificity is crucial for the immune system to effectively function, otherwise it would be unable to differentiate between an invader and a friendly cell. Notice that the word antigen comes from the contraction of *anti*body-*gen*erating.
- **Diversity**: The immune system is able to respond to millions of kinds of invaders, each recognized by its specific antigen. This 'immune memory' is thought to result from millions of years of evolution and contact with myriad organisms and toxic compounds. The diversity of the immune system is a result of an enormous reserve of white blood cells that can synthesize and secrete the appropriate type of antibody.
- **Self/nonself recognition** refers to the immune system's ability to distinguish the body's own antigens from the antigens of foreign invaders. Failure to differentiate self and nonself can lead to autoimmune disorders in which the immune system destroys the body's own tissues.

- **Memory**: The immune system is able to remember antigens it has encountered and to react against them more effectively on subsequent exposures. This concept of memory is familiar to all of us, demonstrated by the immunity conferred after one time exposure to the chicken pox.

There are several other key concepts to be mentioned in this review of the immune system.

- Immunity can either be *actively* or *passively* acquired. Active immunity is demonstrated by the chicken pox, whereby the immunity is dependent upon a person's own immune system. Active immunity can either be acquired (1) naturally, as demonstrated with the chicken pox; or (2) artificially, by vaccinations (see next section). Passive immunity is the transferring of antibodies from one individual to another. This occurs naturally when a pregnant woman passes some of her antibodies across the placenta to the fetus.
- Vaccinations contain dead or weakened microorganisms that can no longer cause disease, but still retain the ability to act as antigens and stimulate an immune response. A vaccinated individual who encounters the actual pathogen will have a quick defense reaction based on an immunological memory developed from exposure to inactive microorganisms.
- B Cells and T Cells: These are common terminologies when discussing topics on the immune system and specific immune diseases such as HIV and AIDS. There are two main classes of white blood cells (lymphocytes) that are responsible for producing the immune response: B cells (B lymphocytes) and T cells (T lymphocytes). The B cells provide immune protection through the synthesis of antibodies that are circulated in the blood plasma and lymph. This is called humoral immunity, relating to the fluids that were called humors by the ancients. The T cells, on the other hand, generate most of their immune protection through direct action of lymphocytes, without the synthesis of antibodies. Immature T cells migrate from the bone marrow to the thymus gland, where they mature into active T cells (T for Thymus). The B cells mainly defend against toxins, free bacteria, and viruses present in the body fluids. In contrast, T cells are active against fungi, protozoans, and worms, in addition to bacteria and viruses inside the host's cells. It is interesting to note that all blood cells, including the immune B and T cells, originate from the stem cells in the bone marrow. Both B and T cells are mostly concentrated in the lymph nodes, spleen, and other lymphatic organs. A person with an infection may experience tender lymph glands, which is a sign of immune response.
- Medical researchers are just beginning to understand the impact of chemicals on our immune system. Not only is our environment flooded with all types of immunotoxic compounds, but our water, foods, and medicines contain them as well. Even worse is the potential effect on the body from the interaction of these chemicals with each other. There are too many variables to consider the true destructive nature of these 'life toxic' chemical soups. And, on top of all this, we must also consider the influence of electromagnetic radiation on our immune systems. We are constantly exposed to these unseen energy fields while in our homes, driving cars, or walking outdoors around power lines.
- Recent studies document how the immune system is compromised during physical and emotional stress. A majority of the medical research is focusing on the connection between the nervous, endocrine (hormone), and the immune systems and how they interact to control homeostasis – the crucial balance of internal biochemical and bioenergetic harmony. For example, the work of Dr. Candice Pert, a

prominent neuroimmunologist at the National Institute of Health (NIH), demonstrated the direct link between the nervous system and the immune system. Her work discovered a network of nerve fibers that penetrate the lymph nodes and thymus glands. Continuation of this work has shown that immunity may be enhanced or hindered by input from the nervous system. Additional studies in this field determined that during times of stress, adrenal gland hormones adversely affect the immune system, decreasing the number of white blood cells. This observation has motivated physiologists and psychologists to consider how our state of mind, including attitude and outlook, affects immunity and general health.

Primary Diseases

Medical Perspective for Immune Diseases

Most diseases of the immune system can only be diagnosed with an examination by a qualified health practitioner. Conditions such as HIV, autoimmune diseases, and cancer require carefully formulated diagnostics and closely monitored treatment protocols. Diagnostics for immune diseases includes tests measuring immunoglobulins, protein screen tests using electrophoresis, and various immune assays. Radioactive studies are often performed to measure immune function. Xray or imaging studies can be used to visualize specific immune organs, such as the thymus gland. New technologies developed from the human genome project have greatly contributed to the diagnostics of genetic based immune disorders. In the near future, we will see many genetic based immune therapies that will change the course of disease in human history forever.

Acquired Immune Deficiency Syndrome (AIDS)

AIDS is an immunodeficiency disorder which is caused by Human Immune Virus (HIV). The virus disrupts normal immune function, decreasing the body's ability to fight infection and suppress the growth of abnormal cells, such as cancer. HIV specifically disrupts the development of the lymphocytes (B and T cells) and cells in the bone marrow, spleen, liver, and lymph.

The initial symptoms of HIV are fatigue, unexplained weight loss, recurrent respiratory and skin infections, fever, swollen lymph glands throughout the body, diarrhea, night sweats, and changes with the genitalia.

The treatment of AIDS is multifaceted. Psychotherapy or counseling are employed to cope with anxiety and depression about having the disease and the likelihood of death.

At this point in time, AIDS is basically considered incurable. There is currently no vaccine to prevent infection or medication to completely destroy the virus in an infected person. However, new drug developments, specifically the most recent introduction of protease inhibitors are a positive sign that the disease is essentially a controllable one. Some medical scientists are predicting that a pharmaceutical will soon be developed that will allow patients with HIV to live long accomplished lives, similar to the treatment for diabetics. There is no cure for diabetes; however, the disease can be successfully managed with the use of insulin and accompanying drugs.

The treatment protocols for HIV are changing at an extremely fast pace, adjusting almost weekly to new discoveries and pharmaceutical developments.

Multitude of complications

AIDS is a disease of complications. HIV in itself only suppresses immune function. But this suppression of immune function allows many opportunistic infections and diseases

to invade the body. Some of the complications include cancer, Karposi's sarcoma (a form of skin cancer), and a type of pneumonia associated with *Pneumocystis carinii*.

The spread of HIV could be 100% prevented if the population followed safe sex precautions. HIV is present in blood, semen, and vaginal secretion. There are trace amounts of the virus in saliva, sweat, and tears; however, these fluids do not pose a risk. The HIV virus is transmitted by the following:

- Unprotected sexual contact with an infected person--vaginal and anal intercourse without a condom. Oral sex without a condom (on men) or a dental dam (on women) is considered risky for the person giving. Sex (vaginal, anal, and oral) with a condom is safe. Kissing, touching, hugging, etc. is 100% safe with an infected person.
- Use of contaminated needles for intravenous drug use.
- Transfusion of blood products from an infected person.

There is no risk in day-to-day non sexual contact with an infected person. Hugging, kissing, touching, massaging, speaking with, and caressing a person with HIV or AIDS is safe, as long as their blood, semen, or vaginal secretions *do not enter* your body. Recently, reports have been published saying that risky sex is again on the rise with the knowledge that newer combination therapies can essentially control AIDS.

Arthritis (Rheumatoid)

Arthritis is an autoimmune disease involving the membrane linings of the joints, cartilage, and muscles. The exact cause of the disease is unknown; however, there is a strong correlation with genetic factors and family history. Risk also increases with emotional or physical stress from surgery, accidents, childbirth, menopause, or work related stress.

Arthritis is three times more common in women than men, beginning between ages 20 and 60, with peak incidence between ages 35 and 45. Juvenile rheumatoid arthritis, similar in etiology and symptoms to adult arthritis, starts at ages 2 to 5 and usually disappears by puberty.

The symptoms of arthritis are redness, pain, warmth, and tenderness in any or all active joints in the hands, wrists, elbows, shoulders, feet, and ankles. The severity of symptoms varies among patients; some experience severe incurable pain, while others have mild irritation. Some individuals may have a low-grade fever and experience morning stiffness. Nodules are sometimes present under the skin. The symptoms of arthritis most often develop over a period of time; however, some individuals may experience sudden onset of pain. Medical diagnostics can detect arthritis through laboratory blood studies of the rheumatoid factor and/or a physical exam and xray of the affected joints.

General measures for arthritis utilize drug agents, physical therapy/manipulation, and surgery to correct deformities. The most commonly prescribed drugs are non-steroidal anti-inflammatory drugs (NSAIDS), such as aspirin, acetaminophen (tylenol), and ibuprofen (advil). Other medications include gold compounds and immunosuppressive drugs. Cortisone compounds are not recommended, because they only offer short term relief at a cost of progressing joint destruction. Physical therapy is recommended for some patients to retain mobility of joints. It is best to remain active, but not to become overtired. Disabled joints should be exercised passively. Cold and damp weather aggravates symptoms. Heat therapy delivers pain relief. Covering hands with gloves is an example of a simple measure that can be taken. Obese patients should lose weight, because the unnecessary weight stresses the joints.

The prognosis is fair. A normal life span is possible if diagnosed early. Some individuals may experience complications of impaired vision or permanent deformity and crippling of the joints. With increasing age, patients' arthritis develops with contracture (muscle shortening) or degeneration of muscles around an inflamed joint. Approximately 10% of individuals will be permanently disabled.
(Note: There is form of arthritis associated with Lyme's disease and other types of pathogens. Septic arthritis is caused by bacteria or fungi that enter the joint.)

Immunodeficiency Disease

Immunodeficiency is a defect in the body's immune system, which prevents the immune system from protecting the body against infectious disease (bacteria, viruses, fungi), cancer, and any foreign material which enters the body. The general causes are congenital birth defects involving an incomplete or absent immune system, use of immunosuppressive drugs or chemicals, radiation treatment, cancers (e.g., Hodgkin's disease), and AIDS. Individuals who overwork or who are under stress for a period of time, even years, can experience a partial breakdown in immune strength, leading to chronic low-grade viral infections, such as those that are thought to accompany chronic fatigue syndromes. For individuals with a family history of immunodeficiency, seek genetic counseling before starting a family.

The two main divisions of immunodeficiency are (1) those who are *inherently* deficient, and (2) those who *acquire* either humoral (B cell) or cell-mediated (T cell) immune deficiency. An example of inherent immunodeficiency is 'severe combined immunodeficiency', a congenital disease where both branches of the immune system fail to function. On the other hand, two examples of acquired immunodeficiency are (1) Hodgkin's disease, a condition where the lymphatic system is damaged, and (2) Acquired Immune Deficiency Syndrome (AIDS), associated with the human immunodeficiency virus (HIV).

The primary symptoms of immunodeficiency are recurrent, severe infections and illnesses. The most prevalent complications include yeast infections, ear or respiratory infections, cancer, meningitis or encephalitis, bleeding disorders, and eczema. The parts of the immune which are most affected include the blood, bone marrow, liver, spleen, thymus gland, and lymph tissues.

Treatment of Immunodeficiency

Pharmaceutical agents consist of medications to build immunity (injections of antibodies, gamma globulin, transfusions of blood compounds) and the use of antibiotics to fight infections.

Transplant operations are performed for bone marrow or thymus gland. Hospitalization is required for serious infections.

Individuals with an immunodeficiency should avoid exposure to persons having a contagious illness. They should also not take any immunosuppressive drugs, vaccinations, or cortisone application.

Medical professional should be contacted immediately if there are signs of infections--chills, fever, muscle aches, headache, dizziness, cough, and sputum that is discolored or blood-streaked.

The prognosis is dependent upon the form of immunodeficiency. Severe forms are usually fatal, while minor forms can be treated successfully. Perhaps, in the future with new genetic technologies, many inherent immune dysfunctions will be prevented with gene replacement therapy.

Autoimmune Diseases

- In autoimmune diseases the immune system goes awry and turns against itself. Examples: Systemic lupus, Rheumatoid arthritis (a crippling autoimmune disease in which inflammation damages cartilage and bone of joints), Insulin-dependent diabetes, Rheumatic fever, and Grave's Disease.
- Allergies
  Allergies are hypersensitivities of the body's defense system to certain environmental antigens called allergens. A histamine response usually occurs from exposure to an allergen. Symptoms of the histamine response include sneezing, runny nose, and smooth muscle contractions that can result in breathing difficulty. The most serious type of allergic response is anaphylactic shock, which is a life threatening reaction to ingested or injected antigens. An example is people with hypersensitivity to wasp or bee stings, or certain foods, like peanuts or fish.

SUMMARY OF KEY FACTS

System role: The immune system is the human body's defense against unwelcome intruders (viruses, bacteria, and other pathogens). The system is also responsible for handling abnormal cell growth, which if not dealt with properly, may develop into cancer.
Tissues and Organs: The blood, bone marrow, liver, spleen, thymus gland, and lymph tissues.
System Terminology: Antibodies, B and T Cells, specific vs. nonspecific; specificity, diversity, self/non self recognition, memory; active vs. passive immunity.
Significant Diseases: Autoimmune, HIV/AIDS, allergies, arthritis, cancer, chronic fatigue syndrome.