

Immunology and Diseases

OBJECTIVES/RATIONALE

The body protects itself from pathogens through various defense mechanisms including immunity. The student will describe the key structures involved in the immune system, types of immune responses, and common immune disorders.

TEKS: 121.15 (c) 4(A-E), 5(A-D), 6(A-D), 7(B,C,D)

TAKS ELA 1, 4
Science 1,2,3

KEY POINTS

POWER POINT

I. Immune system is comprised of groups of cells and organs found throughout body

A. Primary organs include:

- a. thymus gland
 - i. Produces mature T cells. Immature thymocytes leave bone marrow and migrate into the thymus.
 - ii. The mature T cells are then released into the bloodstream.
- b. bone marrow –
 - i. All the cells of the immune system are initially derived from the bone marrow.
 - ii. Bone marrow-derived stem cells differentiate into either mature cells of the immune system or into precursors of cells that migrate out of the bone marrow to continue their maturation elsewhere.
 - iii. The bone marrow produces B cells, natural killer cells, granulocytes and immature thymocytes, in addition to red blood cells and platelets.

B. Secondary organs include:

- c. lymph nodes
 - i. Lymph nodes are found throughout the body.
 - ii. Nodes function as immunologic filters for bodily fluid and lymph - word "lymph" in Greek means a pure, clear stream
 - iii. Composed mostly of T cells, B cells, and macrophages, the nodes filter fluid from tissues.
 - iv. Antigens are filtered out of lymph in lymph nodes.
- d. spleen
 - i. An immunologic filter of the blood.
 - ii. Contains B cells, T cells, macrophages, and red blood cells.
 - iii. In the spleen, B cells become activated and produce large amounts of antibody.
 - iv. Old red blood cells are destroyed in spleen.
- e. tonsils and adenoids
 - i. Prominent masses of lymphoid tissues on either side of the throat.
 - ii. Filters and prevents pathogens from entering respiratory and digestive systems

C. Major cells of immune system (**leukocytes**) arise and develop in primary organs

D. Secondary organs are responsible for:

- a. filtering foreign substances
- b. providing space for **antigenic**

II. Cells of the immune system

A. monocytes – **phagocytic**

lear (PMNs) leukocytes - active in inflammatory process

- a. Basophil
- b. Eosinophil
- c. Neutrophil

D. T Cells and B Cells

- a. Lymphocytes
- b. Mature in the bone marrow

III. Immunocompetence – the ability of certain cells to distinguish between foreign matter and what belongs to the body

IV. Two types of immune responses

A. When foreign substances or toxins invade the body, two types of immune responses are possible in recognition and destruction of antigens:

A. **-mediated immunity**

- 1) rejection of transplanted organs
- 2) delayed immune responses that fight disease
- c. Eighty percent of blood cells are T cells
- d. Originate from stem cells in the bone marrow
- e. The thymus gland controls their maturity (in the process, a large number of antigen-specific cells are produced)
- f. T cells can be a killer, helper, or suppressor:
 - 1) Killer cells bind to surface of invading cell, disrupt the membrane, and destroy it by altering its internal environment
 - 2) Helper cells stimulate B cells to mature into plasma cells, which begin to synthesize and secrete immunoglobulins (proteins with known antibody activity).
 - 3) Suppressor cells reduce the humoral response

B. Humoral immunity

Five major classes of immunoglobulins

- 1) Immunoglobulin G (IgG) makes up about 80% of plasma antibodies. It appears in all body fluids and is the major antibacterial and antiviral antibody.
- 2) Immunoglobulin M (IgM) is the first immunoglobulin produced during an immune response. Its too large to easily cross membrane barriers and is usually present only in the vascular system.
- 3) Immunoglobulin A (IgA) is found mainly in body secretions, such as saliva, sweat, tears, mucus, bile, and colostrum. It defends against pathogens on body surfaces, especially those that enter the respiratory and GI tracts.

- 4) Immunoglobulin D (IgD) is present in plasma and is easily broken down. It's the predominant antibody on the surface of B cells and is mainly an antigen receptor.
 - 5) Immunoglobulin E (IgE) is the antibody involved in immediate hypersensitivity reactions, or allergic reactions that develop within minutes of exposure to an antigen. IgE stimulates the release of mast cell granules, which contain histamine and heparin.
- g. complement system – part of the humoral immunity; It is the major mediator of the inflammatory response and consists of 20 proteins circulating as functionally inactive molecules. System causes inflammation by increasing:
- 1) vascular permeability
 - 2) chemostasis
 - 3) phagocytosis
 - 4) lysis of the foreign cell

V. Types of immunity

- A. active natural immunity – having disease (example: mumps)
- B. active artificial immunity – receiving vaccination (example: MMR)
- C. passive natural immunity – antibodies received through maternal-fetus transmission
- D. passive artificial immunity – injection of antibodies (Gamma Globulin)
- E. natural resistance – the inherited immunity individual may possess due to race, species, or ethnic background (some groups naturally resistant to certain diseases, just as some more susceptible to certain diseases)

VI. Diagnostic tests for immune disorders

- A. Allergy tests
 - a. Skin tests – may be performed by intradermal injection, skin patch, scratch test
 - b. Coombs' test – indicates formation of antibodies on red blood cell
 - i. Test can be used to determine blood type and diagnose certain hemolytic anemias
 - ii. Test may also indicate presence of maternal antibodies against fetal blood type
- B. Autoimmune disorders tests - blood tests that measure specific diseases (example: people with lupus will have positive antinuclear antibody (ANA) test; people with rheumatoid arthritis will often have rheumatoid factor (RF) in blood)
- C. Immunodeficiency disorders tests
 - a. Blood tests that reveal low white cell counts (specifically B and T lymphocytes)
 - b. Blood tests that detect presence of an antibody against a causative pathogen

VII. Common immune system diseases can be divided into two groups:

- A. Hypersensitivity Disorders
 - a. Result of overreaction of immune system to an antigen or allergen
 - b. Further classification: allergy, autoimmunity, isoimmunity
- B. Immune Deficiency Disorders

VIII. Hypersensitivity Disorders

- most familiar types of hypersensitivity problems

- Include: **hay fever asthma urticaria contact dermatitis**
- allergies are acquired hypersensitivities
 - after individual's first exposure to antigen, subsequent or repeated exposure leads to reaction by immune system
 - allergens may cause immediate response (hay fever, asthma, food allergy)
 - allergens may also cause delayed response (contact dermatitis from poison ivy, etc.)
- Local or systemic inflammatory responses of allergies: redness, heat, swelling, pruritus

- Respiratory symptoms: nasal congestion, rhinorrhea, coughing, sneezing, nasal congestion, wheezing
 - elevated blood eosinophil (white blood cell that responds in allergic conditions) level, local or systemic inflammatory responses (redness, heat, swelling, itching)
- A. Hay Fever
- a. a reaction to mucous membranes of nose and upper respiratory tract to an allergen
 - b. allergen usually airborne (may be seasonal or year-round)
 - c. common seasonal allergens: grasses, ragweed pollen, tree pollen
 - d. common year-round allergens: dust, pet dander, food allergies
 - e. Manifestations: sneezing, watery eyes, runny nose, itching
 - f. Treatment: removal of allergen (separation of allergen from sufferer), antihistamines and nose drops to control symptoms, allergy desensitization, air-conditioning environment, moving to different climate
- B. Asthma - also known as bronchial asthma
- a. chronic allergic condition that affects the respiratory system
 - b. when exposed to an allergen, hypersensitive individual has episodes of wheezing due to bronchospasm
 - c. asthma may be caused by allergens (pollen, dust, pet dander, smoke, fumes, etc.), respiratory infections (common cold), temperature changes, exercise, emotional stress
 - d. Manifestations: shortness of breath, difficulty breathing, wheezing, coughing, production of mucus, moist and pale skin, cyanosis of fingers and lips
 - e. Status asthmaticus - attacks that last for several days
 - f. Treatment – avoidance of causative allergens, desensitization, medication, deep breathing exercises, relaxation techniques (muscle relaxation, visualization, biofeedback, etc.)
- C. Urticaria (Hives—sometimes called nettle rash)
- a. Vascular reaction of skin
 - b. Condition caused by contact with external irritant (insect bites, pollen, drugs, food, or plants)
 - c. Manifestations: slightly elevated (edematous) lesions (wheals) that are redder or paler than surrounding skin; lesions are associated with severe pruritus
 - d. Treatment: antihistamines and avoidance to allergen
- D. Anaphylaxis
- a. Acute allergic response to an allergen which can lead to anaphylactic shock (contraction of smooth muscle and dilation of capillaries leading to severe respiratory distress or failure)
 - b. Caused by absorption of antigen into blood either directly or through mucous membranes
 - c. Substances that can commonly cause anaphylaxis include: antibiotics, anesthetics, codeine, insulin, hormones, iodinated X-ray contrast media, vaccines, antitoxins, foods, pollen, mold, animal dander, latex, insect venom (bees, wasps)
 - d. Systemic anaphylactic reaction:
 - i. medical emergency involving release of histamine throughout body tissues
 - ii. individual feels pruritus of throat, tongue, and scalp
 - iii. edema of face and airways leads to difficulty breathing
 - iv. huge drop in blood pressure (shock) and body temperature
 - v. if symptoms are not reversed, death may occur from respiratory and cardiac arrest
 - e. Treatment
 - i. Administration of epinephrine (Adrenalin) - vasoconstrictor and smooth muscle relaxant; will elevate blood pressure, dilate bronchi, decrease laryngeal spasms
 - ii. administration of corticosteroids - powerful anti-inflammatory hormones given to limit histamine production (slows allergic reaction)
 - iii. emergency tracheostomy and mechanical ventilation

- iv. follow-up treatment: identification of allergen, carrying allergy kit which includes Benadryl and vials of epinephrine

E. Allergic Dermatitis

a. Contact Dermatitis

- i. Delayed hypersensitivity reaction to chemical allergens
- ii. Some of the common allergens may be: laundry product, plants, cosmetics, jewelry, various metals
- iii. Common lesions: slightly raised, pruritic area that corresponds with area of contact
- iv. Poison ivy lesions: vesicles (often linear); oozing from vesicles may spread eruption to other body parts

b. Atopic Dermatitis

- i. Hereditary predisposition to atopic allergens
- ii. Usually begins in infancy with exzema of face and scalp, then recurs in child and adulthood with more generalized involvement of trunk and extremities
- iii. Vesicular lesions predominate in infants, while children and adults develop dry, thickened skin lesions
- iv. Characterized by severe pruritus
- v. Specific allergens are not identified, but exacerbation of atopic dermatitis related to substances in environment, temperature variation, and emotional stress (patch testing not useful in atopic dermatitis)

c. Seborrheic Dermatitis

- i. Common form of dermatitis occurring at sites of concentrated sebaceous glands (scalp, face, ears, neck, axillae, breasts, umbilicus, and anogenital regions)
- ii. Usually begins in childhood as fine scaling of scalp (cradle cap) may continue throughout life with expansion to other areas
- iii. Scaly lesions resembling psoriasis.
- iv. Specific cause of seborrheic dermatitis is unknown.

IX. Autoimmune Disorders

- Hypersensitivities in which body fails to recognize its own antigens.
- Failure to recognize self-antigens leads to the body attacking and destroying its own tissues.
- Although several theories exist as to the cause of autoimmune disorders, currently, there is not a definitive cause known.
- Autoimmune disorders include: rheumatic fever, rheumatoid arthritis, myasthenia gravis, systemic lupus erythematosus, and multiple sclerosis

A. Rheumatic Fever

- a. Tends to run in families.
- b. Occurs in small numbers of individuals following group A streptococcal infection (usually strep throat)
 - i. The protein of the strep bacteria is similar to proteins in heart and other connective tissue.
 - ii. Exposure to strep bacteria causes immune system to make antibodies to fight the bacteria—these antibodies also attack tissues of heart and joints since they cannot distinguish differences in proteins.
- c. Rheumatic fever usually occurs one to four weeks after streptococcal infection.
- d. Children and adolescents most commonly affected.
- e. Rheumatic fever is characterized by myocarditis and arthritis.
- f. Onset of disease may be sudden or gradual and includes: fever, malaise, and joint pain.

- g. First occurrence of rheumatic fever may be mild and resolve without permanent damage. Further episodes usually more severe and may lead to permanent scarring and deformity to heart valves.
- h. Treatment: culturing for strep infections; antibiotics; surgical replacement of heart valves may be necessary

B. Rheumatoid Arthritis

- a. Chronic inflammation of connective tissue; joint tissue is primarily affected.
 - i. Metacarpophalangeal joints are initially affected. This leads to hallmark sign of called ulnar deviation of fingers.
 - ii. Progression of the disease often leads to involvement of other joints.
 - iii. Rheumatoid arthritis begins with inflammation of synovial lining of joint leading to pain, stiffness, and joint deformity. Cartilage is eventually destroyed and replaced with granulation tissue (pannus).
 - iv. Rheumatoid nodules appear in subcutaneous tissue around fingers, toes, and elbows.
 - v. Sometimes rheumatoid arthritis results in fusion and loss of joint function (called ankylosis).
- b. Individuals may also have lesions in collagen of lungs, blood vessels, heart, and eyes - anemia and infection are common secondary problems
- c. Cause is associated with production of an abnormal antibody that attacks (or attaches to) body's own cells and tissues.
- d. Onset is most common in women between ages twenty and forty - women affected three times more often than men
- e. Rheumatoid arthritis in children (infants to age 16) may be very severe - called juvenile rheumatoid arthritis or Still's disease
- f. Treatment includes: anti-inflammatory medications, analgesics, corticosteroids during periods of exacerbation, exercise to maintain joint function, joint replacement.

C. Myasthenia Gravis

- a. Characterized by profound muscle fatigue - degree of weakness varies with time of day and activities (generally stronger in mornings due to buildup of acetylcholine).
- b. Disease affects reception of nerve signals to muscle at the neuromuscular junction.
 - i. The neurotransmitter, acetylcholine is produced, but it is not properly received by muscle.
 - ii. Error is due to antibodies attacking muscle receptors (thus, transmission of acetylcholine is blocked).
 - iii. This poor transmission leads to weak muscle contractions and fatigue.
- c. Muscular fatigue:
 - i. Often, the facial muscles are the first resulting in ptosis and diplopia
 - ii. Other muscular problems: dysphagia, dysphonia, difficulty with facial expressions, voluntary muscle fatigue (difficulty lifting arms and legs, standing, walking)
- d. Periods of exacerbation and remission occur with myasthenia gravis.
- e. Treatment: cholinergic medications like Mestinon (prevents normal breakdown of acetylcholine, therefore permitting buildup), plasma exchange to remove circulating antibodies.
- f. Ultimately fatal; death usually due to respiratory failure.

X. Isoimmune Disorders

- Hypersensitivity of one individual to another individual's tissues
- Examples include: blood type reactions, tissue rejections, maternal/fetal reactions

A. Blood Transfusion Reaction

- a. Isoimmune reaction due to incompatible blood typing during transfusion.

- b. Blood types are identified by antigens and divided into four groups: A, B, AB, and O.
- c. Types A and O are the most common.
- d. Each red blood cell has an antigen and corresponding antibody:
 - Blood type A: A antigen and anti-B antibody
 - Blood type B: B antigen and anti-A antibody
 - Blood type O: and both anti-A & anti-B antibody (universal donor)
 - Blood type AB: A & B antigen and **no antibody** (universal recipient)
- e. If blood type with antigen is given to a type that has antibodies against that antigen, the antibodies will attack the antigen and break down the donor RBCs.
- f. Symptoms of transfusion reaction include: chills, shivering, fever; in some cases blood clots form and may be fatal.

B. Erythroblastosis Fetalis

- a. Isoimmune condition where antibodies in mother's blood attack and destroy antigen on baby's red blood cells (ultimately killing fetus)
 - i. In addition to antigens that determine blood type, eighty-five percent of Americans have another antigen called the **Rh factor**. (collective referred to as **Rh+**

Rh-

individuals cannot receive Rh+ blood
can

will

-
-
-

early late

Candida albicans

-
-
- I. Complete a Pathology Report over one of the autoimmune diseases. (see Autoimmune Disease List)
 - II. Complete tutorial (See MEDLINEplus site) on one the following: Rheumatoid Arthritis, Vasculitis, Latex Allergies, Crohn's Disease, Lupus, Multiple Sclerosis, Myasthenia Gravis, Alopecia Areata

MATERIALS NEEDED

<http://news.bbc.co.uk/1/hi/health/1123968.stm> - Article: *Personality Influences Immune System*
_____ - *Women's Immune System: Key to a Long Life*
_____ *Scientists Crack Immune System Secret*

<http://www.users.globalnet.co.uk/~aair/nuts.htm> - Article: *The Nut Allergy*
_____ *Angioedema*

_____ *Primary Biliary Cirrhosis: An Autoimmune Liver Disease*

REFLECTIONS

Pathology Report

Disease

Alternate names

Definition

Etiology

Signs & Symptoms

Diagnostic Tests

Treatment

Complications

Prognosis

Autoimmune Diseases

Alopecia Areata
Anklosing Spondylitis
Antiphospholipid Syndrome
Autoimmune Addison's Disease
Autoimmune Hemolytic Anemia
Autoimmune Hepatitis
Behcet's Disease
Bullous Pemphigoid
Cardiomyopathy
Celiac Sprue-Dermatitis
Chronic Fatigue Syndrome (CFIDS)
Chronic Inflamm. Demyelinating
Chronic Inflamm. Polyneuropathy
Churg-Strauss Syndrome
Cicatricial Pemphigoid
CREST Syndrome
Cold Agglutinin Disease
Crohn's Disease
Discoid Lupus
Essential Mixed Cryoglobulinemia
Fibromyalgia
Grave's Disease
Guillain-Barre
Hashimoto's Thyroiditis
Idiopathic Pulmonary Fibrosis
Idiopathic Thrombocytopenia Purpura (ITP)
IgA Nephropathy
Insulin Dependent Diabetes (Type I)
Lichen Planus
Lupus
Meniere's Disease
Mixed Connective Tissue Disease
Multiple Sclerosis
Myasthenia Gravis
Pemphigus Vulgaris
Pernicious Anemia
Polyarteritis Nodosa
Polychondritis
Polyglanular Syndromes
Polymyalgia Rheumatica
Polymyositis and Dermatomyositis
Primary Agammaglobulinemia
Primary Biliary Cirrhosis
Psoriasis
Raynaud's Phenomenon
Reiter's Syndrome
Rheumatic Fever
Rheumatoid Arthritis
Sarcoidosis
Scleroderma
Sjogren's Syndrome
Stiff-Man Syndrome
Takayasu Arteritis
Temporal Arteritis/Giant Cell Arteritis
Ulcerative Colitis
Uveitis
Vasculitis
Vitiligo

Key Terms:

Answers—Key Terms:

