

Course

Pathophysiology

Unit III

Fundamentals of Pathophysiology

Essential Question

What replaces the job of the kidneys when they fail?

TEKS

§130.208 (c)
(1A) (5D-E)

Prior Student Learning

Basic understanding of urinary system

Estimated time

2 hrs

Rationale

The kidneys use selective permeability in the formation of urine and in maintaining homeostasis.

Objectives

Upon completion of this lesson, the student will be able to:

- Understand the role of the cell membrane
- Understand the cell membrane can be semi-permeable
- Identify the anatomy of the kidney
- Determine the permeability of different types of membranes to various substances

Engage

Discuss the following:

- A man finds his 28-year-old wife unconscious on the kitchen floor. She responds only to painful stimuli. Her pulse is fast, respirations are rapid and deep, and her skin is dry and flushed. There is a sweet, fruity smell to her breath. She has a history of diabetes and that she is on insulin.
- James is a conscious, but combative teenager. He appears pale and diaphoretic, but his vital signs are normal. His friends tell you he is diabetic, and that he skipped lunch to take a test. During the intramural game, he became weak and confused.

Key Points

- Dialysis – derives from the Greek term "dialysis," meaning dissolution: "dia" meaning through, and "lysis" meaning loosening. Dialysis is a procedure where smaller (diffusible) particles can be separated from larger particles (nondiffusible) by selective permeability through a specific membrane.
- The plasma membrane of a cell selectively permits the passage of certain substances, such as nutrients, while excluding others.
- The artificial kidney is a mechanical device that utilizes the principle of dialysis to separate large particles (such as blood cells) from small ones (such as urea and other wastes).
 - diffusion – movement of molecules or ions from a region of higher

concentration of molecules to a region of low concentration of molecules until the molecules are evenly distributed. It may occur through water or the air. Examples:

1. opening a perfume bottle: eventually everyone in the room will be able to smell it
 2. adding food coloring to a beaker of water will result in the water turning one particular color
 3. the movement of oxygen from the blood into the cells of the body
- B. osmosis – process that allows water to move through a selectively permeable membrane from a region of higher concentration to a region of lower concentration
- C. filtration -- process of removing particles from a solution by allowing the liquid to pass through a membrane. Controlled and influenced by gravity or hydrostatic pressure. Example:
1. movement of blood through the glomeruli of the kidneys, which results in many of the smaller particles leaving the blood and entering the glomerular (Bowman's) capsule during the first step of urine formation

IV. Kidney

- A. Two bean-shaped organs behind the abdominal cavity -- **(retroperitoneal)**
- B. On either side of the spine in the lumbar region
- C. Surrounded by a cushion of adipose tissue and fibrous connective tissue (protection for the kidneys)
- D. Each kidney is about the size of a fist and weighs from 4-6 pounds
- E. Cortex region
Cortex means “bark” as in the bark of a tree
- F. Medulla region
Medulla means marrow
- G. Hilum – a depression on the medial border of the kidney

V. Parameters that affect kidney function

- A. Blood pressure
- B. Blood volume
- C. Hormones
1. ADH-Anti Diuretic Hormone, to prevent the production of dilute urine.
 2. Aldosterone: regulates salt and water concentration.
- D. Caffeine
- E. Trauma
- F. Nutritional status
- G. Disease

VI. Diseases of the kidney that result in dialysis treatment

- A. Glomerulonephritis, inflammation of the glomeruli, is caused by a

bacterial infection. The signs and symptoms include edema, oliguria, proteinuria, azotemia, hematuria, and fatigue. Treatment includes antibiotic therapy, diuretics, bed rest, and fluid restrictions. It typically resolves within two weeks.

- B. Cystic disease is a term that encompasses a number of diseases with differing origins but a common factor – cysts.
 - 1. Autosomal dominant polycystic kidney disease (PKD)
 - 2. Autosomal recessive polycystic kidney disease (PKD)
- C. Urologic diseases – involve congenital or acquired dysfunction of the urinary system
 - 1. Renal failure
- D. Diabetes Mellitus: insulin deficiency, inherited, 5 million in USA
 - 1. Type I: insulin dependent diabetes (IDDM)
 - a. Juvenile, rapid onset
 - b. Hereditary predisposition
 - c. Viral destruction of beta cells
 - d. Body lacks ability to produce insulin
 - e. Rx/Tx: insulin injections
 - 2. Type II: non-insulin dependent diabetes (NIDDM)
 - a. Adult/maturity, slow onset
 - b. Obesity causes beta cells to overreact, but they become less responsive, therefore a decrease in insulin secretion
 - c. Rx/Tx: diet, oral replacements
 - 3. Symptoms
 - a. Polydipsia: excessive thirst
 - b. Polyphagia: excessive eating with weight loss
 - c. Polyuria: excessive urination with dehydration
 - d. Glycosuria: sugar in urine due to increase in blood glucose
 - 4. Complications
 - a. Atherosclerosis and heart disease
 - b. Retinopathy: increased blood glucose destroys the retina, 2nd leading cause of blindness
 - c. Renal disease: glucose destroys nephrons
 - d. Circulatory deficiency: gangrene and amputations
 - 5. Side effects
 - a. Diabetic coma: hyperglycemia caused by eating too much or too little insulin causes increased blood glucose (normal = 70-100 mg/100 ml)
 - i. Ketoacidosis: byproduct of fat metabolism
 - ii. Acetone breath: fruity odor, N/V
 - iii. Kussmaul's breathing: rapid, deep, labored
 - iv. Restlessness, confusion, coma
 - v. Rapid, weak pulse, low BP
 - vi. Skin warm, dry, flushed

- vii. Tx: insulin
- b. Insulin shock: hypoglycemia caused by not eating or too much exercise so body has too much insulin
 - i. Dizzy, headache, nervousness
 - ii. Full, rapid pulse
 - iii. Diaphoresis
 - iv. Pale, cold skin
 - v. Tremors, seizures
 - vi. Loss of consciousness, coma
 - vii. Normal breathing, normal BP
 - viii. Tx: sugar ASAP
 - ix. Hypertension

VII. Two types of dialysis:

A. Hemodialysis: Hemodialysis removes wastes and water by circulating blood outside the body through an external filter, called a dialyzer, that contains a semipermeable membrane.

This pressure gradient created by the membrane causes water and dissolved solutes to move from blood to dialysate, and allows the removal of several liters of excess fluid during a typical 3 to 5 hour treatment. *Remember: This treatment is done to clean with external means.*

Peritoneal Dialysis: In peritoneal dialysis wastes and water are removed from the blood inside the body using the peritoneal membrane of the peritoneum of the abdominal cavity as a natural semipermeable membrane. Using glucose in the dialysate, this pressure gradient causes water and dissolved solutes to move from blood to dialysate, and allows the removal of several liters of excess fluid during a typical 3 to 5 hour treatment. Peritoneal dialysis is carried out at home by the patient. *Remember: This treatment is done within the body.*

Activity

- I. Complete the Dialysis Laboratory Investigation.

Assessment

Laboratory Investigation Rubric

Materials

Deionized water
 Sodium chloride
 Glucose
 Raw eggs
 0.1 M silver nitrate solution
 Benedict's solution

1 M nitric acid solution
Bunsen burner
Small test tubes
Droppers
10 ml and 1000 ml graduated cylinders
1000 ml beaker
500 ml beaker
Glass rods
String
Various materials to serve as dialysis membranes (dialysis membrane, cellophane, plastic wrap, wax paper, plastic bag, etc.)
Gloves
Goggles
Biohazard containers
Surface disinfectant
Paper towels

<http://kidney.niddk.nih.gov/index.aspx> -- National Kidney and Urologic Diseases Information Clearinghouse

<http://www2.niddk.nih.gov/> -- The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)

Accommodations for Learning Differences

For reinforcement, the student will draw a kidney and identify the parts where osmosis and filtration occur.

For enrichment, the student will research and report on why severe kidney disease may cause generalized edema.

National and State Education Standards

National Healthcare Foundation Standards and Accountability Criteria:

Foundation Standard 1: Academic Foundation

1.2 Diseases and Disorders

1.21 Describe common diseases and disorders of each body system (prevention, pathology, diagnosis, and treatment).

1.22 Recognize emerging diseases and disorders.

1.23 Investigate biomedical therapies as they relate to the prevention, pathology, and treatment of disease.

TEKS

§130.208 (c) (3)(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and

experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

§130.208 (c) (5)(D) evaluate the effects of chemical agents, environmental pollution, and trauma on the disease process; and

§130.208 (c) (5)(E) research stages in the progression of disease.

Texas College and Career Readiness Standards

SCIENCE

(5) F. Systems and homeostasis

1. Know that organisms possess various structures and processes (feedback loops) that maintain steady internal conditions.

2. Describe, compare, and contrast structures and processes that allow gas exchange, nutrient uptake and processing, waste excretion, nervous and hormonal regulation, and reproduction in plants, animals, and fungi; give examples of each.

(6) (E) 4. Understand chemical equilibrium.

Dialysis Laboratory Investigation

Purpose:

The purpose of this lab is to determine the permeability of different types of membranes to chloride ions, glucose molecules, and egg albumin. This can be used as a comparison to how the body attempts to maintain homeostasis when changes occur.

Background Information:

Materials:

Deionized water
Sodium chloride
Glucose
Raw eggs
0.2M silver nitrate solution
Benedict's solution
1 M nitric acid solution
Bunsen burner
Small test tubes
Droppers
10 ml and 1000 ml graduated cylinders
1000 ml beaker
500 ml beaker
Glass rods
String
Various materials to serve as dialysis membranes (dialysis membrane, cellophane, plastic wrap, wax paper, plastic bag, etc.)
Gloves
Goggles
Biohazard containers
Surface disinfectant
Paper towels

Procedure:

I. Preparation

1. Wash hands and put on gloves and goggles.
2. Assemble equipment and materials.
3. Prepare work area.
4. Test solution - add 10 g of sodium chloride, 10 g of glucose, and 10 g of raw egg white to every 500 ml of deionized water needed for the test.

II. Lab procedure

- A. Create a dialysis bag by placing at least 20 ml of the test solution in each membrane to be tested and secure the solution in the membrane by tying the end with a string. Leave the ends of the string long enough to tie a glass rod to the bag of fluid.
- B. Suspend the glass rod across the mouth of a 500 ml beaker $\frac{3}{4}$ full of deionized water, allowing the bag to be submersed in the water.
- C. Let stand for at least one hour.
- D. Run the following test on the water in the beaker and on the solution in the dialysis bag. *All tests must be made on all the membrane types. There will be six tests for each membrane-beaker fluid combination.*
 1. Test for sodium chloride: Pour 5 ml of liquid from the beaker into a test tube and add a drop of 0.1 M silver nitrate. A cloudy formation in the test tube indicates the presence of NaCl.
 2. Test for glucose: Add 5 ml of Benedict's solution into a test tube and add 5 drops of liquid from the beaker. Gently boil for two minutes over a Bunsen burner or in a water bath. Allow to cool at room temperature. A green, yellow, or red precipitate indicates the presence of glucose.
 3. Test for albumin: Pour about 5 ml of the liquid from the beaker into a small test tube and add 2-3 drops of 1 M nitric acid. The presence of albumin will be detected by the formation of a white, coagulated precipitate.
 4. Repeat the above tests using 5 mL amounts of solution from the dialysis bags tested.
 5. Clean work area with surface disinfectant. Remove goggles and gloves; wash hands.

Data:

Record observations

1. Type of membrane: _____

	Sodium Chloride	Glucose	Albumin
Contents of dialysis bag			
Water			

2. Type of membrane: _____

	Sodium Chloride	Glucose	Albumin
Contents of dialysis bag			
Water			

3. Type of membrane: _____

	Sodium Chloride	Glucose	Albumin
Contents of dialysis bag			
Water			

Conclusion:

1. Which of the membranes prevented any movement of solute particles?
2. Which membranes allowed the *most* solutes to pass?
3. Which solute particles tested positive most often in the beaker fluid?
4. Can any inference be made about the relative size of the solute particles based upon the results of the tests? If so, what is this inference?
5. Predict the consequences of a change in permeability within the kidney?
6. Compare and contrast acute and chronic renal failure with respect to urinary output, prognosis, and treatment.

Laboratory Investigation Rubric

Student: _____ Date: _____

Scoring Criteria	4 Excellent	3 Good	2 Needs Some Improvement	1 Needs Much Improvement	N/A
Problem is appropriately identified.					
Problem is precise, clear, and relevant.					
Association between the problem and the predicted results is direct and relevant.					
All variables are clearly operationalized.					
Demonstrates comprehension of the use of scientific concepts and vocabulary.					
All significant data is measured.					
Data is recorded effectively and efficiently.					
Data table is well designed to the task requirements.					
All graphs are appropriate.					
All data accurately plotted.					
Graph visually compelling, highlights conclusions of the study.					
Conclusion relates directly to hypothesis.					
Conclusion has relevancy in resolution of the original problem.					
Conclusion relates the study to general interest.					