Chapter 20
Fluids and Electrolytes

Fluid (Water)

- Functions
  - Provides an extracellular transportation route to deliver nutrients to the cells and carry waste products from the cells
  - Provides a medium in which chemical reactions, or metabolism, can occur within the cell
  - Acts as a lubricant for tissues
  - Aids in the maintenance of acid-base balance
  - Assists in heat regulation via evaporation

Fluid (Water) cont’d

- Percentage of body weight that is water depends on several factors
- Age
  - Premature infant: 90%
  - Newborn: 70-80%
  - Twelve years to adult: 50-60%
  - Older adults: 45-55%
Fluid Compartments

- Amount of fat
  - Fat contains relatively little water
  - Females have proportionately more body fat than males, which means that females have less body fluid
  - The more obese an individual, the less the percentage of body water
  - Extracellular fluid is lost from the body more rapidly than intracellular fluid

Fluid Compartments cont’d

- Intracellular fluid
  - Largest of the two compartments
  - Contains the fluid inside the billions of cells within the body

- Extracellular fluid
  - Contains any fluid outside the cell
  - Divided into interstitial and intravascular compartments

Fluid Compartments cont’d

- Extracellular fluid
  - Interstitial fluid
    - Between the cells or in the tissue
    - Accounts for approximately 27% of the fluid in the body
    - Examples: lymph, cerebrospinal fluid, and gastrointestinal secretions
  - Intravascular fluid
    - Plasma within the vessels
    - Makes up 7% of fluid volume
Intake and Output

- The normal daily loss of fluids must be equaled by the normal daily intake
- Daily water intake and output is approximately 2500 mL
- Fluid leaves the body through the kidneys, lungs, skin, and GI tract
- Water loss is replenished by ingestion of liquids and foods and by metabolism of food and body tissues

Intake and Output cont’d

- Intake includes all fluids entering the body
  - Fluids can be liquids taken orally or consumed in food, including foods that assume a liquid consistency at room temperature
  - This also includes tube feedings and parenteral intake such as intravenous fluids, blood components, and total parenteral nutrition

Intake and Output cont’d

- Output includes all fluids leaving the body
  - Examples are urine, diarrhea, vomitus, nasogastric suction, and chest tube drainage
  - Also included is drainage from surgical wounds and drainage collected in surgical receptacles such as the Jackson-Pratt, Davol, or Hemovac systems
Intake and Output cont’d

- The kidneys play an extremely important role in fluid balance
- If the kidneys are not functioning properly, the body has great difficulty regulating fluid balance
- Glomerular filtration rate
  - Nephrons filter blood at a rate of 125 mL per min, or about 180 L per day
  - This leads to output of 1-2 L of urine per day

Intake and Output cont’d

- The kidneys must excrete a minimum of 30 mL/hour of urine to eliminate waste products from the body
- The kidneys react to fluid excesses by excreting a more dilute urine; this rids the body of excess fluid and conserves electrolytes
- A simple and accurate method of determining water balance is to weigh the patient under exact conditions
  - 1 L of fluid equals 1 kg (2.2 lb); a weight change of 1 kg will reflect a loss or gain of 1 L of body fluid

Movement of Fluid and Electrolytes

- Substances entering the body begin their journey in the extracellular fluid
- To carry out their functions, they must cross the semipermeable membrane surrounding each body cell to enter the cell
- The fat and protein molecules that make up the membrane are arranged so that some substances can enter the cells and others cannot
Movement of Fluid and Electrolytes cont’d

- Several methods are used by the body to move fluids, electrolytes and other solutes, or dissolved substances into and out of cells
- Passive transport processes
  - No cellular energy is required to move substances from a high concentration to a low concentration
- Active transport processes
  - Cellular energy is required to move substances from a low concentration to a high concentration

Passive Transport

- Diffusion
  - This is the movement of particles in all directions through a solution or gas.
  - Solutes move from an area of higher concentration to an area of lower concentration, which eventually results in an equal distribution of solutes within the two areas

Passive Transport cont’d

- Osmosis
  - This is the movement of water from an area of lower concentration to an area of higher concentration
  - It equalizes the concentration of ions or molecules on both sides of the membrane
  - The flow of water will continue until the number of ions or molecules on both sides are equal.
Passive Transport cont’d

- Osmosis
  - Hypertonic solutions
  - Isotonic solutions
  - Hypotonic solutions

Passive Transport cont’d

- Filtration
  - This is the transfer of water and dissolved substances from an area of higher pressure to an area of lower pressure
  - A force behind filtration is called hydrostatic pressure, or the force pressing outward on a vessel wall
  - The pumping action of the heart is responsible for the amount of force of the hydrostatic pressure that causes water and electrolytes to move from the capillaries to the interstitial fluid

Active Transport

- Requires energy
- Force that moves molecules into cells without regard for their positive or negative charge and against concentration factors that would prevent entry via diffusion
- Moves fluid and electrolytes from an area of low concentration to an area of high concentration
- Substances actively transported through the cell membrane include sodium, potassium, calcium, iron, hydrogen, amino acids, and glucose
Active Transport cont’d

- Electrolytes
  - Electrolytes develop tiny electrical charges when they dissolve in water and break up into particles known as ions.
  - Ions develop either a positive or negative electrical charge.
  - A balance exists between the electrolytes; for each positively charged cation, there must be a negatively charged anion.

Active Transport cont’d

- Sodium
  - A cation
  - Most abundant electrolyte in the body.
  - Normal level: 134-142 mEq/L.
  - Major source is from the diet; frequently must be limited.
  - Functions of sodium: regulates water balance, controls extracellular fluid volume, increases cell membrane permeability, stimulates conduction of nerve impulses and helps maintain neuromuscular irritability, controls contractility of muscles.

Active Transport cont’d

- Sodium
  - Hyponatremia
    - Less than normal concentration of sodium in the blood.
    - Sodium level less than 134 mEq/L.
    - Can occur when there is a sodium loss or a water excess.
    - Body attempts to compensate by decreasing water excretion.
    - Patient likely to also have a potassium imbalance due to fluid being moved into the cells and potassium shifting out of the cells.
Active Transport cont’d

- Sodium
  - Hypernatremia
    - Greater than normal concentration of sodium in the blood
    - Sodium level greater than 145 mEq/L
    - Can occur when there is a sodium excess or a water loss
    - Body attempts to correct the imbalance by conserving water through renal reabsorption
    - Causes fluid to shift from the cells to the interstitial spaces, resulting in cellular dehydration

Active Transport cont’d

- Potassium
  - Dominant intracellular cation
  - Normal level is 3.5-5 mEq/L.
  - Well-balanced diet usually provides adequate potassium; approximately 65 mEq is required each day
  - The routes of potassium excretion are the kidneys, in the feces, and through perspiration
  - The kidneys control the excretion of potassium
  - The main function is regulation of water and electrolyte content within the cell

Active Transport cont’d

- Potassium
  - Hypokalemia
    - Decrease in body’s potassium to a level below 3.5 mEq/L
    - The major cause of loss is renal excretion
    - The kidneys do not conserve potassium; they excrete it even when the body needs it
    - Potassium can be depleted due to excessive GI losses from gastric suctioning or vomiting and the use of diuretics
    - This can affect skeletal muscle and cardiac function
Active Transport cont’d

- Potassium
  - Hyperkalemia
    - Increase in the body’s serum potassium level above 5 mEq/L
    - Gained through intake and lost by excretion
    - The major cause of excess potassium is renal disease; severe tissue damage causes potassium to be released from the cell
    - Excessive increase in foods high in potassium can cause serum levels to increase
    - This can cause cardiac arrest

- Chloride
  - An extracellular anion
  - Normal level is 96-105 mEq/L
  - It is the chief anion in interstitial and intravascular fluid
  - It has the ability to diffuse quickly between the intracellular and extracellular compartments and combines easily with sodium to form sodium chloride or with potassium to form potassium chloride
  - Daily requirement is equal to that of sodium
  - The main route of excretion is the kidneys

Active Transport cont’d

- Chloride
  - Hypochloremia
    - It usually occurs when sodium is lost, because sodium and chloride are frequently paired
    - The most common causes of hypochloremia are vomiting and prolonged nasogastric or fistula drainage
  - Hyperchloremia
    - It rarely occurs, but may be seen when bicarbonate levels fall
Active Transport cont’d

• Calcium
  ➢ A positively charged ion
  ➢ Normal level is 4.5 mEq/L
  ➢ Of calcium in the body, 99% is concentrated in the bones and teeth
  ➢ Calcium is deposited in the bones and mobilized as needed to help keep the blood level constant during any period of insufficient intake
  ➢ Vitamin D, calcitonin, and parathyroid hormone are necessary for absorption and utilization of calcium
  ➢ The best food sources are milk and cheese

Active Transport cont’d

• Calcium
  ➢ Hypocalcemia
    • Develops when the serum level is below 4.5 mEq/L
    • A deficiency may be caused by infusion of excess amounts of citrated blood, excessive loss through diarrhea, inadequate dietary intake, surgical removal of parathyroid function, pancreatic disease, or small bowel disease
    • Signs and symptoms are neuromuscular irritation and increased excitability and tetany

Active Transport cont’d

• Calcium
  ➢ Hypercalcemia
    • It occurs when calcium levels exceed 5.8 mEq/L
    • It may occur when calcium stored in the bones enters the circulation; occurs with immobilization
    • An increased intake of calcium or vitamin D also may be a cause
    • Neuromuscular activity is depressed and renal calculi may develop
Active Transport cont’d

- Phosphorus
  - Chiefly an intracellular anion
  - Normal level is 4 mEq/L
  - Phosphorus and calcium have an inverse relationship in the body; an increase in one causes a decrease in the other
  - The majority is found in bones and teeth combined with calcium
  - Dietary intake is usually 800-1500 mg per day
  - An adequate intake of vitamin D is necessary for the absorption of both calcium and phosphorus

Active Transport cont’d

- Phosphorus
  - Hypophosphatemia
    - Can occur from a dietary insufficiency, impaired kidney function, or maldistribution of phosphate
    - Muscle weakness possible
  - Hyperphosphatemia
    - Most commonly occurs as a result of renal insufficiency; also can occur with increased intake of phosphate or vitamin D
    - Signs and symptoms: tetany, numbness and tingling around the mouth, and muscle spasms

Active Transport cont’d

- Magnesium
  - The second most abundant cation in the intracellular fluid
  - Normal level is 1.5-2.4 mEq/L
  - Although only small amounts are in the blood, it is important in maintaining normal body function
  - The majority is found in bone, muscle, and soft tissue
  - Dietary intake is usually 200-400 mg per day
  - It is commonly distributed in foods: whole grains, fruits, vegetables, meat, fish, legumes, and dairy products
  - The major route of excretion is the kidneys
Active Transport cont’d

- Magnesium
  - Hypomagnesemia
    - Develops when blood levels fall below 1.5 mEq/L
    - A decreased level often parallels decreased potassium
    - Signs and symptoms: increased neuromuscular irritability similar to those observed with hypocalcemia
    - Major causes are increased excretion by the kidneys, impaired absorption from the GI tract, and prolonged malnutrition

Active Transport cont’d

- Magnesium
  - Hypermagnesemia
    - Develops when blood levels exceed 2.5 mEq/L
    - It rarely occurs when kidney function is normal
    - Major causes are impaired renal function, excess magnesium administration, and diabetic ketoacidosis when there is severe water loss
  - An excess of magnesium severely restricts nerve and muscle activity

Active Transport cont’d

- Bicarbonate
  - A main anion of the extracellular fluid
  - Normal level is 22-24 mEq/L
  - It is an alkaline electrolyte whose major function is the regulation of the acid-base balance
  - It acts as a buffer to neutralize acids in the body and maintain the 20:1 bicarbonate/carbonic acid ratio needed to keep the body in homeostasis
  - The kidneys selectively regulate the amount of bicarbonate retained or excreted
Acid-Base Balance

- Acid-base balance means homeostasis of the hydrogen ion concentration in the body fluids.
- The hydrogen ion concentration is determined by the ratio of carbonic acid to bicarbonate in the extracellular fluid.
- The ratio needed for homeostasis is 1 part carbonic acid to 20 parts bicarbonate.
- The symbol used to indicate hydrogen ion balance is pH.
- Arterial blood gases determine whether a solution is acid, neutral, or alkaline; the more hydrogen ions in a solution, the more acid is the solution, and the fewer hydrogen ions, the more alkaline is the solution.

Acid-Base Balance cont’d

- Physiologic buffers.
  - The body has three systems that work to keep the pH in the narrow normal range:
    - Blood buffers: Buffers circulate throughout the body in pairs, neutralizing excess acids or bases by contributing or accepting hydrogen ions.
    - Lungs: By speeding up or slowing down respirations, the lungs can increase or decrease the amount of carbon dioxide in the blood.
    - Kidneys: They excrete varying amounts of acid or base.
- The three systems work closely together to maintain a normal hydrogen ion concentration.

Acid-Base Imbalance

- Respiratory acidosis:
  - This is caused by any condition that impairs normal ventilation.
  - A retention of carbon dioxide occurs with a resultant increase of carbonic acid in the blood.
  - As the pH falls, the Pco₂ level increases.
  - Shallow respirations result because of the retained carbon dioxide.
  - Treatment is aimed at improving ventilation and correcting the primary condition responsible for the imbalance.
Acid-Base Imbalance cont’d

- Respiratory alkalosis
  - This is caused by hyperventilation
  - Respirations that increase in rate, depth, or both can result in loss of excessive amounts of carbon dioxide with a resultant lowering of the carbonic acid level in the blood
  - The pH rises because of the decrease in carbonic acid being blown off with each exhalation
    - Treatment is sedation and reassurance; breathing into a paper bag will cause rebreathing of the exhaled carbon dioxide

Acid-Base Imbalance cont’d

- Metabolic acidosis
  - This can result from a gain of hydrogen ions or a loss of bicarbonate—retaining too many acids or losing too many bases
  - Without sufficient bases, the pH of the blood falls below normal; the bicarbonate level will also drop
  - The effect is hyperventilation, as the lungs attempt to compensate by blowing off carbon dioxide to lower the Pco₂ level
  - Treatment is the administration of sodium bicarbonate

Acid-Base Imbalance cont’d

- Metabolic alkalosis
  - This results when a significant amount of acid is lost from the body or an increase in the bicarbonate level occurs
  - The most common cause is vomiting gastric content, normally high in acid
  - It can also occur in patients who ingest excessive amounts of alkaline agents, such as bicarbonate-containing antacids
  - The central nervous system is depressed
  - Treatment is aimed at the cause
Nursing Diagnoses

- Risk for deficient fluid volume
- Imbalanced nutrition: less than body requirements
- Deficient fluid volume
- Risk for imbalanced fluid volume
- Excess fluid volume
- Risk for impaired skin integrity
- Impaired tissue integrity
- Impaired oral mucous membrane
- Ineffective tissue perfusion
- Decreased cardiac output
- Impaired gas exchange
- Ineffective breathing pattern

Question 1

The nurse is caring for a patient who has dependent edema. What pressure has caused the excess fluid in the interstitial compartment?

1. Oncotic pressure
2. Diffusion pressure
3. Hydrostatic pressure
4. Intraventricular pressure

Question 2

When a nurse evaluates a patient’s fluid intake and output, the fluid intake should be:

1. slightly more than the fluid output.
2. lower than the urine output.
3. higher than the fluid output.
4. equal to the urine output.
Question 3
The nurse suspects that an older adult may have a fluid and electrolyte imbalance. Which assessment best reflects fluid and electrolyte balance in the older adult?

1. Intake and output results
2. Serum laboratory values
3. Condition of the skin
4. Presence of tenting

Question 4
A patient is receiving a diuretic that contributes to the loss of potassium, and the nurse provides dietary teaching. Which food selected by the patient indicates an understanding of an excellent source of potassium?

1. Baked potato
2. Green beans
3. Bran flakes
4. Lean meat

Question 5
A practitioner prescribes hydrochlorothiazide (HCTZ), a diuretic, for a patient who is retaining fluid. The nurse should encourage the patient to ingest nutrients rich in:

1. magnesium.
2. potassium.
3. calcium.
4. sodium.