Module 10
FLUID AND ELECROLYTE IMBALANCES

INTRODUCTION

This module is intended as a brief review of fluid and electrolyte imbalances. It includes a brief description of some of the causes, signs, and symptoms specific to diagnostic studies (in some cases), treatments, and broad nursing interventions associated with these conditions. The module is not intended as a replacement for a medical/surgical textbook. For a more detailed discussion, please refer to a current text. Three self-tests are included and answers are given at the end of the module.

Remember that laboratory values are relative to the extent that there may be a slight variation in what is considered normal range. Depending upon sources consulted and from institution to institution, laboratory values are often based upon the type of testing performed to obtain the values. Therefore, if any of the values printed here differ slightly from another source, the discrepancy is merely a reflection of those slight variations. Always evaluate your patients' laboratory values based upon the norms established in your particular institution.

OBJECTIVES

Upon completion of this module, you should be able to

- Describe the body fluid compartments.
- Describe the three mechanisms of transport between fluid compartments.
- Explain how fluids and electrolytes are regulated by body systems.
- Describe specific fluid and electrolyte imbalances.
- Discuss treatment and nursing care for patients with specific fluid and electrolyte imbalances.

COMMENTS:

The percentage of total body fluid varies by age, sex, and amount of body weight. In a healthy person on a day-to-day basis the percent of body fluid remains relatively constant and is unaffected by the amount of fluid ingested. Forty to sixty percent of body weight is fluid. Since fat does not retain water, the less fat a person has the higher proportion of water to body weight and, conversely, the more body fat, the less water in proportion to body weight.

Body fluid distribution

Body fluids are distributed in two body compartments. The largest amount of body fluid, approximately 75 percent, is retained in the **intracellular** compartment, that is, within the cells. The remaining 25 percent is contained within the **extracellular** fluid compartment. The extracellular fluid compartment consists of fluid known as plasma. Other sources of extracellular fluid include the cerebrospinal fluid, GI secretions, and intraocular fluid. Body fluids do not remain static but move back and forth among compartments.

Spacing

Spacing is a term referring to body fluid distribution through the body fluid compartments. **First spacing** refers to normal fluid distribution between intracellular and extracellular compartments. **Second spacing**

refers to the presence of edema or increased fluid accumulation of interstitial fluid (fluid between cells). **Third spacing** involves the accumulation of fluid where normally very little fluid exists, for example, the peritoneal cavity with ascites, or the bowel in peritonitis, or the edema associated with burns. Abnormal fluid shifts sometimes cause imbalances such as hypovolemia.

Composition

Fluids carry salts, gases, proteins, lipids, and other substances including electrolytes as they move between compartments.

Electrolytes

Electrolytes are electrically charged particles or ions that are made up of molecules that have dissolved and broken down into elemental parts in solution. Some particles carry a positive charge and are called cations, for example, sodium (Na+), potassium (K+), calcium (Ca++), and magnesium (Mg++). Others carry a negative charge; these are called anions. Examples of anions are chloride (Cl--), carbonate (HCO3-), sulfate (SO4--), and phosphate (PO4--). Anions and cations balance themselves to obtain a state of electrical neutrality. Potassium, phosphate, and magnesium are the primary electrolytes found within the cells, while sodium, calcium, and carbonate are the primary electrolytes found outside the cells. There are also substances carrying no electrical charge. These are non-electrolyte substances in solution such as urea, glucose and creatinine.

Regulations by body systems

Fluid and electrolyte concentrations are regulated by various body systems. The kidneys are the primary regulators of fluids and electrolyte balance. They conserve and excrete both fluids and electrolytes in urine output. The skin excretes both fluids and electrolytes though perspiration and evaporation. The lungs excrete water and carbon dioxide as well as taking in oxygen. Since carbon dioxide comes from carbonic acid carried in the blood, the lungs are also instrumental in helping to regulate acid/base balance in extracellular fluids.

The GI tract also excretes a small amount of fluid each day. It should be noted that the actual amounts of fluids and electrolytes lost through the skin and respiratory systems, may vary greatly depending upon factors such as weather conditions and the degree of physical exercise.

Approximate Fluid Losses Per Day by Body System

Urinary	2000ml
Integumentary	400ml
Respiratory	400ml
Gastrointestinal	200ml

Body mechanisms that help in regulation

The following body mechanisms help regulate fluids and electrolytes:

- **Hypothalamus:** stimulates thirst and posterior pituitary gland.

- **Posterior pituitary:** secretes antidiuretic hormone (ADH), which causes water to be retained by renal tubules.
- **Adrenal Cortex:** secretes adrenocorticoids which have an anti-inflammatory effect. Also secretes mineralocorticoids which retain Na+ and excrete K+ (aldosterone). Having properties of both adreno-and mineralocorticoids, the hormone cortisol is secreted when the body is stressed.
- **Kidneys:** releases rennin when there are decreased plasma concentrations and decreased serum Na+.
- **Liver:** produces angiotensinogen which is acted on by rennin to produce angiotensin. Angiotensin in turn causes the adrenal gland to secrete aldosterone.

Mechanisms of transport

Concentrations of particular ions vary in each of the fluid compartments. Because capillary walls are permeable, concentrations of ions are generally similar in the interstitial fluid spaces such as the areas surrounding the cells and the intravascular systems. Concentrations of ions within the cells are different, however, since cell membranes are not readily permeable to most ions. But ions and fluids do pass between the fluid compartments. They do this using three mechanisms of transport: diffusion, osmosis, and active transport.

Diffusion. In diffusion, dissolved particles move from areas of greater concentration to areas of lesser concentration in an attempt to form an equilibrium on both sides of the membrane.

Osmosis: Osmosis occurs when the membrane is either impermeable or semipermeable to particles (such as NaCl) but water molecules in the solution are able to pass through. Water on both sides of the membrane attempts to reach an equilibrium. Water passes from solutions of lesser concentration to those of greater concentration.

Osmotic pressure is the drawing power of a solution for water. The greater the concentration of particles in a solution the greater its power to draw water to it. Plasma protein, for example, is not permeable to capillary walls, therefore, concentration of plasma protein in the vascular system is high. This gives the vascular system the ability to draw water molecules and hold them in a plasma solution within the vessels.

Active transport. Active transport is a mechanism that utilizes energy to achieve equilibrium. In active transport, particles are actually pushed out of the cells through the membrane while other particles are drawn in. Certain enzymes in the cell, such as Adenosine Triphosphatase (ATP), actually act as a “pump” to keep particles moving. For example, within the cell, Na+ ions are exchanged for K+. A carrier molecule binds around the incoming K+ and helps draw it through the cell membrane releasing it once inside the cell. Because this creates a cellular imbalance with too many positive ions, a Na+ ion is next pushed out of the cell to achieve a balance of positive and negative ions. When there is an increase of Na+ concentration within the cell this usually activates the “pump” and a Na+/K+ ion exchange begins.

Self-Test 1

1. In which compartment is the largest amount of body fluid retained?

2. Name three non-electrolyte substances found in solution.

3. Name three mechanisms of fluid and electrolyte transport.

4. What is osmotic pressure?

5. What gland secretes the antidiuretic hormone (ADH)?

Specific Fluid and Electrolytes Imbalances

In determining specific fluid and electrolyte imbalances, it is easiest to measure the extracellular fluid compartment; usually blood sampling is used to measure levels.

Sodium imbalance

The location of sodium is primarily in extracellular fluid. Its function is essential to maintain acid/base balance and fluid electrolyte regulation, especially in the kidneys. It is responsible for many chemical reactions within the cells, especially involving the muscles and nerves and it affects extracellular fluid osmotic pressure.

The following conditions can result from sodium imbalance:

<u>Hypernatremia:</u>

- Measurement: Na+ >145 meq/L
- Definition: excess Na+ or decreased fluid volume
- Some causes: inability to respond to thirst as in confusion
  excess salt intake
  diarrhea
  excess sweating
  diabetes mellitus/diabetes isipidus
  CHF
  renal failure
  improperly managed IV therapy with Na+ solutions
  hyperalimentation or high protein tube feedings without sufficient water
- Signs and symptoms: dry tongue and mouth
  urine
  specific gravity above 1.030
  low grade temperature
  central nervous system
  changes, such as restlessness, irritability, delirium, increased muscle tone, seizures metabolic acidosis, death
- Treatment: often used IV solution of 5% dextrose and water (D_5W); renal dialysis
- Nursing measures: offer fluids to elderly debilitated patients
  monitor intake and output

monitor serum Na+ levels
assess mucous membranes, skin turgor, body temperature, sensorium
urine specific gravity
supplemental water with concentrated tube feedings

Hyponatremia:

- Measurement: Na+ <135 meq/L
- Definition: excess Na+ loss or excess fluid volume
- Some causes: decreased NaCl intake
  diuretics
  increased intake free water
  profuse sweating
  excess IV therapy – 5% D/W'
  aldosterone deficiency
  excess ADH therapy
  nephritic syndrome
  3rd space fluid loss
- Signs and symptoms: postural hypotensino
  weight loss
  weight gain/edema
  weakness, nausea and vomiting
  abdominal cramping
  confusion, seizures, coma with brain swelling
  headache
  specific gravity < 1.010 with diuresis or > 1.010 with water retention
- Treatment (dependent on low Na+ cause): IV therapy -.9% NaCl or hypetonic solutions 3% NaCl for
  Fluid restriction and diuretics for fluid excess
- Nursing measures: assess intake and output, vital signs
  sensorium
  GI symptoms
  Na+ levels
  daily weights
  urine specific gravity
  safety measures to protect patients with altered sensorium

Potassium imbalance

Potassium's location is mostly intracellular, but abnormal levels within the vascular system can be life-threatening. Its function is to help maintain acid/base balance; it affects muscles and nerves as well as intracellular osmotic pressure.

The following conditions can result from potassium imbalance.

Hyperkalemia:

- Measurement: K+ >5.3 meq/L
- Definition: excess K+
- Some causes: oral or IV K+ overdoes
  renal failure
  burns
  massive trauma
  adrenocortical insufficiency
  excess K+ sparing diuretics
- Signs and symptoms: nausea
  diarrhea
  abdominal cramping
  weakness
  paresthesias
  painful muscle cramps and spasticity
  EKG changes
  dysrhythmias that m ay lead to death
- Treatment: K+ restriction in diet and IV fluid
  Kayexalate Insulin and glucose IV to move K+ into cells
  IV Ca++ for cardiac dysrhythmias
  Dialysis
- Nursing measures: assess for signs and symptoms
  monitor K+ levels
  monitor Na+ levels since hyponatremia may cause K+
  increases dietary teaching

Hypokalemia:

- Measurement: K+ <3.5 meq/L
- Definition: K+ deficit
- Some causes: one of the foremost causes is the use of diuretics without
  K+ replacements
  nausea/vomiting diarrhea
  alcoholism
  poor nutrition
  corticosteroid therapy
  diaphoresis
  administration of insulin and glucose illnesses such as

diabetes mellitus, renal disease, ulcerative colitis, adrenal tumors, draining fistulas

- Treatment: treat causes and provide oral or IV K+ replacement

- Nursing measures: assess signs and symptoms, especially in patients on digoxin therapy, patients on diuretics and patients with nasogastric suctioning
  monitor intake and output and serum K+ levels
  protect confused patient from injury
  dietary teaching regarding foods containing potassium

Self Test 2

Match the descriptions in Column A with the appropriate electrolyte condition in Column B

Column A	Column B
a. Hypernatremia	1. caused by use of some diuretics
	2. caused by excess salt intake
b. Hyponatremia	3. assess clients on Digoxin therapy
	4. causes postural hypotension
c. Hyperkalemia	5. give normal saline IV (NaCl 0.9%)
d. Hypokalemia	6. may cause muscle cramps and spasticity
	7. treat with IV 5% D/W
	8. nurse gives water with concentrated tube feedings
	9. give Kayexalate
	10. above 5.5 meq/L

Calcium imbalance

Calcium is located in the extracellular fluids and in teeth and bones; one of its functions is to form teeth and bones. It is also needed for all types of muscle function, blood coagulation, and to sedate nerves. Calcium is associated with phosphates and needs Vitamin D to be absorbed. The following conditions can result from calcium imbalance.

Hypercalcemia:

- Measurement: Ca++ >5 meq/L
- Definition: calcium excess in serum
- Some causes: hyperparathyroidism or tumor of parathyroid gland
  excess intake of Ca++ and Vitamin D prolonged immobility
  multiple myeloma
  widespread bone cancer Paget's disease
- Signs and symptoms: anorexia
  nausea and vomiting
  constipation and weakness
  bone pain and pathological fracture
  polydipsia, polyuria
  flank pain with kidney stone
  confusion, irritability, and seizures
  EKG changes
  Elevated serum albumin (will rise and fall with Ca++ levels)
- Treatment: treat cause
  restrict Ca++ intake
  give oral phosphates (Fleet Phospho-soda)
  hydrate with normal saline and give diuretics to flush Ca++ out
  give Calcitonin
- Nursing measures: assess for signs and symptoms
  monitor intake and output
  observe urine for renal stones
  monitor signs of digoxin toxicity
  protect patients from injury
  teach oncology patients signs and symptoms to watch for

Hypocalcemia:

- Measurement: Ca++ < 4 meq/L

- Definition: calcium deficiency

- Some causes: reduced dietary intake
  diarrhea
  kidney disease and pancreatitis
  hypoparathyroidism
  comsumption of aluminum-containing antacids or laxatives
  diuretics
  corticosteroids

- Signs and symptoms: fatigue
  neuromuscular irritability
  tingling in fingers and around mouth
  tetany
  Trousseaus Sign (compression of upper arm causes hand and finger spasms)
  Chvostek's Sign (tapping on faces causes facial twitching)
  porous bones that fracture easily

- Treatment: treat underlying cause:
  for milder form give oral Ca++ and Vitamin D
  for severe form give Ca++ Gluconate IV or calcium chloride
  aluminum hydroxide or magnesium sulfate or magnesium chloride will elevate serum Ca++

- Nursing measures: assess signs and symptoms
  provide safe environment
  administer IV Ca++ at slow rate while observing for drop in blood pressure, cardiac monitoring if possible
  place on seizure precautions
  monitor serum Ca++ and serum phosphorus levels (phosphorus will be elevated)

Magnesium imbalance

Magnesium is located mostly intracellularly; it is found in bones. Its function is cell metabolism, especially heart, skeletal, and nerve. The following conditions can result from magnesium imbalance:

<u>Hypermagnesemia:</u>

- Measurement: Mg++ > 2.5 meq/L

- Definition: excess of magnesium (a rate imbalance)

- Some causes: patient with renal failure takes excess of Mg++ based antacids or Mg++ based medications to control seizures and is unable to excrete Mg++

misuse of laxatives or antacids containing Mg++
rapid IV infusion of Mg++

- Signs and symptoms: neuromuscular depression with
  diminished reflexes
  paralysis
  depression
  bradycardia
  hypocalcemia

- Treatment: 0.45% NaCl IV and diuretics to help flush Mg++ through kidneys if no kidney failure
  give IV Ca++
  dialysis
  oral phosphorus

- Nursing measures: assess signs and symptoms
  monitor IV fluids
  dietary teaching regarding limiting Mg++ intake in foods

Phosphorus imbalance

Phosphorus is located mostly intracellularly in bones. Very little exists in extracellular fluid. It is needed in the cells to initiate numerous metabolic reactions and in cell division. The following conditions can result from phosphorus imbalance:

<u>Hyperphosphotemia:</u>

- Measurement: $PO_4 > 4.5$ meq/L

- Definition: associated with Ca++ imbalance, reduced Ca++ promotes increased PO_4—and vice versa

- Some causes: renal failure
  increased phosphorus intake through IV infusion enema or blood transfusion
  hypoparathyroidism
  hypocalcemia

- Signs and symptoms: nausea/vomiting
  weakness
  tachycardia
  tetany
  soft tissue calcification with oliguria
  conjunctivitis
  dysrythmias
  symptoms of hypocalcemia

- Treatment: treat cause

reduce phosphorous intake
may give Ca++
give aluminum hydroxide to bind with phosphate and excrete through GI track for severe cases, dialysis

- Nursing measures: assess signs and symptoms
  teach proper use of laxatives and enemas containing phosphorus

Hypophosphatemia:

- Measurement: $PO_4 < 2.5$ meq/L

- Definition: can occur when total body concentrations are increased, decreased, or normal. When PO_4 is low Ca++ is high. Most of the effects are associated with accompanying alterations of electrolytes.

- Some causes: malnutrition
  alcohol withdrawal
  diabetic ketoacidosis
  respiratory alkalosis
  excess use of antacids containing aluminum or magnesium

- Signs and symptoms: numbness, tingling in fingers
  confusion
  seizures
  hypoxia
  chest pain
  muscle pain and weakness

- Treatment: treat cause: if condition is mild, provide phosphorus in food or supplements with Vitamin D;
  if severe, give IV replacement therapy
  Vitamin D enhances absorption

- Nursing measures: assess signs and symptoms, especially signs of hypoxia
  if IV replacement is indicated, give very slowly and monitor symptoms of hyperphosphotemia

Chloride imbalance

Chloride's location is in extracellular fluid. Its function is to maintain serum osmolality with Na+. It is a component of gastric secretions. The following conditions can result from chloride imbalance.

Hyperchloremia:

- Measurement: Cl- > 106 mg/L

- Definition: excess chloride in the serum
- Some causes: excess IV NaCl
  dehydration
  some medications
- Signs and symptoms: weakness
  stuporous
  Coma
  Decrease in central nervous system function
- Treatment: treat underlying cause
- Nursing care: monitor lab values
  provide safety measures

Hypochloremia:

- Measurement: Cl- < 98 mg/L
- Definition: decreased serum chloride
- Some causes: vomiting
  excess urination
  decrease in dietary salt
- Signs and symptoms: decreased respirations
  tetany
  nerve and muscle excitability
- Treatment: give KCI
  treat underlying cause
- Nursing care: assess for signs and symptoms; keep accurate intake and output
  monitor lab values
  provide patient safety measures

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Self Test 3

Column A
a. Hypercalcemia
b. Hypocalcemia
c. Hypermagnesemia
d. Hypomagnesemia
e. Hyperphosphatemia
f. Hypophosphatemia
g. Hypercholoremia`
h. Hypochloremia

Column B
1. causes neuromuscular depression with diminished reflexes
2. causes neuromuscular irritability
3. caused by prolonged immobility
4. caused by antacids and laxatives containing aluminum
5. observe urine for renal stone
6. give aluminum hydroxide
7. assess for signs of hypoxia
8. usually occurs with sodium imbalance
9. less than 95 meq/L
10. give Fleet's Phospho-soda of Calcitonin

Module 10
Answers to Self-Tests

Self-Test 1

1. Intracellular compartment
2. Urea, glucose, creatinine
3. Diffusion, osmosis, and active transport
4. The drawing power of a solution of H_2O
5. Posterior pituitary gland

Self-Test 2

1. b, d
2. a
3. d
4. b
5. b
6. c
7. a
8. a
9. c
10. c

Self-Test 3

1. c
2. b, d, h
3. a
4. b
5. a
6. e
7. f
8. g, h
9. h
10. a