chapter 22

Fluids and Electrolytes

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Objectives

1. List, describe, and compare the body fluid compartments.
2. Discuss active and passive transport processes and give two examples of each.
3. Discuss the role of specific electrolytes in maintaining homeostasis.
4. Describe the cause and effect of deficits and excesses of sodium, potassium, chloride, calcium, magnesium, phosphorus, and bicarbonate.
5. Differentiate between the roles of the buffers, the lungs, and the kidneys in maintaining acid-base balance.
6. Compare and contrast the four primary types of acid-base imbalances.
7. Discuss the role of the nursing process in maintaining fluid, electrolyte, and acid-base balances.
8. Discuss how the very young, the very old, and the obese patient are at risk for fluid volume deficit.

Key Terms

acid-base balance (p. 673)
active transport (p. 664)
adenosine triphosphate (ATP) (ă-DĔN-ō-sēn trī-FŎS-fāt, p. 663)
anions (ĂN-ī-ŏnz, p. 665)
bicarbonate (bī-KĂHR-bō-nāt, p. 673)
blood buffers (p. 674)
calcium (p. 669)
cations (KĂT-ī-ŏnz, p. 665)
chloride (p. 668)
diffusion (p. 663)
electrolytes (ĕ-LĔK-trō-lītz, p. 665)
extracellular (ĕks-tră-SĔL-yū-lăr, p. 661)
filtration (p. 664)
homeostasis (hō-mē-ō-STĀ-sĭs, p. 662)
hypertonic (hī-pŭr-TŎN-ĭk, p. 664)
hypotonic (hī-pō-TŎN-ĭk, p. 664)
interstitial (ĭn-tŭr-STĬSH-ăl, p. 661)
intracellular (ĭn-tră-SĔL-yū-lăr, p. 661)
intravascular (ĭn-tră-VĂS-cyū-lăr, p. 662)
ions (Ī-ŏnz, p. 665)
isotonic (ī-sō-TŎN-ĭk, p. 664)
magnesium (p. 672)
milliequivalent (mEq) (mĭl-ē-ĕ-KWĬV-ă-lĕnt, p. 665)
osmosis (ŏz-MŌ-sĭs, p. 664)
passive transport (p. 663)
phosphorus (FŎS-fŭ-rŭs, p. 671)
potassium (pŏ-TĂS-ē-ŭm, p. 666)
sodium (p. 665)

In this chapter you will find a discussion of body fluids and electrolytes, their normal values, the mechanisms that operate to keep them normal, and some of the more common types of fluid and electrolyte imbalances.

FLUIDS (WATER)

Water has many functions. It provides an extracellular transportation route to deliver nutrients to the cells and carry waste products from the cells. Once inside the cells, it provides a medium in which chemical reactions, or metabolism, is able to occur. Water also acts as a lubricant for tissues. Two other important functions of water are to aid in the maintenance of acid-base balance and to assist in heat regulation by evaporation.

Water is critically important to the body. Water constitutes the largest percentage of body weight. This percentage depends on several factors and varies with each individual. First, age affects the amount of water in the body. A newborn's body weight is comprised of 70% to 80% water. That percentage increases in a premature infant to as high as 90%. The infant begins to lose body fluid most rapidly in the first 6 months, and by 12 years the proportion approaches that of an adult. The percentage water makes up in the body declines from that highest percentage at birth to 50% to 60% in adults and 45% to 55% in the older adult.

Another important influence on the amount of water in the body is the amount of fat in the individual. There is a correlation between water content and fat content; fat contains relatively little water. A woman has proportionately more body fat than a man, which means the woman has less body fluid than the man. The more obese an individual, the smaller the percentage of body water. Both obese and older adults are at risk for complications of illness from dehydration or fluid shifts because they have less fluid reserve in their bodies (see Life Span Considerations for Older Adults

Life Span Considerations

Older Adults

Dehydration

Older adults are at increased risk of dehydration because of the following factors:

- Fat replaces lean muscle as aging progresses, leading to a decrease in total body fluid.
- The aging kidney is less able to concentrate urine, so more fluid is lost.
- Decreases in mobility and diminished sense of thirst often result in decreased fluid intake.
- Incontinent older individuals sometimes restrict fluid intake to reduce the frequency of urination.
- To compensate for changes in taste, older adults often oversalt their food, resulting in electrolyte and fluid imbalances.
- Physiologic changes in the skin and mucous membranes make them less reliable indicators of dehydration.
- Dehydration will sometimes first manifest as mild disorientation.
- Signs and symptoms of dehydration include thirst, dry mucous membranes, increased heart rate, decreased blood pressure, poor skin turgor, and flat neck veins.
- Dehydration increases the risk of orthostatic hypotension.
- Decreased fluid intake increases the likelihood of constipation.
- Because the aging kidney is less efficient at excretion, giving intravenous (IV) infusions or supplements containing sodium or potassium increases the risk of electrolyte imbalance.
- Monitor the complete blood count carefully to detect changes in the hematocrit as it relates to hemoglobin. Decreased plasma volume elevates the hematocrit, whereas the hemoglobin level remains constant.

box). Infants are also at risk for dehydration. More than half of an infant's fluid is extracellular (outside the cells) (Figure 22-1). Extracellular fluid is lost from the body more rapidly than intracellular (inside the cells) fluid. Very young, very old, and obese patients are at a higher risk for developing a deficient fluid volume. A loss of 10% of body fluid is serious in an adult, and a 20% loss is fatal. In an infant those figures are even more significant. A loss of 5% is serious, 10% is very serious, and 15% is fatal.

FLUID COMPARTMENTS

The locations of fluids in the body are identified by categorizing them into compartments. However, *compartment* is an abstract term because rather than being contained in a compartment in a specific area, the fluids are in constant motion throughout the body to carry out their functions.

The body has two primary fluid compartments: intracellular and extracellular (Figure 22-2). Even though each is specific in its location and functions, there is constant interaction between the compartments.

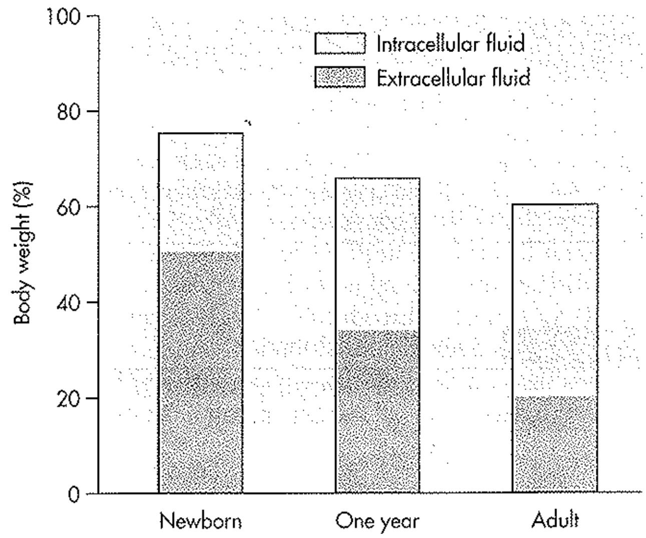


FIGURE 22-1 In the newborn, more than half of total body fluid is extracellular. As the child grows, proportions gradually reach adult levels.

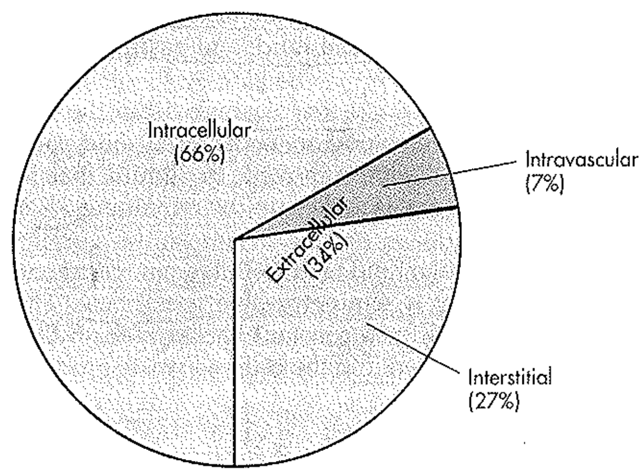


FIGURE 22-2 Volumes of body fluids in each fluid compartment.

The fluid compartments (Tables 22-1 and 22-2) are as follows:

1. Intracellular
2. Extracellular
   a. Interstitial
   b. Intravascular

The intracellular fluid compartment is the larger of the two compartments, comprising 66% of the body's fluid. It contains the fluid inside the billions of cells within the body.

The extracellular compartment contains any fluid outside the cells. This compartment is further divided into the interstitial and the intravascular fluid compartments.

Interstitial fluid is between the cells, or in the tissues. It accounts for approximately 27% of the fluid in

Know This-

Table 22-1 Body Fluid Distribution

COMPARTMENT	DESCRIPTION	FLUID
Intracellular	Fluid within cells	Intracellular fluid (ICF)
Extracellular	Fluid outside cells	Extracellular fluid (ECF)
Intravascular	Fluid within blood vessels	Plasma
Interstitial	Fluid in tissues (between cells or in body spaces)	Examples: interstitial fluid, lymph, cerebrospinal fluid, intraocular fluid, gastrointestinal (GI) secretions, urine, perspiration, exudates

Table 22-2 Body Fluid Distribution

COMPARTMENT	PERCENT OF TOTAL BODY FLUID	FLUID VOLUME (L)
Extracellular fluid		
Interstitial fluid	27	11.2
Intravascular fluid (plasma)	7	2.8
Intracellular fluid	66	42

Table 22-3 Normal Fluid Intake and Output in an Adult Eating 2500 Calories per Day (Approximate Figures)

ROUTE	GAIN (mL)	ROUTE	AMOUNT OF LOSS (mL)
Water in food	1000	Skin	500
Water from oxidation	300	Lungs	350
Water as liquid	1200	Feces	150
		Kidney	1500
Total	2500	Total	2500

the patient's body. Examples of interstitial fluid include lymph, cerebrospinal fluid, and gastrointestinal (GI) secretions.

Intravascular fluid is the plasma within the vessels. The cells of the blood are considered solid particles. After the cells are removed, the liquid that remains is the plasma. It makes up the remaining 7% of fluid volume.

The intracellular and extracellular compartments are separated by a semipermeable membrane. This membrane allows for a constant back-and-forth flow as nutrients are taken into the cell and waste products are carried out.

INTAKE AND OUTPUT- OUTPUT

As water moves through all parts of the body, it is constantly being lost. Fluid leaves the body through the kidneys, the lungs, the skin, and the GI tract. To maintain homeostasis, the normal daily loss must be met by the normal daily intake. Homeostasis is a relative constancy in the internal environment of the body, naturally maintained by adaptive responses that promote healthy survival. In order to maintain homeostasis, it is necessary that bodily fluids and electrolytes remain within the exact limits of normal (Lewis et al., 2007). Daily water intake and output (I&O) is approximately 2500 mL (Table 22-3).

Water loss is replenished in two ways—first, by ingestion of liquids and food, and second, by metabolism, both of food and in body tissues. Intake includes all fluids entering the body. Fluids are either liquids taken orally or those consumed in food, including foods that assume a liquid consistency at room temperature. Additional intake includes tube feedings and parenteral intake such as intravenous (IV) fluids, blood components, and total parenteral nutrition (TPN).

Liquid output includes all fluids leaving the body, including those lost through perspiration and expiration. Urine, diarrhea, vomitus, nasogastric suction, and chest tube drainage are examples of measurable output. Drainage from surgical wounds and drainage collected in surgical receptacles such as the Jackson-Pratt, Davol, or Hemovac systems are also considered liquid output. The determination of exact amounts of fluid loss and fluid replacement is not possible as part of nursing interventions, so you will use approximations. Because it is possible to measure fluid I&O, the importance of accurate record keeping cannot be overemphasized when determining a patient's fluid needs.

The kidneys play an extremely important role in fluid balance. If the kidneys are not functioning properly, the body has great difficulty with regulating fluid balance. The nephrons are the functioning units of the kidney. The nephrons filter blood at a rate of 125 mL/min, or about 180 L/day. This is called the **glomerular filtration rate** and leads to an output of 1 to 2 L (1000 to 2000 mL) of urine per day. The nephrons reabsorb the remaining 178 L or more of fluid.

If the body loses even 1% to 2% of its fluid, the kidneys conserve fluid by reabsorbing more water from the renal filtrate, which results in a more concentrated urine.

It is necessary for the kidneys to excrete a minimum of 30 mL/hr of urine (720 mL/24 hr) 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 by weighing the patient under exact conditions, for example, same time of day, same amount of bed clothing, same type of gown, and same

Skill 22-1 Measuring Intake and Output (I&O)

Nursing Action *(Rationale)*

1. Identify patient. *(Ensures accuracy.)*
2. Explain procedure. *(Enlists patient's cooperation and promotes patient participation.)*
3. Instruct patient to inform staff of all oral intake. Provide a marked intake and output (I&O) container. *(Facilitates accurate I&O measurement.)*
4. Instruct patient not to empty any output collection receptacles and to notify you after elimination. *(Contributes to accurate I&O measurement.)*
5. Alert all staff and remind patient of need to measure I&O. *(Promotes accurate compliance.)*
6. Measure and record all fluids taken orally, gastric tube feedings, and all fluids administered parenterally. *(Helps ensure accurate measurement of intake.)*
7. Wash hands and don gloves. *(Prevents transmission of microorganisms.)*
8. Measure and record output in Foley drainage system, diarrhea stools, nasogastric suction, emesis, ileostomy, and output in surgical wound receptacles such as Davol, Jackson-Pratt, and Hemovac. Measure and record output from chest tube drainage in water-sealed container by marking with felt-tip pen. *(Ensures accurate measurement and proper disposal of output.)*
9. Remove gloves and wash hands. *(Prevents cross-contamination.)*
10. Compute and document I&O on patient's record. *(Ensures accurate documentation of total I&O.)*
11. Be vigilant to maintain accurate I&O when ordered.

attached equipment, such as electrodes. Empty all drainage bags before weighing the patient. **Because 1 L of fluid equals 2.2 pounds (1 kg), a weight change of 2.2 pounds will reflect a loss or gain of 1 L of body fluid** (Skill 22-1). To determine a patient's hydration or dehydration levels, performance of urine specific measurements is appropriate. A urine specific gravity of more than 1.030 indicates concentrated urine (seen in conditions of dehydration), whereas a measurement of less than 1.010 indicates dilute urine (seen in conditions of hydration) (Lewis et al., 2007).

MOVEMENT OF FLUID AND ELECTROLYTES

Substances entering the body begin their journey in the extracellular fluid. However, to carry out their functions, they have to cross the semipermeable membrane surrounding each body cell and 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. Several methods are used to move fluids, electrolytes and other solutes, or dissolved substances from one compartment to another.

A number of processes allow this mass movement of substances into and out of cells. These transport processes are classified under two general headings:

1. Passive transport processes
2. Active transport processes

As implied by their name, active transport processes necessitate the expenditure of energy by the cell, and passive transport processes do not. The energy required for active transport processes is obtained from an important chemical substance called adenosine triphosphate (ATP). ATP is produced in the mitochondria from nutrients and is capable of releasing energy that in turn enables the cell to work. For active transport processes to occur, the breakdown of ATP and the use of the related energy are required.

The details of active and passive transport of substances across cell membranes is much easier to understand if you keep in mind the following two key facts: (1) in passive transport (the movement of small molecules by diffusion across a cell membrane) processes, no cellular energy is required to move substances from a high concentration to a low concentration; and (2) in active transport processes, cellular energy is required to move substances from a low concentration to a high concentration.

PASSIVE TRANSPORT

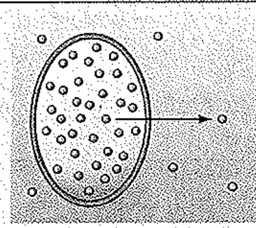
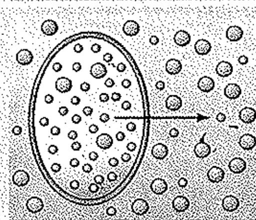
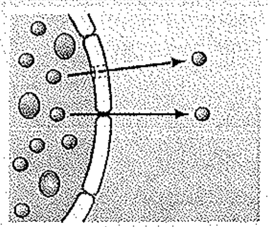
The primary passive transport processes that move substances through the cell membranes include the following:

- Diffusion
- Osmosis
- Filtration

DIFFUSION

Water is able to move freely from one compartment to another by diffusion. Diffusion is the movement of particles in all directions through a solution or gas (Table 22-4). In diffusion, 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. Diffusion occurs, for example, when ink is dropped into a glass of water. The ink will disperse in all directions until it is evenly distributed throughout the fluid. When diffusion occurs in the body, the molecules have the same action as the ink spreading through the water. With each inhalation by the patient, oxygen enters the lungs and moves into

Table 22-4 Passive Transport Processes

PROCESS	DESCRIPTION		EXAMPLES
Diffusion	Movement of particles through a membrane from an area of high concentration to an area of low concentration—that is, down the concentration gradient		Movement of carbon dioxide out of all cells; movement of sodium ions into nerve cells as they conduct an impulse
Osmosis	Diffusion of water through a selectively permeable membrane in the presence of at least one impermeable solute		Diffusion of water molecules into and out of cells to correct imbalances in water concentration
Filtration	Movement of water and small solute particles, but not larger particles, through a filtration membrane; movement occurs from area of high pressure to area of low pressure		In the kidney, water and small solutes move from blood vessels but blood proteins and blood cells do not, thus beginning the formation of urine

From Thibodeau, G.A., & Patton, K.T. (2008). *Structure and function of the human body.* (13th ed.). St. Louis: Mosby.

the intravascular compartment and into the cells by diffusion. Gases, including oxygen, nitrogen, and carbon dioxide, leave the capillaries and diffuse into the cell membrane and become distributed throughout the body (Lewis et al., 2007).

OSMOSIS

Osmosis is the movement of water from an area of lower concentration to an area of higher concentration (see Table 22-4). Osmosis equalizes the concentration of ions or molecules on each side of the membrane (Lewis et al., 2007). The flow of water will continue until the number of ions or molecules on both sides of the membrane is equal. What happens when you boil a hot dog in water is an example of osmosis. The water passes through the hot dog skin, which is a semipermeable membrane, in an attempt to equalize the number of molecules on both sides of the membrane. Finally, when the hot dog is able to hold no more water, the skin, or semipermeable membrane, ruptures.

The red blood cells offer an example of the osmotic process in the body. If extracellular fluid is more concentrated than intracellular fluid, the fluid from inside the cell moves out to the extracellular fluid, causing the red blood cell to shrink. If the fluid among the compartments is in equilibrium, fluid will enter and leave the cell at the same rate and the cell size will not change. Another example is when extracellular fluid is less concentrated than the fluid in the red blood cells. Fluid moves into the cell, causing it to enlarge. The process will sometimes continue until the cell ruptures.

Solutions are classified in the body as hypertonic, isotonic, or hypotonic according to the electrolyte concentration. The concentration of the solution will cause the cells of the body to react the same way the red blood cell does. Hypertonic (a solution of higher osmotic pressure) solutions pull fluid from the cells; isotonic (a solution of same osmotic pressure) solutions expand the body's fluid volume without causing a fluid shift from one compartment to another; and hypotonic (a solution of lower osmotic pressure) solutions move into the cells, causing them to enlarge. Each of these actions occurs through the mechanism of osmosis.

FILTRATION

Filtration is the transfer of water and dissolved substances from an area of higher pressure to an area of lower pressure. An example of filtration occurs at the capillary level of the circulation. A force behind filtration is called **hydrostatic pressure**, which is the force of fluid pressing outward on a vessel wall (see Table 22-4). The pumping action of the heart is responsible for the amount of force, the hydrostatic pressure, that causes water and electrolytes to move from the capillaries to the interstitial fluid.

ACTIVE TRANSPORT

The fluid movements discussed to this point necessitate no energy expenditure by the body; they are examples of passive transport. Active transport requires energy; it is a force that moves molecules into cells without regard for their positive or negative charge and against concentration factors that will prevent entry into the cell via diffusion. Active transport moves fluid and electrolytes from an area of lower concentration to an area of higher concentration.

Substances actively transported through the cell membrane include sodium, potassium, calcium, iron, hydrogen, and amino acids. The movement of glucose into the cells occurs through the process of active transport. Insulin provides the transport for glucose to leave the intravascular compartment and move into the cells, where the glucose can then be used for energy.

ELECTROLYTES

As water moves through the compartments of the body, it contains substances that are sometimes called **minerals or salts** but which are technically known as **electrolytes.** Electrolytes are substances that when in solution, separate (or dissociate) into electrically charged particles. 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. Ions with a positive charge are called cations. Ions with a negative charge are called anions.

The following are examples of cations:

- Sodium (Na^+)
- Potassium (K^+)
- Calcium (Ca^{++})
- Magnesium (Mg^{++})

The following are examples of anions:

- Chloride (Cl^-)
- Bicarbonate (HCO_3^-)
- Sulfate (SO_4^-)
- Hydrogen phosphate (HPO_4^-)

A balance exists among the electrolytes. The principal electrolytes must be present in proper quantities for normal metabolism and function in the body. For this balance to occur, there must be a negatively charged anion for each positively charged cation.

A sample of plasma is taken to measure the electrolytes. The measurement is expressed in milliequivalents (mEq). Rather than electrolytes being measured by their weights, they are measured by their electrical activity. A milliequivalent (mEq) is a measure of the chemical activity or chemical combining power of an ion. The chemical activity of an electrolyte is compared with the chemical activity of hydrogen. One milliequivalent of any electrolyte has the same chemical combining power as 1 mEq of hydrogen. In each fluid compartment in the body, the cations and anions balance each other with their chemical combining power to maintain electrical neutrality, which again keeps the body in homeostasis.

Although the electrolytes move freely among the fluid compartments, each has a primary location. The location and the function of each electrolyte become important in understanding disease processes. The healthy body maintains homeostasis by correcting any excesses or deficiencies of the electrolytes.

Sodium

The normal blood level of sodium (Na^+), a cation and the most abundant electrolyte in the body, is 134 to 142 mEq/L. It is the major extracellular electrolyte and because the plasma sample used to measure electrolyte levels comes from the extracellular fluid, the level is high. In contrast, the intracellular level of sodium is approximately 10 mEq. The major source of sodium comes from the diet. That is true of all the electrolytes. However, unlike the other electrolytes, sodium is a substance that it is frequently necessary to limit in the diet rather than encourage. The kidneys are the primary excretion route for sodium. It is important to know that many electrolytes, such as sodium, not only pass into and out of the body, but also move back and forth between a number of body fluids during each 24-hour period. Figure 22-3 shows the large volumes of sodium-containing internal secretions that are produced each day. During a 24-hour period, more than 8 L of fluid containing 1000 to 1300 mEq of sodium are poured into the digestive system. This sodium, along with most of that contained in the diet, is almost completely reabsorbed. Some major dietary sources of sodium are cheese, table salt, seafood, processed meat, canned vegetables, canned soups, ketchup, and snack foods, such as pretzels and potato chips. Precise regulation and control of sodium levels is required for survival.

The functions of sodium include regulation of the water balance. Sodium controls the extracellular fluid volume mainly through osmotic pressure, because water follows the sodium in the body (where sodium is, water will follow). It also increases cell membrane permeability. Sodium stimulates conduction of nerve impulses and helps maintain neuromuscular irritability. Sodium is important in controlling contractility of muscles, especially the heart.

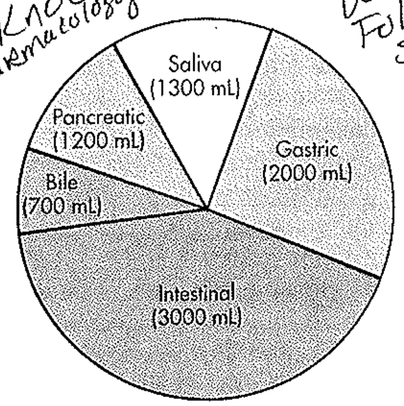


FIGURE 22-3 Sodium-containing internal secretions produced every day.

Hyponatremia

A less-than-normal concentration of sodium in the blood is called hyponatremia. This is possible when there is a sodium loss or a water excess (Box 22-1). Hyponatremia occurs when the sodium drops to less than 134 mEq/L in the extracellular fluid.

When a deficiency results from sodium loss, the body attempts to compensate by decreasing water excretion. Hyponatremia occurs because water is being retained in the body, which has a diluting effect on all of the blood components. The signs and symptoms of hyponatremia depend on the cause and also on how rapid and severe the sodium loss is. As sodium levels decrease in the extracellular fluid, water is pulled into the cells, causing them to become edematous, and as the fluid moves into the cells, potassium is shifted out; therefore the patient is likely to also have a potassium imbalance.

Hypernatremia

Hypernatremia is a greater-than-normal concentration of sodium. The sodium level exceeds 145 mEq/L. It is caused by an excess of sodium or a decrease in body water (Box 22-2). The body attempts to correct the imbalance by conserving water through renal reabsorption. Hypernatremia causes fluid to shift from the cells to the interstitial spaces, resulting in cellular dehydration and an interruption in cellular processes. Again, a potassium imbalance frequently occurs. In sodium retention, potassium is excreted.

Potassium

The normal blood serum level of potassium (K^+), the dominant intracellular cation, is 3.5 to 5 mEq/L. The level of potassium in the extracellular fluid is low because potassium is an intracellular electrolyte. The intracellular level of potassium (usually not measured) is much higher at 150 mEq/L. Of the body's potassium, 98% is in the cells and 2% is in the extracellular fluid.

A well-balanced diet usually provides adequate potassium. Approximately 65 mEq of potassium is required each day. Potassium is widely distributed in natural foods; fruits, such as oranges, bananas, apricots and cantaloupe; legumes; leafy vegetables; potatoes; mushrooms; tomatoes; carrots; and meat are sources of potassium (Box 22-3). The average daily intake of potassium is 60 to 100 mEq.

The routes of potassium excretion are the kidneys (80% to 90%) and in the feces and perspiration (10% to 20%). The kidneys control the excretion of potassium. Sodium and potassium seem to pair off against each other, and the kidneys prefer to conserve sodium, even when both electrolytes are depleted. In both normal and abnormal situations, sodium will be reabsorbed and potassium will be excreted. Because the major route of excretion of potassium is the kidneys, any

Box 22-1 Hyponatremia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES
- Inadequate sodium intake
- Loss of GI fluids
- Vomiting
- Diarrhea
- GI or biliary drainage via nasogastric tube or T-tube
- Fistulas
- Loss through skin
- Diaphoresis
- Large open lesions (burns)
- Shifting of body fluids
- Massive edema
- Ascites
- Burns
- Small bowel obstruction
- Lengthy hydrotherapy

SIGNS AND SYMPTOMS
- Headache*
- Irritability
- Muscle weakness, muscle twitching, tremors
- Fatigue*
- Apathy
- Postural hypotension*
- Nausea and vomiting
- Abdominal cramps
- Apprehension

Severe or Prolonged Deficit
- Shock
- Altered level of consciousness (lethargy, confusion)
- Seizures
- Coma
- Altered level of consciousness usually accompanies a serum sodium level less than 125 mEq/L and indicates that the patient's condition is deteriorating

NURSING INTERVENTIONS
- Monitor I&O of patients receiving diuretic medications
- Monitor and record vital signs, especially blood pressure and pulse
- Monitor neurologic status frequently; report any change in level of consciousness
- Weigh patient daily
- Monitor skin turgor at least every 8 hours
- Restrict fluid intake as ordered, because this is primary treatment for dilutional hyponatremia; post a sign about fluid restriction in the patient's room
- Observe for abnormal GI, renal, or skin losses
- Replace fluid loss with fluids containing sodium, not plain water

GI, Gastrointestinal; *I&O*, intake and output.
*Most common signs and symptoms.

Box 22-2 Hypernatremia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES
- More water than sodium is lost from the body
- Abnormally large intake of sodium
  - —Taking too many salt tablets
  - —Overuse of table salt
  - —IV saline infused too rapidly
  - —Prepared foods: frozen, canned, smoked
  - —Dairy products in large amounts
  - —Consumption of antacids containing sodium

SIGNS AND SYMPTOMS
- Dry, tenacious mucous membranes
- Low urinary output
- Firm, rubbery tissue turgor
- Restlessness, agitation, confusion, flushed skin

Severe or Prolonged Excess
- Manic excitement
- Tachycardia
- Death

NURSING INTERVENTIONS
- Monitor and record vital signs, especially blood pressure and pulse
- Provide a safe environment for confused or agitated patient
- Monitor I&O
- Weigh daily to check for body fluid loss
- Decrease sodium intake in diet
- Monitor water loss from fever, infection, increased respiratory rate
- Monitor serum sodium level

I&O, Intake and output; *IV*, intravenous.

Box 22-3 Foods Rich in Potassium

FRUITS (INCLUDING JUICES)
- Apricots
- Bananas
- Grapefruit
- Melon
- Cantaloupe
- Honeydew
- Dried fruits, figs, dates, raisins
- Oranges

PROTEIN FOODS
- Beef
- Chicken
- Liver
- Pork
- Veal
- Turkey
- Milk
- Nuts, peanut butter

VEGETABLES
- Asparagus
- Dried beans
- Broccoli
- Cabbage
- Carrots
- Celery
- Mushrooms
- Dried peas
- Potatoes (especially skins): white, sweet
- Spinach
- Squash
- Tomatoes

BEVERAGES
- Cocoa
- Cola drinks
- Instant tea and coffee

condition that causes a decrease in urine output also causes potassium retention. Serum potassium levels increase in kidney failure (Lewis et al., 2007). A rise in potassium necessitates continuous monitoring. An important consideration in homeostasis is that kidney function will determine the potassium level in the body. Too little or too much potassium affects the heart muscle and has potential to result in a life-threatening disturbance in cardiac rhythm (dysrhythmia).

The main function of potassium is regulation of water and electrolyte content within the cell. With sodium and calcium, it promotes transmission of nerve impulses and also skeletal muscle function. Potassium assists in the cellular metabolism of carbohydrates and proteins. Another function of potassium is to control the hydrogen ion concentration. When potassium moves out of the cell, sodium and hydrogen ions move in. The result is the regulation of acid-base balance.

Hypokalemia

A decrease in the body's potassium to a level less than 3.5 mEq/L is known as **hypokalemia.** Because the normal range for a serum potassium level is narrow (3.5 to 5 mEq/L), a slight decrease has profound consequences. The major cause of potassium loss is renal excretion (Box 22-4). The kidneys do not conserve potassium and excrete it even when the body needs the potassium. Intestinal fluids contain large amounts of potassium. In excessive GI losses from gastric suctioning or prolonged vomiting, potassium tends to become depleted. Severe diarrhea, fistulas, ileostomy, villous adenoma (tumor of the intestine that produces potassium-containing mucus), and excessive diaphoresis will also sometimes result in potassium loss. The use of diuretics, such as thiazides or furosemide (Lasix), promotes hypokalemia. Conditions that cause injury to the cells in turn cause the release of potas-

Care plan

Box 22-4 Hypokalemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES
- Decreased potassium intake
- Increased potassium loss
  - —Increased aldosterone activity
  - —GI losses (vomiting, diarrhea, GI suctioning)
  - —Ileostomy
  - —Potassium-losing diuretics
  - —Loss from cells, as in trauma, burns, fistulas
  - —Skin losses, diaphoresis
- Conditions causing very large urine output
- Potassium shift into cells
  - —Treatment of acidosis
  - —Metabolic alkalosis
  - —Villous adenoma (tumor of the intestine that produces potassium-containing mucus)

SIGNS AND SYMPTOMS
- Skeletal muscle weakness (especially in lower extremities), leg cramps*
- Paresthesias, hyporeflexia
- Decreased bowel sounds, cramps, and constipation, anorexia, nausea, vomiting*
- Diminished deep tendon reflexes, lethargy, confusion; paralysis involving the respiratory muscles; coma
- Orthostatic hypotension
- Cardiac dysrhythmias; weak, irregular pulse
- ECG changes
- Polyuria

Severe or Prolonged Deficit
- Flaccid paralysis
- Kidney damage
- Paralytic ileus
- Cardiac or respiratory arrest

NURSING INTERVENTIONS
- Carefully assess patients taking digitalis glycosides, especially if also taking a diuretic, for hypoglycemia, which has capacity to potentiate the action of the digitalis glycoside medication and cause toxicity
- Administer potassium chloride (KCl) supplement as prescribed by the physician (oral or IV)
- Whether through a peripheral or central catheter, it is necessary to administer IV potassium with care to prevent serious complications
- IV potassium is always diluted and delivered using an infusion controller
- Encourage increased intake of foods high in potassium
- Monitor bowel sounds
- Monitor serum potassium level
- Monitor I&O (about 40 mEq of potassium is lost in each liter of urine; diuresis has potential to put the patient at a risk for potassium loss)
- During treatment with potassium, it is necessary for the patient's urinary output to be at least 600 mL/day. If urinary output is less than 20 mL/hr for 2 consecutive hours, interrupt the infusion and immediately notify the physician. If renal function is impaired, there is a significant risk of hyperkalemia.†
- Monitor telemetry

ECG, Electrocardiogram; *GI*, gastrointestinal; *I&O*, intake and output; *IV*, intravenous.
*Most common signs and symptoms.
†From Burger, C. (2004). Hypokalemia—averting crisis with early recognition and intervention. *American Journal of Nursing, 104*(11), 61.

sium from the cells to the interstitial spaces and ultimately to the kidneys. If renal function is normal, the potassium will be excreted. Because the normal amounts of potassium are so small, fluctuations have the potential to develop into serious problems. Hypokalemia has the capacity to affect skeletal and cardiac function. The resulting muscle weakness causes life-threatening cardiac conduction abnormalities.

Hyperkalemia

An increase in the body's serum potassium level greater than 5 mEq/L is known as **hyperkalemia.** Because the normal range for a serum potassium level is narrow (3.5 to 5 mEq/L), a slight increase poses the risk of serious consequences. Potassium is gained through intake and lost by excretion. This condition is not as common as hypokalemia as long as renal function is normal. The major cause of potassium excess is renal disease, in which potassium is not excreted adequately (Box 22-5). When severe tissue damage occurs, potassium is released from the cells. Shock often accompanies this damage, resulting in reduced kidney output. The result is an elevated potassium level.

Slight

Causes

Excessive intake of foods high in potassium, especially with decreased urine output, may cause an increased serum potassium level. Other causes of hyperkalemia include (1) excessive use of salt substitutes (most of which use potassium as a substitute for sodium); (2) potassium supplements (oral or IV); (3) infusion of a large volume of blood nearing its expiration date (serum concentration increases the longer donated blood is stored); (4) drugs such as beta blockers, which inhibit potassium shifts into cells; (5) potassium-sparing diuretics such as spironolactone; (6) chemotherapy, which causes cell death or lysis with release of high levels of intracellular potassium into the blood; (7) angiotensin-converting enzyme inhibitors; (8) nonsteroidal antiinflammatory drugs; and (9) aminoglycosides.

Although hyperkalemia is less common than hypokalemia, it is often more dangerous because of cardiac arrest, which is caused by overstimulation of the cardiac muscle. A serum potassium level of 7 mEq/L or greater risks serious cardiac dysrhythmias.

Chloride

The normal blood level of chloride (Cl^-), an extracellular anion, is 96 to 105 mEq/L. It is the chief anion in

Care plans

Box 22-5 Hyperkalemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES

NOTE: Hyperkalemia may be the most dangerous of the electrolyte disorders.

- Potassium intake (parenteral or oral) in excess of kidney's ability to excrete
- Excessive use of salt substitutes
- Renal failure
- Adrenal insufficiency
- Potassium enters the bloodstream from injured cells with extensive trauma (shift of potassium out of the cells into extracellular fluid)
- Metabolic acidosis
- Infusion of large volume of blood nearing expiration date
- Beta blockers
- Potassium-sparing diuretics
- Tumor lysis syndrome after chemotherapy
- Angiotensin-converting enzyme inhibitors
- Nonsteroidal antiinflammatory drugs
- Aminoglycosides

SIGNS AND SYMPTOMS*

- Signs and symptoms are often nonspecific; serum potassium level and electrocardiogram (ECG) tracings are often the best clinical indicators
- Irritability
- Nausea, vomiting†
- Diarrhea, colic†
- Cardiac dysrhythmias†
- ECG changes
- Irregular pulse rate
- Hypotension
- Numbness, tingling
- Paresthesias
- Skeletal muscle weakness, especially of lower extremities

Severe or Prolonged Excess

- Flaccid paralysis
- Cardiac arrest† (serious dysrhythmias become especially dangerous when the serum potassium level reaches 7 mEq/L or more [normal serum potassium level ranges from 3.5 to 5 mEq/L])
- Anuria

NURSING INTERVENTIONS

- Decrease intake of foods high in potassium
- Administer Kayexalate (sodium polystyrene sulfonate) as prescribed by the physician (Kayexalate is possible to give orally, through a nasogastric tube, or as a retention enema); keep in mind when giving Kayexalate that serum sodium level will sometimes rise—watch for congestive heart failure
- Loop diuretics
- Decrease or stop medications associated with high potassium level
- Monitor underlying disorders leading to high potassium level
- Assess vital signs
- Monitor telemetry to detect dysrhythmias
- Monitor I&O (report an output of less than 30 mL/hr; an inability to excrete potassium in the urine will potentially lead to dangerously high potassium level)
- Hemodialysis in acute symptomatic hyperkalemia
- Monitor bowel sounds and number and character of bowel movements
- Monitor serum potassium level

*Prolonged potassium excess results in signs and symptoms similar to those of hypokalemia.
†Most common signs and symptoms.

interstitial and intravascular fluid. Even though chloride accounts for more than two thirds of the anions in the body, it is usually not considered alone. Chloride 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. It is more often linked with sodium.

The daily requirement of chloride is equal to that of sodium (3.65 to 10.85 g/day). Foods containing sodium also contain chloride. The main route of excretion is through the kidneys. Know

Chloride is necessary for the formation of hydrochloric acid in gastric juice. It is also a valuable electrolyte in regulating the osmotic pressure between the compartments and assisting in the regulation of acid-base balance.

Hypochloremia

Hypochloremia 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

Hyperchloremia rarely occurs but is possible when bicarbonate levels fall. The increase in chloride anions represents an attempt to compensate and maintain equal numbers with the cations in the body fluid. Because chloride imbalances rarely occur independently of other electrolytes, there are no specific signs and symptoms to identify a chloride imbalance.

Calcium

The normal blood level of calcium (Ca^{++}), a positively charged ion, is approximately 4.5 mEq/L. Of the 1200 g of calcium in the body, 99% is concentrated in the bones and the teeth, where it is physiologically inactive. The remaining 1% is found in the soft tissue and the extracellular fluid. Calcium is deposited in the bones and mobilized as needed to keep the blood level constant during any period of insufficient intake. Three considerations are important in the blood calcium level:

1. Deposition and resorption of bone
2. Absorption of calcium from the GI tract
3. Excretion of calcium in urine and feces

Vitamin D, calcitonin, and parathyroid hormone (parathormone) are necessary for the absorption and utilization of calcium.

The best food sources of calcium are milk and cheese. Other sources include beans, nuts, cauliflower, lettuce, and egg yolks. The average daily intake is 200 to 2500 mg. The dietary reference intakes (DRIs) vary from 360 mg for infants to 1200 mg for females 15 to 18 years of age. During pregnancy and lactation, 1300 mg is required. Prevention of osteoporosis focuses on adequate calcium intake (1000 mg/day in premenopausal women and postmenopausal women taking estrogen and 1500 mg/day in postmenopausal women who are not receiving supplemental estrogen). Calcium is removed from the body via the urine and feces.

Calcium is required for the formation and maintenance of strong bones and teeth. It is also necessary for normal blood clotting. Calcium has a depressing or sedative effect on neuromuscular irritability and thus promotes normal transmission of nerve impulses; it also helps regulate normal muscle contraction and relaxation. It helps hold body cells together by establishing the thickness and strength of cell membranes. One of its most important functions is to act as an enzyme activator for chemical reactions in the body.

Hypocalcemia

Hypocalcemia develops when the serum level is less than 4.5 mEq/L. Possible deficiencies arise from a variety of problems (Box 22-6):

- Infusion of excess amounts of citrated blood (citrates bind to the calcium)
- Excessive loss through diarrhea
- Inadequate dietary intake of calcium or vitamin D
- Surgical removal of parathyroid glands
- Decreased parathyroid function
- Pancreatic disease
- Small bowel disease

The signs and symptoms of hypocalcemia are neuromuscular irritation and increased excitability. As neuromuscular signs and symptoms increase, tetany is possible. Tetany is a condition characterized by excessive muscle cramps, laryngeal spasms, stridor, carpal spasms (Trousseau's sign), pedal spasms, and contraction of facial muscles (Chvostek's sign) (Figure 22-4).

Hypercalcemia

Hypercalcemia occurs when calcium levels exceed 5.8 mEq/L. It may occur when calcium stored in the bone enters the circulation, for example, in patients who are immobilized (Box 22-7). An increased intake of calcium or vitamin D also causes hypercalcemia.

Box 22-6 Hypocalcemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES

- Excess binding of calcium ions
- Large amount of citrated blood
- Excess alcohol
- Alkalosis
- Dietary deficiency of calcium and vitamin D
- Chronic renal failure
- Pancreatic disease
- Disease of small bowel; malabsorption
- Severe diarrhea
- Anticonvulsants, such as phenobarbital and phenytoin (Dilantin)
- Diuretics (Lasix, Edecrin)
- Draining intestinal fistulas
- Deficiency of parathyroid hormone or vitamin D
- Increased magnesium
- Thyroid surgery (surgical removal of parathyroid glands, removal of parathyroid tumor)
- Injury or disease of parathyroid gland
- Severe burns
- Low serum albumin levels

SIGNS AND SYMPTOMS

- Anxiety, confusion, irritability
- Osteoporosis, pathologic fractures
- Tingling around nose, mouth, ears, fingers, toes*
- Twitching
- Muscle spasm of feet and hands*
- Tetany (note positive Trousseau's or Chvostek's sign [see Figure 22-4])
- Laryngeal spasms
- Nausea, vomiting*
- Hyperactive deep tendon reflexes
- Diarrhea*
- Cardiac dysrhythmias, cardiac arrest
- Calcium deposits in body tissues
- Diminished response to digitalis glycosides

NURSING INTERVENTIONS

- Monitor vital signs; monitor respiratory status, including rate, depth, and rhythm; be alert for stridor, dyspnea, or crowing (laryngeal spasms)
- Monitor pertinent laboratory values including calcium, albumin, and magnesium
- Encourage intake of a diet high in calcium-rich foods, vitamin D, and protein
- Administer calcium and vitamin D as prescribed by the physician
- Monitor treatment of underlying causes
- Acute hypocalcemia necessitates either IV calcium gluconate or calcium chloride
- For acute hypocalcemia, keep a tracheotomy tray and resuscitation bag at bedside in case of laryngeal spasms
- Monitor telemetry
- Monitor serum calcium, albumin, and magnesium levels
- Monitor I&O

I&O, Intake and output; *IV*, intravenous.
*Most common signs and symptoms.

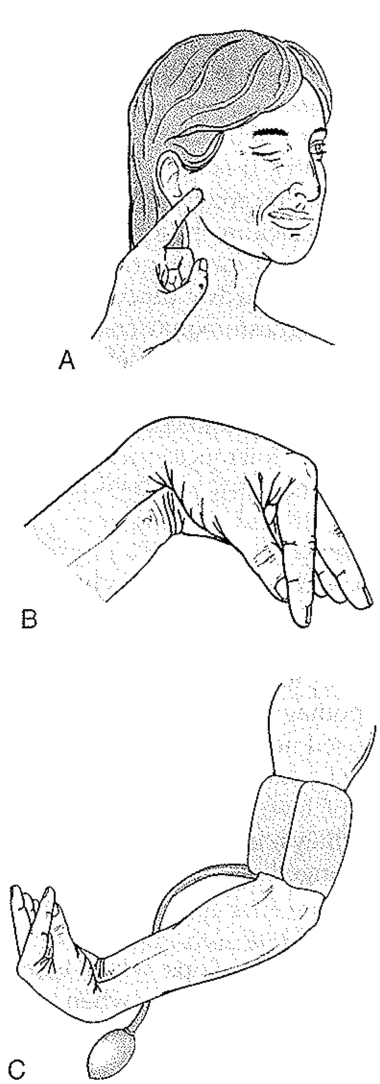


FIGURE 22-4 Tests for hypocalcemia. A, Chvostek's sign is a contraction of facial muscles in response to a light tap over the facial nerve in front of the ear. B, Trousseau's sign is a carpal spasm induced by C, inflating a blood pressure cuff above the systolic pressure for a few minutes.

Box 22-7 Hypercalcemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES
- Loss from bone
- Immobilization
- Metastatic bone cancer
- Multiple myeloma
- Excess intake
- Dietary
- Antacids containing calcium
- Increased absorption
- Increased parathyroid hormone
- Increased vitamin D

SIGNS AND SYMPTOMS
- Anorexia, nausea, vomiting
- Behavioral changes, including confusion
- Thirst, polyuria*
- Renal calculi
- Decreased deep tendon reflexes
- Constipation
- Paralytic ileus
- Lethargy, coma
- Cardiac dysrhythmias, cardiac arrest
- Hypertension
- Decreased muscle tone*
- Decreased GI motility
- Bone pain

NURSING INTERVENTIONS
- Assist in the promotion of excretion of calcium in the urine
- Administer diuretics as ordered by the physician
- Encourage drinking 3000 to 4000 L of fluids per day
- Monitor I&O
- Be aware that in life-threatening hypercalcemia, measures to increase calcium secretion will sometimes include hemodialysis or peritoneal dialysis

GI, Gastrointestinal; *I&O*, intake and output.
*Most common signs and symptoms.

Neuromuscular activity is depressed, and renal calculi may develop because of the excretion of high levels of calcium by the kidneys.

Phosphorus

The normal blood level of phosphorus, chiefly present as hydrogen phosphate (HPO_4^-), an intracellular anion, is approximately 4 mEq/L. Phosphorus and calcium have an inverse relationship in the body: An increase in one causes a decrease in the other. As blood calcium levels increase, a decrease in phosphorus levels is necessary, and vice versa. The majority (70% to 80%) of phosphorus is found combined with calcium in an individual's bones and teeth, 10% is in an individual's muscle, and the remaining 10% is in the nerve tissue of the body.

Dietary intake of phosphorus is usually 800 to 1500 mg/day. The minimum daily requirement is 800 mg. Higher intake during pregnancy and lactation is needed. An adequate intake of vitamin D is necessary for the absorption of both calcium and phosphorus. Because a generous amount of phosphorus is present in many foods, a deficiency seldom occurs. Foods especially high in phosphorus include beef, pork, fish, poultry, milk products, and legumes. The kidneys are responsible for approximately 90% of the excretion of phosphorus. The remainder is excreted in the feces.

With calcium, phosphorus contributes to the support and maintenance of bones and teeth. It is important in many chemical reactions and acts as a buffer to regulate the body's acid-base balance. It promotes the effectiveness of many of the B vitamins, assists in normal nerve and muscle activity, and participates in carbohydrate metabolism.

Hypophosphatemia

Hypophosphatemia is possible as a result of a dietary insufficiency, impaired kidney function, or maldistribution of phosphate. Muscle weakness, especially affecting the respiratory muscles, sometimes occurs.

Hyperphosphatemia

Hyperphosphatemia most commonly occurs as a result of renal insufficiency. Another cause is increased intake of phosphate or vitamin D. Signs and symptoms of tetany, numbness and tingling around the mouth, and muscle spasms develop.

Magnesium

The normal blood level of magnesium (Mg^{++}), the second most abundant cation in the intracellular fluid, is 1.5 to 2.4 mEq/L. Although only small amounts of magnesium are in the blood, it is important in maintaining normal body function. The majority (60%) is found in the bone, 39% in the muscle and the soft tissue, and 1% in the extracellular fluid, most of which is in the cerebrospinal fluid.

Dietary intake is usually 200 to 400 mg daily. The minimum daily requirement is 250 mg for the average adult, 150 mg for an infant, and 400 mg for a female during pregnancy and lactation. Magnesium is another electrolyte commonly distributed in foods. Whole grains, fruits, vegetables, meat, fish, legumes, and dairy products are dietary sources.

The major route of magnesium excretion is the kidneys. There is a correlation between the amount of magnesium and the amount of potassium excreted. The kidneys do not conserve potassium, but they do conserve magnesium; therefore if a magnesium deficiency develops, the body will conserve magnesium at the expense of excreting potassium.

Magnesium has not been a widely recognized electrolyte until recently. It is now linked as a cofactor in the activation of many enzymes. It also promotes regulation of serum calcium, phosphate, and potassium levels and is essential for integrity of nervous tissue, skeletal muscle, and cardiac functioning.

Diets low in magnesium may create a risk for hypertension, cardiac dysrhythmias, ischemic heart disease, and sudden cardiac death. Decreased intracellular magnesium levels may contribute to the hypertension, abnormal glucose tolerance, and insulin resistance common in diabetics.

Hypomagnesemia

Hypomagnesemia develops when blood levels fall to less than 1.5 mEq/L. A decrease in magnesium often parallels decreased potassium, because if the magnesium level is low, the kidneys tend to excrete more potassium. Hypomagnesemia causes signs and symptoms of increased neuromuscular irritability similar to those observed with hypocalcemia (Box 22-8). The major causes of low magnesium are increased excretion by the kidneys, impaired absorption from the GI tract, and prolonged malnutrition.

Hypermagnesemia

Hypermagnesemia develops when blood levels exceed 2.5 mEq/L. It rarely occurs when kidney function is normal. The three major causes are impaired renal function, excess magnesium administration, and dia-

Box 22-8 Hypomagnesemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES

- Decreased intake
  - —Prolonged malnutrition
  - —Starvation
- Impaired absorption from GI tract
  - —Alcoholism
  - —Hypercalcemia
  - —Diarrhea
  - —Draining intestinal fistulas
- Conditions causing large losses of urine
- Prolonged IV feedings without magnesium supplementation

SIGNS AND SYMPTOMS

- Anorexia
- Mental changes*
- Agitation, depression, confusion
- Dysphagia
- Hyperactive deep tendon reflexes
- Nausea and vomiting
- Paresthesias*
- Tetany
- Tremors
- Seizures
- Ataxia
- Cramps, spasticity, tetany
- Tachycardia
- Hypotension
- Cardiac dysrhythmias

NURSING INTERVENTIONS

- Monitor vital signs
- Assess neuromuscular status
- Assess dysphagia
- Increase intake of magnesium-rich foods
- Administer magnesium supplements as prescribed by the physician
- Monitor I&O
- Monitor telemetry
- Institute seizure precautions
- Monitor respiratory status

GI, Gastrointestinal; *I&O*, intake and output; *IV*, intravenous.
*Most common signs and symptoms.

Box 22-9 Hypermagnesemia: Causes, Signs and Symptoms, and Nursing Interventions

CAUSES
- Renal failure
- Diabetic ketoacidosis with severe water loss

SIGNS AND SYMPTOMS
- Hypotension*
- Vasodilation*
- Heat
- Thirst
- Nausea and vomiting
- Loss of deep tendon reflexes
- Respiratory depression

Prolonged or Severe Excess
- Coma
- Cardiac arrest

NURSING INTERVENTIONS
- Promote urine excretion
- Administer diuretics as prescribed by the physician
- Decrease intake of foods or medications high in magnesium
- Monitor I&O

I&O, Intake and output.
*Most common signs and symptoms.

betic ketoacidosis when there is severe water loss (Box 22-9). An excess of magnesium severely restricts nerve and muscle activity.

Bicarbonate

The normal level of bicarbonate (HCO_3^-), one of the main anions in the extracellular fluid, is 22 to 24 mEq/L. It is an alkaline electrolyte whose major function is the regulation of the acid-base balance, also called *acid-alkaline balance.* Bicarbonate acts as a buffer to neutralize acids in the body and maintain the 20:1 bicarbonate to 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 (H^+) concentration in the body fluids. The hydrogen ion concentration is determined by the ratio of carbonic acid (H_2CO_3) to bicarbonate (HCO_3^-) 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. When pH is measured, it is actually the hydrogen ion concentration in the patient's body that is measured. A sample of extracellular fluid, specifically arterial blood, is used to determine the body's pH.

Arterial blood gases will reveal whether the blood is acid, neutral, or alkaline. The more hydrogen ions in a solution, the more acid the solution. The fewer hydrogen ions in a solution, the more alkaline the solution. The terms *base* and *alkaline* are interchangeable; a base is an alkaline substance. An inverse relationship exists between hydrogen ion concentration and the pH level: As the numbers of hydrogen ion increase, the acidity of the solution increases and the pH decreases. The opposite happens with alkalinity—the number of hydrogen ions decreases and the pH increases. A pH of less than 7.35 is acid. A pH of greater than 7.45 is alkaline. The normal pH of arterial blood is approximately 7.45, whereas the normal pH of venous blood and interstitial fluid is approximately 7.35. Between 7.35 and 7.45 is considered normal blood pH. A pH lower than 6.8 or higher than 7.8 is usually fatal (Figure 22-5).

Two general types of disturbances can cause a pH imbalance. One imbalance arises from an increase or a

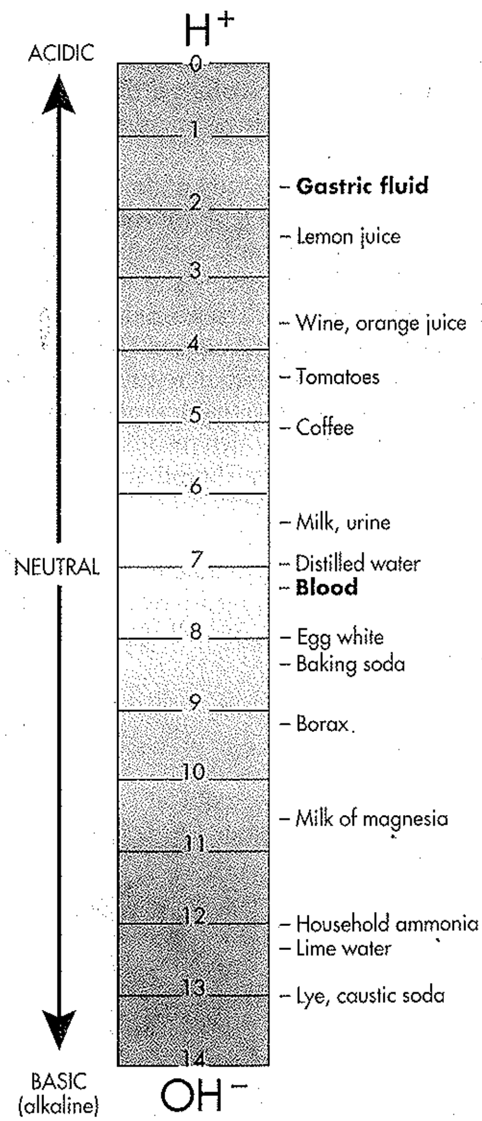


FIGURE 22-5 The pH scale. A pH of 7 is considered neutral. Values toward the top (less than 7) are acidic (the lower the number, the more acidic). Values toward the bottom (greater than 7) are basic (the higher the number, the more basic). Representative fluids and their approximate pHs are listed at the side of the figure.

decrease in the base substance—bicarbonate. The other imbalance results from adding or subtracting the acid substance—carbonic acid. The body's metabolism affects the base side of balance—so a bicarbonate imbalance causes metabolic acidosis or alkalosis. The body's respiratory system affects the acid side of the balance—so a carbonic acid imbalance causes respiratory acidosis or alkalosis. The four primary types of acid-base imbalance (discussed later in the chapter) are **respiratory acidosis, respiratory alkalosis, metabolic acidosis,** and **metabolic alkalosis.** Figure 22-6 shows the carbonic acid/bicarbonate ratio and pH.

The body has three systems that work to keep the pH in the narrow range of normal: the blood buffers, the respiratory system, and the kidneys. These systems are the body's three lines of defense that are constantly working to maintain a normal pH.

Try thinking of the blood buffers as chemical sponges. They circulate throughout the body in pairs, neutralizing excess acids or bases by contributing or accepting hydrogen ions. One buffer will dominate if the solution is too acid; the other if the solution is too alkaline. They work within a fraction of a second to prevent an excessive change in the hydrogen ion concentration. The body has four major buffer systems. The bicarbonate–carbonic acid system is the most important. It is responsible mainly for buffering blood and interstitial fluid. Decreasing the strength of potentially damaging acids and bases reduces the danger these chemicals pose to pH balance. The kidneys assist the bicarbonate buffer system in regulating production of bicarbonate. The lungs assist by regulating the production of carbonic acid, which results from combining carbon dioxide and water. The other systems are the phosphate, protein, and hemoglobin buffer systems.

For every 1 million hydrogen ions that enter the body, the buffer systems are able to neutralize all but five. Once the buffer systems are exhausted, the body calls on the second line of defense: the lungs. By speeding up or slowing down respirations, the lungs have the capacity to increase or decrease the amount of carbon dioxide in the blood. Removing carbon dioxide from the blood lowers the carbonic acid level; this is the mechanism by which the respiratory system regulates pH. Whereas it took seconds for the buffer systems to work, it takes minutes for the lungs to begin to adjust the pH. Even though the respiratory system is slower than the buffers, however, the lungs are able to eliminate large amounts of acid (in the form of carbon dioxide) from the body. Just enough carbon dioxide is retained in the blood to maintain a normal pH level. If the pH drops suddenly from the normal range of 7.35 to 7.45 to 7, the respiratory system is able to return the pH to about 7.2 to 7.3 within 1 minute. Chemoreceptors in the medulla of the brainstem provide the stimulus to increase respirations; however, as the hydrogen ion concentration approaches normal, the stimulus is lost. The buffers will accomplish the remaining adjustments needed to return the level to normal.

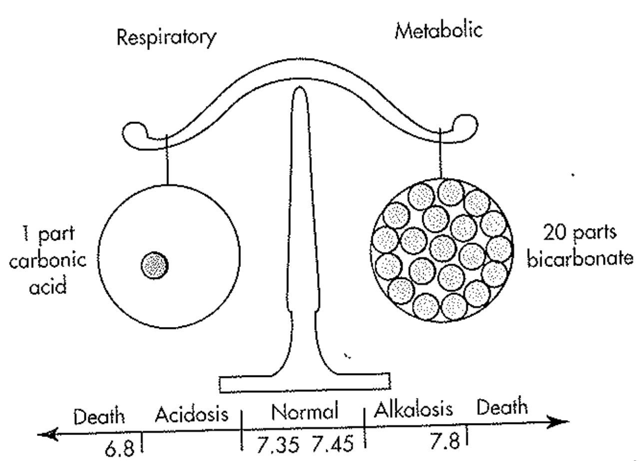


FIGURE 22-6 Carbonic acid to bicarbonate ratio and pH. The normal plasma range is 7.35 to 7.45. A normal pH is maintained by a ratio of 1 part carbonic acid to 20 parts bicarbonate.

The third line of defense is the kidneys. The action of the lungs in coping with an imbalance is simple: We breathe more slowly or more quickly. The kidneys have much more selective control. They are able to excrete varying amounts of acid or base into the urine. If the acidity of blood rises above normal, the kidneys will selectively eliminate more acids so the hydrogen ion concentration increases in the blood. If the blood becomes too alkaline, the kidneys will selectively eliminate more bases, especially bicarbonate. Normal urine is acidic because the body produces excess acids in the metabolic processes that occur continuously in the body. The kidneys are the slowest of the systems, but they are efficient enough to return the pH to exactly normal. Their response takes hours to days.

The three systems work closely together to maintain a normal hydrogen ion concentration. The buffers are immediate and continuous in contributing or accepting hydrogen ions. The respiratory system has the capacity to come into play within minutes, regulating the carbon dioxide level in the blood and thus controlling carbonic acid. The kidneys are the third line of defense, and although they work more slowly than the other two systems, they are able to eliminate either hydrogen ions or bicarbonate ions, which means they can either increase or decrease pH.

ACID-BASE IMBALANCE

Acid-base balance means homeostasis of the hydrogen ion concentration. A steady acid-base balance is normally maintained in the body (Lewis et al., 2007). An upset in acid-base balance results in either acidosis (when blood pH is less than 7.35), or alkalosis (when blood pH is greater than 7.45). The lungs and the kidneys are the two major organs responsible for regulation of the acid and base substances in the body. When imbalances occur, they represent an imbalance in the function of the lungs, the kidneys, or both. Many diseases create a potential for acid-base imbalances as well as fluid and electrolyte problems. Diseases that pose a risk for these imbalances include diabetes mellitus, chronic obstructive pulmonary disease (COPD), and end-stage renal disease, as well as severe vomiting and diarrhea (Lewis et al., 2007).

There are four primary types of acid-base imbalances: respiratory acidosis, respiratory alkalosis, metabolic acidosis, and metabolic alkalosis (Table 22-5).

RESPIRATORY ACIDOSIS

Any condition that impairs normal ventilation causes respiratory acidosis (Box 22-10). Retention of carbon dioxide occurs with a resultant increase of carbonic acid in the blood. As pH falls and the normal 20:1 bicarbonate to carbonic acid ratio is upset, the Pco_2 (partial carbon dioxide) level increases. Shallow respirations result because of the retained carbon dioxide. The patient will also experience a depression of central nervous system activity. Because the lungs are responsible for the respiratory parameters of the acid-base balance, the kidneys, which are responsible for the metabolic parameters, will attempt to compensate by retaining the base substance bicarbonate. During respiratory acidosis, it takes 24 hours for the kidneys to respond in a compensatory mechanism by retaining bicarbonate (Lewis et al., 2007).

Treatment for respiratory acidosis is aimed at improving ventilation. The primary goal is to support the patient's respirations. Intermittent positive-pressure breathing (IPPB) to promote exhalation of carbon dioxide, antibiotic administration for any respiratory infection, adequate hydration (2 to 3 L/day) to keep the mucous membranes moist and aid in removal of secretions, and use of bronchodilators to help reduce bronchial spasms will be possible elements of the treatment regimen. Therapy is also directed at correcting the primary condition responsible for the imbalance.

Table 22-5 Acid-Base Imbalances and Compensatory Mechanisms

ACID-BASE IMBALANCE	MODE OF COMPENSATION
Respiratory acidosis	Kidneys will retain increased amounts of HCO_3^- to increase pH
Respiratory alkalosis	Kidneys will excrete increased amounts of HCO_3^- to lower pH
Metabolic acidosis	Lungs "blow off" CO_2 to raise pH
Metabolic alkalosis	Lungs retain CO_2 to lower pH

From Pagana, K., & Pagana, T. (2006). *Mosby's diagnostic and laboratory test reference.* (6th ed.). St. Louis: Mosby.

RESPIRATORY ALKALOSIS

Respiratory alkalosis is caused by hyperventilation (Box 22-11). Respirations that increase in rate, depth, or both have the potential to result in the 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, which is blown off with each exhalation.

Box 22-10 Respiratory Acidosis: Causes, Common Clinical Signs and Symptoms, and Laboratory Data

CAUSES
- Compromise in any of the three essential parts of breathing—ventilation, perfusion, or diffusion
- Chronic obstructive pulmonary disease
- Pneumonia
- Respiratory failure
- Atelectasis
- Barbiturate or sedative overdose
- Paralysis of respiratory muscles (Guillain-Barré syndrome, poliomyelitis, myasthenia gravis)
- Traumatic injuries to the thorax (flail chest)
- Obesity
- Airway obstruction
- Head injuries
- Stroke (CVA)
- Drowning
- Cystic fibrosis

COMMON CLINICAL SIGNS AND SYMPTOMS

Central Nervous System
- Lethargy
- Disorientation
- Occipital headache
- Decreased deep tendon reflexes
- Dizziness
- Decreasing level of consciousness
- Seizures
- Coma

Cardiopulmonary System
- Dyspnea
- Tachycardia
- Hypotension
- Cardiac dysrhythmias

Musculoskeletal System
- Tremors
- Weakness

LABORATORY DATA
- pH less than 7.35
- $Paco_2$ greater than 45 mm Hg (unless the patient has chronic obstructive pulmonary disease)
- Pao_2 normal or less than 80 mm Hg, depending on severity of acidosis
- O_2 saturation normal or less than 95%, depending on severity of acidosis
- HCO_3^- normal in early respiratory acidosis
- K^+ greater than 5 mEq/L

CVA, Cardiovascular accident.

Box 22-11 Respiratory Alkalosis: Causes, Common Clinical Signs and Symptoms, and Laboratory Data

CAUSES
- Hyperventilation (caused by hypoxia, pulmonary emboli, anxiety, fear, pain, exercise, fever)
- Anemia
- Hypermetabolic states
- Disorders of the central nervous system (head injuries, infections)
- Drugs (aspirin overdose)
- Asthma
- Pneumonia
- Inappropriate mechanical ventilator settings

COMMON CLINICAL SIGNS AND SYMPTOMS

Central Nervous System
- Anxious appearance
- Irritability
- Confusion
- Tingling of the extremities
- Fainting
- Dizziness
- Seizures

Cardiopulmonary System
- Tachypnea
- Cardiac dysrhythmias

Musculoskeletal System
- Tetany
- Muscle weakness

LABORATORY DATA
- pH 7.45 or greater
- $Paco_2$ less than 35 mm Hg
- Pao_2 normal
- O_2 saturation normal
- HCO_3^- 22 to 24 mEq/L (normal)
- K^+ less than 3.5 mEq/L

Box 22-12 Metabolic Acidosis: Causes, Common Clinical Signs and Symptoms, and Laboratory Data

CAUSES
- Starvation
- Dehydration
- Diabetic ketoacidosis
- Lactic acidosis
- Renal failure
- Shock
- Severe diarrhea
- Drugs (methanol, ethanol, formic acid, paraldehyde, aspirin)
- Renal tubular acidosis
- Renal failure

COMMON CLINICAL SIGNS AND SYMPTOMS

Central Nervous System
- Lethargy
- Headache
- Decreasing level of consciousness
- Coma

Cardiopulmonary System
- Kussmaul's respirations (deep, rapid respirations)
- Dysrhythmias
- Warm, flushed skin

Gastrointestinal System
- Anorexia
- Nausea
- Vomiting
- Diarrhea
- Abdominal pain

Musculoskeletal System
- Weakness

LABORATORY DATA
- pH less than 7.35
- $Paco_2$ normal, or less than 35 mm Hg if lungs are compensating
- Pao_2 normal, or less than 35 mm Hg if lungs are compensating
- O_2 saturation normal
- HCO_3^- less than 22 mEq/L
- K^+ greater than 5 mEq/L

The common treatment for respiratory alkalosis is sedation and reassurance. If the cause is anxiety, it helps to make the patient aware of the abnormal breathing pattern. Instruct the patient to breathe slowly to retain and accumulate carbon dioxide in the body. Another effective treatment is for the patient to breathe into a paper bag, which will cause rebreathing of the exhaled carbon dioxide.

METABOLIC ACIDOSIS

Metabolic acidosis is possible as a result of either a gain of hydrogen ions or a loss of bicarbonate—in other words, retaining too many acids (H^+ ions) or losing too many bases (HCO_3^-) (Box 22-12). Examples of metabolic acidosis include diabetic ketoacidosis from ketone accumulation, lactic acid elevation (seen in shock), and acidosis from loss of too many bases (as in severe diarrhea or renal failure) (Lewis et al., 2007).

Without sufficient bases, the pH of the blood falls below the normal 7.35 to 7.45. With the loss of base substances, the bicarbonate level will also drop. The effect of metabolic acidosis is hyperventilation, occurring as the lungs attempt to compensate by blowing off carbon dioxide to lower the Pco_2 level. A patient with diabetic ketoacidosis will often develop Kussmaul's respirations (deep, rapid breathing), which serve to blow off carbon dioxide in an attempt to reverse the condition of metabolic acidosis (Lewis et al., 2007). Administration of sodium bicarbonate is the usual treatment for acidosis.

METABOLIC ALKALOSIS

Metabolic alkalosis results when a significant amount of acid is lost from the body or an increase in the bicarbonate level occurs (Box 22-13). The most common causes of metabolic alkalosis are vomiting gastric con-

Box 22-13 Metabolic Alkalosis: Causes, Common Clinical Signs and Symptoms, and Laboratory Data

CAUSES
- Excessive vomiting
- Prolonged gastric suctioning
- Electrolyte disturbance
- Cushing's disease
- Drugs (steroids, sodium bicarbonate, diuretics); overdose of baking soda, excessive use of antacids such as Mylanta
- Hyperaldosteronism

COMMON CLINICAL SIGNS AND SYMPTOMS

Central Nervous System
- Headache
- Irritability
- Lethargy
- Decreases in level of consciousness
- Seizures

Cardiopulmonary System
- Atrial tachycardia
- Slow, shallow respirations with periods of apnea
- Cardiac dysrhythmias (related to hypokalemia)

Gastrointestinal System
- Nausea
- Vomiting
- Anorexia

Musculoskeletal System
- Numbness and tingling of extremities
- Tremors
- Hypertonicity of muscles, muscle cramps
- Tetany

LABORATORY DATA
- pH greater than 7.45
- $PaCO_2$ normal or greater than 45 mm Hg if lungs are compensating
- PaO_2 normal
- O_2 saturation normal
- HCO_3^- greater than 26 mEq/L
- K^+ less than 3.5 mEq/L

tent (normally high in acid) and gastric suction. Metabolic alkalosis is also possible in patients who ingest excess amounts of alkaline agents, such as bicarbonate-containing antacids (e.g., Alka-Seltzer, soda bicarbonate). Metabolic alkalosis depresses the central nervous system. The respiratory rate is decreased, thus decreasing the amount of carbon dioxide exhaled and raising the level of plasma CO_2 (Lewis et al., 2007). Again, as with the other acid-base imbalances, treatment is aimed at the cause.

NURSING PROCESS

The role of the licensed practical nurse/licensed vocational nurse (LPN/LVN) in the nursing process as stated is that the LPN/LVN will:
- Participate in planning care for patients based on patient needs
- Review patient's plan of care and recommend revisions as needed
- Review and follow defined prioritization for patient care
- Use clinical pathways, care maps, or care plans to guide and review patient care

Assessment

During assessment of fluid, electrolyte, and acid-base balances, you will identify patients at risk for imbalances, the presence of any alterations, and the extent to which body systems are involved. Assessment helps you anticipate the patient's needs for nursing interventions. Gathering assessment data also helps determine the effectiveness of therapies and any adverse reactions to them.

The assessment includes the nursing history; physical examination; measuring and recording of I&O; laboratory studies; and consideration of factors influencing fluid, electrolyte, and acid-base balances.

Nursing Diagnosis

In the areas of fluid, electrolyte, and acid-base balances, it is particularly important that you be skilled and use critical thinking to formulate nursing diagnoses. Use the following nursing diagnoses for fluid, electrolyte, and acid-base alterations:
- Risk for deficient fluid volume
- Imbalanced nutrition: less than body requirements
- Deficient fluid volume
- Risk for imbalanced fluid volume
- Excess fluid volume
- Impaired or risk for impaired skin integrity
- Impaired tissue integrity
- Impaired oral mucous membrane
- Ineffective tissue perfusion
- Decreased cardiac output
- Impaired gas exchange
- Ineffective breathing pattern

The assessment data that establish the risk for or the actual presence of a nursing diagnosis in these areas will often be subtle. Typically, patterns and trends will emerge only when you consciously look for them, because many body systems are involved. For example, relevant assessment data for the nursing diagnosis of deficient fluid volume will perhaps include the presence of insufficient oral intake, weight loss, dry skin and mucous membranes, inelastic skin turgor, decreased blood pressure, and increased heart rate. The serum sodium will possibly be elevated. The urine will potentially be dark, with an elevated specific gravity. In some cases, the volume of the urine will be decreasing over a period of days. The omission of any of these data will lead you to formulate an incomplete picture of the patient's condition and perhaps result in an incorrect diagnosis.

In addition to the accurate clustering of assessment data, it is essential that you precisely identify the related factor for the nursing diagnosis to plan appropriate nursing interventions. For example, for the nursing diagnosis of deficient fluid volume, the related factor is sometimes diarrhea, and sometimes vomiting or difficulty swallowing. This nursing diagnosis is not present if the patient is receiving nothing by mouth (NPO) as part of the treatment regimen. If the related factor is diarrhea, you will administer ordered antidiarrheal medication and provide oral fluids that contain electrolytes and glucose. You will teach the patient to use careful handwashing and to avoid dairy products. In contrast, if the related factor is vomiting, you will administer antiemetics, remove sights and odors that have the potential to induce nausea, and provide a small amount of fluids containing electrolytes. If the related factor is difficulty swallowing, you will attempt to ensure that the patient is maximally stimulated; position the patient in a high Fowler's position or on the side during times of intake; provide foods and fluids with a soft, pureed, or thickened consistency; provide 5-mL amounts with each mouthful; and investigate the need for enteral or total parenteral nutrition.

Expected Outcomes and Planning

The first step in the planning process is setting priorities. Many nursing diagnoses in the areas of fluid, electrolyte, and acid-base balance represent high-priority patient problems. The consequences are potentially serious, even life threatening (e.g., seizures, dysrhythmias, or coma).

During the planning process, you will formulate nursing interventions for use to prevent or treat fluid, electrolyte, and acid-base imbalances. It is important to collaborate with the patient and the family during this part of the assessment and planning processes. The family will be helpful in identifying the subtle changes in behavior associated with these imbalances, such as anxiety, confusion, or irritability. During the planning process, it is important to remember that the patient and the family need to know preventive measures, signs and symptoms to report, and measures that are possible to implement if an imbalance occurs. When medications, special diets, or oral or IV fluids are administered in the home, the patient and the family need careful teaching to be able to perform these interventions safely. Consider the patient's preferences and resources during each step of the planning process (e.g., if the patient needs to be encouraged to increase oral intake, determine the patient's favorite beverages and incorporate them into the plan of care). In the hospital, anticipate the needs of the patient and family for specific information and initiate teaching before discharge so they will be ready for these procedures. The home health nurse continues the teaching plan and evaluates the effectiveness of the home interventions.

You will also work closely with other members of the health care team, such as the physician, the dietitian, or the physical therapist. For example, when you collect new assessment data that suggest the patient is developing a fluid, electrolyte, or acid-base imbalance, you will consult with the physician to determine the need for dietary, pharmacologic, IV fluid, or other therapy. Your responsibilities also include ongoing monitoring of the patient's fluid, electrolyte, and acid-base status to determine the safety of implementing physician and nursing orders and any need for a change in the plan of care. For example, perhaps the physician will order an oral potassium supplement to be given to the patient three times each day. Before administering the first dose each day, verify that the serum potassium level is normal and that the urine output is adequate. Withhold the dose of potassium and consult the physician if the serum level is elevated or if the urine output has decreased.

After priority setting and collaboration with the patient, family, and health care team, you will develop a care plan with your colleagues that is individualized according to the patient's acute or chronic fluid, electrolyte, or acid-base status. The plan is based on one or more of the following goals:

Goal: The patient's fluid, electrolyte, and acid-base balances are restored and maintained.

Outcomes:

The patient's vital signs will return to baseline normal.

The patient will have normal skin turgor.

The patient will have moist oral mucous membranes.

The patient's weight will be stable at baseline normal.

The patient will have no edema.

The patient will have clear breath sounds.

The patient's serum and urine electrolyte and chemistry results and arterial blood gas values will be normal.

The patient's urine output will equal intake.

Implementation

Prevention of fluid, electrolyte, and acid-base imbalances is important. When imbalances occur, you will remove or treat the cause of the imbalance if possible. Other nursing interventions aim to correct the imbalances.

When a patient's fluid volume is depleted, it is possible to replace fluids and electrolytes orally, with IV administration of fluids and blood components, or through total parenteral nutrition if the fluid deficit is caused by malnutrition. For patients with fluid volume excess, implement measures to reduce fluids, such as fluid intake restrictions, reduced sodium intake, and use of diuretics. When the patient has an electrolyte imbalance, provide an appropriate diet and administer supplements when ordered. For patients with acid-base imbalances, initiate such measures as reducing anxiety, improving pulmonary function, controlling the loss of GI content, or ensuring the control of conditions such as diabetes mellitus or renal failure.

Evaluation

Evaluate the interventions by comparing the patient's responses to the expected outcomes of the established goals. Be prepared to revise the plan of care based on the evaluation. Evaluative measures typically include the following:

Goal: Patient's fluid and electrolyte balances are restored and maintained.

Evaluative measures:
Obtain daily weight and monitor.
Obtain patient's vital signs.
Measure all routes of intake and output.
Auscultate for adventitious lung sounds.
Assess oral mucous membranes for dryness or moistness.
Assess tissue turgor for tenting or edema.
Monitor serum electrolytes.

Get Ready for the NCLEX® Examination!

Key Points

- Water is the primary fluid in the body.
- The two fluid compartments are the intracellular and extracellular compartments. The extracellular compartment is composed in turn of the interstitial and intravascular areas.
- Fluid movement takes place by means of three passive transport systems—diffusion, osmosis, and filtration—and one active transport system—active transport by ATP energy.
- Electrolytes are chemical compounds that carry either a positive or negative charge. Positive ions are called cations; negative ions are called anions. To maintain homeostasis, it is necessary for the cations and the anions to balance each other in the body fluids.
- Sodium is the major extracellular cation in the body. Water follows sodium as it moves from one fluid compartment to another.
- Potassium is the major intracellular cation in the body. Imbalances in potassium, either high or low levels, have potential to cause life-threatening cardiac conditions.
- The four types of acid-base imbalance are respiratory acidosis, respiratory alkalosis, metabolic acidosis, and metabolic alkalosis.
- Arterial blood has a normal pH range of 7.35 to 7.45. A pH less than 7.35 is considered abnormally acidic; a pH greater than 7.45 is considered abnormally alkaline. A pH lower than 6.8 or higher than 7.8 is usually fatal.
- Any process that interferes with normal ventilation and causes a decrease or an increase in the excretion of volatile acids poses the risk of causing respiratory acidosis or respiratory alkalosis.
- Any process that interferes with normal production or excretion of nonvolatile hydrogen ions poses the risk of causing metabolic acidosis or metabolic alkalosis.
- Respiratory acidosis or alkalosis will result when the lungs fail to regulate the carbonic acid concentration in the blood. Metabolic acidosis or alkalosis will result when the kidneys fail to regulate the bicarbonate concentration in the blood.
- If the lungs are unable to reassert their function and correct respiratory acidosis, the kidneys will respond in an attempt to correct the imbalance. If the kidneys are unable to reassert their function and correct metabolic acidosis, the lungs will respond in an attempt to correct the imbalance.

Additional Learning Resources

Go to your Companion CD for an audio glossary, animations, video clips, and more.

Evolve Be sure to visit the Evolve site at http://evolve.elsevier.com/Christensen/foundations/ for additional online resources.

Review Questions for the NCLEX® Examination

1. A 66-year-old patient has recently been experiencing excessive edema in his feet. The nurse discusses with the patient the dietary changes that are perhaps causing the water retention associated with the patient's edema. Which electrolyte has the greatest influence on water balance in the body?
   1. Sodium (Na^+)
   2. Potassium (K^+)
   3. Chloride (Cl^-)
   4. Calcium (Ca^{++})
2. Which regulatory system is the body's first line of defense in keeping the pH within normal limits?
   1. Buffers in the blood
   2. Respiratory system
   3. Renal system
   4. Blood pressure
3. The most accurate method to use in determining water balance in the body is to:
   1. weigh the patient daily at the same time each day.
   2. record an accurate 24-hour I&O.
   3. ask the patient to document on an I&O form left at the bedside.
   4. have the same nurse care for the patient each day.
4. A patient is concerned about giving her family adequate amounts of potassium in their diets. She asks the nurse to help plan a meal containing foods with potassium. Which diet contains foods with the most potassium?
   1. Baked chicken, green salad, and fresh fruit plate
   2. Macaroni and cheese, cornbread, and gelatin
   3. Tacos, chips and salsa, and ice cream
   4. Seafood plate, marinated vegetables, sponge cake

5. The major route of excretion of all electrolytes from the body is via the:
   1. skin.
   2. lungs.
   3. kidneys.
   4. feces.

6. Fluid movement in the cells equalizes the ions or the molecules on each side of the semipermeable membrane. The movement of water from an area of lower concentration to an area of higher concentration occurs through:
   1. diffusion.
   2. filtration.
   3. active transport.
   4. osmosis.

7. The largest fluid compartment in the body is the:
   1. intracellular.
   2. extracellular.
   3. interstitial.
   4. intravascular.

8. Diffusion, osmosis, and filtration are all examples of:
   1. active transport.
   2. passive transport.
   3. ATP energy.
   4. Krebs cycle.

9. The term used to indicate hydrogen ion concentration in the body is:
   1. mEq.
   2. ATP.
   3. pH.
   4. mL.

10. The most common cause of hypocalcemia involves a dysfunction of:
    1. antidiuretic hormone.
    2. growth hormone.
    3. parathyroid hormone.
    4. thyroid hormone.

11. A patient has a positive Chvostek's sign. The nurse will expect laboratory tests to reveal:
    1. total serum calcium of less than 8.9 mEq/L.
    2. total serum calcium of greater than 10.1 mEq/L.
    3. ionized calcium of greater than 5.1 mg/dL.
    4. total serum potassium of less than 3 mEq/L.

12. Potassium is responsible for:
    1. building muscle mass.
    2. building bone structure and strength.
    3. neuromuscular and cardiac function.
    4. maintaining normal blood glucose levels.

13. Neuromuscular signs and symptoms of hypokalemia include:
    1. confusion and irritability.
    2. diminished deep tendon reflexes.
    3. parkinsonian type of tremors.
    4. carpopedal spasms.

14. Medications to be given when treating hyperkalemia include:
    1. sodium succinate and mannitol.
    2. mannitol and regular insulin.
    3. sodium polystyrene sulfonate (Kayexalate).
    4. antacids.

15. Because 1 L of fluid equals 2.2 lb (1 kg), a weight change of 2 kg (4.4 lb) will reflect a loss or gain of ________ body fluid.

16. When the body senses hypoxemia or hypercapnia (greater than normal amounts of carbon dioxide in the blood), the chemoreceptors in the medulla of the brainstem respond by:
    1. slowing the respiratory rate.
    2. decreasing the heart rate.
    3. increasing the depth and rate of respirations.
    4. lowering the blood pressure.

17. Which statements concerning a patient with severe hyperkalemia are correct?
    1. Cardiac arrest is possible, especially when serum potassium levels reach 7 mEq/L.
    2. Administer Kayexalate as prescribed by the physician.
    3. Report a urinary output less than 30 mL/hr.
    4. Monitor vital signs every 12 hours.

18. In acute respiratory acidosis, the renal compensatory mechanisms begin to operate within:
    1. 4 to 6 hours.
    2. 24 hours.
    3. 2 to 3 days.
    4. 1 to 2 hours.

19. Daily water intake and output (I&O) is approximately how many mL?
    1. 1500
    2. 3500
    3. 6500
    4. 2500

20. It is necessary for the kidneys to secrete a minimum of how many mL/hr of urine to eliminate waste products from the body?
    1. 30 mL/hr
    2. 60 mL/hr
    3. 20 mL/hr
    4. 100 mL/hr

21. The normal pH of blood is approximately ________.

22. Ketoacid accumulation in diabetic ketoacidosis often results in which type of respirations?
    1. Cheyne-Stokes respirations
    2. Kussmaul's respirations
    3. Bradypnea
    4. Apnea