chapter 25

Fluid, Electrolyte, and Acid-Base Balance

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Objectives

Upon completing this chapter, you should be able to:

Theory

1. Discuss the various functions water performs in the body.
2. List the major electrolytes and the function of each.
3. Describe three ways in which body fluids are continuously being distributed among the fluid compartments.
4. Identify the signs and symptoms of the common fluid and electrolyte imbalances.
5. State the main signs and symptoms of acid-base imbalances.

Clinical Practice

1. Assess an assigned patient for signs of fluid and electrolyte imbalance.
2. From patient laboratory results, identify electrolyte values that are abnormal.
3. Implement teaching for the patient with hypokalemia.
4. Develop a plan of care for a patient who has a fluid and electrolyte imbalance.
5. Identify patients who might be at risk for an acid-base imbalance.

Skills

Skill 25-1 Measuring Intake and Output

Key Terms

acidosis (ă-sĭ-DŌ-sĭs, p. 437)
active transport (p. 434)
alkalosis (ăl-kă-LŌ-sĭs, p. 440)
ascites (ă-SĪ-tēz, p. 436)
dehydration (dē-hī-DRĀ-shŭn, p. 432)
diffusion (dĭ-FŪ-zhŭn, p. 433)
edema (ĕ-DĒ-mă, p. 436)
electrolytes (ĕ-LĔK-trō-līts, p. 432)
extracellular (ĕks-tră-SĔL-ū-lăr, p. 432)
filtration (fĭl-TRĀ-shŭn, p. 434)
hydrostatic pressure (hī-drō-STĂ-tĭk PRĔ-shŭr, p. 434)
hypercalcemia (hī-pĕr-kăl-SĒ-mē-ă, p. 440)
hyperchloremia (hī-pĕr-klōr-Ē-mē-ă, p. 440)
hyperkalemia (hī-pĕr-kă-LĒ-mē-ă, p. 440)
hypermagnesemia (hī-pĕr-măg-nĕ-SĒ-mē-ă, p. 440)
hypernatremia (hī-pĕr-nā-TRĒ-mē-ă, p. 436)
hyperphosphatemia (hī-pĕr-fŏs-fă-TĒ-mē-ă, p. 440)
hypertonic (hī-pĕr-TŎN-ĭk, p. 433)
hyperventilation (p. 441)
hypervolemia (hī-pĕr-vō-LĒ-mē-ă, p. 436)
hypocalcemia (hī-pō-kăl-SĒ-mē-ă, p. 440)
hypochloremia (hī-pō-klōr-Ē-mē-ă, p. 440)
hypokalemia (hī-pō-kă-LĒ-mē-ă, p. 439)
hypomagnesemia (hī-pō-măg-nē-SĒ-mē-ă, p. 440)
hyponatremia (hī-pō-nā-TRĒ-mē-ă, p. 436)
hypophosphatemia (hī-pō-fŏs-fă-TĒ-mē-ă, p. 440)
hypotonic (hī-pō-TŎN-ĭk, p. 434)
hypovolemia (hī-pō-vō-LĒ-mē-ă, p. 432)
interstitial (ĭn-tĕr-STĬSH-ăl, p. 433)
intracellular (ĭn-tră-SĔL-ū-lăr, p. 432)
intravascular (ĭn-tră-văs-kū-lăr, p. 433)
isotonic (ī-sō-TŎN-ĭk, p. 433)
osmosis (ŏz-MŌ-sĭs, p. 433)
tetany (TĔT-ă-nē, p. 443)
transcellular (trănz-SĔ-lū-lăr, p. 433)
turgor (p. 435)

7. When instructing the patient about a colonoscopy, you would include that: *(Select all that apply.)*
   1. the prep for the procedure begins 24 to 48 hours beforehand.
   2. sedation will be given before the procedure.
   3. it is OK to drive home afterward.
   4. there is often some rectal bleeding afterward.

8. A lumbar puncture is a(n) _____ procedure. *(What type of procedure?) (Fill in the blank.)*

9. When caring for the patient who has just undergone a liver biopsy, you must:
   1. keep the patient positioned on the right side for 2 hours.
   2. apply pressure to the aspiration site by hand for 30 minutes.
   3. keep the patient on bed rest for 24 hours.
   4. turn the patient to the left side afterward.

10. When collecting a blood sample with a Vacutainer system, it is important to:
    1. replace the tube stopper firmly for each sample.
    2. release the tourniquet after successful venipuncture.
    3. withdraw the holder and tube at the same time.
    4. stabilize the holder when changing tubes.

Critical Thinking Activities

Read each clinical scenario and discuss the questions with your classmates.

Scenario A

The patient underwent a cardiac catheterization this morning.

1. What assessments would you need to make regularly afterward?
2. If you have difficulty finding the dorsalis pedis pulse in the leg where the catheter was inserted, what would you do?
3. What might it mean if the leg in which the catheter was introduced begins to swell?

Scenario B

The patient has blood chemistries ordered every morning. On the third day, she complains that she doesn't want this done because she is sick and becoming sicker because they are taking all her blood. How would you respond to the patient?

COMPOSITION OF BODY FLUIDS

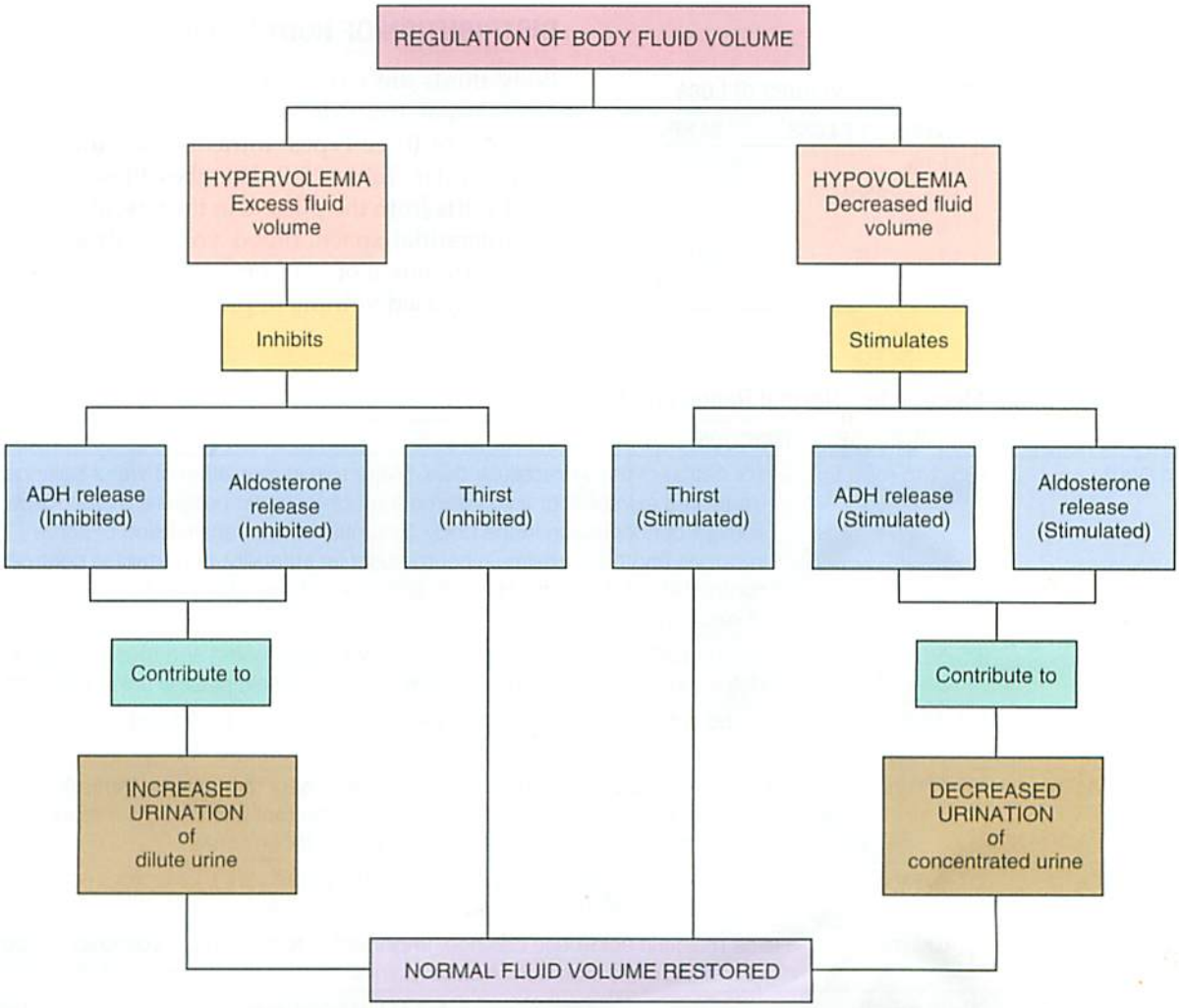
WATER

The two largest constituents of the body fluids are water and electrolytes. Water is present in greater proportion than electrolytes. Water serves many functions, but the four main functions of water in the body are (1) to act as a vehicle for the transportation of substances to and from the cells; (2) to aid heat regulation by providing perspiration, which evaporates; (3) to assist in maintenance of hydrogen (H^+) balance in the body; and (4) to serve as a medium for the enzymatic action of digestion.

More than half of the body's weight is water. The amount varies by age, sex, and health status. The adult male body contains about 60% water; the adult female body, because of more fat tissue, contains about 50% water. The greater the amount of fat the body contains, the less the percentage of water it has because fat contains less water than other tissue. **The infant and the elderly person are more quickly and seriously affected by minor changes in their fluid balance and can become rapidly dehydrated.** The infant, because of its large body surface area compared with body weight, loses more fluid through the skin than the adult. The infant's kidneys are not as efficient as the adult's, and less fluid is reabsorbed. The elderly person has an age-related decline in total body water, diminished thirst sensation, a decrease in urine-concentrating ability of the kidney, and a decrease in effectiveness of antidiuretic hormone (ADH). These factors cause dehydration to occur more quickly than in the younger adult. Dehydration may cause hypovolemia (Concept Map 25-1). If an excess of fluid volume is present in the body, hypervolemia occurs.

Water is critical to maintaining homeostasis because water is the medium in which most metabolic and chemical reactions in the body take place. *Without* sufficient water, cells cannot function and death results.

Water is the avenue for transportation within the body. It carries nutrients to the cells and transports wastes for excretion. Body water continuously moves in and out of the blood, through the lymph vessels, between the cells, and in and out of the cells. Table 25-1 shows sources of water and avenues of water loss.



CONCEPT MAP 25-1 Regulation of body fluid volume. Key: *ADH,* Antidiuretic hormone.

? Think Critically

How might NPO (nothing by mouth) status before tests or surgery affect a person's body?

ELECTROLYTES

Electrolytes are minerals or salts that are dissolved in body fluid. They are measured in milliequivalents per liter (mEq/L), which is a unit of measure of the chemical activity that occurs when the electrolyte reacts with hydrogen. When in solution, they break up into particles known as **ions** that have a tiny electrical charge. The ions develop a positive electrical charge and are then known as **cations,** or they develop a negative electrical charge and are **anions. For each positively charged cation in a fluid compartment, there must be a negatively charged anion so that balance is maintained.** As fluids move from compartment to compartment, the body works to maintain homeostasis in each compartment by balancing the anions and cations so that there is electrical neutrality. Electrolytes move within the body freely, but each has a primary location. Because disturbances in homeostasis upset the normal balance of electrolytes, the location and function of each electrolyte become important in understanding what is occurring in the body. **The major source of electrolytes is from the diet.** Table 25-2 presents the electrolytes, their normal ranges, and their functions.

Table 25-1 Sources of Water and Avenues of Loss

SOURCES	24 HR	AVENUES OF LOSS	24 HR
Oral fluids	1500 mL	Urine	1500 mL
Food	800 mL	Perspiration	400 mL
Metabolism	200 mL	Feces	200 mL
		Expired air	400 mL
Total	2500 mL		2500 mL

NONELECTROLYTES

The intermediate products of metabolism—amino acids (proteins), glucose, and fatty acids—are nonelectrolytes. They remain bound together when dissolved in body fluid. In the healthy individual who is eating normally, the nonelectrolytes circulating in the body fluid remain stable.

BLOOD

The body has 4 to 6 L of circulating blood volume, depending on body size and sex. Erythrocytes (red cells), leukocytes (white cells), and platelets (thrombocytes) are the blood cells that are carried in the plasma. **Any condition that alters body fluid volume also alters the plasma volume of the blood and can affect blood pressure and circulation.** The plasma proteins and colloids contribute to plasma colloid osmotic pressure, which helps keep fluid in the vascular compartment.

DISTRIBUTION OF BODY FLUIDS

Body fluids are either **intracellular** (within the cell) or **extracellular** (outside of the cell). Extracellular fluid (ECF) is of three types: intravascular, interstitial, and transcellular. Table 25-3 describes these fluids. When fluid shifts from the plasma in the vascular space out to the interstitial space, blood volume drops and **dehydration** (removal of water from a tissue) and **hypovolemia** (decreased volume of plasma) may occur.

Table 25-2 The Major Electrolytes: Normal Range and Function

ELECTROLYTE	NORMAL RANGE	FUNCTION
Sodium (Na^+)	135-145 mEq/L	Major cation of the extracellular fluid. Major role in regulation of water balance. Regulates extracellular fluid volume through osmotic pressure. Water follows sodium concentration in the body. Essential to the transmission of nerve impulses and helps maintain neuromuscular irritability. Important in controlling contractility of the heart. Helps maintain acid-base balance. Aids in maintenance of electroneutrality.
Potassium (K^+)	3.5-5.0 mEq/L	Major intracellular cation. Important in nerve transmission and muscle contraction. Helps maintain normal heart rhythm. Helps maintain plasma acid-base balance.
Calcium (Ca^{2+})	8.4-10.6 mg/dL	Involved in formation of bone and teeth. Necessary for blood coagulation. Essential for normal nerve and muscle activity.
Magnesium (Mg^{2+})	1.3-2.1 mg/dL	Necessary for building bones and teeth. Necessary for nerve transmission and is involved in muscle contraction. Plays an important role in many metabolic reactions, where it acts as a cofactor to cellular enzymes.
Phosphate (PO_4^{3-})	2.7-4.5 mg/dL	Necessary for formation of adenosine triphosphate (ATP). Cofactor in carbohydrate, protein, and lipid metabolism. Activates B-complex vitamins.
Chloride (Cl^-)	96-106 mEq/L	Helps maintain acid-base balance. Important in formation of hydrochloric acid for secretion to the stomach. Aids in maintaining plasma electroneutrality.
Bicarbonate (HCO_3^-)	22-26 mEq/L	A buffer that neutralizes excess acids in the body. Helps regulate acid-base balance.

MOVEMENT OF FLUID AND ELECTROLYTES

The amount of fluid leaving the body should be balanced by water entering it. Water is taken in through the ingestion of fluids and food and is produced by cell metabolism. The thirst mechanism located in the hypothalamus helps control fluid balance in the body. It monitors fluid volume and concentration. Hypothalamic receptors sense when fluid is more concentrated and stimulate nerve impulses that are interpreted in the brain as thirst, which motivates the person to drink. Intake of sufficient water lowers the concentration and the receptors are no longer stimulated.

Fluid is lost in the urine and feces and through **insensible** (invisible) losses via exhaled air and through the skin as perspiration. **The kidney is the main organ through which fluid excretion is achieved.** Urine output is affected by several hormones, particularly ADH, aldosterone, and atrial natriuretic peptide (ANP). ADH is secreted by the posterior pituitary. More ADH is released when the blood becomes more concentrated; circulating blood volume is decreased; or the person is experiencing pain, nausea, or stress. With increased ADH, the renal tubules reabsorb more water, and urine output decreases. Aldosterone is released by the adrenal cortex when ECF volume is low or when sodium concentration is elevated, causing reabsorption of sodium from kidney tubules. This creates an osmotic gradient by which more water is retained. The release of aldosterone is stimulated by the renin-angiotensin-aldosterone system. ANP acts to protect the body from fluid overload and is released from sites in the myocardium and the brain. Blood volume and pressure also affect the glomerular filtration rate and urine output.

Water and the substances suspended or dissolved in it must move from compartment to compartment so that they are normally distributed within the body. They must pass through the semipermeable membranes of the body's cells to do this. The heart circulates blood throughout the body. As the blood flows through the capillaries, fluid and solutes can move into the interstitial spaces, where substances in every cell of the body can be exchanged. Several processes move fluids, electrolytes, nutrients, and waste products back and forth across the cell membranes.

Table 25-3 Body Fluid Distribution

BODY FLUID	DISTRIBUTION
Extracellular fluid	Approximately ⅓ of total body water. Transports water, nutrients, oxygen, waste, etc., to and from the cells. Regulated by renal, metabolic, and neurologic factors. High in sodium (Na^+) content.
Intravascular fluid	Fluid within the blood vessels. Consists of plasma and fluid within blood cells. Contains large amounts of protein and electrolytes.
Interstitial fluid	Fluid in the spaces surrounding the cells. High in sodium (Na^+) content.
Transcellular fluid	Includes aqueous humor; saliva; cerebrospinal, pleural, peritoneal, synovial, and pericardial fluids; gastrointestinal secretions; and fluid in urinary system and lymphatics.
Intracellular fluid	About ⅔ of total body fluid. Fluid contained within the cell walls. Most cell walls are permeable to water. High in potassium (K^+) content.

Passive Transport

Diffusion. **Diffusion** is the process by which substances move back and forth across the membrane until they are evenly distributed throughout the available space. Substances move from a high to a low concentration until the concentration on both sides of the membrane is equal. This is called movement down a concentration gradient. Glucose, oxygen, carbon dioxide, water, and other small ions and molecules move by diffusion. It is a process of equalization.

Diffusion may occur by movement along an electrical gradient as well. The attraction between particles of opposite charge and the repellent action between particles of like charge comprise an electrical gradient. Many intracellular proteins have a negative charge that tends to attract the positively charged sodium and potassium ions from the ECF.

Osmosis. **Osmosis** refers to the movement of pure solvent (liquid) across a membrane. Water diffuses by osmosis. When there are differences in concentration of fluids in the various compartments, water moves from the area of less solute concentration to the area of greater concentration until the solutions in the compartments are of equal concentration. The process takes place via a semipermeable membrane—a membrane that allows some substances to pass through but prevents the passage of other substances. Fluid moves between the interstitial and intracellular and the interstitial and intravascular compartments by osmosis. Cell wall membranes are semipermeable, as are the walls of blood vessels.

When living cells are surrounded by a solution that has the same concentration of particles, the water concentration of the intracellular fluids (ICF) and ECF will be equal. Such a solution is termed **isotonic** (of equal solute concentration). If cells are surrounded by a solution that has a greater concentration of solute than the cells, the water in the cells moves to the more concentrated solution, and the cells dehydrate and shrink. The solution is **hypertonic** (of greater concentration) in relation to the cells. If the cells are surrounded by a solution that has less solute than the cells, the solution

is **hypotonic** (of less concentration) in relation to the cells. The particles within the cells exert an osmotic pressure, drawing water inward through the semipermeable membrane. The cells swell from the extra fluid (overhydrate). These concepts are important to the administration of intravenous (IV) fluids (see Chapter 36). Solutions are classified as isotonic, hypertonic, or hypotonic according to their concentration of electrolytes and other solutes. **So, by osmosis, water passes rather freely across cell membranes.** The process of osmosis is essential to the life of the cells and to the balance of water and electrolytes in the body. Osmotic pressure within vessels helps to keep fluid from leaking out into the interstitial spaces (Figure 25-1).

Filtration. **Filtration** is the movement of water and suspended substances outward through a semipermeable membrane. The pumping action of the heart creates **hydrostatic pressure** (pressure exerted by fluid) within the capillaries. Hydrostatic pressure causes fluid to press outward on the vessel. That force promotes filtration, forcing movement of water and electrolytes through the capillary wall to the interstitial fluid (Figure 25-1, *B*).

Active Transport

Active transport, contrary to diffusion, osmosis, and filtration, requires cellular energy. This force can move molecules into cells regardless of their electrical charge or the concentrations already in the cell. **Active transport may move substances from an area of lower concentration to an area of higher concentration.** The energy source for the process is adenosine triphosphate (ATP). ATP is produced during the complex metabolic processes in the body's cells. Enzyme reactions metabolize carbon chains of sugars, fatty acids, and amino acids, yielding carbon dioxide, water, and high-energy phosphate bonds. Active transport can move amino acids, glucose, iron, hydrogen, sodium, potassium, and calcium through the cell membrane (Figure 25-2).

FLUID AND ELECTROLYTE IMBALANCES

Healthy people maintain intake and output (*I & O*) balance by drinking sufficient fluids and eating a balanced diet each day. **The healthy kidney regulates fluid and electrolyte balance by regulating the**

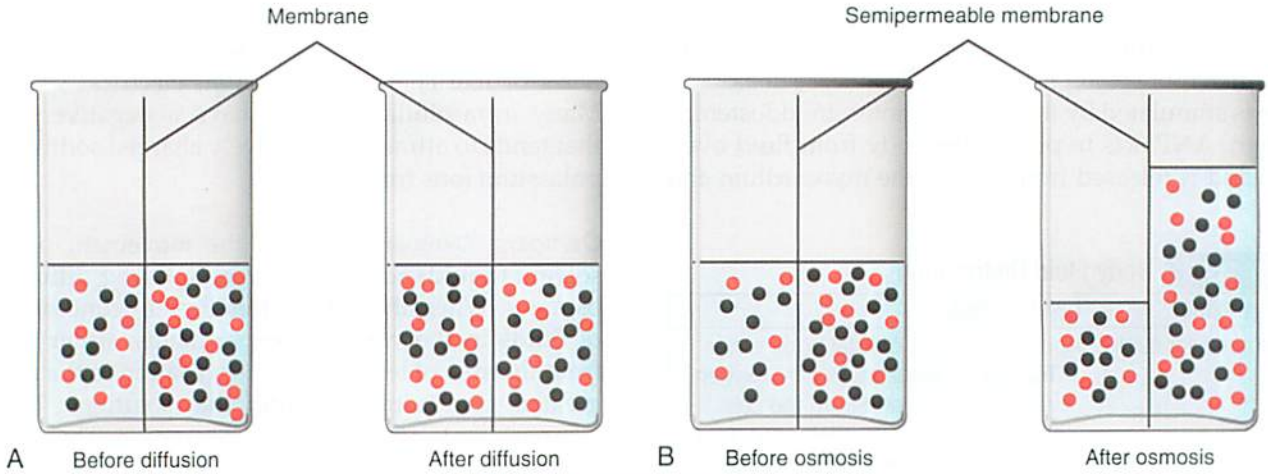


FIGURE 25-1 **A,** Diffusion. **B,** Osmosis.

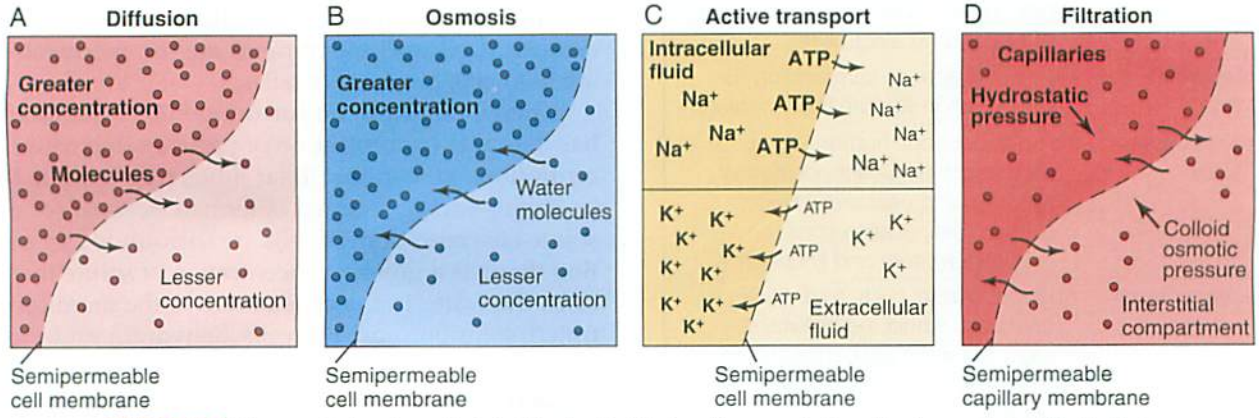


FIGURE 25-2 Movement of water and electrolytes by *A,* diffusion; *B,* osmosis; *C,* active transport; and *D,* filtration.

volume and composition of ECF. Illness affects fluid balance in many ways. The patient may be unable to ingest food or liquids, may have a problem with absorption from the intestinal tract, or may have a kidney impairment that affects excretion or reabsorption of water and electrolytes. Any disease that affects circulation (e.g., congestive heart failure) ultimately affects the distribution and composition of body fluids. Burns, in which large amounts of body fluid may be lost through open wounds, also present problems of fluid balance. **In fact, any seriously ill patient is at risk for a fluid and electrolyte imbalance.**

Elder Care Points

Any patient over age 65 is at risk for confusion from fluid and electrolyte imbalance. Always look for signs of a fluid and electrolyte imbalance when an elderly patient becomes confused.

A fluid imbalance exists when the body has an excess (too much) or a deficit (too little) of water. When this occurs, there will be an accompanying imbalance in the substances dissolved in the water. When considering sodium imbalances, it is important to remember that **water follows sodium in the body**. The sodium concentration causes an osmotic pull, and water goes to where that concentration is highest.

Focused Assessment

Assessing Fluid and Electrolyte Status

For patients admitted with vomiting; diarrhea; high fever; or a history of heart failure, diabetes, renal disease, head injury, thyroid disease, adrenal disease, or inflammatory bowel disease, perform a general head-to-toe assessment and also assess for the following:

- Fatigue
- Weakness
- Tissue turgor
- Edema, dependent or generalized, degree of pitting
- Dyspnea
- Confusion
- Dizziness
- Blood pressure change
- Rapid pulse
- Cool, dry skin
- Sunken eyeballs
- Mucous membranes for dryness
- Venous jugular distention
- Rapidity of hand vein emptying and refill
- Changes in vital signs
- Changes in daily weight
- Alteration in input and output balance

DEFICIENT FLUID VOLUME

Those at risk for deficient fluid volume are (1) patients unable to take in sufficient quantities of fluid because of impaired swallowing, extreme weakness, disorientation, coma, or the unavailability of water; and (2) patients who lose excessive amounts of fluid through prolonged vomiting, diarrhea, hemorrhage, diaphoresis (sweating), or excessive wound drainage. Treatments that can cause a fluid deficit are diuretic therapy and gastrointestinal suction without fluid replacement.

Box 25-1 Signs and Symptoms of Dehydration (Fluid Volume Deficit)

- Complaints of dizziness
- Confusion
- Cool, dry skin
- Dark, concentrated urine
- Decreased blood pressure
- Decreased urine production
- Dry, cracked lips and tongue
- Dry mucous membranes
- Elevated temperature
- Flat neck veins when lying down
- Increased pulse rate
- Poor skin turgor
- Postural hypotension
- Thick saliva
- Thirst
- Weak, thready pulse
- Weakness

Clinical Cues

Keep an accurate record of the amount of drainage removed by suction so that adequate fluid can be replaced and dehydration can be avoided.

Burns and drainage from large wounds or fistulas can deplete the fluid volume. Treatment of fluid volume deficit involves remedying the underlying cause and replacing fluids.

Dehydration

When a fluid deficit occurs, it causes loss of water from the cells (dehydration); when there is too little water in the plasma, water is drawn out of the cells by osmosis to equalize the concentration, and the cells shrivel. Dehydration is treated by fluid administration, either orally or intravenously.

Signs and symptoms of dehydration are listed in Box 25-1. Tissue **turgor** (degree of elasticity) is checked by gently pinching up the skin over the abdomen, forearm, sternum, forehead, or thigh (Figure 25-3). In a person with normal fluid balance, the pinched skin immediately falls back to normal when released. If a fluid deficit is present, the skin may remain elevated or tented for several seconds after the pinch. This test measures skin elasticity as well and is not a valid

Elder Care Points

The elderly person who suffers from nausea, vomiting, or diarrhea is especially prone to dehydration. If the person has fever, this adds to the fluid loss. Because of the fluid and accompanying electrolyte losses, the person may become confused. Offering the patient small amounts of water frequently or an electrolyte solution such as Gatorade, if it can be kept down, helps prevent additional problems.

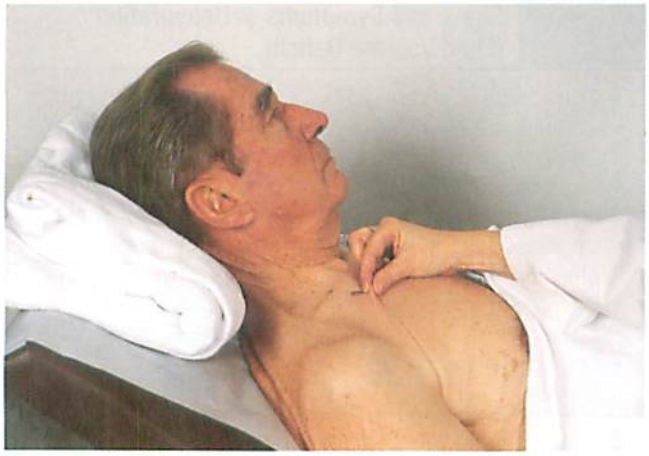


FIGURE 25-3 Testing for tissue turgor and signs of dehydration.

FIGURE 25-4 Example of pitting edema from fluid excess. The finger depressions do not refill quickly after pressure has been exerted.

indicator of fluid status in the elderly. Weight loss is another sign of dehydration. In the infant, severe fluid deficit is evidenced by sunken eyeballs and depression of the anterior fontanel.

EXCESS FLUID VOLUME

Healthy people do not ordinarily drink too much water. When people become ill they may take in more water than they excrete. This can happen if they receive IV fluid too quickly, are given tap water enemas, or are persuaded to drink more fluids than they can eliminate. If these events happen, the patient suffers a fluid volume excess. Impaired elimination, such as occurs in renal failure, is an important cause of fluid volume excess. **Signs of overhydration are weight gain, crackles in the lungs, slow bounding pulse, elevated blood pressure, and possibly edema.** When fluid volume excess occurs, **hypervolemia** (excessive blood volume) may also occur. Hypervolemia causes an elevation of blood pressure.

Edema

Edema is an excessive accumulation of interstitial (tissue) fluid. It is often a sign of fluid overload, but may be from other causes. In ambulatory patients the excessive fluid tends to accumulate in the lower extremities (Figure 25-4). In the bedridden patient the fluid accumulates in the sacral region. These types of fluid accumulations are termed *dependent edema*. Generalized edema occurs when excess interstitial fluid is spread throughout the body. It is most visible in the hands and face, where swelling is detectable. Causes of generalized edema are (1) kidney failure, (2) heart failure, (3) liver failure, and (4) hormonal disorders involving the overproduction of aldosterone and ADH (Figure 25-5). Local edema may be caused by infection or injury and the resulting inflammation.

Treatment involves correcting the underlying cause and assisting the body to rebalance fluid content. The patient may have fluid intake restricted or be given a diuretic drug, which causes the kidneys to increase the excretion of fluid.

? Think Critically

Why should you auscultate the lungs of elderly patients who are receiving IV fluids even if they have no current lung problems?

ELECTROLYTE IMBALANCES

A summary of the normal ranges of the major electrolytes, the causes of imbalances, the signs and symptoms of imbalances, and nursing interventions is provided in Table 25-4.

Sodium Imbalances

Hyponatremia. **A deficit of sodium in the blood is called hyponatremia** (Na^+ <135 mEq/L). This can occur from a sodium loss or an excess of water. This is the most common electrolyte imbalance patients experience. Sodium loss may occur from excessive vomiting or diarrhea when the fluid loss is replaced with plain water. Decreased secretion of aldosterone can result in sodium loss. Congestive heart failure, liver disease with **ascites** (abnormal accumulation of fluid within the peritoneal cavity), and sometimes chronic renal failure result in excessive water retention without concurrent sodium retention. This results in a hypervolemia combined with hyponatremia. The average intake of sodium is 6 to 12 g/day. If there is a problem with water balance, sodium may be restricted in the diet.

Elder Care Points

Elderly patients are more susceptible to hyponatremia than younger ones. Those taking thiazide diuretics or selective serotonin reuptake inhibitors (SSRIs) are particularly at risk for hyponatremia. The problem is especially prevalent in long-term care residents.

Hypernatremia. **When the serum sodium concentration rises above 145 mEq/L, a state of hypernatremia exists.** This occurs when there is an excess of sodium or a loss of body water. Excessive administration of

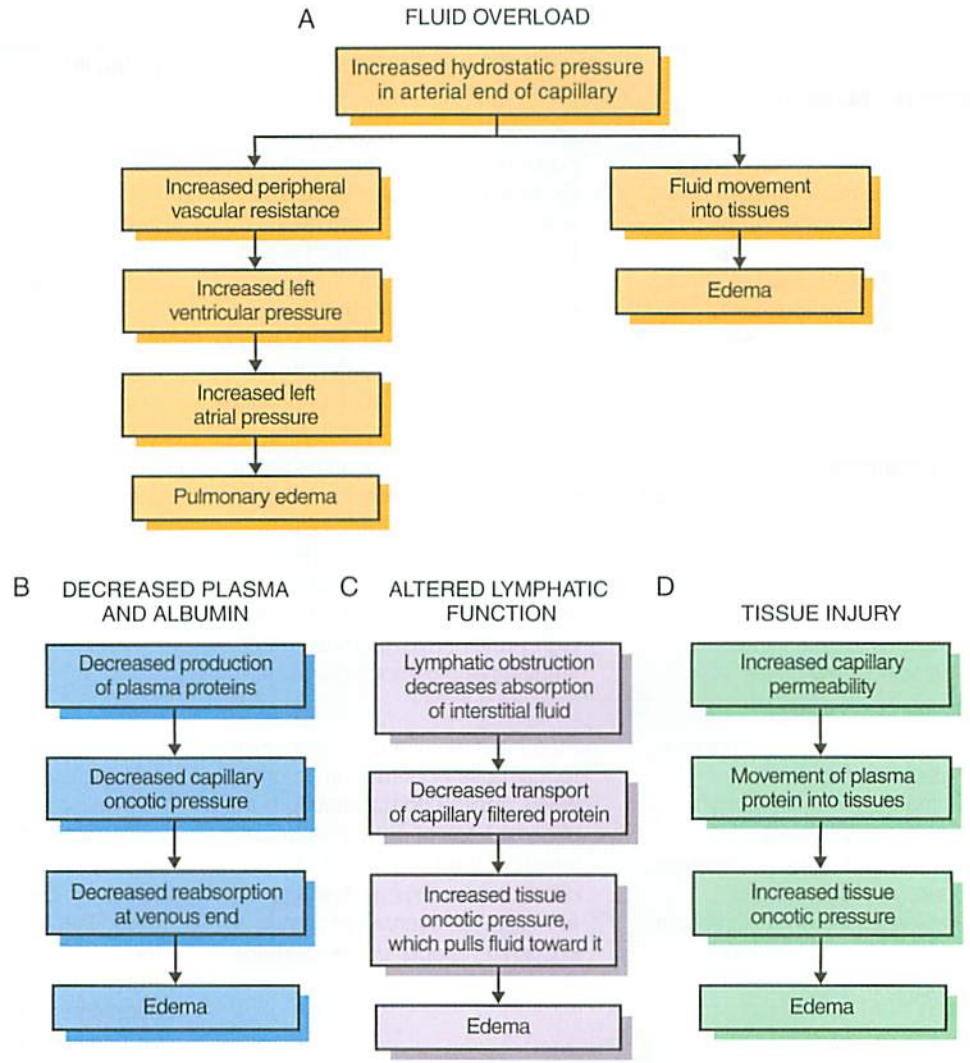


FIGURE 25-5 Mechanisms of edema formation. **A,** Fluid overload. **B,** Decreased plasma and albumin. **C,** Altered lymphatic function. **D,** Tissue injury.

sodium bicarbonate for the treatment of **acidosis** (excess of acid or depletion of alkaline substances in the blood and body tissues) is one cause. More commonly, water loss from fever, respiratory tract infection, or watery diarrhea is the cause.

Clinical Cues

Patients on long-term corticosteroids that cause potassium depletion may develop hypernatremia. Observe for signs of edema in these patients.

Decreased water intake may occur in immobile, confused, or dependent patients or in those who have sustained damage to the thirst center in the hypothalamus. The body tries to correct the situation by conserving water through reabsorption in the renal tubules. Hypernatremia causes an osmotic shift of fluid from the cells to the interstitial spaces, causing cellular dehydration and interruption of normal cell processes. Sodium intake is restricted for the patient with hypernatremia.

Patient Teaching

Foods High in Sodium

The patient who is experiencing a fluid volume excess or is supposed to decrease sodium intake should avoid the foods listed below. The patient who is low in sodium may add some of these foods to the diet.

- Buttermilk
- Canned meats or fish
- Canned soups (regular)
- Canned vegetables (regular)
- Casserole and pasta mixes
- Catsup
- Cheese (all kinds)
- Dried fruits
- Dried soup mixes
- Foods containing monosodium glutamate (MSG)
- Frozen vegetables with sauces
- Gravy mixes
- Ham
- Hot dogs
- Lunch meats
- Olives
- Pickles
- Prepared mustard
- Preserved meats
- Processed foods
- Salted nuts
- Salted popcorn
- Salted snack foods
- Softened water high sodium
- Soy sauce (regu
- Tomato or vec juice

Table 25-4 Electrolyte Imbalances

SERUM VALUE	SIGNS AND SYMPTOMS	CAUSES AND RISK FACTORS	NURSING INTERVENTIONS
Sodium: Normal Range: 135-145 mEq/L			
<135 mEq/L	**Hyponatremia.** Central nervous system and neuromuscular changes resulting from failure of swollen cells to transmit electrical impulses. Mental confusion, headache, altered level of consciousness, anxiety, coma, anorexia, nausea, vomiting, muscle cramps, seizures, decreased sensation.	Inadequate sodium intake, as in patients on low-sodium diets. Excessive intake or retention of water (kidney failure and heart failure). Loss of bile, which is rich in sodium, as a result of fistulas, drainage, gastrointestinal surgery, nausea and vomiting, and suction. Loss of sodium through burn wounds. Administration of IV fluids that do not contain electrolytes.	Restrict water intake as ordered for patients with congestive heart failure, kidney failure, and inadequate antidiuretic hormone production. Liberalize diet of patient on low-sodium diet. Closely monitor patient receiving IV solutions to correct hyponatremia. Replace water loss with fluids containing sodium.
>145 mEq/L	**Hypernatremia.** Dry mucous membranes, loss of skin turgor, intense thirst, flushed skin, oliguria, and possibly elevated temperature; weakness, lethargy, irritability, twitching, seizures, coma, intracranial bleeding. Low-grade fever.	High-sodium diet, inadequate water intake as in comatose, mentally confused, or debilitated patient. Excessive sweating, diarrhea, failure of kidneys to reabsorb water from urine. Administration of high-protein, hyperosmotic tube feedings and osmotic diuretics.	Encourage increased fluid intake; measure I & O; give water between tube feedings; restrict sodium intake; monitor temperature.
Potassium: Normal Range: 3.5-5.0 mEq/L			
<3.5 mEq/L	**Hypokalemia.** Abdominal pain, gaseous distention of intestines; cardiac arrhythmias, muscle weakness, decreased reflexes, paralysis, paralytic ileus, urinary retention, lethargy, confusion, ECG changes, increased urinary pH.	Inadequate intake of potassium-rich foods. Loss of potassium in urine when kidneys do not reabsorb the mineral. Loss of potassium from intestinal tract as a result of diarrhea or vomiting, drainage from fistulas, overuse of gastric suction. Improper use of diuretics.	Instruct patients (especially those taking diuretics) about foods high in potassium content; encourage intake. Observe closely for signs of digitalis toxicity in patients taking this drug. Teach patients to watch for signs of hypokalemia. Administer potassium chloride supplement as ordered. Monitor I & O and cardiac rhythm.
>5.0 mEq/L	**Hyperkalemia.** Muscle weakness, hypotension, paresthesias, paralysis, cardiac arrhythmias, ECG changes.	Conditions that alter kidney function or decrease kidney's ability to excrete potassium. Intestinal obstruction that prevents elimination of potassium in the feces. Addison disease, digitalis toxicity, uncontrolled diabetes mellitus, insulin deficit, crushing injuries, and burns.	Decrease intake of foods high in potassium. Increase fluid intake to enhance urinary excretion of potassium; provide adequate carbohydrate intake to prevent use of body proteins for energy. Carefully administer proper dose of insulin to diabetic patients. Instruct patient in proper use of salt substitutes containing potassium.
Calcium: Normal Range: 8.4-10.6 mg/dL			
<8.4 mg/dL	**Hypocalcemia.** Paresthesias, seizures, muscle spasms, tetany, hand spasm, positive Chvostek sign, positive Trousseau sign, cardiac arrhythmia, wheezing, dyspnea, difficulty swallowing, colic, cardiac failure.	Inadequate dietary intake of calcium and vitamin D. Impaired absorption of calcium from intestinal tract, as in diarrhea, sprue, overuse of laxatives and enemas containing phosphates (phosphorus tends to be more readily absorbed from the intestinal tract than calcium and suppresses calcium retention in the body). The parathyroid regulates calcium and phosphorus levels. Hyposecretion of parathyroid hormone can result in hypocalcemia.	Encourage adults to consume sufficient calcium from cheese, broccoli, shrimp, and other dietary sources. Have 10% calcium gluconate solution at bedside of patient having thyroidectomy in case of surgical damage to the parathyroid glands. Give all oral medicines containing calcium ½ hour before meals to facilitate absorption.

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

Table 25-4 Electrolyte Imbalances—*cont'd*

SERUM VALUE	SIGNS AND SYMPTOMS	CAUSES AND RISK FACTORS	NURSING INTERVENTIONS
>10.6 mg/dL	**Hypercalcemia.** Anorexia, abdominal pain, constipation, polyuria, confusion, renal calculi, pathologic fractures, cardiac arrest.	Excess intake of calcium, as in patient taking antacids indiscriminately. Excess intake of vitamin D. Conditions that cause movement of calcium out of bones and into extracellular fluid (e.g., bone tumor, multiple fractures). Tumors of the lung, stomach, and kidney and multiple myeloma. Immobility and osteoporosis.	Administer diuretics as prescribed to increase urine output and calcium excretion. Monitor I & O; encourage high fluid intake (3000-4000 mL/day).
Magnesium: Normal Range: 1.3-2.1 mEq/L			
<1.3 mEq/L	**Hypomagnesemia.** Insomnia, hyperactive reflexes, leg and foot cramps, twitching, tremors, seizures, cardiac arrhythmias, positive Chvostek sign, positive Trousseau sign, vertigo, hypocalcemia, and hypokalemia.	Chronic malnutrition; chronic diarrhea. Bowel resection with ileostomy or colostomy; chronic alcoholism; prolonged gastric suction; acute pancreatitis; biliary or intestinal fistula; osmotic diuretic therapy; diabetic ketoacidosis.	Diet counseling to help patients at risk increase level of magnesium (e.g., milk and cereals). Monitor closely IV infusions of magnesium. Monitor I & O.
>2.1 mEq/L	**Hypermagnesemia.** Hypotension; sweating and flushing, nausea and vomiting; muscle weakness, paralysis, respiratory depression; cardiac dysrhythmias.	Overuse of antacids and cathartics containing magnesium; aspiration of sea water, as in near drowning. Chronic kidney failure.	Teach patients to avoid abuse of laxatives and antacids; instruct patients with renal problems to avoid over-the-counter drugs that contain magnesium. Encourage fluid intake to increase urinary excretion of magnesium if not contraindicated. Monitor I & O. Administer diuretics as ordered.
Phosphate: Normal Range: 2.7-4.5 mg/dL			
<2.7 mg/dL	**Hypophosphatemia.** Confusion, seizures, numbness, weakness, possible coma. Chronic state may cause rickets and osteomalacia.	Vitamin D deficiency or hyperparathyroidism; use of aluminum-containing antacids.	Assess for vitamin D deficiency, hyperparathyroidism, or overuse of aluminum-containing antacids.
>4.5 mg/dL	**Hyperphosphatemia.** Anorexia, nausea, vomiting.	Renal insufficiency.	Assess for restlessness, confusion, chest pain, and cyanosis. Monitor respirations. Check all electrolyte levels.

Potassium Imbalances

Hypokalemia. **When the potassium level falls below 3.5 mEq/L, hypokalemia exists.** Extra potassium must be given to help correct the imbalance. Hypokalemia may be a result of poor diet, illness causing a shift of potassium from ECF to ICF, or increased potassium loss. Vomiting, diarrhea, gastrointestinal suction, excessive sweating, and diuretic therapy may deplete potassium levels (Hayes, 2003). Potassium-sparing diuretics help restore serum potassium when a diuretic is needed (Kraft et al., 2005). The patient is encouraged to eat foods high in potassium, and IV replacement may be necessary (Kraft et al., 2005).

Patient Teaching

Foods High in Potassium

The patient with hypokalemia should be encouraged to add the foods listed below to the daily diet. Patients in renal failure may need to restrict their intake of these foods.

- Apricots
- Avocados
- Bananas
- Cantaloupe
- Codfish
- Dates
- Meats
- Milk
- Orange juice
- Oranges
- Potatoes
- Raisins
- Salmon
- Tuna

Safety Alert

Hypokalemia

Severe hypokalemia (K^+ <2.5 mEq/L) may cause cardiac arrest. Potassium-wasting diuretics used without potassium replacement can cause hypokalemia. Premature ventricular contractions and changes in the electrocardiogram (ECG) pattern such as ST segment depression, a prolonged Q-T interval, and U wave occurrence may be seen.

Hyperkalemia. **When the serum potassium level rises above 5.0 mEq/L, a state of hyperkalemia exists.** Patients with renal failure, severe burns, or crush injuries and those undergoing major surgery are at risk for hyperkalemia. The mechanical disruption of cell membranes causes a shift of potassium from the ICF to the ECF. Hyperkalemia occurs in overuse of potassium-sparing diuretics, digitalis toxicity, overuse of potassium-containing salt substitutes, uncontrolled diabetes mellitus, and a variety of other illnesses.

Clinical Cues

Hyperkalemia can cause life-threatening cardiac arrhythmia. Tall or peaked T waves may be seen on the ECG. P waves may be small.

Calcium Imbalances

Hypocalcemia. **When the calcium level drops below 8.4 mg/dL, hypocalcemia occurs.** This can result from nutritional deficiency of calcium or vitamin D. Hypocalcemia occurs in disorders in which there is a shift of calcium into the bone. Metastatic cancer invading bone is one such cause. Removal or injury of the parathyroid glands during thyroidectomy causes parathyroid hormone deficiency and consequent hypocalcemia. Excessive infusion of bicarbonate solution, alkalosis (excess of alkaline or decrease of acid substances in the blood and body fluids), blood transfusions, and hypoparathyroidism may cause hypocalcemia.

Hypercalcemia. **Hypercalcemia, a serum calcium level above 10.6 mg/dL,** can occur during periods of lengthy immobilization when calcium is mobilized from the bone or when an excess of calcium or vitamin D is taken into the body. Most cases are related to hyperparathyroidism or malignancy in which there is metastasis with bone resorption. Such malignancies include multiple myeloma and lung or renal cancers.

Magnesium Imbalances

Hypomagnesemia. **Hypomagnesemia, a serum level below 1.3 mEq/L,** results from malabsorption, malnutrition, or increased loss from renal tubular dysfunction or thiazide diuretic use (Stark, 2006). Extensive gastric suction or diarrhea can also cause it. Hypomagnesemia usually is present when hypokalemia and hypocalcemia occur.

Hypermagnesemia. **Hypermagnesemia, a serum level above 2.1 mEq/L,** occurs rarely and usually in the presence of renal failure, although magnesium-containing laxatives or antacids or severe dehydration can cause it.

Anion Imbalances

Imbalances of chloride, phosphate, and bicarbonate accompany cation imbalances because of the principle of electroneutrality. **Hypochloremia, a chloride level below 96 mEq/L, is associated with hyponatremia.** It can also occur with severe vomiting and is seen as a compensatory decrease in acid-base disorders. **Hyperchloremia, a chloride level above 106 mEq/L, occurs along with hypernatremia and a form of metabolic acidosis. Hypophosphatemia occurs when the level of phosphate falls below 2.7 mg/dL.** It may result from use of aluminum-containing antacids that bind phosphate, from vitamin D deficiency, or from hyperparathyroidism. **Hyperphosphatemia, a phosphate level above 4.5 mg/dL, commonly occurs in renal failure.**

Think Critically

Why may some elderly people have a low serum calcium even though they take in sufficient calcium in the diet? What type of fluid and electrolyte imbalances can occur in the patient who is undergoing diuretic therapy? Why?

ACID-BASE BALANCE

Acid-base balance is very important to maintaining homeostasis in the body because cell enzymes can function only within a very narrow range of pH.

pH

pH is a measure of the degree to which a solution is acidic or alkaline. Cell metabolism constantly produces carbon dioxide, which combines with water to form carbonic acid (H_2CO_3), which immediately breaks down into hydrogen ions and bicarbonate ions. The concentration of hydrogen ions (H^+) determines the pH reading. **The normal serum pH is 7.35 to 7.45.** Death may occur at a serum pH below 6.8 or above 7.8. Because of the production of acids by the body's metabolic systems, the body tends to become acidic if homeostasis is upset.

BICARBONATE

Bicarbonate is an important substance in maintaining acid-base balance. **The normal range of bicarbonate (HCO_3^-) is 22 to 26 mEq/L.** The major function of this alkaline electrolyte is the regulation of the acid-base balance in the body. Bicarbonate acts as a buffer to neutralize the excess acids in the body and maintain the bicarbonate-to–carbonic acid ratio at 20:1, which is needed for homeostasis. The kidneys selectively

reabsorb or excrete bicarbonate to regulate serum levels and help maintain acid-base balance.

CONTROL MECHANISMS

For the serum pH to remain within the normal range of 7.35 to 7.45, the ratio of bicarbonate ion to carbonic acid must be 20:1. If one component of the ratio changes, the other must change proportionately to maintain the proper balance for serum pH to be within the normal range. There are three control mechanisms for pH. The first is the blood buffer system, which consists of weak acids and weak bases. These buffer pairs can act quickly to stabilize the serum pH. The buffer pair that is monitored in clinical settings is the sodium bicarbonate–carbonic acid buffer system. When an acid is added to the blood, it combines with the base (bicarbonate) component of the buffer, forming a weaker acid. Because weak acids do not readily release free H^+, changes in serum pH are minimized. When a base is added to the blood, it combines with the acid component of the buffer to form a weaker base. The other blood buffer systems are protein buffers and phosphate buffers. They minimize pH changes but do not remove acid or base from the body.

The second control mechanism for pH is the lungs. In the lungs the hydrogen ion and the bicarbonate ion dissociation reaction can be reversed, and water and carbon dioxide (CO_2) are reformed. The carbon dioxide and water are expired from the lungs, decreasing the amount of acid in the body. The lungs can either expel more carbon dioxide or conserve it to help balance the pH. The respiratory system can readjust quickly to help control serum pH.

The third control mechanism for pH is the urinary system. In the kidney, enzymes promote the dissociation of carbonic acid to free hydrogen ions, which can be excreted in the urine. The bicarbonate ions are returned to the blood to restore the levels of buffer. The kidneys reduce the acid content of the serum by exchanging hydrogen for sodium with the help of aldosterone, and the kidneys can neutralize acids by combining them with ammonia and other chemicals. When there is excess alkali (base), the kidney can also excrete excess bicarbonate. This compensatory ability of the kidney takes more time to work than the compensatory action in the lungs. Figure 25-6 shows the interaction of these control mechanisms.

Clinical Cues

Usually about 3 days are needed for the kidneys to stabilize pH within normal range.

Think Critically

If the blood flow to the kidneys is reduced for a considerable time, what effect might it have on serum pH?

ACID-BASE IMBALANCES

There are four types of acid-base imbalances, as shown in Table 25-5. To determine if an acid-base imbalance exists, the pH, arterial carbon dioxide partial pressure ($Paco_2$), and bicarbonate ion are measured by arterial blood gas analysis performed on a sample of arterial blood. **An increase in hydrogen ions results in acidosis (decrease in pH). A decrease in hydrogen ions results in alkalosis (increase in pH).** Imbalances may be acute or chronic. An initial change in carbon dioxide is nearly always due to a respiratory disorder. Disorders that show an initial change in bicarbonate ions are metabolic. The three control mechanisms continually work together to maintain acid-base balance. When an imbalance occurs, the lungs and kidneys try to **compensate** by working to bring the pH back toward normal limits.

RESPIRATORY ACIDOSIS

Carbon dioxide levels increase in a variety of disorders, including acute problems such as airway obstruction, pneumonia, asthma, or chest injuries. Increased levels are also seen in patients taking opiates, which depress the respiratory rate. Chronic respiratory acidosis is prevalent among people with chronic obstructive pulmonary disease (COPD), also called chronic airflow limitation (CAL).

METABOLIC ACIDOSIS

An excessive loss of bicarbonate ions or an increased production or retention of hydrogen ions leads to metabolic acidosis. The loss of bicarbonate ions with diarrhea is one cause of metabolic acidosis. Metabolic acidosis also occurs when large amounts of acid are produced within the body. This happens when more energy than usual is expended and lactic acid builds up in the body, as occurs when oxygenation of tissue falls. The faulty metabolism of a diabetic patient causes a build up of ketoacids, resulting in metabolic acidosis. The other major cause of metabolic acidosis is kidney disease, in which there is decreased excretion of acids and decreased production of bicarbonate (Concept Map 25-2). In this instance, dialysis is required to maintain the pH within life-permitting limits.

Effects of Acidosis

Acidosis depresses the nervous system, causing headache, lethargy, weakness, and confusion. If the acidosis is unrelieved, coma and death will ensue. Evidence that the compensatory mechanisms are at work in metabolic acidosis is deep rapid breathing (Kussmaul respirations) and secretion of urine with a low pH.

RESPIRATORY ALKALOSIS

Hyperventilation (a rapid respiratory rate) results in respiratory alkalosis. It is usually caused by anxiety, high fever, or an overdose of aspirin. Head injuries

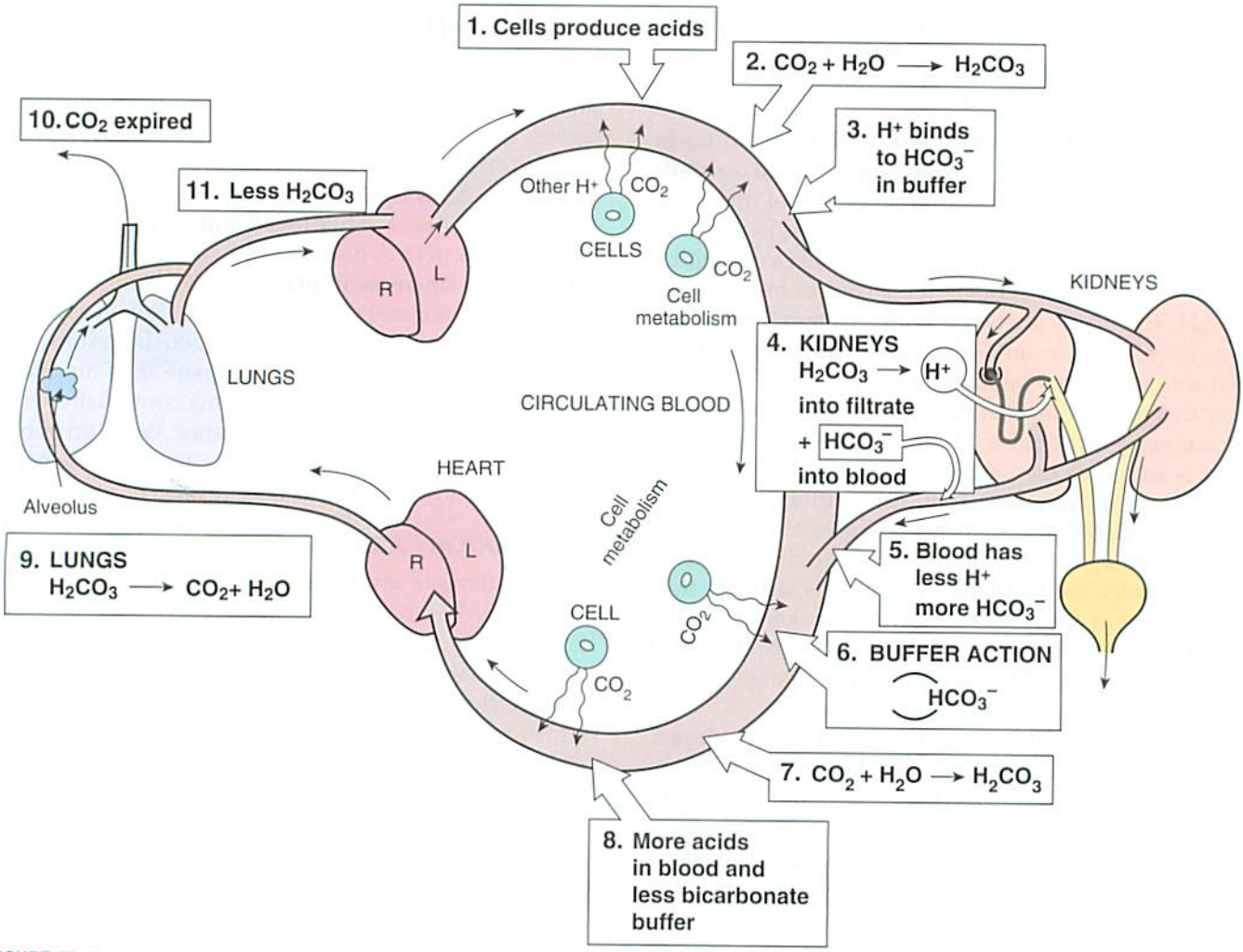


FIGURE 25-6 Regulation of acid-base balance by chemical buffers, respiratory system, and renal system. Key: CO_2, Carbon dioxide; H^+, hydrogen ion; HCO_3^-, bicarbonate; H_2CO_3, carbonic acid; H_2O, water.

Table 25-5 Four Acid-Base Imbalances

IMBALANCE	CAUSES	BLOOD GAS VALUES*
Respiratory acidosis	Slow, shallow respirations Respiratory congestion or obstruction	pH <7.35 $Paco_2$ >45 mm Hg
Metabolic acidosis	Shock (poor circulation) Diabetic ketoacidosis Renal failure Diarrhea	pH <7.35 HCO_3^- <22 mEq/L
Respiratory alkalosis	Hyperventilation	pH >7.45 $Paco_2$ <35 mm Hg
Metabolic alkalosis	Vomiting Excessive antacid intake Hypokalemia	pH >7.45 HCO_3^- >26 mEq/L

*Normal blood gas values: pH: 7.35-7.45; Pao_2: 80-100 mm Hg; $Paco_2$: 35-45 mm Hg; HCO_3^-: 22-26 mEq/L.

may also lead to hyperventilation. Treatment for hyperventilation is to treat the underlying disorder. The person may breathe through a rebreather mask temporarily, mixing the excessively exhaled carbon dioxide with oxygen so that carbon dioxide is inhaled.

METABOLIC ALKALOSIS

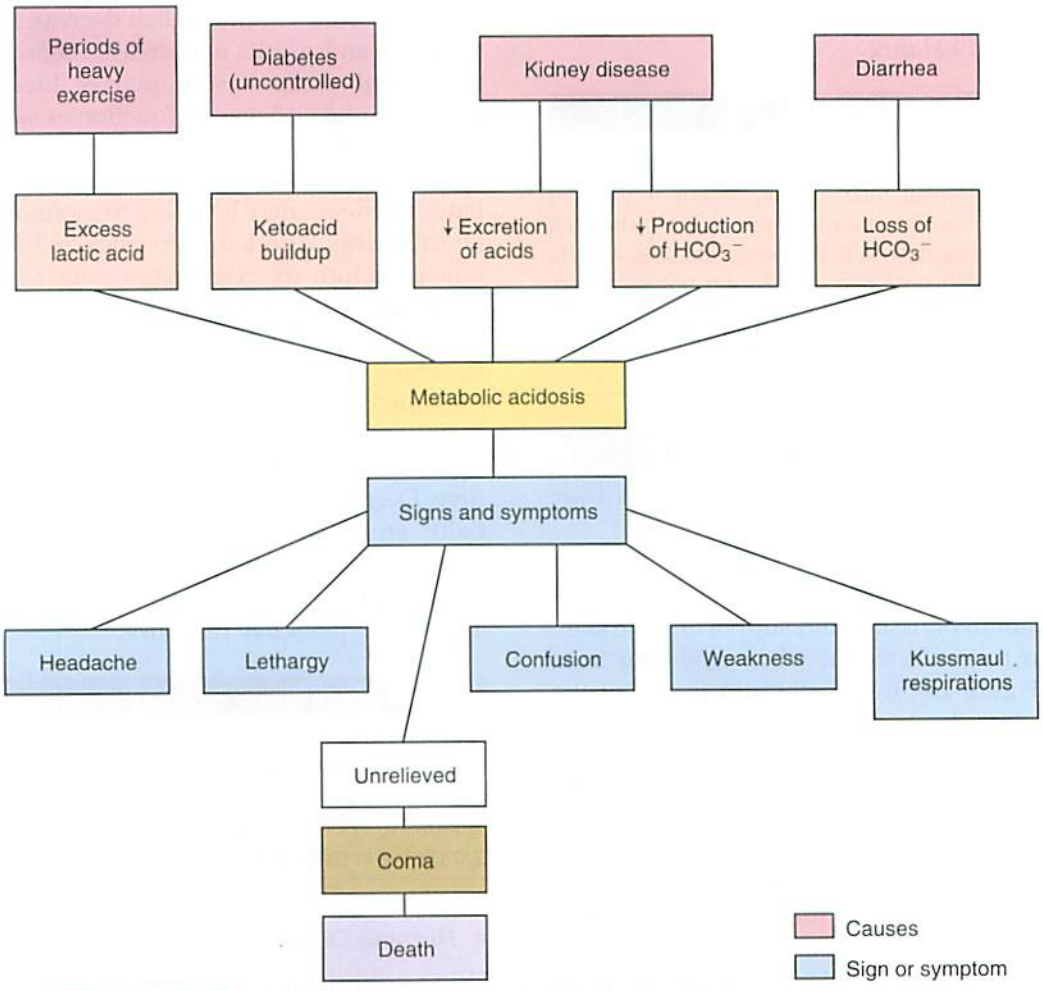
Vomiting resulting in loss of hydrochloric acid from the stomach may cause metabolic alkalosis; gastrointestinal suction can occasionally cause it also.

Clinical Cues

Hypokalemia (low serum potassium) is another cause of metabolic alkalosis as the kidney then retains potassium ions while excreting hydrogen ions. Excessive consumption of antacids with bicarbonate can also upset the acid-base balance and cause alkalosis.

Effects of Alkalosis

Irritability of the nervous system occurs when the pH balance shifts to alkalosis. The patient may display restlessness, muscle twitching, and tingling and numbness



CONCEPT MAP 25-2 Causes, signs, and symptoms of metabolic acidosis. Key: HCO_3^-, Bicarbonate.

of the fingers. If the alkalosis progresses, **tetany** occurs, and seizures and coma result. Tetany is characterized by severe muscle cramps, carpopedal spasms, laryngeal spasms, and stridor (shrill, harsh sound on inspiration).

? Think Critically

Can you identify the type of imbalance that might result from (1) rapid respiratory rate, (2) out-of-control diabetes, (3) renal failure, and (4) eating antacids for a nervous stomach?

More in-depth information about acid-base imbalances will be covered in your medical-surgical nursing courses and can be found in a medical-surgical nursing textbook.

❖ APPLICATION OF THE NURSING PROCESS

▪ Assessment (Data Collection)

First, assess the patient for risk of fluid, electrolyte, or acid-base imbalance. Then assess for physical signs and symptoms of alterations in normal balance. Examine laboratory test results for electrolyte levels that are outside the normal range. Evaluate blood gas levels to determine whether an acid-base imbalance exists and, if so, what type of imbalance is present. Evaluate I & O records to determine whether there is a fluid imbalance. The urine volume the adult usually excretes in 24 hours is approximately 1500 mL. In stressful situations it may decrease slightly from the effects of increased aldosterone and ADH. Urine concentration provides another clue to the fluid status. Urine concentration is commonly measured by the specific gravity. The concentration of urine is compared with the specific gravity of distilled water, which is 1.000. Urine contains urea, electrolytes, and other substances, so its specific gravity will exceed 1.000. Urine specific gravity normally ranges between 1.003 and 1.030. The average range is 1.010 to 1.025. The urine specific gravity is measured with a urinometer, a refractometer, or a dipstick that contains a reagent for specific gravity. Specific gravity is lower in the elderly because the kidneys do not concentrate urine as well as in a younger person.

Tracking daily weight is another way to assess for alterations in fluid balance.

Assignment Considerations

Daily Weight

When assigning the measurement of daily weight, remind the UAP that the weight needs to be measured at the same time every morning, with the patient in the same clothing, on the same scale, after the patient has voided and before eating. Otherwise accurate measurement of weight gain or loss is impossible. Ask the UAP to report to you any change of more than 2.2 lb (1 kg) immediately.

Clinical Cues

A weight gain or loss of 2.2 lb (1 kg) in 24 hours indicates a gain or loss of 1 L of fluid.

Skin turgor (elastic condition) is partially dependent on the amount of tissue fluid supporting the skin. Checking skin turgor is useful when assessing fluid balance (see Figure 25-3). The sternum is one of the most reliable places to check skin turgor.

Edema may be an indicator of fluid volume overload. Look for puffy eyelids and swollen hands. Edema may sometimes be evidenced by a pit developing when a fingertip is pressed into the tissue over a bony prominence, such as the malleolus or tibia, and held for 5 seconds. After the finger is removed, the pit slowly disappears. A better method of assessing the course of peripheral edema is to measure the circumference of the extremity in the same location each day.

Changes in vital signs are pertinent when assessing fluid, electrolyte, and acid-base balance. Fever increases fluid loss and predisposes the patient to fluid volume deficit. A pulse rate greater than 100 bpm may be an early sign of decreased vascular volume from fluid volume deficit. A weak, thready pulse accompanies fluid volume deficit, and a bounding pulse is associated with fluid volume overload. Potassium and magnesium deficits may cause an irregular pulse rate. Rapid breathing may cause an alkaline blood pH by expelling large amounts of carbon dioxide, or it may be the body's way to compensate for an acidic blood pH. Moist respiratory sounds in the absence of cardiac or respiratory disease are a sign of excess fluid in the lungs from fluid overload. Fluid overload causes a rise in systolic blood pressure.

Clinical Cues

To assess for a fluid deficit, measure the blood pressure and pulse in the lying, sitting, and standing positions. If systolic blood pressure drops 20 mm Hg, accompanied by a pulse rate increase of 10 bpm at 1 minute after the position change, deficient fluid volume is suggested.

Severe fluid volume deficit decreases blood flow to the brain and results in decreased sensorium and confusion. Imbalances in sodium have direct effects on the brain volume and mental function as well.

Neuromuscular irritability is assessed when imbalances in calcium and magnesium are suspected. Deep tendon reflexes may be tested to monitor neuromuscular irritability. Check for Chvostek and Trousseau signs when calcium or magnesium deficit is a possibility. Chvostek sign is assessed by tapping the facial nerve about an inch in front of the earlobe. A unilateral twitching of the face is a positive response. A blood pressure cuff is placed on the arm and inflated above systolic pressure for 3 minutes to test for Trousseau sign. If a spasm of the hand occurs, the reaction is positive. Deep tendon reflexes are tested by tapping a partially stretched muscle tendon with a percussion hammer. The extent of the reflex is scored from 0 to 4+, with 0 representing no response, 2+ a normal response, and 4+ a hyperactive response.

Elder Care Points

Checking for tenting is not an accurate way to assess dehydration in the elderly because their skin loses elasticity with aging and will tent with normal hydration. It is better to check for dry mucous membranes, concentrated urine, and other signs and symptoms in these patients.

Nursing Diagnosis

Using critical thinking, analyze the assessment database, identify problem areas, and choose nursing diagnoses. Nursing diagnoses commonly used for patients with fluid, electrolyte, or acid-base imbalances are as follows:

- Deficient fluid volume
- Excess fluid volume
- Risk for imbalanced fluid volume
- Ineffective tissue perfusion
- Decreased cardiac output
- Impaired gas exchange
- Ineffective breathing pattern

Other nursing diagnoses may be appropriate as a result of the fluid, electrolyte, or acid-base imbalance or may be related to the cause of the imbalance, for example, diarrhea.

Planning

Collaboration with the patient and family or caregiver allows the best plan to be devised. Priorities of care are set. The goal is to restore the patient's fluid, electrolyte, or acid-base balance. Individual expected outcomes are written as appropriate. Expected outcomes might be as follows:

- Patient will exhibit normal skin turgor.
- Patient's weight will stabilize at normal baseline.
- Intake and output will be balanced.

Nursing Care Plan 25-1 Care of the Patient with Dehydration

SCENARIO Nina Hiaji, age 76, is placed in the skilled care section of her retirement home. She has been ill for several days with the flu and fever. Her daughter found her confused and lethargic when she came to visit her this morning. Her temperature is 100.8° F (38.2° C), and her blood pressure is 132/72 mm Hg (her normal pressure is 142/88 mm Hg). Her pulse is 96 bpm, and her skin is warm and dry. She is complaining of thirst. Her urine is dark and concentrated. Her oral mucous membranes appear dry, and her saliva is thick and stringy. She is dehydrated and hypernatremic.

***PROBLEM*/NURSING DIAGNOSIS** *Very thirsty with fever and dehydration*/Deficient fluid volume related to fever and lack of intake.

Supporting Assessment Data ***Subjective:*** Thick saliva. ***Objective:*** Poor skin turgor at sternum. Dry mucous membranes. Has had flu for several days and has not been eating or drinking much.

Goals/Expected Outcomes	Nursing Interventions	Selected Rationale	Evaluation
Fluid balance will be normal within 24 hr.	Encourage intake of 8 oz of fluid every hour.	Fluid intake promotes rehydration.	*Is patient taking fluids?* Yes, took 32 oz by noon. Progressing toward goals.
	Provide mouth care every 4 hr and before meals.	Mouth care provides comfort and promotes appetite.	Provided q 4 hr and ac.
Patient will not be confused in 32 hr.	Reorient to person, place, and time frequently.	Reorientation decreases confusion.	*Is patient confused?* Yes, still confused.
	Monitor fluid intake and output and record it. Assess intake related to output.	Monitoring shows progress toward rehydration.	Intake 2645 mL. Output 2480 mL. Is rehydrating.
	Monitor laboratory values of electrolytes for signs of electrolyte imbalance.	Monitoring laboratory values indicates success or failure of interventions.	Laboratory values not available yet.
	Monitor for increasing signs of dehydration; notify physician if they appear.		
	Monitor IV therapy; prevent fluid volume excess. Fluid intake promotes rehydration.	Monitoring helps keep fluid therapy on track as ordered. Progressing toward goals.	IV flowing on time. Continue plan.

Critical Thinking Questions

1. Can you explain the physiologic process of how the flu and fever cause dehydration and hypernatremia?
2. Can you explain the physiologic mechanism of why postural hypotension may occur when a person is dehydrated? What causes the dizziness?

- Blood gases will return to normal.
- Breath sounds will be clear on auscultation.
- There will be no evidence of edema.
- Electrolyte values will be within normal limits.

A specific time frame would be incorporated into the expected outcome. Nursing interventions are chosen to help the patient achieve the outcomes. Nursing Care Plan 25-1 presents examples of expected outcomes and nursing interventions.

Implementation

When patients are unable to take in sufficient fluids on their own, work with the physician to provide an adequate intake of fluid and electrolytes. If patients can swallow and retain fluid, assist them frequently with taking small amounts of fluid. Establish a plan for assisting with both hot and cold liquid consumption. With conscientious care, the need for IV feeding can be avoided. Assessment of what the patient prefers is helpful. In addition to water, offer fruit juices, bouillon, Popsicles, soft drinks, or gelatin. For patients who cannot drink and need only short-term assistance, IV therapy is ordered (Table 25-6). See Chapter 36 for more discussion on IV therapies. For those who will be unable to take in fluids or food on their own for an extended period, a feeding tube must be placed or total parenteral nutrition (TPN) started. Care of the patient with a feeding tube and TPN is discussed in Chapter 27. It is important to track the patient's I & O whether there is a risk of fluid volume imbalance, actual deficit, or actual overhydration (fluid volume excess).

Think Critically

What type of fluid and electrolyte imbalances is the patient who has intestinal flu and suffers from both vomiting and diarrhea likely to have?

Recording Intake and Output

Look at the meal tray before it is removed from the room and record the intake on the shift I & O record.

Table 25-6 Why Use This Intravenous Fluid?

CATEGORY OF FLUID	TYPE OF FLUID AND EXAMPLES	ACTION	USE
Crystalloids	**Isotonic Fluids**		
	0.9% sodium chloride D_5W solution Ringer's solution Lactated Ringer's solution	Raise intravascular volume without causing cellular fluid shifts or changing the electrolyte concentrations in the plasma.	Used for fluid loss from vomiting and diarrhea, for those waiting for blood products, and for fluid loss during surgery.
	Hypertonic Fluids		
	Concentrated dextrose in water: 20%, 30%, 40%, 50%, 60%, or 70% 3% or 5% sodium chloride solution	Draw fluid from the intracellular to the extracellular compartment, thereby relieving cellular edema.	Concentrated dextrose solution is often used to lower cerebral edema.
	Hypotonic Fluid		
	0.45% sodium chloride	Expands intravascular volume.	Used to replace hypotonic fluid losses. A maintenance solution.
Colloids	**Albumin**	Draws fluid from the interstitial and intracellular spaces, replenishing intravascular volume.	Diminish ascites (intraperitoneal fluid), maintain blood pressure, and use in shock when crystalloid solutions are insufficient to maintain vascular volume.

Key: D_5W, 5% Dextrose in water.

Table 25-7 Measurement Equivalents

HOUSEHOLD MEASUREMENT	METRIC EQUIVALENT
15 drops	1 mL
1 teaspoon	5 mL
1 tablespoon	15 mL
1 ounce	30 mL
1 cup (8 ounces)	240 mL
1 pint	500 mL
1 quart	1000 mL
5 ice chips to 1 ice cube (1 ice chip = 1 teaspoon)	25 mL (about ½ volume of chips)

Table 25-8 Common Equivalents of Food Containers*

CONTAINER	VOLUME
Coffee cup	240 mL
Iced tea glass	320 mL
Juice glass	120 mL
Wax drinking cup	180 mL
Styrofoam cup	210 mL
Large glass	230 mL
Cream package	15 mL
Sherbet	90 mL
Soup, clear	120 mL
Soup, thick	180 mL
Gelatin	80 mL
Milk carton	240 mL

*Varies from one facility to another.

Fluids that must be measured include anything that is liquid or will become liquid if left at room temperature (e.g., ice cream, sherbet, milk shakes, gelatin, gruel, and thinned baby cereals). Amounts should be converted from household measures to milliliters or cubic centimeters (Table 25-7). Most facilities provide a list of the equivalent amounts contained in the type or size of dish used by the dietary department (Table 25-8). If this information is not available, and for the home care patient, use a graduated container to measure the capacity of various dishes and glasses. Record the amounts the patient drinks between meals also.

IV fluid infused is added as intake. At the beginning of the shift during the report, note how much is left in an IV container that is in progress. Another IV container may be started during the shift when the old one is totally infused. By adding and subtracting, you can calculate the total amount of IV intake. For example, suppose a patient has 350 mL remaining in the IV bag at the beginning of the shift, it infuses, and a new bag is hung at 1:00 P.M. At the end of the shift, 200 mL has infused from the new bag. Add 350 mL and 200 mL for a total of 550 mL of IV intake for the shift. Enter this amount on the I & O record as intake under the IV column. Most fluids entering the patient's body are recorded as intake; blood and blood products administered are recorded separately (Figure 25-7).

Fluid output is also counted and recorded. The average urine output in a 24-hour period is 1000 to 1500 mL; an output of less than 700 mL in a 24-hour period, or less than 30 mL/hr, should be reported to the charge nurse or physician. To measure urine output, pour the

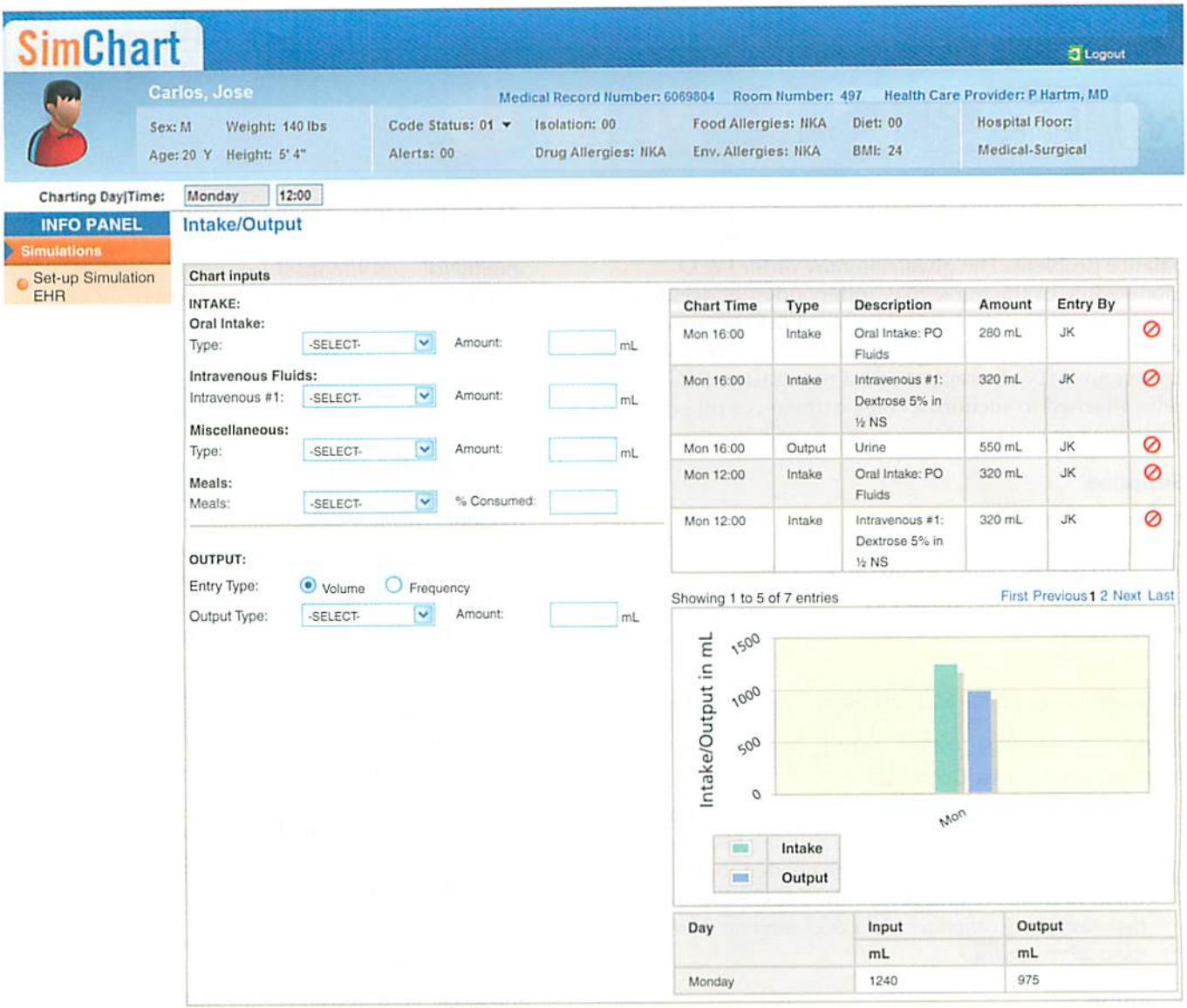


FIGURE 25-7 Intake and output record.

urine from the bedpan or urinal into a graduated container. (Always wear gloves when handling urine containers.) Place the container on a flat surface and read the level of fluid at eye level. Record the amount on the I & O record under output. For the ambulatory patient, give instructions about saving urine and provide a collection container for the toilet. Ask the patient to call when the container needs emptying, or show the patient how to measure and record the urine before disposing of it. Urine drainage bags are emptied before they become full or at least once a shift. The amount is measured and recorded on the I & O record.

Output from all other sources is measured, including drainage from nasogastric tubes, chest tubes, and wound drainage suction devices. If the patient has diarrhea, the liquid stool can be measured in the same manner as urine. Profuse perspiration that requires a change of dampened linen is noted on the I & O record according to agency protocol. Emesis is also measured and recorded as output. At the end of each shift, the total intake and total output are tallied and entered on the 24-hour I & O record in the chart. You do not need a physician's order for instituting the recording of I & O; this is a nursing responsibility (Skill 25-1).

The patient with a fluid volume excess may have an order for fluid restriction. This means that the patient may have only a certain amount of fluid over a 24-hour period. Work out a schedule of fluid intake so that liquids are spaced evenly and the patient does not receive all the allotted liquids in a short time. A typical schedule would be day, 600 mL; evening, 400 mL; night, 200 mL. If not prohibited, hard candies and chewing gum can help relieve thirst. Frequent oral care is essential.

Diuretics are often prescribed, particularly when there is a potential for congestive heart failure or pulmonary edema. Daily weight and electrolyte status must be monitored along with I & O for these patients.

Skill 25-1 Measuring Intake and Output

Intake and output (I & O) are measured and recorded whenever a patient has a potential or an actual fluid balance problem. The physician may order I & O monitoring, or the nurse may independently decide to monitor the patient's I & O. Usually, I & O are measured and recorded for every patient who is receiving intravenous (IV) therapy or has a nasogastric (NG) tube attached to suction, a Foley catheter, or other drainage tube.

Supplies

- I & O record sheet
- Bedpan or urinal
- Graduated measuring container
- "Hat" toilet collection device
- Gloves
- Pen or pencil

Review and carry out the Standard Steps in Appendix D.

NURSING ACTION *(RATIONALE)*

Assessment (Data Collection)

1. Determine need for recording I & O. *(There may be an order or a need to perform this nursing function.)*
2. Assess what equipment will be needed in the room to measure and record the I & O. *(Ensures that measuring container and I & O sheet are in the room when needed.)*

Planning

3. Note on I & O sheet all items that need to be recorded. *(Reminds everyone caring for patient that IV medications, NG tube irrigations, and wound drainage all need to be recorded.)*
4. Place a sign above the toilet stating that I & O is to be recorded. Tell personnel to record all intake. *(Sign above toilet alerts personnel to measure all urine before disposal. Intake will be recorded.)*
5. Ask the patient to use the call light when urine has been collected. *(Alerts personnel to measure the urine.)*

Implementation

6. Explain the procedure to the patient and ask that each amount of fluid taken between meals be recorded. *(The patient must understand the procedure to comply with the recording of I & O.)*
7. Calculate fluid intake before removing a food tray from the room. *(A more accurate count is obtained than when relying on memory.)*
8. Assess fluid intake each time you are in the room. *(It is easier for patients to remember what they drank if questioned soon afterward.)*
9. Put on gloves and measure and record all output. *(Gloves reduce the transfer of microorganisms. Output includes urine, diarrheal stool, emesis, gastric drainage, wound drainage, and excessive perspiration. A graduated container measures all liquid output accurately.)*
10. Dispose of the output in the commode and clean the equipment; remove gloves and perform hand hygiene. *(Removes a medium for growth of pathogens; reduces the transfer of microorganisms.)*
11. Note the amount of output in the correct column on the I & O sheet. *(Writing down the amount immediately helps provide an accurate record.)*
12. Note additional types of intake on the I & O sheet as they occur. *(Jotting down the amount of an IV infusion or the amount of gastric irrigant instilled helps maintain an accurate record of intake.)*
13. At the end of the shift, mark and record the amount of gastric suction secretions, wound drainage in collection devices, and chest drainage. Empty the urine collection bag and measure and record the output. If the suction collection container is full, dispose of the canister according to agency protocol and install a new one. Total the amount of output for the shift. *(For accuracy, all output must be recorded on the I & O sheet. Collection containers are emptied, the level at the end of the shift is marked with the date and time, or containers are replaced if they are full and disposable. All types of output are added together for the shift total.)*
14. At the end of the shift, calculate the amount of IV fluid intake and add it to the intake side of the I & O sheet. *(All IV fluid infused is included as intake.)*
15. After the shift totals have been calculated, enter the amounts on the I & O flow sheet. At the end of a 24-hour period, total the amounts for all shifts for both intake and output. *(The total I & O amount over 24 hours presents the most accurate picture of the patient's fluid balance. What constitutes a normal I & O depends on the patient's condition and on any restrictions imposed.)*
16. Place a new shift I & O sheet in the patient's room; make certain the name and room number are on the sheet. *(A record form must be available for the recording of the I & O).*

Skill 25-1 Measuring Intake and Output—cont'd

Evaluation

17. Determine whether the I & O are within normal limits. Compare the amounts to see if there is any indication of a fluid imbalance. Compare the total with the totals from the previous 2 days to see if either intake or output is increasing. *(If the output is greater or less than the intake, the patient may have a fluid imbalance. Comparison of the totals shows whether there is an increase in intake or output.)*

Documentation

18. Documentation is done on the I & O sheet or on the computer flow sheet.

Critical Thinking Questions

1. What would you do if you recorded the patient's intake for breakfast and 30 minutes later she vomits into the toilet?
2. Your patient is on a full liquid diet, has an IV running at 100 mL/hr, and receives an IV piggyback medication of 50 mL at 2:00 P.M. He has a Foley catheter. What would you include as output on your shift record? What would you include as intake?

Skin care is particularly important in preventing a breakdown over an edematous area. The stretched skin is extremely fragile, has a decreased blood supply, and is no longer flexible. Keep bed linens dry and smooth, and turn the patient frequently to relieve pressure over bony prominences. **Be gentle in repositioning and turning the patient to avoid friction on the skin; use a lift sheet. A break in edematous skin can quickly form a pressure ulcer.**

The patient with a fluid volume excess may be placed on sodium restriction because sodium usually is retained along with water. Table salt is prohibited, and special attention must be paid to the foods and fluids allowed the patient. For items that should be particularly avoided, see the Patient Teaching box on p. 437.

Laboratory values for electrolytes and acid-base balance are monitored to determine whether treatment is effective and imbalances are being corrected. When potassium is ordered, the level is checked before administering the next dose. Urine output is assessed to ensure adequate flow. Orders for fluids are carefully checked before a new IV infusion is begun. Assessment for fluid imbalance is ongoing.

Safety Alert

Administering Potassium IV

If urine output is less than 30 mL/hr, potassium should not be given. Check IV fluids for added potassium before initiating IV therapy. Check the IV fluid that is in progress. Giving potassium when urine flow is inadequate may cause kidney damage.

For the home care patient, thorough teaching is performed so that the patient can meet the requirements for fluid intake or restriction. Adherence to sodium restriction is monitored by periodically checking the patient's food intake. Obtaining feedback regarding comprehension of instructions is a vital part of the teaching. Collaboration with the patient on the plan of care is essential to obtain patient compliance.

When acid-base imbalance occurs, control of the underlying disorder is instituted. Blood gases are monitored, and oxygen and electrolytes are administered as needed. Nursing measures to improve pulmonary function are instituted as appropriate.

Think Critically

What characteristics would you expect to find in a urine specimen from a patient who is dehydrated? How would it differ from a urine specimen from a patient who has a fluid volume excess?

Evaluation

Every 24 hours, evaluation is performed to see whether the nursing interventions are helping the patient meet expected outcomes. If the patient is not progressing toward achievement of the outcomes, problem solving and critical thinking are used to determine why. The plan of care is altered appropriately. When outcomes are met, that portion of the plan is discontinued.

Get Ready for the NCLEX® Examination!

Key Points

- Body fluids are intracellular or extracellular and shift from one compartment to another.
- Fluid moves from compartment to compartment by diffusion, osmosis, filtration, and active transport (see Figures 25-1 and 25-2).
- Fluids are lost from the body through urine, feces, expired air, and perspiration; 24-hour output is approximately 2500 mL.
- Fluid is taken in or produced from liquids, digestion of food, or cell metabolism; this should total 2500 mL/day.
- The kidney is the major organ regulating fluid and electrolyte balance.
- Daily fluid intake in the adult must be at least 1500 mL/day to maintain homeostasis.
- Common causes of fluid volume deficit are vomiting, diarrhea, gastric suction, wound and fistula drainage, and burn injuries.
- A fluid volume deficit results in dehydration (see Box 25-1).
- The elderly and the very young can become dehydrated quickly.
- Signs of fluid volume excess are weight gain; edema; elevated blood pressure; slow, bounding pulse; and crackles in the lungs.
- Causes of edema include kidney failure, heart failure, liver failure, and hormonal disorders.
- Tracking daily weight is a method of determining fluid volume excess or deficit.
- Sodium is the predominant electrolyte in the ECF; potassium is the predominant electrolyte in the ICF.
- Whenever a water imbalance exists, there will be an accompanying sodium imbalance.
- Hyponatremia is a frequent cause of hospitalization of the elderly.
- It is important to know the causes of electrolyte imbalance, the normal range for the major electrolytes, and the signs and symptoms of imbalance (see Table 25-4).
- Acid-base balance is necessary to maintain homeostasis in the body.
- Normal serum pH is 7.35 to 7.45.
- Three mechanisms control pH in the body: the blood buffer system, the lungs, and the kidneys.
- An increase in hydrogen ions results in acidosis, as evidenced by a decrease in pH. There are two types of acidosis: respiratory and metabolic (see Table 25-5).
- Acidosis depresses the nervous system, causing headache, lethargy, weakness, and confusion, and can progress to coma and death.
- A decrease in hydrogen ions results in alkalosis, as evidenced by an increase in pH. There are two types of alkalosis: respiratory and metabolic (see Table 25-5).
- Alkalosis causes irritability of the nervous system with restlessness, muscle twitching, and tingling and numbness of the fingers; it can progress to tetany, seizures, and coma.
- Dependent edema is assessed by checking for pitting by pressing a fingertip against the tissue at a bony prominence.
- Fluid restriction is often necessary for the patient who has excess fluid volume.
- Accurately recording I & O is essential in caring for a patient with a fluid imbalance.

Additional Learning Resources

SG Go to your Study Guide for additional learning activities to help you master this chapter content.

evolve Go to your Evolve website (http://evolve.elsevier.com/deWit/fundamental) for the following FREE learning resources:

- Animations
- Answer Guidelines for Think Critically boxes and Critical Thinking Questions and Activities
- Answers and Rationales for Review Questions for the NCLEX® Examination
- Glossary with pronunciations in English and Spanish
- Interactive Review Questions for the NCLEX® Examination and more!

Review Questions for the NCLEX® Examination

*Choose the **best** answer for each question.*

1. You are starting an intravenous infusion with D5½NS at 150 mL/hr. If the IV tubing delivers 15 drops/mL, you would start the infusion at:
   1. 37.5 or 38 gtt/min
   2. 25 gtt/min
   3. 31 gtt/min
   4. 21 gtt/min

2. The elderly individual is at greater risk for dehydration than the middle-aged adult because: *(Select all that apply.)*
   1. the elderly have a diminished sense of thirst.
   2. the elderly have less muscle mass as years advance.
   3. the elderly person's body is almost 80% water.
   4. compensatory mechanisms work less efficiently.

3. Your patient has been ordered to receive nothing by mouth today because of scheduled diagnostic tests. Even without fluid intake, what amount of fluids would be lost, if any?
   1. The 200 mL normally produced by metabolism of food
   2. None
   3. Only the minimum amount of urine needed to excrete wastes
   4. Urine and obligatory losses, totaling 1500 mL

4. The patient who ate a serving of soup (120 mL), a container of gelatin (80 mL), a glass of iced tea (320 mL), and a serving of sherbet (90 mL) had an intake of _____ mL. *(Fill in the blank.)*