

Fluids, Electrolytes, and Acid-Base Balance NCLEX Review

More than 50% of the human body is composed of fluid, which is divided between the intracellular compartment and the extracellular compartment; the extracellular compartment is further divided into the intravascular, interstitial, and transcellular compartments. Fluid and electrolytes constantly move among these compartments via osmosis, diffusion, filtration, and active transport. Regulation of the body's fluid balance is more complex than just the amount of fluid taken into the body and the amount of fluid excreted from the body. It involves a variety of internal feedback mechanisms, including the thirst mechanism, antidiuretic hormone, renin-angiotensin-aldosterone system, and atrial natriuretic peptide. These basic concepts provide the foundation for understanding the balance of fluid within the human body.

A. Body fluids

1. Constituents.

- Primarily water.
- Contains dissolved substances, such as gases (e.g., oxygen, carbon dioxide), electrolytes, glucose, and urea.

2. Functions.

- Maintains blood volume.
- Controls body temperature.
- Transports substances to and from cells, such as nutrients, gases, and waste products.
- Serves as a medium for metabolic reactions within cells.
- Assists with digestion of nutrients.
- Lubricates joints.

3. Distribution.

- Intracellular and extracellular compartments are separated by selectively permeable membranes of cells and capillaries.
- Total body fluid.
 - Full-term newborn: 70% to 80%.
 - 1-year-old: 64%.
 - Adult male: 55% to 60%.
 - Adult female: 45% to 55%.
 - Older adult: 45% to 50%.
- Intracellular fluid (ICF) is fluid within cells; about 70%.
- Extracellular fluid (ECF) is fluid outside of cells; about 30%.
 - Interstitial: Fluid in the spaces between body cells; about 22%.
 - Intravascular: Fluid within blood vessels (plasma); about 6%.
 - Transcellular: Specific fluids, such as lymph, cerebrospinal, peritoneal, synovial, pleural, intraocular, biliary, and pancreatic; about 2%.
- Third spacing: Accumulation and sequestration of fluid in extracellular spaces as a result of

injury or disease, such as edema, ascites, and pleural effusion.

- Injury or inflammation: Increased capillary permeability permits fluid, electrolytes, and proteins to move into ECF compartment due to trauma, burns, and sepsis.

4. Movement of fluid and electrolytes.

- Fluid intake.
 - Includes oral and intravenous (IV) intake.
 - Recommended oral intake.
 - 2,200 mL/day for women and 3,000 mL/day for men.
 - 80% from drinking fluids and 20% from food.
- b. Fluid output.
 - Sensible fluid loss is fluid loss that is perceived and measurable.
 - Urine: About 1,500 mL/day; varies based on intake and losses via other routes; at least 30 to 50 mL/hr.
 - Feces: 100 to 200 mL/day; soft stools contain more water than hard stools.
 - Insensible fluid loss is fluid loss that is not perceived or easily measurable.
 - Skin: 300 to 600 mL/day; extent of perspiration depends on body and environmental temperature, extent of muscle contraction, and metabolic activity.
 - Lungs: About 300 mL/day; increased respiratory rate increases amount lost.
- Osmosis
 - Osmosis is a passive process whereby water moves across a membrane from a less concentrated solution to a more concentrated solution.
 - Oncotic pressure (osmotic pressure) is the power of a solution to draw water across a semipermeable membrane.
 - For example: Plasma proteins and hypertonic IV solutions increase oncotic pressure because fluid moves from the interstitial compartment into the intravascular compartment.
 - For example: Low levels of protein in the blood, usually due to starvation or liver disease, decrease oncotic pressure because fluid moves from the intravascular compartment into the interstitial compartment.
- Diffusion
 - Diffusion is a passive process whereby molecules move across a membrane from a more concentrated solution to a less concentrated solution.
 - For example: Oxygen moves from the alveoli into the pulmonary capillaries and carbon dioxide moves from the pulmonary capillaries into the alveoli.
- Filtration
 - Filtration is a passive process whereby fluid and smaller molecules move from an area of higher pressure to an area of lower pressure.
 - Hydrostatic pressure is the pressure exerted by a fluid within a closed system against the walls, such as the force exerted by blood against the vascular walls.
 - For example: Increased hydrostatic pressure associated with heart failure or kidney disease promotes movement of fluid out of the intravascular compartment into the interstitial compartment.

Active transport.

- Active transport is an active process whereby metabolic energy moves substances across a membrane from a less concentrated solution to a more concentrated solution.
- For example: The sodium-potassium pump moves sodium out of cells and potassium into cells.

B. Maintenance of fluid balance

1. Thirst mechanism.

- The thirst center in the hypothalamus is stimulated when an increase in the concentration of particles within the intravascular compartment (serum osmolality) occurs.
- An increase in osmolality is caused by a decrease in fluid intake, excessive fluid loss, or excessive sodium intake via the diet or IV fluids.

2. Antidiuretic hormone (ADH).

- ADH causes the kidneys to retain fluid.
- Pressure sensors in the vascular system stimulate or inhibit the release of ADH.

3. Renin-angiotensin-aldosterone system.

- Decreased blood flow or decreased blood pressure stimulates the release of renin from the kidneys.
- Renin stimulates the conversion of angiotensin I to angiotensin II.
- Angiotensin II acts on the kidneys to retain sodium and water and stimulates the adrenal cortex to release aldosterone.
- Aldosterone stimulates the kidneys to reabsorb sodium and excrete potassium.

4. Atrial natriuretic peptide (ANP).

- Atrial stretching in the heart stimulates release of ANP.
- ANP acts as a diuretic by increasing sodium excretion and inhibiting the thirst mechanism.

II. Alterations in Fluid Balance

Fluid imbalances include an inadequate amount of body fluid (deficient fluid volume) or an excessive amount of body fluid (excess fluid volume). These imbalances arise from a variety of conditions, and each has associated clinical manifestations. Nursing care for clients with alterations in fluid balance include many nursing interventions that pertain to both imbalances. However, some are specific to either deficit fluid volume or excess fluid volume. Nurses must have a thorough knowledge of all this information to provide comprehensive nursing care for clients with alterations in fluid balance.

A. Deficient fluid volume

1. Deficient fluid volume is an inadequate amount of body fluid.

2. Hypovolemia is the loss of both fluid and electrolytes in equal or isotonic proportions.

3. Dehydration is the loss of fluid without a significant loss of electrolytes, resulting in a hyperosmolar imbalance.

4. Causes.

- Decreased fluid intake.
- Loss of plasma or blood.
- GI losses by vomiting, diarrhea, or gastric decompression.
- Sweating.
- Adrenal insufficiency.
- Excessive urination (polyuria), possibly due to diuretics or diabetes.

5. Clinical manifestations.

- Weight loss.
- Flushed, dry skin and mucous membranes.
- Decreased tissue turgor; pinched skin on chest just below clavicle, on forehead, or over sternum takes several seconds to return to original position (tenting)
- Thirst.
- Low-grade fever.
- Sunken eyeballs.
- Hypotension, orthostatic hypotension.
- Weak, thready, rapid pulse.
- Flat neck veins.
- Decreased capillary refill.
- Atonic muscles.
- Lethargy.
- Mental confusion.
- Decreased urine output (oliguria, anuria).
- Hemoconcentration results in increased hematocrit (>50%), blood urea nitrogen (>21 mg/dL), and urine specific gravity (>1.029).

B. Excess fluid volume

1. Excess fluid volume is an excessive amount of body fluid.

2. Hypervolemia is an excessive amount of fluid and sodium in isotonic proportions.

3. Causes.

- Excessive sodium intake via diet.
- Excessive IV fluids containing sodium.
- Congestive heart failure. d. Kidney disease.
- Cirrhosis of the liver.
- Increased aldosterone.
- Increased ADH.

4. Clinical manifestations.

- Weight gain.
- Pale, cool skin.
- Edema is excess fluid in subcutaneous tissue; can be dependent, generalized (anasarca), periorbital, pulmonary; increased tissue turgor; use scale for objective measurement of edema.
- Third heart sound (S3gallop) on auscultation of the heart.
- Increased, shallow respirations; dyspnea.
- Crackles on auscultation of the lungs.
- Hypertension.
- Full, bounding, rapid pulse.
- Distended neck veins.
- Muscle weakness, fatigue.
- Mental confusion.
- Diluted urine, possibly with increased volume.
- Hemodilution results in decreased hematocrit (<40%) and blood urea nitrogen (<8 mg/dL).

C. Commonalities of nursing care for clients with alterations in fluid balance

1. Obtain a health history to identify possible causes.
2. Obtain vital signs, including temperature, pulse, respirations, and blood pressure.
3. Assess breath sounds and characteristics of breathing; be aware that crackles and dyspnea indicate possible fluid overload.
4. Assess mucous membranes, presence of thirst, and skin turgor; determine the extent of edema or presence of tenting.
5. Obtain a daily weight.
 - Use the same scale every time; use a standing, chair, or bed scale, depending on the client's ability to stand, sit, or need to remain in bed.
 - Weigh the client at same time every day, such as before breakfast after the first voiding.
 - Weigh the client each day wearing similar clothes or use similar linens when using a bed scale.
 - Notify the primary health-care provider of a change in weight of equal to or more than 2 lb (2.2 lb equal 2,000 mL of fluid) in a day or equal to or more than 5 lb in 1 to 2 weeks.
6. Monitor intake and output (I&O).
 - Institute I&O for clients who are unstable, critically ill, or febrile; are receiving diuretics, continuous or intermittent IV infusions, or tube feedings; have had a procedure; or have fluid restrictions because of conditions such as deficient fluid volume, excessive fluid volume, or heart or kidney failure.
 - Measure all fluid that goes into the body, such as oral, IV, tube feedings, and instillations into the GI tract or urinary bladder.
 - Measure all fluid that exits from the body, such as urine, liquid feces, vomitus, wound drainage, and fluid from gastric decompression; and identify characteristics of output (e.g., color, clarity, and odor).

- Use standard precautions when collecting certain body fluids, such as urine from a urinary retention catheter collection bag or liquid feces; use surgical asepsis when collecting certain body fluids, such as keeping the port of a wound drainage device sterile when collecting wound drainage.
- Measure volume in milliliters with an accurate measuring device and weigh diapers or incontinence pads; do not estimate volume.
- Record solid food that becomes a liquid at room temperature, such as ice cream and gelatin, in its entire volume.
- Record ice chips at half their volume; for example, 4 oz of ice chips equals 2 oz of fluid.
- Document immediately after administration or collection of fluid at the appropriate time on the I&O record.
- Tally volumes of I&O as indicated, such as hourly, at the end of each shift, and at the end of a 24-hour period.
- Teach the client and family about monitoring fluid intake and output; encourage self monitoring of I&O if the client is capable.

7. Assess level of consciousness, energy level, and changes in behavior.

8. Monitor laboratory results, such as hematocrit, blood urea nitrogen, serum electrolytes, creatinine clearance, and urine specific gravity.

9. Provide for safety, such as by assisting the client with getting out of bed.

10. Change position and massage dependent areas (except calves) every 2 hours to prevent pressure ulcers.

11. Facilitate oral fluid intake or restriction: Allot one half during the day, two-thirds of the remaining fluid in the evening, and the rest during the night.

D. Specific nursing care for clients with deficient fluid volume

1. Administer IV fluids as prescribed.

2. Use an intravenous controller device when administering IV fluids.

3. Provide frequent mouth care.

4. Use assistive devices, such as sheep skin, gel cushion, and elbow and heel pads, to protect the skin over bony prominences.

5. Facilitate prescribed oral fluid intake (oral rehydration therapy).

- Set short-term goals, such as 4 oz/hr.
- Offer preferred fluids.
- Serve fluids at appropriate temperatures, such as cold beverages and hot tea and coffee.
- Encourage intake of foods that become liquid at room temperature, such as ice cream and custard.

E. Specific nursing care for clients with excess fluid volume

1. Assess the extent of third spacing by measuring with a centimeter tape over the umbilicus for abdominal girth with ascites and circumference of extremity with peripheral edema or compartment syndrome (mark the site on the extremity for continuity of assessments).
2. Maintain the client in a mid- or high-Fowler position to promote respirations.
3. Restrict dietary sodium as prescribed.
4. Administer prescribed diuretics.
5. Facilitate prescribed fluid restriction.
 - Offer fluids between rather than with meals.
 - Offer ice chips to relieve thirst; liquid volume is half frozen volume.
 - Use a small container to promote perception of a larger volume when providing fluids.
 - Suggest chewing sugarless gum to help keep the oral cavity moist.

III. Electrolytes

Electrolytes are chemical substances that dissociate into electrically charged particles (ions) when dissolved in water. Cations (e.g., sodium, potassium, calcium, and magnesium) have a positive charge. Anions(e.g., chloride, bicarbonate, and phosphate) have a negative charge. Electrolyte balance depends on normal kidney, hypothalamic, adrenocortical, and nervous system functioning. Imbalances can be identified by serum electrolyte levels and clinical manifestations.

A. Common electrolytes

1. Sodium(Na^+): Normal serum level = 135 to 145 mEq/L.
 - Major cation in ECF.
 - Promotes fluid and acid-base balance, nerve impulse conduction, and cellular chemical reactions.
2. Potassium (K^+): Normal serum level = 3.5 to 5.0 mEq/L.
 - Major cation in ICF.
 - Promotes nerve impulse conduction in cardiac, skeletal, and smooth muscles.
 - Serves as a cofactor with enzymes in cellular metabolism.
3. Calcium(Ca^{++}): Normal serum level = 8.5 to 10.5 mEq/L.
 - Promotes bone health and cardiac and neuromuscular function.
 - Serves as a factor in blood clotting.
 - Has its level controlled by parathyroid gland secretion of parathyroid hormone.
 - Has a reciprocal relationship with phosphorous; a decrease or increase in one results in the opposite reaction in the other.
4. Magnesium (Mg^{++}): Normal serum level = 1.32 to 2.14 mEq/L.

- Essential for enzyme and neurochemical activities.
- Promotes cardiac and skeletal muscle excitability.

5. Chloride(Cl^-): Normal serum level = 97 to 107 mEq/L.

- Major anion in ECF.
- Functions with sodium to regulate serum osmolality and blood volume.
- Component of hydrochloric acid (HCl) which is involved with regulating acid-base balance.

6. Bicarbonate(HCO_3^-): Normal serum level = 22 to 26 mEq/L.

- Most important buffer in ECF.
- Helps regulate acid-base balance by neutralizing excess hydrogen ions as part of the carbonic bicarbonate buffering mechanism.

7. Phosphate(PO_4^-): Normal serum level = 2.5 to 4.5 mEq/dL.

- Most important buffer in ECF.
- Helps regulate acid-base balance by neutralizing excess hydrogen ions as part of the phosphate buffer system.
- Essential for functioning of red blood cells, nerves, and muscles.
- Involved in metabolism of proteins, carbohydrates, and fats.

B. Electrolyte imbalances and specific nursing care.

C. Commonalities of nursing care for clients with electrolyte imbalances

1. Perform a history and physical to collect data that may help identify the cause of the imbalance.
2. Monitor laboratory reports for serum electrolyte levels.
3. Assess for clinical manifestations of each electrolyte imbalance.
4. Monitor vital signs.
5. Monitor cardiopulmonary status, particularly for impaired airway, respiratory depression, and dysrhythmias.
6. Administer prescribed oral or IV fluids and electrolytes, using a volume controller for IV administration.
7. Encourage intake or restriction of foods high in the electrolyte of concern, as appropriate.
8. Maintain safety related to decreased level of consciousness, confusion, muscle weakness, and potential for seizures.

IV. Acid-Base Balance

pH reflects the strength of hydrogen ions in a solution. When a state of acid-base balance exists in

the extracellular compartment, pH is 7.35 to 7.45. A pH less than 7.35 is acidic. A pH greater than 7.45 is alkaline. When in balance, body fluid has 27 mEq of bicarbonate (HCO_3^-) per liter and 1.35 mEq of carbonic acid (H_2CO_3) per liter; the bicarbonate-carbonic acid ratio is 20:1. This balance is fragile and is maintained through a variety of mechanisms. When this balance is disrupted, acid-base imbalances occur. Carbonic acid imbalances lead to respiratory acidosis or respiratory alkalosis, and bicarbonate and hydrogen imbalances lead to metabolic acidosis or metabolic alkalosis

Components of Acid Base Balance:

1. Acid.

- Substance that has more hydrogen ions than bicarbonate ions.
- Yields hydrogen ions in solution.

2. Base.

- Substance that has more bicarbonate ions than hydrogen ions.
- Accepts hydrogen ions in solution.

3. Salt.

- Compound that results when an acid and a base are mixed.
- The acid releases H^+ ions while the base releases OH^- ions in a process called hydrolysis.

B. Mechanisms that maintain acid–base balance

1. Buffer mechanisms: First line of defense; respond in seconds.

- Buffer.
 - A buffer is a substance that combines with a strong acid or base to change it to a weaker acid or base.
 - Substance that accepts or releases hydrogen ions to correct an acid-base imbalance.
- Bicarbonate buffer system.
 - Most important buffer in ECFs.
 - Neutralizes excess hydrogen ions.
- Phosphate buffer system.
 - Most important buffer in ICFs.
 - Neutralizes excess hydrogen ions.
- Plasma protein system.
 - Proteins can attract or release hydrogen ions.
 - Functions in both ICF and ECF.
- Hemoglobin system.
 - Chloride shifts into or out of cells, depending on the oxygen level; oxygen is carried in the hemoglobin molecule.
 - As chloride shifts into or out of cells, bicarbonate ions move in the opposite direction.

2. Respiratory mechanisms: Second line of defense; respond in minutes.

- When carbonic acid reaches the lungs, it breaks down into water (H₂O) and carbon dioxide (CO₂).
- Respiratory rate changes depending on the level of CO₂ in ECF under control of the medulla oblongata.
 - Rate increases with increased CO₂.
 - Rate decreases with decreased CO₂.

3. Renal mechanisms: Third line of defense; respond in hours to days.

- Kidneys control the buffer sodium bicarbonate (NaHCO₃) by excreting or conserving hydrogen ions.
- Kidneys also combine ammonia (NH₃) with hydrochloric acid (HCl) to form ammonium (NH₄Cl), which is then excreted.

C. Acid-base imbalances and specific nursing care

For acid-base imbalances and their serum values, causes, compensatory mechanisms, clinical manifestations, and specific nursing care see Table 21.2.

D. Commonalities of nursing care related to acid-base imbalances

1. Perform a history and physical examination to collect data that may help identify the cause.
2. Obtain vital signs.
3. Assess for and maintain a patent airway.
4. Monitor cardiopulmonary status for respiratory impairment or dysrhythmias.
5. Monitor laboratory results for arterial blood gas and serum electrolyte levels.
6. Administer prescribed oral and IV fluids and electrolyte supplements.
7. Maintain client safety; institute seizure precautions when necessary.
8. Monitor I&O.