Fluid,Electrolyte,and Acid-Balance

Dr. sabah Abbas

Instructor, Fundamentals of Nursing Department, College of Nursing, University of Baghdad

Introduction:

The body normally maintains a balance between the amount of fluid taken in and the amount excreted.

Health promotion requires a maintenance of body fluid

and acid-base balance .These interventions include ongoing assessments , modifying dietary and fluid intake, administering medications ,assisting with **I.V.** therapy, and blood replacement..

- **Anatomy and Physiology:**
- Fluids and electrolytes are vital to life and adequate balance is imperative to maintain healthy functioning of the body.
- Fluids and electrolytes are involved in almost every cellular reaction and function.
- Chemical reactions that occur in the body depend upon careful acid and base balance ……

Body Fluids

As the primary body fluid ,water is the most important nutrient of life. Although life can be sustained for many days with out food ,humans can survive for only a few days without water. **Water in the body functions primarily to :**

- Provide a medium for transporting nutrients to cells and wastes from cells.

-Provide a medium for transporting substances such as hormones, enzymes, blood platelets, and red and w.b,c through out the body .

- Facilitate cellular metabolism & proper cellular chemical functioning.

-Act as a solvent for electrolytes & nonelectrolytes

- Help maintain normal body temperature.

- Facilitate digestion & promote elimination

- Act as a tissue lubricant

Body Water &Fluid Compartments

- Total body water or fluid refers to the total amount of the total amount of water , which is approximately 50% - 60% of the body weight in healthy person.
- Fluid is located in two fluid compartments: - intracellular fluid(ICF) or extra cellular fluid (ECF), based on its location in the body.
- **ICF :** IS the fluid with in cells, constituting about70% of the total body water or 40% of the adults body weight.
- **ECF:** is all fluid out side the cell ,accounting for about 30% of total body water or 20% of the adults body weight.

Body Water &Fluid Compartments

- ECF includes two major areas, the intravascular& interstitial compartments .A third areas ,usually minor , compartment is the transcelluar fluids, intravascular fluid, or plasma, is the liquid component of the blood (i.e. fluid found with the vascular system)
- Interstitial fluid : is the fluid that surrounds tissue cells & includes lymph.
- Transcellular fluid include cerebrospinal, pericardial, synovial ,intraocular, & pleural fluids as well as sweat digestive secretions.
- The capillary walls & cell membranes separate the intracellular & extracellular compartments.

Body Water &Fluid Compartments

Variations in fluid content : its is from the normal 50%- 60% of the body weight can occur, depending on such factors as the persons age, body fat ,& gender.

Infants have considerably more total body fluid & ECF than adult. Because ECF is more easily lost from the body than ICF, infants are more prone to fluid volume deficits . Fat cells contain little water. Women tend to have more body fat than men do ,they have also less body fluid than men .

Decreasing percentage of body fluid in older people is related to increase in fat cells. Older adults lose muscle mass as a part of aging .The combined increase of fat & loss of muscle results in reduced total body water,

- After the age of 60 years, total body water is about 45% of persons body weight.
- This decrease in water increases the risk for fluid imbalance in older adults..
- **Fluid balance** : The desirable amount of fluid intake & loss in adults ranges from 1.500 to 3.500 ml. each 24hours, with most people averaging 2.500 to 2.600 ml. per day. persons intake should normally be approximately balance by output or fluid loss. A general rule is that in healthy adults, the output of urine normally the ingestion of liquids &the water from food& oxidation is balanced by the water loss through the feces, the skin, & the respiratory process.

Fluid sources

- The human body obtains water from several sources, including ingested liquids ,food &as a by –product of metabolism.
- Fluid intake is regulated primarily by the thirst mechanism. Located with in the hypothalamus, the thirst control center is stimulated by intracellular dehydration & decreased blood volume.
- The water contained in food is the second largest source of water for the body.
- Water is an an end product of oxidation that occurs during the metabolism of food substances, specifically carbohydrates, fats ,& proteins.

Fluid Losses

Fluid is lost from the body through sensible & insensible losses

Sensible losses : can be measured & include fluid lost during urination, defecation & wounds.

Insensible losses: losses cant be measured or seen &include fluid lost from evaporation the skin & as vapor from the lungs during respiration.

Fluid output **averages** 2.500 to 2.900 ml.\ day

Fluid and Electrolyte Regulation

- Maintaining homeostasis of fluid volume & electrolytes is essential to healthy body functioning. The body produces this balance by shifting fluids between the ECF & ICF. The mechanisms responsible for regulating this shift of fluids & transporting materials to &from intracellular compartments are osmosis, diffusion, active transport, &filtration,
- ***- Fluid and Food Intake and Loss-***
- ***- Skin & Lungs***
- ***Gastrointestinal Tract***
- ***Kidneys***

Terminologies

- **Solute:** Substance dissolved in a solution

- **Solvent:** Liquid that contains a substance in solution

- **Permeability:** Capability of a substance, molecule, or ion to diffuse through a membrane (covering of tissue over a surface, organ, or separating spaces)

Filtration : The movement of fluid through semi permeable membrane from an area with higher hydrostatic pressure to an area with lower hydrostatic pressure creates an outward gain of fluid in the interstitial spaces .

-Osmosis: Solvent molecules move across a membrane to an area where there is a higher concentration of solute that cannot pass through the membrane.

- **Hydrostatic Pressure:** The force of fluid presses outward against the blood vessel wall
- **Diffusion:** Particles move across a permeable membrane and disperse in all directions through a solution or a gas
- **Colloid Osmotic Pressure :** There is a movement of fluid between the intravascular and interstitial compartments, based on the number of solute particles on the concentrated side and presence of a semi permeable membrane.
- **Acid :** is a substance that donates hydrogen ions. For example, hydrochloric acid (HCl) ionizes in water (a solution) to form hydrogen ions and chloride ions. HCl, which is found in gastric juices,
- A **base :**is a substance that accepts hydrogen ions (proton acceptor).

Electrolytes:

An **electrolyte** is a compound that, when dissolved in water or another solvent, forms or dissociates into ions . The electrolytes provide inorganic chemicals for cellular reactions and control mechanisms. Electrolytes have special physiological functions in the body that promote neuromuscular irritability, maintain body fluid osmolarity, regulate acid-base balance, and distribute body fluids between the fluid compartments.

Electrolytes are measured in terms of their electrical combining power, or chemical activity. the quantities of cations and anions in a solution, expressed as mill equivalents per liter (mEq/L). Because electrolytes produce either positively charged ions (cations) or negatively charged ions (anions), they are critical regulators in the distribution of body fluid.

Electrolytes:

The main electrolytes in body fluid are:

sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). The extracellular fluid contains the largest quantities of sodium, chloride, and bicarbonate ions, but only small quantities of potassium, calcium, magnesium, phosphate, sulfate, and organic acid ions.

The intracellular fluid contains only small quantities of sodium and chloride ions and almost no calcium ions. Large quantities of potassium , phosphate ions , magnesium and sulfate ions are contained within intracellular fluid .

Acid-Base Balance

Acid-base balance : refers to the homeostasis of the hydrogen ion concentration in extracellular fluid. The slightest variation in the hydrogen ion concentration causes marked alterations in the rate of cellular chemical reactions. The pH symbol is used to indicate the hydrogen ion concentration of body fluids; 7.35 to 7.45 is the normal pH range of extracellular fluid.

Hydrogen ions (H+), which carry a positive charge, are protons.

Depending on the number of hydrogen ions present, a solution can be either acidic, neutral, or alkaline

Acid-Base Balance:

A neutral solution has a pH of 7. In such a solution there are equal numbers of hydrogen ions (H+) and hydroxyl ions (OH–), which can combine to form water (H2O).

When the number of hydrogen ions is increased, the solution becomes acidic (pH value below 7); a decrease in the number of hydrogen ions causes the solution to become alkaline (pH value above 7).

When the number of free hydrogen ions in a solution increases to the point that the pH value becomes less than **7.35**, the body is in a state of **acidosis**. The opposite occurs with **alkalosis**, in which a pH value higher than **7.45** results from a low hydrogen ion concentration.

Regulators of Acid-Base Balance

The body has three main control systems that regulate acid-base balance to counter acidosis or alkalosis: the

buffer systems; respiration; and renal control of hydrogen ion concentration.

These systems vary in their reaction time in regulating and restoring balance to the hydrogen ion concentration of a solution.

Regulators of Acid-Base Balance

Chemical Buffer systems: A buffer is a substance that prevents body fluids from becoming overly acidic or alkaline. They combine with excess acids or bases to prevent major changes in **PH**, keeping the pH of body fluids as close as possible to normal (**7.35- 7.45**) . Alternately, a buffer may function like an acid& release hydrogen ions when too few are present in a solution.

The body has three buffer systems: **1-** the carbonic acid- sodium bicarbonate buffer system , **2-** the phosphate buffer system, **3-** the protein buffer system .

Regulators of Acid-Base Balance

1- the ratio of carbonic acid (H_2CO_3), the most common acid in human body fluid, to the body's most common base, bicarbonate(HCO_3), is important buffer system of the body. Normal ECF has a ratio 20 part bicarbonic to 1 part carbonic acid. This system buffers as much has 90% of the(H^+) of ECF. The lungs help by regulating the production of a carbonic acid resulting from the combination of co2 & water. The kidneys assists the bicarbonate system by regulating the production of bicarbonate.

Regulators of Acid-Base Balance

2-phospate buffer system:

is active in intracellular fluids, especially in the renal tubules, it converts alkaline sodium phosphate (Na2po4),a weak base , to acid- sodium phosphate(NaH2po4) in the kidneys.

3- **protein buffer system**: is a mixture of plasma proteins & the globin portion of hemoglobin in R.B.C. Because plasma proteins& hemoglobin possess chemical groups that can combine with or liberate hydrogen ions, they tend to minimize changes in pH & serve as excellent buffering agents over a wide range of pH values working both inside & outside the cells.

Respiratory Regulation Of Hydrogen Ions:

Carbon dioxide ,constantly produced by cellular metabolism (carbonic acid H_2CO_3,yields co2 &H_2O), is excreted by exhalation. When the amount of co2 in the blood increases, the sensitive chemoreceptor in the respiratory center in the medulla are stimulated to increase the rate& depth of respirations to eliminate more co2. As more co2 is exhaled, the H_2CO_3 level in the blood decreases,

Respiratory Regulation Of Hydrogen Ions:

the PH of the blood **becomes more alkaline. When** the blood level of co2 decreases, the respiratory center decreases the rate& depth of respirations to retain the Co2 , so that carbonic acid can be formed ,thereby maintaining the delicate balance.

As a results, the lungs are the primary controller of the bodys carbonic acid supply.

- Renal Regulation of Hydrogen Ions

- :The kidneys excrete or retain hydrogen ions &form or excrete bicarbonate ions in response to the PH of the blood.
- In the presence of acidosis, the kidneys excrete hydrogen ions & form &conserve bicarbonate ions, thus raising the PH to the normal range .
- If alkalosis is present, the kidneys retain hydrogen ions & excrete bicarbonate ions in an effort to return to a balanced state. As a result, the concentration of bicarbonate in the plasma is regulated by kidneys.
- The PH of urine varies, depending on the ions that are being excreted, but it is generally between 4.5& 8.2
- Acid-base regulation by the kidneys occurs more slowly than that which occurs by the carbonic acid- sodium bicarbonate system or by respiratory regulation.

Fluid Imbalances

Fluid imbalances occur when the body's compensatory mechanisms are unable to maintain a homeostatic state. Fluid imbalances involve either the volume or distribution of water or electrolytes.

- **Fluid Volume deficit:-** It can be caused by a loss of both water& solutes in the same proportion from the ECF space. The state is commonly known as **hypovolemia** or isotonic fluid loss.

Fluid Imbalances

Both osmotic & hydrostatic pressure changes force the interstitial fluid into the intravascular space in an effort to compensate for the loss of volume in the blood vessels.

As the interstitial space is depleted, its fluid becomes hypertonic, & cellular fluid is then drawn into the interstitial space ,leaving cells without adequate fluid to function properly. Fluid volume deficit can rapidly result in a weight loss of 5% in adults & 10% in infants. A 15% weight loss caused by fluid deficiency usually is life threatening.

–

- Third- space fluid shift refers to a distributional shift of body fluids into the transcellular compartment, such as the pleural, peritoneal(ascites), or pericardial areas: joint cavities :the bowel :or an excess accumulation of fluid in the interstitial space. Third –space shift may occurs as a result of a severe burn. a bowel obstruction or hypolbuminemia..
- **Fluid Volume Excess-** -:Excessive retention of water& sodium in ECF in near equal proportions results in a condition termed fluid volume excess. It also called **hypervolemia** or excess of isotonic fluid . Due to the increased extracellular osmotic pressure from the retained sodium & water, fluid is pulled from the cells to equalize the tonicity. By the time the intracellular & extracellular spaces are isotonic to each other, an excess of both water &sodium in the ECF, whereas the cells are nearly depleted.

The excessive ECF may accumulate in either the intravascular compartments or interstitial spaces.

Accumulation of fluid in the interstitial space is known as **edema ,** can be observed around the eyes, fingers, ankles, and sacral space, & can be accumulate in or around body organs.

Accumulation of fluid may result in a weight gain in excess of 5%.

Electrolyte Imbalances:- . In health, normal homeostatic mechanisms function to maintain electrolyte and acid-base balance. In illness, one or more of the regulating mechanisms may be affected, or the imbalance may become too great for the body to correct without treatment

*-

Hyponatremia :

Sodium is the primary determinant of extracellular fluid concentration because of its high concentration and inability to cross the cell membrane easily. The low extracellular serum sodium causes water to enter the cells in the brain, thereby producing cerebral edema as manifested by the cognitive and sensory changes .

Hypernatremia:

is an excess in the extracellular level of sodium. With an excess of sodium or a loss of water, a hyperosmolar state exists because the ratio of sodium to water is too high. This ratio causes an increase in the extracellular osmotic pressure, which pulls fluid out of the cells into the extracellular space .

Potassium: The normal range of extracellular potassium is narrow (3.5–5.0 mEq/L).

Hypokalemia -is a decrease in the extracellular level of-potassium. Gastrointestinal-tract disturbances and the use of diuretics can place the client at risk for hypokalemia and an acid-base imbalance (metabolic alkalosis). Besides diuretics, other major drug groups that can cause hypokalemia are laxatives, corticosteroids, and antibiotics.

Hyperkalemia : is an increase in the extracellular level of potassium. There are major drug groups that may cause hyperkalemia:

- Potassium-sparing diuretics
- Central nervous system agents
- Oral and intravenous replacement potassium salts

Hyperkalemia can also inhibit the action of digitalis

Chloride

-As previously stated, chloride and water move in the same direction as sodium ions, influencing the osmolality of extracellular

-**Hypochloremia**- is a decrease in the extracellular level of chloride. .Gastrointestinal tract losses may cause a decrease in chloride because of the acid content of gastric juices, mainly hydrogen chloride. Because the bicarbonate ion compensates for the loss of chloride, the client is at risk for developing metabolic alkalosis . signs and symptoms of hypochloremia are muscle twitching and slow, shallow breathing

. **Hyperchloremia** - **is an increase in the extracellular level of chloride. It usually occurs with dehydration, hypernatremia, and metabolic acidosis. The signs and symptoms**

of hyperchloremia are muscle weakness, deep, rapid breathing, and lethargy progressing to unconsciousness if untreated.

Acid-Base Disturbances

It is occur when the carbonic acid or bicarbonate levels become disproportional . The common types of acid-base imbalances are respiratory acidosis and alkalosis and metabolic acidosis and alkalosis.

-- ***Respiratory Alkalosis (Carbonic Acid Deficit)*** :

:Respiratory acidosis is characterized by a decreased hyd rogen ion concentration (a blood pH above 7.45) and a decreased arterial carbon dioxide pressure (less than 35 mm Hg). Respiratory alkalosis is caused by hyperventilation (excessive exhalation of carbon dioxide) resulting in hypocapnia (decreased_arterial carbon dioxide concentration). Hyperventilation can be triggered by hypoxia at high altitudes, anxiety, fear, pain, fever, and rapid mechanical ventilation.

Respiratory Acidosis (Carbonic Acid Excess)

Respiratory acidosis is characterized by an increased hydrogen ion concentration (a blood pH below 7.35), an increased arterial carbon dioxide pressure (greater than 45 mm Hg), and an excess of carbonic acid. Respiratory acidosis is caused by hypoventilation or any condition that depresses ventilation.

Hypoventilation can begin in the respiratory system, as occurs with respiratory failure, or outside the respiratory system, as occurs with drug overdose. Common drugs that can cause central nervous system depression and place the client at risk for respiratory acidosis are narcotics, barbiturates, and anesthetic agents .

- Administering intravenous (I.V.) Therapy

- A relatively common form of therapy for handling fluid disturbances is the use of various solutions with infused intravenously.
- The physician or other licensed healthcare professional prescriptive privileges is responsible for prescribing the kind and a mount of solution to be used.
- The nurse is responsible for initiating, monitoring, and discontinuing the therapy. The nurse must understand the patients need for I.V. therapy , the type of solution being used, its desired effect, and untoward reactions that may occur.

Selected I.V. Solutions

-1- Isotonic solutions:

- 5% dextrose in water (D\W)
- o.9% Nacl (normal saline)
- Lacted Ringers solution

2- Hypotonic solutions:

o.33% Nacl (1\3- strength normal saline)

0.45% Nacl (1\2 strength normal saline)

3- Hypertonic solutions:

Selected I.V. Solutions

5% dextrose in 0.45% Nacl

10% dextrose in water ($D_{10}W$)

5% Dextrose in 0.9 % Nacl (normal saline)