

UNIT 3

BODY FLUIDS AND ELECTROLYTE

BODY FLUIDS

The fluid presents inside the body is known as body fluids.

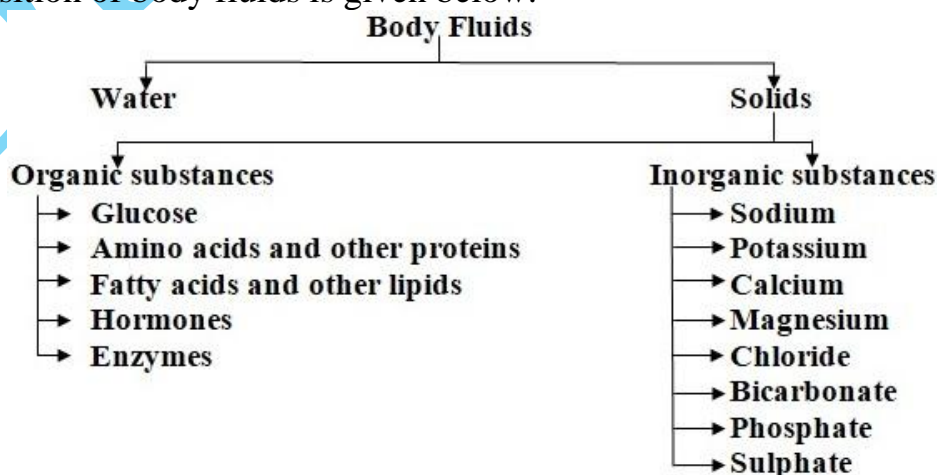
Compartment of Body Fluids or Distribution of Body Fluids

The total amount of water present in the body is about forty (40) litres. It is distributed into two major compartments namely:

1. **Intracellular fluid (ICF):** The fluids present inside the cell is known as intracellular fluid. It is about 55% of the total body water (about 22 litres).
2. **Extracellular fluid (ECF):** The fluid present outside the cell is known as extracellular fluid. It is about 45% of the total body water (about 18 litres). The extracellular fluid is divided into following compartments.
 - a. **Interstitial fluid:** The fluid present in the interstitial space (space between two tissues) is known as interstitial fluids. It is about 12 liter.
 - b. **Intravascular fluid:** The fluid present inside the blood vessels (arteries, veins and capillaries) are known as intravascular fluid. The major intravascular fluid is whole blood volume includes red blood cells, white blood cells, plasma, and platelets and lymph following through the blood vessels and lymphatic vessels respectively. It is about 5.5 liter.
 - c. **Transcellular fluid:** The transcellular fluid is the fluid that fills up the spaces of chambers that are created or formed from the linings of epithelial cells. It is about 0.5 liter. The transcellular fluid includes:
 - Cerebrospinal fluid
 - Intraocular fluid
 - Digestive juices
 - Synovial fluid in synovial joint
 - Fluid in urinary tract
 - Serous fluid: intrapleural fluid, pericardial fluid and peritoneal fluid.

Composition of Body Fluids

Body fluids contain water and solids. The solids are organic and inorganic substances. The normal composition of body fluids is given below:



Functions of Body Fluids

1. Body fluids play important role in homeostasis of body.
2. Body fluids transport nutrients and other essential substances through out the body.

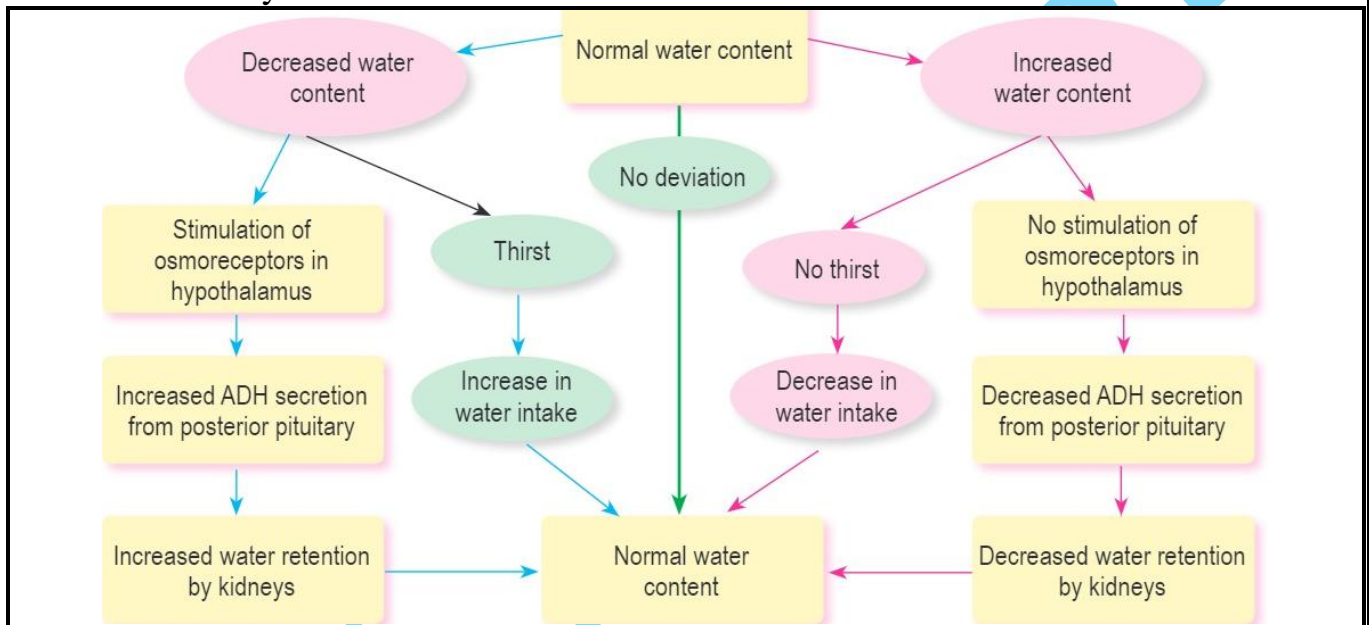
3. Body fluids excrete water, toxins, waste food and waste products.
4. Body fluids stimulate the chemical activities and metabolic processes of cells.
5. Body fluids regulate the normal body temperature.
6. Body fluids help in the digestive process of the body.
7. Body fluids maintain normal acid base balance.
8. Body fluids help to moisten the skin.

MECHANISM OF WATER BALANCE

The body has several mechanisms which work together to maintain the fluid balance. The important mechanisms are:

- Thirst mechanism (Hypothalamus)
- Renal mechanism (Kidneys)

These two mechanisms work together by negative feedback mechanism to maintain the normal fluid level in the body.



ELECTROLYTE

The solution which conducts electricity is known as electrolytes. It conducts electricity due to presence of mobile ions. It is also known as ions. Examples: Sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), bicarbonate (HCO_3^-), phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), magnesium (Mg^{++}) etc.

Type of Electrolytes

When electrolytes are mixed in water, they are divided into types:

- Cation:** Cation is ion which carries positive electrical charges in the body. Examples: Sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), , magnesium (Mg^{++}) etc.
- Anion:** Anion is an ion which carries negative electrical charges in the body. Examples: Chlorine (Cl^-), bicarbonate (HCO_3^-), sulphate (SO_4^-), phosphate (PO_4^-), carbonic acid (HCO_3^-) etc.

Functions of Electrolytes

1. Electrolytes control water balance and fluid distribution in the body.
2. Electrolytes regulate acidity (pH) of the blood.
3. Electrolytes regulate oxygen level in the blood.
4. Electrolytes involve in moving nutrients inside the cells and waste products outside the cells.
5. Electrolytes help in the muscle contraction and nerve transmission.
6. Electrolytes rebuild the damaged tissue.
7. Electrolytes regulate the heart beat.

REGULATION OF BODY FLUID AND ELECTROLYTE BALANCE

The regulation of body fluid and electrolyte balance is a vital physiological process that maintains homeostasis.

1. Kidneys

- a. The kidneys filter blood to produce urine, which helps eliminate excess fluids and electrolytes.
- b. The reabsorption of water and essential electrolytes (sodium, potassium, calcium, etc.) back into the bloodstream based on the body's needs.
- c. The excess water and waste products are excreted in the urine, helping to regulate blood volume and electrolyte concentrations.

2. Hormonal Regulation

Several hormones play a role in regulating body fluid and electrolyte balance:

- | | |
|-------------------------------------|------------------------------------|
| a. Antidiuretic Hormone (ADH) | d. Brain Natriuretic Peptide (BNP) |
| b. Aldosterone | e. Renin |
| c. Atrial Natriuretic Peptide (ANP) | f. Angiotensin II |

3. Neural Regulation

- a. The hypothalamus detects changes in fluid volume, which triggers thirst and the release of ADH.
- b. The sympathetic nervous system can influence renal blood flow, glomerular filtration rate, and hormonal secretion, thus affecting fluid and electrolyte balance.

IMPORTANCE OF FLUID AND ELECTROLYTE BALANCE IN HEALTH

Fluid and electrolyte balance is important for maintaining overall health and proper function. Importance of fluid and electrolyte balance in health includes:

1. Cell function and homeostasis

- Electrolytes such as sodium, potassium, calcium, and magnesium are essential for various cellular processes, including nerve impulse transmission, muscle contraction, and enzyme activity.
- Proper fluid balance helps regulate body temperature, pH levels, and osmotic pressure, which are vital for cellular homeostasis.

2. Fluid distribution

- Fluid balance is necessary for maintaining blood volume.

4. Regulation of blood pressure

- The balance of fluids and electrolytes influences blood pressure regulation. For example, sodium retention can lead to increased blood volume and hypertension.

5. Kidney function

- The kidneys play a vital role in maintaining fluid and electrolyte balance by filtering blood, reabsorbing necessary substances, and excreting waste.

6. Impact on overall health

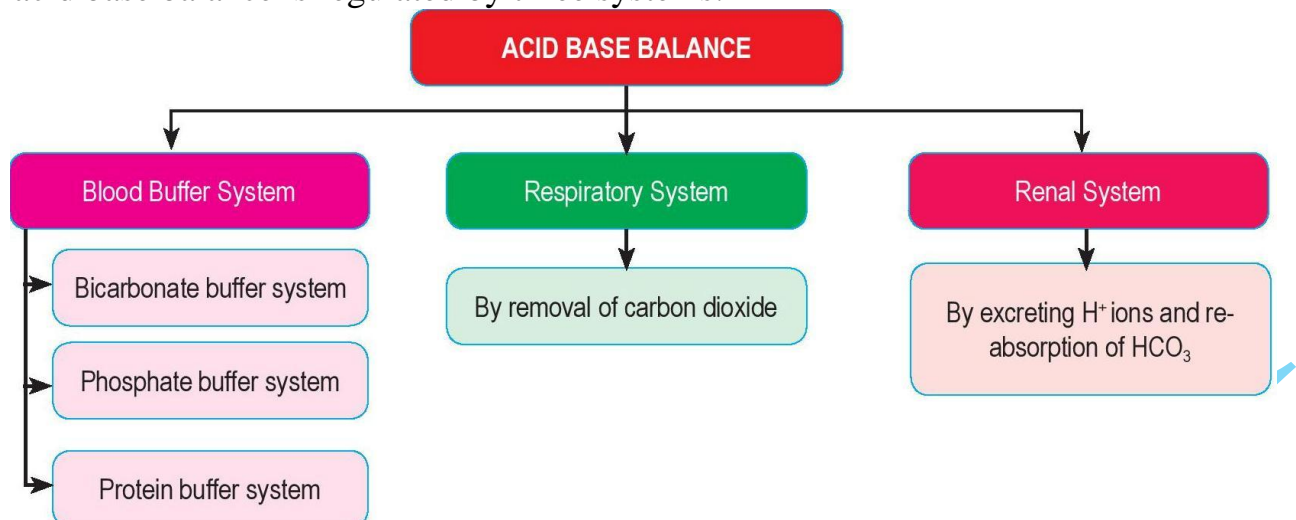
- **Prevention of disorders:** Imbalances can lead to conditions such as dehydration, overhydration, hyponatremia, hyperkalemia, and metabolic disturbances, which can have serious health implications.
- **Recovery from illness:** Maintaining fluid and electrolyte balance is important during recovery from illness, surgery, or strenuous physical activity.

ACID BASE BALANCE

The balancing act in the body between acidity and basicity is known as acid-base balance.

Regulation of Acid Base Balance

The acid base balance is regulated by three systems.



- 1. Buffer System:** Any solution which can resist change in pH even on addition of small amount of strong acid or base is known as buffer system.

Types of buffer system

- a. Bicarbonate buffer system:** It is present in extra cellular fluid.
 - b. Phosphate buffer system:** It consists of a weak acid.
 - c. Protein buffer system:** It is present in the blood, both in the plasma and red blood cells.
- 2. Respiratory System:** Lungs play an important role in the maintenance of acid-base balance by removing CO_2 which is produced during various metabolic activities in the body. This CO_2 combines with water to form carbonic acid. Since carbonic acid is unstable, it splits into H^+ and HCO_3^- .
 - 2. Renal System:** The kidneys are maintaining the acid base balance of the body fluids by the secretion of hydrogen ions and by the retention of bicarbonate ions.

BODY FLUID AND ELECTROLYTE IMBALANCE

BODY FLUID IMBALANCE (APPLIED PHYSIOLOGY OF BODY FLUIDS)

1. Dehydration

Decreased in water content of the body is known as dehydration.

Classification of Dehydration

1. On the Basis of % of Fluids Loss

On the basis of % of fluids loss, the dehydration is of three types:

- a. Mild dehydration:** It occurs when fluid loss is about 5% of total body fluids. Mild dehydration is not very serious and can be treated easily by rehydration.
 - b. Moderate dehydration:** It occurs when fluid loss is about 10% of total body fluids. Moderate dehydration becomes little serious and immediate treatment should be given by rehydration.
 - c. Severe dehydration:** It occurs when fluid loss is about 15% of total body fluids. Severe dehydration becomes severe and life threatening and requires hospitalization and emergency treatment.
- 2. On the Basis of Ratio Between Water Loss and Sodium Loss**
On the basis of ratio between water loss and sodium loss, dehydration is classified into three types:
 - a. Isotonic dehydration:** The balanced loss of water and sodium in the case of diarrhea or vomiting is known as isotonic dehydration.

- b. **Hypertonic dehydration:** The loss of more water than sodium in the case of fever is known as hypertonic dehydration.
- c. **Hypotonic dehydration:** The loss of more sodium than water in the case of excess use of diuretics is known as hypotonic dehydration.

Causes of Dehydration

Some common causes of dehydration are:

1. Insufficient intake of water
2. Severe diarrhea and vomiting
3. Excess urinary output due to renal disorders.
4. Excess loss of water through urine due to endocrine disorders such as diabetes mellitus, diabetes insipidus and adrenal insufficiency.
5. Prolonged physical activity without consuming adequate amount of water in hot environment.
6. Excess sweating leading to heat frustration (extreme loss of water, heat and energy).
7. Use of laxatives or diuretics in order to lose weight quickly.
8. Significant injuries to skin, such as burns or mouth sores, or severe skin diseases or infections (water is lost through the damaged skin).

Signs and Symptoms of Dehydration

1. Mild and moderate dehydration

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|--------------------------------|-----------------------------|
| a. Dryness of the mouth | e. Headache |
| b. Excess thirst | f. Dizziness |
| c. Decrease in sweating | g. Weakness |
| d. Decrease in urine formation | h. Cramps in legs and arms. |

2. Severe dehydration

- | | |
|-------------------------------|------------------------------|
| a. Decrease in blood volume | d. Hypovolemic cardiac shock |
| b. Decrease in cardiac output | e. Fainting. |
| c. Low blood pressure | |

3. Very severe dehydration

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|---------------------------------------------------|------------------|
| a. Damage of organs like brain, liver and kidneys | c. Renal failure |
| b. Mental depression and confusion | d. Convulsions |
| | e. Coma. |

Treatment of Dehydration

Treatment depends upon the severity of dehydration. In mild dehydration, the best treatment is drinking of water and stopping fluid loss. However, in severe dehydration drinking water alone is ineffective because it cannot compensate the salt loss. So the effective treatment for severe dehydration is oral rehydration therapy.

Oral rehydration therapy

Oral rehydration therapy (ORT) is the treatment for dehydration in which an oral rehydration solution (ORS) is administered orally. ORS was formulated by World Health Organization (WHO). This solution contains anhydrous glucose, sodium chloride, potassium chloride and trisodium citrate. In case of very severe dehydration, proper treatment is the intravenous administration of necessary water and electrolytes.

Prevention of Dehydration

Prevention is really the most important treatment for dehydration. Consuming plenty of fluids and foods that have high water content (such as fruits and vegetables) should be enough for most people to prevent dehydration.

People should be cautious about doing activities during extreme heat or the hottest part of the day, and anyone who is exercising should make replenishing fluids a priority.

Since the elderly and very young are most at risk of being dehydrated, special attention should be given to them to make sure they are receiving enough fluids.

2. Overhydration

Overhydration is the condition characterized by great increase in the water content of the body. It is also known as water intoxication, hyperhydration, water excess or water poisoning.

Treatment of overdehydration

Mild water intoxication requires only fluid restriction. In very severe cases, the treatment includes:

- Diuretics to increase water loss through urine.
- Antidiuretic hormone (ADH) receptor antagonists to prevent ADH-induced reabsorption of water from renal tubules.
- Intravenous administration of saline to restore sodium.

ELECTROLYTE IMBALANCE

- Hyponatremia:** Hyponatremia is an electrolyte imbalance and is indicated by a high level of sodium in the blood. The normal range for blood sodium level is 136 to 145 mmol/l.
- Hypernatremia:** Hypernatremia is an electrolyte imbalance and is indicated by a lower than-normal level of sodium in the blood.
- Hypokalemia:** Hypokalemia is a condition refers to serum or plasma levels of potassium ions above 5.0 mm. The normal concentration of potassium in the serum is 3.5 to 5.0 mm.
- Hyperkalemia:** Hyperkalemia is a condition of below normal levels of potassium in the blood serum. Hyperkalemia means serum or plasma levels of potassium ions that fall below 3.5 mm.
- Hypocalcemia:** Hypocalcemia is an abnormally high level of calcium in the blood, usually more than 10.3 milligrams per deciliter of blood. The normal range for blood calcium level is 8.6 to 10.3 mg/dL.
- Hypercalcaemia:** Hypercalcaemia is a condition refers to low blood calcium level in the blood, usually lower than 8.6 mg/dL.
- Hypomagnesaemia:** Hypomagnesaemia is an electrolyte disorder in which there is a high level of magnesium in the blood. The normal range of blood magnesium level is 1.7 to 2.2 mg/dL (0.85 to 1.10 mmol/L).
- Hypermagnesaemia:** Hypermagnesaemia is an electrolyte disturbance which there is a low level of serum magnesium (less than 1.46 mg/dL) in the blood.

Causes of Electrolyte Imbalance

There are several reasons for an electrolyte imbalance, including:

- Kidney disease
- Not replenishing electrolytes or staying hydrated after exercise
- Prolonged periods of vomiting or diarrhea
- Poor diet
- Severe dehydration
- An imbalance of the acid-base, or the proportion of acids and alkalis in the body
- Congestive heart failure
- Cancer treatment
- Some drugs, such as diuretics
- Bulimia

Signs and Symptoms of Electrolyte Imbalance

- Irregular heartbeat
- Weakness
- Bone disorders
- Twitching
- Changes in blood pressure
- Confusion
- Seizures
- Numbness
- Nervous system disorders
- Excessive tiredness
- Convulsions
- Muscle spasm

Treatment of Electrolyte Imbalance

1. Fluid replacement

The fluid replacement in the body during the dehydration has various ways or routes:

- Oral rehydration therapy
- Intravenous therapy
- Nasogastric feeding

a. **Oral rehydration therapy:** The oral rehydration therapy (ORT) is a type of fluid replacement used to prevent or treatment of dehydration especially due to diarrhea. It involves drinking water with modest amounts of sugar and salt added (Oral rehydration solution or ORS) while continuing to drink. The routine therapy also includes supplemental zinc.

b. **Intravenous therapy:** Intravenous therapy (IV therapy) is the infusion of liquid substances directly into a vein. The therapies administered intravenously are often included in the designation of specialty drugs. Intravenous infusions are commonly referred to drips because many systems of administration employ a drip chamber, which prevents air from entering the blood stream (air embolism), and allows an estimation of flow rate.

Intravenous therapy may be used to correct electrolyte imbalances, to deliver medications, for blood transfusion or fluid replacement to correct, for example: Dehydration. The intravenous therapy could also be used for chemotherapy.

c. **Nasogastric feeding:** It is administration of food directly into the stomach using a tube passed into the stomach through the nose or mouth. Breast milk, liquid food, and formula give through the tube directly into the stomach.

TYPES OF REHYDRATION SOLUTION

The concentration of body fluid is expressed in terms of tonicity. Tonicity is the measure of osmolarity. According to tonicity the solutions are classified into three categories.

1. **Isotonic Solution:** The solution having the same effective osmolality (tonicity) as body fluids is known as isotonic solution. Examples: 0.9% sodium chloride solution (normal saline) and 5% of glucose solution.
2. **Hypertonic Solution:** The solution which has greater effective osmolality than the body fluids is known as hypertonic solutions. Example: 2 % sodium chloride solution.
3. **Hypotonic Solution:** The solution which has less effective osmolality than the body fluids is known as hypotonic solutions. Example: 0.3 % of sodium chloride solution.

When the red blood cells or other cells are placed in hypotonic solution, water moves inside the cells resulting in swelling of cells.

BODY FLUIDS AND ELECTROLYTES

