

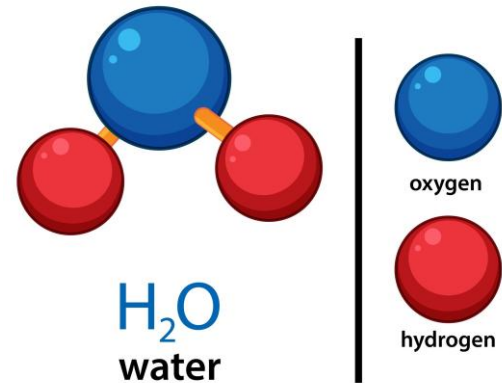


جامعة المستقبل
AL MUSTAQBAL UNIVERSITY
كلية الطب

Lab 3: Water and electrolyte balance

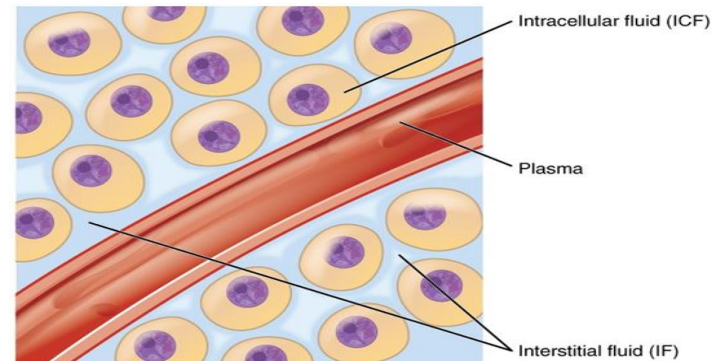
Introduction

- **Water** is a chemical substance with the formula **H₂O**, meaning each molecule is made of:
- 2 hydrogen atoms
- 1 oxygen atom
- It exists in three main states:
- **Liquid** (water we drink)
- **Solid** (ice)
- **Gas** (water vapor or steam)
- Water is the largest component of the human body, accounting for about 60% of body weight in adults



Body Water Distribution

- Total body water \approx 60% of body weight
- Intracellular fluid (ICF): 2/3
- Extracellular fluid (ECF): 1/3
- ECF includes **plasma** and **interstitial fluid**



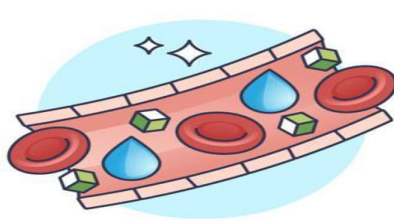
• **Functions of water**

- - Solvent for biochemical reactions
- - Transport of nutrients and waste
- - Support digestion
- - Temperature regulation
- - Lubrication and cushioning
- - Blood pressure regulation

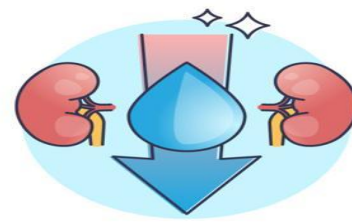
FUNCTIONS OF WATER IN THE HUMAN BODY



**REGULATING BODY
TEMPERATURE**



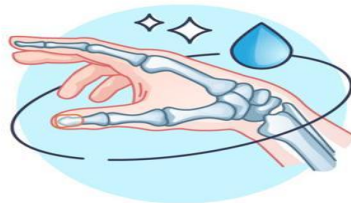
**TRANSPORTING
NUTRIENTS AND OXYGEN**



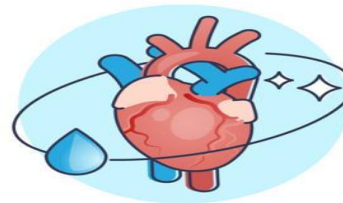
**REMOVING
WASTE PRODUCTS**



**MOISTURIZING
TISSUES**



**LUBRICATING
JOINTS**



**REGULATING
BLOOD PRESSURE**



**SUPPORTING
DIGESTION**

Factors Affecting Water Distribution

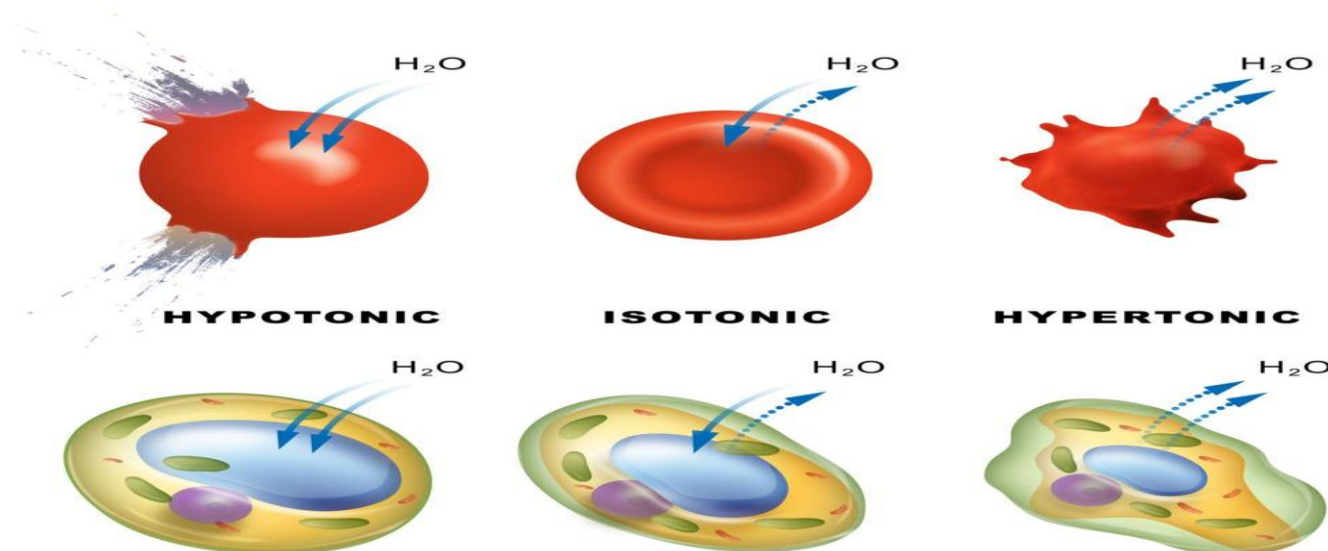
- **Age** → infants have more body water
- **Sex** → males > females (more muscle mass)
- **Body composition** → fat contains less water

Clinical Correlation

- **Dehydration** → decreased blood volume, hypotension
- **Overhydration** → dilution of electrolytes (especially Na^+)
- **Edema** → excess fluid in interstitial spaces

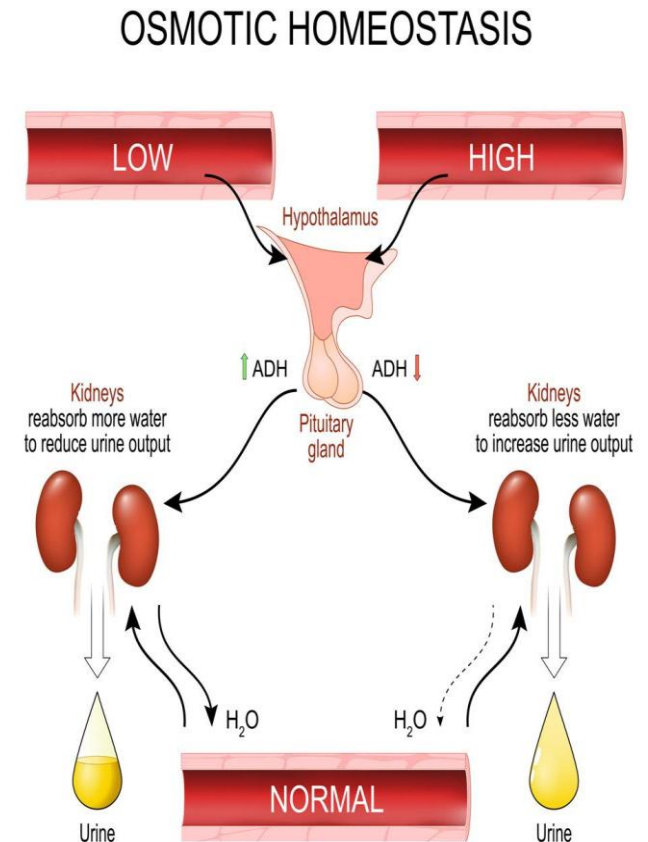
Osmosis and Fluid Movement

- Water moves across semipermeable membranes by **osmosis**, from areas of low solute concentration to high solute concentration.
- Three types of solutions depend on this concept:
- **Isotonic solution:** cells remain normal
- **Hypotonic solution:** water enters cells → swelling
- **Hypertonic solution:** water leaves cells → shrinking
- This concept is crucial in IV fluid therapy.



Regulation of water balance

- Water balance is controlled by:
 - **Hypothalamus (thirst mechanism):**
Detects increased blood osmolarity and triggers thirst to increase water intake.
 - **ADH (antidiuretic hormone):**
Hormone released from the posterior pituitary that increases water reabsorption in the kidneys, reducing urine volume and concentrating it.
 - **Kidneys:**
Regulate water balance by conserving water during dehydration and excreting excess water when fluid intake is high.

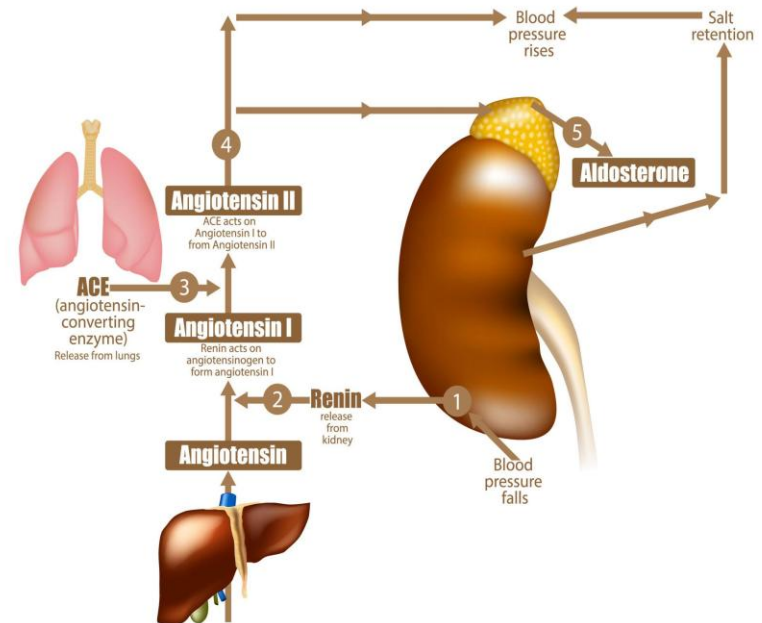


What Are Electrolytes?

- Electrolytes are charged ionized particles in body fluids. Examples: Na^+ , K^+ , Ca^{2+} , Cl^- , Mg^{2+}
- **Electrolytes functions** to regulate:
 - Osmotic pressure
 - Acid–base balance
 - Neuromuscular activity
 - Enzymatic reactions
- Even small disturbances can cause life-threatening arrhythmias or CNS dysfunction.

Electrolyte Balance Regulation

- **Electrolyte Balance** controlled by **hormones and kidneys**
- **Aldosterone:**
 - Increases **sodium reabsorption**
 - Increases potassium excretion
 - Causes water retention
- **RAAS (renin angiotensin aldosterone system):**
 - Activated by low blood pressure or low sodium
 - Increases **sodium and water reabsorption**
 - Raises blood pressure
- **ANP (Atrial Natriuretic Peptide):**
 - Released when blood volume is high
 - Increases sodium and water excretion
 - Lowers blood pressure
- **Kidneys:**
 - Main regulators
 - Control filtration, reabsorption, and excretion of electrolytes
- **Parathyroid hormone**
- Main Ca^{2+} regulator by Increases blood Ca^{2+}



Sodium Balance

- Sodium (Na^+) is the **main extracellular cation**
- Normal serum level: 135–145 mmol/L
- **Main functions:**
- Maintains osmotic pressure
- Regulates fluid balance
- **Controls blood volume & blood pressure**
- Important for nerve and muscle function

Hyponatremia (<135 mmol/L)

- **Causes:** excess water, SIADH (Syndrome of Inappropriate Antidiuretic Hormone), renal disease
- **Symptoms:**
- Headache
- Confusion
- Seizures

Hypernatremia (>145 mmol/L)

- **Causes:** dehydration, water loss
- **Symptoms:**
- Thirst
- Dry skin
- Neurological symptoms

Potassium Balance

- Potassium (K^+) is the **main intracellular cation**
- Normal serum level: 3.5–5.5 mmol/L
- Main functions:
 - Maintains resting membrane potential
 - Essential for nerve conduction
 - Important for muscle contraction (especially heart)

Hypokalemia (<3.5 mmol/L)

- **Causes:** vomiting, diarrhea, diuretics
- **Symptoms:**
 - Muscle weakness
 - Fatigue
 - Cardiac arrhythmias

Hyperkalemia (>5.0 mmol/L)

- **Causes:** renal failure, tissue breakdown
- **Symptoms:**
 - **Dangerous cardiac arrhythmias**
 - ECG changes (peaked T waves)

Calcium Balance

- **Calcium (Ca^{2+}) is the main extracellular divalent cation**
Normal serum level: 2.2–2.6 mmol/L

Main Functions:

- Essential for **bone and teeth formation**
- Important for **muscle contraction** (including heart)
- Required for **nerve transmission**
- Plays a role in **blood clotting**

Hypocalcemia (<2.2 mmol/L)

- **Causes:** vitamin D deficiency, hypoparathyroidism
- **Symptoms:**
 - Muscle cramps (tetany)
 - Seizures
 - Numbness/tingling

Hypercalcemia (>2.6 mmol/L)

- **Causes:** hyperparathyroidism, malignancy
- **Symptoms:**
 - Weakness
 - Kidney stones
 - Cardiac arrhythmias

Magnesium balance

Magnesium (Mg^{2+}) is an important intracellular cation

Normal serum level: 0.7–1.1 mmol/L

Main Functions:

- Cofactor for many **enzymes and ATP reactions**
- Important for **nerve and muscle function**
- Helps regulate **heart rhythm**
- Supports **potassium and calcium balance**

Case Presentation

- A 65-year-old male presents to the emergency department with: Weakness, Confusion and Reduced urine output
- History reveals: Persistent vomiting for 3 days and Poor fluid intake
- **Laboratory Results**
 - Sodium (Na^+): **150** mmol/L (*Normal: 135–145 mmol/L*)
 - Potassium (K^+): **3.1** mmol/L (*Normal: 3.5–5.0 mmol/L*)
 - Chloride (Cl^-): **110** mmol/L (*Normal: 98–106 mmol/L*)
 - Bicarbonate (HCO_3^-): **20** mmol/L (*Normal: 22–28 mmol/L*)

What is the interpretation of the results?

- **Hypernatremia** (\uparrow Na^+)
- **Hypokalemia** (\downarrow K^+)
- Mild metabolic imbalance

What is happening in this patient?

- This patient has been **vomiting for several days** and not drinking enough fluids.
As a result, the body is losing **water and important electrolytes**.

Why is sodium high (Hypernatremia)? and how affect the body ?

- When the body loses more **water than sodium**, the sodium becomes **more concentrated in the blood**, and this leads to **hypernatremia (high Na⁺)**

Effect on the body:

- Water moves out of cells → cells shrink
- Brain cells shrink → causes **confusion and neurological symptoms**

Why is potassium low (Hypokalemia)? and how affect the body ?

- Vomiting causes loss of **potassium from the body**

Effect on the body:

- Muscles become weak
- The heart becomes unstable → risk of **arrhythmias**

What is the role of the lab here?

- Detect electrolyte imbalance early
- Understand the severity of the condition
- Guide treatment (fluids, electrolytes)
- Without lab tests, this condition could be missed and become dangerous

Good luck