WATER AND ELECTROLYTES

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Advance Clinical Biochemistry I (MA 407)

Summer Semester

Week Two

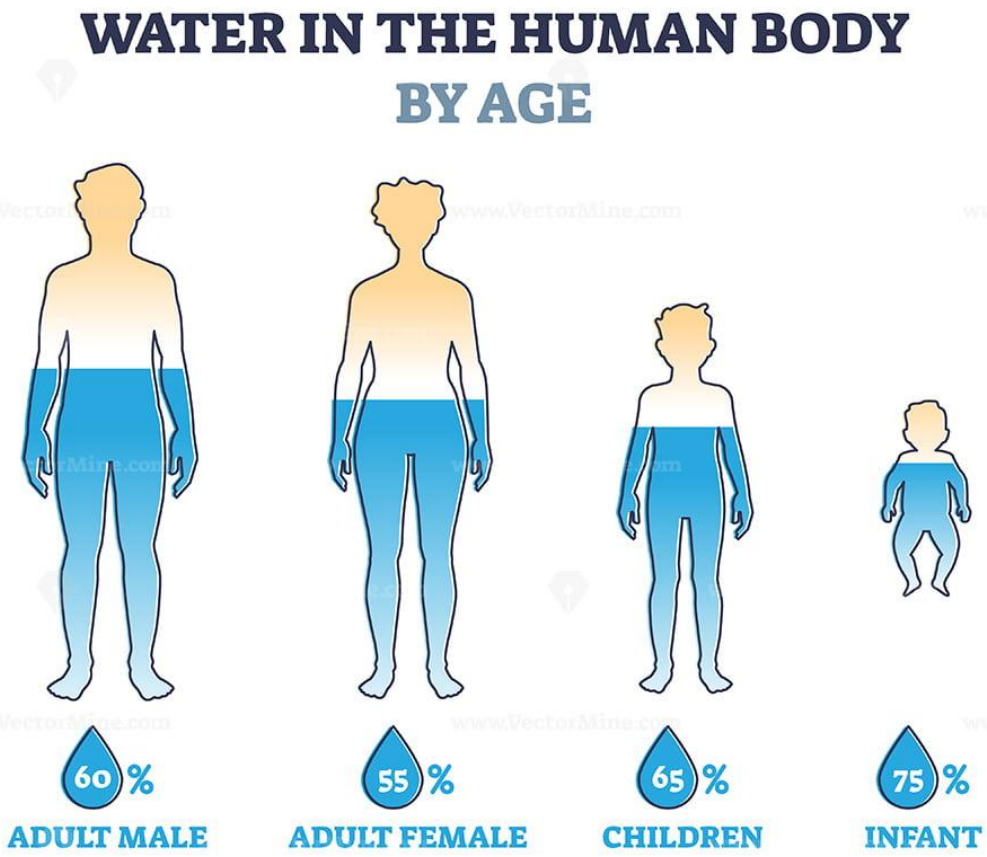
11/08/2024

Outlines

- Water and its biochemical importance.
- Electrolytes and its biochemical importance.
- Disorders of electrolyte homeostasis

Objectives

- At the end of the lesson, the students should be able to:
- Know the importance of water and its distribution in the tissues.
- Know the importance of electrolytes and their distribution across body fluids.
- Understand the clinical effects and management of electrolytes in the body fluids.
- Understand electrolyte imbalance conditions



Water/Medium

- The human body is composed of mostly the water, averagely 60%.
- Water can vary roughly between 45 – 75% in the human adult
- The amount changes slightly with age, gender, and hydration levels.
- Infants have the highest, followed by children then adult.

DISTRIBUTION OF WATER ACROSS MAJOR BODY ORGANS

BIOCHEMICAL FUNCTIONS OF WATER

Water/Medium

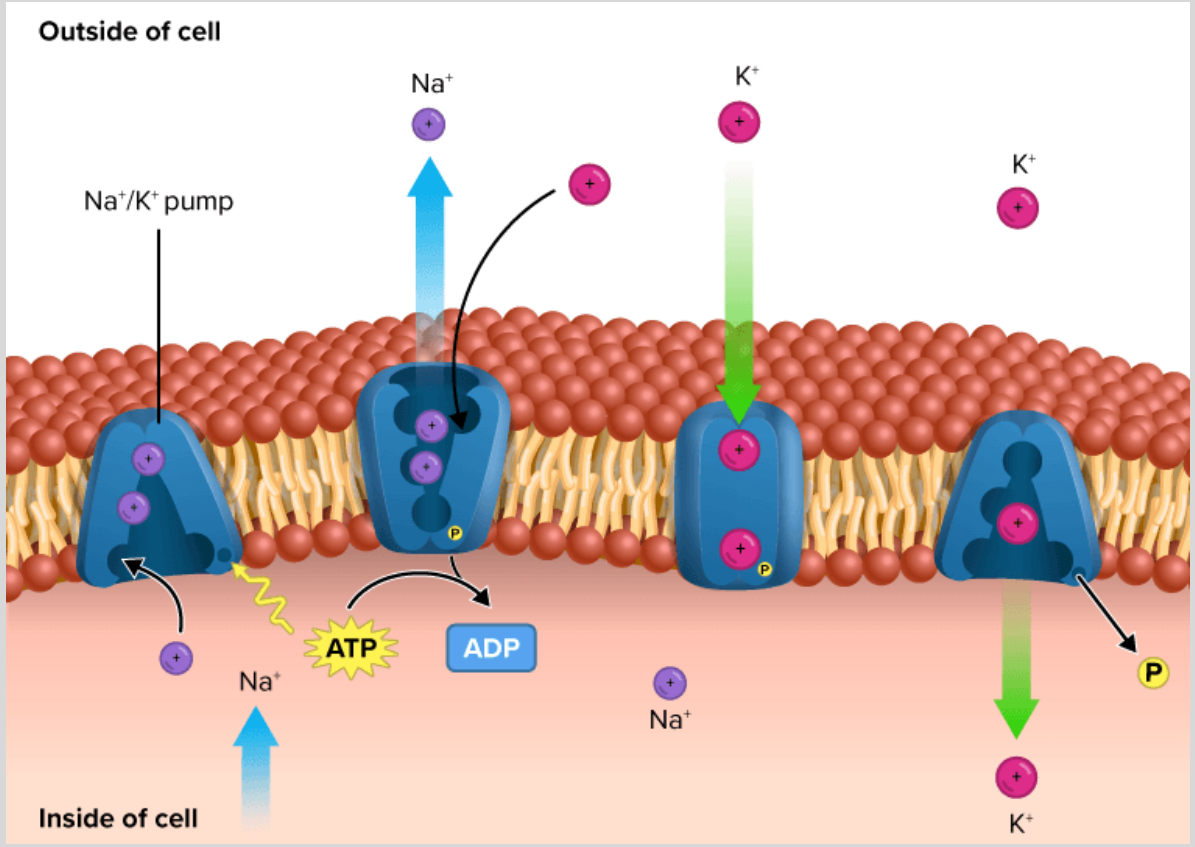
- ✓The common clinical problems in many areas of clinical practice are **Fluid loss**, **retention**, or **redistribution.**
- ✓The management of these conditions is always urgent and requires a rapid assessment of the **historical background of patients.**
- ✓ Both the **internal** and **external** balance of these analytes must be considered.
- ✓The internal balance is the distribution between different body compartments, while the external balance matches **input with output**.

Electrolytes

- Electrolytes come from our food and fluids and are essential for basic life functioning.
- They are needed for maintaining electrical neutrality in cells and generating and conducting action potentials in the nerves and muscles.
- Significant electrolytes include **sodium, potassium, chloride, magnesium, calcium, and phosphate.**
- Electrolytes can be imbalanced, leading to high or low levels that disrupt normal bodily functions and can lead to life-threatening complications.

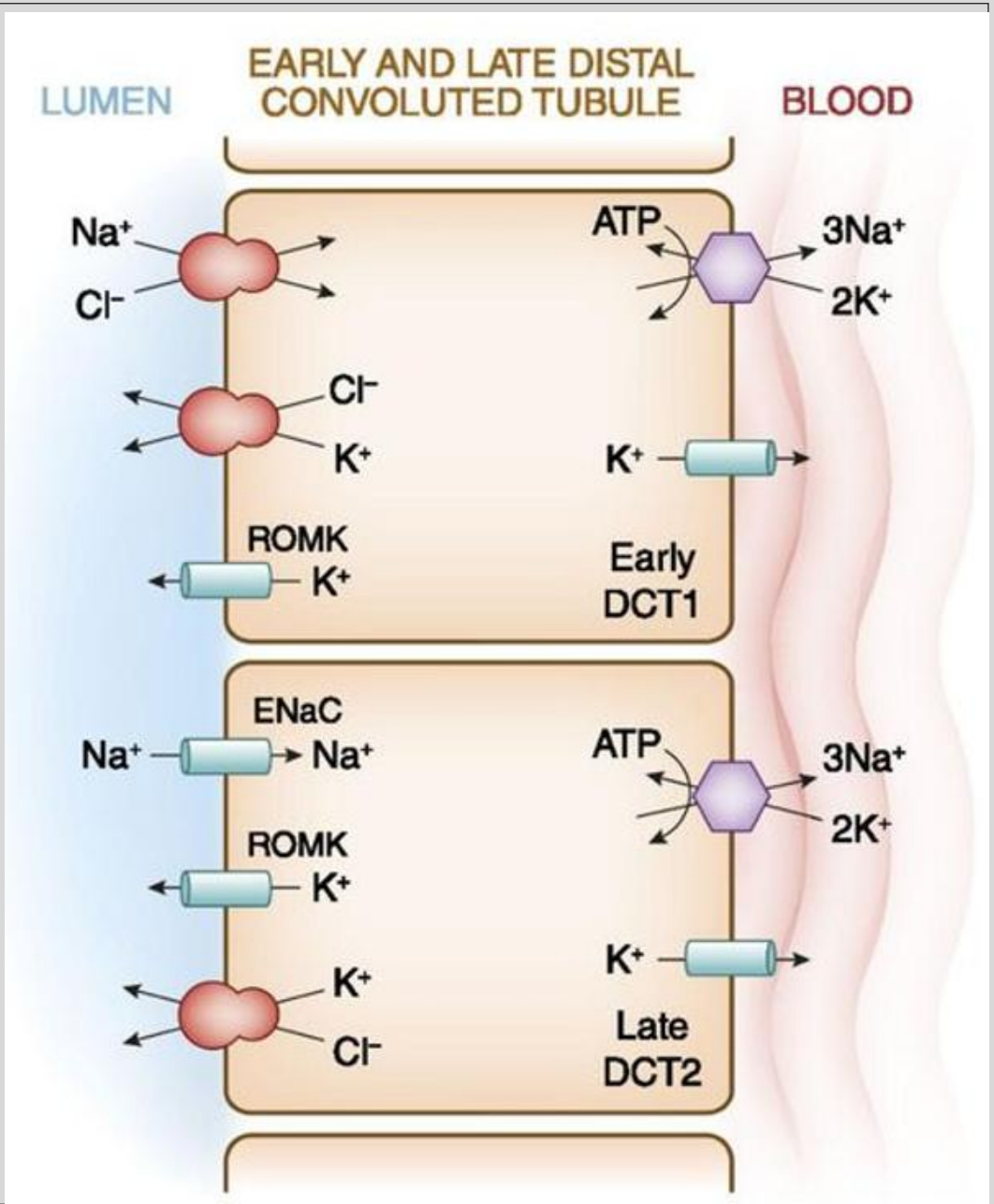
Sodium

- Sodium is one of the essential electrolytes in the extracellular fluid.
- It is responsible for maintaining the extracellular fluid volume and regulating the membrane potential of cells.
- Sodium is exchanged along with potassium across cell membranes as part of active transport.



Sodium

- Sodium regulation occurs in the kidneys, the proximal tubule is where the majority of sodium reabsorption takes place.
- Sodium transport occurs via sodium-chloride symporters, controlled by the hormone **aldosterone.**



Water and Sodium Balance

- The continuous movements of Na^+ and water between plasma and glomerular filtrate, or GI secretions, provide the **potential for large losses, which** may result in serious and rapid alteration in **internal balance.**

- Example, about **25 000 mmol of Na^+** are filtered at the glomerulus in **24 h**, with subsequent reabsorption of about **99%.**

- Likewise, **1000 mmol of Na^+** enters the GI tract in various secretions each day, but **less than 0.5% (5 mmol)** is normally lost in the feces.

Internal distribution

✓In a 70 kg adult, total body water is about **42 L** comprising about **28 L** of ICF and **14 L** of ECF.

✓ Total body Na^+ is about **4200 mmol** and is mainly extracellular – about **50% is in the ECF**, **40% in bone, and 10% in the ICF**.

✓**Osmolality** & **Colloid osmotic pressure** influence the distribution of fluid and electrolytes between the **ICF** and **ECF**

External water and electrolytes balance

- Water & Na^+ intake is largely a consequence of **social habits,** and it varies and controlled by the **sensation of thirst** via the action of **ADH**.

- In the states of **pure water deficiency**, plasma **tonicity increases**, causing a sensation of **thirst** and stimulating **ADH** secretion.

- ADH promotes water reabsorption in a state of water or Na^+ **deficiency and vice versa**.

Regulation of external sodium balance

- Dietary intakes of Na^+ (and Cl^-) **vary worldwide**. A typical 'Western' diet provides 100–200 mmol of both Na^+ and Cl^- daily.

- The normal total body Na^+ can be **maintained** even if intake is **less than 5 mmol** or **greater than 750 mmol** daily.

- Urinary **losses of Na^+** normally **match its intake**. There is **little loss** of ions through the **skin or feces**. But in disease, the **GI tract** can become a **major source of Na^+ loss**.

Disorders of water and sodium homeostasis

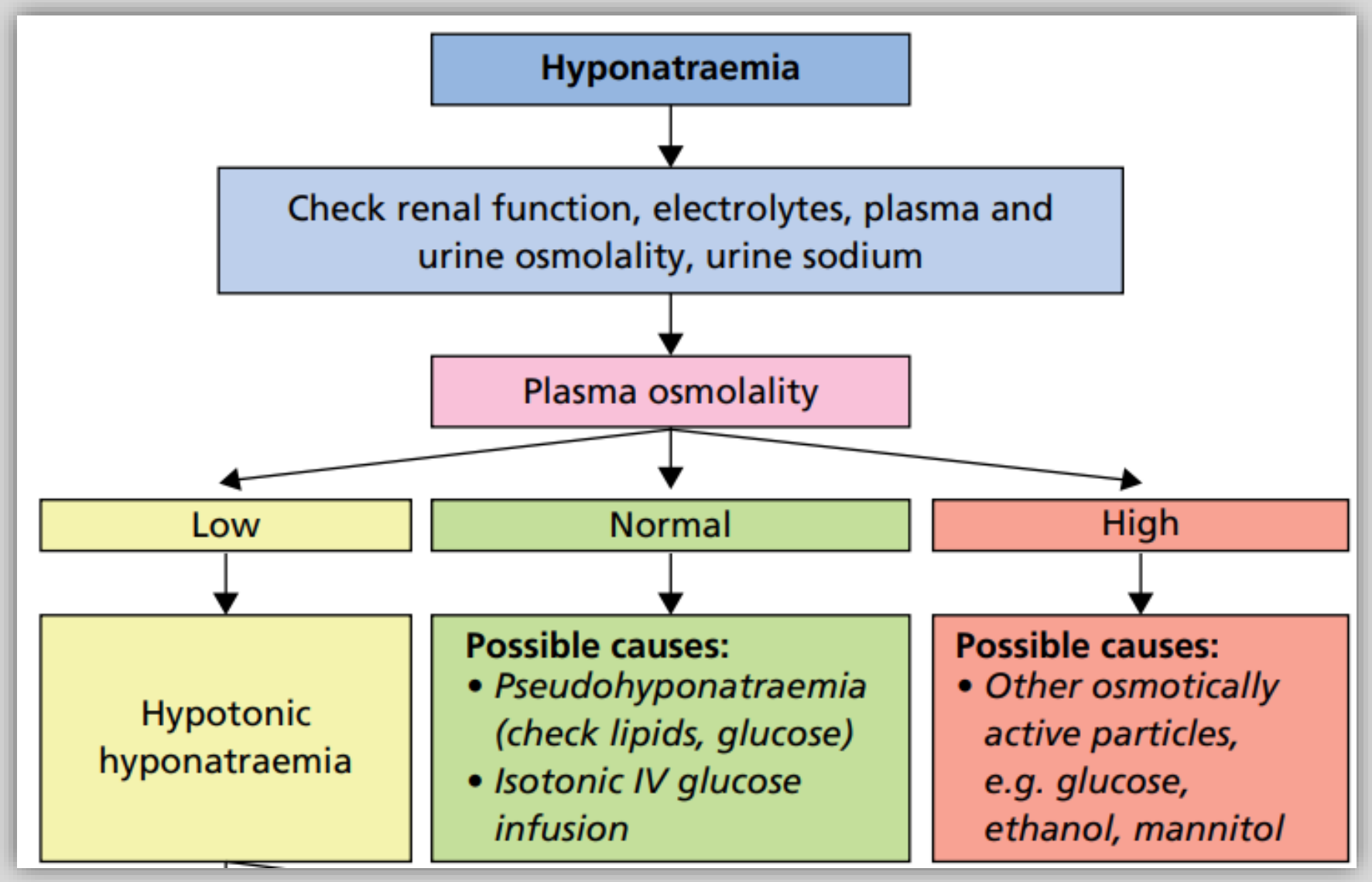
❑Hyponatremia:

- Hyponatremia is the most **common clinical** biochemical **abnormality**, occurring in up to **30%** of hospitalized **patients.**

- It has a wide spectrum of clinical symptoms from **mild** to **life-threatening**.

- Patients with **hyponatremia** can be divided into three categories, on the basis of **low**, **normal**, or **increased ECF volume**.

Distribution of hyponatremia



Causes and Categories of hyponatremia

ECF volume	Categories	Examples
Decreased total body Na^+ (loss of $Na^+ > H_2O$)		
• Extrarenal losses of Na^+ (urine Na^+ <20 mmol/L)	GI tract	Vomiting, diarrhoea
	Skin	Burns, severe dermatitis
	'Internal'	Paralytic ileus, peritoneal fluid
• Renal losses of Na^+ (urine Na^+ >20 mmol/L)	Diuretics	
	Kidneys	Diuretic phase of renal tubular necrosis
	Adrenals	Mineralocorticoid deficiency
Normal or near-normal total body Na^+	Acute conditions	Parenteral administration of water, after surgery or trauma, or during or after delivery
	Chronic conditions	
	Anti-diuretic drugs	Opiates, chlorpropamide
	Kidneys	Chronic renal failure
	Adrenals	Glucocorticoid deficiency
	Vasopressin excess	SIADH (Table 2.6)
	Osmoregulator	Low setting in carcinomatosis
Increased total body Na^+	Acute conditions	Acute renal failure
	Chronic conditions	Oedematous states (see Chapter 2: Hyponatraemia with increased ECF volume)

Hypernatremia

- The most common cause of increased tonicity of body fluids, the ICF volume is decreased due to the movement of water out of cells.

- ***With decreased body sodium***; this is the most common group that occurs usually due to extrarenal loss of hypotonic fluid.

- ***With normal body sodium***; it occurs when there is insensible loss of water and insufficient water intake as replacement (hot climates, unconsciousness or high fever)

- ***With increased body sodium (uncommon)***; the mild type may be caused by an excess of glucocorticoids. Treatment may be with diuretics or, rarely, by renal dialysis.

Causes and category of hypernatremia

Body sodium	Categories	Examples
Decreased body Na^+ (loss of H_2O > Na^+)	Extrarenal	Sweating, diarrhoea
	Renal	Osmotic diuresis (e.g. diabetes mellitus)
Normal body Na^+ (loss of H_2O only)	Extrarenal	Fever, high-temperature climates
	Via kidneys	Diabetes insipidus, prolonged unconsciousness
Increased body Na^+ (retention of Na^+ > H_2O)	Steroid excess	Steroid treatment, Cushing's syndrome, Conn's syndrome
	Intake of Na^+	Self-induced or iatrogenic, oral or parenteral

Summary

- Human body composed of mainly the water, and the quantity varies with age and gender as well as individual organs.
- Electrolytes such as **sodium, potassium, chloride, magnesium, calcium, phosphate,** and **bicarbonates are found from food and fluids, they play crucial role in human health biochemically and physiologically.**
- Na^+ is one of the essential electrolytes in the ECF, its imbalance causes clinical conditions namely hyponatremia and hypernatremia and could advance to life threatening diseases.
- Regulation of water and sodium level improves the function of various organs that leads to systemic well being with eventual improvement in the quality of life.

Take home message

- ✓ Mention 5 biochemical importance of water in the human body
- ✓ What is the average range of water content in a human body?
- ✓ Differentiate between ICF and ECF, and state the one of higher biochemical importance
- ✓ Mention 3 electrolytes with their respective clinical importance
- ✓ Reabsorption of sodium occurs at ..... of the nephron
- ✓ Sodium reabsorption is controlled by ..... hormone.
- ✓ Describe the importance of the internal distribution of water/fluid in the human system
- ✓ Differentiate between hyponatremia and hypernatremia.
- ✓ Which among the two conditions is common and causes more damages to human system?


Questions
Comments
Feedback