PHARMACEUTICAL INORGANIC CHEMISTRY- BP104T

UNIT: 2 (ACIDS, BASES AND BUFFERS)

CLASS: 1

TOPIC: MAJOR EXTRA AND INTRA CELLULAR ELECTROLYTES

Electrolytes: Substance when dissolved in solution separates into ions & is able to carry an electrical current

Cation - positively charged electrolyte e.g. Ca^{++}
Anion - negatively charged electrolyte e.g. Cl^-

But in our body, electrolytes are certain charged nutrients present in our body thathave many important functions like:

- Electrolytes regulate our nerve and muscles function, our body's hydration, blood pH, blood pressure, and rebuilding of damaged tissue.
- The body cells require a perfect pH, osmotic balance and ionic balance. This balance is maintained by the body fluids which contains inorganic and organic solutes. These solutes can be electrolytes, acid, bases, blood products, carbohydrates, amino acids, proteins.

Electrolytic Fluid Compartments: Body contain 60-70% of water

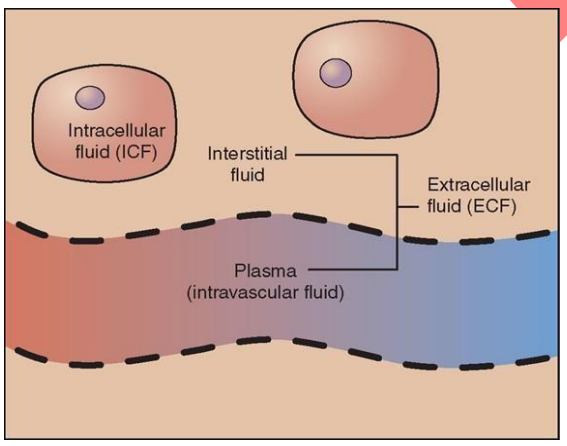
Body fluids

Intracellular Fluid
(Fluid inside the cell)
[45-50% of body weight]

Extracellular fluid

Fluid Plasma or Vascular fluid
(Fluid within blood vascular system)
[4-5% of body weight]

Interstitial
(Between the cell)
[12-15% of body weight]



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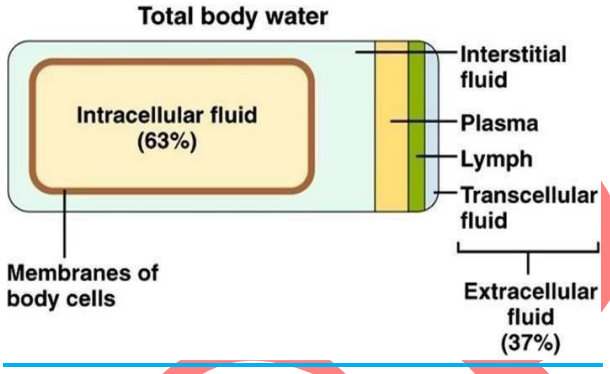
- The term 'extracellular fluid' includes both interstitial and vascular fluids.
- These three compartments are separated from each other by membranes that are permeable to water and many organic and inorganic solutes.
- They are nearly impermeable to macromolecules such as proteins and are selectively permeable to certain ions such as Na+, K+, Mg2+



Functions of Electrolytes:

- Maintain electrolytic balance, including acid-base balance and osmotic equilibrium in various body fluids.
- To facilitate specific metabolic functions by supplying the specific ion to the bodyθ fluids associated with the concerning cell or organ.
- To regulate the total amount of water in body fluids.
- Our heart, muscles and nerve cells use electrolytes to maintain voltage across their cell membranes and to carry electrical impulses to other cells.
- A muscle contraction needs calcium (Ca++), sodium (Na+), and potassium (K+) to be present.
- Deficiency and excess of electrolyte level lead to either weak muscles or muscles that contract too severely.

Electrolytic Imbalance and its causes:

- Body has capacity to adjust slight variation in concentration of electrolytes in fluid compartments.
- Mainly electrolytic level is kept constant by our kidneys and other hormones. Whenever there is a change in concentration of ions in any compartment, water will migrate across the cell membrane to re-establish osmotic equilibrium.
- If body is unable to adjust the concentration of fluid electrolytes then externally "electrolytic replacement therapy" is used.
- Body electrolytic levels tend to alter when water levels in the body changes- when our level of hydration goes up or down.
- Several other causes include:

- Kidney disease
- Vomiting or prolong periods
- Poor diet
- Severe dehydration
- Diarrhea
- Congestive heart failure
- Edema (fluid get accumulated in intestinal space between cell due to low osmotic pressure) Acid-Base imbalance

Symptoms of electrolytic Imbalance:

- The symptoms will depend on which electrolyte is out of balance, and whetherθ that level is too high or too low.
- An altered level of magnesium, sodium, potassium, or calcium may produce one or more of the following symptoms:
  - Irregular heart beat
  - Weakness Bone disorder
  - Blood pressure change Confusion Seizures
  - Nervous system disorder
  - Convulsion Muscle spasm

Major Physiological Ions and their functions:

8 Major Physiological Ions

Cations	Anions
Sodium (Na^+)	Chlorides (Cl^-)
Potassium (K^+)	Bicarbonates (HCO^{3-})
Calcium (Ca^{++})	Phosphates (HPO^{4-})
Magnesium (Mg^{2+})	Sulphates (SO_4^{2-}

MAJOR EXTRACELLULAR IONS

CHLORIDE (Cl^-)

Amount present in body: 50 mEq/Kg; Recommended daily Requirement: 5-10 g as NaCl

Major Food Source: Common table salt, Animal food

Absorption from GIT and Fate in Body (Metabolism): Completely absorbed, eliminated from blood by glomerular filtration and possibly reabsorbed by the kidney tubules

Principle Physiological/ Metabolic Function: Maintenance of proper hydration, osmotic pressure, normal electrolyte balance, acid-base balance, Gastric HCl

Deficiency: Hypochloemia occur due to kidney disease, metabolic acidosis (due to diabetes or renal failure or prolong vomiting)

Excessive Presence: Hyperchloremia in dehydration, decreased renal blood flow associated with congestive heart failure (CHF), severe renal damage and excessive Clintake.

SODIUM (Na^+):

Amount present in body: 1.8 g/Kg; Recommended daily Requirement: Approx. 3-5 g.

Major Food Source: Table salt, baking soda, animal food and some vegetables.

Absorption from GIT and Fate in Body (Metabolism): Completely absorbed, excreted in sweat and urine, kidney regulates sodium contents of the body, hormone aldosterone increases reabsorption in renal tubules.

Principle Physiological/ Metabolic Function: Maintenance of normal hydration & osmotic pressure, acid-base balance, cell membrane permeability, muscle contraction, carbon dioxide transport, transmission of nerve impulses.

Deficiency: Hyponateremia may occur with excess loss of urine (diuresis) in diabetes insipidus, Addison's disease (with reduced secretion of anti-diuretic hormone, aldosterone) diarrhea & vomiting, renal damage.

Excessive Presence: Hypernateremia may occur in hyperadrenalism (Cushing's syndrome) with increased aldosterone production, severe dehydration, certain types of head injury, hypertension.

CALCIUM (Ca^{++})

Amount present in body: 22 g/Kg (99% in bones, rest mainly in extracellular fluid); Recommended daily Requirement: About 1 g.

Major Food Source: Milk and milk products, eggs, green vegetables and some fishes.

Absorption From GIT and Fate in Body (Metabolism): Poorly absorbed (20-40%), variable absorption depend upon body requirements and affected by several factors c.f. increased in vit. D, lactose, acidity; decrease by fat, oxlate, low dietary phosphorous intake; excreted in faeces, parathyroid hormone controls blood Ca++ and phosphate level and mobilization in bones.

Principle Physiological/ Metabolic Function: Hardening of bones and teeth; coagulation of blood, muscle contraction, cell membrane permeability.

Deficiency: Hypocalcemia rickets in children's, poor growth, osteoporosis in adults, hyperexcitability, Cushing's syndrome (hyperactive adrenal cortex)

Excessive Presence: Hypercalcemia fatique, muscle weakness, constipation, anorexia (loss of appetite), cardiac irregularities, renal failure hypercalcemia is associated with hyperparathyroidism, hypervitaminosis D and some bone neoplastic (cancer) diseases.

BICARBONATE (HCO^{3-})

Amount present in body: 25-30 mEq/l in blood or plasma;

Major Food Source: Certain citrus fruits, milk etc. which in vivo converted into HCO3-

Absorption From GIT and Fate in Body (Metabolism): Bicarbonate salt (eg NaHCO3) if taken orally neutralized by gastric acid in stomach. Organic acid radicals lactate, citrate etc. are converted into bicarbonate in vivo. Most CO2 is exhaled by lungs but some as per body requirement converted into carbonic acid (H2CO3) and bicarbonate ion (HCO3-) constituting important physiological buffer.

Principle Physiological/ Metabolic Function: Maintenance of physiological acid-base balance, CO2 transport, maintenance of proper hydration, gastric acid, electrolyte balance.

Deficiency: Metabolic acidosis especially in uncontrolled diabetes with ketosis, renal disease, poisoning by an acid salt, loss of intestinal fluid in vomiting, diarrhoea. Increased respiration (hyperpnea)

Excessive Presence: Metabolic Alkalosis due to ingestion of large quantities of alkalis in treatment of acidity, peptic ulcer, metabolic acidosis, high intestinal obstruction, prolong Vomiting or excessive removal of gastric secretion. In Cushing's disease and during corticotropin or cortisone administration, in hypokalemia

MAJOR INTRACELLULAR IONS

PHOSPHATE (PO_4^{3-})

Amount present in body: 12 g/Kg; Recommended daily Requirement: 800 mg

Major Food Source: Milk and milk products, oatmeal, whole grains, legumes, nuts, egg yolk, meat especially in liver and kidney.

Absorption from GIT and Fate in Body (Metabolism): Easily absorbed by intestine, excretion is mainly through urine via kidney (unlike calcium) only small amount are excreted in faces.

Principle Physiological/ Metabolic Function: like calcium, it is predominant constituent of bones and teeth; building block of several important substance including those used by the cell

for energy (ATP), cell membranes, DNA & RNA, secondary messengers, modulation of enzyme activity, biological buffer etc.

Deficiency: Hypophosphatemia may be associated with vitamin D deficiency, hyperparathyroidism and prolong use of aluminium hydroxide gel antacids. It may leads to rare osteomalacia and cardiac arrhythmia.

Excessive Presence: Hyperphosphatemia may be associated with hypervitaminsois D, renal failure, hypoparathyroidism, it may lead to formation of kidney stone with possible kidney damage.

POTASSIUM (K^+)

Amount present in body: 2.6 g/Kg; Recommended daily Requirement: Approx. 1.5 - 4.5 gm

Major Food Source: Milk and milk products, fruits, vegetables, legumes, whole grain, meat.

Absorption from GIT and Fate in Body (Metabolism): Rapidly absorbed, excess excreted by kidney. Presence in intracellular compartment is 23 times higher than extracellular and this ration is maintained by active transport mechanism; through sodium potassium pump.

Principle Physiological/ Metabolic Function: Electrolyte, acid-base and water balance, buffer constituent, muscle contraction, membrane transport, carbon dioxide transport.

Deficiency: Hypokalemia (hypopotassemia) leading to depressed myocardial function, flaccid and feeble muscle and hypotension may occur from vomiting, diarrhoea, dehydration, burns, haemorrhages, intravenous infusion of potassium-lacking solution (dilution effect), excessive use of diuretics.

Excessive Presence: Hyperkalemia (hyperpotassemia) though less common, can occur with impaired renal functions (lack of excessive K+ excretion) and potassium retention due to acidosis.

MAGNESIUM (Mg^{2+})

Amount present in body: 0.5 g/Kg; Recommended daily Requirement: Approx. 350 mg Major

Food Source: Green vegetables, legumes, whole grain, nuts, beans, meat, milk.

Absorption from GIT and Fate in Body (Metabolism): Not readily absorbed from GIT, absorption retarded by alkaline media, unabsorbed Mg2+ is excreted through urine, bile and intestinal secretion.

Principle Physiological/ Metabolic Function: Essential component of some enzyme involving phosphate metabolism, constituent of bones and teeth; essential for protein synthesis, smooth functioning of neuromuscular function.

Deficiency: Hypomagnesemia can occur due to malnutrition, dietary restriction, chronic alcoholism, malabsorption, GIT disorder, medication and parathyroid hormone imbalance. Personality changes confusion, choreiform movement, tremors, cardiac disorders including vasodilation.

Excessive Presence: Hypermagnesemia (increase in blood levels of magnesium) depress the nervous system and higher levels can induce anaesthesia and paralysis of skeletal muscle.

SULPHATES (SO_4^{2-}):

It is present in the plasma and interstitial fluid on negligible amount. It is ingested through the consumption of plant or animal protein like cysteine. Its deficiency causes "Cystinuria" It is a constituent of protein, mucopolysacchrides, heparin and thiamine. Sulphur containing compounds are important in detoxification mechanism.

2 MARKS QUESTIONS

1. What is the biological importance of sodium and chloride ions?
2. Classify extra and intra cellular electrolytes with examples?

5 MARKS QUESTIONS

1. Explain the physiological role of sodium, calcium, bicarbonates and phosphates

10 MARKS QUESTIONS

1. Describe the physiological role of major intra and extra cellular electrolytes

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