

UNIT-IV

MAJOR INTRA AND EXTRA CELLULAR ELECTROLYTES

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An electrolyte is any substance that dissociates into ions in aqueous solution.

Ions can be positively charged (cations) or negatively charged (anions).

The major electrolytes found in the human body are:

Sodium (Na^+),	Chloride (Cl^-)
Potassium (K^+),	Phosphate (HPO_4^{2-})
Calcium (Ca^{++})	Sulfate (SO_4^{2-})
Magnesium (Mg^{++})	Bicarbonate (HCO_3^-)

Interstitial fluid and blood plasma are similar in their electrolyte make up. Na^+ and Cl^- being the major electrolytes. In the intracellular fluid, K^+ and HPO_4^- are the major electrolytes.

Physiological role of Sodium

- **This plays a crucial role in the excitability of muscles and neurones. It is also of crucial importance in regulating fluid balance in the body.**
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- **Sodium levels are extremely closely regulated by kidney function.**
- **Sodium is easily filtered in the glomerular portion of the kidneys and most of it is reabsorbed in the kidney tubules.**
- **Major factors that control the GFR include the blood pressure at the glomerulus and the stimulation of renal arteriole by the sympathetic nervous system.**
- **The amount of sodium reabsorbed in the proximal convoluted tubule remains almost constantly at around 67%.**

- **It is also a stimulator for aldosterone release from the adrenal glands. Because water has a close chemical affinity for sodium, it will follow that more water is reabsorbed in the kidney as well and this will put up the BP to a normal level.**
- **An increase in the arterial BP will result in the release of atrial natriuretic factor (ANF) from the left and right atria of the heart.**
- **This hormone actually inhibits renin and aldosterone release. By so doing the loss of sodium by the kidneys is enhanced by the decrease of aldosterone stimulated reabsorption.**
- **As we have already seen that water will follow sodium, it follows that water is lost from the body allowing the BP to drop to a normal level.**

Physiological role of Potassium

Potassium is the major cation of intracellular fluid. Concentration within the cells is 28x that of the extra cellular fluids. As with sodium it is extremely important in the correct functioning of excitable cells such as muscles, neurones, sensory receptors etc. It is also importantly involved in the regulation of fluid levels within the cell and in maintaining the correct pH balance within the body.

Potassium output is usually equal to potassium input. Sodium reabsorption by aldosterone is usually in exchange for either hydrogen ions or potassium ions. Therefore if sodium ions are reabsorbed more potassium is lost and vice versa. Thus, high levels of potassium in the interstitial fluid stimulate aldosterone response. Diseases such as Cushing's disease (over production of ACTH) and hyperaldosteronism (overproduction of aldosterone) can lead to a condition known as hypokalaemia (symptoms caused by low potassium levels) which manifests in muscle weakness, flaccid paralysis, cardiac arrhythmia and alkalosis.

The pH balance of the body also affects potassium levels. In acidosis potassium excretion is decreased (leads to hyperkalaemia higher than normal levels of potassium) whereas the opposite occurs in alkalosis.

Physiological role of Calcium

- Calcium is found mainly in the extracellular fluids whilst phosphorous is found mostly in the intracellular fluids. Both are important in the maintenance of healthy bone and teeth.
- Calcium is also important in the transmission of nerve impulses across synapses, the clotting of blood and the contraction of muscles. If the levels of calcium fall below normal level both muscles and nerves become more excitable.

Physiological role of Phosphate

Phosphate is required in the synthesis of nucleic acids and high-energy compounds such as ATP. It is also important in the maintenance of pH balance.

Physiological role of Magnesium

- **Most magnesium is found in the intracellular fluid and in bone. Within cells, magnesium functions in the sodium-potassium pump and as an aid to the action of enzymes.**
- **It plays a role in muscle contraction, action potential conduction, and bone and teeth production.**
- **Aldosterone controls magnesium concentrations in the extracellular fluid. Low Mg^{++} levels result in an increased aldosterone secretion, and the aldosterone increases Mg^{++} reabsorption by the kidneys.**

Physiological role of Chloride

- Chloride (Cl^-) is the most plentiful extracellular anion with an extracellular concentration 26 times that of its intracellular concentration.
- Chloride ions are able to diffuse easily across plasma membranes and their transport is closely linked to sodium movement, which also explains the indirect role of aldosterone in chlorine regulation.
- When sodium is reabsorbed, chlorine follows passively. It helps to regulate osmotic pressure differences between fluid compartments and is essential in pH balance.
- The chloride shift within the blood helps to move bicarbonate ions out of the red blood cells and into the plasma for transport. In the gastric mucosa, chlorine and hydrogen combine to form hydrochloric acid.

Physiological role of Bicarbonate

- Bicarbonate is alkaline, and a vital component of the pH buffering system of the human body (maintaining acid-base homeostasis).
- 70 to 75 percent of CO_2 in the body is converted into carbonic acid (H_2CO_3), which can quickly turn into bicarbonate (HCO_3^-).
- With carbonic acid as the central intermediate species, bicarbonate – in conjunction with water, hydrogen ions, and carbon dioxide – forms this buffering system, which is maintained at the volatile equilibrium required to provide prompt resistance to drastic pH changes in both the acidic and basic directions.
- This is especially important for protecting tissues of the central nervous system, where pH changes too far outside of the normal range in either direction could prove disastrous.
- Bicarbonate also acts to regulate pH in the small intestine. It is released from the pancreas in response to the hormone secretin to neutralize the acidic chyme entering the duodenum from the stomach.