MAJOR INTRA AND EXTRA CELLULAR ELECTROLYTES | Pharmacy Notes

Pharmacy Notes

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Electrolytes: A substance that forms ions when dissolved in water is an **electrolyte**. An ions can have either a **positive** charge (**cation**) or a **negative** charge (**anion**). Human body contains several primary ions of electrolytes. The major electrolytes found in the human body are;-

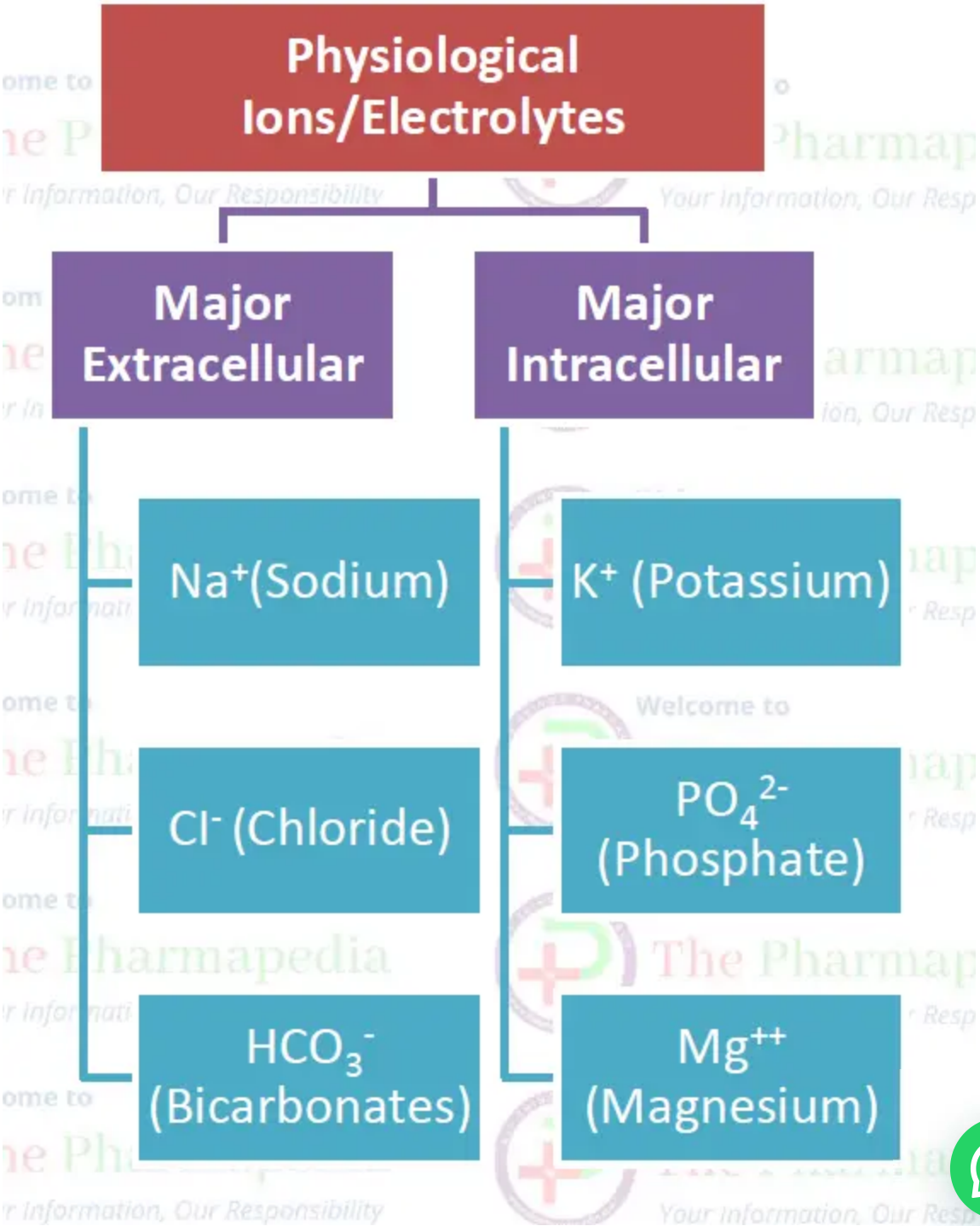
MAJOR ELECTROLYTES

Cation	Anion
Sodium (Na+)	Chloride (Cl-)
Potassium (K+)	Phosphate (HPO4−)

Cation	Anion
Calcium (Ca++)	Sulfate (SO4–)
Magnesium (Mg++)	Bicarbonate (HCO3-)

Major electrolytes

Physiological Ions: the ions which help or maintain normal physiology of our body known as Physiological Ions. These ions are directly associated with normal function & physiology of human body. Physiological Ions are present in both extracellular & Intracellular fluid.



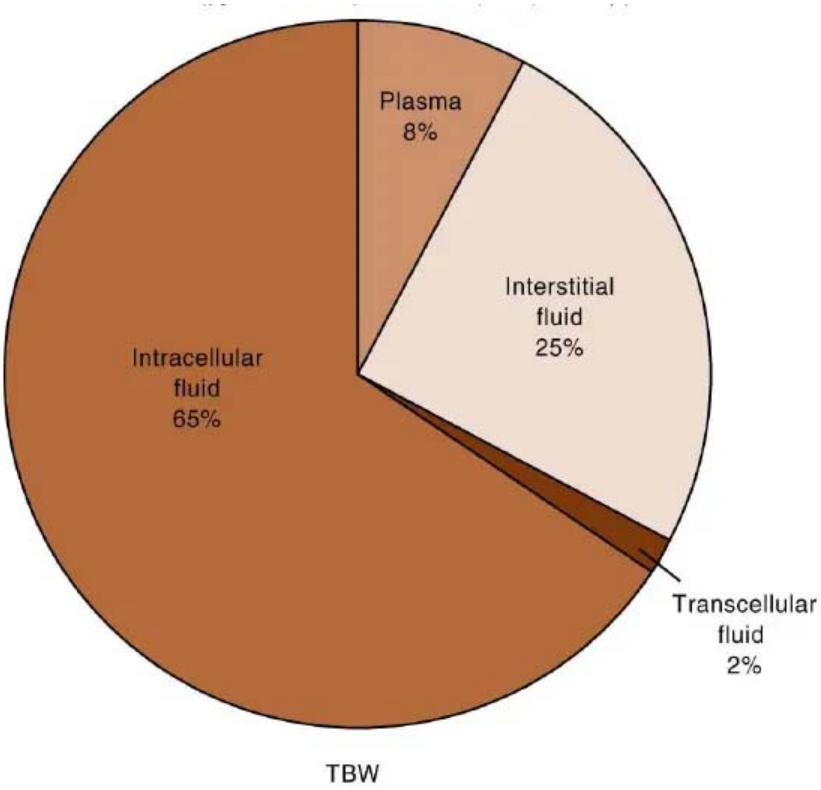
MAJOR INTRA AND EXTRA CELLULAR ELECTROLYTES

> *Amount of K (Potassium) in the body determines the volume of ICF as the chief intracellular cation*
> *Amount of Na (Sodium) in the body determines the volume of ECF as the chief extracellular cation*

The body fluids are solutions of inorganic and organic solutes. The concentration balances of the various components are maintained in order for the cells and tissues to have a constant environment. To maintain the electrolyte balance, there are regulatory mechanisms which controls pH, ionic balances, osmotic balances, etc.

The electrolytic concentration will vary with a particular fluid compartment.

1. Intracelluar fluid – (45 – 50% of body weight and present with in the cell).
2. Extracellular fluid – (12 – 15% of body weight and present outside the cell).
   a. Interstitial fluid – (12 – 15% of body weight and
   b. Plasma or vascular fluid (4 – 5% of body weight)



Total body water

Intracellular water: Fluid inside cells

Extracellular water: Fluid is outside the cells i.e. within interstitial tissues surrounding cells, blood plasma, and lymph

The electrolytes are necessary for maintaining osmotic pressure and electro neutrality (equal number of cations and anions). The electrolytes also essential to transmit impulses.

SODIUM

- Major extracellular cations(142 mEe/litre)
- Source- salt baking soda milk and seafood
- Function of sodium
  - Transmission and conduction of nerve impulses
  - Responsible for osmolarity of vascular fluids
  - Regulation of body fluid levels
  - Sodium shift into cell and potassium shift out of the cell -sodium pump
  - Assist with the regulation of acid base balance by combining with a chloride or bi carbonate

Hyponatremia

It is state of low level of sodium
Hyponatremia occurs due to
Excessive sweating
Diarrhoea and vomiting
Addison disease (decrease secretion of aldosterone)

Hypernatremia

High level of sodium
Due to
Excessive water loss from extracellular fluid as ADH deficiency
Excessive treatment of sodium salt
Cushing syndrome (increased aldosterone)

POTASSIUM

Major intracellular cations (100mE/litre)
Source- vegetables fruits milk legumes meet etc

Function

Promotes conduction and transmitting nerve impulse
Contraction of muscles
Promote enzyme action
Assist in the maintenance of acid base balance
Potassium is necessary for smooth and skeletal muscle contraction
Maintenance of normal cardiac rhythm

Hyperkalemia

High level of potassium
Due to high intake of potassium and kidney malfunction
Hypokalemia can cause cardiac arrhythmias and lead to cardiac arrest by fibrillation.

Hypocalcemia

State of low level of potassium
Due to vomiting diarrhoea burn diabetic coma
Overuse of thiazide diuretics alkalosis

CALCIUM

99% of calcium in the body present in bones and remaining 1% present in extracellular fluid compartment
Only 10% of ingested calcium is absorbed from git
Concentration in plasma about 9.4 mg/dl (9-10 mg/dl)

Function of calcium

Formation of bone and teeth
Helps in blood clotting factor
Contraction of smooth muscles
Maintaining the integrity of mucosal membrane
Cell adhension and function of the individual cell membrane as well regulation of metabolic acidosis

Hypercalcemia

High level of calcium
It causes
Nervous system is depressed and reflex action of CNS can become sluggish.
Also decrease QT interval of heart -lead to cardiac arrhythmia
Cause constipation and lack of appetite and depressed contractility of the muscles wall of GIT

Hypocalcemia

Low level of calcium
Occurs due to vitamin D deficiency and osteoblastic metastasis.

CHLORIDE

Major extracellular anion (103mEq/lite)
Source table salt
Function of chloride
Found in extracellular fluid
Changes the serum osmolarity
Helps in retention of water with sodium
Help in acid base balance
To form hydrochloric acid in stomach by combining with hydrogen ions

Hypochloremia

Decrease chloride concentration
Due to
Salt losing nephritis
Metabolic acidosis
Prolonged vomiting

Hyperchloremia

Increase concentration of chloride
Due to dehydration, decreased renal blood flow in CHF and excess chloride uptake

PHOSPHATE

Principal anion of intracellular fluid compartment
It inorganic phosphate in plasma is found two form

Source milk egg meat legumes

Function of phosphate

It is essential for proper metabolism of calcium normal bone and tooth development
Play important role in Buffer system of the body
Combined with liquid protein carbohydrate nucleic acid and high energy phosphate transport compound
Formation of ATP

Hyperphosphatemia

Due to hypervitaminosis of D, renal failure and hypoparathyroidism

Hypophosphatemia

Due to deficiency of Vitamin D, hyperparathyroidism and long-term aluminium hydroxide antacid therapy

In case of loss of electrolytes in the body due to water imbalance like diarrhoea, vomiting excessive use of diuretics etc. the above functions of electrolytes will be affec

During this condition, the patient should be given with suitable electrolyte in the form of injection or oral solutions to maintain the normal level of electrolyte.

THE ELECTROLYTES USED FOR REPLACEMENT THERAPY

1. Sodium chloride
2. Potassium chloride
3. Calcium chloride
4. Calcium gluconate
5. Potassium gluconate
6. Calcium lactate
7. Dibasic calcium phosphate
8. Tribasic calcium phosphate
9. Magnesium sulfate

1. SODIUM CHLORIDE (NaCl)

Preparation

It can be prepared from sea-water, under ground rock-salt deposits and by chemical means. Sea water contains about 3% of sodium chloride. Purest form of analytical grade sodium chloride is prepared by passing hydrogen chloride gas into a standard solution of the salt. Very pure sodium chloride precipitates out. The crystals are then centrifuged and dried.

Physical Properties

It occurs in the form of colourless, transparent cubical crystals, or as a white crystalline powder. It is odourless and slight saline test. It is slightly hygroscopic due to the presence of small amount of magnesium or calcium chloride. It is freely soluble in water and slightly soluble in alcohol

Chemical Properties

1. Sodium chloride gives white precipitate of silver chloride with solution of silver nitrate.

$NaCl + AgNO_3 \rightarrow AgCl\ (ppt) + NaNO_3$

The precipitate is light sensitive (affected by light) and it is soluble in dilute ammonia soluble in nitric acid.

2. It reacts with sulphuric acid or phosphoric acid to give hydrochloric acid.

$2NaCl + H2SO4 \rightarrow 2HCl + Na_2SO_4$

3. Sodium chloride is easily oxidized to liberate free chlorine.

Heating with Manganese dioxide and concentrated sulphuric acid produces chlorine.

$2NaCl + MnO_2 + 2H_2SO_4 \rightarrow MnSO_4 + Na_2SO_4 + 2H_2O + Cl_2$ (Gas)

Oxidation of solution of sodium chloride is used to prepare sodium hydroxide and chlorine.

Assay :

Modified Volhard's Method:

An accurately weighed quantity is dissolved in water and a known excess of N / 10 silver nitrate solution, concentrated nitric acid and nitrobenzene are added. It is titrated against N/10 ammonium thiocyanate solution using cerric ammonium sulphate as indicator.

Sodium chloride is precipitated as silver chloride by the addition of silver nitrate. Nitrobenzene is added to coagulate the silver chloride so that it will not interfere with the titration of the excess of silver nitrate with N/10 ammonium thiocyanate, since silver chloride reacts slowly with ammonium thiocyante.

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

$AgNO_3 + NH_4SCN \rightarrow AgSCN + NH_4NO_3$

Storage

It should be stored in a well closed container.

Chemical Incompatibility

When sodium chloride is treated with soluble salt of silver, mercurous or lead, the corresponding metallic chloride is precipitated.

$AgNO_3 + NaCl \rightarrow AgCl(ppt) + NaNO_3$

Uses

It produces effect of both chloride ion and sodium ion. Deficiency of sodium chloride leads to "salt Hunger" as indicated by metabolic disturbances etc.

1. It is used as fluid and electrolyte replenisher.
2. It maintains normal osmotic pressure of blood.
3. It is used as saline diuretics.
4. It is used in the formulations of I.V. fluids to maintain the iso-osmotic with blood serum.

Official Preparations of Sodium Chloride

1. Sodium chloride injection, U.S.P.

Contains 0.9% NaCl w/w

Use : Fluid and Electrolyte replenisher, irrigation solution. Dose : I.V. infusion 1 Litre.

2. Bacteriostatic sodium chloride injection, U.S.P Contains 0.9% NaCl.

Use : Sterile vehicle

3. Sodium chloride solution, U.S. P Contains 0.9% NaCl.

Use : Isotonic vehicle.

4. Sodium chloride tablets, U.S.P

Usually 600mg, 1 and 2.25 g tablets are available. Use : Electrolyte replenisher.

5. Dextrose and sodium chloride injection U.S.P.

Available in different strengths and different volumes.

% Dextrose	% NaCl	m. eq/lit	Available volume (ml)
5 %	0.11	18.8	250, 500 & 1000
5 %	0.20	34.2	250, 500 & 1000
5 %	0.225	38.5	250, 500 & 1000

Use : Fluid, nutrient & electrolyte replenisher.

6. Sodium chloride and dextrose tablets N.F.

Usually 200 mg of sodium chloride and 450 mg of dextrose tablets are available.

7. Mannitol and sodium chloride injection, USP

Different strengths and different volume are available.

% Mannitol	% NaCl	m. Eq/lit	Available volume (ml)
5	0.3	51.3	500 & 1000
10	0.3	51.3	500 & 1000
15	0.45	76.9	150 & 500
20	0.45	76.9	250 & 500

POTASSIUM CHLORIDE (KCl)

It may be obtained by separation and purification from its minerals like carnalite (KCl, $MgCl_2.6H_2O$). On laboratory scale it may be prepared by reacting potassium carbonate and hydrochloric acid.

$$K_2CO_3 + 2HCl \rightarrow 2KCl + H_2O + CO_2$$

Physical Properties

It occurs as colourless elongated, or cubical crystals, or as a white granular powder. It is odourless, has a saline taste. It is freely soluble in water, that is neutral to litmus. It is insoluble in alcohol.

Chemical Properties

Potassium chloride reacts with silver nitrate to give silver chloride as precipitate and potassium nitrate. This property is used to estimate the amount of potassium chloride in the pharmaceutical preparations.

Assay

A weighed quantity of substance is dissolved in water and titrated against standardized silver nitrate using potassium chromate as indicator. The end point is formation of brick red colour.

$AgNO_3 + KCl \rightarrow AgCl + KNO_3$

Uses

1. Potassium chloride is used as an electrolyte replenisher, along with sodium chloride and calcium chloride.

2. It is administered orally as solution, elixer or tablets in the case of potassium deficiency.

3. It is also used in the digitalis poisoning

Official preparations of potassium chloride

1. Potassium chloride injection, BP, USP

Available as 1.5g in 10 ml

3 g in 12.5 ml & 20 ml

4.5 & 6g in 30 ml

2. Potassium chloride tablets, USP

Available as enteric-coated tablets containing 300 mg or 1g.

3. Ringers injection, USP Contains 0.03% KCl

Use : Fluid and electrolyte replenisher

Usual dose : Intravenous infusion, 1 litre

4. Lactated Ringer's Injection USP Contains 0.03% KCl.

Use : Systemic alkaliser