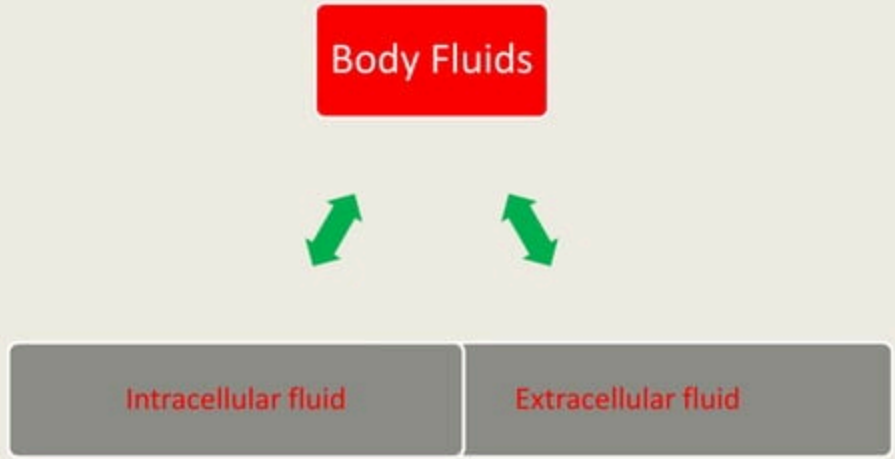
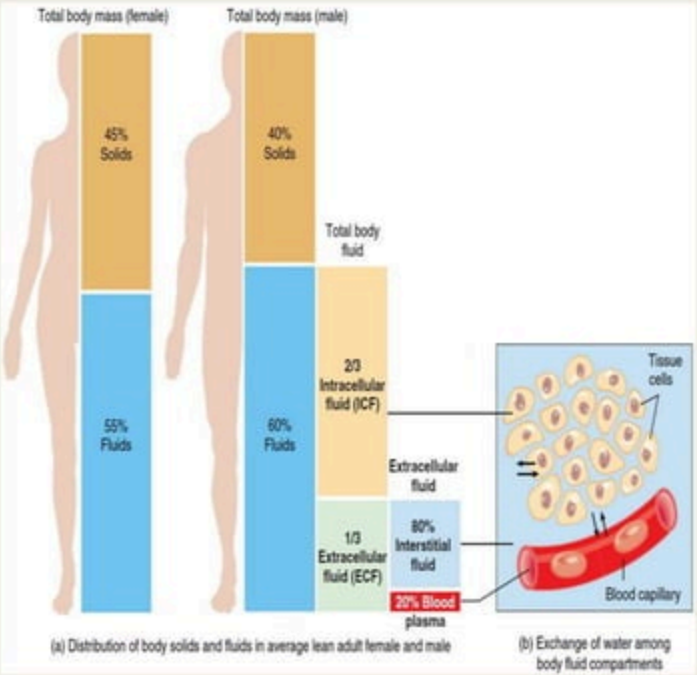
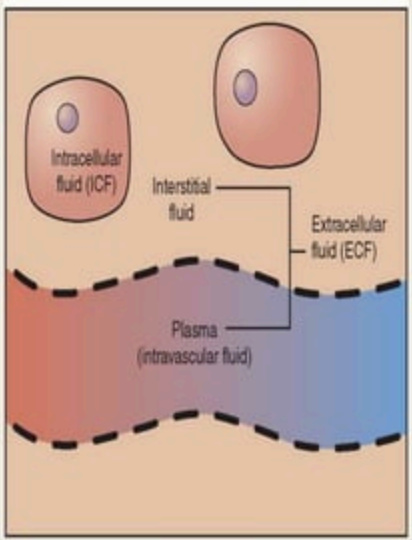
- About 55-56% of the adult human body is fluid.
- Around 60-70% of the volume of body is water
- The fluids in the body are solutions of organic and inorganic solutes which undergo distribution in the following major fluid compartments:

1. Interstitial fluid (**body fluid between blood vessels and cells**)
2. Vascular fluid or plasma fluid
3. Intracellular


Body Fluids
Intracellular fluid
Extracellular fluid


Total body mass (female)
Total body mass (male)
45% Solids
55% Fluids
40% Solids
60% Fluids
Total body fluid
2/3 Intracellular fluid (ICF)
1/3 Extracellular fluid (ECF)
Extracellular fluid
80% Interstitial fluid
20% Blood plasma
Tissue cells
Blood capillary
(a) Distribution of body solids and fluids in average lean adult female and male
(b) Exchange of water among body fluid compartments


Intracellular fluid (ICF)
Interstitial fluid
Extracellular fluid (ECF)
Plasma (intravascular fluid)

- **Intracellular fluid:** fluid inside the cells is called Intracellular fluid.
- **Extracellular fluid:** refers to all the body fluids outside the cells. The extracellular fluid has ions and nutrients needed by the cells for the maintenance of life.

All the body fluids contain electrolytes. The electrolytes conc. varies in these fluids.

- Electrolytes : Substance when dissolved in solution separates into ions & is able to carry an electrical current. Electrolytes also known as ionic solutions.

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

- Cation - positively charged electrolyte e.g. Na+
- Anion - negatively charged electrolyte e.g. Cl-

No. of Cations must equal to no. of Anions for homeostasis to exist in each fluid compartment

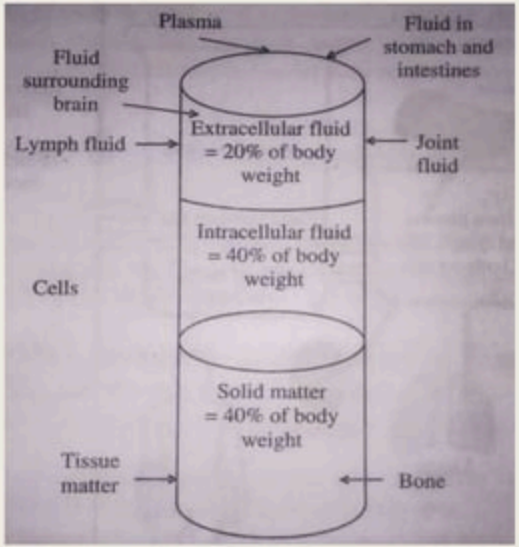
- Electrolytes in body fluid compartments:
- Intracellular: K, Mg, P
- Extracellular: Na, Cl, HCO3 (Bicarbonate)

➢ Physiological Importance of electrolytes:

- Regulation of blood oxygen and pH level, ie., acidity.
- Controlling the fluid distribution and water balance in the body.
- Maintaining an electrical gradient across the cell membranes, crucial for nerve transmission and muscle contraction.
- Allowing the movement of nutrients within the cells and the waste products out of the cells.
- Potassium , sodium and calcium assists muscle contraction.

- Electrolytes are present in the following fluid compartment.

1. Intracellular Compartment
2. Extracellular Compartment
3. Transcellular Compartment



Body fluid compartments

- Intracellular Compartment: It is present within the cell membrane. it constitutes 63% of the total body water.
- General composition of intracellular fluid is:

O2, more K+, PO_4^{3-}, Mg^{++}, SO_4^{2-}, less Na+, Cl-

Concentration of Imp. Ions in intracellular compartment

Ions	Concentration
K+	159mM
Na+	10mM
Cl-	3mM

Major intracellular solutes: Protein 12%, organic phasphates 18%, and inorganic ions 64%.

- **Extracellular Compartment:** It is present outside the cells. it constitutes 37% of the total body water.
- General composition of Extracellular fluid is:

More Na, Cl-, HCO_3^-, less K^+, Ca^{++} PO_4^{3-}, Mg^{++}, SO_4^{2-}

Concentration of Imp. Ions in Extracellular compartment

Ions	Concentration
K^+	3.5-5.0mM
Na^+	135-145mM
Cl^-	100-111mM

- Transcellular Compartment: A single epithelial layer separates the extracellular compartments' subdivision, known as transcellular compartment. The aqueous and vitreous humour of the eye, synovial fluid of the joints, cerebrospinal fluid of the CNS, glandular secretions and serous fluid within the body cavities are present in this compartment.

➢ Functions of major physiological ions:

1. Chloride
2. Phosphate
3. Bicarbonate
4. Sodium
5. Potassium
6. Calcium
7. Magnesium

- **Chloride:** In both vascular and interstitial fluid compartment the major extracellular anion is chloride . Chloride ions involved in maintenance of osmotic pressure, proper hydration, and normal cation-anion balance.
- **Sources of Cl**: main source of chloride is food as it undergoes complete absorption from intestinal track.

1. sea salt
2. table salt
3. Rye
4. Ketchup
5. Olives
6. Tomatoes
7. seaweed

- **Daily requirement:** for adult is about 2.3-2.9gm/day
- **Functions:**

1. The normal cation-anion balance in the compartment.
2. The osmatic balance b/w different fluids of the body is maintained by the Cl ions. Along with the sodium ions.
3. Osmatic pressure and proper hydration is maintained
4. The charge balance of the body fluids
5. Cl ions required for the production of HCl in stomach

- **Phosphate :** The principal intracellular anion is the phosphate (HPO2-4).which is present in the teeth and bones and also is a crucial buffering system related to calcium, fats and carbohydrates utilisation.

Physiological processes, such as formation of buffer systems influencing the acid-base balances, lipids and carbohydrates metabolism, energy storage and transfer, and hydrogen ions, renal excretion, demand the involvement of phosphate ions.

Sources of phosphate: protein rich food like,

1. Seafood
2. Dairy products
3. Meat

- **Daily requirement:** for normal adult is about 700mg/day
- **Functions:**

1. Mild laxative properties.
2. For the development of teeth and bones
3. Metabolism
4. After phosphorylation, many enzymes work as the coenzymes.
5. Phosphorylation helps in the metabolism of glucose and other hexose.
6. Urine pH is lowered by phosphate
7. Treatment of hypophosphatemia is done by the phosphates.

- **Bicarbonate:** The second most common extracellular anion is the bicarbonate (HCO_3^-).
- It is utilised as the most important buffer system of the body, along with carbonic acid. Metabolic alkalosis and acidosis may occurs due to the deficiency of bicarbonate ions.
- **Sources of bicarbonate:** fruits and vegetables
- **Daily requirement:** 325 milligrams (mg) to 2 grams
- **Functions**

1. Metabolic acidosis and kidney disturbances are treated with sodium bicarbonate due to its alkaline nature.
2. Acid-base balance in maintained by the bicarbonate ion.

- **Sodium:** The main extracellular cation is the sodium. Which is essential for maintaining the osmotic pressure and normal hydration. Daily diet of a normal human contain more than sufficient amount of sodium which undergoes complete absorption through the intestinal and urinary track.
- Kidney are the vital regulation of sodium conc. In body . Because excess sodium is excreted by them.
- **Sources of sodium:** Sodium rich food ,

1. Salt
2. Buttermilk
3. Cheese
4. Fish
5. Olives
6. Pulses

- **Daily requirement:** in adult daily requirement of sodium is about 2-5gm/day.
- **Functions:**

1. Osmotic pressure of the body fluids is maintained by the sodium ions.
2. Acid-base equilibrium is regulated by sodium ions in association with bicarbonate and chloride.
3. Cells permeability and muscles irritability are preserved by sodium.
4. Heart normal functioning is maintained by sodium. It also maintains blood pressure.

- **Potassium :** The major intracellular cation present in the body is potassium (K^+) whose conc. In intracellular fluid compartment is 23 times higher than that in the extracellular fluid compartment.
- Potassium ions along with sodium ions are involved in nerve conduction through sodium-potassium pump.
- There is rapid excretion of excess potassium by the kidney.
- **Source of Potassium:** Potassium rich fruits and vagetables

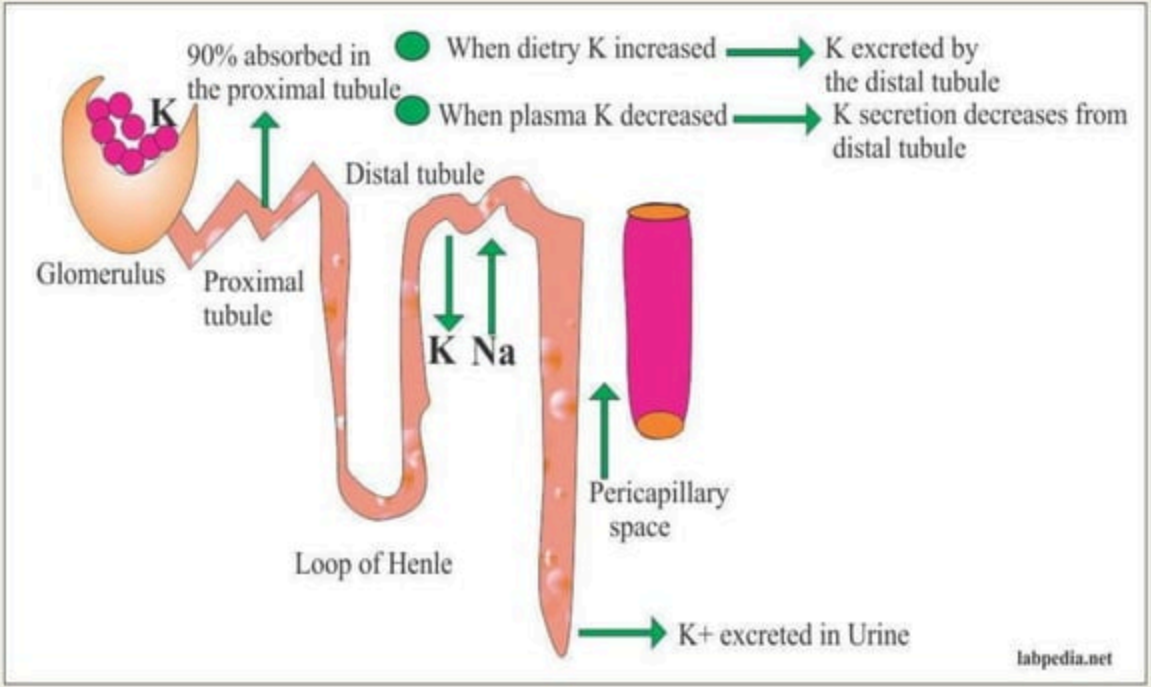
1. Apricots
2. Bananas

3. Oranges
4. Potatoes
5. Mushrooms
6. Milk

- Daily requirement: for adult is about 3.5gm/day
- Functions:

1. Nerve impulse transmission is regulate by potassium
2. Potassium is required for many biological activates e. g., muscle contraction of cadiac or heart
3. Various body fluids electrolyte composition is maintained by potassium

4. The pH regulation by hydrogen ions exchange is done by potassium
5. Treatment and prevention of hypokalaemia or potassium depletion is done with potassium salts.


90% absorbed in the proximal tubule
When dietry K increased
K excreted by the distal tubule
When plasma K decreased
K secretion decreases from distal tubule
K
Distal tubule
Glomerulus
Proximal tubule
K Na
Pericapillary space
Loop of Henle
K+ excreted in Urine
labpedia.net

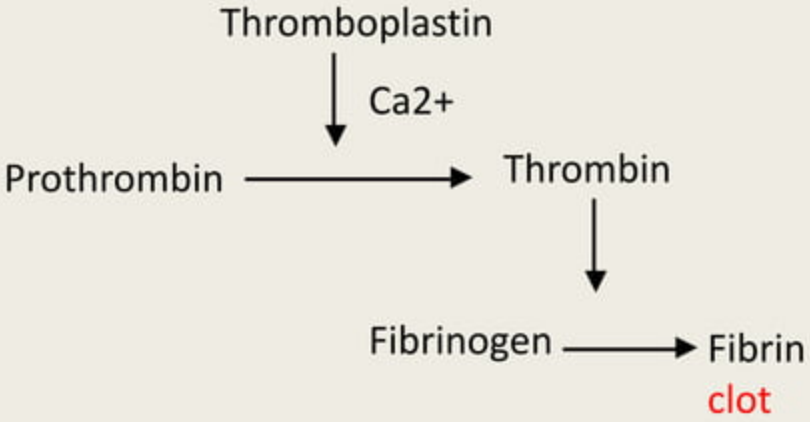
- calcium : An important constitution of teeth and bone is calcium (Ca^{2+}) . Which is involved in muscle functioning and in the blood clotting mechanisms.
- Calcium in higher amount is essential in children for growth and development of bones and tissues. Calcium is also stored in bones.
- 22gm/kg body weight of calcium is present in a human body.
- Source of calcium:

1. Milk
2. Cheese
3. Green vegetable
4. Eggs and fish

- Daily requirement: for adult is about 0.8gm/day
- Functions:

1. Play role in neuromuscular system and in mechanism of excitation-contraction coupling of the muscles.
2. Maintained cardiac function.
3. For maintenance of mucosal membranes, integrity, cell membranes, functioning and cell adhesion.
4. Autonomic nervous system and voluntary system require calcium ions for their normal functioning.
5. Formation of bones, teeth and skulls

➢ 6. Calcium participates in blood coagulation



Mechanism of calcium in blood clotting

- **Magnesium :** It is an important intracellular cation. Half amount of the body's total magnesium content is combined with phosphorous and calcium in the bone
- Large number of enzyme are activated by magnesium, especially carboxylases and kinases. DNA and RNA are also stabilised by magnesium and it is the body's 4th most abundant cation.
- **Source of Magnesium:**

1. Nuts
2. Un-milled grains
3. Green vegetables
4. Beans

- Daily requirement: for adult is about 270-350mg/day
- Functions:

1. For enzymes that transfer phosphate , magnesium acts as a co-factor.
2. For smooth functioning of neuromuscular system and for protein synthesis, magnesium is used.
3. Teeth and bones essentially constitute magnesium.
4. Glucose metabolism done by magnesium.

- **Electrolytes used for replacement therapy:** To maintain the homeostasis, conc. Of electrolytes in the body.
- There are usually three types of solutions used in the replacement therapy.

1. Sodium replacement
2. Calcium replacement.
3. Parenteral magnesium administration

- Sodium potassium replacement:

1. Sodium chloride (NaCl)
2. Potassium chloride (KCl)
3. Compound sodium chloride solution (lactated ringer's solution)
4. Oral rehydration solution (ORS), etc.

➢ Sodium chloride (NaCl) preparation:

- In the laboratory, it is prepared from common salt (impure) in water by passing hydrochloric acid gas. The crystals are precipitated out.
- In industrially, it is prepared by evaporation of sea-water in shallow pans. It contains certain impurities which are removed by dissolving common salt in water in cemented tank. Some alum (Aluminum Sulfate) and lime (Hydrated lime's chemical name is calcium hydroxide)are added. The suspension impurities get settle down easily.

➢ Sodium chloride (NaCl) physical properties:

1. Colourless.
2. Transparent cubes or as a white, crystalline powder.
3. It has a saline taste.
4. It is slightly hygroscopic (Hygroscopy is the phenomenon of attracting and holding water molecules via either absorption or adsorption from the surrounding environment).
5. pH 6.7-7.3
6. Freely soluble in water.

➢ Sodium chloride (NaCl)

Chemical Properties

1. Sodium chloride is rather easily oxidised to liberate free chlorine. For e.g. heating with manganese dioxide & conc. sulphuric aicd produces chlorine.

$$2NaCl + MnO_2 + 2H_2SO_4 \longrightarrow MnSO_4 + Na_2SO_4 + 2H_2O + Cl_2$$

2. Sodium chloride when react with silver nitrate gives a curdy precipitate of silver chloride.

$$NaCl + AgNO_3 \longrightarrow AgCl \downarrow + NaNO_3$$

The precipitate which is affected by light is soluble in dilute ammonia and insoluble in nitricc acid.

Uses

It is used as an electrolyte replenisher, emetic. It can be used in homeopathetic medicine. Solution of sodium chloride may be used as an eye-drop, nasal drop(to relieve nasal congestion) and as a mouthwash (to remove debris).

Assay

An accurately weighed quantity is dissolved in water & a known excess of 0.1M $AgNO_3$ solution, dil. HNO_3 and diethylphthalate are added. It is titrated with 0.1M ammonium thiocynate solution using ferric ammonium sulphate as indicator.

➢ Sodium chloride (NaCl)

This is a modified Volhard's method. Sodium chloride is precipitated as silver chloride by the addition of silver nitrate.

Dibutylphthalate is added to coat the silver chloride so that it will not interfere with the titration off the excess of $AgNO_3$ with 0.1M ammonium thiocyanate, since silver chloride reads slowly with ammonium thiocyanate.

Previously (in I.P. 66) sodium chloride was assayed by direct titration in neutral solution with 0.1N silver nitrate using potassium chomate as indicator.

$$AgNO_3 + NaCl \longrightarrow AgCl\downarrow + NaNO_3$$

$$AgNO_3 + NH_4SCN \longrightarrow AgSCN + NH_4NO_3$$

The same cannot be used now since silver chromate formed at the end point is soluble in acid.

- Calcium replacement.

1. Calcium gluconate
2. Calcium chloride
3. Calcium lactate
4. Calcium levulinate

➢ Calcium gluconate.

Chemical Formula: $[HOCH_2(CHOH)_4COO]_2Ca.H_2O$ **Molecular Weight:** 448.4

Method of Preparation

It is prepared by boiling a solution of gluconic acid with excess of calcium carbonate, filtering and crystallising the substance from filtrate.

$$2\ CH_2(OH)[(CHOH)]_4COOH + CaCO_3 \longrightarrow [HOCH_2(CHOH)_4COO]_2Ca + CO_2\uparrow + H_2O$$

Gluconic acid

Properties

It occurs as odourless, white crystalline powder, tasteless, freely soluble in boiling water, sparingly soluble in water and insoluble in alcohol, ether and chloroform.

Uses: It is used as a source of calcium ion in the treatment of calcium deficiency and hypocalcaemic tetany.

➢ Calcium gluconate.

Assay

The assay is based on complexometric type titration forming a well defined simple complex between calcium and disodium ethylenediamine titracetate (EDTA) using mordant black II as an indicator. The end point is a change of colour from red to blue. In this assay, a solution of magnesium sulphate is added before the titration to make the end point sharp.

Magnesium also forms a similar complex with EDTA. But these titration have to be carried out in the presence of buffer such as strong ammonia-ammonium chloride solution.

$$Ca^{2+} + H_2Y^{2-} \longrightarrow CaY^{2-} + 2H^+$$

An aqueous solution of the substane containing magnesium sulphate and strong ammonia-ammonium chloride is titrated with 0.05M disodium ethylenediaminee tetraacetate, using mordant black II as indicator. From the volume of 0.05M magnesium sulphate is substracted. Each ml o the remainder is equivalent to 0.024420g of $CaC_{12}H_{22}O_{14}.H_2O$.

Official Test for Identity

1. Give the reactions characteristic of calcium.

2. To a solution of the substance in water, ferric chloride solution is added. A yellow colour is produced.

- Electrolyte combination therapy :
  - Oral Rehydration Solution:

- it is given to the patients to prevent or treat mild to moderate fluid loss (5-10% dehydration) resulted due to diarrhoea or when food and liquid intake have been stopped momentarily.
- It provides sodium, chloride, potassium, water and other basic nutrients.
- Sodium transport and water absorption are carried out by a carbohydrate (2-2.5 % glucose) present in it.


Oral Rehydration Salts IP
ORS
W.H.O. RECOMMENDED FORMULA
THE ORAL REHYDRATION THERAPY
Restores body fluids & electrolytes lost due to dehydration
Sachet for Single Use
Composition: Each 4.2 gm pack contains:
Sodium Chloride IP 0.52 g
Potassium Chloride IP 0.30 g
Sodium Citrate IP 0.58 g
Dextrose IP (anhydrous) 2.7 g
Excipients q.s.
Concentration in mmol/litre
Sodium 75.0
Potassium 20.0
Chloride 65.0
Citrate 10.0
Dextrose 75.0
Total Osmolarity (mOsmol)... 245
Cipla


Cipla
Oral Rehydration Salts
W.H.O. RECOMMENDED FORMULA
Ready to Drink
Lemon
Net Contents: 200 ml

ORS Composition :

The standard (310mOsm/L) ORS formula has been replaced by new (245mOsm/L) formula of ORS as per the recommendation of WHO (**World Health Organization**)and UNICEF (**United Nations International Children's Emergency Fund**,)

ORS Composition :

Composition	Amount	Ions	Concentration
NaCl	2.6g	Na+	75mM
KCl	1.5g	K+	20mM
Trisodium citrate	2.9g	Cl-	65mM
Glucose	13.5g	Citrate	10mM
Water	1L	Glucose	75mM
TOTAL OSMOLARITY 245mOsm/L			

ORS administration :

- Patients are suggested to drink ORS at regular intervals of ½ - 1 hour. In the beginning , 5-7.5 % volume is given in every 2-4 hour.
- If a physically weak child refused to drink ORS. It can be given through intragastric drip, with an aim to restore the hydration within 6 hours.

Adverse Effects:

1. Hypernatremia (increase sodium level in blood)
2. Hyperkalaemia (increase conc. Of potassium)
3. Acid-base disturbances occurring occasionally.

NOTE: all these conditions are seen in case of renal failure or if errors occurs in reforming the bulk powders.

➢ Contraindications :

1. Repeated vomiting
2. Renal dysfunction
3. Shock

➢ Precautions:

1. Errors in rebuilding or diluting the viable powder
2. Parenteral replacement therapy is used to maintain electrolyte imbalances that has occurred due to fluid loss, inability to take fluids, serves gastric distension or serves vomiting.