

# Major intra and extra-cellular ELECTROLYTES

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Amit Z Chaudhari

# Flow

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# INTRODUCTION

**Electrolytes (dissolved ions):** chemicals dissociates into cations (+vely charged) and anions when they dissolve in the body fluids. E.g. acids, bases, NaCl

**What are intra and extra cellular Electrolytes?**

[sum15, sum13, win14]

**Intracellular Electrolytes :** present in the cell  
e.g. Potassium and phosphate ions

**Extracellular Electrolytes :** interstitial & vascular compartment  
(present out of cell)  
e.g. Sodium and chloride ions

**Role in the Body:**

- pH control, osmotic balance, perform physiological function and many more

# PHYSIOLOGICAL IONS

## (1) SODIUM

[win13,] [sum15, sum13]

- Location: extracellular compartment as salt  $\text{Na}^+$
- Normal level: 136-142 mEq / L
- Functions:
  - absorbed and excreted by cells ( maintain charge balance btwn the body fluids)
  - Along with  $\text{Cl}^-$  , maintains osmotic balance of all body fluids
  - In kidney, maintains blood-urine volume level

### Hyp *o* *n* *a* *t* *r* *e* *m* *i* *a*

⇒ Low level of sodium ( $\text{Na}^+$ ) in body

[win11]

- Reasons: extreme urine loss (in diabetic insipidus), kidney damage, diarrhea, vomiting, excessive sweating, diarrhea

# PHYSIOLOGICAL IONS

## (1) SODIUM

- Symptoms: muscular weakness, headache, respiratory depression
- Treatment: replenishment therapy

### Hypernatremia

2,2.5 [win11, win11, sum14]

⇒ Increased level of sodium in body

- Reasons: dehydration, high sodium intake
- Symptoms: intense thirst, fatigue
- Treatment: diuretics, cardiotonic drugs, low salt diet



# PHYSIOLOGICAL IONS

## (2) CALCIUM

[win14, win13, win12, win11, win11], 5 [sum14, sum13]

- Location: 1% in extracellular and 99% in bones and teeth
- Functions:

[win11] [sum13]

- blood clotting,
- muscle contraction
- release of ACh from neurons
- Bones and teeth

### Hypocalcemia

[win11] [sum13]

⇒ Decreased  $\text{Ca}^{++}$  level in body

- Reasons: lower absorption, Vit. D deficiency, bone cancer
- Symptoms: tetanic spasms, convulsions

# PHYSIOLOGICAL IONS

## (2) CALCIUM

### Hypercalcaemia

[win11] [sum13]

⇒ Increased level of  $\text{Ca}^{++}$  in body

- Reasons: hypervitaminosis D, bone neoplastic disease
- Symptoms: muscle weakness, constipation, cardiac irregularities

# PHYSIOLOGICAL IONS

## (3) CHLORIDE

- Location: It is majorly found in all body fluid  
Nearly 66% of ion content in plasma is chloride ion
- Normal level: abt 50 mEq / Kg
- Functions:
  - absorbed and excreted by cells ( maintain charge balance btwn the body fluids)
  - Along with  $\text{Na}^+$  , maintains osmotic balance of all body fluids
  - Takes part in formation of gastric acid

### Hypochloremia

⇒ Decreased  $\text{Cl}^-$  level in body

- Reasons: ...



# PHYSIOLOGICAL IONS

## (3) CHLORIDE

- metabolic acidosis seen in diabetes mellitus and renal failure
- Lack of reabsorption from kidney
- Therapy of diuretics
- Excessive vomiting – loss as gastric acid (HCl)

Symptoms: alkalosis, respiratory depression, muscle spasm

### Hyperchloremia

⇒ Increased Cl<sup>-</sup> level in body

- Reasons: excess loss of bicarbonate ions, dehydration, CHF

# PHYSIOLOGICAL IONS

## (4) POTASSIUM

- Location: It is majorly found in intracellular fluid
- Normal level: 3.8 – 5.0 mEq / L
- Functions:
  - Contraction of muscles, especially cardiac muscle
  - maintains osmotic balance
  - transmission of nerve impulses
  - regulate pH by exchange against for hydrogen ion

### Hypokalemia

[sum14]

⇒ Decreased  $K^+$  ion level in body

- Reasons: lower absorption, malnutrition, diarrhoea, much urine lose ( diuretic treatment), heart disease

# PHYSIOLOGICAL IONS

## (4) POTASSIUM

### Hyperkalemia

⇒ Increased  $K^+$  ion level in body

- Reasons: Kidney damage (renal failure), dehydration, cardiac disease, C.N.S. depression
- Symptoms: bradycardia, mental confusion, muscle weakness

# PHYSIOLOGICAL IONS

## (5) MAGNESIUM

- Location: It is majorly found in intracellular fluid, abt 54% in bones and abt 45 % in ICF
- Functions:
  - To activate enzymes which are involved in CH and protein metabolism
  - Neuronal transmission
  - Myocardial function
  - For the function of  $\text{Na}^+ / \text{K}^+$  ATPase pump.

# PHYSIOLOGICAL IONS

## (5) MAGNESIUM

### Hypomagnesaemia

⇒ Decreased  $\text{Mg}^{++}$  ion level in body

- Reasons: lower absorption, malnutrition, diarrhoea, chronic alcoholism
- Symptoms: muscle weakness, confusion, nausea, cardiac arrhythmia

### Hypermagneaemia

⇒ Increased  $\text{Mg}^{++}$  ion level in body

- Reasons: Addison's disease, acute diabetic acidosis, renal failure
- Symptoms: hypotension, cardiac arrest



# PHYSIOLOGICAL IONS

Other ions

Sulphate

Bicarbonate

Phosphate

# ELECTROLYTE REPLACEMENT THERAPY

3,5 [win14, win15, win12]

**Synonym:** Electrolyte replenisher

⇒ Due to serious symptoms of the loss of e-lytes, it is essential to maintain the normal level by external supply of e-lytes . This therapy is called as e-lyte replacement therapy.

**2 type** of supply:

- a. **Rapid initial replacement:** solution contains e-lytes with concentration resemble with the e-lyte concentrations found in extracellular fluids.
- b. **Subsequent replacements:** lower concentration of e-lytes in solution

# ELECTROLYTE REPLACEMENT THERAPY

## Compounds:

### (1) For Sodium replacement

NaCl

Sodium acetate

### (2) For Potassium replacement

Potassium chloride

Potassium acetate

Potassium bicarbonate

### (3) For Calcium replacement

1 [sum14]

Calcium chloride

Calcium lactate

Calcium levulinate

Calcium phosphate

Calcium gluconate

### (4) For Magnesium replacement

MgSO<sub>4</sub> – Epsom salt

*(covered in GI agents)*

MgCl<sub>2</sub>

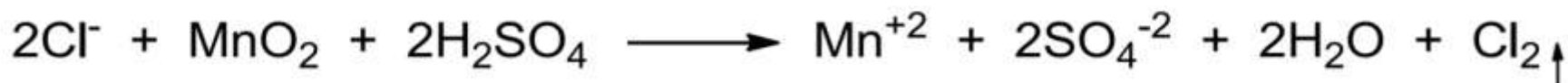
## (1) SODIUM CHLORIDE

### Physical properties:

- White or colorless powder, saline taste
- Soluble in water, insoluble in alcohol

### Chemical properties:

- Oxidized to give chlorine gas



- It react with silver nitrate and gives white ppt of silver chloride



# ELECTROLYTE REPLACEMENT THERAPY

## (1) SODIUM CHLORIDE

### Preparation:

#### a. From sea water

- a. **In lab.** It is prepared from common salts (impure) in water by passing HCl gas. Crystals of NaCl are ppted out

### Assay:

- about 0.1 g and dissolve in 50 ml of water
- Add 50.0 ml of 0.1 M silver nitrate, 5 ml of 2 M nitric acid and 2 ml of dibutyl phthalate
- Titrant: 0.1 M ammonium thiocyanate
- Indicator: ferric ammonium sulphate solution
- End point: colour becomes reddish yellow

1 ml of 0.1 M silver nitrate is equivalent to 0.005844 g of NaCl



# ELECTROLYTE REPLACEMENT THERAPY

## (1) SODIUM CHLORIDE

**Storage:** tightly closed container, in dry place

**Use:**

- Source of sodium and chloride ions (Sodium replacement)
- Making other pharmaceutical formulations like Ringer's injection, ORS.

## (2) POTASSIUM CHLORIDE

### Physical properties:

- White or colorless powder, saline taste
- Soluble in water, insoluble in alcohol

### Preparation:

[win11]

#### a. Lab scale

- Reaction of HCl with  $K_2CO_3$  or  $KHCO_3$



#### b. Industry scale

- From mineral carnallite  $KCl \cdot MgCl_2 \cdot 6H_2O$
- Carnallite is dissolved by treating with hot water.
- Less soluble KCl will crystallizes out on cooling the solution

# ELECTROLYTE REPLACEMENT THERAPY

## (2) POTASSIUM CHLORIDE

### Assay:

- Principle: Mohr's method (Argentometric titration)
- about 0.15 g and dissolve in 50 ml of water
- Titrant: 0.1 M silver nitrate
- Indicator: potassium chromate solution

1 ml of 0.1 M silver nitrate is equivalent to 0.007455 g of KCl

### Use

- Source of potassium ions (potassium replacement)
- Making other pharmaceutical formulations  
like Ringer's injection, ORS
- As diuretic
- In 'Myasthenia gravis'



## (3) CALCIUM GLUCONATE

### Physical properties:

[win12]

- white crystals, granules or powder,
- stable in air, does not lose its  $(C_{12}H_{22}O_{14}Ca \cdot H_2O)$  water of crystallization on drying
- Neutral to litmus paper

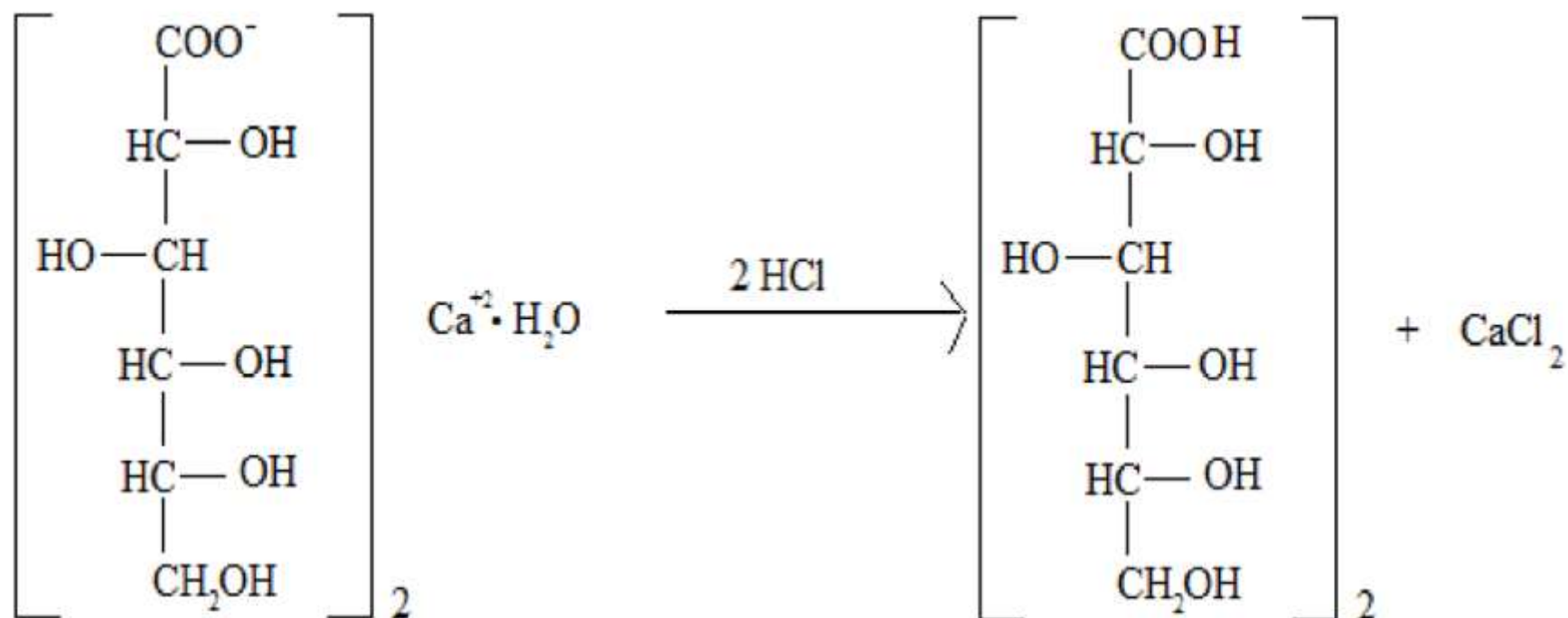
### Chemical properties:

[win12] [sum14]

- When treated with dil. HCl, It is decomposed into gluconic acid and calcium chloride.

# ELECTROLYTE REPLACEMENT THERAPY

## (3) CALCIUM GLUCONATE



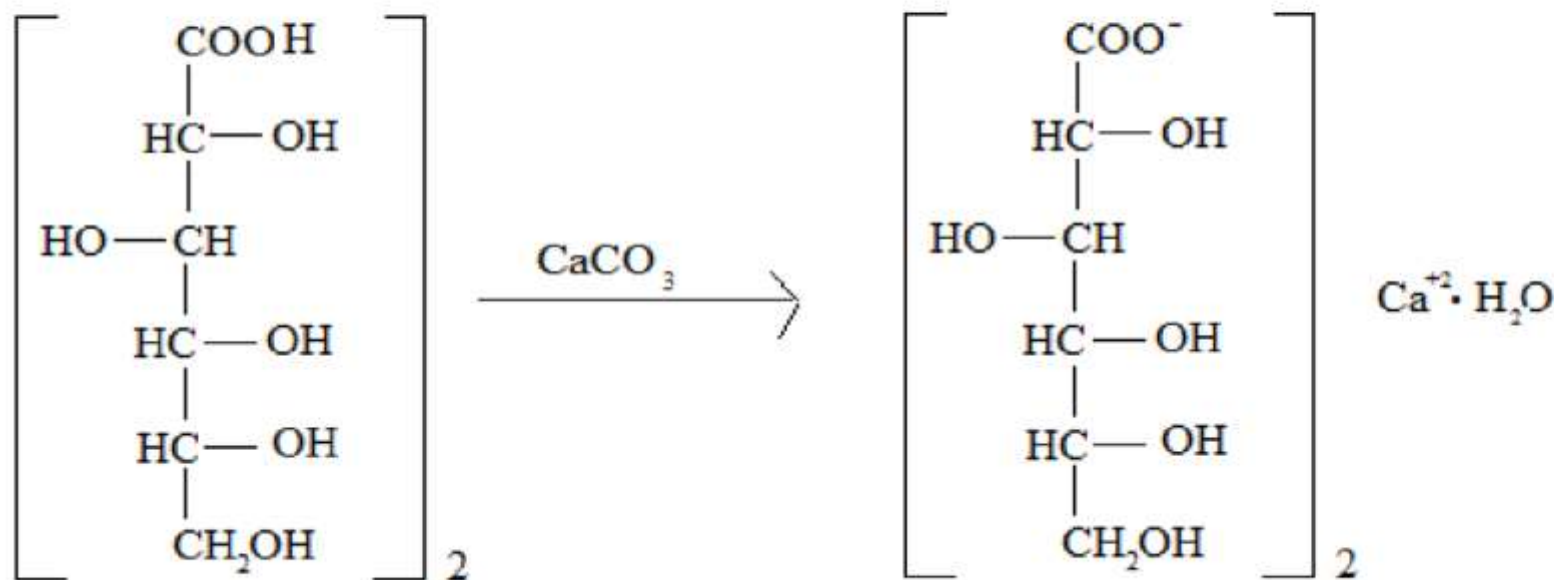


# ELECTROLYTE REPLACEMENT THERAPY

## (3) CALCIUM GLUCONATE

### Preparation:

- It is prepared by boiling a solution of gluconic acid with Ca. carbonate [win12, win14] [sum14, sum14]
- Pdct is filtered and ~~#~~ed out from solution.



## (3) CALCIUM GLUCONATE

### Assay:

[win14] [sum14]

- Principle: Complexometric titration
- 0.5g sample is dissolved in warm water, cool and add 5.0 ml of 0.05 M  $\text{MgSO}_4$  and 10 ml of strong ammonia solution
- Titrant: 0.05 M disod. edetate
- Indicator: mordant black II mixture
- End Point: until deep blue color develops.
- From the volume of 0.05 M disod. edetate required, subtract the volume of the  $\text{MgSO}_4$  solution added for actual reading.
- Factor: 1 ml 0.05 M disod. EDTA  $\equiv$  0.02242g of Ca. gluconate

# ELECTROLYTE REPLACEMENT THERAPY

## (3) CALCIUM GLUCONATE

Assay:

Magnesium sulphate is used in the assay of calcium gluconate ( or calcium lactate).



**Use:** Used in calcium deficiency

[win12]

# ELECTROLYTE COMBINATION THERAPY

⇒ Combination of electrolytes are prepared and given to the patient according to its requirements.

**Conditions** like,

- During surgery
- when the patient unable to take normal diet
- Malnutrition

**Formulations:**

Ringer lactate solution

ORS

## (1) COMPOUND SODIUM INJECTION

**Synonym:** Ringer's injection (Ringer's solution)

**Composition:**

- Each 100ml of soln is having-
  - NLT 0.82g and NMT 0.90g of NaCl
  - NLT 0.0285g and NMT 0.0315g of KCl
  - NLT 0.030g and NMT 0.036g of  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$
- It should be free from microorganism

**Preparation:**

- Ingredients with appropriate quantity are dissolved in WFI
- Solution is filtered and filtrate is sterilized by heating in an autoclave.



## ELECTROLYTE COMBINATION THERAPY

### (1) COMPOUND SODIUM INJECTION

Sodium Chloride .....	8.6g
Potassium Chloride.....	0.3g
Calcium Chloride.....	0.33g
WFI q.s. ....	1000 ml

#### Assay:

- The three salts present in preparation may be assayed individually.

**Use:** electrolyte replenishes

## (2) COMPOUND SOD. LACTATE INJ.

[sum14]

**Synonym:** Ringer Lactate Injection

### **Composition:**

- Each 100ml of soln is having-
  - NLT 0.27g and NMT 0.32g of Na
  - NLT 0.019g and NMT 0.022g of K
  - NLT 0.37g and NMT 0.42g of total chloride
  - NLT 0.025g and NMT 0.029g of  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
  - NLT 0.23g and NMT 0.28g of lactate
- It should be free from microorganism

### **Physical properties:**

- Clear, colourless solution
- Acidic in nature

## ELECTROLYTE COMBINATION THERAPY

### (2) COMPOUND SOD. LACTATE INJ.

#### Preparation:

- NaOH is first dissolved in 200ml WFI
- Add Lactic acid
- Heat in an autoclave at 115 °C for 1 hr
- After cooling soln is neutralised with HCl
- Other ingredients are dissolved in 700ml water and prepared soln is mixed with previous soln
- Make up total volume of 100ml with WFI
- Soln is filtered and sterilized.

# ELECTROLYTE COMBINATION THERAPY

## (2) COMPOUND SOD. LACTATE INJ.

Lactic acid.....	2.4ml
Sodium hydroxide.....	1.15g
Dil. HCl.....	q.s.
Sodium Chloride .....	6.0g
Potassium Chloride.....	0.4g
Calcium Chloride, hydrated.....	0.4g
WFI q.s. ....	1000 ml



### Assay:

- The three salts present in preparation may be assayed individually.

**Use:** electrolyte replenishes

**Storage:** in single dose container of glass or plastic



## (3) ORS

2,5 [win15, win14, win13, win11] [sum15, sum14, sum14, sum13]

### Oral Rehydration Salt

⇒ Oral Rehydration Salts are dry, homogeneously mixed powders containing Dextrose, Sodium Chloride, Potassium Chloride and either Sodium Bicarbonate or Sodium Citrate for use in oral rehydration therapy after being dissolved in the requisite amount of water.

- is a combination of oral electrolytes.

### Composition:

[win14]

- Contains essential electrolytes those are important to maintain the normal functions of the body.
- Also contains sufficient amount of water.



## (3) ORS

- The concentration of electrolytes may be varying depending on the level of loss of particular electrolyte.

### Use:

- In heavy loss of water (dehydration) and loss of electrolytes
- Conditions like severe vomiting, diarrhea and prolonged fever.
- The therapy is done with butter milk, rice, light tea, coconut water etc.

## (3) ORS

### Formulations

WHO Drug Information Vol. 16, No. 2, 2002

(2002; 91 pages) 

The **total substance concentration** (including that contributed by glucose) should be within the range of **200-310 mmol/l**.

**Glucose** should at least equal that of sodium but **should not exceed 111 mmol/l**

**Sodium** should be within the range of **60-90 mEq/l**

**Potassium** should be within the range of **15-25 mEq/l**

**Citrate** should be within the range of **8-12 mmol/l**

**Chloride** should be within the range of **50-80 mEq/l**

# End of topic

## Reference:

In. Ph'cal & Med Che. – Dr. J.S. Quadry

In. Ph'cal Che. – Dr. K.G. Bothara

Ph'cal Che.- In. – Dr. G.R. Chatwal