

MINERALS

Principle elements / major elements / macrominerals.

Nutritionally important minerals

Daily requirement is $> 100 \text{ mg}$.

1. Calcium.
2. Magnesium
3. Phosphorus.
4. Sodium.
5. Potassium.
6. Chloride.
7. Sulphur.

Trace Elements / minor elements or Microminerals.

Daily requirement is $< 100 \text{ mg}$.

Deficiency can lead to serious disorders.

1. IRON.
2. COPPER.
3. ZINC.
4. SELENIUM
5. COBALT.
6. IODINE.
7. MANGANESE.
8. MOLYBDENUM.
9. CHROMIUM.
10. FLUORIDE.

Possibly Essential.

Additional

Calcium

Present in largest quantities in the human body.
99% of Ca present in bones and teeth.

Ca present in 3 forms.

- Ionized form - physiologically active form
- Protein bound form - physiologically inactive.
- Complexed with phosphates, citrates, malates.

Source

Good source - milk
Medium - egg, fish, vegetables
Cereals contain small amount of Ca.

Daily Requirement

Adult - 500 mg/day
Child - 1200 mg/day
Pregnancy & lactation - 1500 mg/day

Physiological functions. (8 mark)

1. Required for activation of several important enzymes.

1 mark
Calmodulin - Ca binding regulatory protein

$\text{Ca}^{2+} + \text{calmodulin}$

$\downarrow$
Ca-bound - calmodulin.

Kinase $\downarrow$ active Kinase.

Enzyme $\downarrow$ Phosphorylated enzyme
Biological effect.

- Enzymes which are activated by Ca^{2+} , mediated by calmodulin

Adenyl cyclase, glycogen synthase, pyruvate carboxylase, pyruvate kinase, PDH etc.

- Enzymes which are directly activated by Ca^{2+} without intervention of calmodulin.

Pancreatic lipase, rennin, enzymes of coagulation pathway.

- Calcification of bones and teeth. depend on adequate intake of Ca.

- Ionic Ca required in blood coagulation (factor IV)

- Necessary for transmission of nerve impulse.

- Regulate contraction of muscle fibres.

- Regulates the permeability of membranes.

- In myocardium, Ca^{2+} prolongs systole

- Acts as second messenger for some hormones.

- Mediate secretion of hormones (insulin, PTH, calcitonin, vasopressin etc)

- Calpains - Ca dependent protein regulate cellular processes.

Absorption of Calcium

Calcium absorption is favoured by:

- Vit D - Calcitriol induces the synthesis of carrier protein, calbindin
- Parathyroid hormone
- Acidity
- Amino acids - Lysine & arginine.

Calcium absorption is decreased by:

- Calcitonin
- Phytic acid.
- Oxalate
- High phosphate content
- Malabsorption syndrom.

Optimum ratio of Ca:P should be 1:1 for proper absorption of both.

Normal level of Ca in blood : 9 - 11 mg/dl

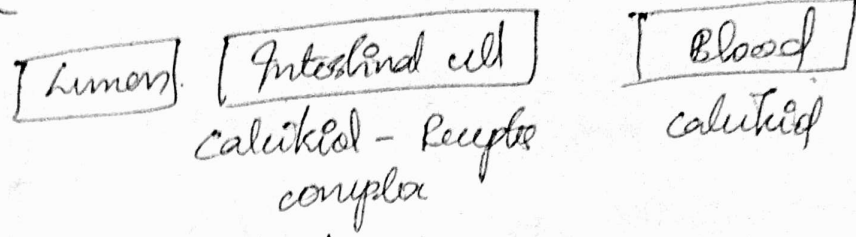
less than 8.8 mg/dl $\rightarrow$ Hypocalcemia

> 11 mg/dl - Hypercalcemia

< 7.5 $\rightarrow$ Tetany

8 marks
Regulation of blood Calcium Intestinal epithelial cells, increases Ca absorption.

Factors regulating blood Ca level



Hormones.

- calicikol.
- PTH.
- Calitonin.

Other factors.

- Phosphorus.
- Serum proteins.
- Alkaloids & acids.
- Renal threshold.

calicikol - Receptor complex binds with DNA

calicikol - Ca^{++} → Ca^{++}

Kidney

→ increases reabsorption of Ca & P by renal tubules.

Vitamin D (calicikol)

- 1, 25 dihydroxycholecalciferol
- act as a steroid hormone
- increases blood calcium level
- act on 3 sites - bone, kidney & intestine

In bone

- increases osteoclasts
- stimulate osteoclast to secrete ALP → local conc. of phosphate increases
- joint product of Ca & P increases → increase mineralization of bone

Intestine

- promotes the absorption of Ca & P from the intestine
- it induces the synthesis of calbindin in

Parathyroid Hormone (PTH)

- secreted from parathyroid gland.
- increases intracellular Ca conc. through the activity of adenylyl cyclase enzyme.

Acts on 3 sites.

bone, kidney, intestine.

PTH increases serum Ca level.

Bone:

PTH causes demineralization (decalcification) through osteoclasts

- PTH induces pyrophosphatase in osteoclasts → no. of osteoclasts are increased →

release Ca^{2+} into surrounding medium $\rightarrow$ it solubilize Ca.

- $\rightarrow$ PTH also secret collagenase from osteoclasts
- $\rightarrow$ causes loss of matrix and bone resorption.
- $\rightarrow$ Mucopolysaccharides and hydroxy proline are excreted through urine.

Kidney

- $\rightarrow$ Increase reabsorption of Ca.
- $\rightarrow$ Decrease renal excretion of Ca and increased renal excretion of phosphates.

Intestine

- $\rightarrow$ stimulate 1^{st} hydroxylation of 25-hydroxyvitamin D in kidney to produce calcitriol.

Intestine : increases reabsorption of Ca

Calcitonin

- $\rightarrow$ Secreted by parafollicular cells of thyroid gland.
- $\rightarrow$ It is a tumour marker.
- $\rightarrow$ Decreases serum Ca level.
- $\rightarrow$ Action of PTH and calcitonin are directly antagonistic.
- $\rightarrow$ Calcitonin inhibit reabsorption of bone.
- $\rightarrow$ Decreases the activity of osteoclasts and increases the

activity of osteoblasts.

Other factors

Phosphorous

- $\rightarrow$ Reciprocal relationship with Ca level.
- $\rightarrow$ Ionic product of Ca & P is 40 in serum (normal adult)
- $\rightarrow$ It should be 50 in children.

Hypoalbuminemia

- $\rightarrow$ In this, total Ca is decreased
- $\rightarrow$ About 0.8 mg/dl of Ca is reduced with lowering of each g/dl of albumin.
- $\rightarrow$ But the ionized form is active, so no deficiency manifestations.

Alkalosis and Acidosis

- $\rightarrow$ Alkalosis favours binding of more Ca with proteins, lowers ionized Ca.
- $\rightarrow$ Here, deficiency manifestations occur.
- $\rightarrow$ Acidosis favours ionization of Ca.

Kidney threshold

Renal threshold level for Ca in blood is 10 mg/dl

Disease state

HYPERCALCEMIA

major cause $\rightarrow$ hyperparathyroidism.

Signs and symptoms.

Osteoporosis.

Pathological fracture of bone.

Hyperchloremic acidosis.

Polyuria.

Urinary calculi.

Ectopic calcification in tissues.

Short QT interval in ECG.

Biochemical findings.

→ Increased level of Ca and ALP in blood.

→ Decreased level of phosphate in blood.

HYPOCALCEMIA

Serum Ca level.

$< 8.8 \text{ mg/dL}$.

$< 8.5 \text{ mg/dL}$ (mild tetany)

$< 7.5 \text{ mg/dL}$ (Tetany)

Causes

Hypoparathyroidism.

Renal failure.

Increased calcitonin.

Deficiency of Vitamin D.

Deficiency of Calcium.

Hypoalbuminemia.

Tetany (Short note)

Life threatening condition.

→ May be due to accidental

surgical removal of parathyroid glands or by autoimmune disease.

→ Neuro-muscular irritability is increased.

Main manifestations include

- carpopedal spasm

- Laryngismus

- Stridor.

Laryngeal spasm may lead to death.

Clinical signs.

→ Chvostek's sign

→ Trousseau's sign.

→ Increased QT interval in ECG.

Osteoporosis

After age of 60, this demineralisation leads to osteoporosis.

most prevalent bone disease.

After age 40-45, Ca absorption ↓, Ca excretion ↑.

Increased risk in old aged people and bed ridden patients.

Phosphorus

→ Intracellular ion.

RDA - 500mg/day

Sources

milk good source.
~~good~~ cereals, nuts, meat moderate sources.

Functions

- Formation of bone and teeth
- production of high energy phosphate compound ATP, GTP, CTP, creatin P.
- Synthesis of nucleotide coenzyme - NAD, NADP.
- Phosphodiester linkage in DNA and RNA.
- Formation of phosphate esters - glucose 6 phosphate, phospholipids
- Phosphate buffer system in blood.
- Activation of enzymes by phosphorylation.

Normal level in serum

Adults = 3-4 mg/dL

children = 5-6 mg/dL

Magnesium

→ Seen in intracellular fluid.

Sources → cereals, beans, fish, leafy vegetables.

RDA

men - 400mg/day

women - 300mg/day

Doses > 600mg may cause diarrhoea.

Functions

- Activator of many enzymes requiring ATP.
eg: Hexokinase, fructokinase, PFK, ALP, adenyl cyclase etc.
- Role in insulin sensitivity
- Reduces neuromuscular irritability

Sodium (Na^+)

major extracellular cation

Normal level in plasma
= 136 - 145 mEq/L

Functions

1. Largely associated with the regulation of acid-base balance (Na_2CO_3)
2. Regulates blood volume and blood pressure.
3. Maintains normal neuromuscular function
4. Maintains normal permeability of cells.
5. Necessary for initiating and maintaining heart beat