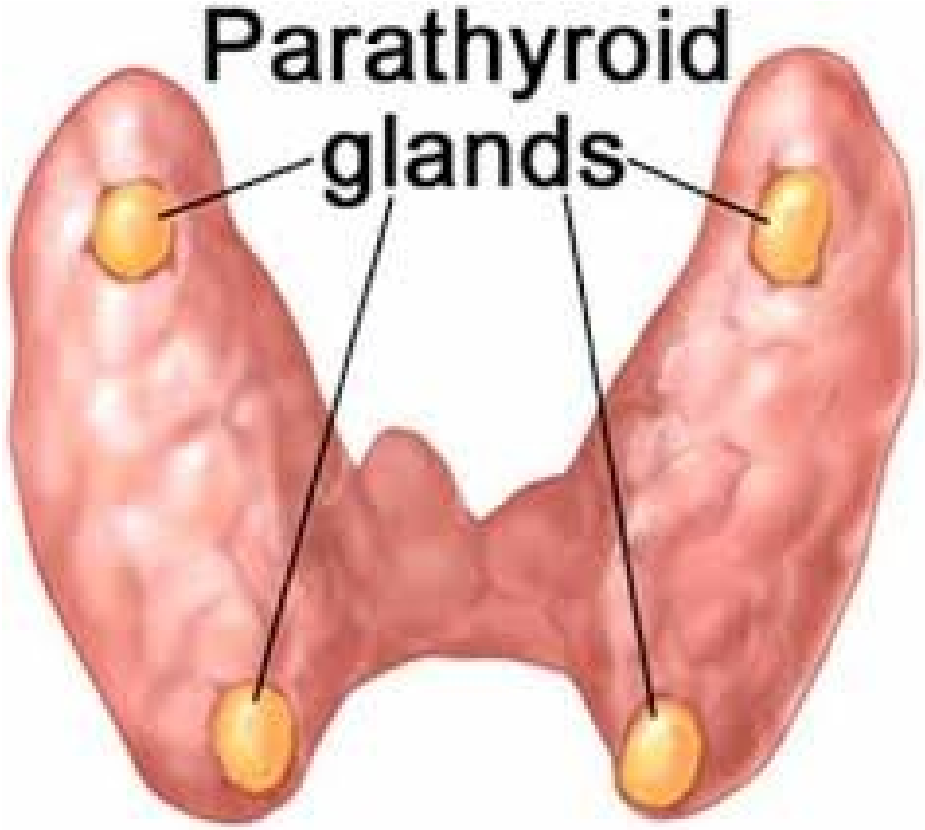
PARATHYROID GLAND

By Dr. Dinesh Chouhan

INTRODUCTION

- Human beings have four parathyroid glands.
- these are situated on the posterior surface of upper and lower poles of thyroid gland.
- Parathyroid glands are very small in size, measuring about 6 mm long, 3 mm wide and 2 mm thick, with dark brown color.



HISTOLOGY

- Each parathyroid gland is made up of chief cells and oxyphil cells.
- Chief cells secrete Parathormone.
- Oxyphil cells are the degenerated chief cells.
- These cells may secrete Parathormone during pathological condition called parathyroid adenoma.

PARATHORMONE

- Parathormone secreted by parathyroid gland.
- Essential for the maintenance of blood calcium level within a very narrow critical level.
- Calcium is an important inorganic ion for many physiological functions.

Source of Secretion

- Parathormone (PTH) is secreted by the chief cells.

Chemistry

- Parathormone is protein in nature, having 84 amino acids.
- Its molecular weight is 9,500.

Half-life and Plasma Level

- Parathormone has a half-life of 10 minutes. Normal plasma level of PTH is about 1.5 to 5.5 ng/dL.

Synthesis

- Parathormone is synthesized from the precursor called prepro-PTH containing 115 amino acids.

Metabolism

- Sixty to seventy percent of PTH is degraded by Kupffer cells of liver, by means of proteolysis. Degradation of about 20% to 30% PTH occurs in kidneys.

ACTIONS OF PARATHORMONE

- PTH plays an important role in maintaining blood calcium level. It also controls blood phosphate level.

I. ON BLOOD CALCIUM LEVEL

- Primary action of PTH is to maintain the blood calcium level within the range of 9 to 11 mg/dL.
- The blood calcium level has to be maintained critically because, it is very important for many of the activities in the body.
- PTH maintains blood calcium level by acting on:

1. Bones
2. Kidney
3. Gastrointestinal tract.

1. ON BONE

- Parathormone enhances the resorption of calcium from the bones by acting on osteoblasts and osteoclasts cells of the bone (osteoclastic activity).
- Resorption of calcium from bones occurs in two phases:

i. Rapid phase
ii. Slow phase.

i. Rapid phase

- Rapid phase occurs within minutes after the release of PTH.
- Immediately after reaching the bone, PTH gets attached with the receptors on the cell membrane of osteoblasts and osteocytes.
- The HR complex increases the calcium pump mechanism, so that calcium ions move out and enter the blood at a faster rate.

ii. Slow phase

- This phase occurs due to the activation of osteoclast cells by PTH.
- When osteoclasts are activated, some substances such as proteolytic enzymes, citric acid and lactic acid are released from lysosomes of these cells.
- All these substances digest or dissolve the organic matrix of the bone, releasing the calcium ions.
- The calcium ions slowly enter the blood.

2. ON KIDNEY

- PTH increases the reabsorption of calcium from the renal tubules along with magnesium ions and hydrogen ions.
- It increases calcium reabsorption mainly from DCT and proximal part of collecting duct.
- PTH also increases the formation of 1,25 dihydroxycholecalciferol (activated form of vitamin D) from 25-hydroxycholecalciferol in kidneys.

3. ON GASTROINTESTINAL TRACT

- PTH increases the absorption of calcium ions from the GI tract indirectly.
- It increases the formation of 1,25 dihydroxycholecalciferol (activated vitamin D) in the kidneys.
- Thus, the activated vitamin D is very essential for the absorption of calcium from the GI tract.

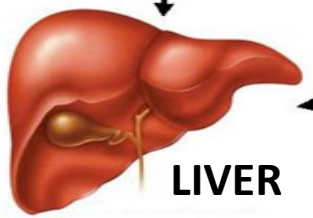
ACTIVATION OF VITAMIN D

Solar energy

SKIN

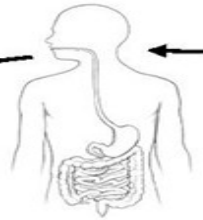
7-dehydrocholesterol ➡ **cholecalciferol**

Vitamin-D



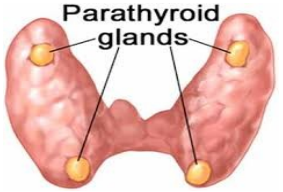
LIVER

Vitamin-D



Oral intake of Vitamin-D through food

Cholecalciferol ➡ **25-hydroxycholecalciferol**



25-hydroxycholecalciferol

PTH from Parathyroid Glands

25-hydroxycholecalciferol

1,25-di hydroxycholecalciferol
(Activated Vit. D)

Absorption of calcium from the GI tract.

Negative Feedback

ACTIONS OF PARATHORMONE ON BLOOD PHOSPHATE LEVEL

- PTH decreases blood level of phosphate by increasing its urinary excretion.
- It also acts on bone and GI tract.

1. On Bone

- Along with calcium resorption, PTH also increases phosphate absorption from the bones.

2. On Kidney

- Phosphaturic action It is the effect of PTH by which phosphate is excreted through urine.
- PTH increases phosphate excretion by inhibiting reabsorption of phosphate from renal tubules.

3. On Gastrointestinal Tract

- Parathormone increases the absorption of phosphate from GI tract through calcitriol.

REGULATION OF PARATHORMONE SECRETION

- Blood level of calcium is the main factor regulating the secretion of PTH.
- Blood phosphate level also regulates PTH secretion.
- Parathormone secretion is inversely proportional to blood calcium level.
- Increase in blood calcium level decreases PTH secretion.

- Conditions when PTH secretion decreases are:

1. Excess quantities of calcium in the diet
2. Increased vitamin D in the diet
3. Increased resorption of calcium from the bones.

- On the other hand, decrease in calcium ion concentration of blood increases PTH secretion, as in the case of rickets, pregnancy and in lactation.
- PTH secretion is directly proportional to blood phosphate level.
- Whenever the blood level of phosphate increases, it stimulates PTH secretion from parathyroid gland.

APPLIED PHYSIOLOGY –

DISORDERS OF PARATHYROID GLANDS

Disorders of parathyroid glands are of two types:

I. Hypoparathyroidism
II. Hyperparathyroidism.

I. HYPOPARATHYROIDISM –

- Hyposecretion of PTH is called hypoparathyroidism. It leads to hypocalcemia (decrease in blood calcium level).

- Causes for Hypoparathyroidism :

1. Surgical removal of parathyroid glands (parathyroidectomy)
2. Removal of parathyroid glands during surgical removal of thyroid gland (thyroidectomy)
3. Autoimmune disease
4. Deficiency of receptors for PTH in the target cells. This condition is called pseudohypoparathyroidism.

Hypocalcemia and Tetany

- Hypoparathyroidism leads to hypocalcemia, by decreasing the resorption of calcium from bones.

- Hypocalcemia causes neuromuscular hyperexcitability, resulting in hypocalcemic tetany.
- Normally, tetany occurs when plasma calcium level falls below 6 mg/dL from its normal value of 9.4 mg/dL.

Hypocalcemic Tetany

- Tetany is an abnormal condition characterized by violent and painful muscular spasm (spasm = involuntary muscular contraction), particularly in feet and hand.
- It is because of hyperexcitability of nerves and skeletal muscles due to calcium deficiency.

II. HYPERPARATHYROIDISM –

- Hypersecretion of PTH is called hyperparathyroidism. It results in hypercalcemia.
- Hypercalcemia are noticed when the blood calcium level increases to 12 mg/dL. The condition becomes severe with 15 mg/dL and lethal when reaches 17 mg/dL.

- Causes for Hyperparathyroidism :

1. Primary hyperparathyroidism is due to the development of tumor in one or more parathyroid glands.
2. Chronic renal failure
3. Vitamin D deficiency
4. Rickets
5. Chronic hyperthyroidism.

Hypercalcemia

- Hypercalcemia is the increase in plasma calcium level. It occurs in hyperparathyroidism.
- Signs and symptoms

i. Depression of the nervous system
ii. Sluggishness of reflex activities
iii. Lack of appetite
iv. Constipation.

Other effects of hypercalcemia:

i. Development of bone diseases such as osteitis fibrosa cystica

ii. Development of parathyroid poisoning.

- It is the condition occur when blood calcium level rises above 15 mg/dL.
- In hyperparathyroidism, the concentration of both calcium and phosphate increases leading to formation of calcium-phosphate crystals.
- These calcium-phosphate crystals deposited in renal tubules, thyroid gland, alveoli of lungs, gastric mucosa and in the wall of the arteries.
- Resulting in dysfunction of these organs.
- Renal stones are formed when it is deposited in kidney.

CALCITONIN

Source of Secretion

- Calcitonin is secreted by the parafollicular cells or clear cells (C cells), situated amongst the follicles in thyroid gland.

Plasma Level and Half-life

- Plasma level of calcitonin is 1 to 2 ng/dL. It has a halflife of 5 to 10 minutes.

Metabolism

- Calcitonin is degraded and excreted by liver and kidney.

ACTIONS OF CALCITONIN

1. On Blood Calcium Level

- Calcitonin plays an important role in controlling the blood calcium level. It decreases the blood calcium level.
- Calcitonin reduces the blood calcium level by acting on bones, kidneys and intestine.

I. On bones

- Calcitonin stimulates osteoblastic activity and facilitates the deposition of calcium on bones.
- At the same time, it suppresses the activity of osteoclasts and inhibits the resorption of calcium from bones.

II. On kidney

- Calcitonin increases excretion of calcium through urine, by inhibiting the reabsorption from the renal tubules.

III. On intestine

- Calcitonin prevents the absorption of calcium from intestine into the blood.

2. On Blood Phosphate Level

- With respect to calcium, calcitonin is an antagonist to PTH.
- But it has similar actions of PTH, with respect to phosphate.
- It decreases the blood level of phosphate by acting on bones and kidneys.

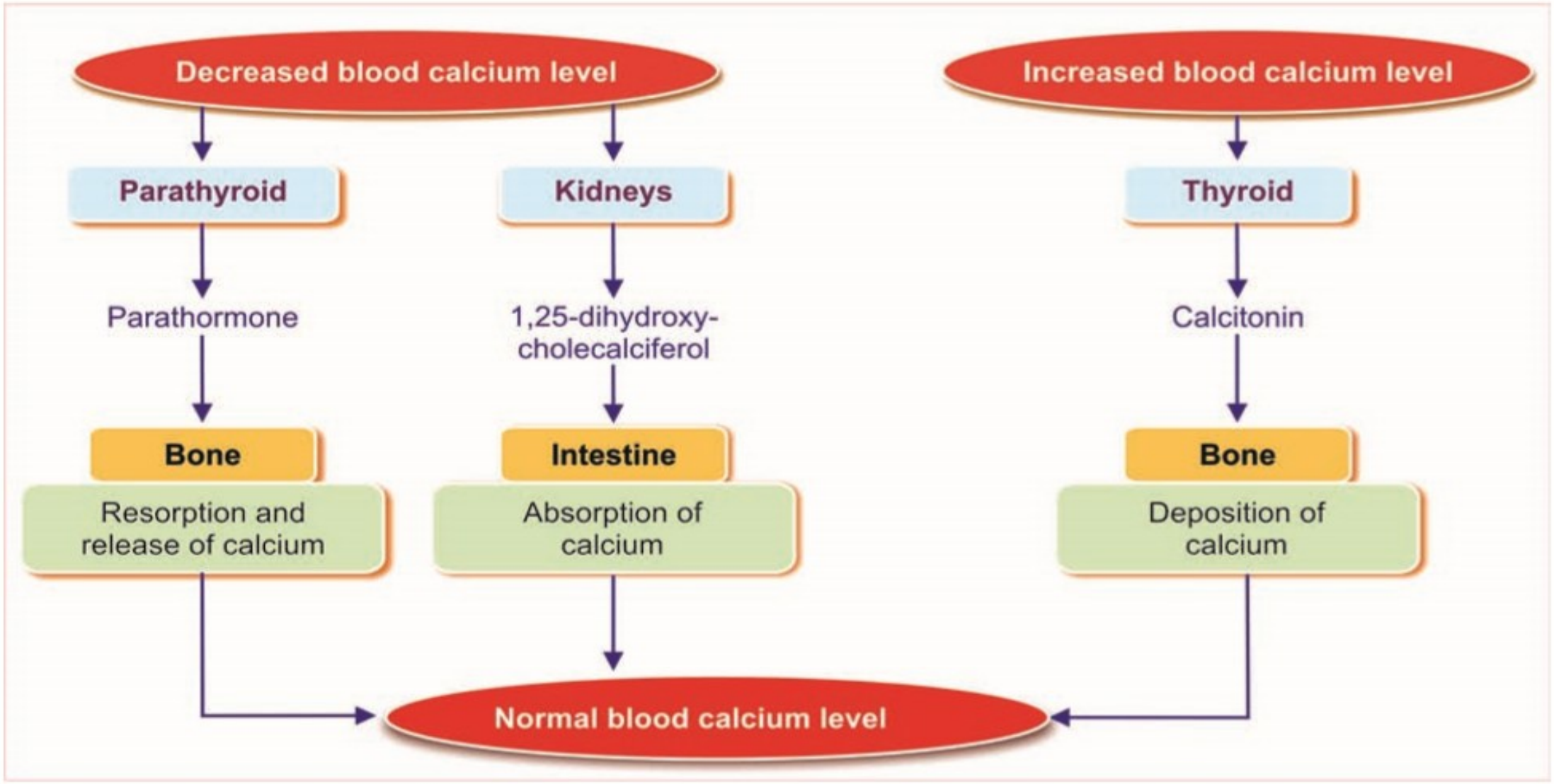
I. On bones

Calcitonin inhibits the resorption of phosphate from bone and stimulates the deposition of phosphate on bones.

II. On kidney

Calcitonin increases the excretion of phosphate through urine, by inhibiting the reabsorption from renal tubules.

REGULATION OF CALCIUM METABOLISM



THANK YOU