37.3D: Hormonal Control of Blood Calcium Levels

Blood levels of calcium are regulated by the parathyroid hormone, which acts on the bones, kidneys, and intestines to keep levels constant.

Learning Objectives

- Explain how blood calcium levels are regulated by parathyroid hormone

Key Points

- The parathyroid hormone (PTH), secreted by the parathyroid glands, is responsible for regulating blood calcium levels; it is released whenever blood calcium levels are low.
- PTH increases blood calcium levels by stimulating osteoclasts, which break down bone to release calcium into the bloodstream.
- PTH increases blood calcium levels by increasing the amount of calcium resorbed by the kidneys before it can be excreted in the urine.
- PTH increases blood calcium levels by triggering the formation of calcitriol, which increases absorption of dietary calcium through the intestines.
- Calcitonin, a hormone produced by the thyroid, acts in opposition to PTH by inhibiting osteoclasts, stimulating osteoblasts, and increasing excretion of calcium into the urine by the kidneys.

Key Terms

- **osteoblast**: a mononucleate cell from which bone develops
• **parathyroid hormone**: a polypeptide hormone that is released by the chief cells of the parathyroid glands and is involved in raising the levels of calcium ions in the blood
• **calcitonin**: a hormone, secreted by parenchymal cells, that regulates calcium and phosphate metabolism
• **hypoparathyroidism**: deficiency of parathyroid hormone
• **hyperparathyroidism**: an abnormal increase in parathyroid gland activity
• **calcitriol**: the active metabolite 1,25-dihydroxycholecalciferol of vitamin D₃ that is involved in the absorption of calcium
• **osteoclast**: a large multinuclear cell associated with the resorption of bone

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**Hormonal Control of Blood Calcium Levels**

Regulation of blood calcium concentrations is important for generation of muscle contractions and nerve impulses, which are electrically stimulated. If calcium levels get too high, membrane permeability to sodium decreases and membranes become less responsive. If calcium levels get too low, membrane permeability to sodium increases and convulsions or muscle spasms may result.

Blood calcium levels are regulated by parathyroid hormone (PTH), which is produced by the parathyroid glands. PTH is released in response to low blood calcium levels. It increases calcium levels by targeting the skeleton, the kidneys, and the intestine. In the skeleton, PTH stimulates osteoclasts, which are cells that cause bone to be reabsorbed, releasing calcium from bone into the blood. PTH also inhibits osteoblasts, cells which deposit bone, reducing calcium deposition in bone. In the intestines, PTH increases dietary calcium absorption and in the kidneys, PTH stimulates re-absorption of the calcium. While PTH acts directly on the kidneys to increase calcium re-absorption, its effects on the intestine are indirect. PTH triggers the formation of calcitriol, an active form of vitamin D, which acts on the intestines to increase absorption of dietary calcium. PTH release is inhibited by rising blood calcium levels.
Regulation of blood calcium levels: Parathyroid hormone (PTH) is released in response to low blood calcium levels. It increases blood calcium levels by stimulating the resorption of bones, increasing calcium resorption in the kidneys, and indirectly increasing calcium absorption in the intestines.

Hyperparathyroidism results from an overproduction of PTH, which leads to excessive amounts of calcium being removed from bones and introduced into blood circulation. This may produce structural weakness of the bones, which can lead to deformation and fractures, plus nervous system impairment due to high blood calcium levels.

Hypoparathyroidism, the underproduction of PTH, results in extremely low levels of blood calcium, which causes impaired muscle function and may result in tetany (severe sustained muscle contraction).

The hormone calcitonin, which is produced by the parafollicular (or C) cells of the thyroid, has the opposite effect on blood calcium levels as PTH. Calcitonin decreases blood calcium levels by inhibiting osteoclasts, stimulating osteoblasts, and stimulating calcium excretion by the kidneys. This results in calcium being added to the bones to promote structural integrity. Calcitonin is most important in children (when it stimulates bone growth), during pregnancy (when it reduces maternal bone loss), and during prolonged starvation (because it reduces bone mass loss). In healthy, nonpregnant, unstarved adults, the role of calcitonin is unclear.