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Conceptual Paper

Nutritionally Induced Secondary Hyperparathyroidism in Companion Dogs

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Abstract

Nutritional secondary hyperparathyroidism (NSH) in companion dogs can occur due to long term deficiency of vitamin D or calcium in the diet. It is characterised by constant high levels of parathyroid hormones (PTH) in response to chronic hypocalcemia, which increases bone resorption rate, making the skeletal structure to wear out. Although it can develop in dogs of any age, growing puppies, specially large breed puppies are more susceptible due to high requirement of dietary calcium. Affected animals commonly suffer from reduced bone density and pathological fractures, and are often presented with pain and paresis. Unbalanced diets deficient in calcium and vitamin D are the main cause of this. Dogs affected with NSH generally recover within a short span of time after receiving a balanced diet.

Keywords: Nutritional Secondary Hyperparathyroidism; Dogs; Calcium; Vitamin D; Parathyroid Hormone; Pathological Fractures; Balanced Diet

Abbreviations

NSH: Nutritional Secondary Hyperparathyroidism; PTH: Parathyroid Hormone; 25-HC: 25-Hydoxy Cholecalciferol;1,25-DHC: 1,25-Dihydroxy Cholecalciferol; NRC: National Research Council

Introduction

Calcium, vitamin D and phosphorous play a key role in the regulation of calcium homeostasis in the body. Calcium in blood is in equilibrium between a free or ionized state (~50%), a protein-bound state (~40-45%) and a complexed or chelated state (~5-10%). Calcium homeostasis involves keeping the serum ionized calcium level within a fixed range. The skeletal system is the largest calcium reservoir in the body, releasing calcium ions into the bloodstream when serum calcium levels drop, to maintain equilibrium. This mechanism of drawing calcium from the skeletal reserve into the bloodstream during hypocalcemia happens under the influence of the parathyroid hormone (PTH)

Role of parathyroid hormone (PTH) in counteracting hypocalcemia

PTH is a peptide hormone produced by the parathyroid glands that plays a crucial role in controlling blood calcium levels. The levels of PTH and serum calcium are inversely proportional. At low serum calcium levels, PTH in conjunction with vitamin D, works at many sites in the body to mobilize calcium stores and increase calcium absorption and reabsorption

When serum ionized calcium levels drop, PTH secretion from the parathyroid glands increases. PTH works in stabilizing the calcium level in the following ways

- PTH stimulates conversion of 25-HC (a metabolite of vitamin D3 or cholecalciferol) to 1,25-DHC in the kidneys. 1,25-DHC is the most biologically active metabolite of vitamin D

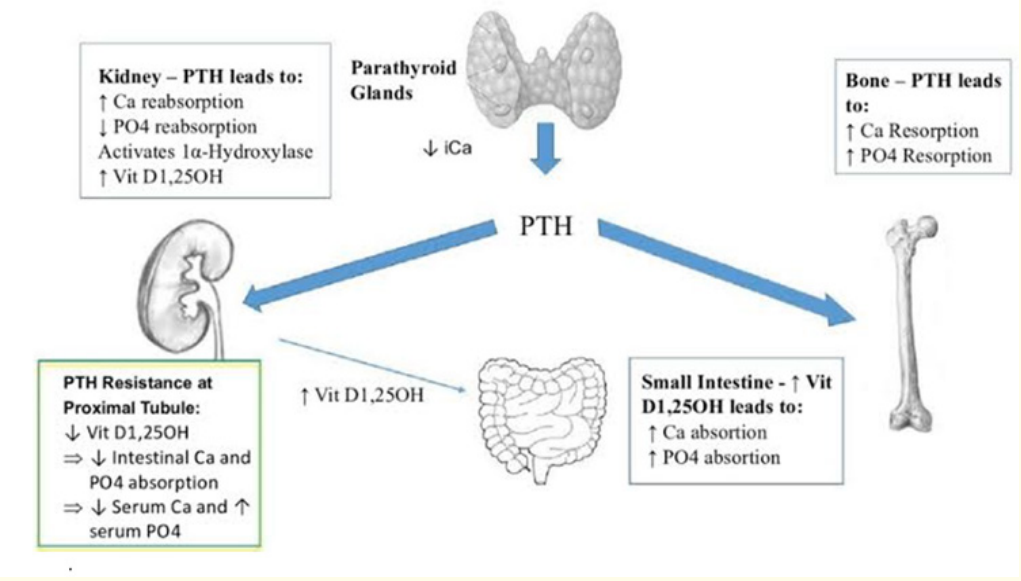

Figure 1: Diagrammatic representation of action of PTH during low calcium levels.

- 1,25-DHC increases the absorption of calcium and phosphorous from the intestines
- PTH increases reabsorption of calcium and excretion of phosphorous in the kidneys
- 1,25-DHC in conjunction with PTH stimulates bone resorption, pulling out calcium and phosphorous from the skeletal system into the bloodstream. PTH works at the cellular level by indirectly stimulating osteoclasts to break down bone

Overall, increased intestinal absorption, renal reabsorption and bone resorption of calcium under the influence of PTH and 1,25-DHC stabilizes the low serum ionized calcium levels

Dietary requirements of calcium, phosphorous and vitamin D in growing and adult dogs

National Research Council (NRC) recommends an intake of-

- 3gms of calcium
- 2.5gms of phosphorous
- 136 IU of vitamin D3
- Per 1000 kcal of food consumed for growing puppies

For adult dogs, NRC recommends an intake of-

- 1gm of calcium
- 0.75gms of phosphorous
- 136 IU of vitamin D3
- Per 1000 kcal of food

For any life stage, the ideal dietary calcium-phosphorous ratio is recommended to be between 1:1 and 2:1

Causes of nutritional hypocalcemia in dogs

Nutritional hypocalcemia can occur in dogs due to the following reasons

- Low intake of calcium- Consumption of calcium at a level below the minimum nutritional requirement will cause hypocalcemia
- Deficiency of vitamin D- Vitamin D is responsible for active absorption of calcium in the intestine. Low intake of vitamin D will hamper calcium absorption, inducing hypocalcemic states
- Improper calcium: phosphorous ratio in the diet- Ca: P in the food consumed should be between 1:1 and 2:1. If phosphorous consumption is excess (say Ca: P of 0.2:1), it causes a state of relative hypocalcemia in the body

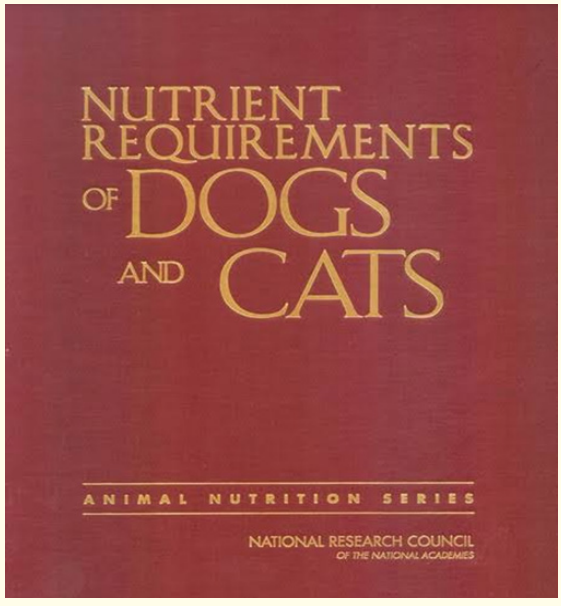

Figure 2: Cover page of the NUTRIENT REQUIREMENTS OF DOGS AND CATS publication by NR.

Development of nutritional secondary hyperparathyroidism

Reduced serum ionized calcium levels (hypocalcemia) will stimulate high production of PTH to maintain calcium equilibrium in the blood. Chronic hypocalcemia causes the parathyroid glands to keep on producing supranormal amounts of PTH, inducing a state of secondary hyperparathyroidism.

Since PTH maintains calcium equilibrium by bone resorption, long term hyperparathyroidism causes bones to wear out gradually. NSH is known to cause osteoclastic bone demineralization with cortical thinning, fibrous tissue replacement of bones and pathological fractures. Growing puppies, specially large breed ones are more susceptible to NSH due to higher demand for calcium.

Neurological symptoms like paresis, pain and reduced spinal reflexes have also been reported in dogs having NSH. The neurological signs associated are considered to be secondary to vertebral body fractures or possibly due to altered circulating blood calcium levels. Low calcium levels can lead to increased nerve excitability, causing muscle twitching or spasms.

Prevention and recovery

Since NSH is a nutritional disorder, solution lies with nutritional approaches only. NSH can be prevented in a dog by feeding a diet containing sufficient amounts of calcium and vitamin D, having calcium: phosphorous in the range of 1:1 to 2:1. Dogs fed a boneless meat diet exclusively, without any supplementation of calcium and vitamin D are at most risk of developing NSH. This is also termed as "All meat syndrome".

For a dog already affected with NSH, correcting the imbalances in calcium, vitamin D and Ca: P ratio recovers the animals within a short span of time generally.

Consuming a well-balanced diet is therefore crucial for any dog, specially young puppies.

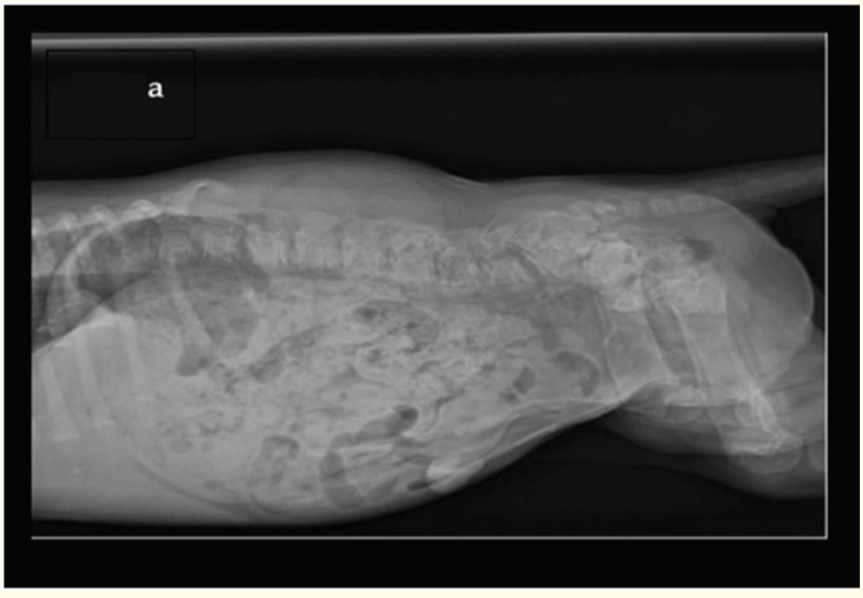

Figure 3: Radiography of lumbosacral area of a dog affected with NSH shows low density of bones.