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A REVIEW OF ESSENTIAL FACTS IN CALCIUM METABOLISM

We have previously pointed out in these pages the fact that in all probability every vitamin had an influence on the metabolism of calcium.

To recapitulate, Vitamin A deficiency is known to cause a precipitation of calcium as kidney stones, indicating that it is instrumental in maintaining calcium in solution or in organic combination (1).

Vitamin B deficiency is known to cause pathology only when accompanied by a calcium deficiency (2). The cramps and convulsions of beriberi are, no doubt, a result of the lowered blood calcium. Howe, in his studies on dental caries in 1921 found that Vitamin B deficiency caused atrophy of the parathyroids. A high protein diet can bring on convulsions if the Vitamin B intake is low (3), an indication that the presence of Vitamin B is necessary to the maintenance of the normal blood calcium level. The Vitamin B requirement is also known to be higher when the thyroid is overactive (4), in the absence of which thyrotoxic symptoms appear sooner. (Note that the thyroid is the physiologic calcium eliminator) (5).

Vitamin C deficiency is characteristically known to result in a decalcification of bone, loosened teeth being a primary indication of scurvy (6).

Vitamin D, of course, is known by all to result in a lowered affinity of blood serum for calcium with attendant reduced assimilation.

Vitamin E is the only vitamin that has not been shown to have a direct connection with calcium metabolism up to the present time.

Vitamin F can be considered an important factor in calcium assimilation because it reduces blood calcium by increasing its diffusion into the tissues, and cooperates with Vitamin D by unloading the blood of its calcium load, probably mainly into muscle cells which are probably the greatest consumers of this element in the adult body. (In the immature economy, Vitamin C is important in its effect of facilitating the deposition of blood calcium in bone). Vitamin F may also be important in aiding the formation of bone, for it definitely hastens the formation of the hypertrophic processes in arthritis, if given alone, while Vitamin C has the opposite effect. It quickly reduces excess blood calcium and is an antidote for hypervitaminosis D, as in sunstroke.

Vitamin G is another factor in maintaining the solubility of calcium, for in its absence, Vitamin D has little or no effect.

In hypovitaminosis G in test animals, cataracts of the eyes quickly form from precipitated calcium. An important clinical use of Vitamin G is in the treatment of arthritis, its merit here, no doubt, being its cooperative effect with Vitamin D, and the use of massive doses of Vitamin D, being, in our opinion, necessary only because of the lack of knowledge that the synergist Vitamin G is deficient.

One important fact to be kept in mind is that the blood calcium may be high and still the patient be deficient in that element. The tissues may be starved even though the transportation system be loaded excessively if those vitamins be lacking that are necessary to cause the diffusion through the vascular walls. A not infrequent cause of kidney disease in children is the hypercalcemia due to overdosage of Vitamin D preparations, and the resultant albuminuria can only be successfully controlled with a regular dosage of Vitamin A. We have a number of such case histories in our files. In one, a boy of nine who had been heavily dosed with Vitamin D concentrate all winter, developed a nephritis in the spring, and was diagnosed as hypervitaminosis D by the attending physician. The parents were warned to keep the youngster out of the sun, which advice was disregarded, and a few hours on the beach in a bathing suit proved fatal through an attack of acute nephritis with toxicosis from sunburn. (See Reference 7 for further details on toxicity of Vitamin D.)

The toxicity of Vitamin D is a result of the high level of blood calcium, and in pregnancy and lactation when the calcium requirement is greater, a correspondingly larger dosage of Vitamin D can be tolerated (8). The greatly increased requirement of all the vitamins in pregnancy and lactation is, no doubt, due mainly to the enhanced calcium metabolism. As we have often emphasized, one of the most spectacular results of vitamin administration is the treatment of the ills of pregnancy.

Authorities agree that we are all in danger of receiving too little calcium in our food. Milk is often pointed out as a carrier of calcium that can compensate for its absence in other foods, such as bread. The pasteurization of milk, however, reduces its assimilable calcium to the point that it fails to contain enough for the growing child (9).

Add to this a vitamin deficiency that reduces the efficiency of assimilation and we have ample reason for the evidences of calcium starvation to be seen on every hand, beginning with maldevelopment of the bones

and teeth in the infant, low resistance and susceptibility to dental caries, colds, children's diseases, etc. in the child and ending with a million consequences of these continuing factors, endocrine imbalance, etc. in the adult.

Northen has demonstrated that this calcium deficiency even extends to the soil on which vegetable crops are grown (10). He even claims that insect parasites refuse to touch plants (tomato and cucumber) that are grown on soil containing all necessary mineral elements - even though intertwined with vines fed from deficient soil that were alive with bugs, showing that this matter of "resistance" includes insect as well as bacterial parasites. This recalls the comment made to me in all seriousness by a veterinarian that he noticed that fleas would often leave a dog that was receiving his vitamins (as "Catalyn").

REFERENCES

- (1) Osborne and Mendel, *J. A. M. A.*, lxi, 32, (1917); Also McCarrison, *Brit. Med. J.*, I, 717 (1927); and Fujimaki, *Japan Med. World*, vi, 29 (1926) through *Chemical Abstracts*, xxiv, 5802.

Berglund, Medes, Huber, Longcope, and Richards, pages 147-149, *The Kidney in Health and Disease* (1935).

"One of the most important and striking recent advances in the pathology of nutrition is the demonstration of urolithiasis through Vitamin A deficiency. Osborne and Mendel discovered urinary or renal calculi in about ten per cent of their rats on diets deficient in Vitamin A, while no calculi were found in the controls on normal diet. This result has been abundantly confirmed by Fujimaki and McCarrison, especially in rats on diets deficient in other factors in addition to Vitamin A. In some cases the vesical calculi (visible by the roentgen-rays) disappeared when the animals were placed on normal diet. Similar results were obtained by Van Leersum, Perlman and Weber, and Tyson and Smith, working on Vitamin A free diets.

"The work of Van Leersum is of especial interest and importance, because he could find no cystitis, but traced the pathogenesis of the calculi to the kidney. In 88 per cent of his test animals, sections showed numerous small calcareo-fatty granular concretions or casts in the renal tubules and ducts. (These somewhat resemble the above-mentioned changes resulting from fat deficiency.) He concluded that degeneration of the renal epithelium caused the calcareous deposits, and that these were carried to the bladder, where they grew to form the larger

concretions. Recently Tyson and Smith have likewise noted that renal calculi frequently appear in rats on low Vitamin A diets. When obstruction to urinary outflow is present, pyonephrosis develops. They conclude that there is no metaplasia of the renal pelvic epithelium without infection, which is present from the beginning in all cases. Furthermore, this abnormal epithelium, with acute or chronic renal infection, may persist following an apparent cure by the addition of Vitamin A (in cod liver oil) to the diet."

- (2) *Tohoku Jol. Exper. Med.*, 184, January, 1935.
 - (3) Mathews, *Physiological Chemistry*, 4th Edition, page 855, William Wood and Co., 1923.
 - (4) Cowgill and Palmieri, *American Journal of Physiology*, page 146, July 1933.
 - (5) Eggs, F., *Deutsche Ztschr. f. Chir.*, 242:321, 1934; *Chem. Abstracts*, 29:2585.
 - (6) Szent - Gyorgy (quoted from *Modern Living*, page 236, November, 1934) states:

"Under normal conditions, you see, there is very little scurvy among human beings. But I began to change my mind when it was shown that the absence of Vitamin C produced the destruction of teeth before the symptoms of scurvy set in."
 - (7) Harris, *British Medical Journal*, 2:367-73, August 26, 1933.
 - (8) Kozelka, Hart and Bohstedt, *Jol. Biol. Chem.*, 100:715-729, May, 1933.
 - (9) Daniels and Stearns, *Jol. Biol. Chem.*, 61:225 (1924).
- Sherman and Smith, *The Vitamins*, Second Edition, page 152 (1931).
- (10) Beach, Rex, *Modern Miracle Men*, *Cosmopolitan*, pages 60-61, 175-178, June 1936.