TROPHIC CHANGES IN THE BONY CAPSULE OF THE LABYRINTH AND IN THE AUDITORY OSSICLES OF RABBITS UNDER THE EFFECT OF VITAMIN D AND PARATHYROCRINE

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Along with other factors, the inadequate effectiveness of surgical treatment of otosclerosis is explained by the fact that the etiology and pathogenesis of this disease have been insufficiently studied. In otosclerosis, changes of the bony tissue of the labyrinth capsule and auditory ossicles leading to disorders in the mechanism of sound conduction and, as a consequence of this, to the development of progressive loss of hearing, have been established. The level of calcium and inorganic phosphorus, and the activity of alkali phosphatase [1,3,4,7-9] changes in the blood of these patients, which indicates disturbance of mineral metabolism.

Since the basic regulators of mineral metabolism are the parathyroid glands and vitamin D, we undertook to study experimentally the morphological changes in the bony capsule of the ear labyrinth and in the auditory ossicles in the presence of artificially induced shifts of mineral metabolism, in particular in hypervitaminosis D and hyperparathyroidism.

METHOD

The experiments were carried out on 67 rabbits divided into four groups. Control animals (12 rabbits) made up the first group; a state of chronic hypervitaminosis D was created in the animals of the second group (38 rabbits); a state of chronic hyperparathyroidism was created in animals of the third group (9 rabbits); a combination of hypervitaminosis D with hyperparathyroidism was induced in animals of the fourth group (8 rabbits). The experiments lasted several days to 10 months. The state of hypervitaminosis D was caused by daily injections of an oil solution of calciferol (vitamin D_2) in doses from 2500 to 25,000 IU; the state of hyperparathyroidism was caused by intramuscular injections of parathyrocrine of series No. 37 containing 25 units in 1 ml. In this case, some animals were injected every day with 1 ml of parathyrocrine and others received injections every other day. At the end of the experiment, the animals were killed by Vittmaak's method of vital fixation, and the pyramids of the temporal bone, which include the ear labyrinth, after preliminary treatment (decalcination, embedment in celloidin) were subjected to a histologic investigation. We prepared serial sections 18-20 μ thick which were stained with hematoxylin-eosin.

RESULTS

In the animals of the first group, the osseous tissue of the labyrinth and the auditory ossicles was thick, compact, had a lamellar structure, and did not contain medullary spaces. The haversian canals and osteocytes were uniformly arranged.

In the histological investigation of preparations from the animals of the second group, we detected appreciable changes in the osseous tissue of the labyrinth and auditory ossicles which were evidenced by foci of cancellous bone in the compact osseous tissue of the above-indicated regions. The process of cancellation was observed in the periosteum (the bony labyrinth thinned out, its boundaries were blurred and mixed with the cancellated osseous tissue of the temporal bone) and in the endochondral layer of the labyrinth capsule. In the latter case, the foci of cancellous tissue were, so to speak, disseminated in the dense bone of the labyrinth capsule and made it spongy (Fig. 1). The formation of such foci were most frequently observed around dilated blood vessels.

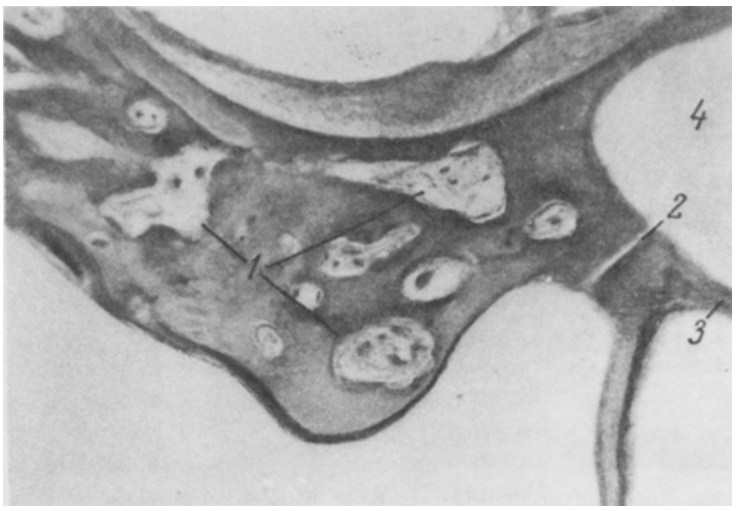

Fig. 1. Multiple foci of osteoporosis in the area of the promontory (1) in hypervitaminosis D; 2) annular ligament; 3) stapedial base; 4) vestibule. Rabbit No. 25. Duration of experiment 125 days. Low magnification. Staining with hematoxylin-eosin.

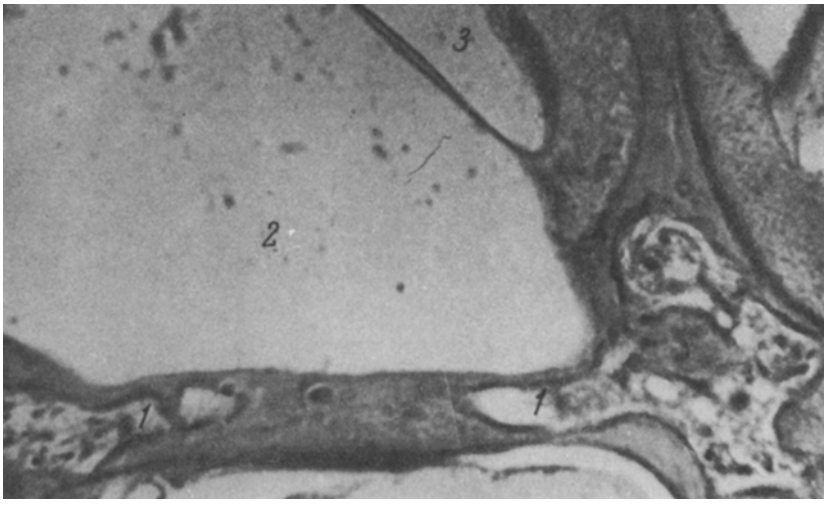

Fig. 2. Ankylosis of the stapedial base in hypervitaminosis D: 1) focus of osteoporosis in region of annular ligament and stapedial base; 2) vestibule; 3) sacculus. Rabbit No. 13. Duration of experiment 156 days. Low magnification. Staining with hematoxylin-eosin.

When the process of cancellation of bone occurred in the region of the periosteum, apparently there was resorption of the compact bone by osteoclasts, which, while destroying the compact osseous tissue, made the boundaries of the labyrinth fantastically tortuous. The foci of the cancellous bone were found both in the region of the cochlea and in the region of the semicircular canals, however, in the region of the cochlea they were found somewhat more frequently. In those cases where the pathological focus was localized at the margin of the oval window, we observed a progression of the pathological process to the annular ligament and further to the stapedial base, which actually led to a destruction of its mobility and consequently to a disturbance in the mechanism of sound conduction (Fig. 2). The compact bone of the auditory ossicles also acquired a cancellated character. In some cases, areas of cancellation were found only in the center of the body of the auditory ossicles (most frequently in the body of the malleus) and primarily in the region of blood vessels, and in other cases cancellation extended to the entire dense osseous tissue and only the periostial layer, which girdled the auditory ossicles as a thin rim, remained compact (Fig. 3).

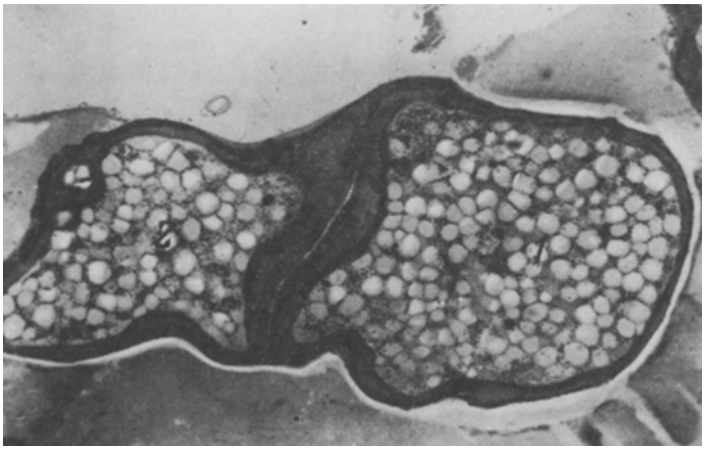

Fig. 3. Head of malleus (1) and body of incus (2) in chronic hypervitaminosis D. Replacement of compact bone by cancellous. Rabbit No. 15. Duration of experiment 138 days. Low magnification. Staining with hematoxylin-eosin.

There is no regular relation between the magnitude of the pathological changes of the bony capsule of the ear labyrinth and ossicles and the duration of the experiment. Thus, in some cases when the experiment was short, the morphological changes of the osseous tissue proved to be appreciable, whereas when the experiment was long, these changes were noted only in limited areas.

The results of the histological investigations permit the assumption that the morphological changes of the bony tissue of the labyrinth capsule and auditory ossicles in hypervitaminosis D occurred both as a consequence of osteoclastic resorption and as a result of some kind of unusual biochemical processes in the bone causing its dissolution. It is possible that the dissolution of bone was caused by the direct effect of vitamin D on the bone through the blood; it is also not precluded that vitamin D affected the osseous tissue indirectly, for example through the endocrine glands. It is known that the function of certain endocrine glands (hypophysis, adrenals, parathyroids, and sexual glands) affect phosphorus-calcium metabolism. Possibly, vitamin D acts on the adrenohypophysial system and causes shifts of its balance toward an increased secretion of mineralocorticoids, which leads to osteoporosis. In this case, vitamin D will be only a stressor, whereas heredity and various conditions of the internal organs and endocrine glands can prove to be the conditional factors [2].

In experimental chronic hyperparathyroidism, as well as in the combination of hyperparathyroidism with hypervitaminosis D, we did not note morphological changes either in the bone capsule of the ear labyrinth or in the auditory ossicles. The osseous tissue in the indicated places was, just as for the control animals, dense; no signs of reorganization of the bone were detected. The data of the morphological investigations permit the assumption that vitamin D apparently affects mineral metabolism of the bone to a greater degree than the parathyroid glands. The fact that in hyperfunction of the parathyroid glands we did not observe the development of morphological changes in the bony labyrinth capsule and in the auditory ossicles gives us grounds to subscribe to Eger's point of view [6], who considers that vitamin D and the parathyroid glands are antagonistic in the effect on processes of bony mineralization. The phenomena of hypervitaminosis D, consequently, will most probably occur in those cases where there is hypofunction of the parathyroid glands.

Thus, for rabbits, morphological changes of the labyrinth, analogous to the changes observed in otosclerosis, are observed in hypervitaminosis D. Apparently, there is a common etiological factor in these disorders.

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