A mechanism of bone tissue loss in monkeys (BION - 11).

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The elucidation of mechanisms of bone tissue loss under the spaceflight conditions remains an actual problem until now. It was established that primary reactions to a mechanical stress evolve at the cellular level, therefore the main attention of the researchers was aimed at studying bone tissue cells and their interactions. With the use of electron microscopy we studied osteoblasts, osteocytes, osteoclasts and stromal cells in bioptats of the iliac bone crest from monkeys flown on board the satellite «BION - 11» during 2 weeks. The flight samples were compared with the vivarium and simulation controls.

The functional state of cells was evaluated by the degree of development of organelles for specific biosyntheses: rough endoplasmic reticulum, Golgy complex, nucleus state, interrelation with a mineralized matrix. The analysis of the obtained results and data of other authors (Klein – Nulend et. al., 2003 etc.) permits to suppose that the following sequence of cell interactions underlies the bone tissue loss during mechanical stress (microgravity): reaction of mechano-sensitive osteocytes to a mechanical stimulus consisting in enhancement of osteolytic processes in cells which results in a partial bone tissue loss along the local unloading.

Simultaneously, the modulating signals are transmitted through a system of canals and processes towards active osteoblasts, surface osteocytes, and bone marrow stromal cells as well. As a reply to a mechanical stimulus there occurs a reduction (slowing down) of proliferation, differentiation and specific functioning. So it was shown that mitochondria in the flight group osteoblasts acquire an electron-dense matrix, the cytoplasmic membrane loses its distinct outlines, the nuclei show enhancement of chromatin condensation, the specific volume of rough endoplasmic reticulum and Golgy complex decreases. The state of rough endoplasmic reticulum (RER) appears to be specific for microgravity and namely: narrow short RER canals without dilations are distributed throughout the cytoplasm and are deprived of spacious organization typical for control osteoblasts. The latter is obviously related with a destruction (reorganization) of microtubules. The interrelation of osteoblasts with a mineralization zone of osteoid is disturbed.

If adaptive osteocytic remodelling is not adequate for unloading force, and exceeds the physiological potencies of cells, they are subject to apoptosis. Then follows the

osteoclastic reaction and resorption of bone matrix in loci of apoptotic osteoblasts and osteocytes. We showed the involvement of macrophages in detritus utilization by osteoblasts and osteocytes in remodelling zones. The macrophagal reaction is followed by osteoblastogenesis which appears to be a restorative stage. However, under microgravity, as judged from the electron microscopic observations, no physiologically adequate rehabilitation of osteogenesis occurs (its scopes are diminished). Moreover, in the remodelling loci a fibrous tissue, not subject to mineralization, may develop. This indicates that under microgravity during remodelling, the rehabilitation of initial bone tissue doesn't take place.