Ultrastructural study of the mitochondria in the submandibular gland, the pancreas and the liver of young rats, exposed to NaF in drinking water

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Abstract

The aim of the experiment was to determine the effect of fluoride on ultrastructural changes in the submandibular gland, the pancreas and the liver. The experimental rats received fluoride in aqueous solutions of sodium fluoride at concentrations of 10.6 NaF/dm^3 and 32.0 NaF/dm^3. In the ultrastructural examination, mitochondria were most damaged.

Key words: Ultrastructural study, rats, submandibular gland, pancreas, liver, natrium fluoride

Introduction

Fluorine, most frequently found in the form of fluorides, shows a high biological activity. Due to its affinity to magnesium and calcium ions, it can affect the activity of many enzymes, mainly oxydoreductases, transferases, hydrolases, enzymes of Krebs cycle, ATP production, protein synthesis, thus disturbing metabolism in the internal organs [1, 2, 3]. In dentistry, it is used in endogenous caries prophylaxis [4]. The aim of the experiment was to examine the effect of fluoride on the mitochondria in the submandibular gland, the pancreas and the liver of young rats, depending on the dose and the administration period. NaF is well soluble in water and easily absorbable in the alimentary tract.

Material and Method

The material for analysis included submandibular glands, pancreases and livers of 90 rats, aged 14, 30 and 90 days, whose mothers, from conception and later with the offspring, received drinking water, containing NaF at the following concentrations: 10.6mg NaF/dm^3 (group I - optimum dose) and 32.0 mg NaF/dm^3 (group II - superoptimum dose). The animals were exposed to fluoride up to 90 days of life. The experiment was terminated on day 120. The tissue material was collected and prepared for ultrastructural analysis, following the generally accepted rules [5].

Results and Discussion

Ultrastructural examinations revealed most pronounced changes in the cell mitochondria. The action of fluoride ions caused alterations in the size and shape of the mitochondria - mitochondrial crests were blurred and the membranes showed features of damage. In experimental Group I, the ultrastructural picture was similar to that, observed in the control group, what may suggest a slight effect of fluoride ions at concentration accepted as optimal. In hepatocytes of 14 and 30 days old rats, only few mitochondria were changed in shape and revealed a condensed mitochondrial matrix. Pronounced alterations in the cells were observed in experimental Group II, in which NaF was administered at a concentration three times higher than that in Group I. The most intensified ultrastructural changes were noted in the submandibular glands, the pancreases and the livers of 30 days old rats in Group II. In 30 days old animals in Group II, the changes were markedly enhanced (Fig. 1, Fig. 2). The mitochondria were polymorphic, with condensed matrix and blurred internal structure. After termination of NaF administration, in the hepatocytes of 120 days old rats the mitochondria were still polymorphic. In the acinar cells of the submandibular gland, evident changes appeared in Group II, growing in intensity with the age and the time of exposure to NaF. In the cells of the submandibular glands of 30 days old rats, swollen mito-

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Figure 1. Rat hepatocyte. Round cell nucleus (N), round mitochondria (M), rough endoplasmic reticulum (RER), glycogen granules (GLY), control group, 30 days, x 4400.

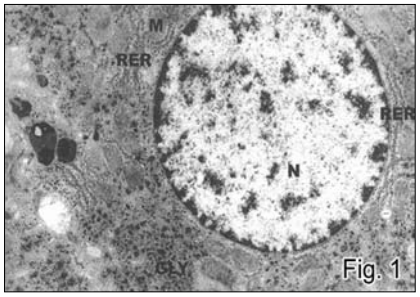


Figure 2. Cell nucleus of hepatocyte (N), with plicated membrane, polymorphic mitochondria (M), shortened and irregular RER channels, activated Golgi apparatus (GA), Group II, 30 days, x 4400

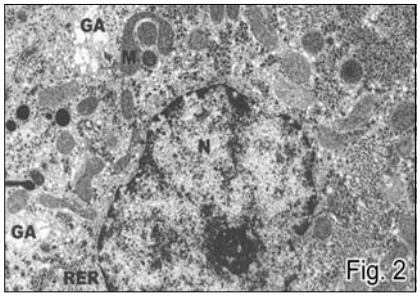


Figure 3. Fragment of acinar cell of the submandibular gland with damaged mitochondria (M), well-developed Golgi apparatus (G), blending secretory granules (*),Group II, 30 days, x 12000.

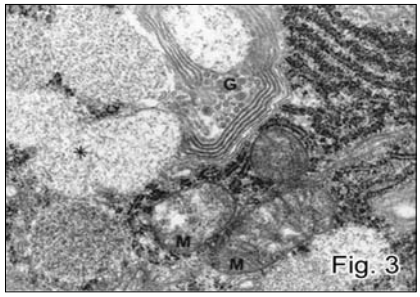
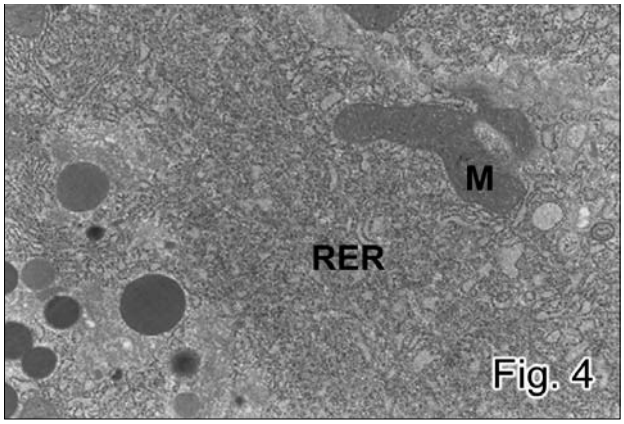


Figure 4. Pancreatic acinar cell, polymorphic mitochondria with condensed matrix (M), large focus of RER degranulation, Group II, 30 days, x 7000.



chondria and destruction of mitochondrial crests of varied degree were observed. (Fig. 3).

In the ultrastructural examination of the pancreas, which structurally resembles the submandibular gland, intensification of changes also increased with the administration time and NaF concentration. Like in the other examined organs, the damage to cell organelles was most pronounced in 30 days old rats in Group II and involved mitochondria, which displayed substantial polymorphism and had condensed matrix (Fig. 4). The most significant morphological changes, observed in the tissues of exposed to NaF animals, included damage to mitochondria of varied degree. Those changes could have disturbed the energetic processes in the cell. Ogoński et al. [6], in in vitro studies, have demonstrated that fluoride ions penetrate mitochondria via simple diffusion. Mitochondrial swelling, observed in the experiment, may be a manifestation of ATP deficiency-related energetic demand and not resulting from degenerative lesions.

Cittanowa et al. [7] consider mitochondria to be the major target of the toxic action of fluoride ions in the kidneys; other researchers have described this effect in the muscles [8]. Lavrushenko has demonstrated fragmentation and disintegration of mitochondrial crests [9].

The enhanced functioning of the secretory apparatus of the cells in the examined organs may be associated with the excretion of exogenous toxins, which have been introduced to the organism. The outcome of the present study, compared to the data reported by other authors, indicate a harmful effect of natrium fluoride on the examined organs of experimental animals, convergent in its biological effects with other toxic agents.

Conclusions

1. Chronic application of a superoptimum NaF dose induces ultrastructural changes in the cells of the submandibular gland, the pancreas and the liver of young rats.
2. The mitochondria are the most damaged organelles in the cells of examined organs.

References

1. Bardsen A, Bjorvatn K. Risk periods in the development of dental fluorosis. Clin Oral Invest, 1998; 2: 155-60.
2. Dąbrowska E, Balunowska M, Letko R. Zagrożenia wynikające z nadmiernej podaży fluoru. Nowa Stomatologia, 2001; 4: 22-7.
3. Grucka-Mamczar E, Machoy Z, Tarnawski R, Briknerer E, Polaniak R, Mamczar A. Wpływ jonu fluorkowego podawanego z wodą pitną na zawartość fluorków, magnezu i wapnia w zębach szczurów. Czas Stomat, 1998; 51: 427-32.
4. Shellis RP, Duckworth RM. Studies on cariostatic mechanisms of fluoride. Int Dent J, 1994; 44: 263-73.
5. Sjonstrand FS. Electron Microscopy of Cells and Tissues. Vol I. Instrumentation and Techniques. Academie Press New York and London; 1967.
6. Ogoński T, Wieczorek P, Paszkiewicz E, Machoy Z. Transport jonów fluorkowych przez wewnętrzną błonę mitochondrialną. Metabolizm Fluoru, 1992; 5: 92-3.
7. Cittanova ML, Lelongt B, Verpont MC, Geniteau-Legendre M, Wahbe F, Prie D, Coriat P, Ronco PM. Fluoride ion toxicity in human kidney collecting duct cells. Anesthesiology, 1996; 84: 428-35.
8. Jing-xi L, Jun-dong W. Effects of NaF on soft tissue structure of rabbits. Fluoride, 1991; 24: 123.
9. Lavrushenko LF, Trunov VI, Okunev VN. Morphofunctional characteristics of some rat hepatocytes ultrastructures under long-period influence of sodium fluoride. Citologia i Genetica, 1980; 14: 10-12.