Relationship evaluation of health status and mineral metabolism in children of newborn and early age

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Abstract. The article presents the study results of fluorine availability of breastfed and early age children depending on the feeding type and in relation to the main bone forming minerals. The content of fluorine and calcium in biological fluids (breast milk, urine) has been determined. Clinical and laboratory indicators reflecting the impairment of fluorine metabolism in children were described. With normal availability of calcium, symptoms of musculoskeletal damage caused by fluorine deficiency have been detected. Diagnosed fluorine-deficient state reflects the disruption of chemical interaction between the main mineral-forming elements of bone tissue — fluorine and calcium. A new way of nutritive support has been proposed for prevention of fluorodeficiency conditions in children.

1 Introduction

The influence of the nutrition and feeding nature on the health state of the child (and then — the adult) is still an actual direction of scientific research in pediatrics. Negative influence of low-quality nutrition is an epigenetic factor, it affects primarily the growing child's body starting from the antenatal period [1, 2, 3].

There is still a tendency of the musculoskeletal system pathology formation in children due to the disturbance of mineral metabolism caused by diet imbalance on certain macro and micronutrients [4, 5]. According to literary data, the prevalence of osteopenia varies in the range of up to 58% of children surveyed, and caries - from 70 — 75% (in southern regions of the Russian Federation) to 95 — 100% (in conditions of the Far North) [2, 6]. It should be noted that the lack of fluorine in drinking water and food is a powerful factor in the development of bone tissue mineral density reduction [4, 6, 7, 8].

It is not surprising that scientific interest in the study of fluorine and its effect on the human body remains in the medical environment of different countries [6, 9, 10, 11, 12, 13, 14, 15]. The researchers proved that the population of the deep parts of the Eurasian mainland with special biogeochemical conditions is in a state of permanent nutrient deficiency on fluorine, and the enrichment of the diet with fluorine starting from the preconceptual period leads to a positive effect on mineral metabolism and promotes proper formation of bone tissue and tooth enamel.

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When studying issues of breastfeeding adequacy, it is necessary to assess fluorine content in mother's milk, which depends on lactation phase: trace amount of fluorine is determined in colostrum, in mature milk — 0.005 — 0.1 mg/l [16].

To assess the body supply level with fluorine at the present stage, a non-invasive technique is used - fluorine excretion determination with urine (fluoruria), as this mineral is excreted mainly through kidneys [11].

Water is the main source of fluorine entry into the human body under physiological conditions, because fluorine in food is much less frequent and depends not only on geochemical terrain, but also the nature of the traditional diet of the population [15]. When developing a strategy to prevent disorders of bone and dental tissue formation in children, it is necessary to consider that local applications of fluorine-containing preparations on dental enamel are only auxiliary methodologies.

It is known [6] that the Ural region of the Russian Federation is a scarce biogeochemical territory in terms of fluorine content in drinking water and soil, and the prevalence of tooth caries and osteopenium remains at a high level despite standard preventive measures.

Objective: to assess health condition and mineral metabolism in children of breastfed and early age in relation to basic bone-forming minerals availability level.

2 Materials and methods

We studied the fluorine supply of 95 children 0-3 years old who are on various types of feeding, including “breastfeeding mother-child” couples with a comprehensive clinical and anamnestic, laboratory and instrumental examination. The body supply with fluorine and calcium was estimated on the level of their excretion with urine (normal values of fluorine excretion 0.5 - 0.7 mg/l [17], calcium - 1.5 - 4.0 mmol/l); calcium - creatinine index was calculated. Statistical analysis of the data obtained was carried out using programs: SPSS 12.0, STATISTICA 6.0.

3 Results and discussion

An objective examination showed that the children examined had clinical symptoms of bone - forming minerals deficiency in the form of musculoskeletal damage symptoms, such as muscular hypotonia, osteomalacia, osteoid hyperplasia, bone hypoplasia (37.9%), tooth enamel darkening (11.6%), caries (1.1%). Among breastfed children, symptoms of mineral metabolism were less likely ($p<0.01$), but decreased fluoruria was noticeable (0.27 ± 0.018 mg/l). The lactating women were sufficiently provided with fluorine because they had normal fluoruria levels (0.72 ± 0.02 mg/L) and fluorine concentrations in breast milk (0.09 ± 0.004 mg/L). We found a direct correlation between fluorine content in breast milk in lactating women and fluorine excretion level ($r=+0.53$; $p<0.05$).

Children on artificial feeding also experienced low levels of fluoruria (0.40 ± 0.01 mg/l).

Fluorine content in breast milk and in adapted milk formulas is not adequate, does not satisfy the physiological need of children for this micronutrient and increases the risk of osteopenia.

Given the synergistic effect of fluorine and calcium on mineral metabolism, we studied calcium excretion with urine, which in both groups examined was within reference values (on average 3.09 ± 0.18 mmol/l). The calcium level objectification criterion - calcium-creatinine index - showed a good calcium supply in the child body (0.65 ± 0.05).

When carrying out statistical comparison of clinical examination and laboratory examination data on the children's provision with bone forming nutrients, the following was revealed in examined children outside feeding nature dependence: a direct close correlation relationship ($r=+0.74$, $p<0.005$) between fluoruria and tooth enamel lesion; a reverse correlation relationship ($r=-0.57$, $p<0.05$) between calcium provision and presence of musculoskeletal system damage markers.

To explain the observed relationships, it is necessary to understand the basic ways of fluorine metabolism in relationship with calcium in the biological apatite cell of bone matrix. In capillary blood involved in metabolic processes in bone tissue, fluorine and calcium are present as variously charged ions: F^{-1} anions and Ca^{2+} cations; as a result, fluorine can accelerate calcium diffusion into bone apatite. Given the small concentrations of fluorine in other body tissues, we argue that at certain concentrations fluorine can increase bone and tooth tissue mineralization by improving calcium absorption.

Taking into account the data of chemical interaction between minerals, in order to prevent the formation of fluorodeficiency conditions in children of breastfed and early age, we first propose to use complex preparation of fluorine and calcium (patent № 2619738, date of registration: 17.05.2017) on the obtaining method and application methods of new biologically active high-purity calcium fluoride. Calcium fluoride synthesized according to the proposed technology is distinguished by less toxicity than sodium fluoride currently used in medicine; it has higher biological activity due to a given dispersion within 0.1-1.0 μm, which in turn leads to the use of small fluorine doses at limited duration of intake. The latter allows to recommend the use of galena forms of calcium fluoride for the enrichment of mass-production infant food products: drinking water, adapted milk formulas, instant porridge.

4 Conclusions

1. Symptoms of musculoskeletal system damage revealed during examination are more due to fluorodeficiency condition with sufficient calcium provision of the children's body. This can be seen as clinical manifestations of chemical relationships impairment between the main bone-forming minerals — fluorine and calcium. Widespread prevalence of mineral metabolism pathology in children of breastfed and early age dictates the need to implement a regional preventive program to prevent the musculoskeletal system pathology formation and increase the health level of children.

2. The new proposed way of enriching the mass-production finished baby food with highly active calcium fluoride is one of the efficient and cost-effective ways of preventing fluorodeficiency conditions in children of breastfed and early age.

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