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Gas'kov, A. Yu., Sabchenkov, M. F. , Yushkov, N. N.
The Bratskiy State University and the Irkutsk State Medical University

Characteristics of the development of iodine-deficient states in children growing up in conditions of contamination of the surrounding environment with fluoride compounds

It is known that in the presence of insufficient function of the thyroid gland a whole spectrum of pathologic conditions develops known at the present time as "iodine-deficiency diseases." The most prevalent manifestations of these diseases include goiter, hypothyroidism, disturbances of physical growth, and intellectual impairments. These disorders are encountered in practically all population groups. Upon prolonged action of the basic pathogenetic factor – a deficiency of iodine – the severity of the disorder can increase substantially, leading to irreversible changes (1, 3, 5).

The hormones of the thyroid gland are products of its follicular cells – iodinated thyronines, specifically triiodothyronine and. tetraiodothyronine. Their essential structural component is iodine, which is obtained from food and water in the form of iodides. With the aid of an active process, the follicular cells accumulate iodide against chemical and electrical gradients. It has been established that the intracellular concentration of this ion is 25 to 50 times in excess of its concentration in the plasma. However, this capability of the thyroid gland is specific in relation to iodine. The cell membranes of the thyroid epithelial cells are incapable of distinguishing among monovalent anions bearing a negative charge. If such anions gain access to the organism in excess, they accumulate concurrently in the thyroid, which leads to a reduction in the uptake of iodine and consequently to insufficient synthesis of thyroid hormones.

Heavy contamination of the surrounding environment with these xenobiotics is due, among other things, to discharges from the aluminum processing industry which contain fluoride compounds. In connection with the significant scientific interest of this there is the problem of the emergence of iodine-deficient states under conditions involving the combined effects on the organism of natural iodine deficits and of anthropogenic (sic) burdens of fluoride compounds on the organism. Children are the most susceptible contingent in the face of iodine deficits; hence, the first-order need is for studies of this category of the populace (2, 4, 6).

The territory of Eastern Siberia is a biogeochemical province characterized by a low level of iodine in the environment. In connection with this in Bratsk, over an extended period of time, universal measures were undertaken for prophylaxis against iodine-deficiency disorders. However the prophylactic measures introduced did not produce significant results, a cause of which, among others, is an unfavorable ecologico-hygienic situation

The present studies were carried out in Bratsk, in the Irkutsk oblast, in the territory of which are located heavy industries for the production of aluminum which are the source of contamination of the environment with fluoride compounds. However, the suburban zone of the city is characterized by differing levels of contamination of the atmosphere with these compounds, which has permitted the delineation of two regions of observation differing in the intensity of effect of the anthropogenic factor (the more heavily contaminated region is the first region 1, and the less contaminated region is the second, region 2).

High levels of contamination of the atmosphere have been detected in both regions of observation, as evidenced by the calculated values of the summary coefficient of atmospheric contamination (Ksum) and the P indices. Their average values over the period of observation in the first region were 38.5 and 53.3, and for the second, 21.7 and 30 respectively, which are characteristic of very high levels of contamination of ambient air. This is due to an excess of the PDK (?) as compared with average annual levels of such harmful substances as nitrogen dioxide, hydrogen fluoride, formaldehyde, phenol, carbon bisulfide, methyl mercaptan, and benzo(a) pyrene. Of major significance for the present investigation is the level of ambient air contamination of the different regions with hydrogen fluoride observation. Its average annual concentration in region 1 was higher than the PDK, and the monthly averages were higher than 2 PDK in 33.3%, 5 PDK in 66.6% of the total number of cases, at the same time as the monthly average concentrations of hydrogen fluoride in region 2 are higher than the PDK in only 8.3% (the most unfavorable month for the dispersion of harmful impurities in the atmosphere) of the total number of tests, while the average annual value was not exceeded. Moreover, the annual average concentration of hydrogen fluoride in the air of region 1 was significantly higher than in region 2.

According to the recommendations of VOZ for the determining the initial signs of iodine deficit, two groups of clinical indices are used – the frequency of goiter in the population according to the data from ultrasound studies of the thyroid, and from biochemical tests of the iodine content of the urine.

As a part of the present work for assessing the distribution and severity of iodine-deficiency disorders there have been epidemiologic studies of the iodine content of the urine in children. The number of those studied amounts to 253 children, of which there were 138 girls and 115 boys. Determination of urinary iodine was accomplished by the spectrophotometric cerium arsenite method. The extent of the iodine deficit was evaluated by the VOZ criteria: an iodine level in the urine less than 20 mcg/l constitutes marked iodine deficiency; from 20 to 49 mcg/l moderate (average), from 50 to 99 mcg/l slight, and 100 mcg/l or more, absence of iodine deficiency. In addition, using a radioimmunologic method with the aid of standard instruments we determined the level of thyroid hormones in the serum.

We measured the content of fluoride in the children by its concentration in the urine and the capacity for uptake by its concentration in bony tissue (milk teeth). Fluoride compounds were assayed by a potentiometric method which permits determination of the total concentration of fluorides.

Upon analysis of the data obtained we started from the following basic assumptions (hypotheses):

-- insufficient intake of iodine in the body leads to the development of iodine-deficiency states;

-- iodine-deficiency states may be the cause of changes in the health indices of the population, including the prevalence of thyroid pathology and changes in the anthropometric indices of child development;

-- the prevalence and severity of iodine-deficient states attributable to living in a biogeochemical province may be aggravated by the anthropogenic burden of the ambient air contaminated with fluoride compounds;

-- the groups of the population investigated live under conditions involving the simultaneous activity of factors of the surrounding environment (contamination of ambient air and inadequate intake of iodine); however, the intensity of effect of the anthropogenic factor differs depending upon the region of habitation.

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In the more contaminated region the average content of iodine in the urine was 30 mcg/l. The prevalence of the severe form of iodine deficiency was 36%, of the moderate form 47% and of the mild form was 17%. In the less contaminated region the average content of iodine in the urine was 44 mcg/l or higher. In this case the distribution of iodine-deficient states of severe degree was 35% of children observed, moderate in 50% and mild in 10%. 5% of children tested had normal levels of iodinuria. So a high degree of distribution of iodine deficiency states was characteristic of both regions of observation.

The level of excretion of fluorine in the urine depends on its concentration in the ambient air. It has been shown that the concentration of fluorine in the urine of children in region 1 was significantly higher than in those of region 2. The result of the determination of fluorine content in the milk teeth of children testifies to accumulation of it in osseous tissues. The demonstrable accumulation of fluorine in biological material detected in children residing in region 1 was 0.34 mg/kg of dry substance, The fluorine content of the teeth of children living in region 2 was significantly lower; however, the level of fluorine content in the teeth of children in both regions was higher than the existing physiologic norm.

The ensuing stage of work entailed the evaluation of thyroid metabolism in children living in different regions of observation and involved computing the volume of the thyroid gland and its hormonal status. Calculation of the volume of the thyroid was conducted in relation to measurements of body surface. The findings testify to the fact that the volume of the thyroid is substantially higher in children in the more contaminated region of Bratsk. Analysis of the hormonal status revealed a significant increase in free triiodothyronine in the group of oobservations. In addition, there was also a much greater
depression of thyrotropic hormone secretion, which may indicate the beginning of an autoimmune process.

Iodine deficiency states are the cause of disorders of physical development in children. In this connection studies were conducted to evaluate the level of physical development and harmonicity of growth of children living in different regions of the city.

Children of both sexes living in the territory of the less contaminated region are taller and have large body mass, with these differences holding for the majority of age groups. Analysis of the level of physical growth of the children showed that in region 2 we encountered much more frequently children with a level of physical development greater than average and much less frequently children below average in this respect. Moreover, in this region there were fewer children with truly low levels of physical growth. In assessing the harmonicity of growth of children of the different observation regions, it must be noted that in the more contaminated region there were far more children whose dysharmonic growth was due to exceptional body mass.

Determination of the simultaneous effects of the environmental factors under investigation was carried out by the method of multiple regression, which permits the determining the direction of effect both of single factors and of groups of factors.

The regression equation derived for observations of the group of children showed a dependence of urinary iodine excretion on the excretion of fluoride which was statistically valid with a positive coefficient of determination (r-squared = 0.85,
$p = 0.004$). The results of the analysis provide evidence that an increase in the urinary excretion of iodine may be seen even in conditions of iodine deficiency.

A subsequent stage in the processing of the material obtained involved determination of the combined influence of iodine and fluorine on the morphologic and functional state of the organism of children and on the volume of the thyroid gland. The action of these elements on the organism was variable. The result obtained show that an increased in the intake of iodine leads

to an increase in children's growth. Increased intake of fluoride is a cause of retardation of annual growth, an increase in body mass and in thyroid volume; at the same time, there are more pronounced changes in thyroid volume in children under conditions of fluoride in the atmospheric (inhaled) air in concentrations exceeding the PDK.

In the presence of average annual concentrations of hydrogen fluoride of 0.032 mg/cubic meter in the territory of the more contaminated region, the daily dose of ingested fluoride compounds may constitute 4.5 to 5mcg/kg, as compared with normal levels of 3 mcg/kg. Existing studies have shown that such a level of activity is an additional risk factor for the development of thyroid pathology.

For the elimination of the demonstrated negative effect it is necessary that the diet of the given group of the population of region 2 be consistent with the therapeutic-prophylactic diet recommended by the "Methods" (?), specifically lipotropic substances (methionine, lecithin, polyunsaturated fatty acids), along with products with a high content of calcium and of vitamins A, E and C in the recommended daily dose.

A high level of prevalence of thyroid pathology among the observed population groups testifies to the necessity of providing individual prophylaxis within the city. The necessary measures must include in the periodic medical examination of children an endocrinologist with the requisite UZI diagnostics. Upon appearance of the initial stages of thyroid pathology it is essential to test the hormone levels in the individual child. This permits, along with the general scheme of prophylactic measures, initiation of the appropriate hormonal therapy for the individual child.

Conclusions: 1 – The evaluation conducted of the level of contamination of the ambient air of the selected regions has shown that it may be characterized as very high. At the same time, the intensity of contamination of the atmosphere of region 1 is substantially higher both with respect to general indices as well as with respect to average monthly and average annual concentrations of harmful substances, including hydrogen fluoride.

2 – The level of fluoride excretion in the urine depends on its concentration in the ambient air. The content of fluoride in the urine in children of region 1 is substantially higher than in children living in region 2 The results of testing the content of fluoride in the milk teeth of children testifies to its accumulation in the bony tissues in concentrations exceeding the physiologic norm.

3 -- The biochemical situation in the Bratsk area is characterized by a low level of iodine content in the environment. Living in conditions of natural iodine insufficiency leads to massive prevalence of iodine deficiency.

4 – Iodine deficiency sates determine the level of physical development of children living in different regions of observation. In evaluating the harmonicity of development of children in different regions of observation it is necessary to note that in region 1 one encounters significantly more often children whose dysharmonic growth is attributable to excessive body mass.

5 – Analysis of the simultaneous action of factors of the environment (iodine deficits and fluorosis) has shown that the basic cause of enlargement of the thyroid in children is an excessive intake of fluorine. (Increasing) the amount of iodine absorbed under conditions of excessive intake of fluorine cannot be an effective prophylactic measure directed at the elimination of iodine deficiency states.

(References)