Boron and Silicon Content in the Hair of Schoolchildren with Endemic Goiter in Oil-Gas Producing Areas of West Kazakhstan

Gulbakit Koshmaganbetova, Khatima Kudabaeva, Ainur Nuftieva, And Yerlan Bazargaliev

Abstract**—** Research aim is to determine the role of misbalance of microelements in the development of endemic goiter in schoolchildren living in oil-gas producing areas of west Kazakhstan. 815 children aged 7-11 were examined. The research was conducted in accordance with protocol recommended by WHO on endemic goiter studies. Multi-element analysis of hair was carried out by using atomic emission spectroscopy. In oil-gas producing areas goiter was revealed in 44,6% and optimal value of urinary iodine was in 56,96% of the examined schoolchildren. In ecologically favorable areas goiter frequency comprised 8,3%, optimal urinary iodine value was revealed in 51,55%. The mean value of iodine, boron, vanadium, manganese, silicon were elevated and zinc and chrome contents were decreased in oil-gas producing areas in comparison with favorable regions. The findings of regression analysis show the elevated content of such microelements as boron and silicon as significant factors influencing on the thyroid volume's change.

Keywords**—**: boron, goiter, schoolchildren, silicon.

I. Introduction

In spite of the fact that in 2013, 111 countries had enough consumption of iodine, iodine deficiency still remains serious medical as well as social problem all over the world for both developed and developing countries [1]. Besides iodine deficiency which plays the leading part in the development of endemic goiter, the alterations in the content of some microelements influencing either on synthesis of thyroid hormones or iodine exchange are also of great pathogenic significance.[2]-[4].

The research findings of Kazakh Academy of Nutrition show that in 1999, 60 percent of women of reproductive age in all regions of Kazakhstan had iodine deficiency of different extent, from 4,0 to 12,0% had high extent [5]. It should be underlined that according to Multiple Indicator Cluster Survey conducted by Kazakh Academy of Nutrition with the support of UNICEF in 2006, iodine deficiency prevalence among women of reproductive age decreased quadruple in comparison with indicators of 1999s and comprised 15 %, the part of households consuming iodised salt reached 92 %, the median urinary iodine value was 235,9 + 166,8 μg/l , on the basis of which Kazakhstan is referred to the group of countries where aims to eliminate iodine deficiency were achieved [6],[7]. Today, universal iodization of dietary and animal salt in Kazakhstan is regulated by the law on prophylaxis of diseases from iodine deficiency dated from14.10.2003 г. № 489–Public Health of the Republic of Kazakhstan.

Nevertheless, the results of pilot study on endemic goiter prevalence carried out by the staff of West Kazakhstan State Medical University named after Marat Ospanov showed that thyreomegaly incidence exceeds sporadic level approximately in 10 times and is 58,9% in Aktobe [8]. Thus, despite the carried out prophylaxis of diseases from iodine deficiency, goiter rate still remains higher among schoolchildren of West Kazakhstan. The Aktobe region is referred to one of unfavorable areas in terms of biogeochemical and ecological regions of Kazakhstan with developed oil, gas and coal-mining and metallurgical areas and also goiter endemic area. In west Kazakhstan anthrotechnogenic province with polluted soil and water by chromium and boron has formed [9],[10]. High prevalence of goiter, possible influence of goitrogenic factors on endemic development served as the reason to conduct the investigation.

The aim of the study was to determine the role of microelement misbalance in the development of endemic goiter in schoolchildren from oil - gas producing areas of western region of the Republic of Kazakhstan.

II. Materials And Methods

The research has been performed in the territory of the Aktobe region and approved by Ethics Committee of the West Kazakhstan State Medical University named after Marat Ospanov (Protocol № 04 date 08.10.2013). Cross-sectional study was conducted within 30th cluster analysis of goiter prevalence in the Aktobe region in accordance with the protocols recommended by WHO studies on endemic goiter [11]. Schoolchildren at prepuberty age 7-11 who permanently live in oil -gas producing areas took participation in the study.

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The equal number of schoolchildren from ecologically favorable areas exclusively agricultural was taken as a control group by random selection method. Schools in districts were also chosen by random sampling. In these schools schoolchildren from 3-4 grades who are permanent residents of this district were examined by all in a row. In Kazakhstan school education is provided free of charge to all citizen. Schoolchildren meeting the investigation criteria (children of prepuberty age, prior written consent of parents or trustees to investigation) were involved in the study. Children with advanced somatic diseases of the heart, liver and kidneys as well as children who underwent thyroid operations were exception. Thyroid gland size and standard norms of thyroid volume in children were determined and assessed depending on the body surface area in accordance with WHO(2007) recommendations according to M.B. Zimmermann standards[11], [12]. A highly qualified physician carried out ultrasonic examination of the thyroid by using portable ultrasonic tool Aloka SSD- 500 (Japan) with sensor 7,5 MHz in accordance with generally accepted recommendations.

Excretion of non-organic iodine in single portion of urine was determined in 30 participants chosen by systematic random sampling in classrooms by use rapid urinary iodide test (the Ukraine) (To avoid iodine vapor, the study was not carried out in medical rooms) [11], [13]. Population was considered to have optimal iodine supply if median of urinary iodine is within 100-300 µg/l .

Biomaterial (hair) was selected to study bioelement status. In the investigated areas by random method children were grouped into 2 groups: one is with goiter and the another group is of children without goiter. Multi-element analysis of hair sample was carried out by combining mass spectrometry and atomic emission spectroscopy inductively coupled plasma methods by means of mass spectrometry Nexion 300D «Perkin Elmer, USA», atomic emission spectroscopy Optima 2000 DV«Perkin Elmer, USA» in research laboratory «Biotic Medicine Center» in Moscow, Russia [14],[15]. The content of 25 chemical elements such as AI, As, Ca, Cd, Co, Cr, Cu, Fe, I, K, Li, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, B, Be, V, Hg, Zn were determined and analysed.

The findings of the study were processed in SAS Programme of Version 9,2. The study results were presented in the form of mean value (M), standard deviation (SD), in case of non-normal distribution Me and interquartile range (25th and 75th**).** Kolmogorov-Smirnov normality test was used for assessing distribution. Two sample t-tests with various dispersion were used to assess statistic significance of discrepancy. The extent of microelements' influence on total thyroid volume was evaluated through multiple regression analysis. Criteria appropriate to p<0,05 was regarded statistically significant.

III. Results And Discussion

30th cluster analysis conducted in western region of Kazakhstan (the Aktobe region) on goiter prevalence among 2257 schoolchildren showed that there is endemia of severe extent in the region. Goiter frequency in schoolchildren of prepuberty age comprised 42,8% [11], [16].

368 schoolchildren from oil-gas producing areas (52,7% boys and 47,3% girls) and 447 residents of ecologically favorable districts (54,3%boys, 45,7% girls) in total 815 schoolchildren were examined during the study. Average age of the schoolchildren was 8,72±0,7. If goiter frequency in oil-gas producing areas comprised 44,6%, then in ecologically favorable areas it was 8,3 % (t=12,65; p<0,001). Excretion of iodine in the urine indicated the adequate supply of population with iodine[11]. 56,96 % of children living in oil-gas producing areas and 51,55% of children from ecologically favorable areas showed optimal value of urinary iodine. It should be noted that 16,45% of children from oil-gas producing areas and 11,34% of children who live in ecologically favorable area had elevated urinary iodine (higher than 300 µg/l).

Thus, discrepancy between adequate iodine supply and high prevalence of endemic goiter is noted in the region. On the basis of this fact the Aktobe region can be considered as an area of endemic goiter and one can assume that goiter intensity is due to not only iodine deficiency in environment but also to endogenous iodine deficiency and influence of other goitrogenic factors, in this case, oil- gas products.

We studied bioelement status of hair in 50 schoolchildren. It is considered that determining the content of microlements in hair as well as their content in blood enables to give informative description of duration and character of chemical microelements' entrance into the body[17]. We conducted analysis of microelement content in the studied areas. Fig. 1 represents accumulation of statistically significant elements in children's hair living in oil-gas producing areas in relation to favorable areas (%).

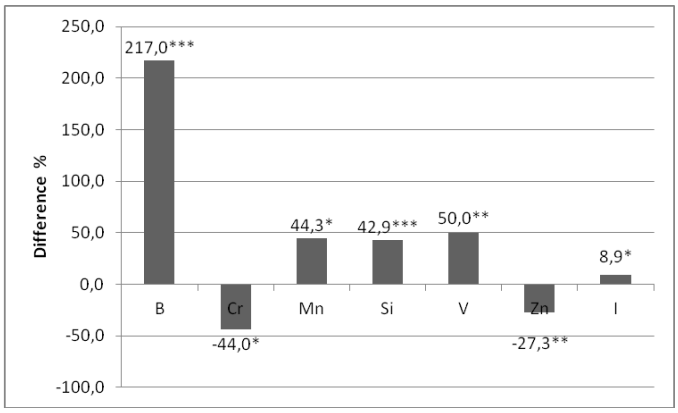

Fig. 1 Difference in accumulation of elements in the hair of schoolchildren living in oil-gas producing areas in relation to favorable areas of the Aktobe region (%)

Note: 0,0 vertical line shows findings from favorable areas; * - difference (p<0,05); ** - p<0,005; ***- p<0,001 between indicators of favorable and oil-gas producing areas

As a result of the study we revealed that in oil-gas producing areas the accumulation of boron (6,15±6,06 µg/g),vanadium(0,09±0,03µg/g), manganese (1,27±0,56 µg/g), silicon(32,0±7,68 µg/g) exceeds the indices in favorable areas. (B - 1,94±1,27 µg/g ; Mn – 0,88±0,43 µg/g ; Si – 22,40±6,39 µg/g ; V – 0,06±0,03 µg/g). In oil-gas producing areas the content of zinc (106,36±28,95 µg/g) and chrome (0,42±0,25 µg/g) have decreased in comparison with those in

favorable areas (146,27±61,59 µg/g) and respectively 0,75±0,49 µg/g, p<0,05).

The content of iodine in the hair of all schoolchildren is within referent value (0,3-10 µg/g) and comprised 1,74±1,98 µg/g. Nevertheless, its content in oil-gas producing areas(1,84±0,70 µg/g), is higher than those in favorable areas(1,69±2,43 µg/g) (p=0,016). The conducted correlation analysis showed that there is positive link between iodine content and Al(r=0,62); Co (r=0,53); Cr (r=0,45); Fe (r=0,66); Li (r=0,54); Se (r=0,45).

The content of macro- and microelements responsible for promoting structural functional parameters of the thyroid was assessed, the content of microelements in the hair of schoolchildren depending on the presence of goiter was analysed.

Fig. 2 and Fig. 3 present the median of boron and silicon contents in the hair of schoolchildren with goiter. The analysis of findings shows that the mean of content of boron (6,33±5,85µg/g) and silicon (31,10±8,18 µg/g) is higher in schoolchildren with goiter than in schoolchildren without it (2,34±2,79 µg/g), (23,82±7,42 µg/g) respectively.

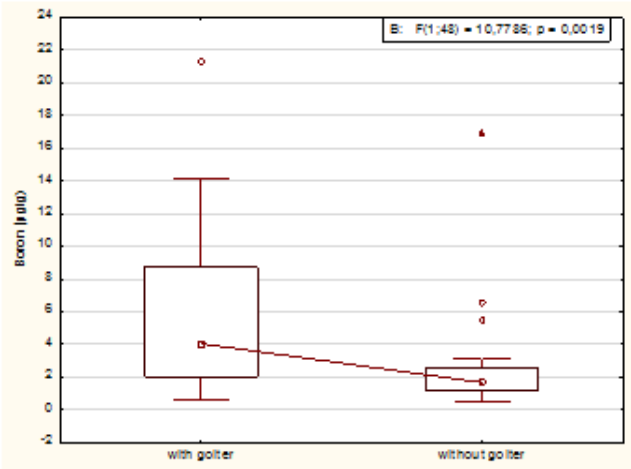

Fig. 2 The content of boron in the hair of schoolchildren from the Aktobe region

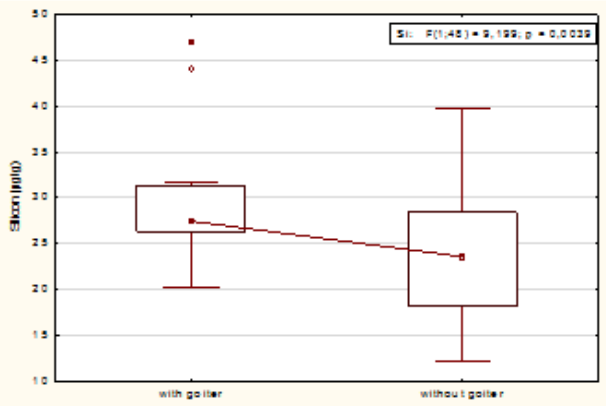

Fig. 3 The content of silicon in the hair of schoolchildren from the Aktobe region

Analysis of literature findings showed that the cause of diseases associated with iodine deficiency may be not only lack of iodine in environment but also deficit or abundance of microelements associated with them [2]-[4]. That's why iodine concentration in hair does not completely reflect the iodine status of schoolchildren. So, schoolchildren with goiter have lower iodine/boron and its coefficient is 0,722 whereas it is 0,722 in schoolchildren without goiter. If iodine/silicon coefficient in schoolchildren with goiter is higher and 0,61 then in schoolchildren without goiter it comprises 0,071

With the purpose to find out the role of microelements for maintaining normal functions and structure of the thyroid gland multiple regression analysis in which total thyroid volume is dependent parameter and the content of microelements is significant factor influencing (p<0,05) on dependent index was carried out. As a result of analysis the equation of thyroid volume's regression dependence on microelement content has been built (F=4,5779, p<0,00048, R2=0 ,47180475)

$Y=0,125+0,182\times B+0,1\times Si$

where Y is total thyroid volume.

The findings of regression analysis demonstrate that significant factors influencing on the change of thyroid volume is the elevated content of such microelements as boron and silicon.

Boron and silicon are microelements with numerous functions in the human body [18]. Presently, there is no information of boron's influence on thyroid function in literature. Experiments on animals and people showed that boron is a biologic active element in food favorably influence on the growth of bone tissue and the function of central nervous system, prevents arthritis development, contributes to hormone action and decreases risks to some types of cancer[19], [20]. Various effects of boron assume that it influences on formation or active substances which participate in numerous biochemical processes [21]. The impact of boron's excess is described in the research conducted in Turkey where harmful effects on the fertility of population for the three generation were not found [22],[23].

According to literature data [24],[25] the an excess of silicon leads to the development of bioelement misbalance which is the cause of malfunction of the thyroid. In some authors' views the elevated rate of silicon in hair does not mean its entrance the body but deficit of this element as a result of its elimination from the body[26]. Our results are consistent with other studies [27],[28]. Thus, misbalance of boron and silicon may interfere with absorption of iodine by the thyroid gland even in its normal consumption. Living for a long time in the territories with marked environment pollution by products of technogenic origin results in disbalance of microelements which together with insufficient iodine in environment contributes to significant growth of thyroid pathology[29],[30].

Our study had some limitations. The study did not assess dietary intake of microelements, the level of thyroid-stimulating hormone and thyroid hormones and we can not speak about them in the study.

IV. Conclusion

In West Kazakhstan (the Aktobe region) endemic goiter of severe extent persists despite the absence of iodine deficiency. An excess of silicon, boron, vanadium and deficit of chrome

and zinc were revealed on the basis of microelement analysis of hair of the children aged 7-11 who live in oil-gas producing areas. Misbalance of silicon and boron plays significant role in the enlargement of thyroid gland in children with goiter, hence requires further investigation in detail.

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