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CORRELATION CONNECTIONS OF CALCIUM METABOLISM DISORDERS IN CHILDREN WITH PAROXYSMAL AUTONOMIC FAILURE AGAINST THE BACK PATHOLOGY OF THE CERVICAL SPINE

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Abstract. *Introduction.* Paroxysmal autonomic failure is one of the pathogenetic forms of autonomic dysfunction. As a result of overloading the autonomic nervous system and disruption of adaptation processes, vegetative crises arise in the body, which are called paroxysms. In recent years, the number of patients has increased and accounts for almost half of all children with clinical forms of autonomic dysfunction [6].

The purpose of this study is to study the correlation of the elemental composition of nutritional status, blood serum, hair, bone mineral density, physical development of children who suffer from paroxysmal vegetative insufficiency against the background of different X-ray manifestations of the cervical spine pathology.

Materials and methods of research. We examined 204 children aged 8-17 years with paroxysmal autonomic failure who underwent a clinical and instrumental examination on the basis of the Center for Vegetative Dysfunctions of Children's Clinical Hospital No. 6 in Kyiv. Instrumental examination included radiography of the cervical spine with functional tests, X-rays of the 1st and 2nd cervical vertebrae through the open mouth, electrocardiography, ultrasound examination of the abdominal cavity organs, rheoencephalography, electroencephalography, daily monitoring of blood pressure, consultations of the neurologist and orthopedist-vertebrologist.

Results. A Correlation analysis was compiled of the nutrient content in the daily volume of food, elemental composition of the blood and the radical hair zone, with indices of the pathology of roentgenography of the cervical spine and bone mineral density, with an estimate of the body mass index in children aged 8-17 years. Patients with paroxysmal vegetative insufficiency were measured against the background of various manifestations of the cervical spine pathology.

Conclusions. The correlation between the indicators of osteopenia and osteoporosis according to the densitometry with copper deficiency ($r=0.304$, $p<0.05$), which through the bromine level ($r=0.379$, $p<0.05$) affects the calcium deficiency in blood serum ($r=0.359$, $p<0.05$). It is important that the decrease in bone mineral density is associated with changes in physical development, more often in the side of body weight increase with $r=0.322$, $p<0.05$, which proves the provoking importance of these microelements in the development of metabolic changes in patients. It was found that the deviation from the normative body mass index in patients with paroxysmal vegetative insufficiency in the presence of the cervical spine pathology is associated with a deficiency of manganese and zinc, which requires the use of appropriate medications in complex treatment drugs to improve the effectiveness of therapy.

Key words: paroxysmal vegetative insufficiency, pathology of roentgenography of the cervical spine, elemental composition, children.

Кореляційні взаємозв'язки порушень метаболізму кальцію у дітей із пароксизмальною автономною недостатністю зумовленою патологією шийного відділу хребта

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Резюме. *Вступ.* Пароксизмальна вегетативна недостатність – одна з патогенетичних форм вегетативної дисфункції. Внаслідок перевантаження вегетативної нервової системи та порушення адаптаційних процесів в організмі виникають вегетативні кризи, які називаються пароксизмами. В останні роки кількість пацієнтів зростає і складає майже половину всіх дітей із клінічними формами вегетативної дисфункції [6].



Мета. Вивчити співвідношення елементарного складу харчового статусу, сироватки крові, волосся, мінеральної щільності кісток, фізичного розвитку дітей, які страждають на пароксизмальну вегетативну недостатність на тлі різних рентгенологічних проявів патології шийного відділу хребта.

Матеріали та методи. Було обстежено 204 дітей віком 8-17 років з пароксизмальною вегетативною недостатністю, які пройшли клінічне та інструментальне обстеження на базі Центру вегетативних дисфункцій дитячої клінічної лікарні № 6 м. Києва. Інструментальне обстеження включало рентгенографію шийного відділу хребта з функціональними тестами, рентгенографію 1-го та 2-го шийних хребців через відкритий рот, електрокардіографію, ультразвукове дослідження органів черевної порожнини, реоенцефалографію, електроенцефалографію, щоденний моніторинг артеріального тиску, консультації невролога та ортопеда-вертебролога.

Результати досліджень. Кореляційний аналіз був здійснений на виявлення взаємозв'язків вмісту поживних речовин у добовому обсязі їжі, елементарному складі крові та радикальній зоні волосся з показниками патології рентгенографії шийного відділу хребта та мінеральної щільності кісток із оцінкою індексу маси тіла у дітей віком 8-17 років. Пацієнтів з пароксизмальною вегетативною недостатністю обстежували на тлі різних проявів патології шийного відділу хребта.

Висновки. Важливо, що зниження мінеральної щільності кісток пов'язане зі змінами фізичного розвитку, частіше в бік збільшення маси тіла з $r=0,322$, $p<0,05$, що доводить провокуючу важливість цих мікроелементів у розвитку обмінних змін у пацієнтів. Було встановлено, що відхилення від нормативного індексу маси тіла у пацієнтів з пароксизмальною вегетативною недостатністю при наявності патології шийного відділу хребта пов'язане з дефіцитом марганцю та цинку, що вимагає використання відповідних медикаментів у комплексному лікуванні для підвищення ефективності терапії.

Ключові слова: пароксизмальна вегетативна недостатність, патологія рентгенографії шийного відділу хребта, елементарний склад біологічних середовищ, діти.

Introduction

Paroxysmal autonomic failure is one of the pathogenetic forms of autonomic dysfunction. As a result of overloading the autonomic nervous system and disruption of adaptation processes, vegetative crises arise in the body, which are called paroxysms. In recent years, the number of patients has increased and accounts for almost half of all children with clinical forms of autonomic dysfunction [6].

The prevalence of the pathology of the cervical spine in Ukraine reaches 47% (Klylovskyy V., 2008), which leads to a decrease in physical activity and affects the quality of life [3].

In the previous works, in 2/3 patients with paroxysmal vegetative insufficiency against the background of the pathology of the cervical spine in the blood plasma and in the radical hair zone, a pronounced deficit of calcium and macronutrients was found that promote its metabolism and take part in the formation of the osteo-connective apparatus and connective tissue, such as copper, manganese, sulfur, chromium [7].

Also in patients with paroxysmal autonomic failure against the background of the pathology of the cervical spine, a pronounced deficiency in the diet of total caloric intake of food (in 98%), an imbalance in the ratio of proteins, fats and carbohydrates, a practical lack of sufficient amounts of trace elements such as Na, Cl, S, Cu, Zn, I, Co, Cr, F with an unbalance of the ratio Ca:P, as 0,25:0,75 [5].

Mineral substances are crucial in creating and maintaining the constancy of the internal environment of the body.

Calcium provides a supporting function for bones. In turn, bone tissue performs in the body the function of «depot» calcium in the body. Calcium has a high biological activity, performs a variety of functions in the body, including the formation of bone tissue, regulation of intracellular processes. The main manifestations of calcium deficiency: decalcification of the skeleton, deforming osteoarthritis, osteoporosis, deformation of the vertebrae, fractures of bones [4].

Today, the relationship between the disruption of physical development, mineral density and the composition of trace elements of blood, hair and diet of children who are paroxysmal with vegetative insufficiency against the background of various manifestations of the cervical spine pathology remains unknown, and therefore this study was conducted.

Purpose

The purpose of this study is to study the correlation of the elemental composition of nutritional status, blood serum, hair, bone mineral density, physical development of children who suffer from paroxysmal vegetative insufficiency against the background of different X-ray manifestations of the cervical spine pathology.



Materials and methods of research

We examined 204 children aged 8-17 years with paroxysmal autonomic failure who underwent a clinical and instrumental examination on the basis of the Center for Vegetative Dysfunctions of Children's Clinical Hospital No. 6 in Kyiv. Instrumental examination included radiography of the cervical spine with functional tests, X-rays of the 1st and 2nd cervical vertebrae through the open mouth, electrocardiography, ultrasound examination of the abdominal cavity organs, rheoencephalography, electroencephalography, daily monitoring of blood pressure, consultations of the neurologist and orthopedist-vertebrologist.

The pathology of the cervical spine based on the data of the X-ray study against paroxysmal autonomic insufficiency was determined in the majority of children – 127 patients (62.3%). The most common X-ray changes in the cervical spine in patients with paroxysmal autonomic failure are instability of cervical vertebrae (in 59 children) – 46.5% and chondrodystrophic disorders (in 68 children) – 53.5%.

For in-depth clinical and instrumental research, 60 children were selected who underwent analysis of the blood plasma, the root zone of the hair for the content of 16 chemical elements (S, Cl, K, Ca, Fe, Ni, Cu, Zn, Br, Cr, Mn, Se, I, Hg, Cd, Pb). The composition of macro- and microelements was studied using a technique for measuring the mass of chemical elements in hair and blood plasma using an X-ray fluorescence method using a portable energy-dispersive X-ray fluorescence spectrometer «ElvaX». According to modern data, methods of selection for the determination of macro- and microelements in bioobjects are methods of elemental hair analysis. The elemental composition of hair is better than other bio-indicator media, reflecting both the effect on man of increased concentrations of a complex of chemical elements, and the provision of physiological requirements for them.

The deviation of the individual microelement profile of the child was recorded using the bioavailable levels of toxic and the limits of the normormolic content of essential chemical elements in the hair of children, which were determined by M. Skalna (2009).

For in-depth instrumental research, 62 children were selected who determined the main

parameters of the child's physical development (height, body weight, chest volume) with an estimate of the body mass index (BMI). BMI was assessed according to the tables [5].

Estimation of the nutrient content in the daily volume of food was conducted with the help of a nutrition test. Accordingly, with the conditions of testing within 3-7 days of observation, the amount of food was recorded and the quality of the dishes consumed by the child was recorded. The estimation of the diet included the calculation of the content of trace elements – Na, K, Ca, Mg, P, Cl, S, Fe, Cu, Zn, I, Co, Mn, Mo, Cr, Se, F; acid-base balance and the amount of calories (kcal).

To assess bone density, an objective (quantitative) method of densitometry was performed. In this study, the method of ultrasound computerized densitometry (echodensitometry) was used because it is effective in diagnosing the initial manifestations of osteoporosis when the loss of bone density does not exceed 3-4%, while in radiologic examination, osteoporosis is diagnosed when bone mineralization in the 25-30%. Data were recorded on paper forms.

Radiography of the cervical spine was performed with functional samples (with maximum flexion and extension) in the direct and lateral projections on the X-ray diagnostic complex RDK-VSM 2005 Production of KPO «Medaparatura» (Ukraine, 2005), as well as X-rays of the 1st and 2nd cervical vertebrae through the open mouth.

The studies were open controlled randomized. Statistical processing was carried out using the MS Excel and 22.0 SPSS software packages. The investigations were carried out, taking into account the requirements of the international committee on bioethics.

The results of the study and their discussion

The obtained results on the study of the interrelations between the deficient level of microelements in the blood serum, in the hair and in the nutritional status of patients with paroxysmal vegetative insufficiency against the background of the cervical spine pathology with their specific signs of radiographic examination, sensitometric indicators of changes in bone mineral density and the body mass index in Table 1.

Table 1

Correlation between the changes in the indicators of instrumental research methods and micronutrient deficiency in patients with paroxysmal autonomic failure against the background of the cervical spine pathology

Indicators	Cr hair	Br hair	Cu blood serum	Mn blood serum	Zn Nutritional Status
Pathology of x-ray	0,299*	0,402*	-	-	-
Disturbance of Bone Mineral Density	-	-	0,304*	-	-
BMI Deviations	-	-	-	0,321*	0,352*

Note: * - $p < 0,05$

The study of parameters of physical development – growth, body weight and BMI - showed that only one third of patients with paroxysmal vegetative insufficiency have normal indices, which were determined within the middle centile corridors and within the 1st standard deviation (Fig. 1) [5].

The asthenic type of the constitution, or BMI, was observed much more often in patients with paroxysmal autonomic failure and with instability of the cervical spine (46.9%). And, regardless of the age of girls, this type of BMI is unreliable (28.1%, $p > 0.05$) was noted more often. Overweight and obesity were rarely defined

(9.3% and 3.13%, respectively), and also more often among girls (6.25%, $p < 0.05$ and 3.16%, $p < 0.05$, respectively) [5].

In patients with paroxysmal autonomic failure with chondrodystrophic disturbances of the cervical spine, or BMI, the asthenic type of build was determined in 30%, overweight in 33.3%, obesity in 3.33% (Figure 1), which confirms a metabolic disorder in such patients. Interestingly, overweight was determined with the same frequency (16.7%), both in boys and girls, and significantly more in patients from 14 to 17 years (23.3%). Obesity was noted in such patients only in boys (3.33%) aged 14-17 years [5].

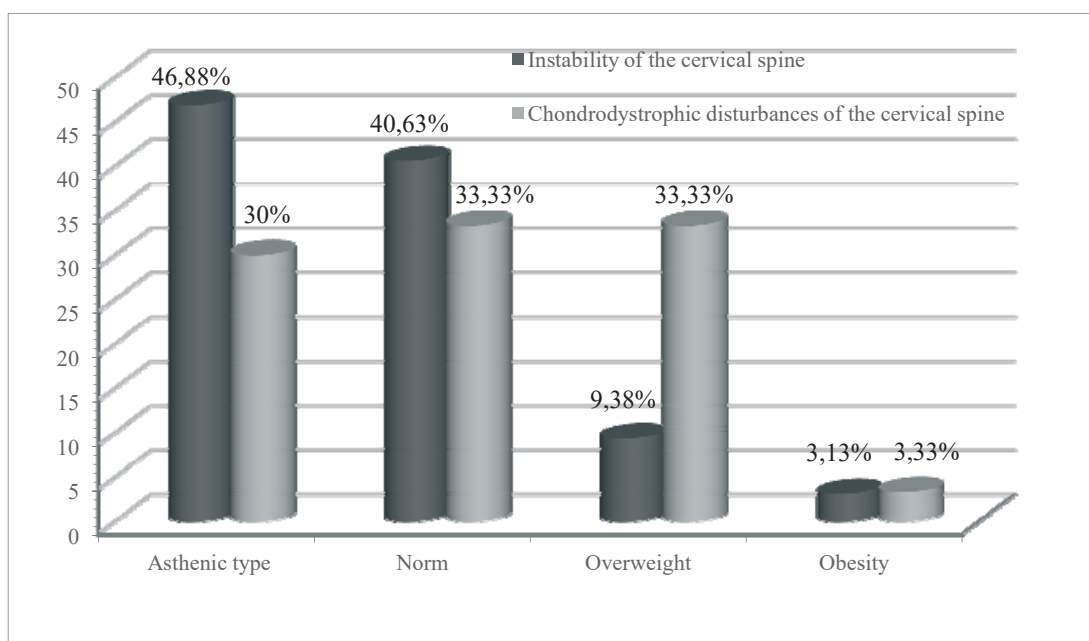


Figure 1. Physical development (BMI) of patients with paroxysmal autonomic failure, depending on the pathology of the cervical spine



So, the signs of osteoporosis and osteopenia as a result of the study of densitometry indicators are reliably associated with a copper deficiency of blood serum ($r=0.304$, $p < 0.05$) and with a deviation of the body mass index ($r=0.322$, $p < 0.05$). The latter, in turn, reliably correlate with the manganese deficiency of blood serum ($r=0.321$, $p < 0.05$) and reduced intake with zinc diets ($r=0.352$, $p < 0.05$). It should be noted that copper takes part in the formation of the structure of connective tissue proteins – collagen and elastin, which are structural components of bone and cartilaginous tissue [4]. Therefore, copper deficiency leads to demineralization of bone tissue and to osteoporosis.

It is known that manganese belongs to the most important bioelements, which is a component of many enzymes and ensures the development of connective tissue, cartilage, bones in the body [4].

In addition, the main manifestations of manganese deficiency are fatigue, weakness, dizziness, as well as degenerative joint changes, a tendency to stretch and dislocate, to osteoporosis, increased overweight, obesity, which was confirmed in our study.

It is known that zinc is part of more than 300 metalloenzymes, in particular alkaline and acidic phosphatases, carbonic anhydrases, DNA- and RNA-polymerases. It is indispensable in the processes of protein biosynthesis, including collagen. In addition, zinc has a stabilizing effect on adrenaline and noradrenaline, due to which it plays an important role in the synaptic transmission in the central nervous system, so it is necessary for the normal course of many biochemical processes and in the formation of bones [2]. It becomes clear why it is important to have a sufficient level of zinc in the diet of patients with paroxysmal vegetative failure against the background of the cervical spine pathology.

The indices of instability and chondrodysplastic changes in the cervical spine in patients with paroxysmal vegetative insufficiency have a reliable correlation directly with chromium deficiency ($r=0.299$, $p < 0.05$) and bromide ($r=0.402$, $p < 0.05$) according to the X-ray study (Table 1), in the hair, which is the depot of microelements in the body of patients.

According to the literature, it is known that in the tissues of organs the chromium content is ten times higher than in the blood. The greatest amount of chromium is present in the liver, intestines, thyroid gland, cartilaginous and bone

tissues. It accelerates the growth of muscle mass, since it is known to be important in regulating blood glucose and blood cholesterol levels. The main manifestations of chromium deficiency: a change in body weight (weight loss, obesity) [4].

As can be seen from the results of the study, chromium deficiency on one hand plays a provocative role in the formation of the cervical spine pathology, and on the other hand, in patients with paroxysmal vegetative insufficiency, promotes the development of metabolic changes and aggravates the functioning of the cardiovascular system. It is also known that bromine participates in the digestive process of fats and carbohydrates, because sodium bromide takes part in the activation of pepsin and pancreatic enzymes [4], so its deficiency can contribute to dismetabolic changes in the cervical spine. Unquestionably the importance of bromides in the regulation of the central nervous system in the intensification of inhibition, while its deficiency pathogenetically affects the manifestations of paroxysmal autonomic insufficiency in children.

The results of the analysis of interrelations between microelements that are directly related to changes in instrumental indices in patients with paroxysmal vegetative insufficiency against the background of the cervical spine pathology (Table 1) and deficiency of compounds that participate in calcium metabolism were interesting. As can be seen in Figure 1, an insufficient level of calcium in the hair is significantly correlated with bromine deficiency ($r=0,282$, $p < 0,05$), and also blood serum calcium – with a deficiency of bromine ($r=0.359$, $p < 0.05$), which emphasizes the great importance of these microelements both for the formation of the cervical spine pathology and for the disturbance of the functioning of the nervous system in patients with paroxysmal vegetative insufficiency.

In turn, the deficiency of bromine in blood serum is significantly correlated with copper deficiency ($r=0,379$, $p < 0,05$) and manganese nutritional status ($r=0.443$, $p < 0.05$), and the level of bromine in hair with sulfur level ($r=0.351$, $p < 0.05$) (Figure 1). Sulfur is a component of the structural protein of the collagen. Chondroitin-sulfate is present in the skin, cartilage, nails, ligaments and in the valves of the myocardium [8]. The exchange of sulfur is controlled by those factors that also have a regulatory effect on protein metabolism (pituitary, thyroid, adrenal, gonadal) hormones. A level of calcium in the

blood serum ($r=0.355$, $p<0.05$) and its level and blood serum ($r=0.417$, $p<0.05$) (Figure 1), which again confirms the need for simultaneous intake in the body of Ca and Zn ions for the effectiveness of calcium metabolism.

But the intake of insufficient amounts of zinc with diets has a link not only to calcium deficiency (Figure 1), but also to a high positive reliable correlation coefficient with a deficiency

of chromium nutrient status ($r=0.664$, $p<0.01$) and low iron densities ($r=0.309$, $p<0.05$), which is simultaneously affected by the level of chromium in the diet ($r=0.356$, $p<0.05$) and bromine in the hair ($r=0.374$, $p<0.05$).

It is interesting that the deficiency in manganese hair with zinc ($r=0.537$, $p<0.05$) and iron with chromium in the hair ($r=0.299$, $p<0.05$) is also reliably associated.

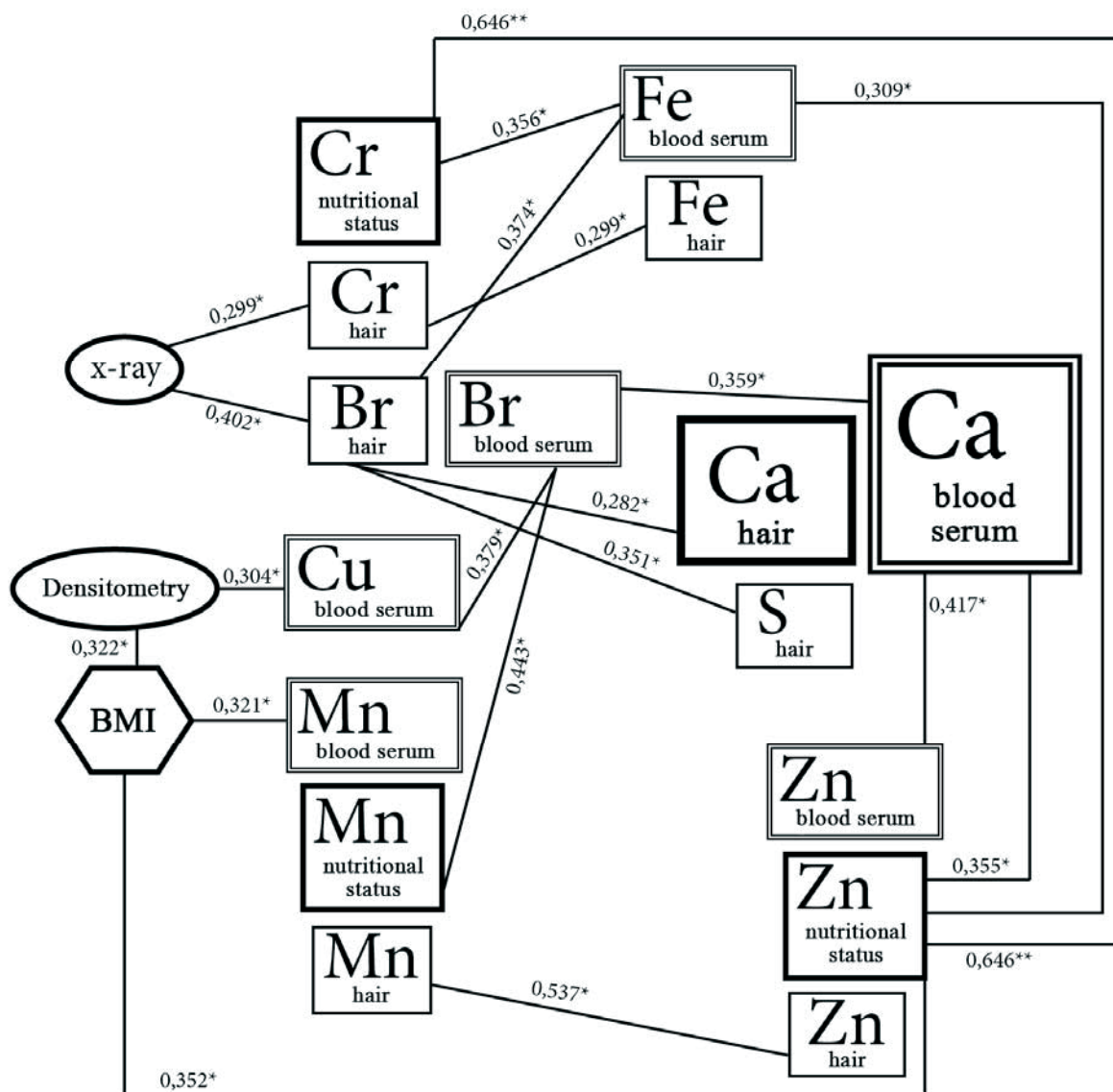


Figure 2. Correlation connections of calcium metabolism disorders in patients with paroxysmal autonomic failure against the background of the cervical spine pathology

It is known that iron deficiency is accompanied by characteristic clinical manifestations, such as headaches, dizziness, weakness, fatigue, similar manifestations of paroxysmal vegetative insufficiency in patients, which certainly confirms the provoking nature

of the deficiency of these trace elements in the development of disregetatism [1, 4, 9].

It should be noted that micronutrient deficiency has its own peculiarities in various manifestations of pathology of the cervical spine in patients with paroxysmal vegetative insufficiency.



Table 2

Deficiency of micronutrients at various displays of the cervical spine pathology in patients with paroxysmal vegetative insufficiency

№	Micronutrients	Instability of the cervical spine (%)	Chondrodystrophic disorders of the cervical spine (%)
1	Ca hair	60,7	59
2	Ca blood serum	67,86	68,2
3	Cr nutritional status	100	84,2
4	Cr hair	100	90,9
5	Br hair	57*	22,7
6	Br blood serum	100	100
7	Fe blood serum	35,7	22,7
8	Fe hair	50	40,9
9	Cu blood serum	67,9	59,1
10	Mn blood serum	25	40,9*
11	Mn nutritional status	76	83,3
12	Mn hair	100	100
13	Zn nutritional status	100	89,5
14	Zn blood serum	10,7	40,9*
15	Zn hair	35,7	68,2*
16	S hair	17,86*	4,55

Note: * - $p < 0,05$

As can be seen from Table 2, the low level of calcium in the blood serum and in the hair is almost identical in almost 2/3 of patients with paroxysmal vegetative insufficiency, regardless of the manifestations of the cervical spine pathology. Chromium deficiency (100%, 84.2%), zinc (100%, 89.5%) in nutritional status, chromium (100%, 90.9%) and manganese were noted in all patients without significant difference in instability and chondrodysplastic changes (100%, 100%) in the hair, bromine blood serum (100%, 100%) (Table 2).

Zinc deficiency in blood serum was determined more often (40.9%, $p < 0.05$) and in hair (68.2%, $p < 0.05$) and manganese of blood serum (40.9%, $p < 0.05$) in patients with chondrodysplastic changes in the cervical spine.

Incidentally, a deficiency of bromine in the hair (57%, $p < 0.05$), iron, copper, and rarely sulfur (17.86%, $p < 0.05$) are unreliable in patients with paroxysmal autonomic failure with the cervical spine instability.

Thus, the obtained data testify to the pathogenetic influence of certain trace elements in changes in calcium metabolism in patients with paroxysmal autonomic failure in the presence of the cervical spine pathology, which requires taking into account the use of schemes of drug therapy and the choice in the diet of foods that are the source of their intake.

Conclusions

1. It has been established that in 2/3 of patients with paroxysmal autonomic failure, various manifestations of cervical spine pathology are associated with changes in calcium metabolism, the deficit of which depends on the low level of bromine and zinc, which confirms the effect of these microelements on the formation of osteogenesis and vegetative regulation in this disease.

2. It has been proved that the x-ray signs of instability and chondrodysplastic changes in the cervical spine in almost 100% of patients



with paroxysmal vegetative insufficiency, are associated with chromium deficiency ($r=0.299$, $p<0.05$) and bromine ($r=0.402$, $p<0.05$) in microelemental hair depot.

3. The correlation between the indicators of osteopenia and osteoporosis according to the densitometry with copper deficiency ($r=0.304$, $p<0.05$), which through the bromine level ($r=0.379$, $p<0.05$) affects the calcium deficiency in blood serum ($r=0.359$, $p<0.05$). It is important that the decrease in bone mineral density is associated with changes in physical development, more often in the side of body weight increase with $r=0.322$, $p<0.05$, which proves the provoking importance of these microelements in the development of metabolic changes in patients.

4. It was found that the deviation from the normative body mass index in patients with paroxysmal vegetative insufficiency in the presence of the cervical spine pathology is associated with a deficiency of manganese and zinc.

5. Correlation relations, which were determined in the framework of calcium metabolism disturbance in children of patients with pancreatitis against the background of the cervical spine pathology, demonstrate the pathogenetic significance of Ca, Zn, Mn, Cu, Cr, Br, Fe, S deficiency, which requires the use of appropriate medications in complex treatment drugs to improve the effectiveness of therapy.

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