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CHRONIC SALT ENVIRONMENT AS A RISK FACTOR OF CARDIOVASCULAR DISEASES OF SALT MINE WORKES

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Summary. This paper examines the influence of the environment on the course of cardiovascular diseases of people who live and work in conditions of «chronic salt environment». It also views the epidemiology of cardiovascular disease among salt mine workers as well as pathophysiological mechanisms of hypertension development and its clinical features in the biogeochemical Carpathian region with a high content of sodium chloride in environmental objects (soil, water, food) and the impact of production factors of salt mine on the human body.

Key words: sodium chloride, chronic salt environment, arterial hypertension, ischemic heart disease.

Introduction. Arterial hypertension and ischemic heart disease occupy one of the leading places among the diseases of the cardiovascular system [1]. Recent studies have shown an increase in the spread of nosology data among people of working age, which necessitates the study of the epidemiology of unorganized and organized populations. Among the complex environmental factors that influence the development of arterial hypertension and ischemic heart disease among workers a great part is occupied by the production factors and nutrition. In particular, the study of the importantance of an excessive admission into the body of sodium chloride in this regard is very topical. The first works which studied the pathophysiological mechanisms of hypertension and its clinical peculiarities in the biogeochemical Carpathian region with a high content of sodium chloride in environmental objects (soil, water, food) were performed in the villages Olexandrivka and Danylovo in Khust district, Transcarpathian region [2]. The surveyed throughout all their life, from generation to generation, consumed 20 g of sodium chloride per day, and the incidence of hypertension and mortality from stroke were 2-3 times higher than similar rates of neighboring regions with normal (10 g/day) consumption of sodium chloride. These studies showed that taste sensitivity to salt of the examined is reduced, and this is one of the reasons why people of this area consume greater amount of sodium chloride. However, these works tackled upon unorganized populations. It was interesting to examine the spread of hypertension and ischemic heart disease in organized populations, particularly, among salt mine workers. There was an attempt to identify their relation to the factors of production, the formed eating habits, as well as high content of sodium chloride in environmental objects (soil, water, food), and to find ways and means of their correction.

The purpose of the study. To investigate the influence of the environment on the course of cardiovascular disease of people who live and work in a «chronic saline environment» and the epidemiology of cardiovascular disease among salt mine workers, together with pathophysiological mechanisms of hypertension and its clinical features in the biogeochemical Carpathian region which has a high content of sodium chloride in environmental objects (soil, water, food).

Materials and methods. A study of the chemical elements in the soil, water, food has been conducted and the data about arterial hypertension morbidity in the villages Olexandrivka and Danylovo in Khust area near Olexandrian deposits of rock salt have been collected. In addition, 1452 employees of the salt mines in Tiachiv district of Transcarpathian region have been examined. The control group consisted of 1309 persons not exposed to «chronic salt environment». The survey included: blood pressure, electrocardiogram registration in 12 standard leads, biochemical identification of lipid content in plasma, daily sodium and potassium content and electrolyte content identification in the blood plasma; assessment of the humoral body systems with the identification of renin activity, concentration of aldosterone, progesterone, cortisol, prostaglandins F and E in plasma. The effect of industrial environment factors of salt mine (microclimatic parameters, concentration of sodium chloride aerosol in the air), food habits and dietary habits, taste sensitivity of miners to salt have also been investigated.

Results and discussion. Chemical analysis of 986 tests of soil has been performed in order to study the chemical composition of the soil on the territory of Olexandrian deposits of rock salt and other towns of Khust district.

Soils on the Olexandrian salt deposits are characterized by a high content of sodium. At a rate of sodium in the soil of black earth (which is taken as a standard) equal to 0,2-0,8 meq% (on average 0,37 ± 0,1 meq%) it ranged from 2,1 to 6,2 meq% (on average 3,7 ± 0,15 meq%) in the village Olexandrivka and its surroundings, which is 10 times higher than the normal one.

Of course, such a great amount of sodium gets from soil into the water and food which is grown in that area, and through it this sodium reaches the human body.

The adverse effect of sodium on the human body is attended with: 1) high soil acidity in the village Olexandrivka and its surroundings (pH = 4,6 ± 0,06 at a rate of 6.5); 2) lack of availability of exchangeable potassium (4,8 ± 0,2 mg% at a rate of 16,6 ± 0,9 mg%); 3) mobile phosphorus (4,4 ± 0,2 mg% at a rate of 17,9 ± 0,3 mg%); 4) low calcium (3,4 ± 0,13 meq% at a rate of 30,6 ± 2,7 meq%) and magnesium (0,7 ± 0,04 meq% at a rate of 5,6 ± 0,9 meq%). The presence of a

large number of ground aluminum (11,4 ± 0,5 mg%) promotes the formation of weakly dissolvable and poorly digestible complexes, which further strengthen the lack of chemical elements in the area.

It is necessary to mention one more feature of soils in the area: the weak supply of micronutrients (except manganese) and their unbalanced relation. Thus, the amount of copper in the soil is 7,5 ± 0,05 mg/kg of dry soil (at a rate of 28,2 ± 3,6 mg/kg), cobalt – 1,2 ± 0,02 mg/kg (at a rate of 13,8 ± 2,0 mg/kg), nickel – 27,3 ± 0,6 mg/kg (at a rate of 40,3 ± 3,6 mg/kg), lead – 6,4 ± 0,08 mg/kg (at a rate of 22,1 ± 2,4 mg/kg), chrome – 7,7 ± 0,08 mg/kg (at a rate of 86,5 ± 2,7 mg/kg) , molybdenum – 0,27 ± 0, 01 mg/kg (at a rate of 2,3 ± 0,3 mg/kg), zinc – 1,5 ± 0,02 mg/kg (at a rate of 52,0 ± 2,0 mg/kg), lithium – 7,3 ± 0,07 mg/kg (at a rate of 39,6 ± 4,6 mg/kg), manganese – 783 ± 5,0 mg/kg (at a rate of 630 ± 112 mg/kg).

Thus, there is an excess of sodium chloride with insufficient amounts of other chemical elements and their unbalanced relation in the soil of this district. Of course, the excess sodium chloride in the soil affects its content in water and food.

In different seasons the chemical composition of drinking water from wells of 316 inhabitants of Khust district was checked, including 130 wells in villages Olexandrivka and Danylovo and 186 wells in other towns of the district. It was established that the water in the wells of Olexandrivka contained 4 times higher amount of chlorides than the normal rate – 1445 ± 67 mg/l (at the rate – 350 mg/l). Wells in other localities of Khust district concentrated sodium chloride ranging inbetween 180-220 mg/l. The concentration of other chemical elements (calcium, magnesium, iron, copper, cobalt, nickel, chromium, molybdenu, lead, zinc) in the wells of Olexandrivka and other towns of the district was 20-80 % less than the normal rate.

In addition, the content of chemical elements was also checked in food that residents of Olexandrivka and total area cultivate and often consume. It was revealed that food grown in soils nearby Olexandrivka contain more sodium chloride than food grown in other localities of the district as well as in the black soil.

Thus, the content of sodium chloride exceeded the norm in: milk – 11,8 %, beet – 13,2 %, wheat flour – 14,2 %, beans seads – 14,7%, tomatoes – 14,8%, chicken eggs – 16,6 %, chicken meat – 23,1 %, carrot – 24,8 %, plums – 30,0 %, green onions – 31,0 %, potatoes – 31,4 %, apples – 31,9 %, cucumbers – 32,5 %, corn – 43,3%, strawberries – 50,0 %, cabbage – 54,6 %.

Other chemical elements (potassium, calcium, magnesium, phosphorus, iron) were 20-40% less than normal in comparison to the products grown on land both near the village Olexandrivka and in other towns of the district.

Also, there was an insufficient number of microelements (except manganese) and their imbalance in all the investigated food products in Olexandrivka and the entire district.

The daily diet of the inhabitants of Alexandrivka and the whole district was analyzed in different seasons to study the number of chemical elements that came with food into their bodies. It was established that the amount of sodium chloride in the daily diet of the inhabitants of the village Alexandrovka is 2,5-3,0 times higher than the normal rate. Thus, with the daily requirement of sodium of 2,3-3,9 g (6,0-10,0 grams of salt) in the body, the residents of Olexandrivka daily received 8,5-9,5 g of sodium or 22,0-24,0 grams of salt. The daily diet of the inhabitants of the rest of the villages in Khust district contained sodium which was within the norm – 2,9-3,6 g (or 7,5-9,0 g of salt). Other chemical elements (calcium, magnesium, phosphorus, iron, copper, zinc, lithium, cobalt, nickel, tin, chromium, molybdenum, thallium) were 12-58 % less than the normal rate. The exception is potassium and manganese which are formally within the normal range in daily diets. The analysis of the coefficient of the sodium / potassium correlation in the daily diet of the residents of Olexandrivka shows that this figure is far from optimal. Thus, if to compare the coefficient rate of sodium / potassium correlation equal to 0,8-0,9 g per day, it is 2,5-5,0 g in the daily diet of residents of Olexandrivka village and 0.8-1.0 in the one of residents of other settlements in Khust district. There is also an unbalanced correlation of microelements in the daily diet of the residents of Olexandrivka and other villages of the district.

The peculiarity of the working environment of the salt mine in Solotvino is the presence of high concentration of salt dust in the air of the working area. Salt dust is 200-6000 times greater than the norm which is 5 mg/m^3 at most terrestrial and underground stations. At working stations with relatively high salt dust (more than 500 mg/m^3) there are 28,4 ± 1,1 % of people, at work stations with relatively medium rate of salt dust (101-500 mg/m^3) there work 34,6 ± 1,2 % of people, whereas at work stations with relatively low salt dust (up 100 mg/m^3) there work 36,9 ± 1,2 % of people. Most people, who have hypertension, work at sites with relatively high rate of salt dust (38,6 ± 3,0 % of persons), 32,2 ± 2,9 % of people with hypertension work in terms of the average salt dust and 29,0 ± 2,8 % of people with hypertension are at sites with relatively low saline dust rate. Thus, most people with hypertension work at the sites where there are relatively high and average rates of salt dust (70,8 ± 2,8 % of people).

Excessive salt dust at the workplace helps to reduce taste sensitivity to salt and its excessive consumption in food. The most frequent boundary level of taste sensitivity to salt among salt mine workers was the high one (70,4 ± 1,2 % vs 7,3 ± 0,5 % among the control group, $p<0,05$). Low boundary level of taste sensitivity to salt was found only with 6,9 ± 0,6 % of salt mine employees. There has been marked an increase in the frequency of high level boundary of taste sensitivity to salt with increasing work seniority in saltmines, due to long influence of production factors, i.e. chronic saline environment. The analysis of the abovementioned data makes it possible to consider reduction of taste sensitivity to salt as a factor of the additional intake of sodium chloride by workers and wide spread of hypertension among the saltmines workers.

The concentration of sodium increases in the blood plasma at the excessive admission of sodium chloride into the body of salt mine workers (145,03 ± 0,73 mmol/l vs 139,5 ± 0,5 mmol/l in the control group of workers, $p<0.05$). In contrast to the medium concentration of sodium in the blood plasma, plasma potassium significantly reduces with the increasing blood pressure.

The study of the average natriuresis of salt mine workers, an indicator of the use of sodium in foods (95-97 % of the admitted into the body sodium excretes with the urine) showed its significant increase in staff of salt-mines, compared with the control group (196,9 ± 2,9 mmol/24h vs 143,9 ± 2,6 mmol/24h, $p<0.05$). It should be mentioned that the amount of sodium in the daily diet of the saltmines dinings 8,4 times exceeded this figure in the daily diet of the dinings of the controlling company.

Low sensitivity to the taste of salt leads to its excessive consumption (adding salt to food not even trying it). This eating habit was wider spread among salt mine workers (52,8 ± 1,3 % vs 16,8 ± 0,7 % in the control group, $p<0,001$).

The change of the biosynthesis of prostaglandins in patients with arterial hypertension under conditions of long-term sodium chloride overload of the body may be one of the reasons for a heavy disease and resistance to the antihypertensive therapy. It is typical for patients with hypertension undergoing long-term chronic salt overload to possess: reduction in renal blood flow and plasma flow, decrease of glomerular filtration rate with an increase in total and renal vascular resistance, increase of plasma aldosterone concentration, increase of the concentration of sodium in erythrocytes and plasma, increase of the levels of prostaglandins F in blood. In addition, at the beginning of the disease predominantly hypokinetic type of circulation forms and increase in blood volume can be marked («volume -sensitive « form of hypertension).

There has been found an increased prevalence of hypertension (40,6 % of subjects) and coronary heart disease (9,9 % of subjects) among the salt mine workers. In its turn, hypertension and dyslipoproteinemia play a major role in the development of coronary heart disease among salt mine employees. For example, the salt mine employees with coronary heart disease had high blood pressure – 71,1 % , which is 2,1 times higher in comparison to the control group, and dyslipidemia (23,2 %), which is 2,2 times higher compared to the rate ($p<0,05$).

Thus, hypertension with excessive intake of sodium chloride into the body has a number of features:

a) Clinical:

- gradual development disease (during 10 - 15 years);
- severe disease, which is often accompanied by a hypertensive crisis with cerebrovascular accident;
- resistance to hypertensive therapy.

b) Hemodynamic :

- hypervolemia (« volume -sensitive « form of hypertension);
- increase of circulating plasma;
- increase in the general and specific peripheral vascular resistance;
- hypokinetic type of circulation;
- violation of electrolyte and microelement homeostasis.

c) The frequency of the disease.

There are three stages of the disease: resistance of the body to sodium chloride, reverse (labile) hypertension, irreversible (stable) hypertension.

Conclusions.

1. Chronic salt environment is a risk factor for cardiovascular morbidity for salt mine workers who live and work in conditions of chronic salt environment and experience the consumption of excessive amounts of salt through food, as well as the inhabitants of the biogeochemical Carpathian region with a high content of sodium chloride in environmental objects (soil, water, food).

2. Change of the biosynthesis of prostaglandins in patients with arterial hypertension under conditions of long-term body overload with sodium chloride may be one of the reasons for the heavy disease and resistance to antihypertensive therapy.

3. Preventative means for hypertension and coronary heart disease should be implemented among salt mine employees, including:

- Automation of basic processes of extraction and processing of salt, usage of advanced respirators by the miners at their work.
- A diet with the restriction of sodium chloride to 5,6 g/d by:

a) usage of salt substitutes («Sanasol», «Salt prevention», etc.);

b) the restriction of products with a high amount of salt in the diet (e.g. ketchup, various sorts of cheese, bouillon cubes, smoked meat, fish, canned tomato juice and vegetables, salted crackers).

- Enrichment of diet products containing potassium and magnesium (potatoes, buckwheat, oatmeal, beans, apricots. peaches, apricots, raisins, prunes, carrots, beets. zucchini) considering that the average daily requirement of potassium is 2,5-5 g per day. It is possible to use vitamin complexes with macro- and micronutrients with the same purpose.
- Regular medical examinations for timely detection and correction of major risk factors for cardiovascular disease (hypertension. excessive weight gain, dyslipidemia).

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