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A.G. Egorova, G.A. Hasner, Z.N. Krivoshapkina

The mineral composition of drinking water as one of the risk factors for formation of the pathology of cardio - vascular system

EGOROVA Aytalina G. - PhD, senior researcher of medical and social and human functional reserve studies YSC SB RAMS
Hasner Galina A. - Junior Researcher of the same laboratory YSC SB RAMS
Krivoshapkina Zoya N.- PhD, Senior Scientist YSC SB RAMS

Long-term laboratory study of drinking water to the level of calcium, magnesium, and hardness in different sources of water: the Lena River, lakes and ground water from wells was conducted. It was established that the low calcium and magnesium, and total hardness of water were recorded in the lake water. Analysis of statistical data on morbidity, mortality, and the infestation has revealed that the population, consuming low-mineralized, soft lake water, is more susceptible to diseases of the circulatory system, as evidenced by relatively high correlation coefficient between mortality from cardiovascular diseases and hardness of drinking water due to the presence of magnesium and calcium salts.

Keywords: drinking water, calcium, magnesium, water hardness, morbidity, mortality, and cardiovascular disease.

There are numerous risk factors for cardiovascular disease. Traditionally, most attention has been paid to factors such as diet, exercise, smoking, serum cholesterol, high blood pressure, diabetes, obesity, age and heredity. Changing of these variables where possible gives a positive effect on reducing the morbidity. At the same time to the risk of cardiovascular disease and mortality and other environmental factors, such as air pollution or drinking water hardness, which receive less attention, may play a role and can have a serious impact on the health of the population.

In recent years a theory according to which the water with low content of electrolytes, causing the stiffness contributes to the development of cardiovascular diseases. According to the results of epidemiological studies a statistically significant, though not very strong inverse correlation between the hardness of drinking water and the level of mortality from cardiovascular disease was revealed [2-4,6]. In foreign studies researchers have reported a correlation between the hardness of drinking water and risk of coronary heart disease - the harder the water, the lower the risk [9,10, 13].

Water hardness is determined by the content of calcium and magnesium. Most studies indicate that magnesium is the most heart protective, and some studies suggest that the most important factor is the ratio of magnesium and calcium. It seems that the high ratio is greater than a low one. Consistency of these findings in a number of studies suggests that the mineral content in the water is a risk factor for diseases of the cardiovascular system [7, 8].

However the relative importance of this factor in comparison with others (such as smoking, obesity, diet, and high pressure) remains unclear.

First in Japan they noticed the connection between the hardness of drinking water and cardiovascular disease, where most of the water sources have soft water with the acidic medium, the lower was the stiffness, and the higher was the incidence of strokes. In communities where water cleaning systems with devices that reduce water hardness were installed and mortality from diseases of the circulatory system increased on average by 20%, compared to those where from the water did not remove hardness salts. Excess calcium at magnesium deficiency, except calcification, can cause heart attacks, cardiac arrest in systole, headaches, premature aging, high blood pressure [11, 12].

In our Republic as a source of water supply are mainly surface water - rivers, lakes, and, to a lesser extent - the underground water.

It is known that in the surface waters all over the republic have lacks of the fluorine and iodine, as well as a reduced content of calcium and magnesium in drinking water is registered.

The results of the long-term studies show that the waters of the major rivers in general, satisfy the quality requirements of Class II sources in accordance with GOST 2761-84 "Sources of centralized drinking water supply" and can be used for drinking after cleaning and disinfection. These waters are low - and middle mineralized, on the chemical composition -calcium bicarbonate, with a satisfactory oxygen regime, poor nutrient components, moderately polluted. Pollutants are mainly oil (1 to 3 PDK) and phenols (3 to 5 PDK). A large part of the population living in areas without central water supply, used water, which is not conforming to the quality of drinking water. [5]

Total hardness - it is a natural property of water caused by the presence in the raw water of so-called hardness salts, i.e. of calcium and magnesium (sulfates, chlorides, carbonates, bicarbonates, etc.).

Water with a total hardness up to 3.5 mEq / L (10 °) is a soft, 3.5 to 7 mEq / L (10-20 °) - moderately hard, from 7 to 10 mEq / L (20-28 °) - tough and more than 10 mEq / L (28 °) - very tough.

Cardiovascular disease (CVD) remains the most pressing problem for medical science, healthcare, due to the high morbidity, permanent incapacity and mortality. In the Republic Sakha (Yakutia) in the past 15 years, mortality among working-age population from the CVD increased in 2.2 times (RF - 1.7 times). Identification of environmental CVD risk factors will disclose the nature of ongoing trends; identify ways and prospects for prevention.

The purpose of this study was to establish a link between the rigidity of calcium, magnesium in drinking water and the levels of morbidity and mortality from cardiovascular disease among the working population of the Republic Sakha (Yakutia).

The material for the study were the YARMIATS statistics data on morbidity and mortality from diseases of the circulatory system of the population of working age, the results of laboratory tests of drinking water FBUZ "TsGiE in RS (Y)" for the period 2005-2008 years on the content of calcium, magnesium, and total hardness by complexmetric determination.

For a comprehensive study of the influence of the mineral composition of drinking water on the incidence and mortality from cardiovascular disease have been identified three areas of the Republic: Megino-Kangalasskii, Churapcha and Khangalassky areas. Site selection was based on the fact that the population of each district uses drinking water from various water sources, respectively, and the mineral content of the water consumed is different. In Megino - Kangalassky area the source of drinking water is wells, in Churapcha - lake water, in Khangalassky – the Lena River.

For a more detailed study of the effects of calcium, magnesium, and hardness in drinking water on cardio - vascular system morbidity of population, living in the study area, in field conditions there has been a single comprehensive medical examination of the indigenous people of working age (312 people) in v. Maya of Megino-Kangalassky, v. Deering of Churapcha and v. Oktemtsy of Khangalassky areas. Comprehensive medical examination included: visiting a neurologist, cardiologist, ECG and biochemical blood cholesterol, triglycerides, VLDL, LDL, HDL, glucose.

Research results:

In analyzing the results of laboratory tests of drinking water received for 2005 to 2008, it was found that the most poor in calcium and magnesium were water lakes. In the drinking water of the Lena River and wells of v. Maya magnesium content was at the same level, and higher calcium content was in river water. The index of total hardness in all investigated water supplies is low.

Thus, in accordance with the Sanitary "Drinking Water" water in all three study water sources can be described as a soft and weak-mineralized (Table 1).

Assessing the impact of risk factors on population health was carried out under the incidence of diseases of the circulatory system and mortality from this class of diseases. Comparative analysis of average annual incidence rates for diseases of the circulatory system uptake in 2005-2008 in the study areas showed that the lowest level was observed in Khangalassky area, high – Churapcha (Table 2).

The average annual mortality rate of working age population from CVD for the observed period are presented in Table. 3. It can be seen that the greatest number of deaths rate from CVD was also observed in Churapcha area, which is in 14% higher than in areas where the river and underground water from wells is used.

Results of a comprehensive medical examination revealed that, among the surveyed population prevalence of diseases of the circulatory system accounted for 100 examined in v. Maya Megino-Kangalassky District - 24.5, v. Deering Churapcha - 81.6 and v. Oktemtsy Khangalassky - 51.2 (Table 4). The average age of the surveyed: in v. Maya - 38 years, v. Deering - 51, v. Oktemtsy - 48 years. By nationality 99% - the Yakuts.

Thus, a comparative analysis of morbidity and mortality from CVD, as well as the affection of the population of working age on the results of a one-time physical examination showed that the population, consuming low-mineralized, soft lake water, is more susceptible to diseases of the circulatory system.

During the correlation analysis between mortality from cardiovascular disease among the population of working age and mineral composition of drinking water in the country as a whole it was established the presence of reliable feedback stiffness ($r = -0,34$, $p \geq 0,05$), magnesium concentration ($r = -0,41$, $p \geq 0,01$) with mortality, which supports the hypothesis that a deficiency of nutrients such as calcium and magnesium is a risk factor for cardiovascular disease.

During the correlation analysis on the three study areas also were received relatively high correlations between mortality from cardio-vascular system diseases and the hardness of drinking water ($r = -0,96$) and magnesium content ($r = -0,94$).

Private correlation analysis showed a direct relationship between the incidence of high blood pressure, and calcium ($r = 0,93$), magnesium ($r = 0,94$), stiffness ($r = 0,917$). The obtained result confirms the hypothesis that the lack of these elements in drinking water is a risk factor for cardio - vascular system diseases.

The final stage of our study was to reveal the association between calcium and magnesium content and hardness in drinking water and blood biochemical parameters, for which a significant correlation with diseases of the cardiovascular system: LDL, cholesterol, glucose was determined.

Study of serum lipid spectrum in the working population, consuming drinking water from various water sources, showed that the biochemical parameters did not exceed the generally accepted normal values, but at the same time there were significant differences (Table 5).

A significant high level of serum glucose in Churapcha area residents compared with residents of Megino-Kangalassky was revealed. Levels of total cholesterol, LDL-C were significantly higher in people of Churapcha and Khangalassky areas compared with residents of Megino-Kangalassky. Because of the significantly lower HDL value atherogenic ratio was higher than normal among residents of Khangalassky district.

During the private correlation analysis statistically significant associations were not identified, but, sufficiently high correlation coefficients between the content of HDL cholesterol ($r = -0,92$), triglycerides ($r = 0,917$), and the hardness of drinking water were received. The results suggest the need for further research to establish the effect of micronutrient deficiencies of calcium and magnesium in drinking water on the blood biochemical composition and, therefore, the incidence of cardio - vascular diseases.

Correlation analysis between the obtained results of biochemical blood tests and the

incidence of cardio - vascular diseases of the population in the study area revealed the presence of significant inverse correlation ($p < 0,05$) between the incidence of cerebrovascular disease and blood glucose ($r = -0,99$), acute myocardial infarction morbidity and LDL ($r = -0,99$), cholesterol ($r = -0,99$), coronary heart disease and LDL (= r-0, 99), glucose ($r = -0, 99$).

Thus, the results obtained in the course of the study, allow establishing the fact that lack of calcium, magnesium, and low value of hardness in drinking water is one of the risk factors of cardio - vascular diseases in the population living in the area. Since to fill deficiency of specified elements in drinking water is not possible, it is necessary to continue the study to assess the adequacy of calcium and magnesium from food in order to develop a comprehensive program to solve this important issue.

The afore-cited lets us to consider as a well-founded previously extended suggestion about possible association between mortality from cardiovascular diseases and mineral composition of the water (calcium, magnesium, water hardness).

Attention to these environmental risk factors as the mineral composition of drinking water can lead to a significant reduction in the load on the health care system associated with cardiovascular diseases.

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Table 1

Mean annual rates of calcium, magnesium and total hardness in drinking water in the study area

District	Calcium	Magnesium	Total hardness
	MPC 100 mg / liter	MPC 50 mg / liter	MPC 7 mEq / L
Megino-Kangalasskii	17,3	24,0	2,9
Churapchinskii	7,3	18,5	2,4
Khangalasskii	34,0	32,4	3,8

Table 2

The average annual morbidity of diseases of the circulatory system among the adult population in 2005-2008 in the study area (on 1000 inhabitants)

Morbidity	Megino-Kangalasskii	Khangalasskii	Churapchinskii
Cardiovascular diseases	200,3	136,2	215,2
Including illnesses, characterized by high blood pressure	69,9	50,4	79,1
Coronary heart disease	56,6	28,9	29,1
Acute myocardial infarction	1,1	0,7	0,6
Cerebrovascular diseases	23,4	14,7	15,9
Other causes	49,3	41,5	90,5

Table 3

The average annual mortality rate of the population of working age from diseases of the circulatory system in the study area in 2005-2008 (on 1000 of corresponding age)

Mortality from CVD	Megino-Kangalasskii	Khangalasskii	Churapchinskii
All CVD	1,81	1,79	2,06
Including diseases, characterized by high blood pressure	0,03	0,03	-
Coronary heart disease	0,54	0,56	0,21
Acute myocardial infarction	0,08	0,18	0,08
Cerebrovascular diseases	0,62	0,5	0,62
Other causes	0,54	0,52	1,15

Table 4

Pathology of the blood circulatory system of the population inspected in three settlements (on 100 surveyed)

Indicators of pathology	v. Maya Megino-Kangalasskii	v. Deering Churapchinskii	v. Oktemtsy Khangalasskii	Total
Total CVD	24,5	81,6	51,2	53,7
Including diseases, characterized by high blood pressure	17,4	38,6	26,0	27,7
Cerebrovascular diseases	1,0	20,2	15,0	12,7
Other heart diseases	4,1	10,5	0,8	5,0
CHD	1,0	10,5	8,7	7,1

Table 5

Levels of biochemical parameters of blood serum at the inspected population in the studied settlements (mmol / L)

Biochemical tests	Maya Megino-Kangalassky	Deering Churapchinskii	Oktemtsy Khangalasskii
Glucose	4,97±0,08+ p=0,000	4,92±0,09	4,23±0,06** p=0,000
Triglycerides	0,95±0,05	0,97±0,05	0,88±0,05
Cholesterol	5,41±0,09+ p=0,000	5,57±0,25	4,85±0,09** p=0,002
HDL cholesterol	1,44±0,03	1,31±0,04* p=0,041	1,45±0,04** p=0,017
LDL cholesterol	3,52±0,08+ p=0,000	3,61±0,09	2,98±0,08** p=0,000
VLDL	0,44±0,02	0,44±0,02	0,42±0,03
Atherogenic factor	2,84±0,09	3,24±0,13	2,5±0,09** p=0,001

Note: * Authenticity between Churapcha and Khangalassky districts,
+ authenticity between Churapcha and Megino-Kangalassky districts,
** authenticity between Khangalassky and Megino-Kangalassky districts.