

Ecologically Determined Violations of the Electrophysiological State of the Myocardium in Children Living in The Industrial District of the City of Vladikavkaz

Dzilihova K.M.

Department of Children's Diseases No. 2,
North Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia
Department of Dentistry № 1,
North-Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia
galiat@list.ru

Dzgoeva M.G.

Department of Dentistry № 1,
North-Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia
galiat@list.ru

Kaloev Z.D.

Department of Children's Diseases No. 2,
North Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia

Dzgoeva Z.G.

Department of Dentistry № 3,
North-Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia

Cerecova A.A.

galiat@list.ru
Department of Dentistry № 1,
North-Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia
galiat@list.ru

Tibilova F.L.

Department of Dentistry № 1,
North-Ossetian State Medical Academy, Ministry of Health
of the Russian Federation,
Vladikavkaz, Russia
galiat@list.ru

Beslekova T.A.

Department of Dentistry № 1,
North-Ossetian State Medical Academy, Ministry of Health of the Russian Federation,
Vladikavkaz, Russia
galiat@list.ru

Abstract – To clarify the effect of chronic eco-toxicity with heavy metals on the state of the cardiovascular system of children, 120 schoolchildren of grades 1–8 living and studying in the Industrial district of the city of Vladikavkaz were examined, close to heavy metallurgy enterprises. The survey included the study of medical records, analysis of the results of the survey of parents, clinical examination of children. Features of the electrophysiological state of the myocardium were studied by electrocardiography. School-age children from an environmentally unfriendly region determine an increased

concentration of ECG signs of impaired automatism, excitability and conduction, as well as ventricular myocardial repolarization processes, indicating electrical instability of the myocardium against the background of autonomic effects dysfunction in the cardiovascular system. In general, the totality of the clinical manifestations of the influence of ecotoxins of the Industrial District on a children's organism can be defined as a manifestation of the syndrome of environmental maladjustment. The identification of cardiac arrhythmias in children from an environmentally unfriendly area must be considered in the

regulation of physical activity and the formation of risk groups for the occurrence of life-threatening arrhythmias.

Key words – ecology, electrophysiological state of the myocardium, adolescents.

I. INTRODUCTION

Significant environmental pollution alters the formation of ecosystems throughout the world. According to modern concepts, the impact of environmental factors on a person makes a significant (from 10 to 20 %) contribution to the formation of his health. Available information sources contain a significant number of publications confirming the pathological influence of xenobiotics [1–3].

Our republic, which has heavy metallurgy enterprises on its territory, as well as large motor traffic flows, located in the mountainous and foothill territories of the Caucasus, with a characteristic wind rose, is affected by a wide range of ecopathogenic factors, the main place among which is occupied by heavy metals.

Possessing affinity for cell membrane structures, heavy metals exhibit toxic effects in all physiological systems and metabolic processes of the human body [3–7]

The high toxicity of heavy metals is due to their ability to accumulate in the body without undergoing decomposition, while actively interfering with metabolic processes, they lead to a deficiency of essential elements, replacing them in metal-containing proteins [8–10].

Basically, the points of application of the toxic effects of heavy metals are the cardiovascular system, kidneys, liver, bone marrow [2–5].

Scientific studies of the ecological situation in the Republic of North Ossetia-Alania over the past decades have revealed significant exogenous soil contamination with heavy metals (lead, cadmium, zinc, mercury, etc.) due to the work of industrial enterprises. More than 3 million tons of waste accumulated in the city of Vladikavkaz, while soil pollution significantly exceeds the background concentration in lead by 10 times, in cadmium from 3 to 8 times [1,11,12].

The risk of environmental problems and living conditions is especially high for the health and development of children. During the period of growth and development of the child, the physiological processes under the influence of various negative influences are easily transformed into pathological states [13–15]. The dangerous level of pollution by emissions of ecotoxins covers large areas of residential areas, schools and kindergartens, which cannot but be accompanied by toxic effects on the child's body, both in antenatal and postnatal ontogenesis.

II. THE PURPOSE OF THE STUDY

The purpose of the study is to clarify the clinical forms of ecopathology caused by heavy metals and the clinical features of the impaired myocardial function in schoolchildren living and studying in the Industrial District of Vladikavkaz.

III. MATERIAL AND RESEARCH METHODS

The research was carried out within the framework of a comprehensive interdepartmental scientific work based on children's clinics number 3 and number 4 in Vladikavkaz in 2010–2017.

A survey was conducted of children and adolescents permanently residing in the zone of ecological trouble, as well as those studying in schools No. 6 and No. 23 of the city of Vladikavkaz, which are closest to the industrial enterprise. The survey coverage was 87 % of the list of students in grades 1–8 of these schools.

Medical documentation of children's polyclinics was used in the work: "History of the development of the child" – f.112/u, and "Medical card of the child" – 026/u.

Clinical and functional studies of the cardiovascular system, as one of the main target organs for ecotoxins, were carried out in children and adolescents permanently residing in the zone of ecological trouble and for comparison in children from an ecologically safe region of the republic.

To solve the research program, 120 children of schoolchildren No. 6 and No. 23 of the city of Vladikavkaz were included in the research (58 children, 7–10 years old – a group of younger school age and 62 children, 11–14 years old – a group of older school age). The control consisted of 105 healthy children of the same age groups (in the youngest 50, in the oldest 55) living in the Digorsky district of the republic. In accordance with the requirements of the Committee on Biomedical Ethics, the survey was conducted with the written consent of the parents.

Features of the electrophysiological state of the myocardium were detected by electrocardiography (ECG). The recording was carried out using the Alton-06 twelve-channel electrocardiograph at a speed of 50 mm / s at rest. Evaluation of the data obtained was carried out according to the generally accepted method, considering the characteristics of ECG in children at different age periods.

Statistical processing of the data was performed using the standard software of the software Statistics for Windows 10.0. The reliability of intergroup differences for averages and relative values was determined considering the error of representativeness according to Student's criterion ($p < 0.05$).

IV. DISCUSSION OF THE RESULTS

Despite the diversity of clinical manifestations, the most characteristic complaint in children in the Industrial District was headache (in the younger group – 86.2 % in the older group – 95.2 %). The intensity and duration of the headache was more pronounced in the older group. Syncope of various origins occurred in anamnesis in 16.7 % of children. More than half (54.2 %) of children fixed their attention on unpleasant sensations in the heart area. Usually these sensations were not leading, but with persistent complaints of cardialgia became the central link of the symptom complex. Complaints of general weakness and fatigue were presented by more than half of the children of both the youngest (55.2 %) and the older (65.8 %) age groups. Excessive tiredness during mental exertion (60.8 %) prevailed over physical overwork (34.2 %).

The combination of clinical manifestations of the influence of ecotoxicants of the Industrial District can be defined as a manifestation of the syndrome of environmental maladjustment [15].

The leading role in the formation of the main clinical manifestations of the syndrome of environmental maladaptation belonged to dysfunction of the autonomic influences in the cardiovascular system and changes in the functional state of the myocardium, one of the manifestations of which are cardiac rhythm disorders.

ECG studies in children revealed a dysfunction of automatism, conduction and excitability of the myocardium. Myocardial functional state disorders were more significant in children of both age groups from an environmentally unfavorable area.

According to the literature, sinus arrhythmia of varying severity in childhood occurs in 94 % of children. Sinus arrhythmia, not dependent on the phases of respiration, occurs in children with labile autonomic nervous system; may occur with organic lesions of the myocardium, with an increase in intracranial pressure, while taking various medications [16,17].

In children living in the Industrial Zone, sinus arrhythmia was detected in 63.3 %. In more than half of the cases (53.9 %), the arrhythmia was not of respiratory origin.

Children in the younger group tended to bradycardia, tachycardia was detected three times less often; in the older group, bradycardia and tachycardia occurred with the same frequency. (Table 1).

TABLE I. THE FREQUENCY OF OCCURRENCE OF CARDIAC ARRHYTHMIAS AND THE MYOCARDIAL REPOLARIZATION PROCESSOR IN CHILDREN AND ADOLESCENTS LIVING IN CONDITIONS OF ENVIRONMENTAL TROUBLE

ECG abnormalities	Industrial district of Vladikavkaz				Control			
	7–10 years (n=58)		11–14 years (n=62)		7–10 years n=50		11–14 years (n=55)	
	P (%)	m	P (%)	m	P (%)	m	P	m
Bradyarrhythmia	46.6*	6.5	33.9*	6.01	16.0	5.18	16.4	4.99
Tachyarrhythmia	15.5	4.75	30.6	5.85	10.0	4.24	23.6	5.73
Rhythm Driver Migration	20.1	5.26	25.8	5.55	8.0	3.84	14.5	4.75
Extrasystole	6.9	3.33	19.4*	5.02	0.0	0.0	5.5	3.07
AV blockade	5.2*	2.92	13.7*	4.36	0.0	0.0	3.6	2.5
Incomplete blockade of the right bundle of His	24.1*	5.62	29.0*	5.76	8.0	3.84	10.9	4.75
Syndrome of predilection of the ventricles	6.9	3.33	16.1*	4.67	2.0	1.98	1.8	1.79
Disorders of ventricular repolarization	25.9*	5.75	38.7*	6.19	10.0	4.24	16.4	5.0

a. * statistical significance of differences between groups of the same age ($p<0.05$)

In children of the control group, moderate sinus arrhythmia was noted in 33.3 % of cases, the rest of the rhythm was assessed as regular. In most children, the arrhythmia was respiratory in nature and was regarded as a physiological phenomenon. Bradyarrhythmias were detected significantly

more often in children from the ecologically unfavorable zone (Table 1).

Fluctuations in the heart rate are determined not only in sinus arrhythmia, but also in case of migratory rhythm. Migration of the pacemaker can sometimes be detected in healthy children with autonomic dysfunction, acquired and congenital heart defects. There are several options for the migration of the pacemaker: from the lower (rarely from the middle) sections of the right atrium, the atrioventricular (AV) connection, and the rarely observed ectopic rhythms from the left atrium [16,17].

Children from an environmentally unfriendly area showed a statistically significant migration of the pacemaker: one in four in the younger and one in five were in the older group, which was twice as often as in the control groups (Table 1). The most frequent (57.5 %) variant was the migration of the pacemaker from the lower parts of the right atrium. The movement of the pacemaker between the sinus and atrioventricular nodes occurred in 27.5 % of cases.

The overall detectability of extrasystolic arrhythmias in our studies in children from an environmentally disadvantaged area was 13.3 %. In the older age group, extrasystole was determined significantly more often than in children of primary school age ($p<0.05$). In most cases, the registered extrasystoles were rare, supraventricular. In 4 (6.2 %) adolescents, monotopic rare ventricular extrasystoles were detected. In the control group, supraventricular premature beats were detected in 5.5 % of adolescent cases and corresponded to the literature data on the prevalence of extrasystoles in healthy children (0.8–2.9 %) [17].

Conduction disorders in the examined children were represented by atrioventricular blockade (AVB), intraventricular blockade (IVB) and ventricular predisposition syndromes (VPS).

The detection of AVB I degree in children from an environmentally unfriendly area in the older group was 12.9 %; the youngest is 5.2 %. Three (4.8 %) adolescents were diagnosed with AVB grade II (type 2 – type I and type 1 type 1). The average duration of the P-Q interval in children with this type of conduction disturbance was 0.229 ± 0.037 s.

In the control group AVB I degree was detected only in 3.6 % of children in the older group and had a functional origin. The average duration of the P-Q interval for this type of blockade in the control group was 0.198 ± 0.029 s.

From IVB more often incomplete blockade of the right leg of the bundle of His (NBPPNG). According to the literature, the frequency of NBPPNG in healthy individuals ranges from 2.3 to 30.0 % [17]. In our studies, NBPPNG in children of both age groups from an ecologically unfavorable area was detected in 26.7 % of the patients, which was significantly more frequent than in the control group (9.5 %).

At children's age, there are various variants of VPS. Changes characteristic of these syndromes are often detected in a random ECG study, so their true prevalence in the pediatric population is unknown [16,17]. Our studies have shown that VPS was significantly more common among children from an environmentally disadvantaged area – 11.7 %; in the control group – 1.9 %. Most of the VPS was

represented by the CLC phenomenon, which has no clinical manifestations. And only 2 children from an environmentally unfriendly area had Wolff-Parkinson-White syndrome (14.3 % of all VPS), which was characterized by complaints of recurrent tachycardia, palpitations, and syncopal states.

Disturbance of metabolism and myocardial repolarization processes, characterized by a decrease in the voltage of the T wave or its inversion in standard and left chest leads, was found in every third child (32.5 %) from an ecologically unfavorable area, which was significantly higher than the analogous indicator in control children 13.3 % ($p<0.05$).

V.CONCLUSION

Thus, the results of the work have established that the totality of clinical manifestations of the influence of ecotoxins in the Industrial District of Vladikavkaz can be characterized as a syndrome of environmental maladjustment, the leading role in the pathogenesis of which belongs to dysfunctions of autonomic influences including in the cardiovascular system.

Children of school age from an environmentally unfriendly area are determined by an increased concentration of ECG signs of impaired automatism, excitability and conduction, as well as repolarization processes, indicating electrical instability of the myocardium.

The identification of cardiac arrhythmias in children from an environmentally unfriendly area must be considered in the regulation of physical activity and the formation of risk groups for the occurrence of life-threatening arrhythmias.

References

- [1] Yu.V. Kodzaev, S.A. Troshchak, N.Yu. Vonsovich, "Public Health and the Impact of Environmental Factors on It", Mining Inform. and Analyt. Bull., pp. 97–101, 2005.
- [2] T. Jin, M. Nordberg, W. Frech et al., "Cadmium Biomonitoring and Renal Dysfunction among Biopetals in China (Chi-naCad)", J. Biometals, no. 15, pp. 377–410, 2002.
- [3] M. Tellez-Plaza, A. Navas-Acien, C.M. Crainiceanu, E. Guallar, "National Health and Nutrition Examination Survey (NHANES)", J. Environ Health Perspect., vol. 16, no. 1, pp. 51–56, 2008.
- [4] N.A. Osipova, E.G. Yazikov, E.P. Yankovich, "Heavy metals in soil and vegetables as a risk factor for human health", Fundam. Res., vol. 8, no. 3, pp. 681–686, 2013.
- [5] N.A. Chernykh, Yu.I. Baeva, "Heavy Metals and Human Health", Bull. of Peoples' Friendship Univer. of Russia, Ser.: Ecology and life safety, no. 1, pp. 125–134, 2004.
- [6] I.V. Chikeneva, "Consequences of the impact of heavy metals on the environment in the zone of impact of industrial enterprises", Sci. and method. Electr. magazine Concept, no. 12, pp. 66–70, 2013. Retrieved from: <http://e-koncept.ru/2013/13254.htm>.
- [7] R. Mamtani, P. Stern, I. Dawood, "Cheemal, S. Metals and Disease: A Global Primary Health Care", J. of Toxicology, 2011. DOI: 10.1155 / 2011/319136.
- [8] C.J. Choi, V. Anantharam, D.P. Martin et al., "Manganese upregulates cellular prion protein and contributes to altered stabilization and proteolysis: relevance to role of metals in pathogenesis of prion disease", J. Toxicol. Sci., no. 115, pp. 535–546, 2010.
- [9] M. Templeton Douglas, Liu Ying, "Multiple roles of cadmium in cell death and survival", Chemico-Biolog. Interactions, no. 188. pp.267–275, 2010.
- [10] Poonam Kakkar, Farhat N. Jaffery, "Biological markers for metal toxicity", J. Environmental Toxicol. and Pharmacol., vol. 19, no. 2, pp. 353–349, 2005.
- [11] V.Kh. Dzaparov, "The threat to life safety in the region of RNO-Alania", Bull. of Magnitogorsk State Techn. Univer. named after G.I. Nosov, vol. 3, no. 27, pp. 75–76, 2009.
- [12] K.G. Sabeev, S.G. Bideev, "Heavy Metals and Their Impact on Human Health", Bull. of the Regional Branch of the Russian Geographical Society in the Republic of North Ossetia-Alania, no. 12, pp. 16–18, 2009.
- [13] Yu.E. Veltishchev, "Children's Ecopathology", Pediatrics. J. named after G.N. Speransky, no. 4, pp. 26–30, 2005.
- [14] J. Grigg, "Environmental toxins; their impact on children's health", Arch. Dis. Child., vol. 89, no. 3, pp. 244–260, 2004.
- [15] J. Xu, L. Sheng, Z. Yan, L. Hong, "Blood Lead and Cadmium Levels in Children: A Study Conducted in Changchun, Jilin Province, China", Paediatrics & Child Health., vol. 19, no. 2, pp. 73–76, 2014.
- [16] M.Yu. Galaktionova, "Individually typological characteristics of rhythm disturbances and cardiac conduction in children", Bull. of Surgut State Univer. Med., vol. 4, no. 14, pp. 16–20, 2012.
- [17] E.G. Zurnacheva, A.S. Kalmykova, R.V. Stupin et al., "The frequency of occurrence of cardiac rhythm disorders in the structure of pediatric cardiac pathology", Questions of modern pediatrics, vol. 5, no. 1, p. 217a, 2006.