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CYTOGENETIC MONITORING OF THE RISK OF ENVIRONMENTAL IMPACT ON PUBLIC HEALTH IN THE REPUBLIC OF BASHKORTOSTAN

A.T. Volkova, O.S. Tselousova, I.A. Potapova[1]

SBEI HPE "Bashkir State Medical University", Russian Ministry of Health,
Russian Federation, Ufa, 3, Lenina St., 450000

Abstract. A cytogenetic monitoring of the environmental impact on public health was conducted by studying cytogenetic indicators of buccal epithelial cells in residents of the northern and southern districts of Ufa and the rural population of the Republic of Bashkortostan. The residents of the northern and southern district of Ufa are referred to the groups of moderate and high risk of cytogenetic disorders (Iac 3,39 art. 4,10, respectively). The rural population are referred to the group of low risk of cytogenetic disorders (Iac 1,68). The index of accumulation of cytogenetic damage in the residents of Ufa is 2 – 2.44 times higher as compared to the index in rural residents which is explained by the impact of urban genotoxic factors.
Key words: cytogenetic monitoring, buccal epithelial cells, karyologic test, micronucleus, proliferation, apoptosis, of cytogenetic disorder accumulation.

Today people are surrounded by a large amount of various potentially hazardous factors which impose threat to human health. For this reason, socio-hygienic control and monitoring of the impact of environmental factors on public health is essential. The method of cytogenetic monitoring based on the studies of cytogenetic status of the nasal and mouth mucous membranes is an informative and non-invasive method that can be used to assess the impact of hazardous environmental factors on human health [4, 5]. The indicators of genome instability in the buccal epithelial cells are micronuclei that make up the chromosome material developed as a result of a DNA molecule breakage (cytogenetic indicators) or damage in the structure and amount of chromosomes during mitosis in response to the action of genotoxic environmental factors. To determine the level of stability of a genome and assess the level of genotoxicity of the environment, it is possible to use, in addition to micronuclei, karyologic indicators of nuclei destruction in buccal epithelial cells that changed in the process of apoptosis or necrosis [5, 6]. The presence of micronuclei in the buccal epithelial cells indicates an impact of exo- and endogenic genotoxic factors on human body [1].

Cytogenetic monitoring is a part of socio-hygienic monitoring in the assessment of the level of environmental safety for humans since it allows assessing the level of damage of the genetic apparatus of cells of each individual with the account for their adjustment or

Volkova Alfiya Talkheevna – Senior Lecturer, Department of Biology (e-mail: volkovaufa@mail.ru; tel. 8 (347) 272-57-82).
Tselousova Olga Sergeevna – Candidate of Biological Sciences; Associate Professor, Department of Biology (e-mail: priemka_bashgmu@mail.ru; tel. 8 (347) 272-92-31).
Potapova Irina Anatolievna – place of study, Medical-Prophylactic Faculty, 6 course (e-mail: priemka_bashgmu@mail.ru; tel. 8 (347) 272-92-31).

maladjustment to certain environmental settings and comparing with the results of the environmental risk assessment studies [7]. Therefore, cytogenetic monitoring assesses the state of public health (prenosological diagnostics) as well as the level of genotoxicity of the environment (in the region, city, and district).

The purpose of the research was to study the risk of development of cytogenetic disorders in the residents of the northern and southern districts of Ufa and the rural population of the Republic of Bashkortostan.

Materials and research methods. Researchers studied the samples of buccal epithelial cells of rural and urban residents of the northern and southern districts of Ufa including 1st year students at BSMU (see Table 1). The average age of females was 18.3±0.14 years old, males – 18.3±0.31 years old.

Buccal swabs were prepared and analyzed under the "Assessment of Cytological and Cytogenetic Status of Human Nasal and Mouth Mucous Membranes" guidelines [4] and the classification of karyological indicators by L.P. Sychyova [6]. At least 1,000 normal cells were analyzed in each individual.

Table 1

Characteristics and size of the research sample

Rural residents	Ufa residents	
	Southern district	Northern district
23	46	27
Total cells analyzed:		
24801	48117	28633

To assess the cytogenetic status of an individual, we used the Index of accumulation of cytogenetic damage (Iac). The Index of accumulation of cytogenetic damage (Iac) was calculated as a product of the integrated index of cytogenetic damages (sum of the cells with micronuclei, nuclear protrusions, and internuclear bridges per mill - Ic – cytogenetic index) and the integrated index of proliferation (sum of cells with two or more nuclei per mill Ip – index of proliferation) divided by the apoptotic index (sum of cells in apoptosis including chromatin condensation accounted for as vacuolization of a nucleus per mill Iapop – apoptotic index): $Iac=(Ic\cdot Ip/Iapop)\cdot 100$. Calculation of the Index of accumulation of cytogenetic damage makes it possible to distinguish 3 risk groups: low ($Iac \leq 2$), moderate ($2 < Iac < 4$) and high ($Iac \geq 4$) risk [8].

The study was conducted in Ufa which is considered to be a city with a high level of formaldehyde, benzo(a)pyrene, and nitrogen dioxide pollution caused by local industrial enterprises and heavy traffic. The quality of water is low due to the impact of waste water from the local plants as well as emergency discharges and drain of pollutants.

In 2010, the index of environmental pollution (IEP) equaled 10.3 and was calculated for formaldehyde, benzo(a)pyrene, and nitrogen dioxide concentrations [2]. In 2011, the IEP for formaldehyde, benzo(a)pyrene, nitrogen dioxide, and suspended substances in Ufa equaled 7.5 [3]. In 2006-2010, the average concentrations of nitrogen oxide, hydrogen chloride, xylene, toluene, and ethylbenzene went up. These compounds have mutagenic and carcinogenic properties thus resulting in a negative effect on the local population [2].

Research results and discussion. The analysis of the risk of cytogenetic disorders in Ufa residents as compared to the conditional control group comprised of the rural residents of the Republic of Bashkortostan is presented in Table 2 below.

Table 2

Cytogenetic indicators of buccal epithelial cells (per 1000 cells)

Indicators	Rural residents	Ufa residents	
		Southern district	Northern district
Cytogenetic indicators, ‰			
Frequency of cells with micronuclei	0,48 ± 0,124	1,48 ± 0,193	1,22 ± 0,263
Frequency of cells with protrusions	0,70 ± 0,203	1,24 ± 0,233	0,63 ± 0,240
Integrated index of cytogenetic effect (sum of cells with micronuclei and protrusions)	1,12 ± 0,215	2,72 ± 0,301	1,85 ± 0,336
Index of proliferation, ‰			
Frequency of cells with two nuclei	0,91 ± 0,301	1,65 ± 0,257	1,63 ± 0,330
Frequency of cells with double nuclei	0,04 ± 0,043	0,15 ± 0,054	0,30 ± 0,104
Integrated index of proliferation (sum of cells with two nuclei and double nuclei)	0,96 ± 0,298	1,80 ± 0,267	1,93 ± 0,370
Index of early nucleus destruction, ‰			
Frequency of cells chromatin condensation	86,83±18,687	144,00±13,739	114,67±21,203
Frequency of cells with nucleus vacuolization	33,00 ± 6,676	22,50 ± 5,193	25,15 ± 4,952
Index of nucleus destruction completion, ‰			
Frequency of cells with karyopyknosis	11,13 ± 1,504	9,11 ± 1,558	12,37 ± 2,740
Frequency of cells with karyorrhexis	2,74 ± 0,849	2,76 ± 0,792	3,22 ± 1,212
Frequency of cells with full karyolysis	17,13 ± 3,724	14,07 ± 2,207	24,07 ± 10,264
Apoptotic index (sum of cells with early and late nucleus destruction)	150,83 ± 23,631	192,43 ± 18,347	179,44 ± 26,568

It was revealed that the residents of the southern and northern districts of Ufa fall into the groups of moderate and high risk of cytogenetic damages (Iac 3.39 and 4.10 respectively). Rural residents fall into the group of a low risk of cytogenetic damages (Iac 1.68). As compared to rural residents, Ufa residents had a 2 – 2.44 variance in the index of accumulation of cytogenetic damage. This indicts a high level of damage of the genetic cell apparatus in the Ufa residents caused by long-term exposure to genotoxic environmental factors. The risk of cytogenetic damage in the residents of the northern district of Ufa is higher than in the residents of the southern district which is possible determined by higher pollution from local industrial enterprises concentrated mainly in the northern part of Ufa.

Conclusions. Consequently, cytogenetic monitoring reveals the areas of high

environmental risks for public health. As a rule, these are regions with the highest level of cytogenetic damages; their population experiences continuous exposure to aggressive technogenic and chemical factors. The assessment of cytogenetic status can help describe chronic effects of environmental exposure as well as determine the impact of hazardous factors in emergency situation. The assessment of cytogenetic status over time can provide information about the activation of the mechanisms of adjustment or mal-adjustment which can serve as a source material for further hygienic activities. Cytogenetic monitoring as a method of assessment of individual and average group level of cytogenetic damages may be an effective indicator of effectiveness of the recommended activities.

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