Teenagers' heart rate variability during inhalation volatile solvents

Preminina Oksana Sergeevna
Candidate of Biological sciences, Associate Professor
Northern (Arctic) Federal University (NARFU)
Cherkasova Anna Sergeevna
Candidate of Biological sciences, Associate Professor
Northern (Arctic) Federal University (NARFU)
Boreiko Anna Pavlovna
Candidate of Biological sciences, Associate Professor
Northern (Arctic) Federal University (NARFU)
Chub Igor Sergeevich
Candidate of Biological sciences, Associate Professor
Northern (Arctic) Federal University (NARFU)
Kunavin Mikhail Alexeyevich
Candidate of Biological sciences, Associate Professor
Northern (Arctic) Federal University (NARFU)

Summary. This publication presents results of comprehensive heart rate variability research, which achieve recent data about European Northland teenagers' cardiovascular system conditions during inhalation volatile solvents. It was registered, that vapors of solvents affect at functional conditions of 11-16 years old teenagers' cardiovascular system and heart rate variability.

Discovered peculiarities of alterations of teenagers' heart rate variability during inhalation volatile solvents have vital value to ecological and age physiology and this research can stand as a basement for further examinations.

Keywords: European Northland teenagers', volatile solvents, heart rate variability.

Materials and methods

Among the key trends that characterize the drug situation in the Russian Federation, the greatest concern is the steady rejuvenation of consumers of psychoactive substances (surfactants). Adolescents abuse drugs 7.5 times more often than people of all other ages, and non-narcotic surfactants-11.4 times more often [1].

Puberty is an important stage of growth, development of the teenager and his socialization as a person. With the formation of personality in modern adolescents-northerners is the assimilation of both positive skills and negative social stereotypes, this is manifested in an increase in the

number of adolescents who use surfactants [2].

Neurotoxic period, accompanied by the use of psychoactive substances, leads to total damage in the state of health. As a result of the action of volatile solvents (VS) on the functions of the parameters of external respiration, metabolism in structures and orgVNS is disturbed, this in turn has a General toxic effect, changes the functionality and structure of cell membranes, affects the ratio of biochemical structures, enzymes and causes disturbances at the molecular and systemic levels [3]. With systematic involvement, surfactants cause powerful adaptive failures, stable desynchronization and destabilization of biochemical responses, functional processes and cellular nutrition disorders [4].

Examinations of teenagers observed at the doctor of the narcologist upon the use of VS were carried out. Of all the minors we studied, abusing VS, children 11-12 years were 30.1%, 13-14 years-35.4%, 15-16 years-34.5%.

The use of VS mainly falls on 13-14 years. The first VS test most often occurs at the age of 11 years (33%).

When studying the social status of abusers of toxic substances, a pronounced tendency of growth of consumption of VS among students of secondary schools was found-81.3%, the remaining 18.7% were not students of educational institutions. The greatest prevalence of VS abuse was found among boys (up to 80%).

In the studied children, the frequency of consumption of VS varied - from one to several times in 30 days. The largest component (91.1%) is a group of people who use VS more than once a month.

Materials and methods. The frame of the study was the results of a survey of 300 adolescents of the Arkhangelsk region aged 11 to 16 years, including 213 boys and 87 girls. The surveyed had no chronic diseases, they had an average level of physical development and were engaged in physical culture according to state programs in the main group [5].

The control group consists of adolescents who do not use VS, the main group – adolescents who use VS. According to the international classification of diseases (ICD-10: mental and behavioral disorders due to the use of volatile solvents (F18)), each subject was diagnosed by a narcologist.

The study took place in a specially equipped office with a comfortable temperature regime in the morning. Subjects were taken for examination after 10-15 minutes of rest, on an empty stomach or 2 hours after eating.

Before the beginning of the study, height and weight were measured according to the generally accepted method. Then, at rest, systolic arterial pressure (SAP) and diastolic (DAP) were measured by the Korotkov auscultative method, as well as heart rate (HR).

The heart rate variability was determined using cardiointervalographic (CIG) study by R. M. Bayevsky (1998) using portable diagnostic complex "VARICARD 1.4" (IVNMT "Ramen", Ryazan). A standard scheme for studying the regulation of heart rate (RHR) in the supine position was used. Registration of HR was carried out within 5 minutes in the II standard lead [6].

Below are the studied HRV parameters.

Indicators characterizing the time domain-statistical: standard deviation of the dynamic series of R-R-intervals (SDNN), mode (Mo), mode amplitude (AMO), standard difference characteristic (RMSSD), the difference between the highest and lowest values of the dynamic series of R-R intervals (MxDMn), the ratio of the maximum possible to the minimum possible values of the dynamic series of R-R intervals (φn), the number of cardiointervals whose difference characteristics are more than 50 MS (PNN 50); parameters of the wave structure of the dynamic series of cardiointervals: the value of the first correlation coefficient (SS1), the number of shifts to the first zero value of the correlation coefficient (SS0); voltage indicators: the voltage index of regulatory systems (SI).

The spectral analysis of wave parameters used the following frequency ranges:

- high frequency oscillations of the HF (High Frequency) 2 to 7 sec, 0.5-0.15 Hz;
- low-frequency oscillations in the LF (Low Frequency) 7-20 h, 0,15-0,05 Hz;
- ultra-low frequency oscillations VLF (Very Low Frequency) 20-70 sec, 0.05-0.015 Hz.

Studied indicators frequency range: power spectrum (PLF) in the frequency band of short waves, power spectrum (PHF) in the frequency range of long waves spectral power (PVLF) in the frequency range of ultrashort waves, the highs component of all spectra, the values of the periods of the peaks in all ranges of the power spectrum in the frequency range HF, LF and VLF as a percentage to the entire range, the average power spectrum in all bands, the average power spectrum (P), total spectral power (∑P), index of activation of the subcortical nerve centers (IAP), the index of centralization (IC) [7].

Statistical analysis of the obtained data array was performed using software packages Stadia 5.0, Statistica 5.0, EXCEL 2002. The reliability of the difference between the compared indicators was determined by the student's t-criterion. The differences at the significance level of 95% ($p<0.05$) were taken as significant.

Results and discussion

The analysis of the data obtained in males 11-13 years of age of the control group revealed differences in time indicators compared to the control group, despite the fact that the average duration of cardiointervals (Mo) is actually equal. The functional lag of maturation of the departments of the vegetative nervous system (VNS) in boys 11-13 years, using VS, from their peers was revealed. This is evidenced by the negative dynamics of the time parameters of HRV: the

difference of the largest and smallest values of the dynamic series of RR intervals and the mean square difference characteristic. The latent periodicity of RHR, which is indicated by the value of the correlation coefficient after the first shift, increases significantly in the main group, which indicates the automation of VNS control. This fact is confirmed by frequency indicators: boys of the main group have lower characteristics of respiratory modulation (RHF, AHF) and slightly higher characteristics of the low – frequency part of the spectrum (RLF, ALF), as well as a marker of sympathetic activity – the index of centralization. In addition, boys who use VS have a more significant stress index. This reflects the prevalence of rates of maturation of brain structures in boys of the control group and the lag – in the main, as well as increased stress of the functional system in boys who use VS.

Spectral parameters have no significant differences between them, and their "weight shares" are almost the same in males of the control group of 11-13 years. The obtained results confirm the opinion that a certain balance between adrenergic and cholinergic effects on RHR is achieved in children aged 11-13. In males of the main group, at the age of 14-16 years, there is an increase in prasympathetic activity, which is accompanied by a significant increase in respiratory modulation (PHF, AHF) and a decrease in sympathetic activity, which is indicated by the dynamics of changes in non-respiratory periodicals (PLF, ALF). The ratio of the maximum possible to the minimum possible value of the dynamic series of RR intervals in the boys of the main group is lower than in the control group. Analog trends are present in the change in the values of the parameters of the standard deviation of the dynamic series of RR intervals and the coefficient of variation, which indicates a shift of vegetative homeostasis towards the predominance of the parasympathetic Department of the VNS. Discoordination of changes in the parameters of the heart rate in boys with age, namely: unidirectional changes in the mode and its amplitude indicate the instability of the mechanisms of regulation of RHR.

There were no significant differences between the control and the main groups in the temporal indices of HRV in women. The analysis of HRV spectral parameters revealed the following regularities: indicators characterizing the high-frequency component of the spectrum (PHF, THF) in girls of the main group are significantly lower than in the control group and are at the upper limit of the norm. Indicators of slow-wave components (RLF, ALF, TLF) RHR in girls using VS, significantly higher than in girls of the control group. The percentage of low-and ultra-low-frequency HRV component exceeds the proportion of high-frequency component in girls of the main group.

Individual assessment of the stress index revealed a shift in the autonomic balance in children who use toxicants.

In boys who use VS, of all age groups, the dominant type of vegetative tone is vagotonia,

the percentage of which is significantly higher than in boys of the control group. The proportion of autonav in the major groups are the same, but lower than in the control groups. Boys who use toxicants, the proportion of simpatikotonia slightly higher. The analysis of the stress index (SI) in girls revealed the following patterns: in girls who use VS, the proportion of sympathicotonics and vagotonics is higher, and eutonics is lower than in the control group. There is a tendency to increase sympathetic influences in girls of the main group, which is a statement of the fact of greater tension in their regulatory systems.

To assess the level of organization in the functional system of regulation of sinus RHR, the relationship of mode with other HRV indicators was studied.

In boys of the control group 11-13, the rhythm driver was in direct relationship with the indicators of vagal activity. In the children of the main group, there were close inverse relationships of the rhythm driver with the indicators of sympathetic activity and direct with the parameters of parasympathetic regulation of the VNS. The rhythm driver in the control group of boys 14-16 years old had similar intra-systemic relationships. In the main group, there was a significant interaction with indicators of parasympathetic activity, while compared with boys who use VS, younger age, the number of these relationships increased significantly. The relationship with the sympathetic Department of regulation of the VNS remained.

For the rhythm driver in the main group of girls is characterized by a greater number of close relationships with parasympathetic regulation. Based on the analysis of spectral characteristics of HRV can be assumed that girls between the study and control group there is a strict differentiation: the girls of the main group is dominated by sympathetic effects in the regulation of cardiac rhythm, and the girls of the control group, the proportion of vagal influences above amounts mediately modulation at the RHR [8].

There is an increase in the absolute time and spectral HRV indices with an increase in the length of VS reception. With the increase in the intake time, a shift towards the predominance of vagal activity is clearly observed, which is confirmed by an increase in the high-frequency components of spectral analysis (RHF) in children with a long history of toxicant use. The increase in the index of centralization at the initial stages of constant intake of toxicants indicates an increased activity of the Central structures of the brain. Compared with the period of initiation of VS administration, the decrease in the indices of low-frequency HRV components reflects the shift of vegetative homeostasis towards the Autonomous regulation circuit and some lag in the process of functional maturation of the VNS departments.

In General, boys who use VS are characterized by a predominance of the Autonomous regulation circuit, which can be explained by two independent mechanisms: cholinergically induced decrease in the release of norepinephrine in response to sympathetic stimulation and cholinergic

suppression of the response to adrenergic stimulus.

References

1. *Aktual'nye problemy narkosituatsii v molodezhnoy srede: sostoyanie, tendentsii, profilaktika* [Current Problems of Drug Situation Among Young People: State, Trends, Prevention]. Moscow, 2015. 191 p.

2. Toporkova N.Yu. Analiz rezul'tatov issledovaniya tsentral'noy gemodinamiki u detey [Analysis of the Research Results on Central Haemodynamics in Children]. *Novoe slovo v nauke: perspektivy razvitiya* [Advances in Science: Prospects for Development]. Cheboksary, 2015, pp. 56–57.

3. Bersenev E.Yu. Sportivnaya spetsializatsiya i osobennosti vegetativnoy regulyatsii serdechnogo ritma [Sports Specialization and Features of the Autonomic Regulation of Heart Rhythm]. *Variabel'nost' serdechnogo ritma: Teoreticheskie aspekty i prakticheskoe primenenie* [Heart Rate Variability: Theoretical Aspects and Practical Application]. Izhevsk, 2008, pp. 42–45.

4. Pitkevich Yu.E. Variabel'nost' serdechnogo ritma u sportsmenov [Heart Rate Variability in Sportsmen]. *Problemy zdorov'ya i ekologii*, 2010, no. 4, pp. 101–106.

5. Baevskiy R.M., Ivanov G.G. Variabel'nost' serdechnogo ritma: teoreticheskie aspekty i vozmozhnosti klinicheskogo primeneniya [Heart Rate Variability: Theoretical Aspects and Clinical Application]. *Ul'trozvukovaya i funktsional'naya diagnostika*, 2001, no. 3, pp. 108–127.

6. Shlyk N.I. Management of Athletic Training Taking into Account Individual Heart Rate Variability Characteristics. *Hum. Physiol.*, 2016, vol. 42, no. 6, pp. 655–664.

7. Baevskiy R.M., Ivanov G.G., Chireykin L.V., Gavrilushkin A.P., Dovgalevskiy P.Ya., Kukushkin Yu.A., Mironova T.F., Prilutskiy D.A., Semenov A.V., Fedorov V.F., Fleyshman A.N., Medvedev M.M. Analiz variabel'nosti serdechnogo ritma pri ispol'zovanii razlichnykh elektrokardiograficheskikh sistem (chast' 1) [Analysis of Heart Rate Variability Using Different Electrocardiographic Systems (Part 1)]. *Vestnik aritmologii*, 2002, no. 24, pp. 65–86.

8. Bokeriya L.A., Bokeriya O.L., Volkovskaya I.V. Variabel'nost' serdechnogo ritma: metody izmereniya, interpretatsiya, klinicheskoe ispol'zovanie [Heart Rate Variability: Measurement Methods, Interpretation, Clinical Use]. *Annaly aritmologii*, 2009, no. 4, pp.21–32.