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Functional research methods for vibration disease

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Abstract. The paper presents the results of the study of the functional state of the peripheral nervous system in occupational patients with vibration disease. According to the findings, it has been established that modern diagnostics of occupational diseases is largely based on the data of many instrumental studies, which are usually united in the general concept of "functional diagnostics". Wide introduction of electroencephalography, rheography, electromyography and other methods into everyday professional pathology practice causes the increasing demand for special methods on these questions[3,15]. The expediency of publishing a complex methodical approach to diagnostics of occupational diseases is determined by the established practice of creating functional diagnostics departments in scientific-research institute of sanitation, hygiene and occupational diseases, medical-sanitary parts of industrial enterprises, multidisciplinary medical associations of the republic[1,14].

Keywords: vibration disease, occupational diseases, rheoencephalography, rheovasography, peripheral nervous system.

Relevance. One of the main tasks of clinical diagnostic laboratories is the study of disease pathogenesis and the development of special techniques for detecting the early reversible stage of the pathological process, preceding the appearance of marked clinical signs, based on the obtained data [1, 3].

Detection of a disease at an early stage of its development is a difficult task [6]. In the clinic of occupational diseases, this task is greatly facilitated by the fact that the etiological factor is known and the effect of this factor on the organism throughout its exposure can be observed [2, 7]. Recognition of the disease in the preclinical period allows timely therapeutic and preventive measures to be taken and thus to prevent the development of its severe forms [5, 8, 7].

Previous studies on the health of workers engaged in open-pit and underground mining have revealed negative changes in the respiratory system, peripheral nervous system [4, 9]. One of the most common harmful physical factors in production is vibration. Negative effect of industrial vibration on human body leads to formation of vibration disease [11].

Numerous studies indicate that in the conditions of modern production, vibration disease is characterized by prolongation of the development period, mitigation of the severity of specific manifestations and frequent combinations with general systemic diseases [13]. In 90-100% of patients under 55 years of age, general somatic diseases are formed simultaneously, despite the predominance of initial forms of vibration disease; in 1/3 of patients, polymorbidity is determined [12]. A large number of studies by domestic and foreign authors are devoted to the clinical and diagnostic issues of vibration disease [10]. This disease is manifested by changes in metabolic processes, cardiovascular and nervous systems, musculoskeletal system. It is known that the formation of the symptom complex of vibration disease is based on a complex mechanism of neuroreflex and neurohumoral disorders, which lead to the development of congestive excitation and to persistent subsequent changes both in the receptor apparatus and in various parts of the central nervous system (CNS). The authors studied the manifestations of prolonged exposure to vibration on vibration sensitivity receptors, in which the excitability of the corresponding

overlying centres increases. Vibration has a general biological effect on any cells, tissues and organs [5].

The pathological effect of CNS on vascular tone results in specific angiospastic syndrome. In this case, particularly sensitive to the action of vibration are sections of the synaptic nervous system that regulate peripheral vascular tone [8]. According to some authors, the direct damaging effect of vibration on vascular endothelium and the development of complex regulatory disorders, with the simultaneous or sequential formation of neurohumoral and reflex disorders, leads to changes in microcirculation and transcapillary exchange and progression of tissue hypoxia [3].

Studies on neurohumoral and hormonal dysfunction in vibration disease found changes in histamine-serotonin content [7].

Further, disturbances in microcirculation and tissue metabolism result in trophic disorders. Dystrophic changes are revealed mainly in the nervous system (demyelination and disintegration of axial cylinders with the development of polyneuropathy) and musculoskeletal system [1]. The collagen-synthesising function is impaired in persons exposed to vibration. Namely: activation of connective tissue metabolic processes and collagen fibre breakdown. In addition, under the influence of vibration the body develops functional deviations from the autonomic and central nervous systems [8].

Analysis of the studied literature has shown that at present in our country there are not enough scientific studies aimed at the study of working conditions of mining industry workers, the effect of industrial vibration on the body of workers, early diagnosis and prevention of development of this pathology are insufficiently studied.

Purpose of the study: Study of the peripheral nervous system condition in patients with vibration disease according to the results of functional research methods.

Material and Research Methods: Clinic of Research Institute of Sanitary, Hygiene and Occupational Diseases examined 63 patients with occupational neurological pathology: including 47 patients, employees of mines of Angren ore

administration (ARU) of Almalyk mining and smelting plant (JSC OMMP), 6 patients - workers of JSC "Uzbekugol". To reveal peculiarities of formation of pathology of peripheral nervous system and musculoskeletal system a complex of clinical-functional researches was applied, including:

- cerebral and peripheral haemodynamics study with determination of Neurosoft rheoencephalography (REG) and rheovasography (RVG) indices.

Taking into account the nature of the exposure to vibration, all those surveyed were divided into two groups. Group 1 consisted of 41 people with the first degree of vibration disease from local vibration exposure. The main part of this group consisted of tunnelers - 80.6%, and 19.4% of the surveyed - miners of mining faces. The average age of those examined was 49.8±0.42 years, the length of service in the vibration-prone occupation was 22.9±0.56 years.

The 2nd group - with the first degree of vibration disease from general vibration exposure. They are 37,9% - excavators operators, 27,6% - drill operators, 17,2% - underground mine and supply machines operators, 17,3% - bulldozers operators. The average age was 50,0±0,8 years, length of service - 24,2±0,6 years. Group 3 - control group consisted of 30 people - workers of administrative staff, who had no contact with occupational hazards during work, without signs of cardiovascular and nervous system damage, according to a comprehensive examination, recognized as healthy. Rheoencephalographic studies were performed on a 4-channel rheograph. When analyzing the rheographic curves, both qualitative signs (regularity of waves, shape, presence of additional waves in the descending part of the curve and their severity) and quantitative indicators were taken into account. We determined the following indexes on all leads: amplitude of arterial component A (in ohms), time of maximum rise of arterial component α (c, s), reflecting the degree of stretching of the vascular wall, duration of the whole pulse wave T (c, s), percentage ratio of duration of ascending segment to time of full period of the whole pulse wave α/T 100%, which more fully gives an idea of vascular tone rheographic index (RI) - ratio of rheographic wave amplitude value (in mm) to calibration signal value; diastolic index (DI) - ratio of amplitude on dicrotic level to A (in %); dicrotic

index (DI) - ratio of amplitude on incisura level to A (in %); asymmetry coefficient (CA) calculated according to (К1-К3)/К2 100%, where К1 - the highest amplitude of symmetric areas. Rheoencephalographic studies were performed on a 4-channel rheograph. When analyzing the rheographic curves, both qualitative signs (regularity of waves, shape, presence of additional waves in the descending part of the curve and their severity) and quantitative indicators were taken into account. We determined the following indexes on all leads: amplitude of arterial component A (in ohms), time of maximum rise of arterial component α (c, s), reflecting the degree of stretching of the vascular wall, duration of the whole pulse wave T (c, s), percentage ratio of duration of ascending segment to time of full period of the whole pulse wave α/T 100%, which more fully gives an idea of vascular tone rheographic index (RI) - ratio of rheographic wave amplitude value (in mm) to the calibration signal value; diastolic index (DI) - ratio of dicrotic level amplitude to A (in %); dicrotic index (DI) - ratio of incisura level amplitude to A (in %); asymmetry coefficient (CA) calculated according to (K1-K3)/K2 100%, where K1 - the highest amplitude of symmetric areas. Registration of bioelectrical activity of flexor and extensor muscles of the feet and hands was performed on a Neurosoft rheovasograph using surface electrodes.

Results and Discussions: Rheoencephalographic (REG) curves at visual analysis in patients with vibration disease of initial (I) and moderate (II) degrees were characterized by REG wave reduction, mild to moderately pronounced asymmetry, presence of hump-shaped curve type and pulse wave rounding, dicrotic tooth shift to the top or base. This indicates impaired elasto-tonic properties of cerebral vessels and decreased intensity of blood filling in the intracranial vessels. Often qualitative analysis revealed the presence of additional teeth on the descending wave, indicating the presence of increased venous resistance.

The average values of the main REG indices in the FM (frontal) and OM (mastoid) leads in groups I and II of the control group are shown in Table 1.

The study of the cerebral vessels blood-flow intensity according to the rheoencephalograms in the standard fronto-mastoid lead in patients in groups I and II shows that the intracranial vessels blood-flow intensity concerning the middle and

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anterior cerebral artery basins was sharply reduced in comparison with the control group. The rheographic index in group I decreased to 0.09±0.006. However, with the development of vibration disease to a moderate degree, as shown by the RI data of group II, the pulse blood pressure tended to decrease significantly (0,06±0,074). The difference of average values in groups I and II in comparison with the control is statistically significant.

Comparison of the obtained rheoencephalograms from the frontotemporal and occipitotemporal leads showed that the most marked changes of intracranial blood flow intensity occurred in the patients with both primary (0,08±0,006 Îhm) and moderate (0,057±0,001 Îhm) degrees in the vertebrobasilar system basin. When analyzing the structure of the rheoencephalograms, the shape of the curves (highly elevated diastolic part above the isoline), which is most accurately characterized by the ratio of the rheographic wave size to the height of the dicrotic tooth (DCI), attracted attention.

The prevalence of changes in occipito-maxillary leads was seen in the dicrotic index and indicated the state of medium and small caliber vessels or peripheral vascular resistance. Increased dicrotic index in patients with initial and moderately severe vibration disease indicated a change in elasto-tonic properties of vessels of mainly middle and small caliber. The prevalence of these indices in OM leads indicates the predominance of changes in the vertebrobasilar system basin in comparison with the cerebrovascular circulation, both in general and in the basin of the anterior and middle cerebral arteries.

The changes in venous outflow or resistance were most clearly detected when studying the cerebral circulation. The diastolic index was elevated in both group I and group II patients when analysing the rheoencephalograms recorded from FM and OM leads.

Table 1

Mean values of the main REG parameters recorded in FM and OM leads, depending on the severity of the process (X±m%)

Indicators	Monitoring		WB Stage I.		P	WB Stage II.		P_1	P_2
	FM	OM	FM	OM		FM	OM		
α, s	0,12±0,07	0,11±0,09	0,10±0,01	0,09±0,01	<0,05	0,1±0,0005	0,10±0,01	<0,05	<0,05
T, s	0,81±0,04	0,80±0,01	0,66±0,02	0,66±0,02	<0,05	0,73±0,12	0,66±0,03	<0,05	<0,05
(α,)/T%	18,2±1,1	18,4±0,9	13,1±0,6	12,1±0,58	<0,01	12,6±3,25	12,5±0,7	<0,01	<0,01
RI, Ohm	0,13±0,1	0,13±0,1	0,09±0,006	0,08±0,006	<0,01	0,06±0,074	0,057±0,001	<0,01	<0,05
RI, Ohm	0,13±0,08	0,13±0,08	0,08±0,006	0,07±0,006	<0,01	0,06±0,065	0,053±0,01	<0,01	<0,05
DPI, %	51±1,9	51,4±1,7	69,6±3,7	60,3±4,48	<0,05	75,1±1,8	67±2,6	<0,01	<0,01
DPI, %	51,5±1,2	51,2±1,4	67,46±2,6	61,7±4,44	<0,05	75,2±1,9	67±2,8	<0,05	<0,01
DPI, %	53,0±4,2	53,0±4,1	65,5±3,8	57,3±4,48	<0,05	71,4±2,2	65,7±2,6	<0,05	<0,01
DCI, %	52,5±4,1	52,1±4,1	63,5±2,7	55,8±5,0	<0,01	70,9±2,1	50,4±2,9	<0,01	<0,05

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Class	1,2±0,9	1,3±0,9	23,7±4,0	23,8±7,9	<0,01	29,6±4,2	21,2±1,2	<0,01	<0,05

Note: P-validity of differences between group I and control;

P1 between group II and control; P2 between groups I and II.

There was a correlation between the degree of venous resistance increase and the disease severity, i.e. if in the group I patients the venous resistance was 65.5±3.8% in FM and 57.3±4.48% in OM leads, in the group II - 71.4±2.2 and 55.7±2.6% respectively. As can be seen from Table 1, venous resistance was also more pronounced in the vertebrobasilar system.

Consequently, the most pronounced changes in the shape of the rheoencephalographic curves were already observed in the initial stage of the vibration disease, and with the development of its moderately pronounced stage, they became more distinct and profound. The changes are manifested by a sharp decrease of the rheographic index, disturbance of elasto-tonic properties (similar to hypotony) of all vessels, with a certain predominance of medium and small caliber vessels, and an increase in venous resistance. Vessels of the vertebrobasilar system are affected earlier and to a greater extent in both initial and moderate degree of vibration disease compared to those of the anterior and middle cerebral arteries. Early dyscirculation in the vertebrobasilar system basin contributes to the dysfunction of the structural structures of the brainstem with the subsequent development of dysfunction of the reticular formation and vasomotor centres, causing further development and progression of vibration disease.

Clinical and rheovasographic parameters in vibration disease. The rheovasographic curves recorded in the area of the lower third of the forearm and lower leg showed a shift to the top of the rheographic wave isoline in comparison with the control (45,1% - at I stage and 67,2% at II stage of the vibration disease). This phenomenon was most pronounced on the rheograms of the lower extremities. At the same time, 37.5% of patients in the upper extremities and 43.4% in the lower extremities in Group I and 41.4% and 48.5% in Group II, respectively, had the signs of the vascular tone decrease, which was manifested by the acute vertex and dicrotic tooth shift to isoline. Some patients along with a weak dicrotic tooth had additional waves in the descending part of the wave that was an indirect sign of venous outflow obstruction. In severe angiodystonic syndromes the details of the rheowave

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practically disappeared, there was a gentle rise of anacrotum, flattening of the rheowave apex and its displacement to the isoline.

Quantitative analysis of rheovasograms of the upper and lower extremities revealed certain deviations of rheographic parameters depending on the severity of the disease (Table 2).

Intensity of pulse blood-filling of the upper and lower extremities and other parameters of the rheogram at the initial degree of severity, both due to the effect of the local vibration below the control and as a result of the general vibration, differed to a certain extent from the control group.

Thus, the mean values of the rheographic index in the I and II groups of patients were significantly lower than in the control.

A significant decrease in the pulse blood-filling of the foot vessels, observed both in the initial and in the moderately severe degree of vibration disease, indicates a greater involvement of the lower limb vessels in the pathological process. The patients in both groups had disorders of elasto-tonic properties of the vessels of the hypotonic type, as evidenced by the dicrotic index. Thus, DCI in the first group of patients was statistically significantly reduced both in the upper and in the lower extremities. In patients with a moderate degree of vibration disease, the decrease in the vascular tone of small and medium caliber vessels was the most pronounced. Often they had changes associated with impaired venous outflow, as indicated by a decrease in diastolic index (DI).

Table 2

Changes in mean values of the main RVH indices of the upper and lower extremities in patients with vibration disease vibration disease depending on the severity of the process (X±m%)

Indicators	Control		WB Stage I.		P	WB Stage II .		P_1	P_2
	upper extremity	lower extremity	upper extremity	lower extremity		upper extremity	lower extremity		
α, s	0,198±0,1	0,194±0,1	0,141±0,1	0,135±0,08	<0,05	0,09±0,04	0,07±0,01	<0,01	<0,05
T, s	0,97±0,01	0,99±0,02	0,76±0,01	0,70±0,12	<0,05	0,63±0,08	0,065±0,01	<0,01	<0,05
(α,)/T%	20,4±0,2	19,5±0,1	17,3±0,1	16,9±0,5	<0,05	14,1±0,3	14,0±0,1	<0,01	<0,05
RI, Ohm	0,12±0,4	0,14±0,11	0,099±0,001	0,089±0,004	<0,05	0,076±0,001	0,060±0,002	<0,001	<0,05
RI, Ohm	0,11±0,1	0,15±0,21	0,096±0,001	0,088±0,003	<0,01	0,073±0,001	0,058±0,001	<0,001	<0,05
DPI, %	56,5±1,4	55,1±2,1	49,5±2,1	47,5±2,2	<0,05	43,5±2,13	39,9±1,2	<0,05	<0,01
DPI, %	54,1±1,7	55,3±2,4	47,1±2,1	46,9±2,12	<0,05	41,4±2,09	38,1±1,1	<0,05	<0,01
DPI, %	52,9±2,5	56,1±2,1	49,8±1,1	47,5±1,7	<0,05	42,5±1,2	37,7±2,1	<0,05	<0,05
DCI, %	53,1±2,5	56,3±2,9	48,7±1,9	46,5±2,4	<0,05	42,6±1,4	37,8±2,8	<0,05	<0,01

Class	2,3±2,1	2,1±1,2	14,1±0,9	14,4±2,1	<0,05	17,8±1,5	18,7±1,2	<0,05	<0,01

Consequently, changes in rheovasographic indices of the upper and lower extremities are observed in initial and moderately severe vibration disease. The level of rheographic pulse wave reduction depends on the severity of the disease of vessels supplying blood to the feet and hands. The development of elasto-tonic disturbances of medium- and small-calibre vessels of the limbs as hypotonia contributes to worsening of blood circulation disturbances. Joining to the above mentioned circulatory disturbances of the limbs of the venous outflow obstruction with the increase of its resistance points to the dyscirculation not only in the system of arteries and arterioles, but also in the venous system. Such condition of large, small and medium caliber vessels, as evidenced by rheovasographic indices, leads to circulatory disorders of the microcirculatory bed of extremities, in this regard, the study of microcirculation of the nail bed of upper and lower extremities is of particular importance.

Conclusion: The results of EEG studies revealed that the vessels of the vertebrobasilar system are affected earlier and to a greater extent in both the initial and moderate degree of vibration disease compared to the vessels of the anterior and middle cerebral arteries. Early dyscirculation in the vertebrobasilar system basin contributes to the dysfunction of the structural formations of the brain stem with the subsequent development of dysfunction of the reticular formation and vasomotor centres, causing further development and progression of vibration disease.

According to the obtained RVG parameters in the vibration disease revealed dyscirculation in the system of arteries and arterioles and in the venous system, which leads to disorders of blood circulation in the microcirculatory bed of the limbs, in this regard, the study of microcirculation of the nail bed of the upper and lower limbs is of particular importance.

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