ENGLISH VERSION: RELATIONSHIP BETWEEN ADSORPTION-RHEOLOGICAL PROPERTIES OF SERUM IN HEMORRHAGIC VASCULITIS AND ECOLOGY IN REGIONS OF PATIENTS' RESIDENCE*

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The aim of the work: to assess the physic-chemical adsorption and rheological properties of the blood serum of patients with hemorrhagic vasculitis (HV) according to the hygienic condition of the air, water and soil in regions of patients residence. Materials and methods. The study involved 144 patients with HV (56% of men and 44% women with the average age 26 years). Indicators of surface viscosity (SV), bulk viscosity (BV), surface elasticity (SE), module of viscoelasticity (MV), relaxation time (RT), the surface tension at t = 0,01 sec (ST1) , t = sec 1 (ST2), t = 100 sec (ST3), and the equilibrium (static) surface tension at $t \to \infty$ (ST4), the angle of inclination (AI) and phasic angle (PA) of tensiograms were studied using computer tensioreometry of serum, surfactant criterion of interfacial activity (SCIA) were calculated. The results were compared with environmental pollution by xenobiotics and microelements of air, water and soil of zones of patients residence. Results and discussion. Adsorption-rheological properties of serum of patients with HV depend on the integrated degree of pollution by xenobiotics of air and drinking water (but not of soil by chemical elements), the degree of emissions and accumulation of industrial waste in it, the nature of the impact of modernization of agriculture, metallurgical, chemical and engineering industries in the regions, levels of 3,4-benzpyrene (ST2, PA), phenol (BV, PA), ammonia (SCIA), nitrogen dioxide (ST1, ST2, ST3), carbon dioxide (SE, RT, ST1, ST2, ST4) in the breathing air, the degree of mineralization and hardness of drinking water (MV), the parameters of toxic microelements and essential zinc (ST3) in the soil. Conclusions. Breach of the adsorption-rheological properties of blood serum in HV depend on hygienic condition of air, water and soil in regions of patients residence, the environmental burden on the atmosphere by the different branches of industry and agriculture.

Key words: hemorrhagic vasculitis, blood, adsorption, rheology, ecology, air, water, soil.

Introduction

It is commonly known that the most widespread option of systemic vasculitis is immune complex hemorrhagic vasculitis (HV) [2, 8], the prevalence of which depends on the environmental components of patients' regions of residence [12, 13]. The adverse effects of environmental pollution on the blood vessels are now well established in terms of energy industry development [11], the production of building materials [10] metallurgic [1, 4] chemical [3] and other industries [9].

The exogenous xenobiotics contribute to the formation of vascular endothelial dysfunction, followed by severe disorders of rheological properties of blood [15]. Pathogenesis of HV has not been sufficiently studied, however, certain significance is attributed to vascular endothelial dysfunction which in these patients is accompanied by disorder of rheological properties of blood [14] with high-viscosity of plasma [5, 6]. It should be noted that the severity of changes of this physicochemical property of blood in systemic vasculitis is determined by the negative impact on endothelial cells of the vascular wall [7]. The impact of the environmental components on the state of adsorption-rheological properties of blood (ARPB) in patients with HV has not been studied.

The aim of the research: to evaluate physical and chemical ARPB in patients with HV, depending on the hygienic condition of air, water and soil of regions of patients' residence.

Material and methods

The study included 53 patients with HV aged from 15 to 53 (average age 29 ± 1.4 years). Among these patients, 60% were male and 40% female. The disease duration was 9 ± 0.8 years. The age of onset of the pathological process ranged from 8 to 39 years (average 20 ± 1.2 years). The acute course of the disease occurred in 19% of cases, the 1st degree of activity of pathological process – in 15%, 2nd – in 38%, the third – in 47%. At the previous stages, skin lesions in the form of palpable hemorrhagic purpura occurred in all patients without exception. At the moment of examination, pathology of skin was detected in 77% of cases, pathology of kidneys – in 70%, of heart – in 53%, of joints – in 47%, of the liver – in 25%, of the digestive tract – in 15%, of skeletal muscles – in 9%. Antibodies to proteinase-3 in the blood serum were detected in 4% of examined patients, for myeloperoxidase – in 68%, hyperimmunoglobulinemia (>M+SD of health indicators) – in 89%. The level of immunoglobulin (Ig) A in the blood was 0.15 ± 2.7 mmol/l, IgA/ΣIg – 12.3 ± 0.77%, rheumatoid factor – 6.1 ± 0.54 mU/ml. Hypertension was detected in 36% of cases. The parameters of average arterial pressure in examined patients amounted 106.0 ± 2.28 mm Hg, total peripheral vascular resistance – 2545.9 ± 109.10 $dyn \cdot s \cdot cm^{-5}$, the glomerular filtration rate – 113.6 ± 3.23 ml/min (by Cockroft-Gault formula). In 23% of the total number of patients and in 32% of the patients with glomerulonephritis, renal failure was detected (chronic kidney disease, stage I). Disorders of myocardial excitability were detected in 17% of cases, the electrical conduction of the heart – in 30%, changes in the heart chambers and valves – in 40% and 25% respectively, left ventricular diastolic dysfunction – in 4%.

In order to assess the ARPB, dynamic interfacial tensiometry was conducted using computer equipment "MPT2-Lauda" (Germany), "ADSA-Toronto" (Germany–Canada) and "PAT2-Sinterface" (Germany). We studied the surface viscosity (SV), surface elasticity (SE), the viscoelasticity module (VE), the relaxation time (RT) and the dynamic surface tension at the "lifetime" of the surface of 0.01 seconds (ST1), 1 second (ST2), 100 sec (ST3), and the equilibrium or static (ST4), calculated ratio ST4 / ST1, the angle

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of inclination (AI) and phase angle (PA) of tensiorheogram, determined surfactant criterion of interfacial activity (SCIA). Using the rotational viscometer "Low-Shear-30" (Switzerland) we investigated the bulk viscosity (BV) of serum.

Hygienic estimation of anthropogenic pollution of environment was based on determination of xenobiotics in the air, soil and drinking water. Data were obtained in the result of laboratory tests of sanitary stations, regional offices of the State Committee on hydrometeorology and environmental control and ecological safety. In the soil in 33 regions of Donetsk oblast the levels of trace elements (TE) – Ba, Be, Bi, Co, Cr, Cu, Hg, Li, Mn, Mo, Ni, Pb, Sn, Ti, V and Zn were investigated.

Statistical analysis of the results of research was carried out by computer variational, non-parametric, correlation, single-factor (ANOVA) and multi-factor (ANOVA / MANOVA) dispersion analysis (programs "Microsoft Excel" and "Statistica-Stat-Soft", USA). We evaluated average values (M), their standard errors (m), standard deviations (SD), the correlation coefficients (r), the criteria for dispersion (D), Student (t), Wilcoxon-Rao (WR) and the accuracy of statistical parameters (p).

Results and Discussion

In patients with HV, as compared to healthy control group (Table 1), we observed a significant increase in BV of blood by 23%, ST2 by 2%, ST3 by 5%, ST4 by 8%, parameters of ST4 / ST1 by 10%, PA by 38 % with decrease of SV by 21%, VE by 20%, ST1 by 2% and SCIA by 21%, which is ascertained (more or less M ± SD healthy) in 42%, 47%, 43%, 55%, 53% , 55%, 47%, 18.9%, 34% and 85% of examined patients respectively.

Table 1.
Parameters of ARPB in patients with HV and healthy individuals (M±SD±m)

Parameters	Groups of examined individuals		Groups' differences	
	patients with HV (n=53)	healthy (n=52)	t	p
SV, mN/m	12.2±1.91±0.26	15.5±1.70±0.24	9.37	<0.001
BV, MPa×s	1.6±0.32±0.05	1.3±0.21±0.03	5.15	<0.001
SE, mN/m	41.5±6.11±0.84	42.8±4.94±0.69	1.19	0.238
VE, mN/m	18.9±4.44±0.61	23.7±7.58±1.05	3.94	<0.001
RT, s	105.3±24.94±3.43	114.0±23.14±3.21	1.85	0.068
ST1, mN/m	71.8±1.92±0.26	73.0±2.07±0.29	3.30	0.001
ST2, mN/m	68.8±1.97±0.27	67.8±1.46±0.20	2.72	0.008
ST3, mN/m	59.4±3.50±0.48	56.5±3.82±0.53	4.07	<0.001
ST4, mN/m	46.1±5.18±0.71	42.7±2.02±0.28	4.36	<0.001
ST4/ST1, %	64.3±8.00±1.10	58.5±3.47±0.48	4.80	<0.001
AI, $mN/m^{-1}\times s^{1/2}$	16.0±4.80±0.66	17.8±5.18±0.72	1.82	0.071
PA, $mN/m^{-1}\times s^{1/2}$	200.6±49.23±6.76	145.5±58.03±8.05	5.25	<0.001
SCIA, r.u.	2.2±0.29±0.04	2.8±0.21±0.03	11.88	<0.001

As the multi-factor analysis by Wilcoxon-Rao displays, the integral state of ARPB in HV is affected by the degree of disease activity and severity. The performed ANOVA/MANOVA shows the reliable impact on physical and chemical properties of the blood serum in lesions of the pancreas, nervous system and heart. AI of tensiograms is closely associated with the severity of changes in the nervous system and valvular heart disease. BV parameters are affected by the degree of activity of HV, pathologies of kidneys and nervous system, SE is influenced by the changes in gastro-intestinal tract, RT – of pancreas and liver, SCIA – of pancreatic and nervous system. In addition, RT depends on the presence of hypertension and PA of tensiograms – on kidney failure in patients.

It has been found that integrated degree of air pollution (Q) has a significant impact on the following parameters in HV: SE, RT, ST1, ST2, ST3, ST4, ST4/ST1 and AI, and the nature of drinking water (R) affects only the level of interfacial activity in the long time area of the surface existence, and the content of the TE in the soil (S) does not affect the ARPB of patients. These data are represented in Table 2.

Table 2.
Degree of dispersion impact of integrated ecological factors on ARPB in patients with HV

Parameters of ARPB	Environmental factors					
	Q		R		S	
	D	p	D	p	D	p
SV	0.54	0.818	0.70	0.691	0.87	0.549
BV	1.02	0.369	1.27	0.289	0.38	0.689
SE	3.53	0.001	1.17	0.335	0.37	0.986
VE	0.30	0.994	1.35	0.222	0.75	0.730
RT	2.01	0.049	0.57	0.927	0.52	0.956
ST1	3.37	0.006	0.98	0.460	0.64	0.722
ST2	4.27	0.001	1.33	0.253	0.92	0.521
ST3	2.38	0.018	2.48	0.014	0.26	0.994
ST4	8.69	<0.001	1.13	0.371	0.37	0.984
ST4/ST1	3.83	<0.001	0.86	0.641	0.62	0.884
AI	1.96	0.044	1.87	0.057	0.38	0.982
PA	1.53	0.239	1.59	0.218	0.41	0.978
SCIA	2.08	0.156	0.38	0.543	1.88	0.177

The parameters of ST4 and ST4/ ST1 directly correlate with index Q, while AI and PA correlate inversely. ST4 and ST4/ ST1 have a positive relationship with the R, which also negatively correlates with PA of tensiograms. Taking into account the one-way ANOVA test, the following conclusion has been made: poor ecological state of the atmosphere in the areas of HV patients' residence causes an increase in the equilibrium interfacial activity of blood serum, which should be considered when analyzing the parameters of ARPB.

As the multi-factor analysis by Wilcoxon-Rao displays, the integral state of ARPB in HV patients is affected by the levels of emissions and accumulation of industrial wastes. According to the results of the ANOVA, the level of emissions of industrial wastes into the atmosphere in the area of territory per year determines the parameters of RT, ST1, ST2, ST3, ST4, ST4/ST1 and PA, per person – ST1, ST2, ST3, ST4, ST4/ST1 and PA, while the level of accumulation of industrial wastes in the atmosphere affects the parameters of the SE, ST1, ST2, ST3, ST4, ST4/ST1 and PA. Correlation analysis (Table 3) indicates the direct relationship between the equilibrium interfacial activity and ST4/ST1 index with the degree of air pollution by industrial enterprises.

Table 3.

Reliability of correlation relationships between levels of air pollution by industrial enterprises, transport and agriculture and ARPB in patients with HV (p r)

Parameters of ARPB	Nature of ecological impact levels			
	atmospheric discharge of industrial wastes		atmospheric accumulation of industrial wastes	
	$t/km^2/yr$	kg/p/yr	$t^3/km^2/yr$	t/p/yr
SV	0.400	0.484	0.690	0.794
BV	0.393	0.743	0.703	0.898
SE	0.703	0.748	0.980	0.970
VE	0.370	0.542	0.448	0.484
RT	0.207	0.236	0.206	0.191
ST1	0.071	0.287	0.082	0.290
ST2	0.051	0.112	0.099	0.282
ST3	0.064	0.106	0.079	0.280
ST4	↑<0.001	↑<0.001	↑0.005	0.060
ST4/ST1	↑<0.001	↑<0.001	↑0.003	↑0.049
AI	0.163	0.186	0.630	0.726
PA	↓0.037	0.182	0.576	0.998
SCIA	0.364	0.179	0.065	0.167
PSA	0.179	0.075	0.070	0.243

Note: ↑ reliable direct correlation, ↓ reliable inverse correlation.

Only the high level of development in the coal mining and power industry region does not have the dispersion effect on certain indicators of ARPB in HV patients. In its turn, there is lack of dependence on air pollution by individual industries in terms of BV, ST3, ST4, AI and SCIA. However, development of steel industry affects the parameters of SE, RT, ST1, ST2, ST4/ST1 and PA, chemical industry – by RT, ST1, ST2 and PA, engineering – to SE and ST4/ST1, the strong development of railway and automobile transport service – SV, agriculture – VE, RT and PA.

The high degree of development in the metallurgical industry increases the equilibrium surface activity, as evidenced by the direct correlations with ST4 and ST4/ST1, possibly due to the decrease of macromolecular surfactants in the blood of HV patients. In addition, there is a direct correlation of BV with the development of production of building materials, and SCIA – with the level of agro-industrial complex.

With individual components of inhaled air in HV, the parameters of SV, VE and PA are not dependent, there is no influence of sulfur dioxide on the parameters of ARPB. The concentration of 3,4-benzopyrene determines the values of ST4/ST1 and PA, phenol – BV and PA, ammonia – SCIA, nitrogen dioxide – ST1, ST2 and ST3, carbon dioxide – SE, RT, ST1, ST2, ST4, and ST4/ST1, hydrogen sulfide – SE, RT, ST2, ST4/ ST1 and PA.

According to the data of performed ANOVA, the nature of components in drinking water does not affect the parameters of ARPB in HV patients. In its turn, the VE parameters are inversely dependent on mineralization and hardness of water, as evidenced by correlation analysis.

The target of further research was the dependence of ARPB in HV on the level of TE in the soil. We selected the indicators that had both reliable dispersion and correlation associations. Only one parameter has both of these associations – the impact of Zn in soil on ST3, and correlation between these indicators.

Conclusion

Thus, changes in ARPB in HV depend on the integral extent of atmospheric pollution with xenobiotics, accumulation of wastes of mainly metallurgical industry, the levels of carbon dioxide in the air, which is primarily related to equilibrium interfacial activity of serum, as well as mineralization and hardness of drinking water in respect of viscoelastic properties of blood, dependence of ARPB on the nature of microelement composition of the soil, where the basic importance is attributed to Zn and ST3.

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