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ASSESSING MORPHOFUNCTIONAL STATE OF MICROCIRCULATION CHANNEL IN SMOKING YOUNG MALES

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According to statistical data provided by the World Health Organization, death causes related to smoking annually account for approximately six million deaths all over the world, and here more than five million deaths are directly caused by smoking and more than 600 hundred thousand deaths occur due to passive smoking.

In order to study effects produced by smoking on human microcirculation, we examined capillary blood flow and morphofunctional state of capillaries in smoking and non-smoking people.

195 practically healthy young males aged 17–21 took part in our research; at that moment they were studying at the North-East State University. Microcirculation parameters were examined with non-invasive techniques, namely via computer capillaroscopy performed in a zone of skin swelling near the nail-bed.

We obtained 12 quantitative parameters to characterize the microcirculation channel. Having analyzed the data, we revealed a shift in artery-venous ratio of a capillary dimensions towards a greater diameter of an artery section and smaller diameter of a venous section in a capillary among smoking young males; there was also a decrease in capillary length. Research results allowed revealing a significant correlation between smoking and capillary deformation. Blood capillaries were more twisted and erythrocytic sludges were more apparent among smoking people.

The results we obtained can be added to a database that is applied to create recommendations on healthy lifestyle among young people in order to prevent risks of smoking-related diseases.

Key words: *microcirculation, microcirculation channel, capillary blood flow, capillaroscopy, nail-bed, young males, smoking.*

Studies on morphofunctional and functional state of blood capillaries are interesting both in terms of their fundamental and applied significance as the microcirculation channel is a reactive area where biochemical and immunologic processes occur. As is well known, blood and tissues in a body are connected via capillaries [2, 3]. Capillaries are the most sensitive component in the vascular system and the most susceptible to impacts exerted by exo- and endogenous factors [4–6].

At present the microcirculation channel is usually examined with computer capillaroscopy; the procedure is conventionally performed on capillaries in the skin swelling near the nail-bed as it allows intravital studying of capillaries and estimating their functional state objectively. Such results can't be obtained via any other non-invasive procedure [7, 8].

Scientific literature that focuses on issues related to effects produced on a body by smoking has very few works that dwell on examining blood capillaries. However, these works usually describe clinical cases when damage is already done to organs and systems in a body or concentrate on thermal

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and toxic impacts exerted by smoking directly on the vessels in contact zones of the oral cavity. They also contain data obtained via procedures aimed at examining blood flow; such procedures don't allow visualizing any morphological changes in the circulatory channel.

Therefore, visualization of blood flow and capillaries stricture is the most significant issue in assessing influence exerted by tobacco smoking on blood microcirculation.

Given all the above-mentioned, we chose the following research goal: to examine impacts exerted by tobacco smoking on morphofucntional state of capillaries in smoking young males.

Research object and methods. Our participants were practically healthy young males aged 17–21 (n = 195); they were students at the North-East State University (Magadan).

To perform comparative analysis and reveal any changes in the system of blood microcirculation caused by long-term addiction to smoking, we divided out examined young males into two groups. The first group was a control one and included non-smoking young males (n = 155); the second one was a test group and included young males with their smoking experience ranging from 1 to 10 years (n = 40).

Capillaries structure and microcirculation were examined in the skin swelling near the nail-bed with "Capillaroscan-1" computer capillaroscope (Moscow, "New Energy Technologies, Skolkovo" LLC). All the examined young males didn't have frostbites or any other injuries that could produce effects on microcirculation in capillaries located in the nail-bed. The research was accomplished according to ethic principles stated in Helsinki Declaration (2008). Prior to the research, all the participants gave their informed written consent to it.

Morphometric parameters were calculated with a software package provided for the capillaroscope. Microcirculation was registered with uninterrupted video-recording and the software package allowed assessing all the visually observed processes and anatomic structures together with obtaining averaged values for the velocity at which erythrocytes moved in the examined capillaries.

We analyzed the following parameters: blood flow velocity in the arterial, venous, and transitional sections, length and diameter of various sections in capillaries, size of the perivascular zone, capillary network density, an extent to which capillaries were twisted, frequency of erythrocytic sludges, and temperature of an examined skin section.

All the examined parameters were statistically processed with MS Excel; we determined whether distribution was normal or not, mean value and its error (M±m), and significance of discrepancy with Student's t-test. Critical significance was fixed at $p \leq 0.05$. We also performed correlation analysis as per Pearson's test to assess a correlation between morphological structures of capillaries and dynamic properties of microcirculation [9].

Results and discussion. Table 1 contains the results of our comparative analysis performed on blood microcirculation parameters in smoking and non-smoking young males.

We revealed statistically significant differences between smoking and non-smoking young males as per morphofucntional parameters of microcirculation. Thus, the groups had different diameters of the arterial and venous sections in a capillary, different number of erythrocytic sludges, different capillary lengths and coefficients of capillary deformation.

Capillary lumen is known to determine flow capacity for blood corpuscles [4]. Registered values of capillary diameters and blood flow velocity in both examined groups were within physiological standards, had weak correlations with blood flow velocity and an extent to which capillaries were twisted, and

Table 1

Compared parameters of blood flow and capillary structure in smoking and non-smoking young males

Parameters	Non-smoking, *n* = 155	Smoking, *n* = 40	Significance
Arterial section diameter, µm	8.4±0.1	8.8±0.1	p<0.01
Venous section diameter, µm	12.2±0.2	11.6±0.1	p<0.002
Transitional section diameter, µm	16.9±0.2	16.6±0.2	p=0.20
Capillary length, µm	323.0±5.9	302.0±6.9	p<0.03
Capillary network density, rel. units	0.041±0.001	0.039±0.001	p=0.09
Perivascular zone, µm	91.9±1.5	89.0±1.7	p=0.22
Velocity in the arterial section, µm\sec	231.5±8.3	204.2±8.8	p=0.44
Velocity in the venous section, µm\sec	154.3±6.2	148.1±6.9	p=0.51
Velocity in the transitional section, µm\sec	181.8±7.0	193.5±9.8	p=0.34
Sludges, units\sec	3.1±0.1	3.9±0.3	p<0.01
Coefficient of deformation, rel. units	0.3±0.01	0.4±0.01	p<0.05
Skin temperature, t°	30.6±0.4	29.9±0.2	p=0.08

didn't depend on how long a young male had been smoking. However, we detected certain deviations among smoking young males as diameters in the arterial section of capillaries tended to be bigger among them, and those in the venous one tended to be smaller. We should note that those capillary diameters were diameters of the visible erythrocytic flow due to capillary walls not being visible in an optical capillaroscope. Therefore, we can assume that more apparent erythrocytes aggregation in smoking young males makes the arterial capillary section widen.

The perivascular zone is a significant parameter that characterizes intensity of the transcapillary exchange [8]. Size of the perivascular zone depends on an overall exchange surface of a capillary that is determined by its length and diameter. Although we detected significant discrepancies between groups as regards capillary length and diameters, there were no significant differences in sizes of perivascular zones.

Obviously, capillaries in smoking young males are shorter due to a higher coefficient of deformation determined for the vessels. It was confirmed by data obtained via correlation analysis as the coefficient of deformation tended to have an inverse correlation with a capillary length and amounted to $r = -0,6$ ($p < 0.05$). An extent to which capillaries were twisted had not only quantitative but also qualitative properties as smoking young males tended to have more apparently deformed capillaries (Figure 1).

At the same time we detected a correlation between the coefficient of deformation and capillary network density. The greatest number of capillaries per one unit of area was detected in young males with the most twisted capillaries. Probably, a greater number of capillaries is a compensatory mechanism that allows making up for insufficient blood supply in tissues.

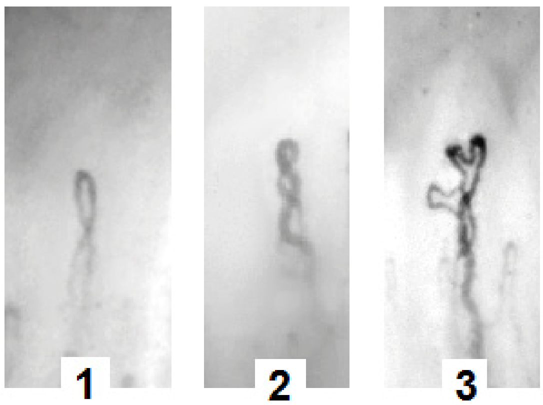

Figure 1. Deformation types observed in capillaries. 1 is a single intersection; 2 is two or more intersections; 3 is a bushy capillary

According to the obtained data smoking young males also had the greatest number of erythrocytic sludges. When erythrocytes aggregation and disaggregation conform to standards, they support efficient exchange function of blood and stable intravascular pressure [10]. However, pathological occurrence of erythrocytic sludges is accompanied with tissues getting poorer provision with oxygen [11, 12]. It happens due to aggregation preventing blood cells from entering capillaries and making for bypassing blood flow that doesn't run through capillary networks [13]. In its turn, lower density of functional capillaries leads to a decrease in efficient area of transcapillary exchange [14]. As a number of sludges grows, a mechanism that provides stable pressure in capillaries becomes less and less efficient [15].

We didn't detect any significant differences between two groups as regards temperature of the examined skin area. Mathematical modeling and experiments show that heat exchange with blood flow doesn't occur in capillaries [16]. Therefore, heat emission occurs due to larger vessels, and not capillaries.

Conclusion. We applied computer capillaroscopy to compare parameters of the microcirculatory channel in smoking and non-smoking young males. We detected certain discrepancies, such as shorter capillaries, wider arterial sections and narrower venous sections of capillaries among smoking young males. We obtained parameters of deviations in microvessels, such as capillary deformations and erythrocytic sludges that were more apparent among smoking young males.

These changes are a common basis for microcirculatory disorders in future [17]. It was detected that greater density of capillary networks could be considered as an adaptive sign that allowed making up for insufficient blood supply up to a certain moment.

It is also important to note that when adaptation mechanisms of the microcirculation system are depleted, long-term non-compensated disorders in metabolic processes in any section of the vascular system ultimately result in structural changes; such changes become apparent when a disease occurs.

Taking into account global long-term experience in examining effects produced by smoking on a human body, we can unambiguously state that tobacco smoking is a factor exerting negative influence on health and life quality. However, an extent to which this factor influences blood microcirculation and the structure of this influence require additional research. The results we obtained can enrich a database applied to work out recommendations on preventing smoking-related diseases and on making young people pursue a healthy lifestyle.

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