

Interdisciplinary Collaboration: Screening of Systemic Blood Flow at a Dental Appointment \ Russia

Victoriya N. Naumova¹, Dmitriy V. Mikhilchenko², Julia A. Makedonova^{3*},
Tatyana V. Kolesova⁴, Larisa N. Denisenko⁵

1. Assoc. Prof, DDS, PhD Volgograd State Medical University, Department of Propaedeutics of dental diseases Department of Propaedeutics of Dental Diseases/ Russia.
2. Assoc. Prof, DDS, PhD Volgograd State Medical University, Department of Propaedeutics of dental diseases, Dean of the Dental Faculty Department of Propaedeutics of Dental Diseases / Russia.
3. M.D., associate professor of the Department of Therapeutic Dentistry Volgograd State Medical University; Senior Researcher of the Pathology Laboratory of the Volgograd Medical Scientific Center / Russia.
4. Assoc. Prof, DDS, PhD Volgograd State Medical University, Department of Propaedeutics of dental diseases Department of Propaedeutics of Dental Diseases / Russia.
5. Assoc. Prof, DDS, PhD Volgograd State Medical University, Department of Propaedeutics of dental diseases Department of Propaedeutics of Dental Diseases / Russia.

Abstract

Periodontal diseases often occur against the background of diseases of the cardiovascular system. This is quite natural, since microcirculatory disorders of these pathologies have a general orientation. This study shows the relationship of microcirculatory changes in the oral cavity and pathology of the cardiovascular system according to laser Doppler flowmetry. With the help of LDF – gram and amplitude-frequency analysis, the capillary blood flow was examined in periodontal diseases against the background of cardiovascular pathology when compared with similar data in a healthy category of patients of dental clinics in the same age group. Blood flow in the gingival mucosa and on the palmar surface of the IV finger of the left hand was investigated. Microcirculatory disorders caused by a decrease in the contribution of active and an increase in the contribution of passive oscillations in the microcirculation bed were revealed. In periodontal diseases, screening of systemic blood flow is recommended for early detection of cardiovascular diseases.

Clinical article (J Int Dent Med Res 2020; 13(1): 216-222)

Keywords: Laser Doppler flowmetry, periodontal disease, hypertension, relationship.

Received date: 22 October 2019

Accept date: 19 November 2019

Introduction

The prevalence of major dental diseases among the population reaches 95-100%, while in Russia, among all pathological processes of the oral cavity, periodontal diseases are detected in 98% of the surveyed^{1,2}. The high prevalence of periodontal diseases dictates the need to search for optimal methods of prevention and treatment, taking into account the pathogenetic mechanisms of development^{3,4}.

It was found that among patients seeking dental care in health care institutions, every third

person has various somatic diseases in the compensated form and almost every second (45.9%) visitor to dental clinics has risk factors for the development of organ pathology^{5,6}. Thus, patients with somatic pathology are at high risk, which requires the development of organizational and practical measures for the preparation and conduct of dental interventions in this population.⁷ Dental manipulations in patients with somatic pathology can negatively affect their General condition, complicating the course of the underlying disease. At the same time, concomitant pathology can negatively affect the results of treatment at the dentist.^{8,9}

The health of the oral cavity depends on the state of the microcirculation bed, which provides tissue trophism. A close relationship between periodontal disease and pathology of the cardiovascular system, and in particular, with coronary heart disease (CHD), has been established.¹⁰ Arterial hypertension (AH) occurs

*Corresponding author:

Julia A. Makedonova

Department of Therapeutic Dentistry
Volgograd State Medical University; Senior Researcher of the
Pathology Laboratory of the Volgograd Medical Scientific Center
/ Russia.

E-mail: mihai-m@yandex.ru

in 40% of the working population and ranks 1st among the causes of mortality from cardiovascular diseases¹¹. The increase in cases of cardiovascular complications is associated with hypertensive crises, the main cause of which is stress¹². One of the most important factors in the pathogenesis of hypertension are microcirculatory disorders, which serves as the basis for inflammatory and destructive periodontal diseases.¹³ Changes in the microcirculation bed progress with the development of the disease and are closely interrelated not only with the severity of hypertension, but also with the degree of damage to periodontal tissues. It was found that the microcirculation bed of the periodontium - the active zone in the hemodynamics of the whole organism-undergoes changes with constant or frequent stresses of the vascular system¹⁴.

Great importance in the occurrence and development of both hypertension and generalized periodontitis is attached to increased activity of the sympathetic division of the autonomic nervous system, which leads to dysfunction of the centers that regulate vascular tone and blood pressure; microcirculatory disorders, increased vascular permeability, including in periodontal tissues.¹⁵

In patients with chronic generalized periodontitis, occurring against the background of hypertension, hypoxia contributes to an increase in the excitability of the sympatho-adrenal system, swelling of the endothelium of the vascular wall, deterioration of redox processes in periodontal tissues, reduction of adaptive capability¹⁶. These data are confirmed by studies indicating that the vast majority of patients with hypertension have pronounced inflammatory and destructive processes in the periodontium; they are characterized by high caries susceptibility and poor oral hygiene.¹⁷ At the same time, there is no clear idea about the features of microcirculatory disorders in the periodontium, arising on the background of diseases of the cardiovascular system, which was the reason for the study of this problem and the development of prognostic criteria in the dental care system.

Objective: to assess the relationship of microcirculatory changes in the soft tissues of the oral cavity and cardiovascular pathology using laser Doppler flowmetry.

Materials and methods

To identify the incidence of patients with cardiovascular disease at the dental reception by random sampling at the initial visit to the dentist for the treatment of chronic generalized periodontitis of moderate severity, 228 people aged 35-65 years were examined.

Of the total number of patients in the further study involved 95 people with chronic generalized periodontitis and diseases of the cardiovascular system (coronary artery disease, angina, hypertension I degree). 35 people formed a control group for comparative analysis of microcirculatory changes in this age group. The average age of the examined patients was 44.3 ± 4.9 years. Among the surveyed women dominated (77 people-81.05%).

On initial admission was conducted a survey of patients to ascertain the complaints, anamnesis of disease and anamnesis of life. The purpose of the survey was to clarify the relationship of periodontal pathology with the general condition of the body. Clinical examination of the oral cavity was carried out in accordance with WHO recommendations; periodontal examination included visual assessment, determination of the depth of pathological pockets (or dental sulcus), pathological tooth mobility, degree of bleeding gums, as well as hygiene indices¹⁸.

Laser Doppler vascular flowmetry was performed in a dental chair, in the patient's sitting position; possible postural reflexes were taken into account. For registration of blood flow in periodontal tissues the device of Russian production LAKK-OP was used. The study was conducted at a room temperature of about 22-24 C at the same time of day. Within 15 minutes before the diagnosis, the patient was in a calm state, did not take food or drinks that affect the state of microcirculation, did not smoke.

To determine microcirculatory disorders in periodontal tissues, the sensor of the LACC analyzer (laser analyzer of capillary blood flow) was fixed on the oral mucosa in the zone of periodontal tissue lesion. Measurement of capillary blood flow on the palmar surface of the IV finger of the left hand was measured both in patients with a history of cardiovascular diseases and in a group of healthy individuals to compare the results. The left hand was at the level of the subject's heart. The sensor was fixed with a

special tripod.

After registering the LDF-grams, the average values of the signal amplitude were displayed on the computer monitor. The value of the average flow of blood perfusion – M – for 10 minutes, the standard deviation – σ and the integral index of variations – KV of this process were determined. In addition to calculating the numerical characteristics of the flow of red blood cells in microvessels, rhythmic changes in this flow were also analyzed with the help of a special program. Amplitude-frequency analysis of microcirculation in all patients was performed by Wavelet transform method. The values of rhythms of blood flow oscillations in the microcirculation bed were determined by the following indicators – VLF (very low-frequency oscillations), LFH, LFM (low-frequency oscillations), HF (high-frequency oscillations), CF (pulse oscillations).

The rhythmic structure of flaxmotion is revealed by the amplitude-frequency spectrum of LDF-grams and is the result of various (neurogenic, myogenic, respiratory, cardiac and endogenous) effects on the state of microcirculation. The frequency and amplitude of very low-frequency oscillations (VLF) is associated with periodic contractions of endotheliocytes; low-frequency oscillations (LFM; LFH) are caused by the activity of smooth myocytes in arterioles; high-frequency oscillations (HF) - changes in pressure in the venous Department of the bed and pulse oscillations (CF) - changes in intravascular pressure synchronized with the CARDIORHYTHM of blood flow fluctuations.

The data obtained as a result of the studies were processed by variational-statistical method on IBM PC/AT "Pentium-IV" in Windows 2000 environment using the application package Statistica 6 (Statsoft-Russia, 1999) and Microsoft Exsel Windows 2000. The statistical analysis was carried out by the method of variational statistics with the determination of the average value (M), its average error ($\pm m$), evaluation of the reliability of the difference in groups using the student's criterion (t). The difference between the compared indicators was considered reliable at $p < 0.05$, $t \geq 2$.

Results

In a group of healthy individuals, laser Doppler flowmetry revealed the normative

parameters of microcirculation. The level of capillary blood flow in periodontal tissues according to the microcirculation parameter (PM) was 31.09 ± 0.9 perfusion units. Parameter M characterizes the average flow of erythrocytes per unit volume of tissue in the probed area in the registration time interval. The mean square deviation of blood flow oscillations (COE) was 3.52 ± 0.004 perf. the unit Parameter COE or σ characterizes the value of temporal variability of microcirculation, referred to in microvascular semantics as "flux". The coefficient of variation (CV) was $11.17 \pm 0.01\%$. CV objectively reflects the state of microcirculation.

Amplitude-frequency indices of microcirculatory changes in periodontal tissues correspond to the normative parameters of LDF for healthy people (table.1). As can be seen from the distribution of amplitudes of blood flow rhythms, oscillations in the neurogenic range prevail, the amplitude of pulse (HF) and respiratory (CF) waves is within the normal range.

Frequency range	VLF	LF _H	LF _M	HF	CF
A	1,700±0,15	1,710±0,13	0,990±0,2	0,350±0,09	0,200±0,05
F	0,020±0,0002	0,025±0,0004	0,100±0,01	0,448±0,03	1,263±0,06
A/3q	15,994±1,88	16,088±1,6	9,314±0,80	3,293±0,73	1,882±0,99
A/M	5,330±0,9	5,361±0,6	3,104±0,4	1,097±0,2	0,627±0,1

Table 1. Amplitude-frequency analysis of periodontal tissues in healthy people.

Frequency range	VLF	LF _H	LF _M	HF	CF
A	1,380±0,12	1,640±0,11	0,900±0,02	0,310±0,07	0,210±0,05
F	0,020±0,0002	0,028±0,0003	0,100±0,01	0,398±0,02	1,121±0,04
A/3q	15,156±1,66	18,011±1,7	9,884±0,7	3,405±0,5	2,306±0,75
A/M	5,221±0,7	6,204±0,4	3,405±0,3	1,173±0,2	0,794±0,1

Table 2. Spectral decomposition of LDF-grams in healthy people.

It should be noted that due to anatomical and physiological characteristics of blood flow in different areas of the body, the average values of microcirculation can vary significantly. Complex LDF-metric study of microcirculation in healthy people allowed to establish the following indicators: M- 26.43 ± 0.13 perf.ed; the level of "flax" - 3.04 ± 0.02 perf.ed; CV was $11.48 \pm 0.1\%$, which corresponds to the mesoemic type of tissue blood flow, characterized by average blood flow parameters and well-pronounced aperiodicity of oscillations. This LDF-gram reflects the high level of mobility of red blood cells in tissues.

Amplitude-frequency analysis of LDF-metric on the Palmar surface of the IV finger of

the left hand in healthy people is presented in table 2.

According to table 2, the contribution of various rhythmic components of flaxmotion in LDF – gram revealed no pathological changes, which is important for assessing the state of microcirculation. The contribution of passive oscillations was: HF-oscillations-6.98%; CF-oscillations-4.68%. Active modulations are under the control of both the myogenic mechanism, which is more characterized by the periodicity of flaxmotion, and the neurogenic mechanism, which is characterized by aperiodic constrictor phases. Myogenic LFM oscillations were 20.2%; neurogenic LFN oscillations – 36.9% and endothelial-31.2%, respectively.

The analysis of the amplitude-frequency spectrum of the periodontal and IV fingers of the left hand in healthy people did not reveal microcirculatory disorders of capillary blood flow. However, the analysis of the data of capillary blood flow of periodontal tissues revealed small changes in microcirculation, which indicates minor stagnation in the oral cavity and corresponds to the normative parameters in this age group.

The state of the microcirculatory bed in patients with chronic generalized periodontitis differed significantly from those of healthy individuals, and microcirculation disorders in periodontal and cardiovascular diseases had a General orientation.

In patients with periodontal disease, the average diagnostic parameters of tissue blood flow were statistically significantly lower than those obtained during the examination of healthy individuals, which indicated stagnation of blood in the microcirculatory bed of the gums. The microcirculation index was 30.39 ± 0.1 perf.units, the "flax" index and coefficient of variation are statistically lower than the control group (0.58 ± 0.001 perf.units and $1.94 \pm 0.02\%$) at $p < 0.05$.

The increase in the level of the LDF signal was the more pronounced, the more disorders of blood circulation were observed. In some cases, there was also an increase in the microcirculation index, which is associated with an increase in stagnation in the periodontal tissues.

The rhythmic structure of blood flow oscillations also changed – the amplitude of low-frequency oscillations decreased, which is associated with the weakening of the vasomotor

rhythm and, as a consequence, the strengthening of the heart rhythm to a greater extent (Fig.1).

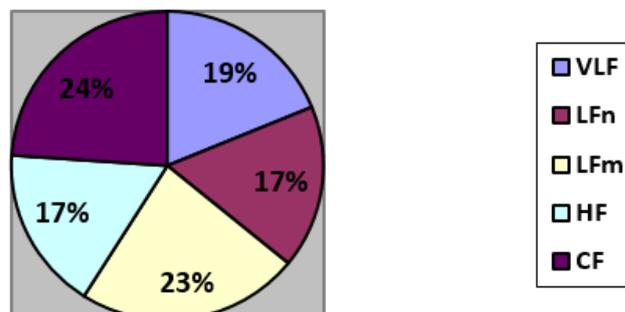


Figure 1. Contribution of active and passive vibrations, in percent.

The data obtained indicate a violation of microcirculation in periodontal tissues, which is characterized by increased blood flow, expansion of microvessels, increased permeability of the vascular wall. At the same time, the flux and coefficient of variation are significantly and reliably lower than normal, the amplitude of vasomotor waves is reduced, the HF rhythm is increased, the amplitude of the CF rhythm is also increased. It is established that in this group there is a significant increase in the pulse wave, which means an increase in the inflow of arterial blood into the microcirculation bed. The pulse wave frequency was 1.258 Hz, which is a prerequisite for referral of patients who deny the presence of CVD to a cardiologist, since a significant increase in the amplitude of the pulse wave is typical for persons with diseases of the cardiovascular system.

Indicators of LDF-metry registered on the Palmar surface of the terminal phalanx of the IV finger of the left hand were also significantly lower than similar indicators in healthy individuals. the microcirculation Index was 24.63 ± 0.3 perf.ed; SKO- $1,92 \pm 0,003$ perf. ed and the coefficient of variation KV 7.78 per cent. A significant decrease in the level of "flax" and CV indicates more pronounced inflammatory changes in periodontal tissues against the background of cardiovascular pathology.

The amplitude-frequency calculation of the results in the main group was carried out by comparing with similar data in healthy individuals. the results of the study indicate that LDF-grams of patients suffering from cardiovascular diseases are characterized by a decrease in PM,

COD and amplitude of low-frequency LF-oscillations. In patients, a relatively low curve with suppression of the amplitude of low-frequency oscillations is registered (table.3).

Frequency range	VLF	LF _H	LF _M	HF	CF
A	0,82±0,01	0,64±0,02	0,42±0,01	0,2±0,03	0,35±0,01
F	0,016±0,0002	0,04±0,0001	0,089±0,01	0,398±0,02	1,121±0,1
A/3q	14,271±1,52	11,138±1,13	7,309±0,6	3,481±0,4	6,091±0,5
A/M	3,329±0,2	2,598±0,1	1,705±0,2	0,812±0,01	1,421±0,1

Table 3. Amplitude-frequency spectrum in patients with cardiovascular disease.

The nature of changes in the microcirculation in this group is associated with a decrease in blood flow, which is based on spasm of arterioles, a decrease in the number of functioning capillaries, slowing blood flow and increased aggregation of red blood cells. Microcirculation parameters are lower than normal, flux is reduced; LF-rhythm suppression is observed, the amplitude of vasomotor waves is reduced, and the amplitude of the pulse wave increases compared to the norm. All changes in the above indicators allow to suspect the presence of pathology of the cardiovascular system and are the basis for sending patients without a history of CVD to consult a cardiologist.

As a result of the study in the basic part of the study of periodontal microcirculation using laser Doppler flowmetry revealed a significant decrease in the coefficient of variation in the group of patients with chronic generalized periodontitis compared with the group of healthy individuals (1.94±0.02 and 11.48±0.1%, respectively, p<0.05). High standard deviation (almost 6 times!) in a group of healthy individuals indicates the active functioning of microcirculation control mechanisms. When comparing capillary blood flow on the Palmar surface of the IV finger of the left hand in the group of healthy individuals and in the group of patients with somatic pathology, microcirculation changes were of a similar nature. Thus, CV in patients with cardiovascular disease was 1.5 times lower than in healthy individuals in the same age group. And the increase in the coefficient of variation (CV) reflects an improvement in the state of microcirculation, as it is associated with an increase in the level of "flax" as a result of activation of endothelial secretion, neurogenic and myogenic control mechanisms at a virtually unchanged value of M.

When assessing the state of perfusion

control mechanisms by the values of the amplitudes of micro-blood flow oscillations in specific frequency ranges, significant differences between the study groups were also revealed (Fig.2).

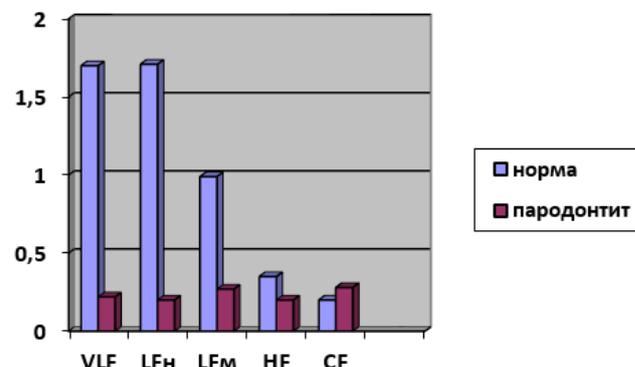


Figure 2. The amplitude-frequency analysis of the microcirculation of periodontal tissues in comparison

The analysis of rhythmic components of oscillations of tissue blood flow in periodontal tissues, performed using Wavelet transform, showed that in a group of healthy individuals the dominant vasomotor rhythm, the contribution of high-frequency oscillations is extremely insignificant. In pathology, on the contrary, the contribution of passive mechanisms of regulation of tissue blood flow increased against the background of a decrease in the amplitudes of low-frequency oscillations. The revealed dynamics demonstrates a decrease in the active mechanisms of blood flow modulation, mainly due to vasomotor rhythm.

When spectral decomposition into frequencies of the results obtained in the study of the IV finger of the Palmar surface of the left hand in both groups also obtained significantly different data (Fig.3).

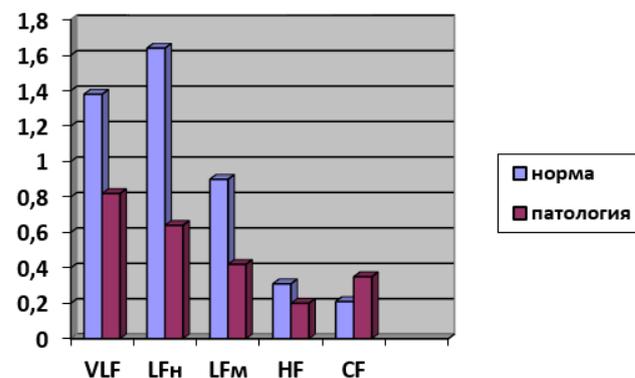


Figure 3. Distribution of amplitude of blood flow rhythms.

In patients with pathology of the cardiovascular system, the contribution of endothelial, neurogenic and myogenic oscillations is reduced, while there is an increase in the amplitudes of high-frequency oscillations, to a greater extent the amplitude of the pulse wave, which indicates a decrease in the elasticity of the vascular wall, the possible presence of hypertension or other diseases of vascular genesis.

Thus, the study of the state of the microcirculatory bed in patients with periodontitis revealed significant violations of blood flow in the periodontal vessels. In patients with cardiovascular disease, capillary blood flow rates in laser Doppler flowmetry were significantly lower compared to patients without comorbidities ($p < 0.05$).

Discussion

During the last decade, the problem of prevention and treatment of chronic diseases of the oral mucosa has received considerable attention from domestic and foreign researchers. This is due to an increase in the negative impact on the human body of immunosuppressive environmental factors, the widespread use of drugs with antibacterial properties, lack of research of patients. The development of interdisciplinary interaction of medical specialists justifies the need for the introduction of modern diagnostic technologies in the complex management of patients. Effective diagnosis is the basis for successful treatment¹⁹.

Laser Doppler flowmetry is a method that can objectively record the state of blood flow at a certain time interval. The advantage of LDF-metry is non-invasive technique, high information content and the ability to assess the state of blood flow of the study area at any stage of treatment. On the basis of the data obtained with the help of LDF-metry, it is possible to analyze the state and disorders of the microcirculation system, to identify pathology at an early stage of development, to exercise objective control over the treatment activities and individual selection of pharmacological agents²⁰.

Conclusions

Parameters of laser Doppler flowmetry in patients with chronic generalized periodontitis

with concomitant cardiovascular disease indicate the predominant involvement of the arterial link of the microcirculation bed of the periodontium in the process. All patients older than 35 years with periodontal disease should be screened for CVD, due to the presence of latent comorbidities in most of them. In the study of periodontal blood flow, it is recommended to conduct a General analysis of microcirculation for early diagnosis of possible cardiovascular diseases. The data obtained by us revealed a direct relationship between CVD and regional circulatory disorders of periodontal tissues.

Acknowledgements

The authors thank, the local authorities (Volgograd State Medical University) for their support and contributes in this study.

Declaration of Interest

The authors report no conflicts of interest pertaining to any of the products or companies discussed in this article.

References

1. Dmitrieva L. A. Therapeutic dentistry. M.: Medicine, [in Russian] 2003.894 p.
2. Malezhik L. P. Some aspects of immune reactions in chronic generalized periodontitis in elderly people [in Russian] / L. p. Malezhik, Yu. I. Pinelis, M. S. Malezhik/ / Stomatology.2011; 90.(6):8-10.
3. Gazhva S. and Medicamentous schemes of conservative treatment of chronic forms of periodontitis [in Russian] / S. I. Gazhva, A. I. Voronina, D. A. Kulkova// Fundamental researches.-2013; 5 (1): 55-57.
4. Makedonova Yu. A., Porojskiy S. V., Firsova I. V. justification of the choice of method for the prevention of periodontal disease [in Russian] // Dentistry. 2016; 95 (6): 35-36.
5. Gorbacheva I. A. Connection of diseases of internal organs with inflammatory lesions of the oral cavity [in Russian] / I. A. Gorbacheva, L. Yu. Orekhova/ / Periodontology.2009;3:3-7.
6. Maslak E. E., Naumova V. N. Cooperation of dentists and doctors-endocrinologists on the identification and management of patients with diabetes: aspects of interdisciplinary interaction [in Russian] / Diabetes. 2019;22 (1): 35-43.
7. Grigorovich E. S., Cherkashin D. S., Gorodilov R. V.. Clinical indicators of the periodontal condition in patients with chronic generalized periodontitis with different histologically determined outcome of the anti-inflammatory stage of treatment [in Russian] / Diabetes/ 2010; 1:19-23.
8. Kutusheva A.V. periodontal Diseases and "systemic diseases": known past, promising future/ A.V. Kutusheva, D. R. Bogatyreva, a.m. Burduli [in Russian] // Periodontology.;2009;1:3-6.
9. Yakovlev A.T., Danilina T.F., Naumova V.N. [et al.] Immunological peculiarities of adaptation of patients with cardiovascular diseases to the non-removable dentures on the background of balneological immunocorrection./ Indo American Journal of Pharmaceautical Sciences. 2017. 4 (11): 4602-4606.

10. Cannell J.J. On the epidemiology of influenza/ J.J. Cannell, M. Zaslloff, C.F. Garland, et al// *Virology Journal*. 2008;5:149.
11. Ravaeva M. Yu., Chuyan E. N., Drevvetnyak N. A. The role of nitric oxide in the development of endothelial dysfunction [in Russian] // *Uchenye zapiski Tavricheskogo Natsionalnogo Universiteta im. V.I. Vernadsky*. 2013; 26 (65): 147-157.
12. Rossi M., Ricco R., Carpi A. Spectral analysis of skin laser Doppler blood perfusion signal during cutaneous hyperemia in response to acetylcholine iontophoresis and ischemia in normal subjects // *Clin. Hemorheol. Microcirc.* 2004; 31:303–310.
13. Kozlov V.I., Azizov G.A., Ibragim R.Kh. et al. Individually-typological features of microcirculation in humans [in Russian] // *Regional blood circulation and microcirculation*. 2005; 1: 77–78.
14. Kozlov V.I., Gurova O.A., Litvin F.B. Disorders of tissue blood flow, their pathogenesis and classification [in Russian] // *Regional blood circulation and microcirculation*. 2007; 1: 75–76.
15. Arunachalam, L.T. Effect of low level laser therapy on revascularization of free gingival graft using ultrasound Doppler flowmetry / L.T. Arunachalam, U. Sudhakar, A.S Janarthanam // *J Indian Soc Periodontol*. 2014.18 (3): 403-407.
16. Sabantseva EG. Pathophysiological characteristics of microcirculation disorders in inflammatory and destructive diseases of the oral mucosa / EG Sabantseva [in Russian] // *Regional blood circulation and microcirculation*. 2006; 5 (1): 30-36.
17. Roeykens H. Use of laser Doppler flowmetry in dentistry / H. Roeykens, S. Nammour, R. De Moor // *Rev Beige Med Dent*. 2009; 64 (3): 114-128.
18. Maksimovskaya L.N. The state of the gum tissue microcirculation system in patients with inflammatory periodontal diseases against the background of different stages of GERD [Text] / L.N. Maksimovskaya, ETC. Dzhamaaldinova, M.A. Sokolova [in Russian] // *Dentistry for all*. 2011; 1: p. 14-17.
19. Poroykiy S. V., Firsova I. V., Mikhachenko D. V., Makedonova Yu. A., Fomichev E. V. Comparative study of reparative regeneration of the oral mucosa in the experiment [in Russian] / *Yakut medical journal*. 2018; 4: 30-33
20. Laser Doppler flowmetry in assessing the mechanisms of regulation of tooth pulp microcirculation [Text] / S.N. Ermoliev, A.P. Sheriev, Yu.S. Tulip. [in Russian] // *Bulletin of the Scientific Center for Cardiovascular Surgery. A.N. Bakulev RAMS "Cardiovascular diseases."* Application. 2008; 9 (6): 155.