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The relationship between microcirculatory changes in general blood flow and periodontium in pregnant women

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Abstract:
Objective: to identify the relationship between microcirculatory changes in the general blood flow and periodontium in pregnant women.
Materials and Methods. The study involved 98 pregnant women who were examined for microcirculatory changes in the fourth finger of the left hand and periodontium. The control group consisted of 30 nonpregnant women. Laser Doppler flowmetry was carried out in two stages. At stage 1, vasomotor activity of vessels was studied, while at stage 2, the contribution of high- and low-frequency oscillations to the overall modulation of blood flow was examined. A correlation analysis of microcirculatory changes in the general blood flow and periodontium was performed.
Results. Pregnant women exhibited a reduction in vasomotor activity of vessels and a deterioration in the local blood flow rate. The coefficient of variation was 1.6 times smaller than in the control group (p=0.03). The percentages of the contribution of pulse and respiration waveforms were 7.6 (p=0.03) and 1.5 times (p=0.03) higher than in the control group, in the modulation spectrum of which the amplitude of myogenic genesis prevailed. We revealed a functional relationship between the local blood flow rate in the oral cavity microvessels and the vasomotor activity of the fourth finger of the left hand (Pearson correlation coefficient: 1.0).
Conclusion. The revealed relationship confirms the homogeneity of changes in microcirculatory disorder both in periodontium and in the general blood flow in the entire body. This fact must be taken into account when managing pregnant women by a dentist and a gynecologist.

Keywords: microcirculatory changes in general blood flow, microcirculatory changes in periodontium, laser Doppler flowmetry, periodontium

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Introduction

During pregnancy, a number of physiological processes occur that affect both the general condition of the body and the functioning of individual organs and systems [1]. The oral cavity, which constitutes the beginning of the digestive system, is no exception [2]. Restructuring of the immune system and increase in the body's need for vitamins and microelements are predictors for the development of various dental diseases. According to available publications, the overall prevalence of the oral mucosa diseases in pregnant women is 11.8% [3]. Among the most common pathologies of the oral mucosa, gingival hypertrophy, candidiasis, and pyogenic granuloma should be noted. During pregnancy, substantial fluctuations in the level of female sex hormones occur [4]. Progesterone and estrogen levels reach their maximum values by the end of the third trimester [5, 6]. Receptors for these hormones are present in periodontal cells, which makes them a possible target and serves as a predictor for inflammation. It is well known that an increase in the level of sex hormones during pregnancy correlates with an enlarged incidence of periodontal diseases [7]. The clinical picture of the marginal periodontium inflammation in pregnant women is similar to the manifestations of gingivitis and periodontitis caused by poor oral hygiene, but the amount of plaque is small. An increase in the severity of the clinical picture is observed in the second and third trimesters, usually against the background of a satisfactory oral hygiene index. Hyperplasia of marginal periodontal tissue, the formation of gingival pockets, and bleeding on probing are characteristic [8]. Loss of attachment and the formation of bone pockets occur infrequently.

During pregnancy, various microcirculatory changes occur [9], which are predictors for the development of periodontal diseases. Pathology of periodontal tissues can cause unfavorable pregnancy outcomes such as premature birth with low birth weight [10]. It is imperative to conduct a prompt assessment of the state of blood flow at the tissue level at an early stage [11]. One of the methods allowing to detect microcirculatory disorders in the development of

dental pathology at early stages of their development is laser Doppler flowmetry (LDF) [12]. Until now, a cause-and-effect relationship between the state of microcirculation in the oral cavity and the general state of local blood flow has not been proven yet. The depth of the vessels and the density of the functioning capillaries are different. When conducting LDF, the direction of the main blood flows in relation to the skin surface, relative to which the optical probe of the analyzer is fixed, is of great importance [13]. That is why, one of the areas for measuring microcirculation is the palmar surface of the fourth finger of the left hand, containing a large number of arteriovenous anastomoses [14], due to which the mean blood flow rate is higher relative to different areas of the body.

Objective – to identify the relationship between microcirculatory changes in the general blood flow and periodontium in pregnant women.

Materials and Methods

A total of 98 pregnant women with a mean age of 25.9±2.3 years (study group) were examined. Their medical history was studied, complaints regarding the oral cavity were analyzed in detail, and attention was paid to the presence of concomitant pathology of the gastrointestinal tract, along with cardiovascular and endocrine systems.

Inclusion criteria were:

1. Patients aged 18 to 44 years (young age sensu the classification by the World Health Organization);

2. Pregnancy (second trimester);

3. Informed voluntary consent of patients to undergo all studies according to the protocol;

4. Absence of acute somatic diseases.

Non-inclusion criteria were:

1. Individuals under 18 and over 45 years of age.

2. Presence of malignant neoplasms.

3. Presence of acute somatic diseases, as well as chronic illnesses in the stage of decompensation.

4. Lack of informed consent from patients;

5. Refusal of patients to participate in the study at any stage;

6. Socially vulnerable groups of the population.

Exclusion criteria:

1. Failure of the patient to comply with recommendations for prevention and treatment;

2. Intolerance to the prescribed pharmaceutical drugs, identified during the study;

3. Refusal of the patient to continue participating in the study.

The study sample (n=98) was formed according to the inclusion and non-inclusion/exclusion criteria in a randomized controlled clinical trial based on medical records of pregnant women. In addition, a control group (non-pregnant patients) of the similar age category (n=30) was formed. Virtually healthy pregnant women had no complaints. Stable values were obtained when assessing the dental status. The CFE + cf index (C, F and E designate the sums of carious, filled and extracted teeth in a single examined person; c and a specify caries and fillings on baby teeth) was 5.61±0.35. Oral hygiene was assessed as satisfactory: PCR=9.2±0.2%. The values of Svrakov iodine number, bleeding index, and periodontal screening and recording (PSR) were equal to zero.

The flow chart of the study design is presented in *Figure 1*.

LDF was recorded in a sitting position using the palmar surface of the fourth finger of the left hand. The hand was held at the level of the pregnant woman's heart. The microcirculation parameter M (perfusion units), the mean square deviation (perfusion units) and the coefficient of variation were calculated. The microcirculation parameter M is the level of tissue volume perfusion per unit of time, measured in perfusion units. This parameter is variable and random; the mean square deviation (□) characterizes the amplitude of blood flow oscillations relative to the parameter M, i.e., the magnitude of the temporal variability of microcirculation. This parameter is directly dependent on the coefficient of variation (CV) calculated using the following formula:

$$CV = \frac{M}{\delta} \times 100\%$$

The higher the standard deviation, the better the vasomotor activity of the vessels and the better the functioning of the tissue blood flow modulation mechanisms. A reduction in the coefficient of variation reflects the suppression of active vasomotor mechanisms. At stage II of the examination, a spectral analysis of oscillation biorhythms was performed using the wavelet transform method for an in-depth study of microcirculation disorders. The contribution of various rhythmic components of blood flow oscillations to the overall blood flow modulation was determined:

VLF – endothelial oscillations;

LFH – neurogenic blood flow oscillations;

LFм – myogenic oscillations;

HF – respiratory wave amplitude;

CF – pulse wave amplitude.

Microcirculatory changes were assessed by a dentist and a gynecologist. The dentist performed LDF of the periodontium in the dental chair. The gynecologist assessed the state of blood flow in the fourth finger on the palmar surface of the left hand.

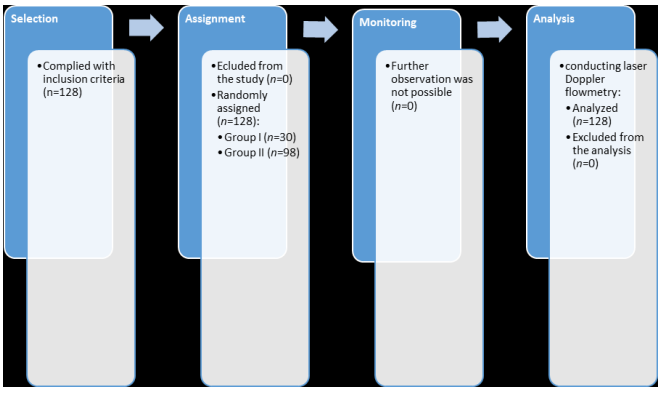

Figure 1. Study design

The obtained values were compared with the parameters of the control group.

We employed statistical methods to measure the mean (M), standard deviation (σ), and standard error of the mean (m). To assess the significance of differences, Student's t-test was used. The level of compliance with the null hypothesis was assumed at 95% ($p<0.05$). The normality of the distribution was confirmed using the Kolmogorov-Smirnov test. The data were processed in Microsoft Excel 2017 for the MS Windows 10 operating system (Microsoft Corp., USA) and in StatSoft Statistica 13.0 software.

Results

Patients attending a gynecologist complained of weakness (18 people or 18.4%, fatigue (7 people or 7.1%), and dizziness (24 women or 24.5%). Impaired taste sensitivity was stated by 67 (68.4%) people. The patients did not complain of anything else. Chronic tongue trauma detected during a random examination, which could become malignant, was detected in 3 (3.1%) pregnant women. The incidence of caries and periodontal diseases was 100%.

The results of the LDF study are summarized in *Table*.

The microcirculation parameter was quite variable, and it is inappropriate to focus on its increase or decrease. However, the standard deviation of the amplitude of blood flow oscillations relative to the parameter M in the periodontium of pregnant women was 3.1 times smaller ($p=0.03$) and the coefficient of variation was 4.1 times smaller ($p=0.034$), which characterizes the deterioration of the local blood flow rate and insufficient blood perfusion.

The analysis of the LDF study on the palmar surface of the fourth finger corresponded to the results obtained during the examination by a dentist. In pregnant women, the standard deviation and the coefficient of variation were 1.6 times smaller relative to the control values ($p=0.03$). Correlation analysis of the vasomotor activity of the vessels revealed a functional relationship between the state of microcirculation of the palmar surface of the fourth finger in the left hand and the periodontium of pregnant women (Pearson correlation coefficient was 1.0; *Figure 2*).

Thus, with insufficient vasomotor activity of the microvessels in the palmar surface of the fourth finger in the left hand, it is reasonable to assume the development of microcirculatory disorders in the periodontal tissues, which in turn is one of the causes of the development of periodontal diseases and lesions of oral mucosa.

Table. Results of laser Doppler flowmetry study

Parameter	Patient group			
	Control group		Study group (pregnant women)	
	Fourth finger	Periodontium	Fourth finger	Periodontium
M, perfusion units	25.3±2.3	22.6±1.4	24.6±1.8	30.6±2.6
δ, perfusion units	3.1±0.3*	5.6±0.3**	1.9±0.4*	1.8±0.3**
CV, %	12.4±1.4*	24.8±2.6**	7.7±1.1*	6.0±0.8**

Significance of differences in relation to the parameters of a similar measurement area in the control group: *$p<0.05$; **$p<0.001$.

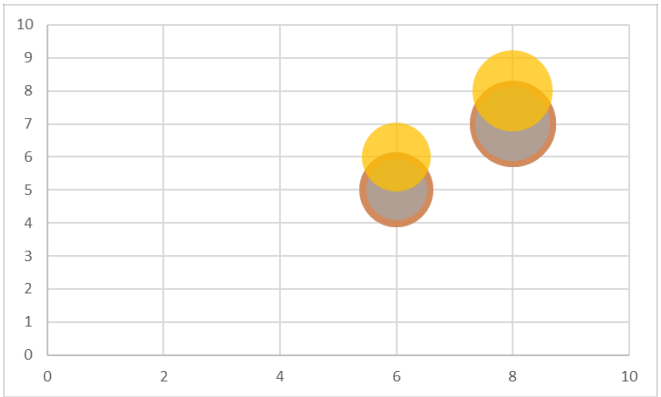

Figure 2. Correlation between the coefficient of variation of the fourth finger of the left hand and the periodontium in pregnant women

In the control group, using the wavelet transform method, we calculated the contributions by endothelial, neurogenic, myogenic, respiratory and cardiac oscillations to the overall modulation of blood flow as 23.1±1.2%, 19.8±1.3%, 41.2±1.5%, 12.4±1.1% and 2.9±0.8%, respectively. In the control group, the contribution of slow oscillatory activity to the overall modulation of blood flow prevailed.

In pregnant women, the percentage of the contribution of endothelial oscillations did not differ statistically significantly from the control group and amounted to 23.8±1.3%. However, the contributions of the amplitudes of the respiratory and pulse waves were 1.5 times and 7.6 times higher, respectively, and amounted to 18.2±1.7% and 22.3±1.6%, while the contributions of neurogenic and myogenic oscillations were 18.9±1.3% and 16.8±1.3%, i.e., 2.5 times smaller than in the control group.

Discussion

Our study confirmed that LDF revealed a correlation between the condition of the periodontal tissue and the modulation of the general blood flow. Changes in the vasomotor activity of the vessels and the amplitudes of oscillations of active and passive factors were similar. In pregnant women, a deterioration in the local blood flow rate was observed both when measuring the microvessels of the fourth finger of the left hand and in the periodontium. At the same time, an increase in the contribution of passive oscillations to the general modulation of blood flow was probably due to changes in systolic and diastolic pressure. Normally, high-frequency waves are under the control of the amplitude of myogenic oscillations, a decrease in which characterizes the suppression of the neurogenic vasomotor mechanism. It should be noted that the identified hemodynamic disorders are reversible: a change in high- and low-frequency oscillations indicates a weakening of the contribution of active mechanisms and an increase in the contribution of passive hemodynamic waves, which contributes to the possibility of considering the cause of periodontal diseases during pregnancy.

Conclusion

The results of our study demonstrate that pregnant women have microcirculatory changes both in the oral cavity and in the overall blood flow on the palmar surface of the fourth finger of the left hand. Conducting an LDF study allows identifying hemodynamics. The identified relationship

should be taken into account when managing pregnant women by both a dentist and a gynecologist. An integrated approach to managing pregnant women, collaboration between gynecologists and dentists, along with regular visits to the dentist by pregnant women, can prevent the development of various dental diseases. Conducting a full diagnosis, including LDF in the examination protocol for pregnant women will allow for early verification of both periodontal diseases and an assessment of the state of microcirculation of the entire body, which should be taken into account when managing this category of patients.

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Conflict of interest. The authors declare no obvious or potential conflicts of interest related to the publication of this article.

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