

An Improved Method for Improving Microcirculation in the Lower Extremities in Patients with Diabetic Angiopathy

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Abstract Introduction. The problem of the occurrence and treatment of purulent-necrotic complications in patients with diabetic foot syndrome (DFS) is far from being solved and, despite the successes of modern medicine, contains a large number of unresolved issues of both theoretical and practical nature. In the treatment of diabetic angiopathy of the lower extremities, the main attention is paid to the restoration of blood flow and insufficient attention is paid to the elimination of microcirculatory disorders. **The purpose of the study.** To increase the effectiveness of treatment of patients with diabetic angiopathy of the lower extremities by improving microcirculation in the periphery of the lower extremities. Materials and methods of research. The paper analyzes the results of a comprehensive examination and treatment of 322 patients with diabetic foot syndrome (DFS) who were on inpatient treatment in the department of purulent surgery of the Bukhara Regional Multidisciplinary Medical Center in the period from 2017 to 2023. Among the patients, there was a predominance of 221 men (68.6%), 101 women (31.4%). The average age of the patients was 62.5 ± 13.2 years. The duration of diabetes mellitus was 15.13 ± 5.64 g. **Results and their discussion.** The study of indicators of local cutaneous blood flow was carried out using Doppler flowmetry, which was performed in 126 (91.9%) patients of the main group, and 165 (89.2%) patients of the comparison group. Flowmetry was performed before and after treatment. At rest, basal blood flow (PMIs) was determined and the response to an occlusion test was evaluated. When evaluating the results of the occlusal test, the microcirculation reserve index (RM) was used, calculated as the ratio of the maximum post-occlusal microcirculation index (pmmax.) to the PMisx index. before occlusion. Tmax was also evaluated. – the time required to achieve PMMAX. Patients of both groups before treatment showed a significant decrease in the value of PM when measuring basal blood flow on the foot: 0.72 ± 0.24 pf. units – in the main group and 0.75 ± 0.62 pf. units – in the comparison group. The LDF-grams taken on the ischemic foot were monophasic and low-amplitude. A characteristic feature was the absence of a change in the PM value in response to an occlusive test. **Conclusions.** The effect of electromagnetic radiation by the Barva-Flex photonic matrix emitter significantly increases basal blood flow and increases the reserve capabilities of the microcirculatory bed.

Keywords Diabetic angiopathy of the lower extremities, Electromagnetic radiation, BarvaFlex

1. Introduction

The problem of the occurrence and treatment of purulent-necrotic complications in patients with diabetic foot syndrome (DFS) is far from being solved and, despite the successes of modern medicine, contains a large number of unresolved issues of both theoretical and practical nature. In the treatment of diabetic angiopathy of the lower extremities, the main attention is paid to the restoration of blood flow and insufficient attention is paid to the elimination of microcirculatory disorders [8,10,11,13]. The existing methods of conservative and physiotherapeutic methods of

treatment are often ineffective and are of an auxiliary nature. The state of nutritive blood flow and the dynamics of interstitial oxygen tension in conditions of critical ischemia have been poorly studied [2,9,12]. There are many unresolved questions about the role of a systemic inflammatory reaction and its effect on the course of ischemia of the limb [4,7,14]. There is practically no data on the effect on the microcirculatory bed of leukocyte-thrombocyte conglomerates formed in conditions of systemic inflammation, and existing works are fragmentary, contradictory and interpreted ambiguously [1,5]. The peculiarities of the local inflammatory reaction, as well as the course of wound infection in conditions of tissue ischemia, are insufficiently covered. To date, no clear algorithm has been developed for the treatment of purulent-necrotic complications in patients with diabetic angiopathy of the lower extremities [3,6]. Given the unresolved nature of these problems, the goals and objectives of

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studying the local influence of electromagnetic radiation on the course of the wound process are predetermined.

2. The Purpose of the Study

To increase the effectiveness of treatment of patients with diabetic angiopathy of the lower extremities by improving microcirculation in the periphery of the lower extremities.

3. Materials and Methods of Research

The paper analyzes the results of a comprehensive examination and treatment of 322 patients with diabetic foot syndrome (SDS) who were on inpatient treatment in the department of purulent surgery of the Bukhara Regional Multidisciplinary Medical Center in the period from 2017 to 2023. Among the patients, there was a predominance of 221 men (68.6%), 101 women (31.4%). The average age of the patients was 62.5 ± 13.2 years. The duration of diabetes mellitus was 15.13 ± 5.64 g.

E. Wagner's classification (1979) was used to determine the degree of lesion of the foot tissues. Patients underwent ultrasound Dopplerography and color duplex mapping of the vessels of the lower extremities, radiography of the foot. The state of carbohydrate metabolism was monitored in the laboratory. Wound healing was assessed according to laser Doppler flowmetry.

All patients were divided into two groups: the main group and the comparison group. The main group consisted of 137 (42.5%) patients, and the comparison group of 185 (57.4%) patients. Both groups were comparable in gender, age, and degree of trophic changes. Patients of both groups received traditional treatment: daily correction of glucose levels with constant laboratory monitoring, metabolic drugs (alpha-lipoic acid preparations, B vitamins), disaggregants, angiotropic drugs, dressings with adhesive dressings, antibacterial therapy was adjusted taking into account the isolated microflora and its sensitivity to antimicrobial drugs.

Patients of the main group, in addition to standard conservative therapy, were exposed to the popliteal pits by electromagnetic radiation with a photonic matrix emitter "Barvaflex" (Fig. 1). A patent for the invention was obtained for this method by the Intellectual Property Agency of the Republic of Uzbekistan (IAP 07441).

The problem is solved by the fact that in the method of treatment of diabetic angiopathy, which includes exposure to a magnetic field, exposure to a magnetic field includes electromagnetic radiation with a photonic matrix emitter "Barva-Flex" with 24 LED emitters, with wavelengths in the range of 600-570 nm, in pulsed mode (with a total pulse power of 120 watts per pulse), the effect is carried out in contact, on the area of the popliteal pits, the medial surface of the ankle joints, calf muscles, pain points in the foot area for 2-3 minutes per field, up to 20 minutes per procedure, for a course of 10-12 daily procedures. At the same time,

exposure to electromagnetic radiation with a photonic matrix emitter "Barvaflex" is carried out against the background of hypoglycemic therapy with the achievement of individual target values of glycosylated hemoglobin for each patient.



Figure 1. Korobov photonic matrix emitter "Barva-Flex/SIK"

Photonic matrices have a flexible base that allows the matrices to repeat the shape of the part of the human body to which they are applied. The Barva-Flex photonic matrices with 24 LED emitters are a plate 1 with two eyelets 2 and 3, which allow fixing the matrix on the patient's body using elastic straps. The matrix is made of hypoallergenic medical rubber and does not cause irritation of the skin. The power supply of light sources is carried out from the mains (220 V, 50 Hz) through an adapter 8, to which the matrix is connected using a cable 5 with a connector 6. The effect is electromagnetic radiation with wavelengths in the range of 600-570 nm on the area of the popliteal pits, medial surface of the ankle joints, calf muscles, pain points in the area of the feet 2-3 minutes per field. The procedure lasts 20 minutes. The course consists of 10 daily procedures. The method provides an improvement in blood circulation, a decrease in the severity of pain, swelling and discomfort, and changes in the color of the skin due to the use of magnetic laser exposure. Design features and technical characteristics of photonic-magnetic matrices Korobova A. - Korobova V. "Barva-Flex".

Structurally, photonic-magnetic matrices are made in the form of two independent matrices - photonic and magnetic, which allows them to be used both separately and together. A distinctive feature of photonic matrices is that they have a flexible base. This allows the matrices to repeat the shape of the part of the human body to which they are applied, which ensures the most efficient transmission of radiation from light sources without loss of reflection at the air-human skin boundary.

The basic version of the matrix, schematically shown in Figure 2, contains 24 light sources (laser or LED) arranged equidistant in 4 rows of 6 light sources in each row. In

special modifications, the light sources are arranged in three rows of eight in each row, or in two rows of 12 in each row.

The Barva-Flex photonic matrices are a plate (1) with two eyelets (2 and 3), which allow fixing the matrix on the patient's body using elastic straps.

The matrix is made of hypoallergenic medical rubber and does not cause irritation of the skin. The light sources are powered from the mains (220 V, 50 Hz) via an adapter (8), to which the matrix is connected using a cable 5 with connector 6.

If it is necessary to combine the effects of light and a constant magnetic field, a magnetic matrix 7 is installed on the photonic matrix. The magnetic matrix also has a flexible base made of hypoallergenic medical rubber. Annular permanent magnets are geometrically arranged in the same way as light sources in a photonic matrix. The inner diameter of the ring magnets has a size that allows you to install a magnetic matrix for food products of appropriate sizes that are put on the matrix. In case of contamination, the surface of the matrix can be treated with a washing powder solution and disinfected with 70% ethyl alcohol solution.

4. Results and Their Discussion

The study of indicators of local cutaneous blood flow was carried out using Doppler flowmetry, which was performed in 126 (91.9%) patients of the main group, and 165 (89.2%) patients of the comparison group. Flowmetry

was performed before and after treatment. At rest, basal blood flow (PMIs) was determined and the response to an occlusion test was evaluated. When evaluating the results of the occlusal test, the microcirculation reserve index (RM) was used, calculated as the ratio of the maximum post-occlusal microcirculation index (pmmax.) to the PMisx index. before occlusion. Tmax was also evaluated. – the time required to achieve PMMAX. Patients of both groups before treatment showed a significant decrease in the value of PM when measuring basal blood flow on the foot: 0.72 ± 0.24 pf. units – in the main group and 0.75 ± 0.62 pf. units – in the comparison group. The LDF-grams taken on the ischemic foot were monophasic and low-amplitude. A characteristic feature was the absence of a change in the PM value in response to an occlusive test. Decomposition of LDF-grams into their component harmonics using wavelet analysis showed the absence of amplitudes of microcirculatory rhythms. The occlusion test revealed a significant decrease in PM in both groups ($86.3 \pm 13.6\%$ – in the main group and $79.4 \pm 21.5\%$ – in the comparison group, with a norm of $246.7 \pm 28.3\%$), an elongation of Tmax.

Up to 182.6 ± 34.5 and 176.8 ± 27.3 s, respectively. The performed direct revascularization led to short-term venous hypertension, the phenomena of which significantly decreased in patients exposed to electromagnetic radiation by a photonic matrix emitter "Barvaflex". Analysis of LDF-grams after treatment indicated an improvement in tissue blood flow in patients of both groups, but its severity differed (Fig. 3).

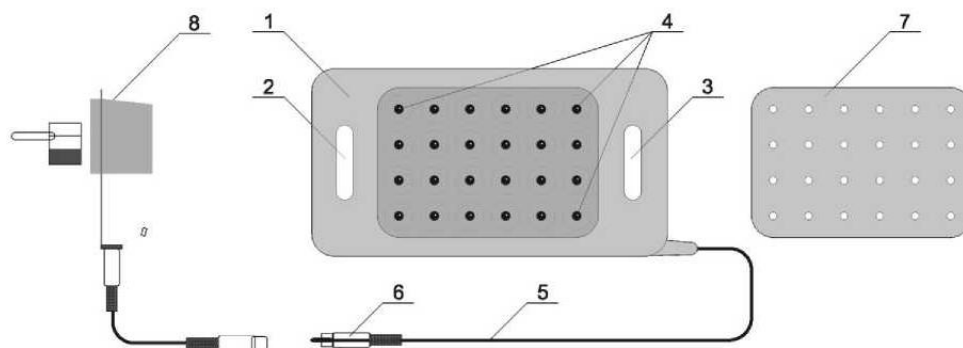


Figure 2. Scheme of photonic and magnetic matrices "Barva-Flex" (description in the text)

Table 1. The main functional parameters of microcirculation before and after treatment of patients of the studied groups

Indicators	Main group (n=126)		Comparison Group (n=165)		Monitoring of indicators
	Before treatment	After treatment	Before treatment	After treatment	
Basal blood flow (PMisx., pf. units)	0.72 ± 0.24	$1.84 \pm 0.67^*$	0.75 ± 0.62	1.24 ± 0.17	1.76 ± 0.32
Maximum post-occlusive blood flow (pmmax.)	7.5 ± 1.37	$34.8 \pm 0.27^*$	7.9 ± 0.47	15.4 ± 0.63	21.7 ± 0.92
Microcirculation reserve, %	86.3 ± 13.6	$257.8 \pm 72.1^*$	79.4 ± 21.5	141.7 ± 45.3	246.7 ± 28.3
Time to reach the maximum post-occlusive blood flow, sec	182.6 ± 34.5	$28.4 \pm 6.9^*$	176.8 ± 27.3	$86.4 \pm 31.7^*$	17.5 ± 5.2

Note: * ($p < 0.05$) - for the main group (after treatment)



Figure 3. Application of a patient with a neuroischemic form of SDS by electromagnetic radiation with a photonic matrix emitter "Barva-Flex"

Thus, in the main group there was an increase in basal blood flow (PMisc. was 1.84 ± 0.67 pf.units) with an increase in pmmax. up to 34.8 ± 0.27 pf. units (an increase of 78.5%), the time to achieve the maximum increase in blood flow decreased (Tmax. approached the level of 28.4 ± 6.3 s) and the microcirculation reserve increased (RM increased to $207.8 \pm 72.1\%$). Against the background of treatment by exposure to electromagnetic radiation with a photonic matrix emitter "Barvaflex", the appearance of amplitudes of active microcirculatory rhythms (endothelial, neurogenic and myogenic) and amplitudes of passive rhythms (respiratory and cardiac) was noted. These changes indicate a positive effect of electromagnetic radiation when applied topically. Patients in the comparison group showed less pronounced positive dynamics. Basal blood flow by the end of treatment was 1.24 ± 0.17 pf. units, Tmax. it decreased to 86.3 ± 31.7 s, and the growth of the microcirculation reserve was determined at the level of $141 \pm 45.3\%$. At the same time, the growth of PMMAX. it was marked up to 15.4 ± 0.63 pf. units, which amounted to 51.3%. Table 1 shows changes in microcirculation indicators. Data analysis showed that the increase in PMMAX. in the main group, it was 27.2% in relation to the comparison group, the indicators in which did not reach the norm values. The positive effect of electromagnetic radiation is confirmed by a decrease in the time to reach the maximum post-occlusive blood flow (PMMAX. in the main group, it was achieved

57.9 seconds faster than in the comparison group), and the increase in blood flow reserve was 66.2% ($p < 0.05$). The improvement in the functioning of the microcirculatory bed was accompanied by an increase in the intracranial oxygen tension against the background of a decrease in the intensity of systemic inflammation (Table 1).

The appearance of microcirculatory rhythms amplitudes in patients of the main group was especially pronounced in the spectrum of active rhythms. In patients of the comparison group, the amplitude of the neurogenic rhythm prevailed during occlusive hyperthermia. These changes are explained by the membrane-stabilizing effect of electromagnetic radiation, which reduces endothelial dysfunction, causing the restoration of sympathetic regulation of blood flow. The predominance of the neurogenic component in patients of the comparison group indicates a persistent increased discharge through microvessels with neurogenic regulation, a significant proportion of which is arteriovenular shunts.

Despite the therapy, there was practically no improvement in microcirculation in 12 (9.5%) patients of the main and 43 (26.1%) comparison groups. A sharp decrease in basal blood flow, the absence of an increase in tissue perfusion, depletion of the reserve capabilities of the microcirculatory bed persisted throughout the treatment and indicated a deep dysfunction of tissue blood flow. Eventually, all these patients underwent "high" limb amputation.

5. Conclusions

A method for the treatment of diabetic angiopathy, including physical impact on the affected area, physical impact is electromagnetic radiation by a photonic matrix emitter "Barva-Flex" with 24 LED emitters, with wavelengths in the range of 600-570 nm, in pulse mode (total pulse power of 120 watts per pulse), which is carried out in contact, on the area of popliteal pits, medial surface of the ankle joints, calf muscles, pain points in the foot area for 2-3 minutes per field, up to 20 minutes per procedure, for a course of 10-12 daily procedures. The effect of electromagnetic radiation by the Barva-Flex photonic matrix emitter significantly increases basal blood flow and increases the reserve capabilities of the microcirculatory bed.

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