LASER THERAPY OF PURULENT NECROTIC FOOT LESIONS IN PATIENTS WITH TYPE II DIABETES MELLITUS

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Treatment of purulent necrotic processes is an exacting problem in surgical diabetology. The number of patients with diabetes mellitus doubles every 10-15 years. The population of patients with diabetes mellitus and purulent necrotic diseases has increased twofold over the past five years. The rate of amputations in the presence of diabetic gangrene amounts to 55 percent and the mortality rate to 30 percent. According to the Russian Health Ministry, there have been 11,256 extremity amputations for diabetic gangrene in 1993 alone. In the U.S., 85 million dollars was spent on treatment of this patient population in 1992, with 45,000 dollars per patient. This makes the problem a great socio-medical challenge.

Despite progress in treatment of diabetes mellitus, there is no consensus on therapy of patients with diabetes complicated by purulent necrotic foot lesions.

What encouraging reported evidence is available at present concerns results of minor surgery aimed at preservation of supporting function of feet and use of different types of lasers in multimodality therapy. Carbohydrate, lipid and protein metabolic disorders in insulin-resistent type II diabetes mellitus depress oxidation processes, causing energy deficiency. The body's adaptive potential declines, and mobilization of humoral and cell-mediated immunity, anti-oxidant protection and detoxication processes are impaired.

By causing functional compromise of the antioxidant system, energy deficiency alters the lipid peroxidation/antioxidant system relationship, which presents as an increase in concentrations of lipid peroxidation products (Schiff bases, diene conjugates and lipofuscin). Enzyme-mediated antioxidant protection (superoxide dismutase, catalase, glutathione peroxidase) concurrently declines. Accumulation of lipid peroxidation products in blood results in hemostasis impairment and capillary circulation abnormalities. Mixed hypoxia intervenes, with generalization of free radical processes which cause multiple organic insufficiency.

Studies have shown that patients with diabetes mellitus complicated by purulent necrotic lower extremity lesions have dyslipidemia (hypercholesterolemia and hypertriglyceridemia) coexisting with phospholipid metabolic disorders (higher serum phosphatidyl choline and lower sphingomyelin levels). Erythrocyte membranes of patients have lower percent contents of phospholipids, higher ether cholesterol levels and twofold increased ether cholesterol/phospholipid (EC/PL) ratios. The higher EC/PL ratio makes membranes rigid and affects their function: transmembrane transport, enzymatic activity ad reception.

Microcirculatory disorders are a key pathogenetic factor in trophic abnormalities associated with diabetes mellitus.

Studies of lower extremity microcirculation in diabetic patients have shown that the onset of diabetic microangiopathy dramatically impairs microcirculation, especially in distal portions of legs. Severity of circulatory disorders directly correlates with the depth of purulent necrotic lesions of foot tissues. Therefore, structural and functional abnormalities of small vessels and Doppler microcirculation findings can provide important diagnostic clues to soft tissue trophic disorders and predictions of therapy efficacy.

We have surveyed our experience with purulent necrotic foot lesions in 154 patients with diabetes mellitus who were treated at the Moscow Regional Laser Center.

Microangioscopy of affected and intact foot skin areas, lesion surfaces and the thigh and shin skin was conducted in all patients. Microcirculatory findings and their score evaluation were entered on a special form for semiquantitative assessment of microcirculation in the affected and intact foot skin and after surgical treatment. A microcirculation index was computed after score evaluation.

Laser Doppler flowmetry was performed using a LAKK-01 circulation analyzer. Skin biophotometry used an UNIK-01 device for measurement of the laser radiation reflection coefficient (890 nm wavelength).

Low-intensive laser radiation (LILR) therapy used

(1) Pulsed laser therapeutic device UZOR (890 nm wavelength).

(2) Helium-neon lasers ALOK-1, ALOK-2 and ATOLL for continuous intravenous blood irradiation (633 nm wavelength).

High-energy carbon dioxide lasers Skalpel-1 and Skalpel-3 (10.6 nm wavelength) were used in surgical treatment of lesions.

Laser therapy of patients improved the lipid pattern in serum and in erythrocyte membranes. Free cholesterol and triglyceride levels decreased and cell membrane lipids returned to normal. Monitored kinetics of the cholesterol ester/free cholesterol ratios, which depict structural and functional membrane changes, showed a lower viscosity and rigidity of membranes and changes in their surface charges.

Lysophosphatidyl choline, phosphatidyl cholinase (PC) and phosphatidyl choline levels increased, phosphatidyl ethanolamoine level stabilized and the sphingolmyelase (SM) level decreased after treatment.

The membrane rigidity coefficient as the SM/PC ratio was 0.25. Serum saturation normalized (264,83 +- 17.78 units). These findings indicated a phospholipid change toward higher levels of "liquid" fractions and a higher serum antioxidant activity.

Examination of foot tissue microcirculation after infrared laser treatment showed a physiological capillary response to photoactivation. Brisker microcirculation was seen during laser treatment and hours after it. A course of infrared laser therapy of patients with diabetic lower extremity angiopathy produced stable activation of foot microcirculation. Preoperative and immediate postoperative infrared laser irradiation hastened normalization of foot microcirculation as compared with controls.

A pathophysiological rationale for noninvasive, "transcutaneous" LILR for correction of microcirculatory disorders is a target effect on capillary tone, return of vascular motility and improvement of the adaptive potential of the microcirculation system due to changes in its nutritive component.

Microcirculation activation after surgical treatment and infrared laser therapy was most prominent in distal extremities: 50 percent in the shin and 40 percent in toes. The asymmetry coefficient decreased at all levels, an important event, given that diabetes affects distal vessels.

Microcirculation was activated by combined use of intravenous laser irradiation of blood (ILIB) and surgical laser treatment of purulent necrotic foot lesions. This treatment resulted in a 38 percent decrease in the biomicroscopic microcirculation index, indicating restored permeability of the tissue-blood barrier, in a lower incidence of structural capillary abnormalities, alleviation of precapillary spasticity and an increase in the number of functional capillaries. Diameters of arterial capillaries increased, with a higher blood influx into the capillary bed. By contrast, diameters of transitional capillaries decreased and made 26 percent of pretreatment values. These structural changes ameliorated capillary congestion and improved capillary flow. Treatment increased the density of functional capillaries by an average 75 percent, a good predictor of stable improvement of tissue nutrition.

We used laser therapy in 90 patients. The rate of high amputations was 23.3 percent in 43 patients of the index group whose management included laser therapy. The amputation rate was 79.8 percent in a control group of 54 patients who received conventional treatment without laser irradiation. There were nine amputations in the patient group in which preoperative and postoperative infrared (IR) laser therapy was included in multimodality management, while only one patient was amputated in the group where therapy combined the IR laser, ILIB and the helium-neon laser (HNL). The rate of minor operations was 72.7 percent in the IR group, 90 percent in the IR plus ILIB group and 20.4 percent in the control group.

The survey indicates the obvious advantage of IR, ILIB and HNL combination in patients requiring minor surgery.

In summary, therapy results were excellent in 20 percent of index group patients (as compared to 1.5 percent in the control group), and good in 67.8 percent of the index and 14.1 percent of the control groups. Results were unsatisfactory in 2.2 percent of index and 17.2 percent of control patients.