Effect of Low-Intensity Luminescence on Reparative Processes in Skin Wounds in the Rat

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Low-intensity noncoherent luminescent radiation stimulates reparative processes in soft tissue wounds of rats. The stimulation is dependent on the frequency of light pulsation and the luminescence spectrum.

Key Words: *luminescent radiation; laser radiation; phototherapy, soft tissue wounds*

Special fiber-optic sources of luminescent light with a relatively broad spectral range (50-100 nm) have recently been developed [6]. In contrast to monochromatic laser radiation, these sources provide monochromatized radiation or, taking into account the mechanism of its creation and its specific features, luminescent monochromatized noncoherent radiation (LMNR) [7]. LMNR is not subject to the restrictions imposed on the premises and work regime of personnel operating laser phototherapeutic apparatus [8]. In light of the findings confirming the absence of a specific influence of lasers on biological objects [7,10], the replacement of laser light in phototherapeutic procedures [2-4,9] by noncoherent broad-band radiation seems expedient.

MATERIALS AND METHODS

The sources of low-intensity noncoherent radiation were based on two-layer optical fibers with a transparent shell of methylmethacrylate and butylmethacrylate copolymer with a polystyrene core containing the photoluminescent additives phenalemine-439 and phenalemine-160), and on optical fibers made from fluorine-substituted methylmethacrylate with a methylmethacrylate core with rhodamine 6g-chloride. These additives enabled us to obtain three different LMNR: red (600-680 nm, spectral maximum 635 nm), orange (600-680 nm, spectral maximum 605 nm), and green (500-580 nm, spectral maximum 540 nm).

Experiments were performed on rats of the same litter after a 10-day quarantine period during which the animals were kept in individual cages under the same conditions. Rats with signs of spontaneous pathology were not included in the study. Wounds were produced with a scalpel on the back (5-cm cuts limited by the fascia were made along the body axis) under local Novocain (0.25%) anesthesia. The wound was closed immediately with three silk sutures placed at a distance of 1 cm from each other. The operation field was pretreated with 5% iodine [1].

The reparative processes were controlled by determining scar firmness after complete epithelization by the method of wound tensiometry [2]. In addition, visual and histological studies of the scars were performed on days 3, 5, 7, and 10 of wound modeling.

The treatment sessions with LMNR were started the day after the operation. An optical polymer fiber 0.8 mm in diameter was used. The distance between the distal end of the fiber and the tissue was 1-2 mm; exposure time was 15 min. The power density was 20 mW/cm^2. The procedure was performed every day during a 5-day period. The animals were euthanized on days 5 and 7 by ether overdose. Tissue samples with scars

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were then taken. The results were analyzed using Student's t test ($p<0.05$).

RESULTS

It was found that scar firmness increases after treatment of a linear operation wound with LMNR. The increase is dependent on the frequency and spectrum of LMNR. Red LMNR in continuous and pulse regimes (2, 20, and 40 Hz) were used in 4 experimental series. After 5 sessions of irradiation the following values were obtained by the method of wound tensiometry: 1000±45, 1100±62, 1240±52, and 1570±47 g. In the control group (sham irradiation) this value was equal to 800±50 g. Each group consisted of 10 rats. The effect of the spectral composition was examined in 3 subsequent experimental series. Rats (10 in each group) were irradiated with red (group I), orange (group II), or green (group III) LMNR. Sham irradiation was used in the control group. The following values were obtained after tensiometry: 1600±50, 1200±50, and 900±50 g for the groups, respectively, and 800±50 g for the control group.

The effect of the duration of the procedure on the firmness of the postoperative scar was studied in 4 series. The first and second series were controls. In the first series animals were sacrificed on day 5 and in the second series on day 7 of the study. The rats of the 3rd series were treated with red LMNR at a pulse frequency of 40 Hz and were sacrificed on day 5; the experimental conditions were the same in the 4th series but the rats were sacrificed on day 7.

All the control rats developed a moderate posttraumatic inflammation on days 2 and 3 after the operation. Proliferation of cells, predominantly of fibroblasts, and vessels from the dermis and subcutaneous fat with subsequent formation of granulation tissue was observed on postoperative days 3 and 4. Transformation of thin argyrophilic fibers into fuchsinophilic collagen fibers started on day 5. By the 7th day the granulation tissue was converted into young connective tissue with scar formation. The simultaneous regeneration of the epidermis was characterized by mitoses and increased RNA and glycogen contents. Mature collagen fibers with a high glycogen content and well-structured epidermis were found in LMNR-treated rats as early as on day 5. It should be noted that LMNR had an effect mainly on the collagen fibers, accelerating their maturation.

Thus, we have demonstrated the possibility of stimulating reparative processes in soft tissue wounds with LMNR.

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