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Dynamics of Burn Wound Healing in Rats Irradiated by Nanosecond Microwave Pulses

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ABSTRACT

This paper reports on the dynamics of burn wound healing in lab rats irradiated by nanosecond microwave pulses (100 ns, 10 GHz) at a repetition frequency of 8 Hz and peak power densities of 140 W/cm^2 and 1500 W/cm^2, using a laboratory source based on a MI-505 magnetron. It was observed that during the first 14 days after standard burn infliction (metal rod of diameter 2 cm heated to 100^{0}C), followed by four sessions of local microwave irradiation (one session per day), the difference between the wound healing rates in the control and irradiated rats was insignificant. On the 19th day, the healing of burns in the irradiated rats revealed statistically significant acceleration of partial eschar separation observed by the 12th day, with complete epithelization by the 28th day. The efficacy of repetitive microwaves for burn healing was higher at 140 W/cm^2 than at 1500 W/cm^2. The data suggest that nanosecond repetitive pulsed microwaves can provide faster burn healing in rats.

Keywords: Wound healing; Skin regeneration; Nanosecond repetitive pulsed microwaves

Introduction

The problem of skin regeneration after burns, which is ranked high on the list of injuries by the World Health Organization, remains a frontier of biomedical sciences [1]. In addition to pain, wound inflammation is critical as a cause of unfavorable outcomes in burn surgery and therapy. According to some data [2], microwave radiation can decrease the intensity of inflammation through increasing the microcirculation in a lesion and the adjacent tissues. It is also supposed that direct activation of cells participating in wound healing (lymphocytes, fibroblasts, stem cells) [3] is possible via nanosecond repetitive pulsed microwave irradiation [4].

Methods

For the laboratory research, we used 30 mature female Wistar rats, each of weight 230–250 g, kept in standard vivarium conditions under natural light with free access to water and food. It was observed that during the first 14 days after standard burn infliction (metal rod of diameter 2 cm heated to 100 °C), followed by four sessions of local microwave irradiation (one session per day), the difference between the wound healing rates in the control and irradiated rats was insignificant. Throughout the experiment, all rats were kept in special cages, each occupied by two rats separated by a transparent wall to exclude their contact and mutual influence on the healing of the burn wounds. Within 5 h after the formation of burns, the test groups of lab rats were exposed daily (four days in total) to a single session of 4000 nanosecond microwave pulses at a repetition frequency of 8 Hz and a peak power density of 140 W/cm^2 and 1500 W/cm^2, respectively. The irradiation was local as the bodies of the rats, except for the burn regions, were each covered with a microwave absorbing material. The inflammation state of the burn region was assessed by blood testing (levels of hemoglobin, erythrocytes, platelets, leukocytes and their subpopulations) on a

PCE-90 vet analyzer (High Technology, USA), through anesthetized (CO_2) blood sampling from a gum into a clean dry Microvette vial (tri-potassium EDTA, Germany).

Results

In the group of rats irradiated at 1500 W/cm^2, the wound area during the first 14 days was about the same as in the control group. On the 19th day, the healing of burns in the irradiated rats revealed statistically significant acceleration of partial eschar separation observed by the 12th day, with complete epithelization by the 28th day. The efficacy of repetitive microwaves for burn healing was higher at 140 W/cm^2 than at 1500 W/cm^2. According to our hematological analysis, the number of blood corpuscles in the control and irradiated rats throughout the experiment did not show any statistically significant changes with respect to the physiological standard. At the same time, a clear tendency for growth was observed in the number of granulocytes, which can stimulate skin regeneration in burn regions through infection protection, blood flow support, and tissue nutrition.

Discussion

The experimental data obtained can be extrapolated with a high accuracy to human burns. It is highly probable that nanosecond microwave pulses will provide shorter times of successful burn wound healing in humans without any traumatic scarring. Such simple noninvasive treatment with repetitive pulsed microwaves will induce neither pain sensation nor adverse aftereffects, as its intensity is low and safe to humans. The observed acceleration of burn wound healing is a new promising result for the potential use of microwaves in cosmetology and therapeutic practice.

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