CALCULATION OF 1-D DISTRIBUTION OF THERMAL DAMAGES IN TISSUE DURING SURFACE CYCLIC IRRADIATION BY POWERFUL LIGHT SOURCE

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Introduction

Thermotherapy of surface lesions using long continuous irradiation can result in thermal damage of underlaying intact tissue. Use of short heating with the subsequent cooling is advisable in these cases.

Materials and methods

We have developed the calculation program for kinetics of 1-D distribution of thermal necrosis in tissue during surface cyclic irradiation by powerful light source at following assumptions. The irradiation zone sizes are much more than depth of damage. Tissue is homogenous. In this case the photons concentration, N, in tissue is described by equation (1);

$$N = N_0 \exp(-x), \tag{1}$$

where N_0 - surface photons concentration, $x = \beta z$, β- effective absorption parameter, z –depth. Temperature distribution is described by the equation of heat conductivity. Following boundary conditions were used: 1) heat exchange on a surface is absent or 2) surface temperature is maintained as constant (for example, using intensive air-blowing). Rate, W, of accumulation of the thermal damages resulting in further to cells death is described by Arrhenius equation (2) at temperature higher than 42^0C:

$$W = A \exp(-E/kT), \tag{2}$$

where k – Boltzmann constant, T - absolute temperature. Parameters A and E were determined from experimental data on thermal necrosis of mice tail skin in temperature range 42-46^0C [1].

Results and discussion

Some examples of 1-D distributions of the share of killed cells in tissue every 2 min during 4 cycles (2 min - irradiation is "on", 8 min - irradiation is "off") are shown in Fig.1.

a c b

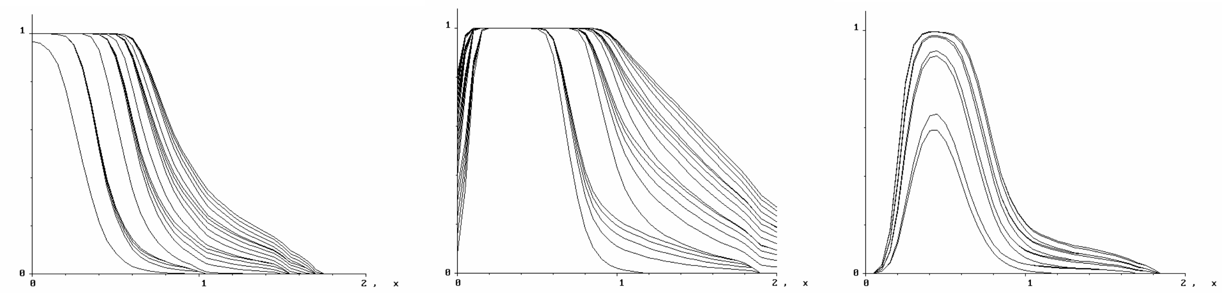

Fig.1. Distribution of the share of killed cells in tissue. a - heat exchange on surface is absent, P = 0.5 W/cm^2; b – Ts = Tb, P = 1 W/cm^2; c - Ts = Tb + 9^0C, P = 1 W/cm^2 (P – irradiation power density, Ts – surface temperature, Tb – body temperature).

The obtained results allow to conclude nonstationary irradiation techniques enable protecting underlaying intact tissue better than stationary irradiation. It is clear, surface tissue protecting can be provided using air-blowing if necessary.

References

1. S.P. Yarmonenko, A.G. Konoplyannikov, A.A. Vainson. Clinical Radiobiology (in Russian), Moscow, “Medicine”, 1992.