Радіобіологічне товариство України
Інститут клітинної біології та генетичної інженерії НАН України
Національний університет біоресурсів і природокористування України

VI З'ЇЗД
РАДІОБІОЛОГІЧНОГО ТОВАРИСТВА УКРАЇНИ

Київ, 5-9 жовтня 2015 року

ТЕЗИ ДОПОВІДЕЙ

Київ 2015

MATHEMATICAL MODELING OF OXYGEN DISTRIBUTION IN MALIGNANT TUMORS

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Radiation therapy is a widespread way of treating cancer diseases. Tumors of different shapes, in particular, vary in the degree of convergence or divergence of oxygen diffusion flows in them. Following simple geometric considerations, it becomes obvious that the highest convergence degree of oxygen diffusion flows is characteristic of spherical tumors with oxygen coming from the surface, while the highest divergence degree is typical of cylindrical tumors surrounding a blood vessel coaxial with the tumor and supplying it with oxygen (a cylindrical tumor with internal oxygenation is hereinafter referred to as CI). In case of a flat-layer tumor, oxygen diffusion flows are parallel to each other. Based on general considerations, it is evident that the more convergent oxygen diffusion flows in the tumor, the thicker both the normoxic and the hypoxic tumor layers, and, as a consequence, the larger maximum dimensions of the specified tumor types. Taking into consideration that the spherical tumor and the cylindrical CI tumor, dealt with in the paper, are extreme cases in terms of convergence or divergence of oxygen diffusion flows, we think it reasonable to cite the values of abovementioned dimensions for two other simple-geometry tumors: flat-layer tumor and CE cylindrical tumor (with oxygen coming from the outer surface of the tumor). Suppose R_s, R_{ce}, X and R_{ci} are the abovementioned maximum dimensions (radii for the sphere and cylinders) of tumors of the following shapes: spherical, CE cylindrical, flat-layer and CI cylindrical respectively. It is worth mentioning that, in case of CI, the value of ρ, blood vessel radius, is required for the estimation of the specified parameters. We will take it equal to $4 \cdot 10^{-3}$ mm for our estimates.

Estimates were performed for two oxygen tension values of 3.32 kPa and 1.99 kPa, corresponding to oxygen concentration values c_0 : c_{01} = 25 mm Hg and c_{02} = 15 mm Hg respectively. Calculating the ratios of these dimensions (R_s/R_{ce}, R_{ce}/X, X/R_{ci}) for c_{01} concentration we obtain a value not exceeding 1.44 mm for fully normoxic tumors and not exceeding 1.33 mm for tumors with both normoxic and hypoxic regions but without a necrotic zone. These ratios do not exceed 1.73 mm and 1.27 mm respectively for c_{02} concentration.