Iranian Journal of Physics Research, Vol. 23, No. 1, 2023
DOI: 10.47176/ijpr.23.1.11603

The effect of laser beam profile on brain cancer treatment through photothermal therapy

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(Received 17 November 2022 ; in final form 18 February 2022)

Abstract

Brain cancer has the lowest survival percentage among different cancers and it has caused the death of people under 40 more than others. Therefore, in this paper, the treatment of brain cancer with non-invasive photothermal therapy is investigated and the effect of various treatment factors including laser power full .width at half maximum (FWHM) of the laser beam profile on the success of the treatment is evaluated The simulations are performed by solving the three-dimensional Pennes bioheat transfer equation, Beer–Lambert law, and by considering the presence of gold nanorods, the Gaussian laser profile, as well as the initial and boundary conditions with the finite element method (FEM). The results of the investigations demonstrate that the laser power and radius of the laser spot are two important quantities in the success of the treatment. These two quantities affect the dose of thermal energy received by the cancerous tissue and control the temperature and fraction of tumour and tissue damage in different positions. Also, smaller and larger radii of laser spot than 1.1R (R is the radius of the brain tumour) lead to more and less temperature differences, respectively, in different parts of the tumour. However, the highest temperature and temperature rate can be obtained at the upper center point of the cancerous tissue in all treatment conditions. In addition, increasing the laser power from 0.5 to 1 W causes an increase in the temperature in different points of the tumour and irreversible destruction continues even after turning off the laser due to the tumor temperature in a different position beeing higher than 42 °C, as well as heat transfer due to conduction and convection.

Keywords: brain cancer, laser therapy, metal nanostructures, non-invasive treatment, photothermal therapy (PTT).

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