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The Thermo-optical Treatment of Cancer by Laser Light with Ag Nanoparticles

HasanTuhmaz H.
College of medicine
University of Thi-Qar
Thi-Qar, Iraq
hassantuhmaz@yahoo.com

***Abstract*— In this paper, the photo thermal treatment of cancer with Ag nano- particles is studied. The PTT for tissue under the effect of heat by laser source with injection of silver nano- particles on the affected area. Bio-heat equation is solved by the numerical simulation methods. Results are summarized in the effect on the increasing of temperature at different time durations. These results are looked that the depth penetration of laser that lead to increasing heat raising during the increasing the time duration of exposure. Then, it estimated the peak value of depth on limited temperature.**

Keywords:cancer, Phototherapy, nanotechnology.

I. INTRODUCTION

By the improvement of computational technology, mathematical modeling of temperature delivery in human tissue is convert prevalent. Acceptable to adopt the bio-heat equation to investigate temperature distribution, numerous mathematical models are being used. Although several analytical and numerical methods have been developed in the literature, finite difference methods used (Liu *et al.*, 2008). An important factor of nanoparticles is that the properties of the materials that make up these nanoparticles change when reduced to the nanoscale. This includes quantum confinement in semiconductor nanoparticles, super Para magnetism in magnetic nanoparticles, and surface plasmon resonance in noble metal nanoparticles. These nanoparticles can act as carriers for these drugs because it is possible biofunctionalized drugs to the particle or encapsulate them within the particle. Additionally, it is possible to target certain biomarkers by conjugating antibodies and other targeting particles such as peptides onto the surface of these nanoparticles (Bernardi *et al.*, 2008; Lowery *et al.*, 2004).The temperature delivery during laser behavior is expected with a newly advanced human skin model. The finite difference method is applied for modeling of numerical simulations to analyze the temperature changes in human skin. The objective of this research is modeling the laser {tissue interaction to optimize the effective parameters in order to understand optimal laser dosage to prevent damage (Liu *et al.*, 2008; El-Sayed *et al.*, 2006).

The medical treatment applications for cancer, laser light sources used to produce the photo-thermal effects in tissue. In this treatment, the most important topic is to control the temperature increase and pathology (Huang *et al.*, 2007; Stern *et al.*, 2007). The thermal response of the tissue that is exposed to laser light mainly depends on the photo-thermal properties of both the tissue and the light source, such as exposure time, beam wavelength, frequency of the beam, and the area and type of tissue exposed to the beam. In medical behavior applications with light, expectation of the thermal response of tissue can be understood by utilizing simulation tools such that choice oflaser light dosage and exposure duration on the subject tissue can be done appropriately (Lowery *et al.*, 2004).

II.MATERAIL AND METHODS

Biological tissues with Temperature delivery can be analyzed via definite mathematical models, one of the most common of which is the Pennes bio-heat equation (Bernardi *et al.*, 2008). The reason why the Pennes bio-heat equation is still widely in use, despite many alternative enhanced models in the literature, lies behind its easiness and accuracy providing in numerical study.The damage severity be influenced by on few factors, as well as exposure time, wavelength of the beam, energy of the beam and the area and type of tissue showing to the beam.The modeling of the physical interaction of light with biological tissue was tried in some recent research. The objective consists mainly of two concerns: the optical spread of light, and it is thermal distribution in biological tissue. Simulations of biological tissue with the Pennes equation are rather good for micro-vessels; although, in the situation of large vessels, a more complex technique is needed.

To create are presentative instance, the mathematical exhibiting is practical to irradiation of the liver. the relationship, known as the Lambert law. For incident intensity I_0, the transmitted intensity Ion a distance l will be:

$$I = I_0 \ e^{-\alpha_a l} \quad (1)$$

The absorption coefficient α_a can thus be understood as the probability that a photon will be absorbed by the medium per unit length ($\alpha_a = \alpha_{am} + \alpha_{an}$) where α_{am} and α_{an} are the absorption of the human tissue and

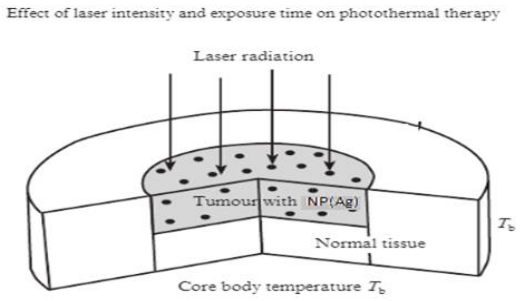
nanoparticles, correspondingly. .
The reciprocal of the absorption coefficient, known as the absorption length, is the distance necessary for the intensity of the beam to drop to e^{-1} of the primary intensity.
The absorption of light laser is obtained agreeing to the relation:

$$Q_{laser} = \frac{\partial I}{\partial x} \qquad (2)$$

The Pennes equation is solved initially for layer of human liver model which temperature distribution can be predicted using different diode laser light radiation burns at steady state. Furthermore, a multilayer model is used to investigate the effects of the energy of the beam and exposure duration.

2.1. Bio-heat equation

Light absorbed by the tissue results in local temperature increase. The bio-heat equation describes the tissue heat transfer due to the deposited laser light taking into account conduction, convection by blood, and possible at sources (Q). This mechanism can be seen as figure (1):



III. RESULTS AND DISCUSSION

Fig.1.Geometry of the interaction model of laser beam with tumor tissues.

The bio-heat transfer equation was introduced by Pennes in 1948 to model heat transfer in perfused tissue such that:

$$\delta_{ts}\rho C\frac{\delta T}{\delta t} + \nabla\cdot(-k\nabla T) = \rho_b C_b \omega_b (T_b - T) + Q_{met} + Q_{laser}, \qquad (2)$$

where:

ρ = density of tissue (kg cm^{-3}),

C = specific heat of tissue (J kg^{-1} °C^{-1}),

T = temperature (°C),

k = thermal conductivity of tissue (W cm^{-1} °C^{-1}),

C_b = specific heat of blood (J kg^{-1} °C^{-1}),

w_b = volumetric perfusion rate (kg s^{-1} cm^{-3}),

T_b = temperature of arterial blood (°C).

Tumor cancer cells were found to be thermally sensitive due to their reduced heat tolerance because of the poor blood supply. Even with sustained angiogenesis the vasculature in cancerous tumors is very irregular. Thus, one technique being explored for cancer therapy is a hyperthermia-based procedure, thermal therapy, in which diseased tissue is heated to high temperatures in the hyperthermia regime (ranging from 42-47° C) which results in cell death. Another class of nano vector is known as nanoparticles, which are synthesized particles with a diameter within the nanometer range. Nanoparticles have been composed of many different materials including titanium dioxide, iron oxide (magnetically excited), gold, silver (noble metals–optically excited), and cadmium selenide (semiconductor nanoparticles). Nevertheless, studies on thermo-optical modeling use either the FEM or a simple, explicit one-step FDTD method. Convergence is achieved in the simple, explicit one-step FDTD method via limited time and spatial step ranges. However, the need to use very small steps for reaching a solution makes the computational simulation time rise drastically. Moreover, numerical predictions near the boundaries of the spatial numerical grid can be invalid due to the boundaries when the continuity condition is imposed.

TABLE 1. Thermal properties for biological tissue

Materal prpoerties	Units	Symbol	Liver
Density	Kg/m^3	p	1060
Thermal Conductivity	W/mK	k	0.51
Specific heat Capacity	J/kg	c	3639

These results are appeared as:
Figure(1) is shown to the Scheme variation of the depth with temperature under duration time (2 minutes), Color map for variation of the depth with temperature under duration time (1 minutes) as shown in figure (2) and The cumulative effect of duration time increasing on two variables (heat depth and temperature)see figure (3).

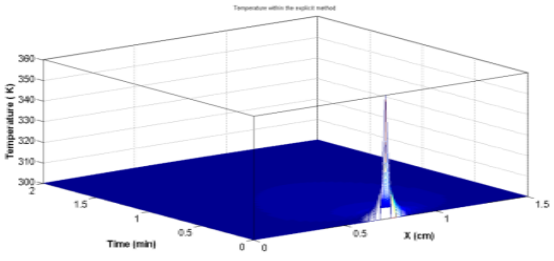


Fig.2.Scheme variation of the depth with temperature under duration time (2 minutes)

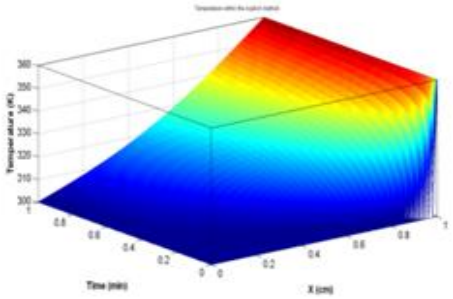


Fig.3.Color map for variation of the depth with tempareture

under duration time (1 minutes)

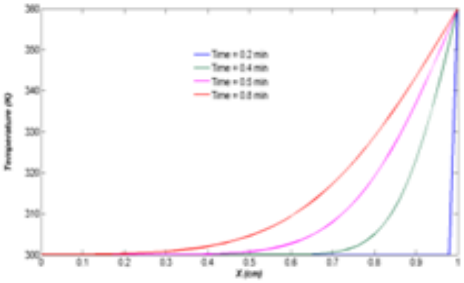


Fig. (4): The effect of duration timeincreasing on two variables

(heat depth and temperature)

IV . CONCLUSIONS

The results appeared that the effect of temperature increasing is procured the increasing in depth penetration with the limit time duration of exposure. The limiting of temperature was estimated in the value (360K) for keeping the other tissue cells. The time duration was tested with (2 min). We conclude the treatment of the tumor in these processes successes with using the nanoparticles.

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