Monte Carlo simulation of a beam for photodynamic therapy applications

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ABSTRACT

Photodynamic therapy (PDT) consists of administration of a photosensitizing agent following by irradiation on the target volume with wavelength beam to able to activate the photosensitizer. The aim of the present work is to investigate the use of monochromatic, low-energy beams for photodynamic therapy applications. Monte Carlo simulations are performed for distinct target volumes irradiated by a non-laser light source (low-energy x-rays). Models of soft tissue, neoplastic cells, and a mixture of the later with photoactive drugs, are considered. For each case, the energy fluence distribution at a given depth is calculated. To conclude,the obtained results are compared and discussed.

Keywords: Photodynamic therapy, Non-laser, Monte Carlo, PENELOPE

1. INTRODUCTION

PDT is a therapeutic modality recommended for treating tumor cells (Felsher, 2003). In this work, our goal is to conduct an investigation of the use a low-energy X-ray light source for PDT.

2. MATERIALS AND METHODS

PENELOPE code (Salvat, 2015; Sempau et al., 1997) were used to simulate a light source of 50eV. The phantom is a cylinder (17 cm diameter and a 22 cm length). The simulates phantom were filled with three specific materials, modelled in PENELOPE. First, the phantom is filled with soft, normal tissue. Second, it is filled with a material representing neoplastic cells (Brualla et al., 2014). Finally, the phantom is filled with a mixture of aminolevulinic 5-acid (ALA), which is a photosensitizing agent (Wachowska et al., 2011) , and neoplastic cells material.

3. RESULTS

A difference of ~ 8% is found when comparing the average energy fluence of neoplastic cells and soft tissue. Although appreciable, such value becomes small if compared to the average difference of ~ 20% between the tumor and the mixture of ALA and neoplastic cells.

4. DISCUSSION AND CONCLUSION

The increase of ~20% in the energy fluence distribution when mixing ALA to neoplastic cells suggests that a low energy x-ray light source could work for PDT. Moreover, by optimizing the chosen parameters, it could be possible to obtain even higher values for the energy fluence distribution of the tumor and ALA mix. However, more simulations with a broader range of parameters, non-laser light sources (Wang et al., 2011; Valentine et al., 2012;), and other photosensitizers should be performed. Also, it would be interesting to investigate how the addition of nanoparticles (Hong et al., 2016) would affect the obtained results. Finally, comparison of simulation results and experimental data would allow one to verify the reliability of the adopted models for the evaluated materials, and the obtained results.

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