A Paris System-Based Implant Approach to Hyperthermia Cancer Tumor with Gold Seeds and Ultrasound

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C. Austerlitz[1], Andre L. S. Barros[2], I. Gkigkitzis[3] I. Haranas[4], Diana Campos[5], Dengsong Zhu[1]

[1]Southern Illinois University, USA, [2]Federal University of Pernambuco, BR, [3]East Carolina University, USA, [4]Wilfrid Laurier University, Waterloo, Canada, [5]Clínica Diana Campos, Recife, BR.

BACKGROUND

A new methodology to treat cancer tumor with gold seed and ultrasound has been proposed in the scientific literature. In vivo and in vitro experiments as well as computational code have been performed and developed to test the feasibility and have provided subsidies to such methodology [1-4]

All the above-mentioned experiments and modeling were based on the use of a single gold rod 1-cm height and 0.1-cm diameter. From both simulations and measurements it were predicted that such a single gold rod would be enough to hyperthermia tissue up to about 0.5 cm radial distance from the gold rod. However, to do so, the rod's temperature should reach ablation temperature and requires long ultrasound exposure. Since the bio-heat propagation in tissue depends on the seed dimension and hyperthermia treatment on the tissue's temperature and exposure length, the treatment length may be minimized by improving the homogeneity of the bio-heat distribution inside the tissue to be treated. To date, there is no found in the scientific literature about the bio-heat propagation in tissue due to several implanted gold seeds exposed to ultrasound.

This work has had the objective to test the feasibility of a Paris system-based implant [5] for a uniform distribution of heat from implanted gold rods in tissue irradiated with ultrasound.

Keywords: Ultrasound; Gold rods; Paris system, Implant, Hyperthermia; Cancer; BALB/c mice; bio-heat transfer; tissue; temperature

MATERIAL AND METHODS

Experiments with single-plane implants using parallel equidistant 1.018 ± 0.015 cm height and 0.136 ± 0.001 cm diameter 24-K gold rods) arranged in triangular and square shapes were performed in Mus Musculus white mice (medial dorsal region). The mice were anesthetized and gold rods were implanted by means of a trocar needle and the implanted region was insonated with a 4-cm diameter transducer oscillating with a nominal frequency of 1 MHz and power of about 75 W. Intramuscular tissue temperature measurements were taken using implantable needle type thermocouples affixed to a portable Fluke thermometer. Superficial tissue temperature profile was also measured with a FLIR infrared camera and thermographic analysis were performed using the ImageJ computer software. In both cases, the central implant planes have been assigned to that approximately bisects all the implanted rods.

RESULTS

Measured with the needle type thermistor, for the triangular implant, the percentage deviation between the maximum and minimum temperature within the triangular plane was 5%. For a square shape, this percentage deviation was 6%. The thermographic analysis have shown a deviation of 3% and 5% for the triangular and square shapes, respectively.

Fig. 1. Gold seeds implanted in a triangular shape in a BALB/c mice

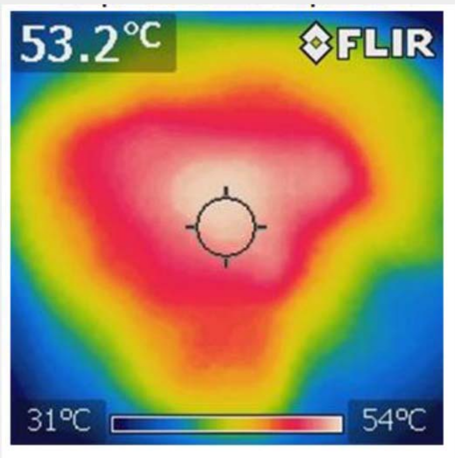

Fig. 2. Infrared pictures of the triangular and square pattern after 30 min exposure.

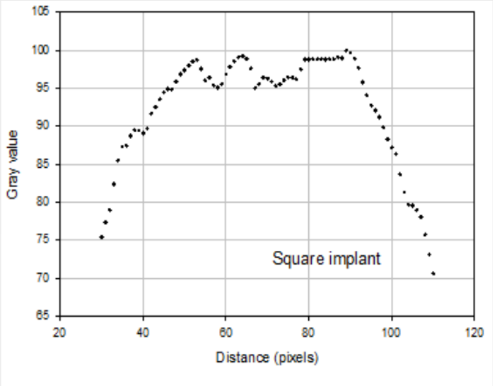

Fig. 3. Temperature profile of a line running through the location of the triangular central plane.

CONCLUSIONS

Based on the temperature measurements with needle type thermistor and thermographic analysis, the Paris system-based implant approach for gold rods implanted in tissue and exposed to ultrasound may greatly improve the bio-heat propagation and sustain a constant temperature profile inside triangular and square patterns formed by gold rods implants. Additionally, the Paris system may minimize ablations areas and treatment length in hyperthermia if used in cancer tumor treatment

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