

MICROWAVE ABLATION VERSUS PLASMONIC NANOPARTICLE-MEDIATED PHOTOTHERMAL THERAPY FOR TREATMENT OF LIVER TUMORS

Mir Hadi Razeghi K [1], Abdul Kareem Parchur [1], Jaidip M. Jagtap [1], Gayatri Sharma [1], Venkateswara Rao Gogineni [2], Sarah Beth White [2], Amit Joshi [1,2]

[1] Department of Biomedical Engineering, Medical College of Wisconsin, Milwaukee, WI

[2] Department of Radiology, Medical College of Wisconsin, Milwaukee, WI

ABSTRACT

Microwave Ablation is an established clinical modality for ablation of liver tumors. Electromagnetic waves are delivered via a percutaneously placed antenna in the tumor. Commercial microwave probes can heat up the tissue to far more than hyperthermia region, however the thermal contours are not controllable and thus therapy outcome depends critically on the skill of radiologist placing the probe. Microwave ablation can cause irreversible damage to healthy surrounding tissue. Here, we contrast and computationally compare microwave ablation with low power near-infrared (NIR) laser ablation mediated with NIR resonant and tumor trapping gold nanoparticles and demonstrate that laser-nanoparticle ablation can maintain enough temperature for ablation, while restricting the ablation envelope to tumors and spare normal tissue.

Keywords: Microwave Ablation, Photothermal Therapy, Plasmonic Nanoparticles, Gold Nanorod, Near-Infrared Resonant.

INTRODUCTION

Localized thermal ablation therapy such as microwave (MW) is widely used to treat cancer cells [1-3]. In MW ablation, an electromagnetic antenna is used to deliver electromagnetic fields to surrounding tissue. The oscillation of polar species like water molecules in tissue, due to electromagnetic fields, produces frictional heat and increases the local temperature. Microwave ablation has many advantages, among them is a relatively large heating zone, that is less affected by tissue properties compared to other methods such as radiofrequency ablation (RFA).

Most conventional MW antennas operate at 2.45 and 0.915 GHz [3,4]. In a 2.45 GHz antenna, the ablation zone is relatively small. Therefore, it is more suitable for smaller tumors. Theoretically, a 0.915 GHz MW antenna has deeper heating, but the energy deposition is relatively low [4]. The energy dose to tumor can be compensated with higher generator power at the cost of increased off-target tissue damage compared to high frequency MW antennas [5]. Several studies have evaluated the effects of MW device and heating parameters and local tissue reactions and the quality and shape of ablation zone, however control on tumor ablation zone while avoiding collateral damage is challenging [6]. Conventional ablation methods do not discriminate between tumors and normal tissue. Thus, outcomes critically depend on operator skill in placing the ablative probe; and, conflicting efficacy results have been reported in the literature [6,7]. Alternative Chemo or radio-embolization therapy is also limited by dose-limiting toxicity, difficulty in site-selective delivery, and size and location of the tumor. There is a pressing need for novel and tumor-selective interventional radiology (IR)-guided liver cancer therapies to improve the dismal long-term survival and quality of life of liver tumor patients.

Near-infrared (NIR) resonant gold nanoparticles (Au-NPs) are very promising for low power laser ablation therapy of cancer by preferentially absorbing deep penetrating NIR light and convert it to thermal therapy source [7]. NIR plasmonic therapy is based on the geometry and composition dependent tunable surface plasmon resonance and absorption cross-section enhancement of Au-NPs. Au-NPs can be designed to selectively accumulate in tumors following systemic delivery thus confining the thermal therapy sources within tumors and avoiding collateral damage, as very low

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