Designed and Experimental Validation of a Sleeved Antenna for Microwave Ablation

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Microwave ablation technique has been reported to be a promising option in the treatment of liver diseases. It exhibits ability to heat tissue to a higher temperature, heat large tumor volume with less dependent on thermal conduction and less susceptibility to heat sinks without the need of a grounding pad when compared with radiofrequency ablation. Microwave antenna plays important roles in electromagnetic energy delivery during ablation of tissues. Monopole, triaxial, single slot, dual slot and helical antennas have been proposed for the efficient delivery of microwave power into biological tissues. Antenna geometries such as slot size, slot position, slot number and abutted end have been found to affect microwave distributions in the ablated tissue. Detrimental backward heating and small tumor ablation size are the shortcomings attributed to most of these antennas. Microwave ablation a form of thermal therapy has been mostly focused on the treatment of liver diseases with paucity of information on its application to other tissues. The aim of this study is to develop a suitable antenna for microwave ablation of different tissues in the field of tumor management. COMSOL Multiphysics version 4.4 (Stockholm, Sweden), which is based on finite element methods (FEM), was used to design and simulate monopole and dual slot with sleeve antennas. Power, specific absorption rate (SAR), temperature and necrosis distributions in the selected tissues were determined using these antennas. Monopole and dual slot with sleeve antennas were designed, simulated, constructed and applied in this study based on a semi-rigid coaxial cable. Ex vivo experiments were performed on liver, lung, muscle and heart of bovine obtained from a public animal slaughter house. The microwave energy was delivered using a 2.45 GHz solid-state microwave generator at 40 W for 3, 5 and 10 min. Aspect ratio, ablation length and ablation diameter were also determined on ablated tissues and compared with simulated results. The dual slot antenna with sleeve produces localised microwave energy better than the monopole antenna in all ablated tissues using simulation and experimental validation methods. There were significant differences in ablation diameter and aspect ratio between the sleeve antenna and monopole antenna. Additionally, there were no significant differences between the simulation and experimental results. This study demonstrated that the dual slot antenna with sleeve produced larger ablation zones and higher sphericity index in ex vivo bovine tissues with minimal backward heating when compared with the monopole antenna.