

Hepatic Microwave Ablation with Multiple Antennae Results in Synergistically Larger Zones of Coagulation Necrosis.

Purpose: Microwave ablation (MWA) is a promising technology for local therapy of surgically unresectable liver tumors. As opposed to radiofrequency ablation (RFA) devices, which are constrained by the Faraday effect, more than one microwave probe may be used at a time. We hypothesized that multiple probe MWA would create synergistically large zones of coagulation necrosis due to shielding of the lesion center from blood-flow mediated cooling.

Methods: A total of 18 microwave lesions were created in the livers of 8 domestic swine, using a prototype 13 gauge microwave antennae (Vivant Medical, Mountain View, CA). Ablations were generated with either a single probe (n= 5) or in a multiple probe configuration (n= 13). All ablations were generated at 40W and lasted 10 minutes. Multiple probe ablations were conducted with three microwave antennae in a triangular array, with the distance between antennae varied from 0.5 to 3.0 cm. After immediate sacrifice, livers were perfused with formalin by the portal vein. Specimens were sectioned at 3mm intervals and a standard computer scanner was used to digitize each section at 600dpi. Lesion dimensions and volumes were then calculated using ImageJ software (NIMH, Bethesda, MD). Multiple-probe lesions were also assigned a shape score from 1 (discontinuous) to 5 (round) based on the percent deflection from a circle at the section with the greatest ablation diameter.

Results: Single antenna microwave ablation resulted in lesions with a diameter and volume of $2.2\pm 0.7\text{cm}$ and $7.4\pm 5.4\text{cm}^3$ respectively. Multiple probe ablation generated lesions with a diameter of $4.4\pm 0.8\text{cm}$ and mean volume of $42.2\pm 17.4\text{cm}^3$ (single vs. multiple probe ablations ANOVA $p<0.001$ for diameter and $p<0.003$ for volume). Among the multiple probe ablations, lesion shape but not size was significantly correlated with the distance between antennae (Spearman correlation coefficient for shape $r=-0.74$, $p<0.004$ and for volume $r=0.23$, $p=0.43$). Lesions created with probe separation of 1.7 cm or less were generally round and confluent, while clefts were present at greater than 1.7 cm of distance between probes ($p<0.001$, unpaired t-test).

Conclusions: MWA has several theoretical advantages over currently available radiofrequency devices. Unlike RFA, MWA is not limited to 100°C by the rise in electrical impedance associated with tissue charring. Also, MWA has a larger zone of active heating compared to RF (2cm vs. 1-2mm, respectively). Most promising, microwave ablation can be performed using multiple simultaneous probes, resulting in synergistically large zones of necrosis. In this in vivo animal model, 3-probe MWA lesions were 6 times greater in volume than single-probe lesions. Multiple probe ablation should reduce the need for repeat treatments, decrease inadequate treatment of large tumors, and increase the speed of treatment, thereby decreasing the complication rate.