ABLATION DYNAMICS OF Subsequent Thermal Doses Delivered to Previously Heat-Damaged Tissue During Magnetic Resonance-Guided Laser Induced Thermal Therapy

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INTRODUCTION

• Magnetic resonance-guided laser-induced thermal therapy is a minimally invasive surgical technique used to treat a number of intracranial pathologies. Most treatment sessions require delivery of multiple thermal doses in a single session.

• Objective: to determine the differences in ablation dynamics between naïve tissue vs. damaged tissue.
METHODS

- Examined 160 ablations from 60 patients across various surgical indications
- Laser power was kept constant within each case
- Ablation rate determined by dividing final ablation area ($TDE_{\text{max}}$) by ablation duration ($t_{\text{max}}$)
- Data analyzed using repeated measures analysis:
  - 34 cases required 2 thermal doses
  - 15 cases required 3 thermal doses
  - 11 cases required 4 or more thermal doses
- Within each case, compared differences between:
  - Ablation rate
  - Ablation duration
  - $TDE_{\text{max}}$ (ablation area)
- Also considered degree of overlap and effect on change in ablation rate
RESULTS

**Top Panel** - Ablation rates of cases requiring 2, 3, and 4 ablations, with SEM (vertical lines) following GLM RM analysis.
- Significant decline in ablation rate in successive ablations regardless of number of ablations.

**Middle Panel** - The duration required to reach $TDE_{\text{max}}$ in cases requiring 2, 3, and 4 ablations, with SEM (vertical lines) following GLM RM analysis.
- No significant changes in ablation duration across each analysis series

**Bottom Panel** - Ablation area of cases requiring 2, 3, and 4 ablations with SEM (vertical lines) following GLM RM analysis.
- Significant decline in ablation area in subsequent ablations compared to previous ablation.
DISCUSSION

• Possible sources of reduced ablation efficiency in subsequent ablations:
  • Elevation of tissue temperature between 60-100 degrees Celsius has been shown to cause thermal denaturation and contraction of intracellular cellular proteins along with collapse of the cytoskeleton, both of which are capable of altering the thermal conductivity and specific heat of tissue.
  • The thermal capacity of a given tissue is dominated by its perfusion, and regional increases in perfusion accompany regional changes in temperature. Local increases in perfusion create heat sinks, which reduce efficiency of heat distribution throughout tissue, thereby reducing ablation rate and ablative area.
CONCLUSIONS

• Ablation of previously-ablated tissue results in a reduced ablation rate and a reduced $TDE_{max}$.

• Each successive thermal dose in a series of sequential ablations results in a decreased ablation rate relative to that of the previous ablation.

• In the absence of a change in power, operators should anticipate a possible reduction in TDE when ablating partially-damaged tissue for a similar amount of time compared to the preceding ablation.

• Future studies are needed to investigate the effect of irrigation rate on ablation dynamics, as all ablations included in this study were done so with the irrigation rate set between 1 and 2.