Differences in RF-induced Heating per unit of SAR of a Deep Brain Stimulation Implant Across Two MR Systems

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BACKGROUND: The specific absorption rate (SAR), or the amount of RF power absorbed per unit of mass of an object indicated in W/kg, is often used as the metric for applied RF power in safety recommendations for performing MRI procedures in patients with elongated, conductive implants (e.g., neurostimulation systems, etc.) **(1-3)**. However, there currently is no single, universal means by which SAR is determined, as the various MR system manufacturers use proprietary and evolving models of the human body upon which to base their SAR calculation. Using a phantom model, we have previously demonstrated substantial differences in the heating profile of a fully-implanted neurostimulation system used for deep brain stimulation between two different-generation MR Systems from the same manufacturer using body coil RF transmit (**4**). The current report extends that line of work by demonstrating similar differences between MR systems using a t/r head coil configuration, a configuration that is particularly relevant given that it complies with current FDA-approved labeling for MRI Safety guidelines associated with the implant system evaluated.

PURPOSE: To compare the MRI-related heating per unit of console-reported "head" averaged specific absorption rate (SAR-H) of the same implant exposed to two different generation 1.5-Tesla/64 MHz MR systems.

METHODS: MRI was performed using two different 1.5-Tesla MR systems (System #1: Symphony and System #2 Avanto: Siemens Medical Solutions, Malvern, PA) using the transmit/receive head coil). A gel-filled phantom of the human head and torso was fitted with a bilateral neurostimulation system used for deep brain stimulation (DBS) known to exhibit excessive heating under certain conditions **(2)**. Temperatures were recorded at the bilateral electrodes using a fluoroptic thermometry system (Model 3100, Luxtron, Santa Clara, CA) with the phantom landmarked at the level of the distal tip of the bilateral leads. The experimental set-up was transported carefully between the two scanners without modifying any aspect of the phantom/temperature probe configuration. Temperature changes were normalized to console-reported values of SAR for the head and compared between the two MR systems. Statistical comparison was based upon differences in the normalized slope (i.e., regression equation coefficient) of the ΔT/SAR-H per unit time heating curve created for each system.

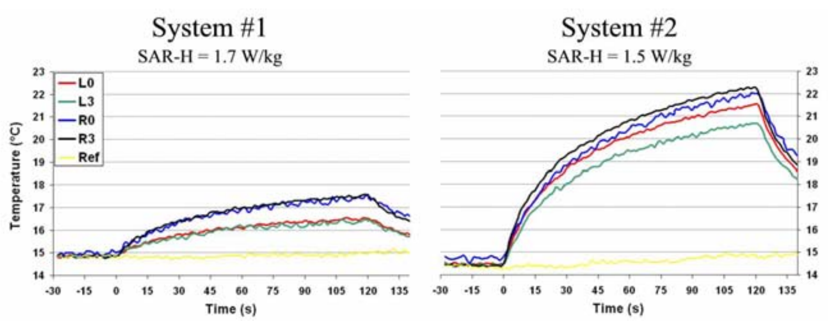

Figure 1. Sample raw temperature data from each of five probes (see legend) as recorded from each of the two MR systems. Console-reported SAR-H values are shown at the top of each graph. Note the higher ΔT for System #2 despite a lower reported value of SAR-H.

RESULTS: Figure 1 shows a sample of raw data from a single scan. The five probes, four contacts of the DBS lead plus a midline reference, are displayed with the console-reported value of SAR-H shown at the top of each graph. Figure 2 compares the mean (+/- SD) regression equation coefficient, fitted using the least squares method, of the transformed heating data for System #1 (light shading) and System #2 (dark shading). Data are shown for each of the four DBS contacts monitored.

DISCUSSION: Significant differences exist in the amount of MRI-related heating per unit of head SAR of a DBS implant across two different 1.5-T MR systems using the t/r head coil configuration. Specifically, the rate of heating per unit of SAR-H of one MR system was as much as 3.5 times that of another. The current results are of particular relevance in that the data were derived using a configuration of the MR system and the implant consistent with the FDA-approved safety guidelines provided by the implant manufacturer (**1**). The results further underscore the notion that implant heating profiles expressed as ΔT/ SAR are specific to a given MR system and cannot be generalized across systems.

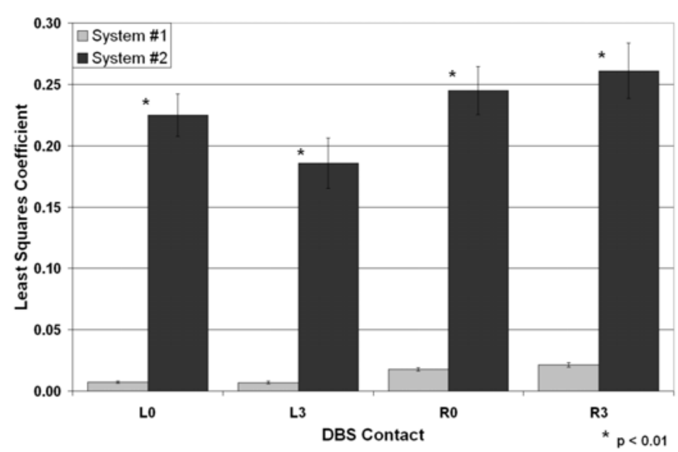

Figure 2. Column graph comparing the mean (+/- SD) regression equation coefficient, fitted using the least squares method, of the transformed heating data for System #1 (light shading) and System #2 (dark shading). Data are shown for each of the four DBS contacts monitored. As suggested by Figure 1, the slope of the heating curve is significantly and consistently higher for System #2, although the magnitude of the difference varies somewhat by contact.

REFERENCES

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