Specific Absorption Rate: A Specious Dosimeter of MRI-Related Heating for Metallic Implants

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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, often is used for safety recommendations when performing MRI procedures in patients with conductive implants (e.g., neurostimulation systems, infusion pumps, cochlear implants, 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. Modeling systems for SAR vary not only between MR system manufacturers but also constitute an evolving process that can change as a given manufacturer upgrades a system's software.

PURPOSE: To compare the MRI-related heating per unit of whole body averaged specific absorption rate (SAR) of the same metallic implant exposed to two different 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 Vision: Siemens Medical Solutions, Malvern, PA) using the transmit/receive body 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) at specific landmarks along the phantom body. The experimental set-up was duplicated for each scanner. Temperature changes were normalized to whole body averaged SAR and compared between the two MR systems.

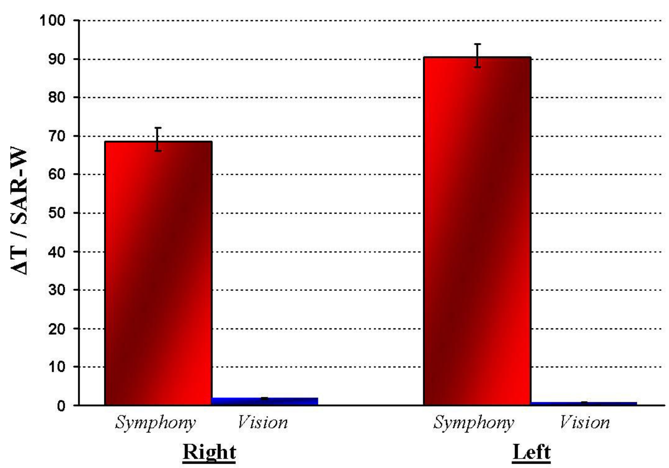

Figure 1. Median temperature change per unit of whole body averaged SAR, as recorded at contact 0 of the right and left electrode of the neurostimulation system, on the Symphony (red) and Vision (blue) MR platforms. Error bars show 1st and 3rd quartiles.

RESULTS: As shown in Figure 1, the median temperature change normalized to the whole body averaged SAR was significantly higher ($p < 0.001$) for one 1.5-T MR system (System #1) compared to the other (System #2). The magnitude of this difference was maximal when the landmark of the transmit/receive body coil was placed over the implanted electrode contacts (landmark = 76.5 cm) and decreased rapidly as the landmark was moved caudally along the phantom (Figure 2).

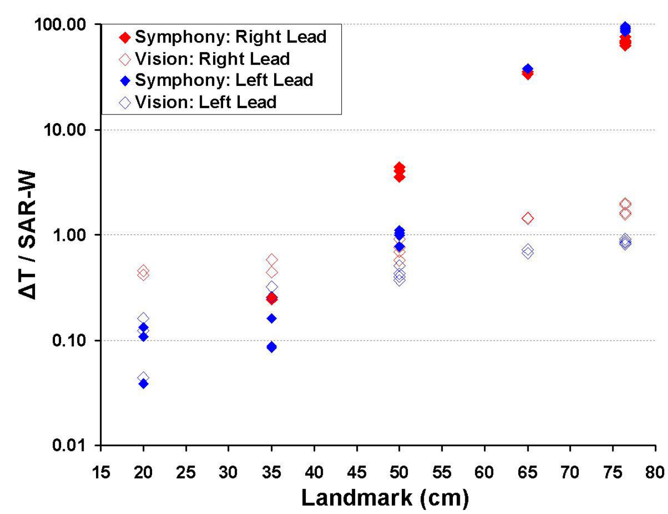

Figure 2. Normalized temperature changes, plotted on a log scale, as a function of body coil landmark. Note that the tips of the DBS leads were located at 76.5 cm while the pectorally-placed implantable pulse generator was located at 50 cm. Thus, lower landmark numbers reflect more caudal positioning.

DISCUSSION: Marked differences exist in the amount of MRI-related heating per unit of whole body averaged SAR of a DBS implant across two different 1.5-T MR systems. Therefore, at least for certain implant types, SAR-based guidelines developed on one MR system should not be generalized to other MR systems. There is a critical need to determine a more suitable measure of RF power delivery in order to prevent injuries to patients with implants. Comparisons based on the use of a transmit/receive head RF coil are pending. Note that the manufacturer does not recommend using MRI in patients with implanted stimulators.

REFERENCES

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