RF-Exposure Conditions vs. Induced Heating with Interventional Catheters: A Computational Study

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**Introduction:** Magnetic Resonance Imaging (MRI) is one of the most used imaging technologies; while MRI is considered a safe technology, there are still risks to patients that need to be controlled and mitigated. One of the risks is radiofrequency (RF)-induced heating of tissue, which is enhanced in the presence of conductive medical devices\textsuperscript{1}. While there are guidelines and standards that help ensuring safety of patients with implanted medical devices\textsuperscript{2}, currently there are no standards to address RF-induced heating during MRI in patients with partially implanted conductive devices (e.g., MR-guided cardiac ablation devices). The aim of this study was to assess how the specific configuration of the RF coil affects RF-induced heating with generic partially-implanted catheters.

**Materials and Methods:** The Transfer Function (TF) of a generic dual-wire lead was measured using the reciprocity approach\textsuperscript{3,4}. Numerical simulations results with an anatomically realistic human body model (“Duke” of the Virtual Population\textsuperscript{5}) exposed to thirty-two 64 MHz (1.5T) RF coil feeding conditions were implemented, by varying the polarization of the RF-field and the position of the feeding sources\textsuperscript{6}. An insertion path of 35cm in depth inside the body model and of 85 cm outside the body (Fig. 1a) was selected for the analysis. The tangential component of the electric field, $E_{\text{tan}}$, along the path (Figure 1a) was extracted from the numerical simulations and used as input of the experimentally-calculated TF\textsuperscript{5}. The temperature rise $\Delta T$ induced at the tip of a lead was thus calculated according to the following equation: $\Delta T = |\sum (\text{TF} \cdot E_{\text{tan}})|^2$, as shown in Fig. 1a.

**Results and Discussion:** Temperature rise varied with polarization and RF-coil feeding conditions. Moreover, for this specific setup, counterclockwise (CCW) polarization led to lower heating with respect to the clockwise (CW) one. The maximum temperature increase was below 50°C for all the cases. Results suggest that the specific feeding conditions of the RF-coil need to be taken into account in the analysis of RF-induced heating.

**Translational Impact:** This is a preliminary study aiming to apply the TF approach to partially implanted devices to assess the effect of RF-source configuration on the temperature increase.


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