On The Consequences of Wrapping Patients with RF Shielding Materials

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Introduction.

A recent development in MR imaging is the practice of wrapping various body parts of patients with RF absorbing/shielding material. The intended purpose of this shielding is to prevent unwanted parts of the patient's body from appearing within the field of view (FOV). Shielding parts of the body from the B_1 field eliminates unwanted signal and potentially enables faster scanning by the avoidance or minimization of FOV oversampling. With the understanding that some users may like to wrap parts of the patient during scanning, we have investigated the potential safety and performance consequences of wrapping the torso of a human body model with a flexible RF shielding carbon fiber like (graphite) sleeve during whole-body RF excitation [1]. Electromagnetic field simulations have been used to evaluate the effect on SAR and RF power demand during normal RF exposure, using the system body coil, for a human body model partially wrapped with a carbon (graphite) sleeve intended to shield parts of the body against the applied RF field.

Materials & Methods.

Electro-magnetic (EM) field simulations were performed using HFSS (Ansoft, USA). EM fields were simulated for the Ansoft 5 mm human body model placed within the standard bandpass birdcage coil model of a clinical whole-body MRI system tuned to 128 MHz. Identical simulations were performed with and without a 2 mm thick carbon (graphite) sleeve modeled around the lower half of the torso. An additional simulation was performed for a non-continuous carbon sleeve, with overlap, to mimic a more realistic practical scenario. In each case, the input power for the simulation was scaled to achieve equal mean B_1^+ within the transverse slice at iso-center of the body coil. The properties modeled included the B_1^+ field uniformity, global and local SAR, input power demand and absorbed power in the sleeve.

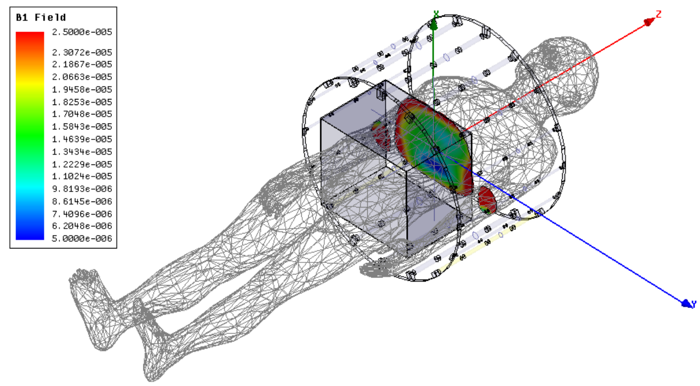

Figure 1: Human body model inside birdcage coil partially wrapped with a carbon (graphite) sleeve intended to mimic a carbon fiber wrap.

Results.

Figure 1 shows the body model and carbon sleeve location covering the lower half of the torso extending out of the body coil. Figure 2 (top) shows a comparison of B_1^+ uniformity with and without the sleeve, demonstrating the shielding effect of the sleeve. A consequence of the sleeve is the appearance of a local SAR hotspot (bottom row) and enhancement of local SAR at the places where the sleeve transitions to the body within the coil. Results for a non-continuous overlapped sleeve (not shown) are similar. Comparison of input power and SAR indicate that the presence of the carbon sleeve requires a 20% (continuous) to 40% (overlapped) higher input power to achieve the desired mean B_1^+ in the slice of interest. Examination of the global SAR indicates that this higher input power demand elevates the whole-body SAR by 10% to 20%. The presence of the sleeve disturbs the B_1^+ field which consequently redistributes the E field leading to a 60% increase in peak local SAR which is reduced to a 20% increase for a non-continuous (overlapping) sleeve.

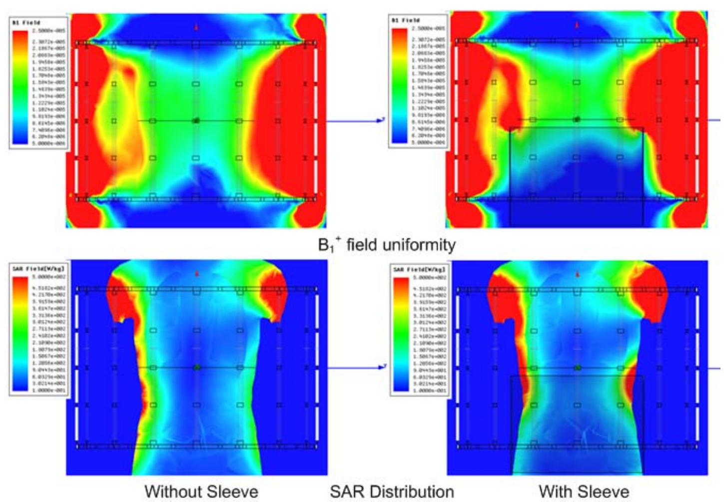

Figure 2: Coronal B_1^+ and SAR distribution with and without the carbon sleeve. While the carbon sleeve is effective in shielding the lower torso, it also creates a local SAR hotspot.

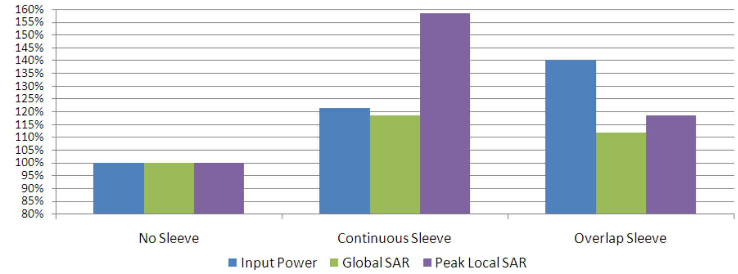

Figure 3: The relative impact of the carbon sleeve on input power, global SAR and peak SAR.

Conclusions.

The presence of an RF absorbing/shielding sleeve creates an additional load inside the body coil which causes re-distribution of the E-field and requires increased input power together resulting in elevated global and local SAR. A typical MRI system will compensate for the additional load by supplying more power (if available). A further consequence of this is that the SAR computed by the system will be in error which may result in RF exposure beyond the established safety guidelines [2].

References.

[1] Nicolaescu I., Journal of Optoelectronics and advanced materials, Vol. 8, No. 1, 2006. [2] IEC 60601-2-33 guidelines.