SAR comparison for infant due to different positioning within an MRI head coil

Z. Wang[1], O. Arthurs[2], D. Yeo[3], and F. Robb[1]
[1]GE Healthcare Coils, Aurora, OH, United States, [2]2University of Cambridge, Cambridgeshire, United Kingdom, [3]GE Global Research, Niskayuna, NY, United States

Introduction: Pediatric body MR imaging is limited by the lack of dedicated coils. Many infants are typically imaged using adult head or knee coils, but the SAR consequences are unknown. Compared to adults, infants have several unique physiological and physical characteristics that may influence the thermal risk during RF exposure. These include smaller sizes (larger proportion of body exposed to RF), higher surface area to volume ratios, higher head to body length (and area) ratios, shorter limbs, reduced subcutaneous fat and involuntary reflexes (changing orientation and distance of limbs with respect to coil). In this work, we use EM numerical modeling to evaluate the local SAR deposition in an infant body model imaged by an adult head coil. SAR is a first-order prediction of the potential thermal risk experienced by the subject.

Method: A whole body infant model was placed in a standard transmit head coil. The infant model is a 2 mm isometric resolution model of an 8-week old, 4.2 kg female baby with 56 different organ types [1]. Tissues in an infant have lower electrical conductivity and permittivity values than tissues in an adult. We adopted total body water (TBW) methods to interpolate the conductivity and relative permittivity values based on age-related tissue density [2]. The model was modified to adapt to commercially available finite-difference time-domain (FDTD) software: SEMCAD X (SPEAG, Zurich, Switzerland). The coil was driven with 32 current sources placed in the end-rings and 22.5-degree phase-shift between adjacent rungs. This method has shown practically identical results to driving the coil on resonance in quadrature at either two or four locations up to 128 MHz [4]. Two clinically relevant landmark positions were considered: the chest (e.g., for cardiac imaging), and the umbilicus (e.g., for abdominal or pelvic imaging) in the centre of the coil. The data was normalized such that the whole body average SAR = 2W/kg for a 1.5 Tesla magnet, i.e., the 6-min temporally averaged whole body SAR limit for normal scan mode [3]. Local SAR in one meshed cell (SAR1c) and averaged over 1 gram (SAR1g) and 10 g (SAR10g) [3] were calculated.

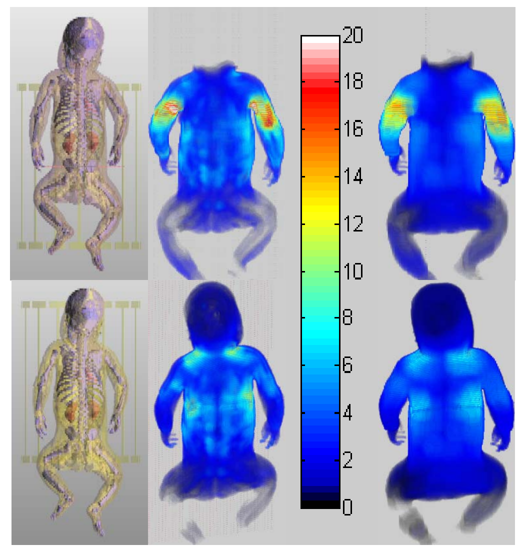

Fig. 1. 3D SAR1g (middle) and SAR10g (right) distribution depending on clinical infant position: Umbilicus-centered (top) and chest-centered (bottom). Unit of color scale is in W/ kg.

Results and Discussion: The estimated maximum SAR1c at the umbilicus-centered and chest-centered positions are 66.8W/kg and 68.73W/kg, respectively. Moreover, the estimated maximum SAR1g are 29.98W/kg and 17.28W/kg for these two positions. When placed in the umbilicus-centered position, the maximum estimated SAR10g is 16.59W/kg in the arms (just within the IEC long term SAR limit for extremities in the normal mode, i.e., 20 W/ kg) but only 9.2W/kg at the chest-centered position, which is also marginally within IEC's long term local SAR limits for the trunk and head (normal mode), i.e., 10 W/ kg (Fig 1). SAR values were highest in the arms (umbilicus-centered) and neck (chest-centered) as they are closest to the transmit coil end-ring area, where the electrical field is highest (Fig 1). It is observed that with the application of identical transmit power, the infant body model absorbs more RF power (higher SAR values) when electrical property values specific to infants are used, compared to when adult-specific tissue properties are used. Therefore, using adult tissue properties in an infant model may underestimate the RF heating risk for a baby in an MRI scan.

Conclusion and Discussion:
FDTD simulation is being developed as a tool for estimating local SAR in pediatrics. Our results suggest that estimated SAR distributions vary with different body positions, and that local SAR limits could potentially be exceeded when infants are placed within existing coils designed for adults. This data highlights a need for specific pediatric coils to be designed and evaluated. The SAR modeling work with the infant model can also aid in the selection of a safe adult MR coil when imaging infants. Other thermally relevant characteristics of infants, e.g., higher proportions of thermoregulatory brown adipose tissue for heat generation and presence of soft-spots (fontanelles) in skull, may be investigated in future work.

Acknowledgement: This works was funded in part by NIH 5R01EB005307-2.

References
[1] N. P-Henss, et al, Phys. Med. Biol. 47 (2002) 89–106; [2] J. Wang, et al, IEEE Trans. EMC, 48(2),408-413, 2006; [3] IEC 60601-2-33, 3rd ed.,2010; [4] W. Liu et al. Appl. Magn. Reson. 2005;29:5-18