SAR and SNR comparison for infants between adult head and knee MRI coils

Zhangwei Wang[1], Owen Arthurs[2], Desmond T.B. Yeo[3], Gemma R Cook[2], and Fraser J Robb[1]
[1]Coils, GE Healthcare, Aurora, OH, United States, [2]Radiology, University of Cambridge, Cambridge, United Kingdom, [3]GE Global Research, Niskayuna, NY, United States

Introduction: Pediatric body MR imaging is limited by a lack of dedicated coils. Children have several unique physiological and physical characteristics that may influence the thermal risk during RF exposure, compared to adults. 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). However, most infants are typically imaged using adult head, knee or surface coils, but the signal to noise (SNR) and thermal consequences have not been formally evaluated. In this work, we use EM numerical modeling to formally evaluate the SNR and local SAR deposition in an infant body model by an adult head and knee coil.

Method: A whole body infant model was placed in a standard transmit/receive head coil, then knee coil. The head coil is 280 mm (diameter) x 340 mm (length), number of channels, birdcage, whereas the knee coil is 240 x 200 mm. The model geometry is shown in Fig.1 (top). The infant model is a 2mm isometric resolution model of an 8-week old, 4.2 kg female baby with 56 different organ types [1]. The model geometry is shown in Fig. 1 (top). 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 [2]. The total body water (TBW) method was adopted to interpolate the tissue conductivity and relative permittivity values based on age-related tissue density [3]. The model was modified to adapt to commercially available finite-difference time-domain (FDTD) software: SEMCAD X (SPEAG, Zurich, Switzerland). 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 [4]. Local SAR of averaged over 1g and 10 g (SAR10g) [4] were calculated.

Results: The central coronal plane SNR (middle) and SAR1g (bottom) are shown in Fig.1, with peak SAR1g and SAR10g provided in Table 1. Overall, the knee coil can provide higher SNR than the head coil. Using the head coil, 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. Using the knee coil, the highest SAR was in the arms, as the arms are closer to the coil rungs in the smaller knee coil (than the head coil), which induces higher tissue power absorption. In the knee coil, the neck/shoulder area has higher SAR at the chest-centered mode, and the leg/pelvis area has higher SAR at the umbilicus-centered mode (see Fig 1). Therefore, the SNR and SAR distributions are both clinic landmark and coil geometry related.

Table 1. Peak SAR1g and SAR10g at different landmark and coil type (the data are normalized to whole body average SAR=2w/kg)

	head coil		knee coil	
	chest	umbilicus	chest	umbilicus
peak SAR1g(w/kg)	18.52	31.05	78.69	60.64
peak SAR10g(w/kg)	9.31	16.70	29.98	35.91

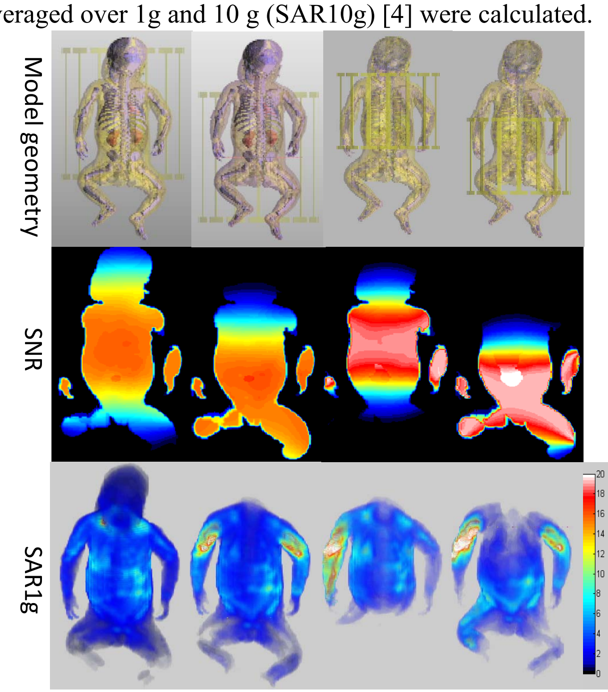

Fig. 1. The (top) model geometry, (middle row) SNR, and (bottom row) SAR1g distribution. Left two columns: infant model placed in chest and umbilicus-centric positions in head coil. Right two columns: model placed in chest and umbilicus-centric positions in knee coil.

Conclusion and Discussion:
Our results suggest that estimated SAR distribution varies with different clinic landmark and coil geometry, and that local SAR is relatively high when infants are imaged using existing coils designed for adults. SNR and SAR modeling can help to evaluate which RF coils may be best suited to a particular paediatric clinical situation, and this work further highlights a need for specific coils to be optimized across a range of paediatric imaging conditions.

References
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