

# An Assessment of the Suitability of the Body and Adult Head Coils for Transmission During Paediatric Magnetic Resonance Imaging

G.R. Cook<sup>1</sup>, M.J. Graves<sup>1</sup>, F.J. Robb<sup>2</sup>, D.J. Lomas<sup>1</sup>

<sup>1</sup>Department of Radiology, University of Cambridge, Cambridge, United Kingdom

<sup>2</sup>General Electric Healthcare Coils, Aurora, Ohio, USA

## Abstract

MRI offers physiological and diagnostic advantages over other modalities (CT, PET) and, if examining a paediatric patient, the lack of ionizing radiation is especially important. However, the process for infants is limited by the radio-frequency (RF) coils currently available which are optimized for adult anatomy. Simulation is used to confirm the safety of the coil and design performance. The aim of this work is to calculate Specific Absorption Rate (SAR) and the homogeneity of the RF transmit field (B1+) when imaging infants using COMSOL Multiphysics®.

### Use of COMSOL Multiphysics®

The electromagnetic characterization of birdcage-type coils - used to create the transmitted field - can be simulated using the RF Module provided by COMSOL Multiphysics® [1]. This coil geometry can be parameterised and therefore easily adapted to differently sized designs. After tuning, two voltage ports create a quadrature excitation. The tuned coil is loaded by an anatomical model and B1+ is then assessed for homogeneity within a region of interest (ROI). An FEM-compatible baby model was built for this purpose (Figure 1).

SAR values are normalized to the research regulatory limit of 4W/kg over the entire body and the patient volume is subsequently examined for local 'hot spots' which exceed the local SAR limit for a 1g cube of tissue. Voxel phantoms have been employed previously in the examination of adult phantoms using the FDTD method [3], but place computational constraints on FEM meshes and solvers. Variables and MATLAB Simulink were used to calculate SAR at regular positions without the use of voxel-based anatomical models.

Though SAR and temperature increase are related, physiological factors may influence their location [4]. COMSOL's Bioheat Transfer interface enables tissue heating calculation with consideration of both metabolic rates of tissues and perfusion of blood.

### Results

Initial results confirm that the body coil produces a more homogeneous B1+ (Figure 2). However, maximum normalised SAR is lower for the local coil transmit - with a maximum value

of 63.35 W/kg compared to 67.37W/kg - though in both instances the value did exceed 1g limits in the neck and arm regions. Thermal maps indicate small temperature rises in the highest SAR regions but also cooling from the skin surface (Figures 3-4).

### Conclusions

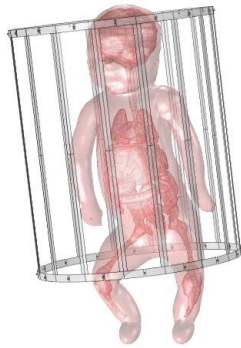
The lower SAR arising from local transmit seems counter-intuitive as the baby is closer to the conducting elements and SAR is proportional to the electric field, however, small changes between the relative position of the patient have been shown to alter this maximum greatly [3,5]; inside the local (head) coil the baby is not entirely exposed to RF so SAR is reduced.

The COMSOL Multiphysics® simulation conforms to previous calculations of SAR maps using the industry standard software [5]. With confidence in this result other aspects of coil optimisation and safety for paediatrics can be addressed, such as Signal to Noise Ratio or the effect of thermo-regulation on patient temperature change.

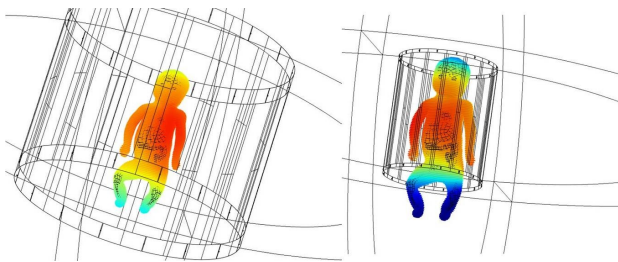
## Reference

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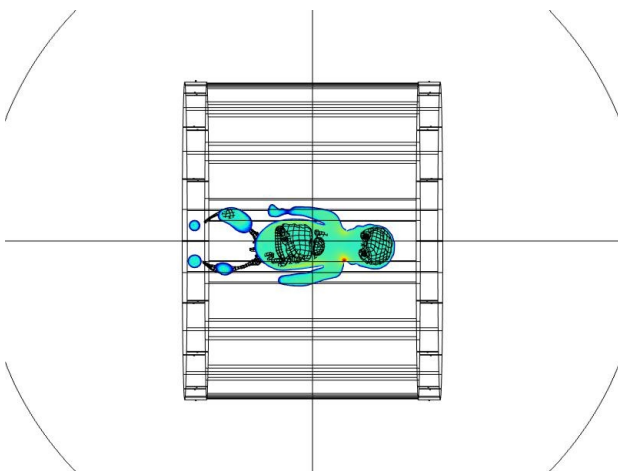
## Figures used in the abstract



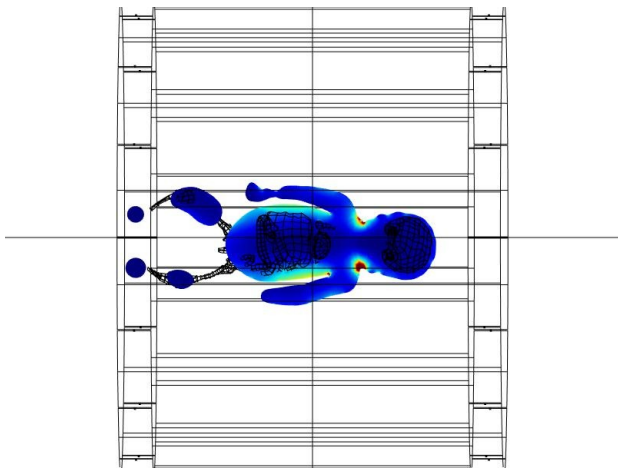
**Figure 1:** The head coil geometry with anatomical model of a baby.



**Figure 2:** Transmit Field ( $B_{1+}$ ) maps for multiple coronal planes through the body (left) and head (right) coils.



**Figure 3:** A temperature map for a plane through the isocenter of the body coil.



**Figure 4:** Normalised SAR map for plane through the isocenter of the body coil.