Numerical Investigation into Effects of a Receive Array on SAR in MRI

Z. Wang[1], J. Jin[1], C. M. Collins[2], S. Zhao[1], S. Oh[2], Q. X. Yang[2], and F. J. Robb[1]

[1]GE Healthcare Coils, Aurora, OH, United States, [2]Department of Radiology, College of Medicine, The Pennsylvania State University, Hershey, PA, United States

Introduction

Currently, the "hybrid" coil system, consisting of a large birdcage coil for transmission and multi-element array as the receive coil, is widely used in clinical MRI. This design can acquire images with short acquisition time and high SNR, and has particular advantage in parallel imaging. However, relatively little research is focused on safety in the "hybrid" coil environment. In this work, numerical calculation is adopted to investigate SAR variation in the human body models due to loading/unloading a twelve-channel torso coil.

Methods

Three-dimensional anatomical models NORMAN and NAOMI [1,2] were obtained from the Health Protection Agency (HPA, UK). Originally, NORMAN has a size of 277x148x871 at 2mm isometric resolution and 37 tissue types and NAOMI has a size of 294x124x791 at 2mm isometric resolution and 40 tissue types. They were resampled to 5x5x5mm^3 and adapted to commercially-available finite-difference time-domain software "xFDTD" (REMCOM; State College, PA). The dielectric values of the tissues were taken from *http://niremf.ifac.cnr.it/tissprop*. For this study, a 16-rung body size (61 cm coil diameter and 62 cm length, 66cm shield diameter and 122 cm length, as in a GE Signa 1.5T system) high-pass birdcage coil was modeled at 64MHz. With the torso coil (six anterior and six posterior elements each with a size of 240x180mm) in the center of the birdcage coil, one clinical configuration is considered. The coil geometry and the human body models are shown in Fig.1. The torso coil model included coil elements, cables, blocking networks, cable baluns (traps), and feeding board etc as a holistic system. At first, field calculations were performed with the human body and birdcage coil only. The coil was driven with 32 current sources which were placed in the middle of end-ring elements and a 22.5-degree phase-shift was set 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 [3]. Second, the results were normalized to the whole body average SAR=2W/kg (based on IEC regulatory limits [4]). Then, the current source amplitude values were updated and the torso coil was also loaded to run the model again. Finally, the SAR variation between these two cases was examined.

Results & Discussion

NORMAN and NAOMI have different SAR distributions since they have different mass, shape, organ geometry and the absorption power. Local SAR values are higher in the peripheral area of the body in both models as previously predicted. The SAR distributions on the coronal and sagittal planes passing through the center of the heart are shown in Fig. 2. From the calculation, the whole body average SAR of NORMAN is increased to 2.14W/kg while the value for NAOMI is increased to 2.18W/kg when the torso coil is loaded compared to 2.0 W/kg when the coil is absent. During RF transmission, the induced voltages drop on blocking circuits, baluns and cable traps of the coil elements and significantly alter the local field distribution, therefore increasing the whole body average SAR. The higher SAR value of NAOMI is probably because the cable is closer to the right leg of NAOMI and the cable length is also longer to avoid contact of the cable wire with tissues. However, both increases are less than 10% and maximum one-cell SAR rise is from 20.68W/Kg to 22.83W/Kg(2.15W/Kg increment, approximately 10%). Thus, under normal conditions it appears that the torso coil does not change SAR by more than 10%. The difference of SAR distribution with/without torso coil is shown in Fig.3 at the central coronal and sagittal plane. There is a pronounced effect in the area of the coccyx in both models due to effects from the feeding board.

Reference

[1] P. Dimbylow, Phy. Med. Bio. 1997;42: 479-490 [2] P. Dimbylow, Phy. Med. Bio. 2005;50:1047-1070
[3] W. Liu *et al*. Appl. Magn. Reson. 2005;29:5-18 [4] IEC 60601-2-33, 2006-02

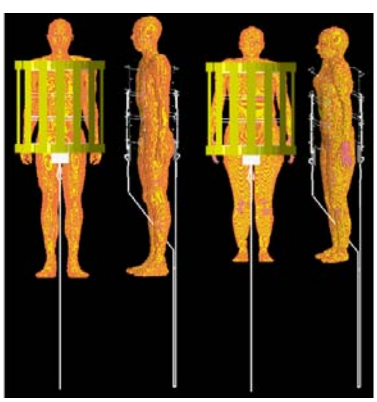

Fig. 1. The human body model and coil geometry (shield hidden). Left two are front and side (birdcage coil hidden) view of NORMAN. Right two are front and side view of NAOMI

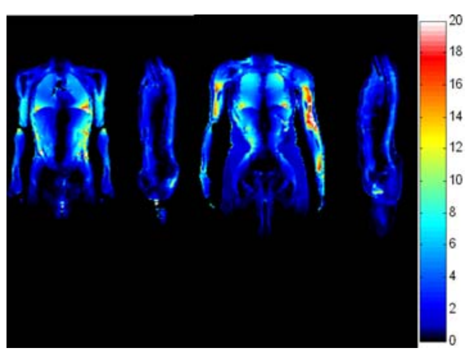

Fig.2. SAR distribution on coronal and sagittal planes passing through the center of the heart(Left two for NORMAN and right two for NAOMI).

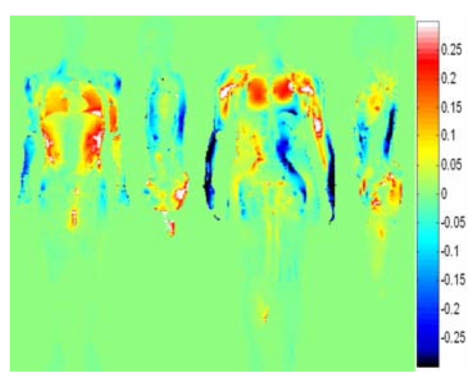

Fig.3. Difference of SAR distribution with and without torso coil(with minus without). The slices are the same as Fig.2.