Comparisons of SARs in Human Fetuses from Simple and Realistic Portable Radio Terminals

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Abstract

Recently, as the electromagnetic (EM) devices such as the mobile phones are increasing and developing, it is essential to evaluate the radio frequency (RF) dosimetry for pregnant females and their fetuses under various situations. Therefore, we have calculated specific absorption rate (SAR) in a fetus when the wireless radio terminal was placed close to the abdomen of a pregnant female. However, the structure of the radio terminal was simple as like a dipole antenna and planar inverted-F antenna with a metallic case. Therefore, we present the calculated SAR in a fetus exposed to EM waves from realistic EM source model using the pregnant female models of 13th, 18th, and 26th week gestation.

1. Introduction

Recently, as the technology of portable radio terminals based on the use of electromagnetic (EM) waves has been developing and increasing rapidly, the many people, including pregnant females, being exposed to EM waves from these EM devices such as mobile phones.

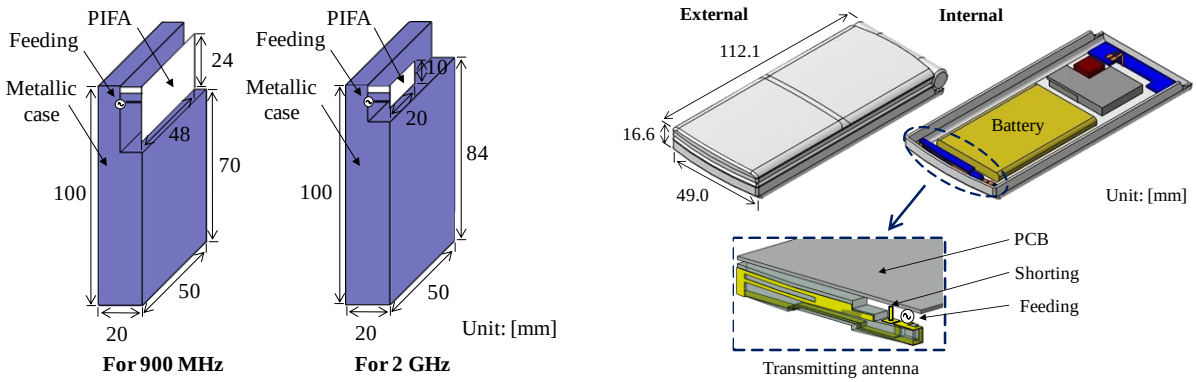
Previously, we have estimated the specific absorption rate (SAR: [W/kg]) in a pregnant female and her fetus exposed to EM wave when dipole antennas and planar inverted-F antennas (PIFAs) with a metallic case for 900 MHz and 2 GHz as the EM source [1], [2]. The structures of these EM sources, however, were simple to assume actual portable radio terminals. In this study, we calculated the SARs in human fetuses at the 13th, 18th and 26th gestational ages exposed to EM waves radiated from a realistic numerical model of the mobile communication terminal [3]. In addition, the SARs in the fetuses radiated from the realistic and simple (PIFA) were compared.

2. Materials and Methods

Figure 1(a) illustrates the PIFA models with a metallic case having a $2 \times 2 \times 2$ mm^3 voxel grid as simple EM sources. Figure 1(b) shows the realistic closed flip phone model with $0.1 \times 0.1 \times 0.1$ mm^3 voxel grid. A transmitting antenna in the flip phone model was connected the printed circuit board by a feeding and shorting as shown in Figure 1(b). The operating frequencies of the antenna are 900MHz and 2 GHz supposed the 3rd mobile communication system. We confirmed the transmitting antennas of the both EM source models resonate at the 900 MHz and 2 GHz. In this study, for the worst case evaluation, the radiated powers were 0.25 W at both frequencies in consideration of the maximum power in the 3rd mobile communication system. In this study, we used the numerical models of the pregnant

females with each fetus of 13th, 18th, and 26th gestational week [4]. The each placenta of 13th, 18th and 26th gestational week pregnant female models is placed –y direction from the fetus.

Figure 2 illustrates the calculation model. The distance between the EM source models and surface of the maternal skin is 10 mm and the height of the feeding gap is set at the center of the fetal head to evaluate the worst case at fetal head in both EM source models. All calculations were performed by XFdtd ver.7.2.2.2 [5], which is software of the numerical electromagnetic analysis, with the graphics processing units.



(a) PIFA models with a metallic case

(b) A realistic numerical model of a flip phone

Figure 1. Simple and realistic EM source models

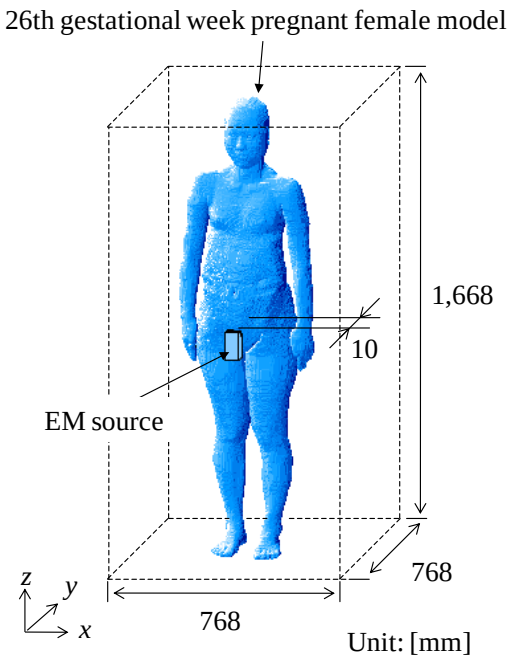


Figure 2. Calculation model

3. Results

Table 1 shows the peak maternal 10-g-averaged SARs from the PIFA (simple) models and the flip phone (realistic) model. At 900 MHz, the largest difference between the maternal SARs from the simple and realistic model is

25% for the 13th gestational week model. At 2 GHz, the largest difference is 20% for the 13th gestational week model. The maternal 10-g-averaged SARs vary with gestational week because of the difference in the shape of the maternal abdomen due to development of the fetus.

Table 2 shows the peak fetal 10-g-averaged SARs from the PIFA models and the flip phone model. At 900 MHz, the largest difference between fetal SARs from the simple and realistic model is 9% for the 18th gestational week model. At 2 GHz, the largest difference is 27% for the 13th gestational week model. The fetal 10-g-averaged SAR from the flip phone model at 900 MHz is the highest for the 26th gestational week model (approximately 0.12 W/kg); however, the highest fetal SAR is approximately one fifth that of the maternal SAR from the flip phone model at 900 MHz for the 26th gestational week model. Comparing the frequencies, fetal SARs at 900 MHz are higher than those at 2 GHz, in contrast to that of the maternal SARs. This is because the wavelength at 900 MHz is longer than that at 2 GHz, and therefore the EM wave at 900 MHz penetrates the maternal body more deeply.

The highest fetal and maternal SARs out of the mismatch loss were approximately 0.12 W/kg and 1.36 W/kg, respectively. In addition, these values were below the safety guidelines sufficiently (2 W/kg) [6].

Table 1. Maternal peak 10-g-averaged SAR [W/kg]

	900 MHz			2 GHz		
	13th model	18th model	26th model	13th model	18th model	26th model
PIFA	0.76	0.64	0.50	1.22	1.15	0.94
Flip phone	0.61	0.54	0.53	1.01	1.36	1.11

Table 2. Fetal peak 10-g-averaged SAR [W/kg]

	900 MHz			2 GHz		
	13th model	18th model	26th model	13th model	18th model	26th model
PIFA	0.083	0.099	0.124	0.018	0.060	0.081
Flip phone	0.081	0.091	0.130	0.024	0.079	0.108

4. Conclusion

In this study, we estimated the maternal and fetal SARs in pregnant females exposed to EM waves radiated from simple EM sources (PIFA models) and a realistic EM source model (flip phone model) using 13th, 18th, and 26th gestational week pregnant female models. Operating frequencies at the antenna of both EM sources were 900 MHz and 2 GHz. We found that the difference between the simple EM source and the realistic one in the maternal and fetal SARs is within 30% in this case, and also the fetal SARs are substantially lower than the maternal SARs for each gestational model. We also confirmed that maternal SARs at 2 GHz are higher than those at 900 MHz; on the other hand, fetal SARs at 2 GHz are lower than those at 900 MHz because of the radiation penetration depth.

5. Acknowledgement

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6. References

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