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Evaluation of SAR around an Implanted Cardiac Pacemaker Caused by Mobile Radio Terminal

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1. Introduction

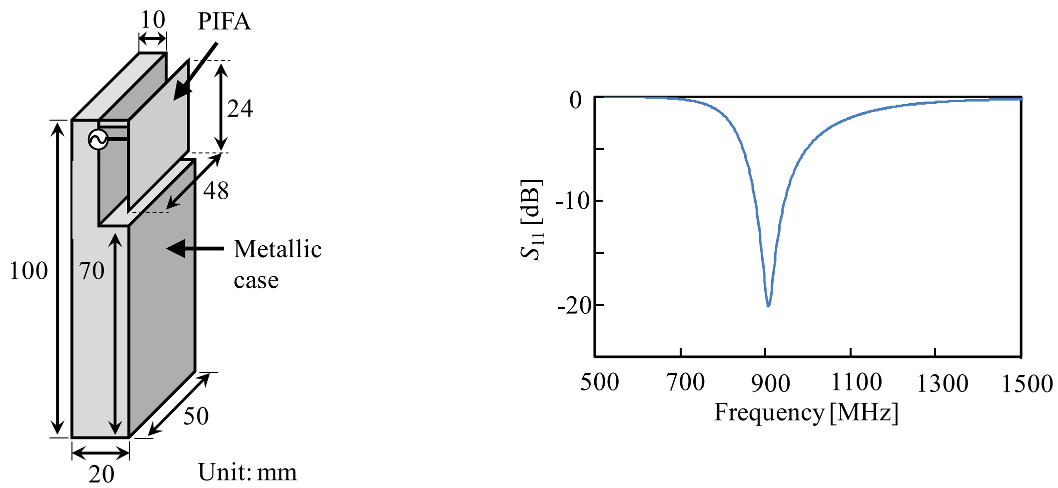
Recently, electromagnetic interference (EMI) of an implanted cardiac pacemaker with a mobile radio terminal has been investigated [1]-[3]. Based on these studies, national authorities have recommended that a mobile radio terminal should keep 22 cm from the pacemaker in Japan [4].

More recent studies have investigated the specific absorption rate (SAR) distribution in the human body, particularly around a pacemaker, when a mobile radio terminal is nearby, such as on a crowded train [5]. Here, SAR enhancement around the pacemaker was found by numerical computation with FDTD (finite difference time domain) method. A possible reason of SAR enhancement around the pacemaker inside human body is multiple reflections of EM waves between the surface of a metallic implant and human body [6].

In the previous study, a mobile phone model is designed to resonate at 2 GHz, simulating the third generation mobile phone of CDMA2000 or W-CDMA. Here, 900 MHz band is also widely used in resent mobile phone systems. In this study, SAR around the pacemaker is calculated with mobile phone model resonating at 900 MHz.

2. Calculation Model

Figure 1 (a) shows the numerical models of the mobile phone. The mobile phone is modelled with planar inverted-F antenna (PIFA) mounted on a metal case that simulates circuit board, battery etc., a type typically used for third-generation (3G) mobile phones. This model resonates at 900 MHz, operating frequency of 3G mobile phone. Figure 1 (b) shows reflecting coefficient at feeding point of mobile phone model. Figure 2 shows the numerical model used for the cardiac pacemaker, which was assumed to be embedded in a parallelepiped torso model. It is the same as that used by Wang *et al*. [7] and consists of a pacemaker housing and a lead wire. The pacemaker housing is 40×30×6 mm, the length of the lead wire is 240 mm and the diameter is 2 mm. A gap between the lead wire and the pacemaker housing is 2 mm. Figure 3 shows the arrangement of each model. The pacemaker model is embedded in the torso model at a depth of 14 mm. In this study, two different types of torso models are employed. Torso model which has the electrical properties of the human muscle is named as torso A, and torso B has layer construction with three different tissues. Torso B has 2 mm skin, 20 mm fat and 48 mm muscle [8]. These torso models are both 250×70×500 mm. The distance between the mobile phone model and the torso model is 15 mm. Here, in order to identify position of the mobile phone, where SAR become highest, mobile phone model is scanned in *x*-*z* plane.



(a) PIFA with a metallic case. (b) Reflecting coefficient at the feeding point.

Figure 1: Numerical model of the mobile phone.

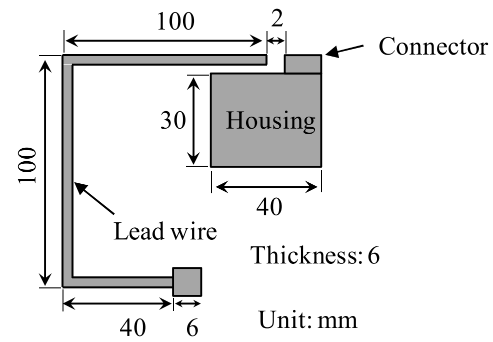
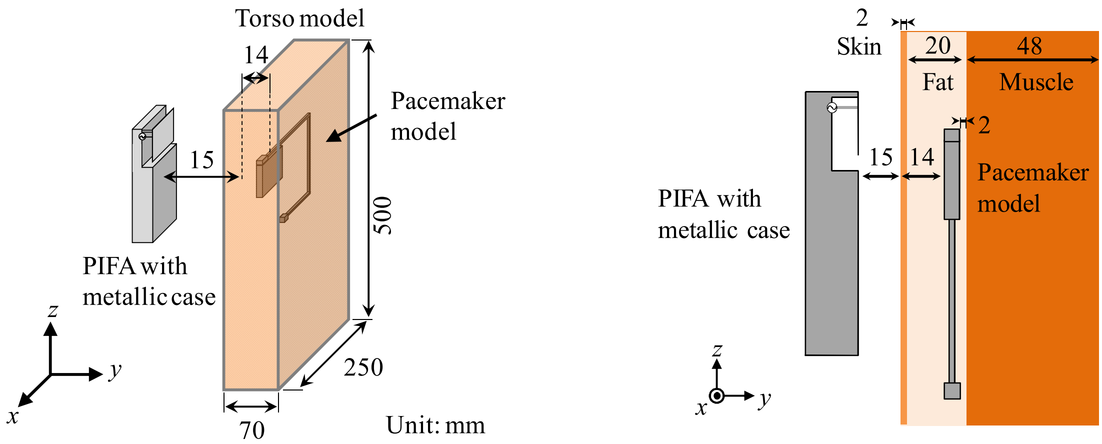


Figure 2: Numerical model of the cardiac pacemaker.

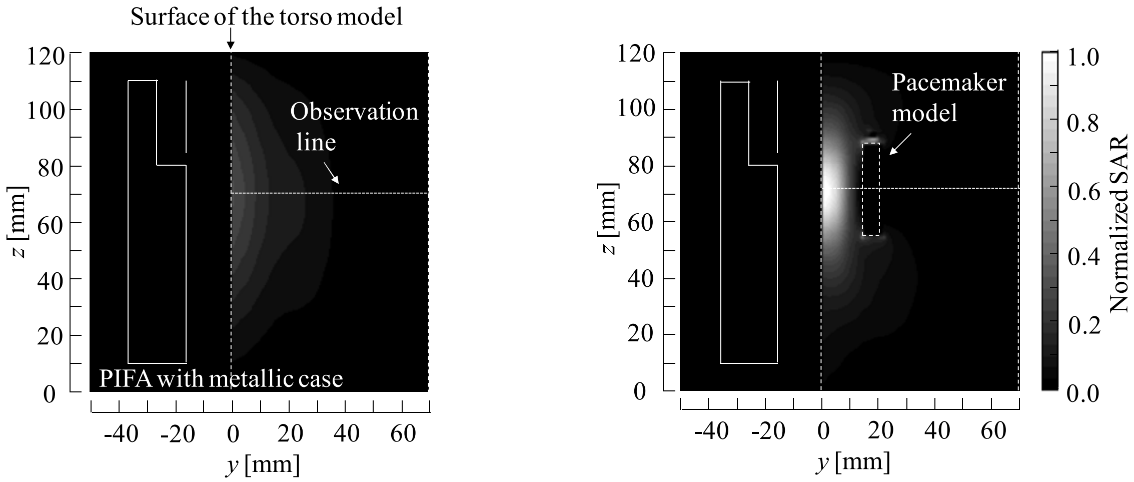


(a) Torso A. (b) Torso B.

Figure 3: Arrangement of each model.

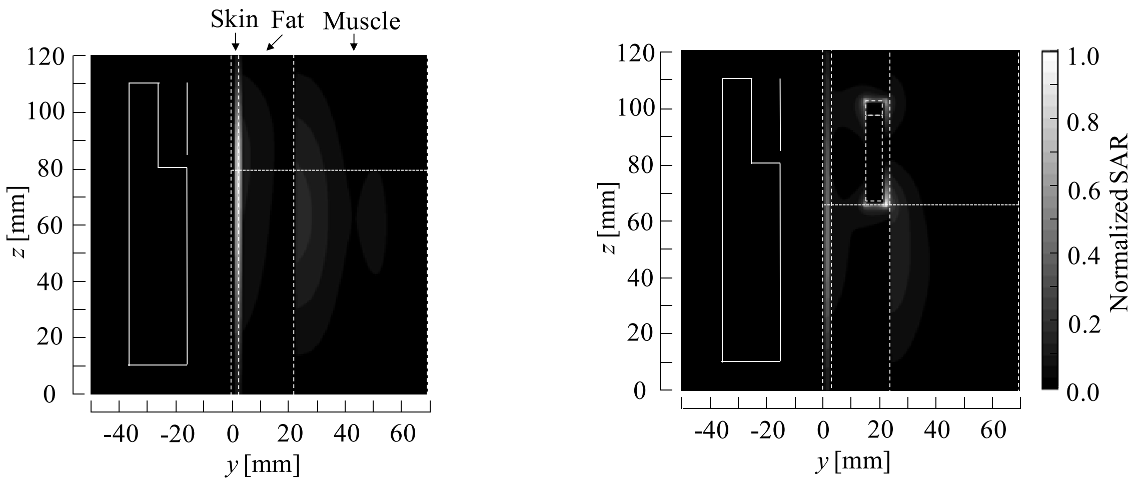
3. Calculated Results

Figure 4 show the SAR distributions in each torso model. Here, observation plane of SAR is set to include the highest SAR point. Figure 4 (a) shows the SAR distributions in the torso A with or without pacemaker model. Here, SAR values are normalized with the maximum value calculated with the pacemaker model embedded. From these two figures, SAR becomes higher with the pacemaker model and the highest SAR occurs on the surface of the torso. This SAR enhancement effect at the surface of the torso was also occurred with 2 GHz mobile phone [5]. Figure 4 (b) shows the SAR distributions in the torso B with or without pacemaker model. Here, SAR is normalized in the same way as the case of torso A. With the pacemaker, SAR becomes highest nearby the edge of pacemaker housing. Generally, intensity of electromagnetic field becomes high nearby the edge of objects. Furthermore, absorption of electromagnetic energy is small in skin and fat because the skin layer is too thin compared with wave length and electrical conductivity of the fat is too low compared with those of skin and muscle. Here, an amount of electromagnetic energy absorption depends on the electrical conductivity of a tissue. Figure 5 shows the SAR distributions on an observation line. The Observation line is a straight line along the *y*-axis, include the point of maximum SAR value. From the figure 5 (b), local enhancement of SAR is observed around the pacemaker. From these results, local SAR enhancement likely occurs around the pacemaker housing in case of an actual human body.



Without pacemaker model. With pacemaker model.

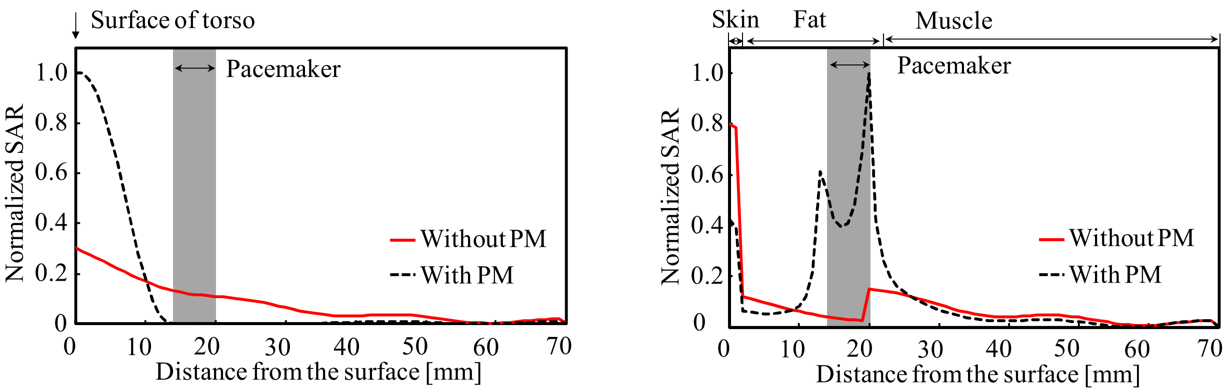
(a): SAR distributions in torso A.



Without pacemaker model. With pacemaker model.

(b): SAR distributions in torso B.

Figure 4: SAR distributions on the each observation plane.
(Observation line in each figure is used in figure 5.)



(a) Torso A. (b) Torso B.

Figure 5: SAR distributions on the each observation line.

5. Conclusion

In this study, SAR distributions in two different types or torso models due to the mobile phone resonates at 900 MHz were calculated. In both torso models, the enhancement of SAR was observed with the pacemaker. With the torso A which is composed of uniform muscle, SAR was enhanced on the surface near the mobile phone. While, in the case of the torso B composed of three different tissues, SAR was locally enhanced nearby the pacemaker housing. Thus, characteristics of coupling between the mobile phone and the pacemaker depend on the structure of the torso model. As a result, local SAR enhancement likely occurs around the pacemaker housing in case of an actual human body.

Acknowledgments

A part of this research is financially supported by the Ministry of Internal Affairs and Communications in the government of Japan.

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