Influence of Use Conditions and Mobile Phone Categories on SAR Distributions in Different Anatomical Structures in the Brain

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Abstract

Concern has arisen that the use of mobile phones might cause brain tumors. In this study, we estimated SAR distributions in different anatomical structures of the brain for different use conditions and Japanese mobile phone categories for the purpose of exposure assessment in epidemiological studies on RF exposure and brain cancer risk. Our results suggested a great variability of RF exposure in the different sites according to use conditions and mobile phone categories and highlighted the importance of evaluating the risk by connecting the tumor location to classes of phones used by participating subjects in epidemiological studies.

1. Introduction

The widespread use of mobile phones over the last 15 years has generated interest about possible health effects of electromagnetic field (EMF). An international collaborative case-control study called INTERPHONE [1] has been conducted in order to evaluate the hypothetical relationship between tumors incidence in the head and neck and EMF exposure from mobile phones; Japan was one of the countries participating to the study [2, 3]. An important issue within INTERPHONE was the evaluation of radio frequency (RF) exposure levels at the specific location of tumors for participating subjects [1, 3].

As information about precise location of brain tumors is not always available in mobile phone epidemiological studies, INTERPHONE study conducted an analysis of the spatial distribution of RF energy absorption in different anatomical structures of the brain [4]. Use conditions are generally not known for each participating subject in epidemiological studies. And in the analysis conducted by INTERPHONE, use conditions as well as types of phones (except for the frequency band considered in the study as the main general characteristic of the phones) were therefore not taken into account. Which raised the following questions: What if we know the use conditions and the phone type for each participant? Are distributions of the specific absorption rate of energy (SAR) in the different anatomical locations in the brain dependent on the phone model and conditions of use? An additional study was therefore performed in Japan to evaluate the effect of use conditions and phone model on the exposure of the different anatomical structures of the brain.

Using phone categories and specific SAR distributions developed for each category in the Japanese numerical TARO model in a previous study [5], we evaluated the influence of use conditions and classes of phone on the distribution of maximum and average SAR values in major anatomical structures of the brain.

2. Materials and Method

In order to evaluate SAR distributions in different anatomical locations in the brain, the left half part of the brain of the Japanese numerical model TARO was mapped by different IDs identifying major anatomical locations of the brain at a 10 mm resolution: the temporal (340 1cm-cubes), parietal (191 1cm-cubes), frontal (352 1cm-cubes) and occipital (96 1cm-cubes) lobes, the cerebellum (123 1cm-cubes) and the brain stem (81 1cm-cubes). The 10 mm resolution is the resolution used in INTERPHONE study by medical doctors to localize tumors [1]. Figure 1 represents a surface view of the left hemisphere of TARO brain, with specific anatomical structures highlighted by different colors.

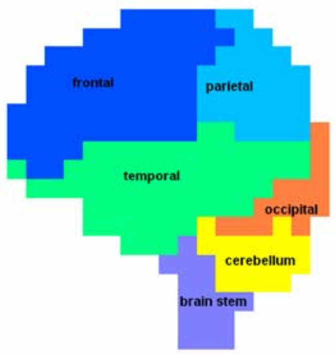

Figure 1 Major anatomical structures of TARO model brain at a 10 mm resolution.

We used a previous work that focused on classification of Japanese mobile phones according to their SAR distribution pattern into small numbers of categories, consistent with the characteristics obtained from external views of phones and technical specifications [5]. In this study, the phones were categorized, considering four different use conditions separately, for cheek/out, cheek/in and tilt/out use conditions into respectively 4 (CO 1 to CO 4), 3 (CI 1 to CI 3) and 6 (TO 1 to TO 6) categories [5]. They could not be categorized for tilt/in conditions and we are therefore not using tilt/in use conditions in the following analysis. For each category, 3D SAR distributions were estimated with a spatial resolution of 1 cm in TARO model head [5].

For each use condition and each phone category, the average SAR values at the different anatomical locations of TARO model were calculated by averaging over all the cubes in the specific anatomical structure. We also calculated maximum SAR values in each structure. Relative SAR values were obtained in percentage of the maximum 1cm-cube SAR in the brain. All the results presented in this paper consider the left half part of the brain for a left side use of the phone.

3. Results and discussion

Table 1 shows, for cheek/out use conditions, the distribution of the average and maximum relative SAR by anatomical structure and phone category, expressed as % of the SAR in the brain cube with the highest absolute SAR value. Figure 2 represents, for cheek/out use conditions, surface views of 1 cm-cube SAR distributions in the brain for each phone category.

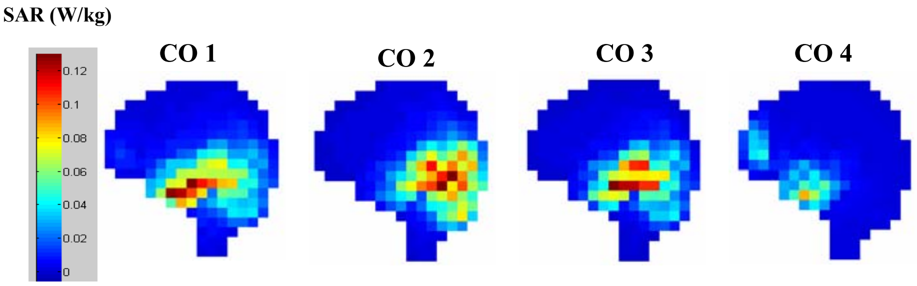

Figure 2 Cheek/out: Surface view of SAR distributions in the left hemisphere of the brain (1 cm resolution) for each phone category (using the same color scale) for a phone held on the left side.

Table 1 Cheek/out: Distribution of the average and maximum relative SAR by anatomical structure and phone category, expressed as % of the SAR in the brain cube with the highest absolute SAR value – *for a phone held on the left side of the head and in anatomical locations in the left half of the brain.*

Category	CO 1		CO 2		CO 3		CO 4	
Structure	Avg SAR	Max SAR	Avg SAR	Max SAR	Avg SAR	Max SAR	Avg SAR	Max SAR
Temporal	13.6%	100%	11%	100%	9.4%	100%	5.9%	100%
Frontal	1.2%	11.2%	0.7%	8.3%	0.5%	7.5%	2.4%	50.5%
Parietal	2.3%	19%	4%	49%	1.5%	21.6%	0.2%	1.4%
Occipital	6.3%	42.9%	14.6%	78.7%	4.5%	42.5%	0.28%	4.3%
Cerebellum	8.5%	34.1%	12.5%	61.6%	4.9%	31.1%	0.6%	5.2%
Brain stem	3.2%	16%	1.8%	8.5%	0.7%	6%	0.9%	4.7%

Our results suggested a variability of RF exposure of the different sites according to the use conditions and mobile phone categories. Exposure, especially for structures at the back of the brain like cerebellum and occipital lobe, was found very sensitive to the antenna extraction and laterality but less sensitive to the use position. The maximum SAR was always obtained in the temporal lobe and the temporal lobe was generally the highest exposed anatomical structure, except for flip type phones, antenna on top, extracted, for which absorption is localized at the back of the head (see Fig. 2 and Table 1, category CO 2), which has for consequence to make the occipital lobe and the cerebellum the highest exposed structures. Occipital lobe and cerebellum were anyway generally the second highest exposed structures whereas exposure of parietal and frontal lobes were usually low. Only for flip phones, antenna in the center (see Fig. 2 and Table 1, category CO 4), the frontal lobe was the second highest exposed structure.

The cerebellum exposure was found relatively high considering assumptions in previous epidemiological studies which evaluated the exposure of the cerebellum as low. Numerical simulations, consistent with our results, have shown that this exposure should effectively not be considered as low. Relative average and maximum SAR values were moreover found particularly variable for the cerebellum structure, depending on the type of phone and the antenna extraction, position and laterality.

All these results proved how important it is in epidemiological studies to be able to link the location of tumor with the class of mobile phones used by participating subjects.

4. References

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