SCIENTIFIC PROGRESS MADE IN COMPUTATIONAL DOSIMETRY HAS BEEN EXCEPTIONAL

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Abstract

GAO recommended FCC to reassess and, if appropriate, change its current RF exposure safety rules. It also mentioned that FCC is working on a draft document which has the potential to address GAO's recommendations. Only time will tell what FCC may possibly do or whether going forward to change its current RF exposure safety rules or not. If FCC does decide to change its current RF exposure safety rules, it would do well to note that since 1998, the scientific progress made in computational dosimetry has been exceptional.

The CTIA, an organization representing the wireless communications industry stated in a news release [1], "CTIA welcomes the Federal Communications Commission's (FCC) continued careful oversight of this issue," in its response to the Government Accountability Office (GAO) report on cell phone safety [2]. GAO recommended FCC to reassess and, if appropriate, change its current RF exposure safety rules. It also mentioned that FCC is working on a draft document which has the potential to address GAO's recommendations.

The GAO report was issued following a year-long investigation into the adequacy of the FCC's rules that was requested by Reps. Edward J. Markey (D-Mass.), Henry Waxman (D-Calif.) and Anna Eshoo (D-Calif.), members of the House Energy and Commerce Committee that has oversight authority over the FCC and the telecommunications industry.

The Environmental Working Group (EWG) applauded the three members of U.S. Congress for prompting the GAO investigation [3]. It commended GAO for the report demonstrating "the need for the FCC to review its cell phone safety standards." and expects "FCC will use the GAO's findings to update its safety standards for wireless devices."

At first glance, for a change, both the environmental group and the wireless industry seem to be on the same page.

Given the EWG's recommendation of "simple steps that cell phone users can take to decrease their exposure, such as using a era phone headset and texting rather than talking," it is not a stretch to surmise that the EWG's most

favored outcome would be a FCC review that would lead to a substantial reduction of the current cell phone exposure limits.

On the other hand, the wireless industry's enchantment with the GAO report or the prospect of FCC reviewing its rules on radiation exposure from cell phones may actually be pointed in the opposite direction, if past foretells the future. For instance, when the safety limits for localized exposure was relaxed by a factor of two or more in the 2006 IEEE "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields," the Mobile Manufacturing Forum (MMF) was thrilled, notwithstanding the pinnae (external human ears) was separated out from rest of the head by this IEEE operation [4]. I will come back to the relaxed limits in due course.

The GAO report [2] indicate that the "FCC RF energy exposure limit may not reflect the latest research," since FCC set the RF energy exposure limit for mobile phones in 1996, "based on recommendations from federal health and safety agencies and international organizations." One of the international organizations namely, IEEE "updated its exposure limit recommendation, based on new research," in 2006. This new recommended limit allows for more RF exposure (by a factor of two or more).

The GAO report was the result of a year-long effort during which its staff reviewed scientific research and interviewed experts in fields such as public health and engineering, officials from federal agencies, and representatives of academic institutions and consumer groups. To the best of my knowledge the staff report was not circulated for comment by the interviewed experts.

It is fair to note that the 2006 updated of IEEE exposure standard was mostly an endeavor to harmonize with the existing International Commission on Nonionizing Radiation Protection (ICNIRP) guidelines, published in 1998 [5].

To be sure, the 2006 IEEE standard departs in major ways from its prior edition. One thing it did not do is to reduce exposure limit. This column will focus on some of the more salient aspects applicable to cellular mobile communication.

In the frequency range of 100 kHz to 3 GHz, the new IEEE standard specific energy absorption rate (SAR) for localized exposure is 2.0 W/kg, the same as ICNIRP (the FCC value is 1.6 W/kg) for most parts of the extremities (arms and legs distal from the elbows and knees, respectively, including the fingers, toes, hands, and feet), the IEEE basic restriction expressed in terms of SAR is 4.0 W/kg (the FCC value is 1.6 W/kg). The value of SAR is obtained by averaging over any 10 g of tissue, defined as a volume in the shape of a cube (the FCC averaging mass is 1 g).

Moreover, the new IEEE standard introduced an exclusion for the pinnae or the external ears by relaxation of the above mentioned basic SAR restriction from 2 W/kg to 4 W/kg. In effect, the IEEE standard formally declared, for its purposes, the pinnae is the same as the extremities (arms, legs, fingers, toes, hands and feet). This decision separates out tissues in the pinnae and severs the ear from the rest of the human head. The allowable SAR for other tissues in the head is 2 W/kg. Could this be a concession to the cell phone industry? Under operating conditions, where the cell phone is positioned next to the head, SAR is the highest in tissues of the pinnae.

Of equal, if not more, significance is the basic restriction for localized exposure at 2 W/kg in terms of SAR averaged over an increase mass of 10 g of tissue. The SAR value has been increased from 1.6 W/kg averaged over any 1 g of tissue to 2 W/kg over any 10 g of tissue. Aside from the numerical difference between the SARs (1.6 to 2.0), the volume of tissue mass used to define the SARs in the new IEEE standard was increased from 1 g to 10 g. The increase in tissue mass can have a profound influence on the actual quantity of RF energy allowed to be deposited in tissue by the new exposure standard. It has been well established that the distribution of absorbed microwave energy is non-uniform and it varies greatly from point to point, tissue to tissue inside a body. An averaging volume that is as large as 10 g would tend to flatten the SAR distribution, whether it is computed or measured. And the smoothing tends to artificially reduce the resulting SAR value. Thus, a 10 g SAR at 2 W/kg would be equivalent to 1 g SARs of 5 W/kg or higher. Simply put, the absorbed energy averaged over a defined tissue mass of 10 g is inherently low, compared to a 1 g SAR.

The answer to the question of whether the updated exposure limits promulgated by the new IEEE recommendation are based on new research is a qualified no for several reasons.

1. The increase in allowable SAR values from 1.6 W/kg averaged over any 1 g of tissue to 2 W/kg over any 10 g of tissue in the new IEEE standard actually conformed to an older set of ICNIRP guidelines.
2. The choice of averaging SAR over a tissue mass of 10 g instead of 1 g is regressive in that it is less accurate and ignores progress made in the past couple of decades in computational and experimental determination of SAR. The previous use of a 10 g mass was necessitated by the then available gross spheroid body models instead of the currently wide available detailed anatomical models with precisions considerable greater than 1 g of tissue.
3. The close attention to cell phone exposure and wide availability of precision computational determination of SAR in anatomical models have revealed the pinnae as a site of high SAR for a cell phone is used next to the head, which is a new finding. But the new IEEE standard elected to deal with it in other (rather bizarre) ways.

As an example, at 2.5 GHz, the RF field penetration depth in muscle tissue for a flat region is about 1.7 cm. A linear dimension of approximately 2.15 cm in the shape of a cube would be needed to make up 10 g of muscle tissue. Clearly, the exponentially attenuated SAR would be significantly greater close to (and more concentrated in) the superficial layer of muscle tissue, which would be easily revealed by the 1 g SAR but masked by a 10 g SAR.

It should be noted that the sensitivity and resolution of present day computational algorithms and resources, and experimental measurement schemes can provide accurate SAR values with a spatial resolution on the order of a 1 mm or less, in dimensions. Also the 1 g SAR is scientifically a more precise representation of localized RF or microwave energy absorption, and a more biologically significant measure of SAR distribution inside the body or head than a 10 g SAR.

Only time will tell what FCC may possibly do or whether going forward to change its current RF exposure safety rules or not.

If FCC does decide to change its current RF exposure safety rules, it would do well to note that since 1998, the scientific progress made in computational dosimetry has been exceptional. Instead of the homogeneous geometric models of human and animal bodies, most, if not all computational studies are based on heterogeneous, realistic anatomical models using voxels of 1.0 mm or better resolution in biological tissues. To acknowledge this scientific achievement, the averaging volume has been changed to a volume of $2 \times 2 \times 2$ mm^3 for induced electric field and local SAR in the most recent ICNIRP guidelines for frequencies below 100 kHz [6].

A fair summary of the biological research results would be that they do not conclusively demonstrate evidence that proves or disproves a health risk from cell phone exposure. It is factual that more studies showed no health effect. However, except for the animal studies, a majority of the studies were short-term investigations. That includes epidemiological studies head and neck cancers in cell phone users, as seen from previous articles of this column.

Nevertheless, the World Health Organization's International Agency for Research on Cancer (IARC) recently announced its conclusion, while not entirely unanimous, acknowledged published scientific papers reporting increased risks for gliomas (a type of malignant brain cancer) and acoustic neuromas (a non malignant tumor of the auditory nerve on the side of the brain) among heavy or long-term users of cellular mobile telephones.

Perhaps not surprisingly some other groups of epidemiologist, reviewing the same data or papers, concluded that the increased risk was entirely

explicable by various biases or errors. In their judgment there is little possibility that cell phone use could increase the risk of glioma or acoustic neuroma in users.

References:

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[4] J.C. Lin, “A New IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Radiation,” *IEEE Antennas & Propagation Magazine*, vol. 48, no.1, pp. 157-159, February 2006

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