Thematic Area TA10 - Non Ionizing Radiation.
Occupational Exposure to Microwave Radiation in Diathermia Units

M. A. Martínez[1], M. Téllez[2]
I. Santa Olalla[2] and A. Úbeda[1]

[1]Servicio de Investigación-BEM, Hospital Ramón y Cajal, 28034 Madrid, Spain.
[2]Servicio de Radiofísica y Radioprotección, Hospital La Paz, 28034 Madrid , Spain.

INTRODUCTION

Directive 2004/40/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from electromagnetic fields establish Basic Restrictions and Reference Levels for occupational exposure to electric and magnetic fields in the 0 Hz to 300 GHz range [1, 2]. This Directive stresses the need for taking periodical measurements of exposure levels in occupational environments in order to avoid potential harmful effects caused by acute, instantaneous exposures to non ionizing radiation (NIR).

Physiotherapists working in Diathermia Units are chronically exposed to microwave (MW) radiation at a typical frequency of 2.45 GHz. However, few studies have investigated in situ the exposure levels in such occupational environments. The lack of more complete dosimetric information has hindered the interpretation of a number of epidemiological data on increased incidence of reproductive outcomes among female physiotherapists working with MW during pregnancy. These outcomes include delayed conception, spontaneous abortion, stillbirth, preterm birth after exposure of fathers, birth defects in aggregate, low birth weight and increased male-female sex ratio[3 - 9]. It has been proposed that such disorders, together with increased incidences of cardiovascular ailments, insomnia, headache or dizziness detected among MW therapists[10] could be due in part to chronic exposure to the microwave radiation.

The purpose of the present study is to characterize the levels of occupational exposure to MW radiation among electrotherapists. The recorded data show that the typical exposure levels meet the abovementioned European Directive. The figures indicate that the average exposure levels vary within a wide range, depending of factors like the number of MW apparatuses operating simultaneously, the age of the apparatuses and the orientation and distribution of the MW equipment in the room.

MATERIAL AND METHODS

Dosimetry

The study was conducted in four public hospitals located at the North sector of Madrid, having diathermia units in which MW treatments are currently applied. Serial recordings of 6 – 10 consecutive minutes were taken in areas close to the MW equipment, in which the therapists can regularly stay for relatively long time lapses. The measurements were conducted under real conditions of treatment of patients. With the help of the workers the dosimetric tasks were executed with minimal perturbation of the patients and null interference with the treatments.

Equipment

Measurements were taken with a PMM8053 meter equipped with an electric field probe EP105.

Technical specifications of the meter:

- *Frequency Range: 5 Hz-18 GHz*
- *Dynamic Range: > 100 dB*

- *Operating range: (E): 0,03 V/m to 100 KV/m*
- *Resolution: 0,01 to 10 V/m*
- *Sensitivity: 0,1 to 1 V/m*

All data were recorded with the meter installed on a wooden tripod with the sensor of the probe located at a height of 150 cm. In order to prevent potential artifacts in the measurements because of absorption or reflection of the signal, the sensor was always kept apart from persons, walls or electronic equipment.

Safety criterion and methodological limitations in the estimation of occupational exposure

The dosimetric data were compared to the Reference Levels in Directive 2004/40/EC for the frequency of interest in the study: 2.45-GHz MW (Table). It is necessary to point out that the purpose of the Directive is to guarantee the "minimal" conditions of occupational safety for acute, instantaneous exposure to NIR. The objectives of the Directive do not include the protection of the workers against chronic exposure to weak NIR, whose potential noxiousness has not been sufficiently established.

Table

Frequency of the emission	**Electric field E (V/m)**	Magnetic field H (A/m)	Power density (W/m^2)
2,45 GHz	**137**	0,36	50

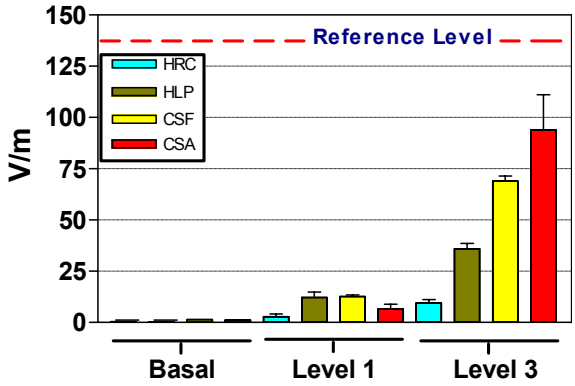
Reference Levels in Directive 2004/40/EC for protection against occupational exposure to 2.45-GHz radiation

Directive 2004/40/EC establishes that the exposure values have to be estimated from measurements of the parameters included in the Table. The values must be expressed in RMS units of unperturbed, plane wave (far field) averaged over any 6-minute period. In the present study the condition of imperturbation of the emission cannot be fulfilled, since the presence of the patient, walls and other apparatuses in the room significantly influence (absorb or reflect) the MW signal. Despite of this unavoidable methodological constrain, the obtained dosimetric data are consistent and coherent. Consequently, we propose that the applied protocol allows for efficient and dependable estimation of MW exposure in the investigated occupational environments.

RESULTS AND CONCLUSSIONS

The Figure summarizes a selection of preliminary data of occupational exposure levels in the four hospitals investigated (HRC, HLP, CSF and CSA). The represented values correspond to time-weighted average ± SD of the electric field intensity (V/m) recorded over 6 to 10-minute lapses, in three different conditions: Basal Level, when none of the MW apparatuses in the room was in operation; Level 1, when only the MW apparatus closest to the chosen measurement spot was on duty, while the other apparatuses in the room were off; and Level 3, when three or more MW apparatuses in the room were operating simultaneously.

Figure



Values (V/m; time-weighted average ± SD) recorded at the four studied hospitals. Basal Level, Level 1 and Level 3 (see text for details) in each of the hospitals are compared to the corresponding Reference Level (red dotted line) in Directive 2004/40/EC

When compared to the corresponding Reference Level in the table (E = 137 V/m for a 2.45-MHz frequency), the data summarized in the figure reveal that the estimated exposure levels meet the limits imposed by Directive 2004/40/EC. Nevertheless, in the chosen measurement areas, routinely used by the workers, relatively strong E values were recorded: 70 V/m (CSF hospital, Level 3) or 120 V/m (CSA hospital, Level 3). These exposure values can be exceeded significantly at distances closer to the MW devices, which are regularly reached by the therapists when operating active equipment or when interacting with the patient during the treatment (data not shown).

A preliminary analysis of the obtained data reveals that the exposure levels in the studied areas are a function of a number of factors, including the location and orientation of the MW devices, model and age of the apparatuses, number of devices

operating simultaneously or the dimensions, distribution and masonry of the room and of the cabinets for MW therapy.

The knowledge of the characteristics and levels of exposure to MW radiation in Electrotherapy Units is essential to the development of strategies addressed both to avoid risks of occupational overexposure and to minimize the daily exposure doses. So it recommends Directive 2004/40/EC, which emphasizes the point that the observance of the limits does not necessarily warrants protection against potential interaction of the electromagnetic signal with active implants, like pacemakers or cochlear implants that the therapists could bear. Also, the Directive establish that the objective of the proposed limits is the protection of the workers against immediate effects (thermal effects in the case of MW) of occasional exposures to strong fields, but not against hypothetical deleterious effects of chronic exposures to weaker, non-thermal doses of radiation, like those recorded in the present study.

The available epidemiologic and experimental evidence on harmful effects of chronic, occupational exposure to non-thermal MW radiation is scarce, little conclusive and lacks of a mechanistic basis. Nevertheless, some authors consider that such evidence constitutes a basis plausible enough as to invoke the cautionary principle. These authors have recommended the adoption of basic strategies of exposure prevention and minimization.

In conclusion, the present study summarizes preliminary data addressed to complete the present knowledge on the MW-exposure doses and conditions in workers exposed chronically to relatively high, though non-thermal, levels of that NIR. The obtained data are of direct application to radiation protection in occupational media provided that: 1) help to detect and eradicate practices and situations that result in overexposure; 2) they constitute a basis for the design and development of strategies for exposure control and minimization, and 3) they represent a dosimetric support necessary to properly interpret past and future epidemiologic and experimental data on potential health effects of chronic exposures to MW radiation at work. The described results will be extended through additional dosimetric recordings in other hospitals. The dosimetric data will be compared to the results of questionnaires among the electrotherapists working at the units studied. The objective is to identify potential relationships between exposure doses and specific diseases or level of risk perception among the investigated professional group.

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