Oncological hyperthermia:

working exposure assessment to RF field

Simona Valbonesi[1*], Marina Barbiroli[2], Mario Frullone[1], Ermanno Papotti[3] , Silvia Vaccari[3], and Andrea Vanore[4]

[1]Consorzio Elettra 2000, Pontecchio Marconi, Italy, [2]Department of Electronics, Computer Sciences and Systems – DEIS – University of Bologna, Bologna, Italy, [3]Health Physics Department, University of Parma, Parma, Italy, [4]Prevention and Protection Office – ASL 1, Massa Carrara, Italy

*Corresponding author e-mail: simona@mail.elettra2000.it

Introduction

Hypertermia is a cancer treatment used to support traditional therapy which consist in selectively administer heat through a RF field (13.56 MHz) in order to raise up deep tumor temperature to 42-45°C. Similar to all other irradiation methods, RF fields exposure is not restricted to the target region; scattered fields can lead to potential over exposure of nerby persons, in particular medical staff and nurses [1]. In this paper we evaluated the professional exposure to RF field within Oncological hyperthermia environment. Measurements and evalutations performed have shown that, in condition of maximum exposure Directive 2004/40/EC [2] action values for electric field and limbs induced current can be overrated. The same happens for limits if we consider whole body SAR, while for SAR localised at limbs the limit is exceeded only if we consider SAR_{10} applied to a portion of muscolar tissue.

Materials and Methods

Measurements and evaluations heve been performed on a EHY 2000 Hot-OncoTherm medical equipment installed within Oncologic Dept. of Massa Carrara Hospital. The test protocol involved the measurement of electric field (E) levels and induced current at limbs in different points within the treatment room, starting from the applicator's centre on a 10 cm step diagonal until the room exit door and in conditions of maximum exposure (larger plate applicator at 150 W).

We studied electic field and induced current patterns (at 10-110-150-190 cm from the floor) and we evaluated whole body SAR and SAR_{10} localised at limbs taking into account anisotropies due to tissues differences. At the specific frequency thermal effects are predominant [3,4]; the biological effect are correlated with the absorbed power density, or in an equivalent way, with the current density:

$$J = \sqrt{\sigma P} \qquad (1)$$

Where σ is the electric conductivity and depends on the amount of water contained in biological tissues, on cellular architecture and on RF applied signal frequency.

The dosimetric evaluation have been performed by calculating the SAR, which expresses the power absorbed per unit mass:

$$SAR = \frac{\sigma E^2}{2\rho} \qquad (2)$$

both ρ and σ depend on the intrinsic characteristics of the biological tissue.

We used (2) to evaluate whole body SAR by approximating the whole human body to a a high water content tissue, such as muscle tissue; this kind of approximation leads to a SAR maximization. The frequency depending values of σ were extrapolated using the interactive form developed by IFAC CNR [5] on the basis of the parametric model for biological tissues dielectric properties calculation developed by Gabriel [6,7]. Localized SAR calculation was performed by applying (2) to a limb model based on a series of concentric cylinders composed in the order by: red bone marrow, spongious bone and muscolar tissue.

Results

Electric field (Fig.1) decreases moving away along the diagonal; levels are below Directive 2004/40/EC action values at a distance of about 60 cm from the applicator, ICNIRP limits [8] for general popolation are met only at a distance not inferior to 100 cm from the applicator.

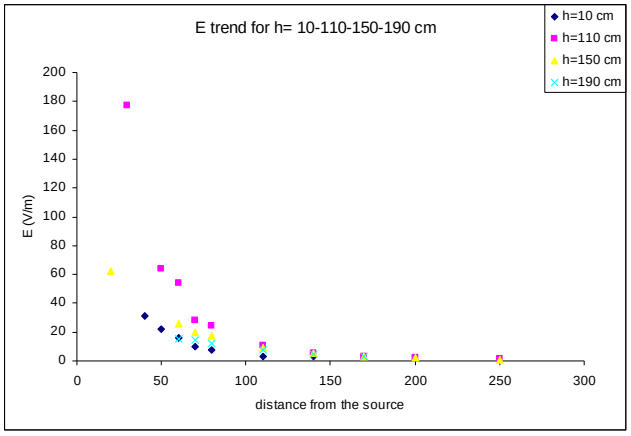

Figure 1. Electric Field at different heights from floor

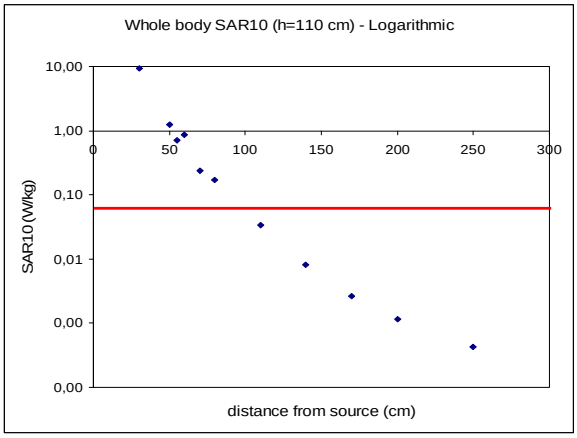

Figure 2. Whole body SAR (h=110)

Whole body SAR exceeds the Directive 2004/40/EC limits up to a distance of 60 cm from the applicator (Fig. 2). For what concern local SAR to upper limbs, in all cases the calculated value does not exceed the 10W/kg limit reported in the Directive, if we consider just muscolar tissue there could be a SAR_{10} overrun when the operator approach the applicator with the hands (the limit is exceeded at 20-25 cm from plate applicator's centre). For what concern lower limbs calculated SAR_{10} values are well below the limit.

For induced current at limbs no action values (100 mA) overtaking has been reported.

Summary and Conclusions

Performed measurements and numerical evaluations have shown that both electric fields level and SARs exceed action values and limits set out in Directive 2004/40/CE for distances up to 55/60 cm from the applicator. From this work results it was possibile to highlight safety/no safety zones for workers and general public within treatment room. If we consider instead the outdoor appliances (corridors, waiting rooms, ecc...) no action values (or limits) overcome have been recorded; electric field levels and SARs are well below limits and action values reported in ICNIRP Guidelines referred to general public.

References

[1] N. Leitgeb, A. Omerspahic and F. Niedermayr, Exposure of Non-Target Tissues in Medical Diathermy. *Bioelectromagnetics,* 31:12-19, 2010.

[2] Commission of the European Union EU 2004 *Physical Agents (Electromagnetic Fields) Directive 2004/40/EC*

[3] World Health Organization *Environmental Health Criteria Document 16 Radiofrequency and Microwaves*; 1981.

[4] World Health *Organization Environmental Health Criteria Document 16 (Revised version). Electromagnetic fields in the range of 300 Hz to 300 GHz*, 1993.

[5] D. Andreuccetti , R. Fossi,, C. Petrucci, Calculation of the Dielectric Properties of Body Tissues in the frequency range 10 Hz - 100 GHz. *IFAC CNR website*

[6] C.Gabriel,, S.Gabriel, Compilation of the Dielectric Properties of Body Tissues at RF and Microwave Frequencies .*Internet document*

[7] M. Zankl, A. Wittman , The adult male voxel Golem segmented for whole body CT patient data . *Radiat. Environ. Biophys* 40: 153-162, 2001

[8] ICNIRP. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). *Health Physics* 74 (4): 494-522; 1998.