Oncological hyperthermia:
working exposure assessment to RF field

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Introduction

Hyperthermia 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
nearby 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 evaluations performed have shown that, in
are overrated. The same happens for SAR limits if we consider whole body SAR, while for SAR localised at limbs the
limit is exceeded only if we consider SAR to 10 applied to a portion of muscolar tissue.

Materials and Methods

Measurements and evaluations have 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 electric field and induced current patterns (at 10-110-150-190 cm from the floor) and we evaluated whole
body SAR and SAR to 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:

\[ J = \sqrt{\sigma P} \]  

(1)

Where \( \sigma \) 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:

\[ SAR = \frac{\sigma E^2}{2\rho} \]  

(2)

both \( \rho \) and \( \sigma \) 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 \( \sigma \)
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 population are met only at a distance not inferior to 100 cm from the applicator.

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 muscular tissue there could be a SAR10 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 SAR10 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 possible 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