EXPERIMENTAL EVALUATION OF RADIATION INTENSITY VARIATIONS CAUSED BY CFMA-LIKE EM APPLICATORS

Gelvich[*2], E.A., Kramer-Ageev[1], E.A., Mazokhin[2], V.N., Mogilenets[1], N.N.
1. Moscow Engineering Physics Institute (MEPhI), Moscow, Russia
2. State Research and Production Corporation "Istok", Fryazino, Russia

Introduction

The highest thermal enhancement ratio (TER) of ionizing radiation efficacy, produced by hyperthermia, occurs when radiation and hyperthermia (HT) act simultaneously (further on – Simultaneous Radiation and Hyperthermia – SRH). The external SRH (ESRH) clinical trials have been pioneered in USA in 1992 [1]. They confirmed the clinical feasibility and efficacy of ESRH. Nevertheless, there remain many problems which need further investigations and development to make this treatment modality clinically significant. Among them is the problem of development of convenient for operation and suited to ESRH hyperthermic EM applicators. We suggested using for this purpose CFMA-like microstrip devices. In our previous study [2] we investigated theoretically the influence of CFMA-like applicators (MA's) on ionizing radiation intensity at the surface of irradiated tissues. It was shown that, if the irradiated tissues are tightly covered with a MA, then at relatively low photon energy (<200 keV) the MA does significantly decrease the low energy ionizing radiation intensity (up to 20–35%), whereas at high energy photons (> 1 MeV) the decrease of radiation intensity, caused by the MA, must not exceed (2–10 %) depending on the photon energy.

The purpose of the study, described below, was to check the theoretically obtained results experimentally.

Materials and Methods

As a subject for investigations, there was chosen a sample from a series of CFMA-SRH microstrip EM applicators especially designed to minimize absorption of the ionizing radiation [3]. Its aperture was equal 190x190 cm^2. Measurements of the applicator's attenuation coefficient were done in three varieties of the applicator configurations: a"dry" applicator (without water in the water bolus); the same applicator with a 1cm thick water layer in the bolus, and with a 2cm thick water layer. Beyond this, analogues measurements were accomplished apart with the silicon applicator frame with the water bolus. As a source of γ-rays there was used Co^{60} ($\tilde{E}$=1.25 MeV), the main source of γ-rays in Russian clinics Since in some clinics are used X-ray installations as yet, the same measurements were done with an X-ray source with an accelerating voltage of 147.5 kV and a beam current of 2mA.The low energy photons of the X-rays were filtered out by a 6mm thick aluminum plate. Thus, the estimated effective energy of the rays beyond the filter was 52 keV.

The Co^{60} γ-source was placed in a *Pb* well with walls 10 cm high and 5 cm thick. The well was covered with a thin (3mm thick) veneer plate. The CFMA-SRH applicator or its silicon frame with a silicon bolus was placed on the veneer plate. The dosimeter of γ-rays

was located above the tested item at a distance of 5cm.The X-rays dose rate was measured by means of an ionization chamber, which was located on a laboratory table in a *Pb* well to eliminate the reflected irradiation. The tested item was placed on the veneer plate over the well. The center of the Roentgen tube anode was located at a distance of 0.5m above the tested applicator (or bolus).

Results of the measurements are presented in Tables 1 and 2.The condition “Applicator” differs from the condition “Silicon frame and water bolus” in that the “Applicator” contains an additional element – the irradiating microwave antenna.

As it follows from Table 1, adding of the antenna does not introduce a noticeably additional attenuation of the γ-rays. Attenuation of the γ-radiation dose produced by the applicator as a whole does not exceed 7% when the water layer in the bolus is 1cm thick and 12% when the water layer thickness is 2cm.

Table 1. Attenuation coefficients of the applicator as a whole and of the silicon frame and water bolus. Co^{60} γ-rays

Conditions	Applicator	Silicon bolus [1)]
Without water	1.03 ± 1.3 %	1.01 ± 1.2 %
Water layer 1 cm	1.07 ± 1.6 %	1.05 ± 1.5 %
Water layer 2cm	1.12 ± 1.7 %	1.125 ± 1.6 %
1) Silicon frame and water bolus		

Table 2. Attenuation coefficients of the applicator as a whole and of the silicon frame and water bolus. *X*-rays, U_{anode}= 147.5 kV; U_{eff}=52kV

Conditions	Applicator	Silicon bolus [1)]
Without water	1.40 ± 1.4%	1.38 ± 1.4%
Water layer 1 cm	1.74 ± 2%	1.68 ± 2%
Water layer 2cm	2.00 ± 7%	1.76 ± 7%
1) Silicon frame and water bolus		

Attenuation of the X-rays by the CFMA-SRH applicator are characterized with attenuation coefficients (AC) shown in Table2. Apart of the high value of AC, there is evident the increasing influence of the water layer. Unlike the previous measurements with γ-rays, there is a significant difference between the AC values of the “Applicator” and “Silicon bolus” measurements with the water layer. We assume that this effect is due to the position of the X-ray source above the water bolus whereas the metallic antenna was under the water layer. Thus, the antenna additionally absorbed the scattered by the water layer low energy photons.

Conclusion

The measured values of the attenuation coefficients of the CFMA-SRH applicator for γ-rays of Co^{60} does not exceed 1.07 with a 1cm thick water layer in the bolus and 1.12 with a 2cm water layer and coincide in the limits of the experimental error with the calculated value in [2]. In case of the X-ray irradiation there is a discrepancy between the calculated and experimentally measured values of about 20%. The reason for this effect can be the mentioned above additional absorption of low energy scattered photons arising due to the structure of the experimental installation. This subject would be examined further.

References:

1. Moros,E.G., et al., 1995, IJH, v.11, No.1; 2.Gelvich,E.A.,Klimanov,V.A.,et al., 2005, ESHO-2005, Abstracts, Graz, June-2005; 3. Mazokhin, V.N., et al., at this ESHO Meeting.

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