METROLOGICAL EVALUATION OF AN APPARATUS FOR ULTRASOUND TREATMENT IN FUNDAMENTAL BIO-EFFECTS RESEARCH

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Abstract: Ultrasound's application in biological tissues and cells in vitro is of great interest as a basic investigation tool to relate thermal and non-thermal bio-effects of ultrasound treatment. In order to accomplish the treatment accordingly to the most recent international guides on good practices on that field of research, a proper metrological evaluation of the apparatus throughout which the ultrasound is applied is a prior demand. The present work details a methodology used to determine physical and metrological ultrasound characteristics of a treatment area for biological materials.

Key words: ultrasound, biotechnology, experimental procedure, metrology.

1. INTRODUCTION

Ultrasound is among the most studied and applied physical interventions in medical imaging diagnostic and therapy practice. However, the bio-effects are much more close to an empirical approach than a methodological and systematic fundamental research [1]. Basically, systematic approaches to bio-effects of ultrasound are divided in thermal and non-thermal effects. Thermal effects produced in tissues are usually derived from continuous mode application [2]. However, the degree of heating depends not only on the intensity of the ultrasound wave but also on the duration of application. The correct settings of those parameters are important to avoid irreversible changes in the biological tissue [3]. Many references standardize the way measurements should be performed to determine particular ultrasonic field characteristics in a particular region of interest or average characteristics of the whole field [4][5][6][7][8][9]. Nonetheless, most researches on biological effects of ultrasound treatment or application do not follow a meticulous procedure to determine and to report the ultrasonic field that is in fact present in the region where the effect is claimed to occur [10].

The present work details a procedure to evaluate the ultrasonic field in a region intended to be used to treat, a priory, any kind of microbiological material, such as in vitro cells' culture or living ex-vivo tissues, for instance.

2. MATERIAL AND METHODS

The main parameters to be defined accordingly to the procedure proposed by this paper are the effective radiation area (Are), total output power (P), spatial-peak temporal-peak Intensity (Isptp), spatial-peak temporal-average Intensity (Ispta), spatial-peak pulse-average Intensity (Isppa), spatial-average temporal-average intensity (Isata), spatial-average pulse-average intensity (Isapa), mechanical index (MI), and thermal index (TI). All parameters are assessed accordingly to [5] and [11]

2.1. Equipment and instrumentation

Measurements were carried out at Inmetro's Laboratory of Ultrasound facilities, as described in [12]. Figure 1 portrays the position system using in the present work.

2.2. Experimental procedure

The parameters were measured both in the near field and in the far field, representing the actual treatment situation that the giga is planned to be use. The experimental procedure followed that one described in [12], i.e., the results were assessed after 4 measurements in repeatability conditions. Uncertainties were assessed accordingly to [12] as well.

For the proposed testing apparatus, the field was mapped using transducers with nominal frequencies of 1.0 MHz, 2.25 MHz and 3.5 MHz.

Fig. 1 (a)

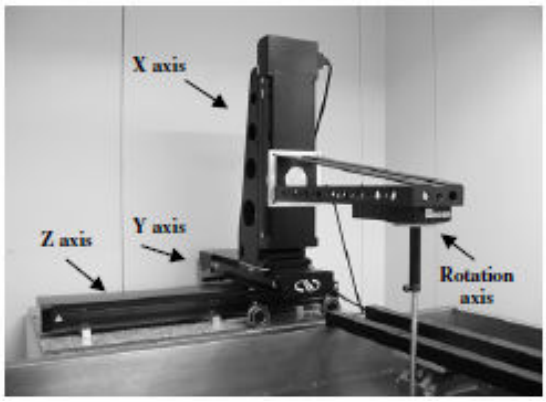

Fig. 1 (b)

Fig. 1. (a) General view of the ultrasonic pressure field mapping system. The water bath can be seen in the background. (b) Details of the positioning system.

4. RESULTS, DISCUSSION AND CONCLUSION

All results will be presented in the complete paper, as it takes a considerable amount of space.

As a general comment, it can be stated that no technical difficult was found to determine the defined parameters, provided that a proper scanning facility similar to the one described in [12] is available.

The procedure showed to be useful to evaluate any ultrasound treatment apparatus, and can generate results regarding ultrasonic field characteristics that can be classified as Level 3 (most reliable) accordingly to [10].

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