TESTING OF BEAM CHARACTERISTICS OF PHYSIOTHERAPY ULTRASOUND TRANSDUCERS BY ANALYZING THERMAL IMAGES

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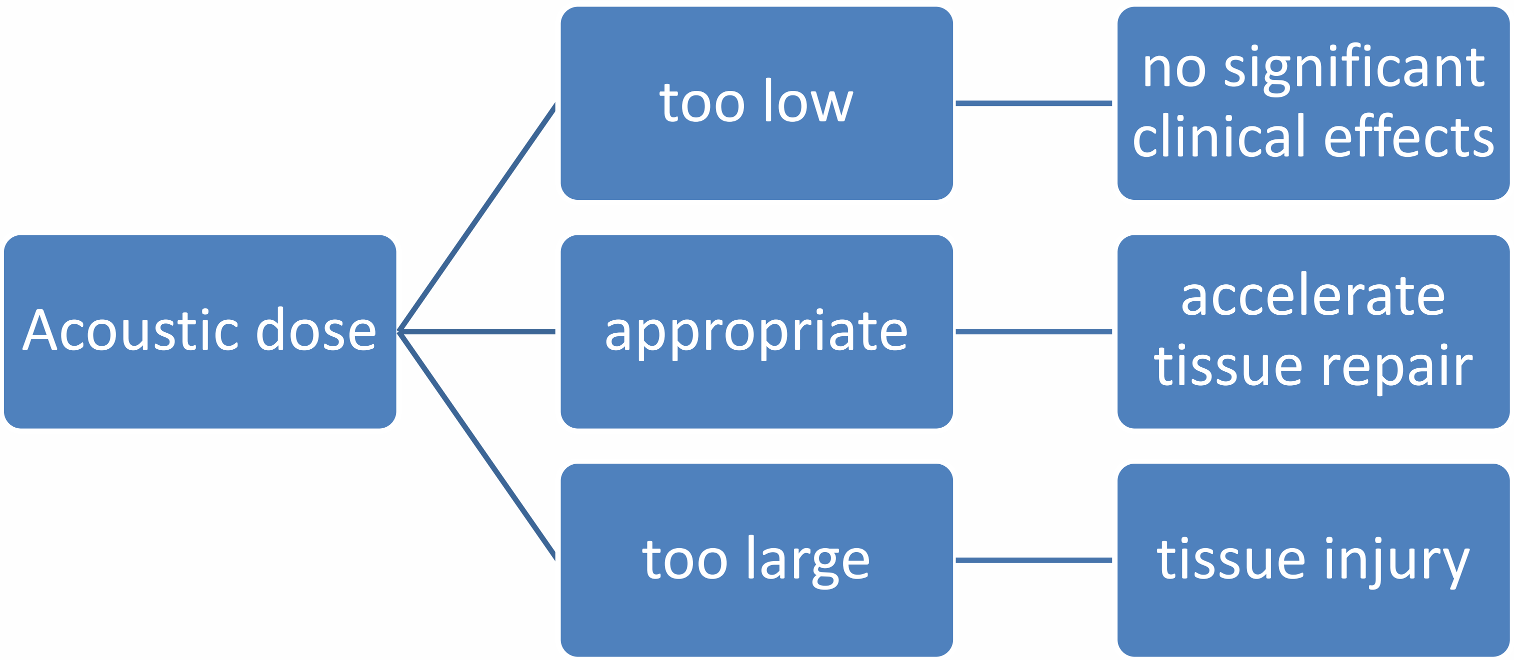
INTRODUCTION

Effects of physiotherapy ultrasound



Quality control of ultrasonic devices is important

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standardize method - ultrasonic pressure field mapping using hydrophones

- require a specially equipped laboratory

an alternative method -

the thermal image technique

- suitable for routine tests in clinical environment

Fig.1. Experimental set-up used in our measurements

Output Requirements for Physiotherapy Ultrasound

- **effective intensity (I)-** ratio of the output power (P) and the **effective radiating area (A_{ER})**

$$I = \frac{P}{A_{ER}}$$

➢ **intensity** of physiotherapy system **is limited to 3 W/cm²**

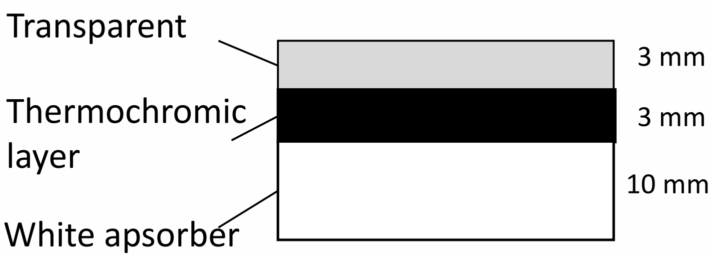
- **beam non-uniformity ratio (R_{BN})-** ratio of the highest intensity to the average intensity.

➢ **if $R_{BN} > 8$ transducer is considered unsafe**

MATERIALS AND METHODS

Materials

- thermochromic tile



- ultrasound transducer
- coupling gel
- digital camera on stand
- ruler
- diffuse lighting

Methods

1. capture “reference image”
2. take “beam profile image” after ultrasonic exposure
3. determination of A_{ER} and R_{BN} using our algorithm for postprocessing of images

RESULTS

Comparison of thermal images obtained for two transducers

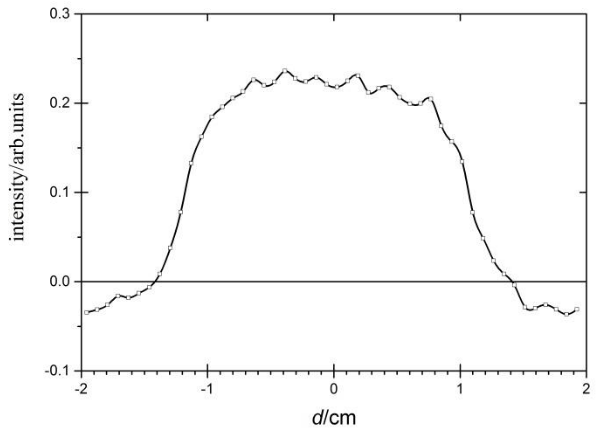
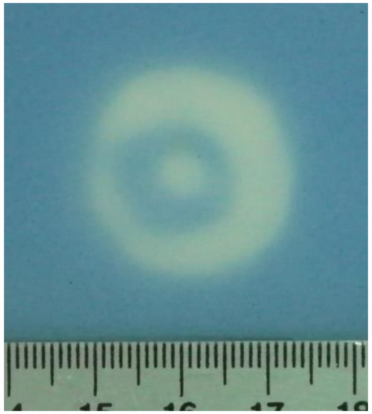


Fig. 2. Thermal image and horizontal beam profile image for transducer with *f* = 3 MHz. *I*=2 W/cm². 5 s ultrasound exposure



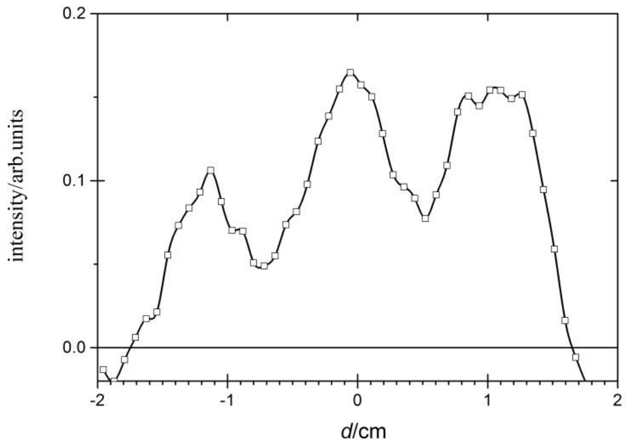


Fig. 3. Thermal image and horizontal beam profile image for transducer with *f* = 3.3 MHz, *I*=2 W/cm², 5 s ultrasound exposure

Beam profiles measured using different intensities for the same transducer

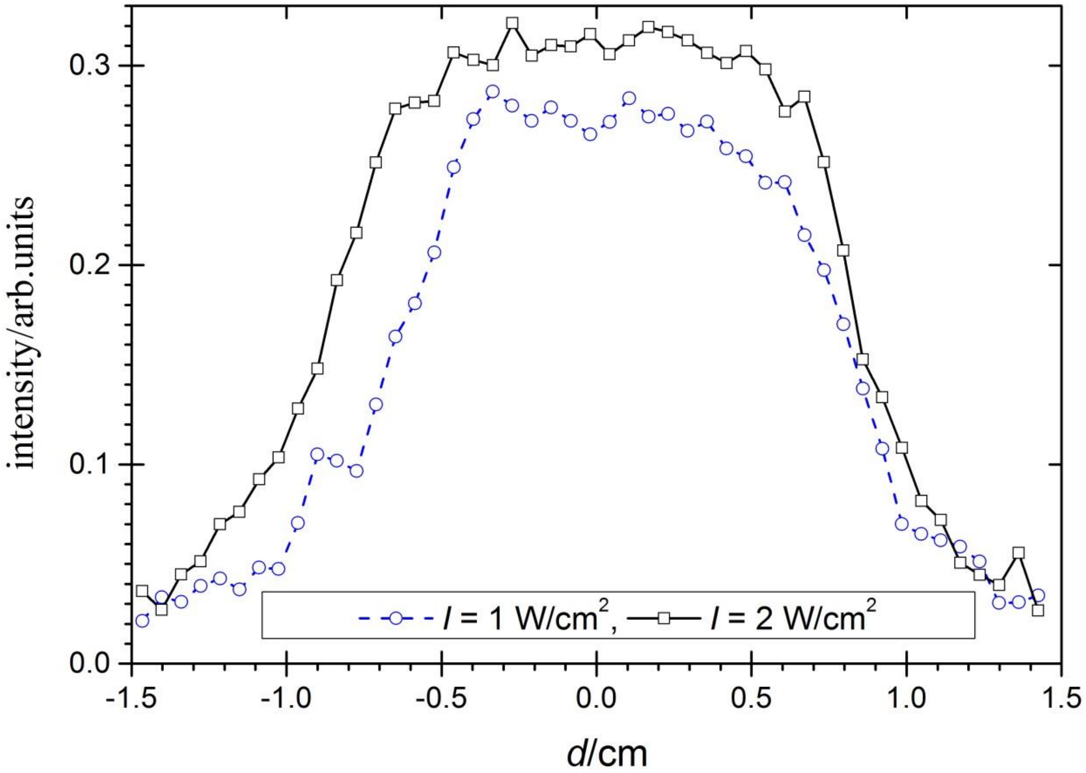


Fig.4. Beam profiles measured using different nominal intensities for the same transducer with f = 1 MHz and 5 s ultrasound exposure.

I / Wcm^{-2}	A_{ER}/cm^2	R_{BN}
1	4.51	2.96
2	4.70	2.79

Changing of thermal image and corresponding beam profiles with time after insonation

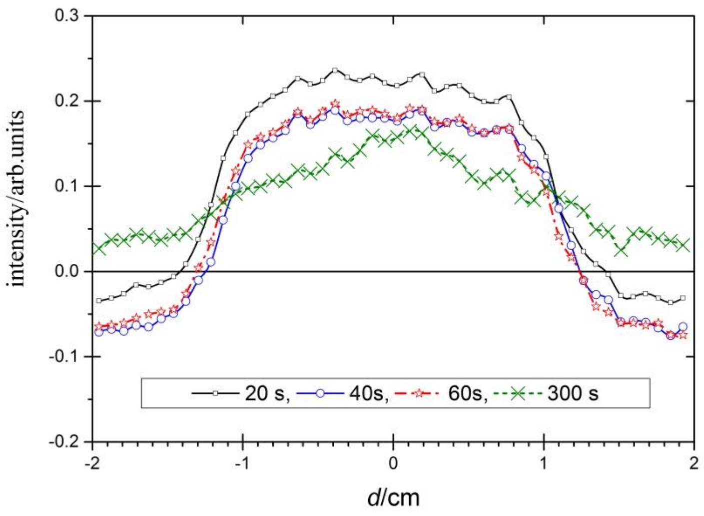


Fig 5. Changing of beam profiles with time passed after insonation for transducer with f = 3 MHz, I = 2 W/cm^2, 5 s ultrasound exposure

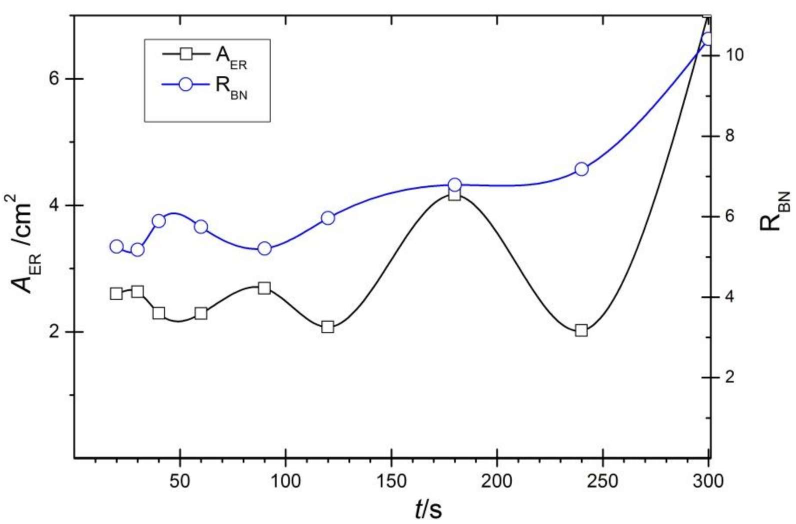


Fig 6. Changing of parameters A_{ER} and R_{BN} with time after insonation.

Changing of thermal image and corresponding beam profiles with time of ultrasound exposure

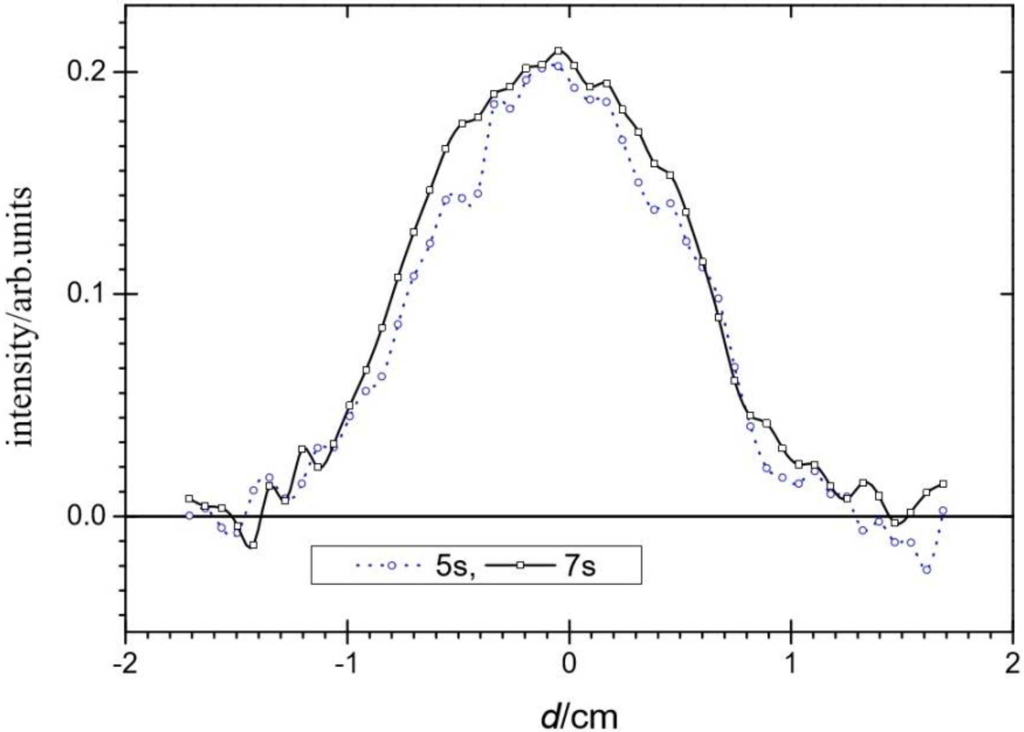


Fig. 7. Thermal images and corresponding beam profiles for different ultrasound exposure durations for transducer with f = 1 MHz, I = 2 W/cm^2

exposure /s	A_{ER}/cm^2	R_{BN}
3*	-	-
5	3.3	3.46
7	3.45	2.78

*Exposure duration of 3 s was too short for obtaining good quality thermal image for determination of A_{ER} and R_{BN}

Conclusions

- thermal image technique can ce used for determination of beam non-unitormity ratio R_{BN} and effective radiating area A_{ER}
- analysis of thermal images gives relatively constant A_{ER} and R_{BN} values during first minute after insonation
- exposure duration of 5s was found to be optimal for transducer working at intensity 2 W/cm^2