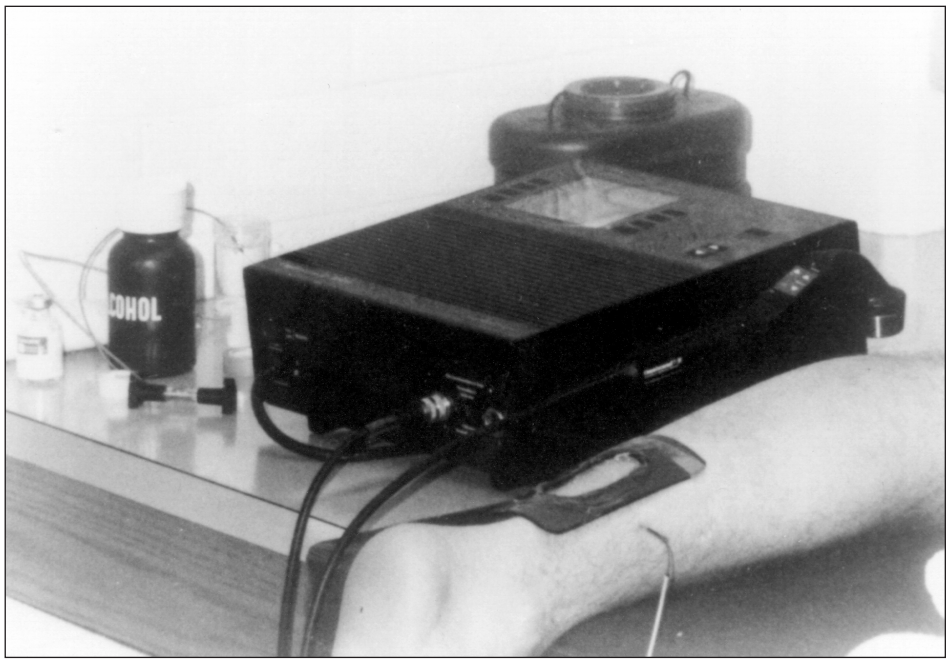
Grant Information Summary:

A Breakthrough on Comfortable Ultrasound Treatment: Beam Non-uniformity Ratio is Only Half of the Equation

Practical Implications:

An effective ultrasound treatment is dependent on the quality of the crystal. A low BNR does not always produce a comfortable treatment, with uniform heating of the tissues. A new term "PAMBNR" defined.



Background

When was the last time you administered ultrasound and the patient complained of pain? One cause of painful ultrasound treatments is using a crystal with a poor beam non-uniformity ratio (BNR). An ultrasound beam is not uniform along its longitudinal axis, but produces some "peaks" or areas of higher than average intensity. The BNR is the ratio between the average intensity (W/cm^2) divided by the peak intensity. I surmised that ultrasound treatment with a high BNR (>5:1) would be painful, whereas a low BNR (<4:1) treatment would be comfortable.

Objective

To compare comfort and peak muscle temperature from ultrasound transducers with different BNR's.

Design and Setting

Double-blind repeated measures on three variables, heat, pain and duration. Data was gathered at Brigham Young University's therapeutic modality research center.

Subjects

36 male student volunteers, had a thermistor inserted 3 cms into their calf muscle.

Measurements

Temperature was recorded each min. during ultrasound treatments (1 MHZ) from 3 transducers (5cm^2) with differing BNR's. Initial intensity was 1.2 W/cm^2, which increased .2W/cm^2 every 2 minutes, for 10 min. or until subjects could no longer tolerate the treatment (ave. intensity = 1.6 W/cm^2). Subjects then rated their tolerance to the treatment using a visual scale (VAS) (0 = no pain, 10 = extreme pain).

Results

The BNR's of each crystal and their respective peak temperature increases, VAS, and treatment duration are displayed in the table. Crystal A was more comfortable than B and C; and it produced appropriate temperatures. Crystals B and C produced hot spots based upon the VAS, treatment duration and higher than expected peak temperatures.

Discussion

Why was transducer C uncomfortable even though it had a low BNR? Even though transducer A and C had similar peak intensities (thus low BNR's), transducer C produced this peak intensity over a larger area of the crystal. Thus, BNR is not the only determination of a comfortable ultrasound treatment, but the amount of area across the crystal where peak intensity occurs must be considered. Thus a more precise definition of beam non-uniformity ratio is *Peak Area at the Maximum* BNR (PAMBNR).

Conclusion

Contrary to what was previously thought, an ultrasound crystal with a low BNR is no guarantee of a comfortable treatment. A low BNR with a small area of peak intensity (PAMBNR) will produce a comfortable treatment at therapeutic temperatures when correct parameters are used.

Table	CRYSTAL A	CRYSTAL B	CRYSTAL C
BNR	2.32:1	7.75:1	2.38:1
Temp. Increase:	3 C	4.2 C	.4.5 C
Pain:	1.45	5.8	6.1
Duration/Min.	10	8.8	9.0
Hot spot area	0.57 cm	0.28 cm	1.42 cm
Total Power	.204W	.277W	.803W
Peak intensity:	3.58 Wcm^2	9.89 W/cm^2	5.65 W/cm^2

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Draper DO, Castel JC, Castel D. Rate of temperature increase in human muscle during 1 MHZ and 3 MHZ continuous ultrasound. *J Orthop Sports Phys Ther.* 1995; 22: 142-150.

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