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7th World Congress of Biomechanics

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John B. Hynes Veterans Memorial Convention Center
900 Boylston Street | Boston, Massachusetts 02215

Presentation Abstract

Session:	Thursday General Poster Session
Presentation:	Nonlinear Derating Method for Estimating the HIFU Induced Temperature Rise in a Tissue Medium
Presentation Time:	Thursday, Jul 10, 2014, 9:00 AM - 5:00 PM

Author(s): **S. A. R. Dibaji**[1], M. R. Myers[2], J. E. Soneson[2], R. K. Banerjee[1];
[1]University of Cincinnati, Cincinnati, OH, [2]U. S. Food and Drug Administration, Silver Spring, MD.

Abstract: Introduction: In assessing the influence of HIFU on biological tissue, semi-empirical mathematical models can be useful for predicting thermal effects. These models require values of the pressure amplitude in the tissue of interest, which can be difficult to obtain. Therefore, techniques for nonlinearly transforming pressure amplitudes measured in water to values appropriate for tissue (nonlinear derating) are desirable. The derated pressures can then be used to estimate the HIFU induced temperature rise in tissue.

Methods: Water pressure amplitudes were obtained by solving the nonlinear KZK equation and suitably reduced using a combination of "source derating" (calculations in water performed at a lower source pressure than in tissue) and "endpoint derating" (attenuating the calculated water pressure by the term $\exp(-\varepsilon n \alpha z)$, where ε is a attenuation number: $0 \leq \varepsilon \leq 1$, n is the harmonic number, α is the tissue acoustic absorptivity and z is the scaled axial coordinate). The reduced water pressure amplitudes inserted as a known quantity into the nonlinear side of the tissue propagation equation. The resulting linear, first-order equations were solved to obtain the modal amplitudes in tissue. The derived tissue pressure harmonics by this method were used in the Green-function solution of the bioheat equation [1], to compute the focal temperature rise ([[unable to display character: ∆]]T) in tissue.

Results: The contours of [[unable to display character: ∆]]T error (difference between the computed focal [[unable to display character: ∆]]T by this derating method and the direct calculation in tissue) are plotted as a function of ε and N_{water} / N_{tissue} (where N is the coefficient of nonlinearity), for gains of 20, 40 and 60. Fig. 1 shows the contours of [[unable to display character: ∆]]T error as a function of ε and N_{water} / N_{tissue}, for gain of 20. The results showed that, with proper combinations of source derating and endpoint derating, [[unable to display character: ∆]]T in tissue could be reproduced by derating within 5% error.

Conclusion: Advantages of the derating approach presented include a) ease of computation and b) readily obtained temperature estimates from the water measurements.

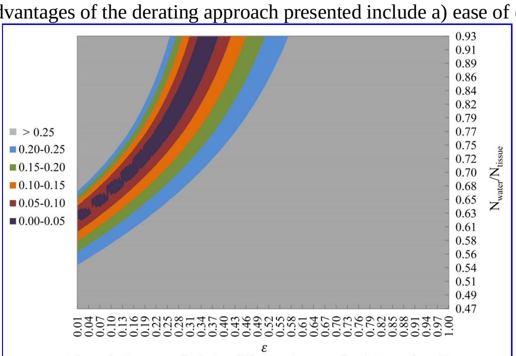

Figure 1. Contours of relative difference between focal ΔT produced by the derating technique and by direct calculation in tissue, as a function of the parameters N_{water}/N_{tissue} and ε, for gain of 20.

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