EFFECT OF ACOUSTICALLY-INDUCED PRESSURES ON THE PERMEABILITY OF A BULLFROG URINARY BLADDER

by

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Abstract

This thesis focuses on understanding the non-thermal effects of ultrasound on the permeability of living tissues, including the effects of cavitation.

For this purpose a device that creates a well-controlled ultrasound field capable of producing spontaneous cavitation at a desire location and at a specific power was needed. In order to accomplish this goal a high-Q acoustic chamber that resonates at a desired frequency was designed based on a finite element method (FEM) fluid structure interaction code (i.e., ATILA). The design required that a biological tissue be immersed inside a highly degassed liquid media to avoid random bubble nucleation. Live frog bladders were used as the living tissue due to their high resistance to hypoxia.

Tissue permeability was measured using two radiolabeled isotopes, ^{14}C-Urea and ^{3}H-D-Mannitol; both of these solutes being hydrophilic and consequently having a high resistance to diffuse through the tissue.

The change in permeability due to the ultrasound was correlated with physical damage to the bladder using confocal microscopy imaging.

A statistical study was conducted to correlate the results considering the wide range of variability in the initial permeability of bladders extracted from different frogs.

An increase in the permeability for Urea and Mannitol was found in all experiments where significant cavitation was present, and recovery did not occur in the absence of ultrasound. For experiments where cavitation was absent there was no evidence for an increase in permeability. Weak increases in permeability were found in experiments where isolated and brief cavitation events occurred; in these cases the initial permeability levels were recovered after the ultrasound was removed.

Imaging results correlated the permeability increase to the level of physical damage to the bladder. A rupture of the tissue was clearly observed in all tissues exposed to continuous cavitation. In contrast, when the permeability was unaltered by ultrasound, no evidence of damage was found. Experiments showing a minor increase in permeability were correlated with isolated cavitation events, and the tissue recovered its initial permeability value after the ultrasound was removed. When inspected with confocal microscopy no damage to these tissue samples was detected.