QUANTIFICATION OF FREQUENCY-DEPENDENT ANGULAR SCATTERING OF ULTRASOUND BY TISSUE-MIMICKING MATERIALS AND EXCISED MAMMALIAN TISSUES

William John Davros

Scattering was measured using the differential scattering cross section per unit volume. A computer controlled apparatus was constructed for doing the measurements.

An accuracy of 13% ($\pm$ one standard deviation) was estimated using low attenuation targets consisting of small glass beads distributed in agar. Frequencies used were 2.0 MHz through 7.0 MHz. Accuracy was independent of scattering angle.

Precision obtainable was $\pm$13% ($\pm$ one standard deviation) for scattering angles between 45$\sp\circ$ and 170$\sp\circ$ at frequencies of 2.25 MHz, 3.5 MHz, 5.0 MHz, and 7.0 MHz. Precision was not a strong function of scattering angle.

Attenuation, speed of sound, density, and scattering as a function of angle were measured from dog liver and human female breast tissue. The results showed that at frequencies of 2.0 MHz and 2.5 MHz forward scattering dominated. At 4.0 MHz the scattering was nearly isotropic. Near backscattering from breast tissue demonstrated a frequency dependence of f$\sp{1.7}$.

Scattering measurements from dog liver tissue were measured from eleven donor livers at frequencies of 2.25 MHz, 3.5 MHz, 5.0 MHz, and 7.0 MHz. Some observations made concerning data from dog liver included, the dominance of forward scattering at 2.25 MHz, and the continual decrease in forward scattering as the frequency increased. Dog liver near backscattering data exhibited a frequency dependence of f$\sp{0.6}$.

Ultrasonic scattering was modeled as a random walk process of vectors on the complex plane. The Rayleigh distribution function p(D) was used as the parent distribution. The signal-to-noise ratio, SNR$\sb{\rm o},$ was found to be a constant 1.91 for the Rayleigh distribution. Data from a target consisting of glass beads in agar were found to conform very closely (SNR$\sb{\rm o}$ = 1.98) in a Rayleigh pdf. Scattering data from dog liver tissue and human breast tissue were tested for conformity to the Rayleigh pdf. Dog liver tissue had a SNR$\sb{\rm o}$ = 2.06 and human breast tissue had a SNR$\sb{\rm o}$ = 2.08. This evidence supported the hypothesis that the scatterers within these two tissues were spatially and randomly distributed, that they were numerous, and that contributions to the total scattering due to coherent effects were small.