Experimental methods for accurate determination of acoustic backscatter coefficients

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Current clinical ultrasound images are qualitative and their interpretation is subjective; i.e., current imaging is system and operator dependent. A quantitative measure of the scattering properties intrinsic to tissue, such as the acoustic backscatter coefficient, would remove system and operator dependencies and allow formation of quantitatively correct images.

We have rigorously tested a method of data reduction for determining acoustic backscatter coefficients from time-gated echo signals. Phantoms with well characterized ultrasonic properties, including their scattering properties, were the basis for these tests. Among these phantoms were some that had low acoustic attenuation, and several that have attenuation coefficients similar to that of most soft tissues.

Initial work appears in the thesis of M. F. Insana, in which the method of data reduction was derived and initially tested. In that work, nonfocused transducers and long duration pulses and time-gates were employed to acquire echo signals from a well characterized phantom placed in the far-field of the pressure beam.

To be a potent clinical tool, however, the method must be proven accurate for a broad range of experimental conditions. A broad range of clinically-relevant experimental tests form the basis of this thesis work. Results obtained with focused or nonfocused transducers excited by narrow-band pulses are independent of transducer-to-scattering-volume distance and time-gate duration. These results are also accurate, typically within 10 percent of values determined independently based on the physical properties of the constituent materials.

A technique was developed that allows accurate determination of backscatter coefficients over the -12dB echo signal band width when broad-band pulses and short duration time-gates are employed. This technique was applied to data acquired with three focused transducers with nominal resonnant frequencies of 1.6, 2.25 and 5 MHz. Results obtained with this broad-band analysis technique are accurate, typically well within the uncertainty of this measurement.