Reference phantom method for acoustic backscatter coefficient and attenuation coefficient measurements

LinXin Yao

In previous work in our laboratory accurate backscatter coefficient measurements were obtained with a data reduction method that explicitly accounts for experimental factors involved in recording echo data. An alternative, relative processing method for determining the backscatter coefficient and the attenuation coefficient is presented here. This method involves comparison of echo data from a sample with data recorded from a reference phantom whose backscatter and attenuation coefficients are known. The ratio of the signals cancels depth-dependent instrumentation factors. This saves the efforts of beam profile computation and various calibrations. The attenuation coefficient and backscatter coefficient of the sample are found from these ratios and the known acoustic properties of the reference phantom.

This method is tested using tissue-mimicking phantoms with known scattering and attenuation properties. Various experiments have been done using clinical scanners with different transducers to compute attenuation coefficients and backscatter coefficients, and to make quantitative images. This method has been found to be accurate for media containing Rayleigh scatterers, as well as samples containing intermediate-size scatterers. Accuracy was maintained over different frequency bands and for a wide range of transducer-to-ROI distances.

Measurements were done in vivo for human livers, kidneys and dog myocardium. The results have shown that the reference phantom method simplifies the measurement procedure as well as keeps the accuracy, and therefore is practical clinically.

Statistical uncertainties propagated in the data reduction have been analyzed in detail. Formulae are deduced to predict statistical errors in the attenuation and backscatter coefficients measured with the reference phantom method. Spatial correlations of the echo signals are also considered. A 2-dimensional lateral correlation matrix is introduced to compute the number of effective independent lines from the acoustic lines acquired by a clinical scanner, and a 1-dimensional axial correlation array is used to estimate the number of effective independent samples along a line. Thus, for a given volume of tissue the uncertainty in the attenuation and backscatter coefficients measured from scattered echo data can be computed.