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Quantitative Ultrasound: Transition from the Laboratory to the Clinic[1]

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There is a long history of development and testing of quantitative methods in medical ultrasound. From the initial attempts to scan breasts with ultrasound in the early 1950's, there was a simultaneous attempt to classify tissue as benign or malignant based on the appearance of the echo signal on an oscilloscope. Since that time, there has been substantial improvement in the ultrasound systems used, the models to describe wave propagation in random media, the methods of signal detection theory, and the combination of those models and methods into parameter estimation techniques. One particularly useful measure in ultrasonics is the acoustic differential scattering cross section per unit volume in the special case of the 180° (as occurs in pulse-echo ultrasound imaging) which is known as the backscatter coefficient. The backscatter coefficient, and parameters derived from it, can be used to objectively measure quantities that are used clinically to subjectively describe ultrasound images. For example, the "echogenicity" (relative ultrasound image brightness) of the renal cortex is commonly compared to that of the liver. Investigating the possibility of liver disease, it is assumed the renal cortex echogenicity is normal. Investigating the kidney, it is assumed the liver echogenicity is normal. Objective measures of backscatter remove these assumptions. There is a 30-year history of accurate estimates of acoustic backscatter coefficients with laboratory systems. Twenty years ago that ability was extended to clinical imaging systems with array transducers. Recent studies involving multiple laboratories and a variety of clinical imaging systems has demonstrated system-independent estimates of acoustic backscatter coefficients in well-characterized media (agreement within about 1.5dB over about a 1-decade frequency range). Advancements that made this possible, transition of this and similar capabilities into medical practice and the prospects for quantitative image-based biomarkers will be discussed.

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