

Effect of split-focus on ultrasound propagation through the rib cage for focused ultrasound surgery

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The presence of the rib cage is greatly hindering the clinical applicability of focused ultrasound surgery (FUS) for various internal organs, including the liver, kidney, and pancreas. The main problems associated with the rib cage are considered to be: a) the strong reflections that occur at the soft tissue/rib interfaces, b) the highly attenuating effects of the ribs, and c) the scattering and diffraction that occurs at the ribs boundaries.

In this study, a 2D ultrasound scanning system was used to directly measure the acoustic field in the focal plane after propagation of focused ultrasound through rib mimicking absorbing material, tissue mimicking phantom with rib anatomy, and porcine ribs. Various acoustic sources were considered, including a single-element bowl transducer (Precision Acoustics, UK), a 208-element bowl transducer and a 1000-element planar matrix transducer (both ExAblate, InSightec, Israel). Numerical simulations were also performed with finite element analysis software (PZFlex, Weidlinger Associates, USA) to investigate the acoustic pattern changes with different geometric configurations.

Due to the defocusing nature of the ribs or rib-mimics, the acoustic pressure level at the focus was substantially reduced. This study quantitatively analyzed the effect of focus-splitting associated with the ribs to provide reference information for further clinical applications.