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Towards the modeling of high-frequency ultrasound scattering from cells

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High-frequency ultrasound is a novel method to detect cell death based on changes in cell morphology that cause alterations in the acoustic properties of cell ensembles in tissues. In previous work, our group has suggested that for cells with a nucleus to cell volume ratio of 0.33, the backscatter response from single cells was best modeled as a fluid sphere. However, for cells with a larger nucleus, neither the fluid nor the elastic sphere models showed a good agreement. We hypothesize that cells with a large nucleus ratio (> 0.33) may be modeled as an elastic sphere surrounded by a fluid shell. In this work, the backscatter response from non-nucleated cells (Strongylocentrotus purpuratus oocytes) was measured Experimental RF lines were acquired using the VisualSonics VS40B ultrasound biomicroscope using 20 and 40 MHz transducers. A finite-element model of wave propagation was developed to solve high-frequency ultrasound scattering from spheres. A very good agreement was found suggesting that the cytoplasm of the oocytes is of fluid nature. Finally, a finite-element model treating the cells as having an elastic nucleus surrounded by a fluid shell is compared to experimental measurements. The implications of these findings on the prediction of ultrasound backscatter from cells are discussed.