Perfusion Effects in Magnetic Resonance Guided Focused Ultrasound Thermal Therapy

Shannon M. Bragg-Sitton, R. Jason Stafford, and John D. Hazle
UT M .D. Anderson Cancer Center
Houston, TX

Focused ultrasound surgery has been investigated as a therapy for nearly as long as ultrasound has been used as a diagnostic tool. However, its application has been limited and its success diminished without accurate guidance and tracking techniques to assess tissue damage during sonication. Magnetic resonance (MR) imaging offers solutions to both of these issues. The proton resonance shift is temperature sensitive, resulting in a phase shift in gradient echo images that is linearly proportional to the change in temperature. By acquiring images before, during, and after sonication, the temperature elevation in the treatment region can be mapped over time. Knowledge of the temperature tolerance of a given tissue can then be used to determine the extent of tissue damage. Data have been collected from several tissue models, including paraspinal muscle and kidney cortex in a rabbit. Sonication was performed both with the animal anesthetized and post-mortum to determine effects of heat dissipation by blood perfusion on thermal lesion development. Complex difference phase images were calculated from the real and imaginary image reconstructions at different times following the start of sonication. These data were used to track phase changes over time. Analysis of these results correlated well with the size and location of lesions that were observed in post-sonication pathology studies.