Assessment of Histotripsy Liquefaction with Multi-Modal Imaging In Vitro

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Introduction and Purpose

- Histotripsy liquefies tissue via mechanical action of bubble clouds
  - Treatment of liver, kidney, prostate, thrombosis
- Multi-modal image guidance could improve clinical translation and treatment outcomes
  - Diagnostic ultrasound imaging visualizes bubble cloud activity
  - MRI visualizes changes in tissue structure

Materials and Methods

- Construct agarose phantoms with 15% v/v porcine red blood cell layers
- Initiate 1 MHz histotripsy insonations of 13 – 25 MPa peak negative pressure, 100 Hz pulse repetition frequency, 5 cycle pulse duration
- Acquire B-mode ultrasound and passive cavitation imaging (PCI) data during insonation
- Acquire 3T MR T1, T2W images, and T1, T2, and ADC maps
- Section phantoms and register liquefaction zones with diagnostic ultrasound/MRI images
- Assess prediction of liquefaction from diagnostic ultrasound imaging or MRI via ROC analysis

Results

- Phantom liquefaction, high PCI power and B-mode grayscale, and changes in MR parameters correlated well spatially
  - T1 increased in the liquefaction zone, and T2 exhibited spatially varying changes
  - Largest changes in T2 corresponded to areas of low PCI/B-mode grayscale intensity
  - T2W and gross imaging indicated changes in structure of the liquefaction zone as peak negative pressure increased
  - Areas under the ROC curve (AUCs) were significantly greater than 0.5, indicating improved prediction of liquefaction locations over guessing for all imaging modalities

Conclusions

- Ultrasound and MR imaging supply complimentary information regarding histotripsy liquefaction
- Multi-modal imaging with diagnostic ultrasound and MRI may improve assessment of histotripsy treatment zones
- This in vitro study is limited in its approximation of actual tissue liquefaction, and the results presented should be validated with in vivo studies

References


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