## Magnetic Resonance-guided High-Intensity Focused Ultrasound for mild hyperthermia therapy of pelvic targets in an *in vivo* Porcine Model

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### Background, Motivation, and Objective

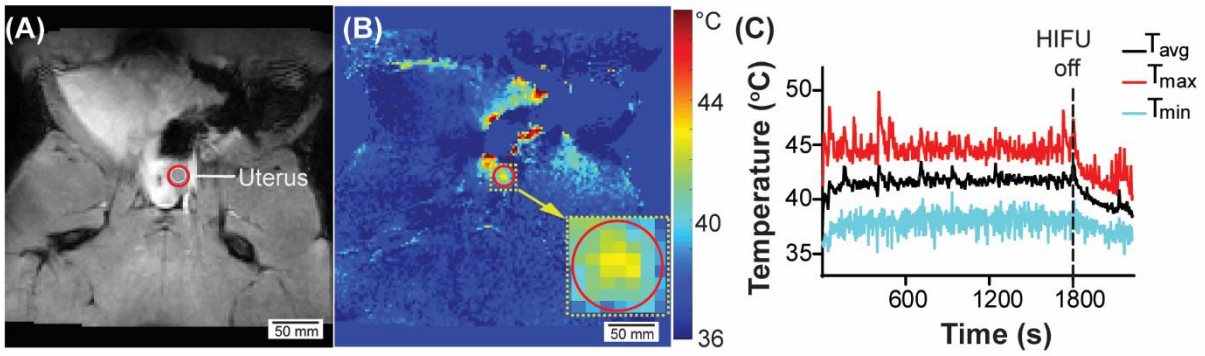
Mild hyperthermia (MHT), which refers to increasing the tissue temperature to 40–45°C for an extended period of time (up to 1 hour), has been reported to be one of the most effective sensitizers for radiation therapy and chemotherapy. The objective of this study was to assess the feasibility and safety of delivering localized and accurate MHT to pelvic targets using a clinical magnetic resonance-guided high-intensity focused ultrasound (MRgHIFU) system in an *in vivo* porcine model.

### Statement of Contribution/Methods

14 MHT sessions were delivered to 1-3 sites in 6 pigs using a clinical MRgHIFU system (Sonalleve V2, Profound Medical Inc.). MHT target sites were: muscle adjacent to the ventral or dorsal urinary bladder wall, and the uterus. A region of interest (ROI) with a diameter of 18 mm was selected based on the MR images (Fig. A). The targeted temperature was 42°C and treatment duration was 30 min. Temperature maintenance via feedback control was provided by multi-plane MR thermometry acquired every 3.7s. The acquired MR thermometry images were quantified using the following metrics calculated within the ROI: the spatial mean temperature ($T_{avg}$), the maximum temperature ($T_{max}$), the minimum temperature ($T_{min}$), the temperature that only 10% of the pixels reached ($T_{10}$), the temperature that 90% of the pixels reached ($T_{90}$), and the spatial standard deviation of the temperature of all the pixels within the ROI ($\sigma_T$). Contrast-enhanced T1-weighted MRI and gross pathology were performed to assess thermal damage.

### Results/Discussion

The tissue within the ROI was heated homogeneously and stably (Fig. B&C). Across all MHT sessions, the average difference between $T_{avg}$ and target temperature was 0.45°C. The temporal average of $\sigma_T$ was 1.54°C. The average $T_{avg}$ variation during 30-min was 0.80°C. The temporal average of the largest difference between the $T_{avg}$ to either $T_{10}$ or $T_{90}$ was 2.10°C. The average time for $T_{avg}$ to reach >41°C or to cool to <40°C was 57.10 s and 51.90 s, respectively. No abnormally-perfused tissue within the ultrasound beam path was detected on MRI, nor was any thermal damage evident on gross pathology. This study demonstrated that MRgHIFU MHT can be locally and accurately administered to a variety of clinically-relevant pelvic targets.




(A) ROI (red circle) selected on the MRI axial view of the pelvic region. (B) The representative average temperature map of a 30-minute MHT session of the uterus. (C) Representative temperature curves including $T_{avg}$, $T_{max}$, and $T_{min}$ of a MHT session of the uterus.