Analysis of Endogenous Tissue Sodium Concentration in Human Prostate Cancer as a Biomarker of Tumor Aggression

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Introduction: Over-treatment of prostate cancer (PCa) is a persistent problem in men’s healthcare [1,2]. It consumes limited healthcare resources and reduces the quality of life for patients as most men will die with this disease rather than as a result of it [3,4]. Reliable lesion detection and characterization is required to classify patients for immediate treatment or active surveillance. The goal of this study is to determine whether tissue sodium concentration (TSC) assessed by sodium MRI is related to tumor grade in patients with PCa.

Methods: Imaging data were acquired from ten men with biopsy-proven PCa. This included in vivo multi-parametric MRI and sodium MRI obtained at 3 Tesla. Post surgery, fiducial markers were added to the prostates for ex vivo MRI and histology. Ex and in vivo images were manually co-registered prior to integration with histology data for analysis. Sodium images were acquired using a custom endorectal (ER) receive-only radio frequency (RF) coil and an asymmetric transmit-only birdcage RF coil. A normalization procedure was used to correct the receive sensitivity profile of the sodium ER coil [5]. Absolute TSC was computed from the normalized sodium images using three vials containing known concentrations of saline solution, which were incorporated into the ER coil as reference standards. Prostate lesions were contoured by a pathologist on four histological sections and assigned a Gleason score. The corresponding average TSC was calculated for each lesion in the peripheral zone of the prostate and compared with TSC for healthy peripheral zone tissue.

Results: Full data analysis has been completed for 3 of 10 subjects. TSC measurements ranged from ~65 mM in healthy prostate to over 100 mM in Gleason 4 lesions. Percent changes in measured TSC were calculated as: \(100 \times \frac{\text{TSC}_{\text{Lesion}} - \text{TSC}_{\text{Healthy}}}{\text{TSC}_{\text{Healthy}}}.\) Percent changes have a positive correspondence with Gleason score for all subjects. A statistically significant difference in TSC measurements was observed between highly aggressive lesions (≥ Gleason 4+3) and moderately aggressive lesions (≤ Gleason 3+4).

Discussion: These preliminary results suggest that TSC assessed by sodium MRI has utility for non-invasive characterization of prostate lesions. Improved detection and characterization of prostate lesions using new imaging methods such as sodium MRI could help increase the confidence of men with early-stage disease to choose active surveillance instead of radical treatment.