SATURATION DURATION AND POWER OPTIMIZATION FOR APT MRI OF PROSTATE CANCER

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Target Audience: Radiologists, physicists and data scientists focusing on the novel intrinsic MRI contrast for prostate cancer.

Purpose: A preliminary study has shown that Amide proton transfer (APT) MRI bears the potential to localize and stage prostate cancer due to the difference in protein content and/or pH in tumor tissue as compared to normal prostate tissue[1,2]. However there are multiple parameters such as saturation power and saturation duration that affect the APT MRI contrast [3]. These effect are also expected to vary over different tissue types. In this work, the effect of saturation length and saturation power on APT value for prostate cancer was studied.

Methods: The IRB approved study included 23 patients who underwent multi-parameteric prostate (mp-)MRI on a clinical 3T MRI scanner with 2-channel RF transmission (Achieva 3T-TX, Philips Heathcare, Best, NL) using the anterior half of a 32 channel cardiac coil (Invivo; Gainesville, FL, USA) and an endorectal coil (BPX-30, Medrad, Pittsburgh, PA, USA). Suspicious lesions were identified on clinical mp-MRI and were biopsied using TRUS/MRI fusion guided biopsy. In addition to clinical mp-MRI, multiple 2D APT MRI were obtained– for 12 patients using different saturation durations (Saturation durations: T_{sat}=0.6sec, 1.0sec, 2.0sec and 3.0sec at a saturation power of 2uT) and for the other 11 patients with different saturation power levels ($B1_{rms}$=0.5uT, 1.0uT, 1.5uT, 2.0uT and 2.5 uT with a duration of T_{sat}=2sec) in a single-shot FSE sequence. Arbitrary long saturation with a duty cycle of 100% using 100 ms pulse-elements was achieved by alternated activation of the RF transmission channels[4]. The 2D slice for APT MRI was planned in axial orientation over the dominant lesion of prostate identified by the radiologist using T2W and ADC images during the scanning session. Single shot FSE data acquisition was used to acquire a Z-spectral series of MRI images at 21 equidistant saturation frequencies from -5ppm to +5ppm and one off-resonant saturation (-1560 ppm) for normalization. Dual-echo GRE B0 maps were obtained prior to the APT data acquisition. Z-spectra for each pixel were obtained by fitting a 13th-order polynomial to the B0-corrected image series. Magnetization transfer asymmetry (MTR) was also computed. ROI over whole prostate and suspicious cancerous region was drawn.

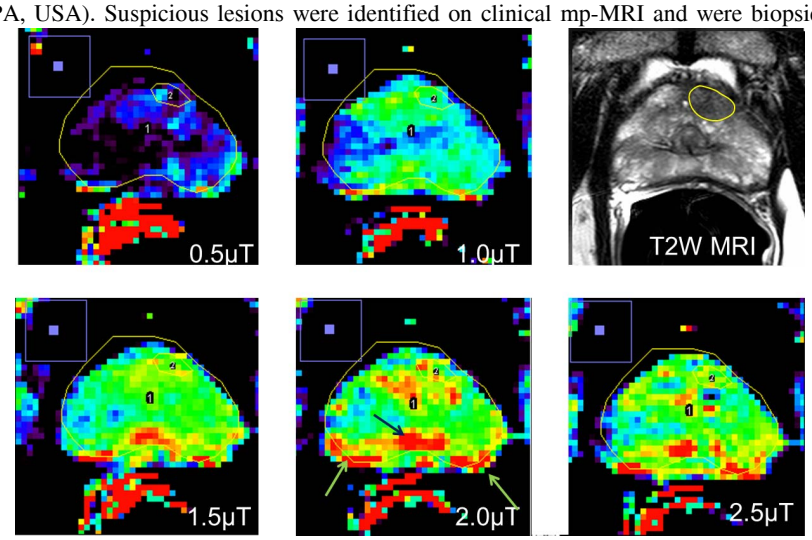

Fig 1: Gleason 6 tumor(green roi in T2WMRI) and whole tumor marked for a patient with PSA 6.69ng/ml. APT images (3.5ppm) obtained with saturation duration Tsat=2 sec and $B1_{rms}$=0.5μT, 1.0μT, 1.5μT, 2.0μT and 2.5μT. High APT contrast over urethra (purple arrow in 2.0μT) and spurious APT in PZ (green arrows in 2.0μT) is marked.

Results: APT weighted image (MTR asymmetry at +3.5ppm) for an example patient with varying saturation power at T_{sat}=2sec is shown in Fig 1. The MTR asymmetry and Z-spectral curves for varying saturation power and duration are shown in Figure 2. MTR asymmetry peaked at 3.5ppm offset frequency suggesting a strong APT signal over the cancer ROI at $B1_{rms}$=2μT. However the peak shifts with different saturation power levels. The MTR asymmetry decreases with the increase in T_{sat} from 0.6sec to 3.0sec. The level of MTR asymmetry increased with the increase in saturation power from 0.5μT to 2.0μT. At a higher power level, the saturation frequency of the peak MTR asymmetry shifted to larger offsets with the increase in saturation power.

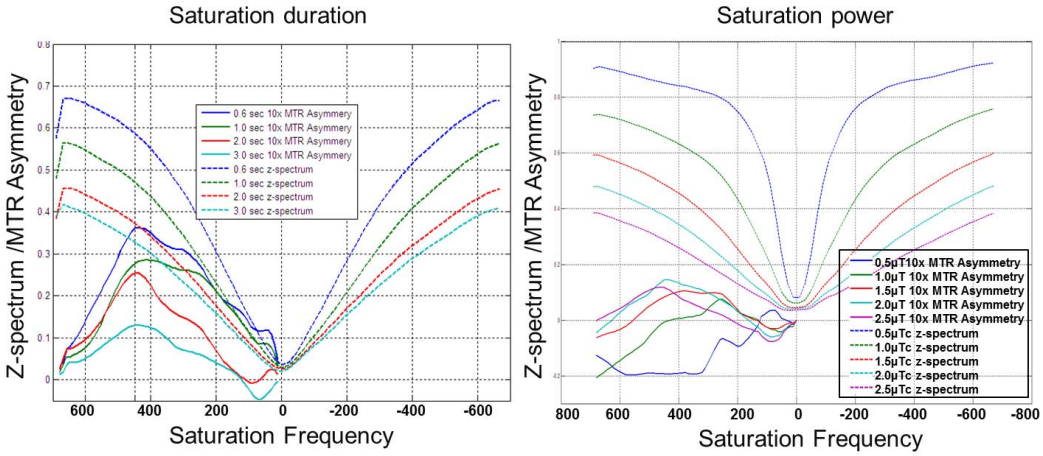

Fig 2: Mean MTR asymmetry and 10 time scaled z-spectrum curves for cancer ROI of all the patients over the saturation frequency of -5ppm to 5ppm. Left hand side: T_{sat}= 0.6sec, 1.0sec, 2sec, 3.0sec. (B1=2.0μT). Right hand side:$B1_{rms}$=0.5μT, 1.0μT, 1.5μT, 2.0μT and 2.5μT (T_{sat}= 2sec).

Discussion and Conclusion: APT MRI contrast of prostate cancer changes with the duration and power of the saturation RF pulse. MTR asymmetry increased with the decrease in the pulse duration. Also the peak of MTR asymmetry shifted with the change in saturation power suggesting different exchanging protons were targeted at different saturation power. Spurious MTR was observed over prostate especially in peripheral zone which could be due to the incoherent rectal spasm and bladder filling motion. Further study is required to compensate the artifacts arising due to incoherent motion and validate the optimal saturation parameter choice for APT based tumor tissue characterization.

References: [1] Jia G.. et al. JMRI 33.3 (2011): 647-654. [2] Jia, G et.al. ISMRM 2013 : 2531. [3] Togoao, O. et.al. ISMRM 2012 : 0744. [4] Keupp J. et al. ISMRM 19:710(2011).