

³¹P MRSI as an Early Indicator of Response to Radiation Treatment in Liver Cancer

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Introduction: Phosphorous Magnetic Resonance Spectroscopic Imaging (³¹P MRSI) is a noninvasive tool that has been shown to differentiate the phosphorous metabolic profiles of healthy and malignant liver tissue [1]. This pilot study investigates whether ³¹P MRSI has the potential to identify treatment response much sooner (e.g., within 1 month) than conventional methods. In contrast, the standard RECIST criteria to monitor response can take up to 6 months to show response to radiation therapy, often with ambiguous or erroneous results. By looking at the change in ratio of the phosphomonoester (PME) and phosphodiester (PDE) peaks between pre- and post-treatment, we have predicted the response of patients undergoing radiation therapy for hepatocellular carcinoma (HCC) one month post-treatment.

Methods: HCC patients undergoing stereotactic body radiation therapy (SBRT) or selective internal radiation therapy with yttrium-90 (⁹⁰Y) were recruited for this study. All subjects gave written informed consent prior to participating. ³¹P MRSI data (16x16 matrix, FOV=400x400x30 mm³, TR = 1 s, TE=2.3 ms) was acquired on a 3T whole-body scanner (MAGNETOM Trio, A Tim System, Siemens Healthcare, Germany) using a dual-tuned 8-channel ¹H/³¹P array coil [2]. Both healthy volunteers and several patients were scanned multiple times pre-treatment to determine the systematic variation in spectroscopic data acquisition and quantification, which led us to set a 25% change in PME/PDE ratio as an indicator threshold: If the PME/PDE ratio was found to have decreased by more than 25% between the pre- and post-treatment scans, then the patient was predicted to be responding positively to the treatment. For analysis, the spectra were preprocessed offline in jMRUI and were quantified with AMARES [3].

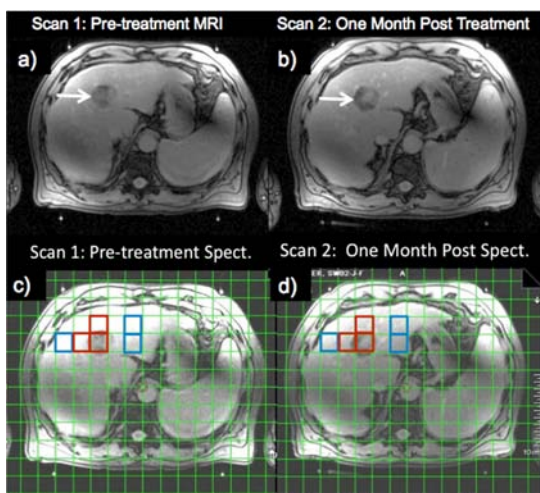


Figure 1: Pre (a) and 1-month post (b) treatment MRI scans of a HCC patient, showing ambiguous results. ³¹P MRSI setup for the same patient pre (c) and 1-month post (d) treatment. Red boxes indicate tumor-containing voxels and blue boxes indicate healthy voxels used for analysis.

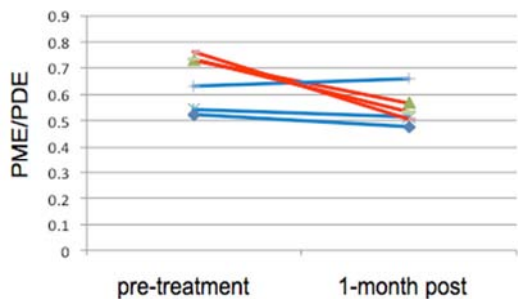


Figure 2: A 27.8% decrease in PME/PDE ratio can be seen for the cancer tissue (red), compared to a 6.3% variance in the healthy tissue (blue), indicating a positive response to the treatment.

Results: Figure 1 shows a patient receiving SBRT treatment whose response was ambiguous one month after SBRT treatment according to the RECIST criteria. Figure 2 shows the change in PME/PDE ratio in tumor-containing voxels between pre- and post-treatment for this patient, noting a 27.8% decrease in the post treatment evaluation, compared to a 6.3% variance in healthy tissue voxels. Five months later, this patient was confirmed as responder by RECIST criteria. Our results from five other patients (two treated with SBRT and three treated with ⁹⁰Y) show that ³¹P MRSI was capable of correctly predicting radiation therapy treatment response in all six cases so far.

Discussion/Conclusion: Our preliminary results show that ³¹P MRSI is potentially a valid technique for monitoring early treatment response. There appears to be a strong correlation between one-month post-treatment ³¹P MRSI prediction when compared with six-month RECIST analysis, indicating that the ³¹P MRSI-based technique is superior in assessing and predicting early response of HCC compared to conventional imaging-based analysis. Decreasing the long scan times and accounting for respiratory motion could allow for reduction in the current systematic variation, allowing for improved sensitivity. Additional patient data is currently being acquired to build on the promising results of this pilot study for further validation using a rigorous statistical analysis.

References

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