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Using Quantitative Susceptibility Mapping (QSM) for Detection of Brain Tumor in Mice

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ABSTRACT

Many cancer imaging studies focus on individual biomarkers such as oxygenation, pH, or relaxivity, whereas tumor microenvironments are defined by complex interactions among multiple parameters. To support future treatment-response assessment, we aim to develop a multiparametric imaging library incorporating pH-derived habitats. In this preliminary study, six mice were imaged at 7T using a Bruker MRI system with a cryogenic probe. Quantitative susceptibility mapping (QSM) and R2* measurements were derived from multi-echo gradient-echo acquisitions and analyzed within matched tumor and healthy brain tissue regions. Median QSM values were higher in tumors (0.0166 ppm) than in healthy tissue (0.0105 ppm), while median R2* values were also elevated in tumors (44.0 s^{-1} vs. 33.7 s^{-1}). However, correlations between tumor and healthy tissue measurements were weak, and statistical testing showed no significant differences (QSM: r = 0.0783, p = 0.317; R2*: r = −0.021, p = 0.553). These preliminary results suggest that tumors exhibit modestly increased susceptibility and R2* values relative to healthy tissue, although larger studies are needed to establish the statistical significance and clinical utility of these biomarkers within multiparametric tumor habitat analyses.

INTRODUCTION

The magnetic susceptibility of biological tissues is of considerable clinical and research interest because it provides insight into underlying physiological and pathological processes, including iron accumulation, blood oxygenation, myelination, and tissue microstructure[1–3]. Quantitative susceptibility mapping (QSM) is an advanced magnetic resonance imaging (MRI) technique that reconstructs spatial distributions of magnetic susceptibility from phase information obtained in gradient-echo acquisitions[4]. By exploiting subtle magnetic field perturbations generated by susceptibility differences among tissues, QSM enables noninvasive and quantitative assessment of tissue composition with high spatial resolution. Over the past decade, QSM has demonstrated significant potential in the detection and characterization of a variety of neurological disorders, including traumatic brain injury, multiple sclerosis, neurodegenerative diseases, cerebral microbleeds, and vascular abnormalities[5-8]. In addition, QSM-derived measurements have been shown to correlate with important biological markers such as iron concentration and deoxygenated blood content, making the technique valuable for investigating disease mechanisms and progression.

Despite these advances, relatively few studies have explored the application of QSM in preclinical animal models, where high-field MRI systems provide opportunities for improved spatial resolution and enhanced susceptibility contrast. Preclinical imaging is particularly important for evaluating emerging biomarkers and understanding the biological basis of imaging findings before translation to clinical practice. Brain tumors can alter the local magnetic environment through changes in vascularity, hemorrhage, oxygenation status, and iron metabolism, all of which may be detectable using susceptibility-based imaging techniques. Furthermore, R2* mapping, which is sensitive to magnetic field inhomogeneities arising from similar tissue properties, may provide complementary information to QSM regarding tumor microenvironment characteristics. In this poster presentation, we investigate the feasibility of using QSM and R2* mapping to differentiate tumor tissue from healthy brain tissue in a mouse model and evaluate their potential as imaging biomarkers for tumor detection.

METHODS AND MATERIALS

A total of 6 mice were scanned on a 7 Tesla horizonal magnet (Agilent Technologies) using Bruker electronics (BioSpec AV3HD) with a cryogenic probe. The mice were injected with tumors two weeks prior to the imaging session. Coronal T2-weighted images were acquired with a TurboRARE sequence using TR=6.6s, TE=65ms, flip angle of 15°, FOV of 20x20mm^2, matrix size of 256x256, 15 slices with 0.5mm slice thickness to cover the entire brain, and a RARE factor of 24. For QSM calculation, coronal T2* images were acquired using a 3D multiple-echo gradient-echo sequence with the same positioning. FOV and resolution were TR=34ms, flip angle of 15°, 7 echoes, TE1=3.16ms and ΔTE=4.25ms.

For image reconstruction, raw magnitude and phase images of all echoes were processed using an open-source Matlab package developed by Bergen et al from Johns Hopkins University[9] with the standard FMRIB Software Library (FSL)[10] for brain mask generation. QSM maps were calculated by applying Laplacian-based phase-unwrapping[11] followed by sophisticated harmonic artifact reduction for phase data with variable spherical kernels" (V-SHARP)[8,12] to correct for background fields. ROIs of the same size were drawn in imageJ around tumor sites and in healthy brain tissues to calculate the mean susceptibility fields and R2*. Bland-Altman analysis and p-test were then performed to study the statistical difference of the measurements.

RESULTS

Figure 1(A) shows a representative T2-weighted slice of one of the mice scanned with tumor segmentation shown as a red overlayed circle. **Figures 1(B)** and **1(C)** show the corresponding QSM and R2* maps, respectively. **Figure 2** shows the box plot comparing the QSM values inside the tumors across 30 ROIs in all 5 mice with those in healthy brain tissues. Specifically, the tumors showed a median QSM of 0.0166ppm, with 25% to 75% range of 0ppm to 0.0378ppm and lower and upper adjacent of -0.0581ppm and 0.0958ppm, respectively. The healthy tissues had a median QSM of 0.0105ppm, with 25% to 75% range of 0.0011ppm to 0.0233ppm and lower and upper adjacent of -0.0318ppm and 0.0558ppm, respectively. The Pearson's correlation coefficient was 0.0783, and the p-value was 0.317. **Figure 3** shows the box plot comparing the R2* values inside the same ROIs across tumors and healthy tissues. Specifically, the tumors showed a median R2* of 44.0s^{-1}, with 25% to 75% range of 33.2s^{-1} to 55.2s^{-1}, and lower and upper adjacent of 14.4s^{-1} and 87.9s^{-1}, respectively. The healthy tissues had a median R2* of 33.7s^{-1}, with 25% to 75% range of 24.1s^{-1} to 46.4s^{-1} and lower and upper adjacent of 1.6s^{-1} and 61.1s^{-1}, respectively. The Pearson's correlation coefficient was -0.021, and the p-value was 0.553.

RESULTS (Continued)

Discussion & Conclusion

In this poster presentation, we showed a preliminary study of utilizing QSM for tumor detection in mouse brain in a pre-clinical setting. The tumor site showed on average slightly higher QSM values, with a higher degree of variation due to the inhomogeneous nature of the tumor. R2* values in the tumors were significantly higher than those in healthy tissues, with a similarly larger variation. However, the p-tests on both QSM and R2* showed weak statistical significance to support the use of QSM as a biomarker to detect the presence of brain tumors.

In future studies, a bigger subset of animals with different tumor volumes should be investigated in order to find a meaningful correction. The QSM sequence parameters should also be optimized for higher quality results. T1 mapping, perfusion and oxygenation measurements should also be implemented to build a library of multi-parametric data to aid tumor detection.

REFERENCES

1. K Deh et al, JMRI 2018
2. A Deistung et al, NMR Biomed 2017
3. MH Beauchamp et al, Cortex 2013
4. Y Wang et al, MRM 2015
5. A Gozt et al, Neuroscience 2021
6. C Wisnieff et al, MRM 2015
7. Y Wang et al, MRM 2015
8. K Shmueli et al, MRM 2009
9. JMG van Bergen et al, Am J Neuroadiol 2016
10. MA Schofield et al, Opt Lett 2003
11. M Jenkinson et al, NeuroImage 2012
12. PS Ozbay et al, NMR Biomed 2017

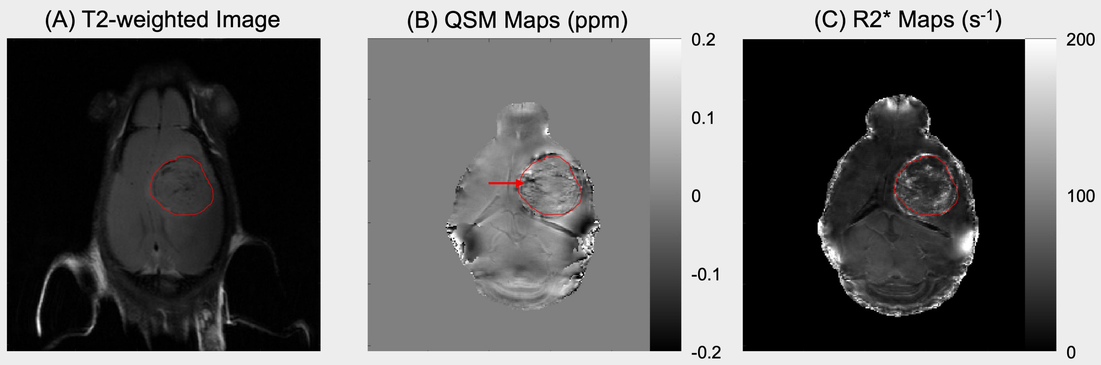

Figure 1: The T2-weighted reference anatomical image (A), QSM map (B) and T2* map (C) in one of the mice scanned.

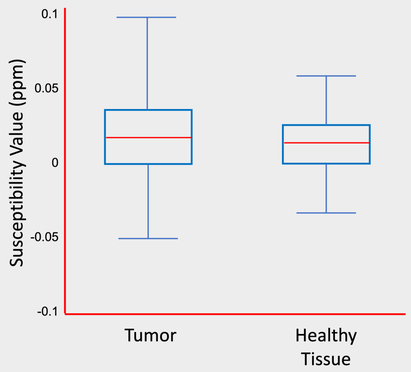

Figure 2: Box plot showing QSM values in tumors and healthy brain tissues.

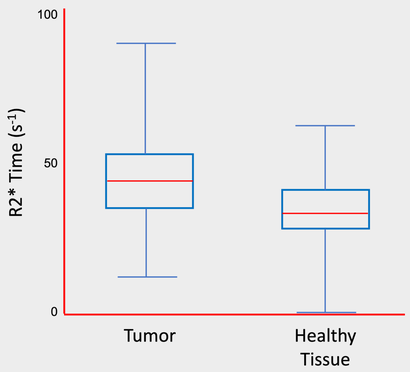

Figure 3: Box plot showing R2* values in tumors and healthy brain tissues.

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