Automated 3D MRSI of Patients with Brain Tumors

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Introduction: Proton Magnetic Resonance Spectroscopic Imaging (MRSI) is a valuable modality for diagnosis and evaluation of brain diseases. Two of the major difficulties with implementing MRSI in a clinical setting are limited coverage and difficulty in prescription. Automated prescription has been used in anatomical brain MRI before to ensure the consistency of image orientation (1) and has been proposed for use in MRSI (2, 3). This study focused on evaluating of automatically prescribed 3D MRSI in serial imaging of patients with malignant gliomas.

Methods: The automated prescription technique (2) included acquisition of an anatomical MRI image which is obtained as part of the standard clinical protocol, optimization of the oblique PRESS box parameters, optimization of the placement of OVS sat bands, and loading of the calculated parameters into a customized 3D MRSI pulse sequence. Eight patients who received at least two MRSI examinations with the automated protocols were selected for this study. The patients were chosen sequentially.

To estimate the consistency of the prescription, the volume of brain tissue that was covered by two MRSI exams from the same subject was calculated as the volume of the intersection of the aligned coverage masks. To compare the data quality, the spectroscopic parameters, such as peak SNR, metabolite ratios and peak linewidth were calculated within the covered volume. Additionally, spectral quality within the tumor was assessed by analyzing the same parameters within the T2 lesions as defined by manually outlined ROIs.

Results: Fig. 1 shows an example of a dataset, acquired from a patient with brain tumor. The automated prescription was able to cover most of the supratentorial brain, including almost all of the T2 lesion. The oblique PRESS box covered inferior areas of the brain posteriorly, while avoiding the orbits and sinuses in the anterior areas of the brain.

The algorithm was able to achieve high consistency of prescription despite differences in subject positioning (Fig 2a, average covered volume overlap: 88%). In almost all exams the T2 lesion was well covered by the MRSI volume of interest (Fig 2b). In most cases the mean metabolite ratios within the T2 lesion show very consistent results between exams of the same patient (Fig. 2c). For patient 4 it was not possible to reliably quantify the ratios due to the T2 lesion being very small (less than 7 cc). For patient 7 choline became less elevated in the second exam. This could be attributed to averaging over a much larger T2 lesion. The mean NAA SNR for the whole covered volume in all exams was 13.14±9.01 and 8.24±4.49 within the T2 lesions. Mean NAA linewidth was 12.01±2.81 Hz throughout the whole volume and 11.43±2.87 Hz within the T2 lesion. The mean SNR of the magnitude NAA and lipid peaks within the T2 lesion (Fig. 2d) indicates that the lipid signal was much smaller than the signal from NAA and did not interfere with NAA quantification, which is crucial for interpretation of brain MRSI data.

Discussion: Realizing the true clinical value of brain MRSI requires that data are acquired from the whole brain as easily as conventional imaging data. The technique developed in this project came closer to this goal than previous approaches (3,4,5). A large coverage volume reduced the risk that some of the diagnostically relevant tissues would be left outside the volume of interest, while the oblique orientation of the PRESS box ensured better coverage of the inferior regions of the brain. Automatic prescription also improved the consistency of prescription. This is especially important for serial scans of the same patient. A large overlap between the covered volumes in these scans will improve the detection of metabolic changes as disease progresses.

In conclusion, automated 3D MRSI has been successfully implemented for serial imaging of patients with malignant brain tumors. This technique demonstrated robust coverage of the tumor, high consistency of prescription and very good data quality within the T2 lesion. It validates the feasibility of automatically prescribed 3D MRSI in routine brain tumor imaging.

References and Acknowledgements: [1] Itt L. et al, MRM, 2001; [2] Ozhinsky E. et al., Proc 17th ISMRM, 2009: 2376; [3] Yung KT et al, MRM, 2011; [4] Ozhinsky E. et al., JMRI 2011; [5] Martinez-Ramon M., et al., MRM 2010;

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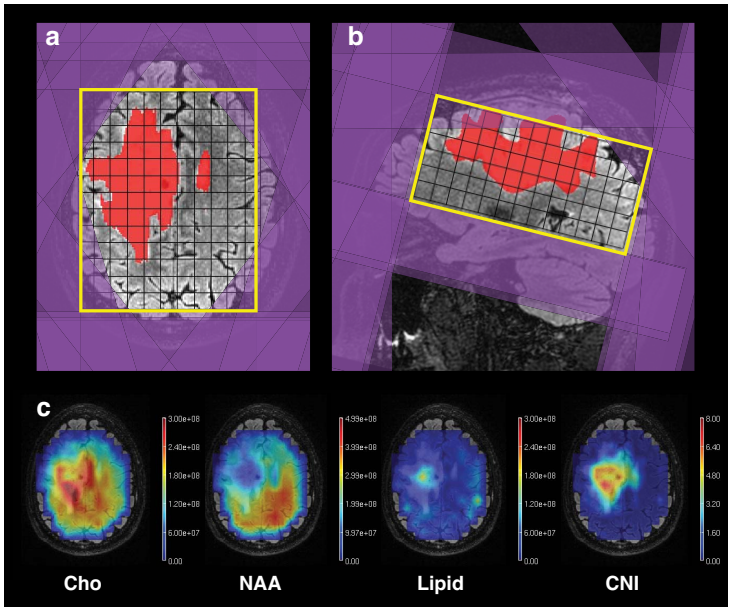

Fig. 1. a, b: Automatically generated MRSI prescription (yellow - PRESS box, purple - sat bands), T2 lesion mask shown in red; c: Metabolite maps.

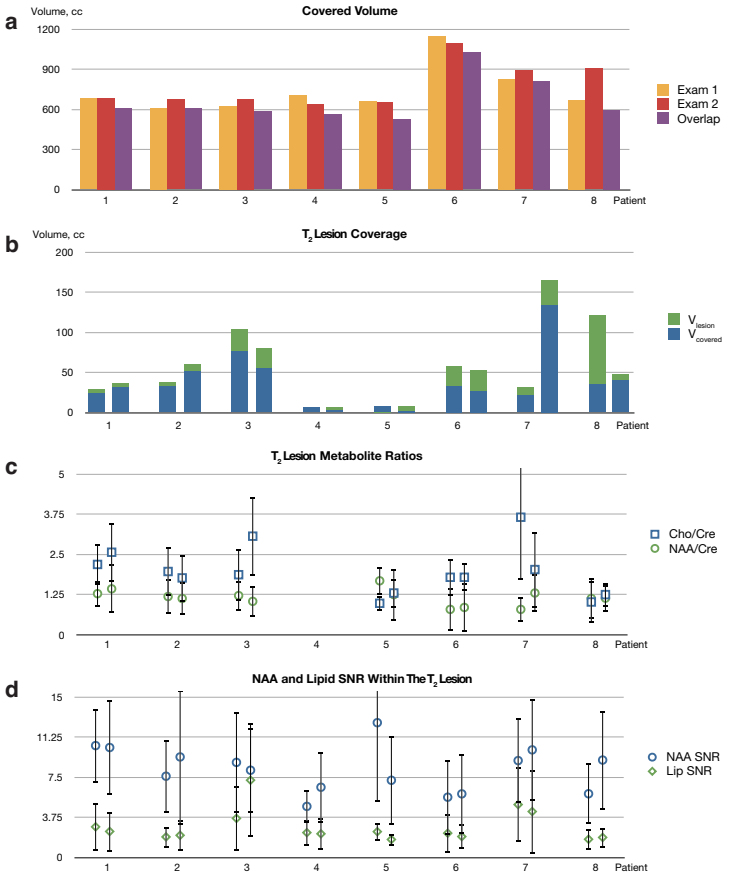

Fig. 2. a: Covered volumes for the two exams of each patient and their overlap; b: The volume of the T2 lesion (green) and T2 lesion covered by MRSI (blue); c, d: Met. ratios and mag. NAA and Lip. SNR within the T2 lesion