Improved preoperative diagnostics of brain tumors by quantification of 1H-MRSI metabolites

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Introduction:

[1]H-MRSI is a noninvasive tool for investigating the spatial distribution of metabolic changes in brain lesions. Brain tumors show increased levels of choline-containing compounds (Cho) and a reduction in N-acetyl-aspartate (NAA) and creatine (tCr) [1,2]. The range of Cho increase and NAA decrease is compatible with the range of tumor infiltration [3,4]. However, to our knowledge this is the first study to correlate absolute metabolite concentrations with histopathologic findings. It is often difficult to achive an unambiguous grading for tumors in conventional MRI, especially for gliomas WHO grade II and III, which is essential for further therapeutic planning.

Methods:

16 patient (9 male, 7 female, 32 ± 7 years), all with gliomas (WHO grade II and III), and age- and sex-matched healthy controls (33 ± 9 years) were examined. All studies were performed on a 1.5 Tesla clinical whole body scanner (MAGNETOM Sonata, Siemens Erlangen, Germany) equipped with the standard head coil using a standard CSI sequence with PRESS volume preselection and CHESS water suppression, TR/TE = 1600/135 ms, 24 x 24 circular phase-encoding scheme, 16 x 16 cm FOV, slice thickness 10 mm and 2 NEX (total 13 min). The PRESS excitation volume was positioned to exclude lipids of the skull and subcutaneous fat. For patients the whole, or at least the bulk, of the tumor was covered. Absolute metabolite concentrations for [Cho], [tCr] and [tNAA] were calculated using LCModel [5] and corrected for relaxation times effects. Metabolic maps of Cho and NAA were calculated, integrated in a co-registered anatomical MRI dataset (T2w TSE) and transferred to a streotactic system for MRSI guided biopsy sampling. The method was validated with results from the control group.

Results:

In all spectra we obtained SNR ≥ 3 and FWHM ≤ 0.075 ppm for 0.25 cm^3 voxels. Metabolite ratios with standard deviations SD > 20%, as given by LCModel, were not included in the statistical analysis. As compared to normal brain in patients and controls, tumor spectra showed significantly higher absolute concentrations of [Cho] and lower for [tCr] and [tNAA] (t-test for paired samples), respectively. Comparison of the histopathological findings of the MRSI guided biopsy-samples spread across the tumor with absolute metabolite values in corresponding voxels located at the biopsy sampling point, showed a linear correlation for [Cho] (Fig. 1) and [tNAA] (Fig. 2), but not for [tCr]. Furthermore, after averaging the absolute metabolite values for whole tumor of each single patient, we found significant lower levels for [Cho] and higher levels for [tNAA] in WHO grade II tumors (7 patients) compared to the WHO grade II tumor group (9 patients). Most important, we found clear differences for the [Cho]/[tNAA] value averaged over the tumor center voxels which were for all patients with a WHO grade II tumor less than 0.8 whereas for all patients with a WHO grade II tumor greater than 0.8 (Fig. 3).

Figure1:

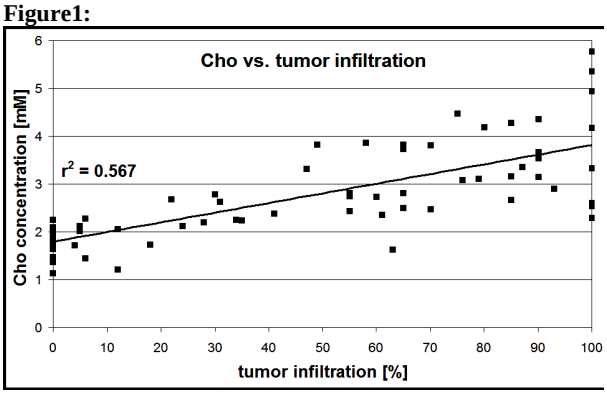
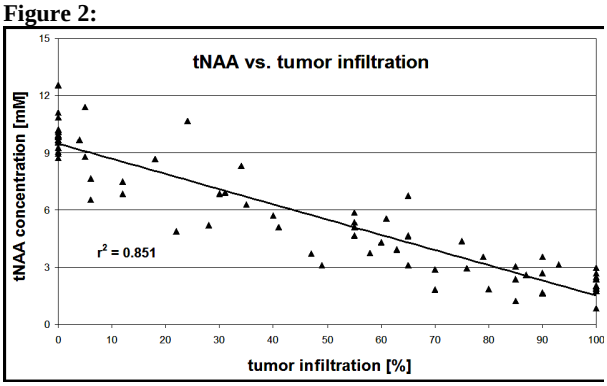


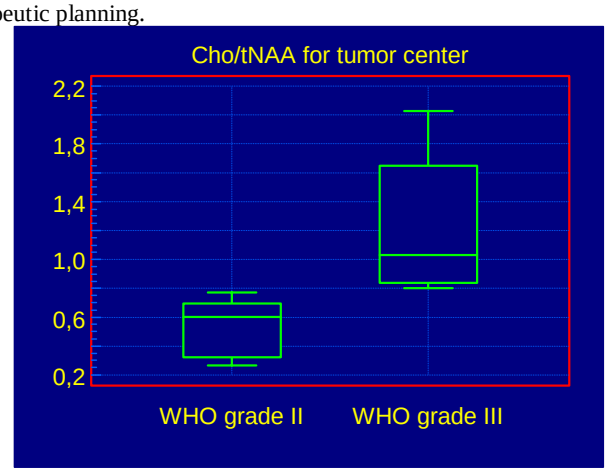
Figure 2:



Discussion:

Absolute quantification of MRSI data to study metabolic changes in the whole tumor enables the spatial distribution of tumor infiltration in different patients to be compared. The correlation between absolute [Cho] (Fig. 1) and [tNAA] (Fig. 2) concentrations and the scale of tumor infiltration allows an estimation of the extent of the pathologic changes in a defined tumor region preoperatively. The results for the [Cho]/[tNAA] value averaged over the tumor center (Fig. 3) can be used for preoperative grading of gliomas. Both results may be very helpful for diagnostics and therapeutic planning.

Figure 3:



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