Short echo time 1H-MRSI of glioma brain tumors referenced to metabolite levels of normal brain.

A.J. Idema[1], J.P. Wijnen[2], and A. Heerschap[3]
[1]*Neurosurgery, UMC St Radboud, Nijmegen, Netherlands,* [2]*UMC Utrecht, Utrecht, Netherlands,* [3]*Radiology, UMC St Radboud, Nijmegen, Netherlands*

Target audience: neuro-radiology, neurosurgery, neurology, neuro-oncology and radiotherapy.
Introduction: Conventional MR imaging is not sufficient for delineation of brain tumors, due to infiltration into normal brain tissue, and for the differentiation of pseudo from real progression or response [1]. Proton MRS metabolic imaging is able to identify metabolic alterations caused by infiltration. In glioma brain tumors this has been done with long echo time MRS. With short echo time other and more metabolites can be observed.
The **purpose** of our study is to find metabolites and ratios with short echo time 1H-MRSI, which show the possible infiltration of tumor into normal brain tissue.
Methods: 23 volunteers and 20 patients with a glioma brain tumor were scanned with ^{1}H-MRSI (3 Tesla, s-LASER sequence[2], 30 ms echo time, fat saturation slabs for suppressing lipid signals from the skull, repeated with one-average acquisition without water suppression for water reference data set). Postprocessing of the MRS data was performed with LC Model with strong quality criteria (CRLB<20%, FWHM>0.125ppm, SNR<15, combined phase-data-shift between -50 and 50). After postprocessing, the normal distribution of the different metabolites and ratios from the volunteers was used. The 1% and 99% percentile was used for defining abnormal concentrations and ratios.
Results: the mean, standard deviation, median, 1% and 99% percentiles of the important different metabolite ratios from the normal volunteers are given in table 1. Different parts of the tumor are accentuated with different metabolite ratios. The central necrotic part of the tumor is delineated with lipids. The body of the tumor is defined by the total Choline / total N-AcetylAspartate (tCho/tNAA) and tCho / total Creatine (tCr) ratio and the more infiltrative part is demarcated with the myo-Inositol and Glycine (mIGly) / tNAA or myo-Inositol (mI) / tNAA ratio. The Glutamine / Glutamate ratio (Gln/Glu) and Glycine / mI ratio appear to represent different parts of the active tumor (for 2 representative examples see figure 1 and 2).
Discussion: A lower tNAA seems to be representative for both the infiltrating part and the active part of the tumor, depending on the numerator of the ratio. With tCho as numerator the more active part is delineated while with mI the more infiltrative part of the tumor is delineated. The Gln/Glu ratio represents possibly the more vascular active part, while Glycine/mI the active proliferating part. The question remains what is the clinical importance of these different parts of the tumor. Follow up during radiotherapy, chemotherapy or natural development might resolve these questions.
Conclusion: with short echo time 3D multivoxel MRSI different parts of the tumor can be defined based on metabolite concentrations and ratios not found in MR spectra of normal brain (<1%).

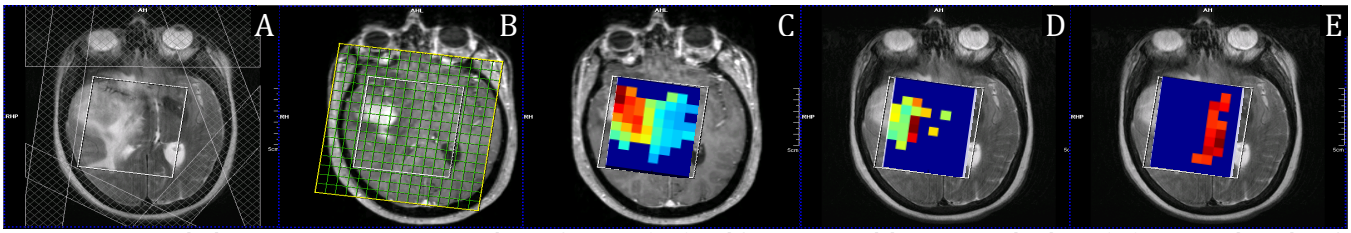

Figure 1. Patient with oligoastrocytoma, WHO III. *A* Volume of interest (VOI) and fat saturation slabs in T2-weighted MRI (T2). *B* VOI and voxels in field of view (FOV) in T1-weighted MRI after Gadolinium (T1). *C* Voxels with ratio of tCho / tNAA > 99% percentile (T1). *D* Voxels with ratio of Gln/Glu > 99% percentile (T2). *E* Voxels with ratio mI / tNAA > 99% percentile (T2).

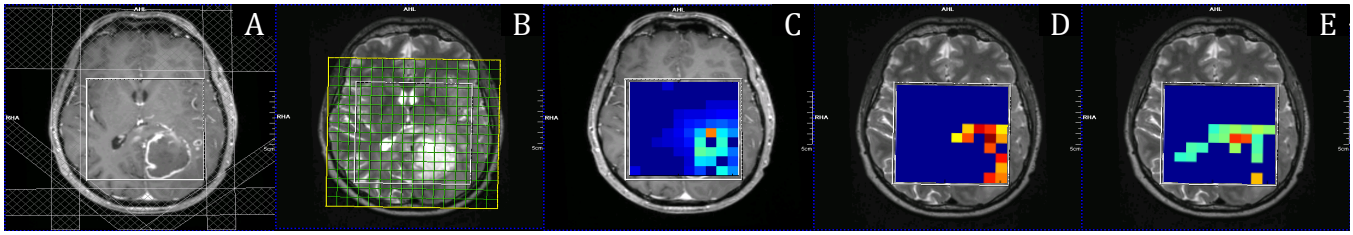

Figure 2. Patient with glioblastoma, WHO IV. *A* Volume of interest (VOI) and fat saturation slabs in T1-weighted MRI after Gadolinium (T1). *B* VOI and voxels in FOV in T2-weighted MRI (T2). *C* Voxels with ratio of tCho / tNAA > 99% percentile (T1) *D* Voxels with ratio of Gln / Glu > 99% percentile (T2). *E* Voxels with ratio mIGly / tNAA > 99% percentile (T2).

Table 1.

	tCho/tNAA	tCho/tCr	Gln/Glu	mI/tNAA	mIGly/tNAA	Glycine/mI
Mean	0,189	0,279	0,454	0,629	0,659	0,250
Stand Dev	0,044	0,062	0,145	0,119	0,124	0,151
Median	0,188	0,280	0,424	0,626	0,650	0,200
1% perc	0,099	0,159	0,245	0,356	0,408	0,118
99% perc	0,304	0,437	0,981	0,931	1,039	0,841

References. *1*. Nelson SJ. Assessment of therapeutic response and treatment planning for brain tumors using metabolic and physiological MRI. *NMR Biomed.* 2011; 24: 734-49. *2*. Scheenen TW, Klomp DW, Wijnen JP, et al. Short echo time 1H-MRSI of the human brain at 3T with minimal chemical shift displacement errors using adiabatic refocusing pulses. *Magn Reson Med.* 2008; 59: 1-6.