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„Image Guided Glioma Surgery Using 1H MRSI Spectroscopy“

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Image Guided Glioma Surgery Using 1H MRSI Spectroscopy

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INTRODUCTION

Proton MR spectroscopic imaging (MRSI) is a non-invasive method to investigate changes in the spatial distribution of Choline (Cho), Creatine (tCr) and N-acetyl-aspartate (NAA) in brain tumors. In our study maps of Cho/NAA ratios were calculated and automatic segmentation of the tumors was performed. Absolute molar concentrations of [Cho], [tCr] and [NAA+NAAG] (N-acetyl-aspartyl-glutamate) for tumor and normal brain were also calculated using LCModel. Significantly higher levels of [Cho] ($p = 0.017$) and lower levels for [tCr] ($p = 0.043$) and [NAA+NAAG] ($p = 0.002$) were found in tumors compared to normal brain.

MATERIAL AND METHOD

All studies were performed on a 1.5 Tesla clinical whole body scanner (MAGNETOM Sonata, Siemens Erlangen, Germany) equipped with the standard quadrature head coil using a standard CSI sequence with PRESS volume preselection, TR/TE = 1600/135 ms, 24 x 24 circular phase-encoding scheme, 16 x 16 cm FOV, slice thickness 10 mm, 50 % Hamming-filter and 2 NEX (total 13 min). Three CHESS pulses prior to the PRESS excitation achieved water suppression. The PRESS excitation volume (white rectangle in Fig. 1A) was positioned to exclude lipids of the skull and subcutaneous fat. For patients we covered the whole, or at least the bulk, of the tumor, and as much normal tissue as possible. Metabolic maps for Cho, tCr and NAA as well as the map of the Cho/NAA ratios (Fig. 1B) were calculated by integration of peak areas and smooth linear interpolation to a 256 x 256 matrix. A "healthy region" of predominantly white matter (Fig. 1) was selected in contralateral brain, at sufficient distance from the lesion to allow segmentation based on the assumption of Gaussian distribution of the Cho/NAA values for normal brain (tested independently). The contours of the segmented tumor (Fig.1 C) were used to select the tumor-containing voxels. Absolute metabolite concentrations for [Cho], [tCr] and [NAA+NAAG] ([tNAA]) were calculated using LCModel.

RESULTS

In all cases the implementation of the metabolic maps into frameless stereotaxy was successful and stereotactic biopsies were acquired using the spectral data. A relation could be demonstrated between the metabolic changes and tumor cell density ranging from 60 - 100 % in the maximum pathologic area to 5 - 15 % in the border zone. Interestingly the tumor areas defined by the metabolic maps and histopathologically confirmed by biopsy exceeded the T2 weighted signal change in all cases ranging from 6 - 32 % in the exam volume (Fig. 2).

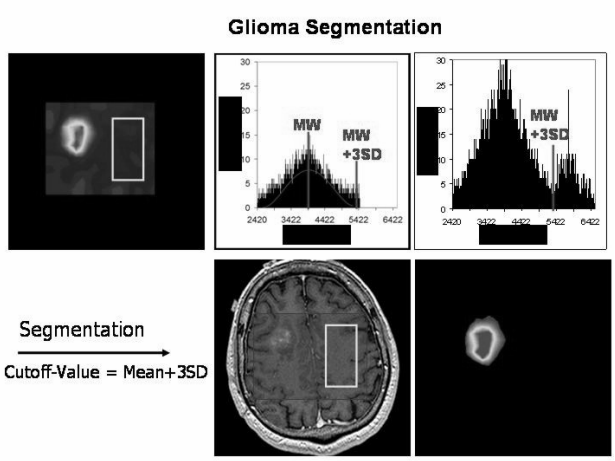

Fig. 1: VOI-map of the Cho/NAA ratios with selected "healthy region" (rectangle). Histogram of the selected "healthy region" with the calculated Gaussian distribution and the mean and mean+3SD of this histogram. Histogram of the whole Cho/NAA map overlaid with the position of mean+3SD cutoff calculated. Metabolic image of the segmented tumor.

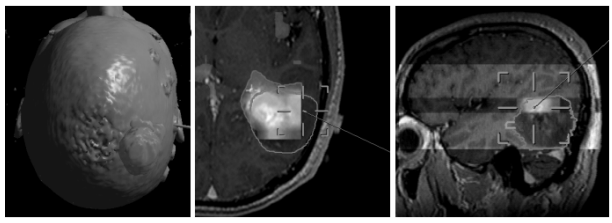

Fig. 2: The area of the pathological metabolic map exceeds the area of the T2 weighted pathology.

DISCUSSION

Signal differences between normal brain and tumor in Cho and NAA maps are sufficient to show the localization of the tumor, but not for delineation of the border zone. Partial volume effects of cerebrospinal fluid in sulci and ventricles also affect the levels of the metabolites measured in normal brain tissue. For delineation of the border zone of the tumor Cho/NAA-ratios are more suitable. The contrast: tumor vs. normal brain is improved, because of the utilization of both, the increase

of Cho and decrease and NAA. In addition, Cho/NAA-ratios in normal brain are less affected by partial volume effects from CSF. 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. Absolute [Cho], [tCr] and [tNAA] concentrations for the selected "healthy" contralateral region in patients and controls are in good agreement with the findings of others. The lower limits for [Cho] =1.46 mM and the upper limits for [tNAA] = 5.49 mM in tumors are used as threshold values for delineation of pathologic changes. Both, spectroscopic images of the segmented tumor and threshold tumor values may be helpful for therapeutic planning.

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