Correlation between choline concentrations and trace values in human brain tumors

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Introduction:

Diffusion magnetic resonance imaging (DI) and spectroscopic imaging (SI) have proven to be useful in the clinical assessment of brain tumors. An active tumor can be characterized by an increased choline signal and low ADC values [1]. Moreover, a statistically significant inverse correlation between the choline (Cho) signal intensity and an Trace (Tr) values in brain tumors of various etiology has been described [2]. In the above studies the correlation analysis was performed on the data from several tumors acquired in the different subjects, however, no attempt has been made to use this knowledge when examining a single subject. The aim of this preliminary study is to test, whether the existence of the inverse correlation between the Cho signal intensity and the Tr value can be used to identify and characterize the borders of brain tumors in individual subjects.

Methods:

Four patients with histologicaly verified glioblastoma (G-IV type) have been involved in the study. The measurement protocol included conventional MR imaging (TSE, TE/TR/NA=99ms/5400ms/1), DI (EPI-Trace, TE/TR/NA=137ms/8000ms/8) and SI (2D PRESS-SI, 16x16, FOV=160x160mm, TE/TR/NA=135ms/1500ms/2). All measurements were performed on 1.5T scanner with transmit-receive CP head coil. SI data were analyzed using the program CULICH [3] with LCModel [4]. Data processing included mild k-space filtering (Hamming filter) and zero filling to 32x32 voxels followed by the calculation of absolute concentrations of Cho.

To analyze the correlation between choline concentrations and Tr values in the different parts of tumors, new CULICH plug-in has been developed enabling to mark out regions in the brain interactively and to calculate correlation between metabolite (Cho) concentration values and corresponding Tr values for each voxel in the selected region. To exclude areas with low spectra quality only the voxels with corresponding error (Cramer-Rao bound (CRB)) of calculated Cho concentrations bellow specified threshold (CRBs<50%) were included in the analysis. To account for the different DI and SI slice thickness the average Tr value from DI slices covering the SI slice has been used in each voxel.

Results:

Depending on the region selected, several distinct areas can be observed in the dependence of Cho on Tr as apparent in Fig. 1: 1) Pixels corresponding to low Tr and normal Cho values represent healthy tissue, 2) pixels showing the inverse Cho - Tr correlation represent (according to above mentioned studies[1,2]) areas of the active tumor. 3) pixels corresponding to high Tr but not aligned along regressed Cho - Tr line represent necrosis or edema. Described dependence was observed in three of four patients. The disagreement in the last patient can be explained by the pure quality of the acquired spectra. Each of three tissues types can be identified in the MR images by selecting appropriate points in the graph of Cho - Tr dependence and displaying corresponding voxels in the MR image, as shown in Fig 2. Voxels corresponding to points in the area of the inverse Cho - Tr correlation correspond to the different tumor stage according to the their position (i.e. Tr or Cho value) in the dependence. Moreover, the determination of the slope of the regressed line and its error helps to find the boundary between Cho concentrations in healthy tissue and in the tumor.

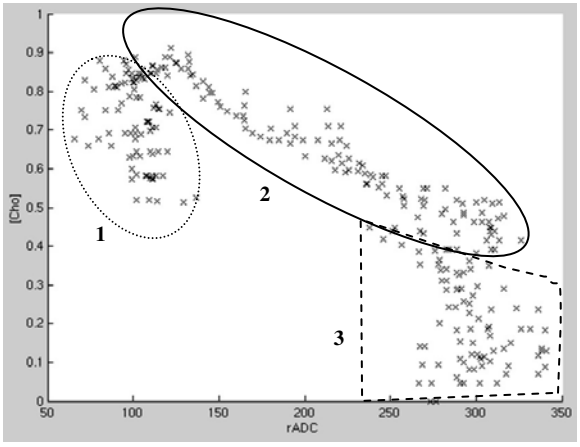

Fig.1 Dependence of Cho on Tr (rADC) values for all analyzed voxels. Each cross represents the ordered pair of (Tr, Cho) values corresponding to one voxel in the analyzed area . Both Cho and Tr values are given in arbitrary units.

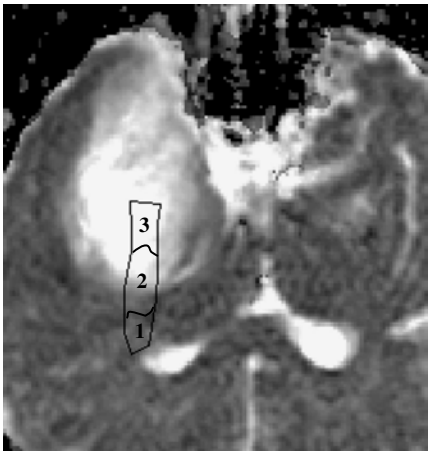

Fig.2 Identification of voxels corresponding to regions 1,2 and 3 shown in Fig.1. The outer line incloses the analyzed area.

Conclusion:

Results of this preliminary study show that the analysis of the correlation between Cho concentrations and Tr values on the pixel-by- pixel basis enables the regional identification of the pathologic state of the tissue. The main issue of the proposed method consists in the exact determination of the slope of the Cho-Tr dependence, particularly in the automated identification of the points the slope calculation should be applied to and in the partial overlapping of points from different regions. The increase of accuracy could be achieved by imposing additional constraints on border values of Tr or Cho. Also, since each correlation analysis is influenced by errors of both correlated variables, the accuracy of Cho concentrations and Tr values is of high importance. The proposed correlation analysis brings additional information compared to the separate evaluation of Cho images or Tr maps.

Acknowledgments:

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