GADOLINIUM EFFECT ON CHOLINE SIGNAL IN BRAIN TUMORS AS A FUNCTION OF T1 ENHANCEMENT.

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Introduction:

Conventional magnetic resonance imaging (MRI) is the most useful radiological technique in the diagnosis of intracranial tumors but only in 30 to 60% of cases, depending on the histological type of the tumor, the diagnosis is correctly made. In vivo proton magnetic resonance spectroscopy (1H-MRS) allows non-invasive evaluation of tumor metabolic profile and it is useful in the diagnosis of brain tumors and in characterization of metabolic changes associated with tumor progression, degree of malignancy, and response to treatment.

A critical point to obtain representative spectra is the correct voxel positioning in the most representative and solid portion of the tumor. Paramagnetic contrast administration may be useful to better select the most solid and representative area of the tumor. There is however some experimental data suggesting that MR spectroscopy should be performed before contrast administration because the paramagnetic contrast could cause loss of the choline (Cho) signal [1]. This is still controversial in the literature. Some authors did not find any significant effect of the paramagnetic contrast in the tumor spectra but different techniques were used [2-4]. Theoretical simulations show that the Gd effect on Cho signal depends on the Cho T1 and T2 relaxation times, the echo time (TE) and repetition time (TR) of the sequence, and the Gd concentration in the tissue. The aim of this study was to determine how the administration of the paramagnetic contrast affects Cho signal of brain tumors using our standard clinical 1H-MRS sequence (TE/TR=135/1500ms), and how this effect is related to Gd concentration estimated by the T1 enhancement.

Patients and Methods:

13 patients with intracranial tumors were enrolled in this study after giving informed consent. The tumors were glioblastomas (8 patients), metastases (2 patients), an astrocytoma (1 patient), a primitive neuroectodermal tumor (PNET) (1 patient), and an oligodendroglioma (1 patient). All patients underwent MRI and multivoxel 1H-MRS performed at 1.5 T on a GE Horizon LX 9.1 scanner (GE Healthcare, Milwaukee, WI, USA) using the standard quadrature head coil. MRI included an axial T1 weighted spin echo sequence (TR/TE 466/14 ms) before and after the paramagnetic contrast injection. Multivoxel 1H-MRS was performed covering the largest area of the T2 abnormality at the site of the tumor using the method of point-resolved spectroscopy (PRESS) (TR/TE 1500/135 ms) before and 10 minutes after a double dose (0,2 mmol/kg) injection of gadoterate meglumine (Dotarem). Field of view was 24 cm and matrix size was 16 x 16 resulting in an individual voxel size of 15 X 15 X 10 mm^3. MRS raw data were processed using SAGE software (GE Healthcare, Milwaukee, WI, USA), which enabled to select the individual voxels of interest. For these voxels Cho quantification was performed using LCModel software [5]. Cho signal was quantified in institutional units for both MRS acquisitions, before and after Gd administration (Cho_{pre} and Cho_{post} respectively), and the percentage variation Cho_{VAR} was quantified according to equation: $Cho_{VAR}=[(Cho_{post}-Cho_{pre})/Cho_{pre}]x100$

In order to estimate Gd uptake, maps of T1 were created to calculate the T1 enhancement, using the values of the non-enhanced (pre) axial T1-weighted and enhanced (post) axial T1-weighted based on the equation: $T1\ enhancement=[(T1W_{post}-T1W_{pre})/T1W_{pre}]x100$

T1 enhancement was calculated individually for the voxels studied by MRS.

Results:

We were able to measure Cho signal before and after Gd administration for a total of 70 voxels located on tumor areas. For Cho_{pre} and Cho_{post} we obtained mean values of 542±245 and 528±241, respectively. A paired t-test did not find significant differences between both measures. We found a mean Cho_{VAR} of 1±34% (ranging from -47% to 204%). For the 70 voxels we were able to quantify T1 enhancement only for 63 voxels. Figure 1 displays Cho_{VAR} as a function of T1 enhancement. The figure in the left includes all 63 voxels. In the right figure two "outsider" points with Cho_{VAR} higher than 100% were deleted in order to appreciate better the other point values.

Discussion:

We could not reproduce the mean Cho_{VAR} of -15% described in the literature [4, 6]. This might be due to the different type of tumors sampled, as we believed that it depends very much on the Gd uptake and distribution properties of the tissue. When we observed the individual Cho_{VAR} for each voxel we found a large variation from negative to positive values. Theoretical simulations of Cho signal changes as a function of Gd concentration based on a model of dipolar interaction between Gd and Cho show that, depending on the Gd concentration in the tissue, the Cho signal might increase or decrease. For a T2-weighted 1H-MRS sequence, as the one we used in this study, with a TE/TR of 135/1500ms they predicted to have a Cho signal increase for low Gd concentrations and signal decrease for higher Gd concentrations. On MRI images we can indirectly quantify the absorbed Gd concentration by observing the T1 enhancement. When looking at the Cho_{VAR} as a function of T1 enhancement we found a tendency of higher positive Cho for lower T1 enhancement and a decrease of Cho signal for higher T1 enhancement, which is in agreement with the theoretical model of a dipolar relaxation mechanism between Gd and Cho in the extracellular space.

Conclusion:

It might be dangerous to assume that Gd injection has a minor and predictable effect on detected Cho signal in tumors. Our results reinforce the idea that this effect depends strongly on the Gd concentration in the tissue.

References:

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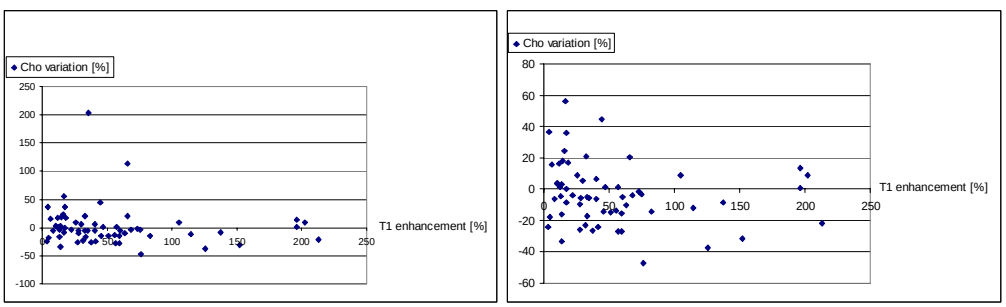

Figure 1: Cho variation [%] as a function of T1 enhancement [%] measured for the same voxel. Left: All 63 analyzed voxels. Right: Same as left without values above 100% of Cho variation.