



Application of Magnetic Resonance Spectroscopy in the Differentiation of High-Grade Brain Neoplasm and Inflammatory Brain Lesions

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Abstract

This study aims at evaluating the application of magnetic resonance spectroscopy (MRS) in the differential diagnosis of brain tumors and inflammatory brain lesions. The examinations of 81 individuals, who performed brain MRS and were retrospectively analyzed. The patients with ages between 10 and 80 years old, were divided into two groups. Group A consisted of 42 individuals with diagnoses of cerebral tuberculomas, brain abscess and Group B was formed of 39 individuals with diagnosis of glial neoplasms. On analyzing the ROC curve, the discriminatory boundary for the Cho/Cr ratio between inflammatory lesions and tumors was 1.97 and for the NAA/Cr ratio it was 1.12. MRS is an important method useful in the distinction of inflammatory brain lesions and high-degree tumors when the Cho/Cr ratio is greater than 1.97 and the NAA/Cr ratio is less than 1.12. And so this method is important in the planning of treatment and monitoring of the therapeutic efficiency.

Key Words: magnetic resonance image, spectroscopy, brain, neoplasm, inflammatory lesion.

Magnetic resonance spectroscopy (MRS) is a relatively fast, non-invasive method that provides metabolic/biochemical information of the normal brain parenchyma and of pathological processes^{1,2}. Spectroscopy utilizes the same physical principles as conventional magnetic resonance, but differs in the way that the data are processed and presented; instead of images, amplitude by frequency plots are obtained¹.

There are few published studies concerning the differentiation between inflammatory lesions and brain tumors employing MRS and all that exist are

related to the differential diagnosis of lymphoma and inflammatory lesions in patients with human immunodeficiency virus (HIV) infections³⁻⁶. HIV may initially manifest with neurological symptoms which at times mimic tumors^{7,8}.

This study aims at evaluating the application of MRS in the differential diagnosis of brain tumors and inflammatory brain lesions.

Method

The examinations of 41 individuals, who performed brain MRS from 2004 to 2007, were

retrospectively analyzed. The patients, of both genders, with ages between 10 and 80 years old, were divided into two groups. Group A consisted of 22 individuals with diagnoses of cerebral toxoplasmosis with single or multiple lesions confirmed by cerebrospinal fluid (CSF) and clinico-radiological responses to anti-toxoplasmosis therapy. Group B was formed of 19 individuals with diagnosis of glial neoplasms (Grade III and IV gliomas according to the World Health Organization classification) confirmed by means of anatomopathological studies.

The inclusion criteria utilized in this study were that patients were older than 10 years old, the MRS was of a good technical standard, the voxel included the highest possible volume of pathological tissue and the etiological diagnosis of the lesions were definitive.

The MRI examinations were performed in the Magnetic Resonance Service using a Philips Medical Systems Gyroscan Intera (Best, Netherlands) 1.5 Tesla scanner.

The protocol included turbo spin-echo axial T2-weighted sequences (TE 110, TR 4466, 5mm slice thickness and 1-mm gap); spin-echo sagittal T1-weighted (TE 15, TR 550, 5-mm slice thickness and 1-mm gap); axial fluid-attenuated inversion recovery - FLAIR (TE 120, TR 6000, 5-mm slice thickness and 1-mm gap); axial diffusion weighted (TE 86, TR 1000, 5-mm slice thickness and 1-mm gap) and spin-echo axial, sagittal and coronal T1-weighted imaging after intravenous administration of paramagnetic contrast at 0.1 mmol/kg (TE 15, TR 550, 5-mm slice thickness and 1-mm gap).

The RMS was achieved during conventional MR image acquisition. The single-voxel technique was employed using a standard voxel volume of 8.0 cm³ (2.0 × 2.0 × 2.0 cm) or at least 3.37 cm³ (1.5 × 1.5 × 1.5 cm) applied in smaller lesions. The parameters utilized for acquisition were the PRESS technique using a TE of 144 ms. Shimming was automatically performed, followed by chemically selected saturation (CHE HE SS) for water suppression. Metabolites were always shown, on the x axis in parts per million (ppm)

and on the y axis, by the height of the metabolite peaks in an expressed scale at an arbitrary intensity.

The metabolites studied were choline (Cho) which appears at 3.22 ppm, creatine (Cr) at 3.02, N-acetyl aspartate (NAA) at 2.01 ppm, Lipid at 0.8 to 1.3 ppm and lactate at 1.32 to 1.33 ppm. The Cho/Cr and NAA/Cr ratios were analyzed as was the presence of lipids and lactate.

The sensitivity and specificity of MRS in the distinction of inflammatory lesions and brain tumors by means of the Cho/Cr and NAA/Cr ratios were estimated by analyzing the ROC curve and by multiple logistic regression. The results are presented as percentages with 95% confidence intervals. An alpha error of 5% was considered acceptable. This work was approved by the institution's Research Ethics Committee.

Results

Of the 41 patients included in the study, Group A with diagnosis of granulomas, had a mean age of 36 years old and Group B, with diagnosis of glial neoplasms had a mean age of 51 years old. Seven patients had grade III and twelve had grade IV glial neoplasms

On analyzing the ROC curve, the discriminatory boundary for the Cho/Cr ratio between inflammatory lesions and tumors was 1.97. The sensitivity of the Cho/Cr ratio to detect neoplasms was 77% (95% CI: 61–89) with a p-value=0.001 and the specificity was 79% (95% CI: 63–90) with a p-value=0.001. The sensitivity of the NAA/Cr ratio to detect neoplasms was 64% (95% CI: 47–78) with a p-value=0.108 and the specificity was 69% (95% CI: 52–82) with a p-value=0.020.

On analyzing together, the specificity of the method increased to 97.6% with a p-value=0.001 when the Cho/Cr ratio was greater than 1.97 and the NAA/Cr ratio was less than 1.12 at detect neoplasm (Fig 1).

Multiple logical regression analysis, established with a reference value of 1.97, was significant for the Cho/Cr ratio (p-value=0.001 and Odds Ratio=11.9), the NAA/Cr ratio (p-value=0.03 and

Odds Ratio=3.6) and for age (p-value=0.02 and Odds Ratio=1.04).

No discriminatory power was observed for the presence of lipid and lactate metabolites.

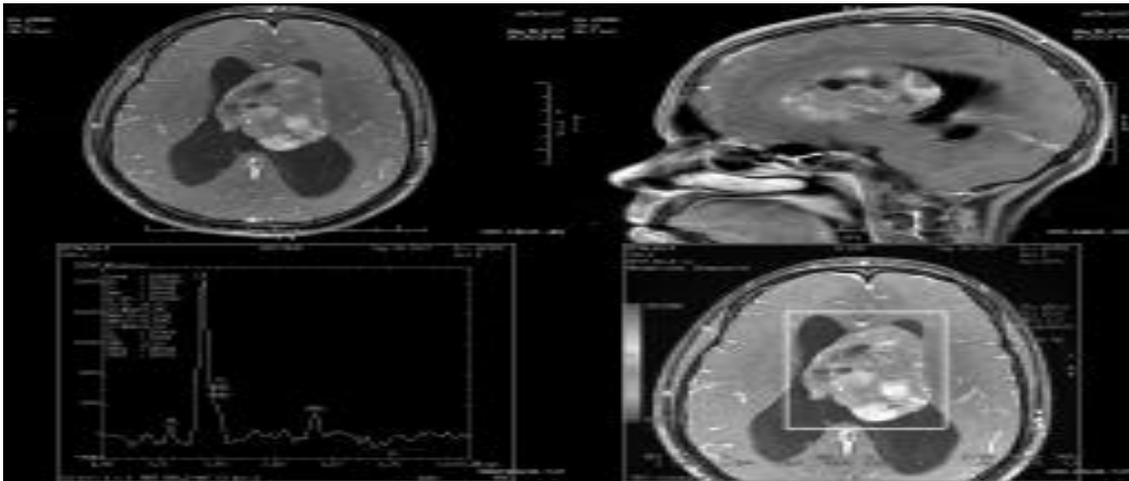


Fig of central neurocytoma showing grossly increased choline and decreased NAA and creat with peak values of ch/NAA ratio varies from 3.7 to 7.05

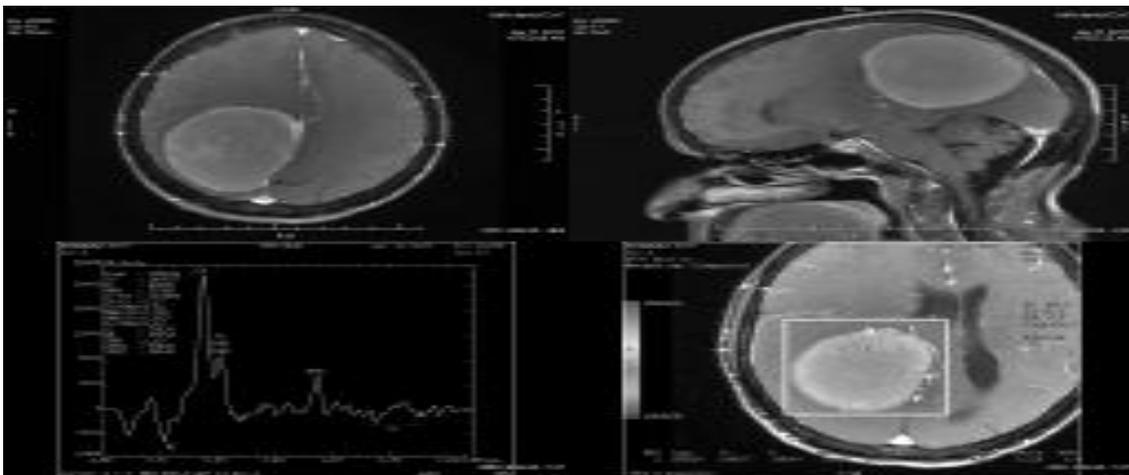


Fig of meningioma showing alanine peak and moderately raised choline

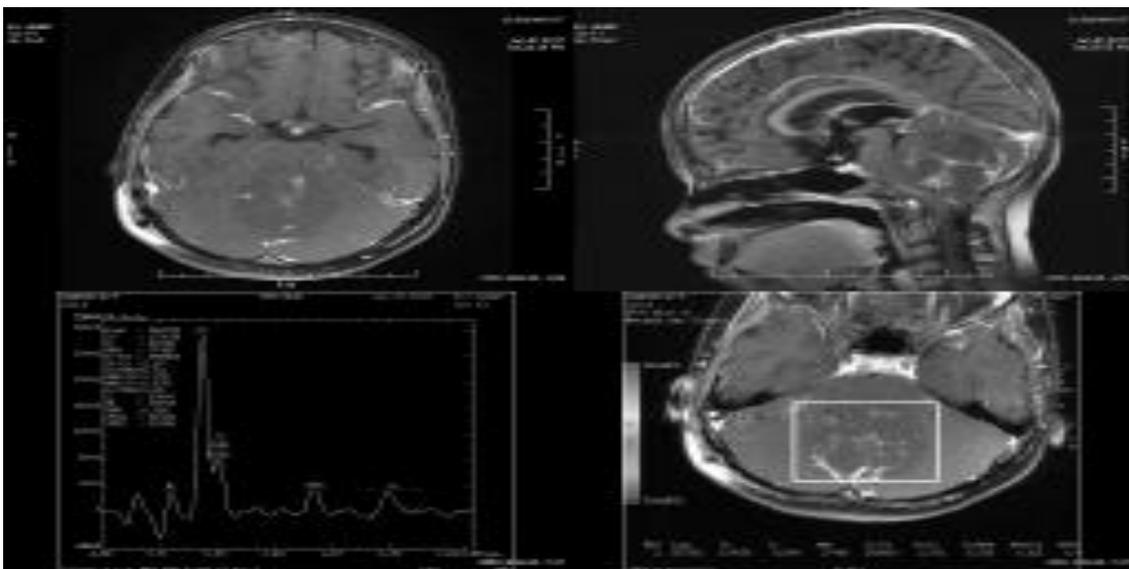


Fig 3 fourth ventricular medulloblastoma showing high elevated choline with high Ch/NAA values of 7.2

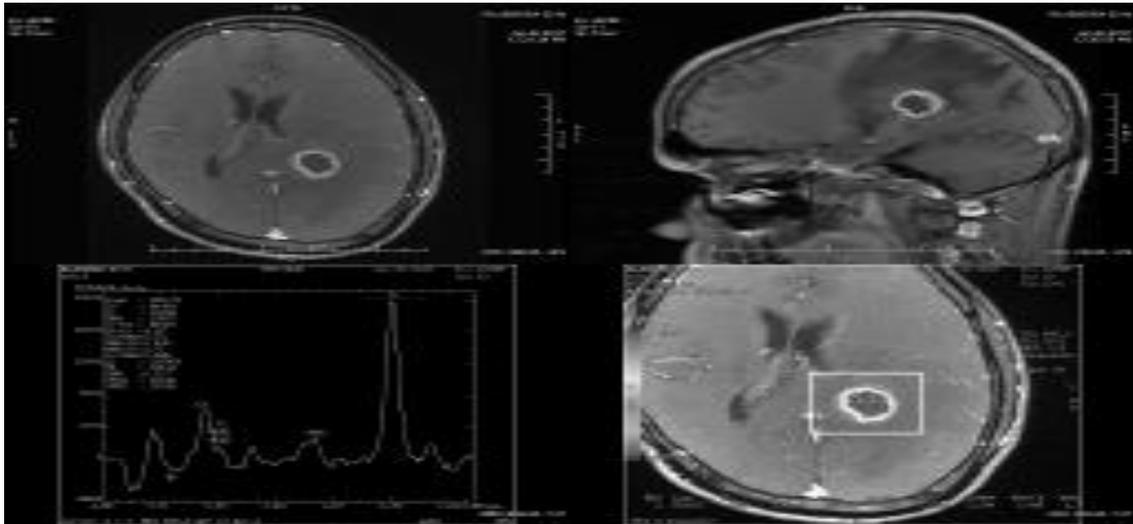


Fig showing ring enhancing lesion with lipid lactate peak Ch/NAA 1.8 s/o tuberculoma

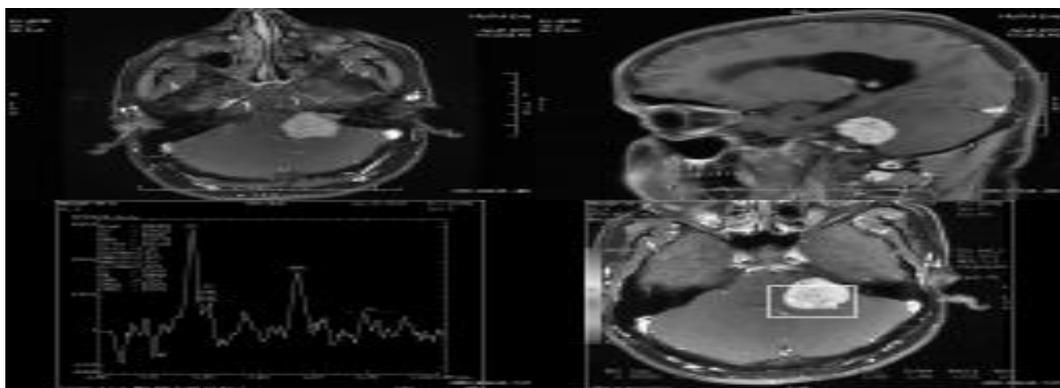


Fig showing acoustic schwannoma with Ch/NAA value of 1.8 to 2.5

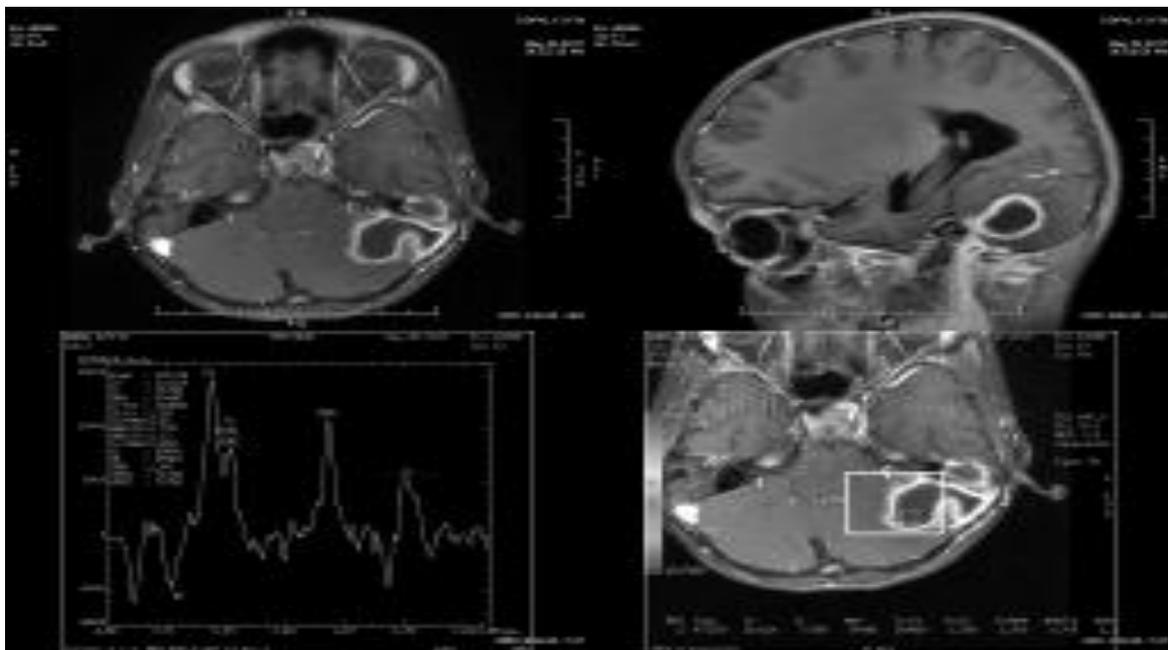


Fig showing elevated lipid lactate and mild decreased NAA low Ch/NAA s/o cerebellar abscess

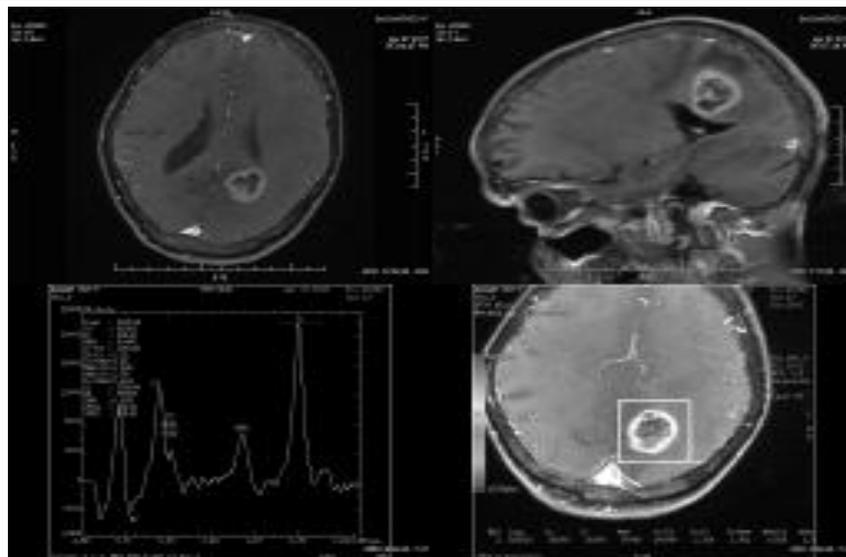


Fig showing elevated lipid lactate and low Ch/NAA of 1.7 s/o tuberculoma

Discussion

The present study showed that MRS can discriminate between high-degree glial tumors and cerebral granulomas when the Cho/Cr ratio is greater than 1.97 (Figs 2 and 3). The use of the Cho/Cr ratio in the evaluation of neoplastic lesions has already been described in the literature as Cho is an important constituent of cell membranes with increases occurring when there are increases in cell synthesis and conversion to carcinogenic cells, while creatine is generally stable^{8,9}. NAA is found in normal neurons and when altered, reductions occur both in tumors and in inflammatory lesions thereby indicating neuronal loss. The NAA/Cr ratio has discriminatory value when analyzed together with the Cho/Cr ratio increasing the specificity of the method¹⁰.

As of yet we have no knowledge of MRS investigations comparing high-degree glial tumors and cerebral toxoplasmosis and thus there are few published data to compare with the results of this study. Existing publications are conflicting and compare cerebral toxoplasmosis with lymphomas, which is the most common brain tumor in patients with HIV. Chinn et al.⁴ studied 18 patients with cerebral toxoplasmosis and 9 with lymphomas and concluded that the Cho/Cr and NAA/Cr ratios are not useful in the differentiation of the two diseases; this conclusion was also supported by

Simone et al.⁵ Chang et al.³, who studied 11 patients with cerebral toxoplasmosis and 8 with lymphomas, did not utilize ratios between metabolites in their studies but ascertained that MRS is useful for differentiation, thus agreeing with the conclusion of Harting et al.¹¹

In MRS studies evaluating gliomas, Meng Law et al.¹² reported that this method is useful in the differentiation of high- and low-degree glial tumors with the Cho/Cr ratio being higher than 1.56 in high-degree tumors. These data are sustained in studies by Fayed et al.¹³ who demonstrated that a Cho/Cr ratio greater than 1.55 has a discriminatory power to differentiate between high- and low-grade gliomas¹³⁻¹⁵.

The differentiation between inflammatory lesions and tumors may help in the early establishment of therapy which is essential for better prognoses with cerebral toxoplasmosis lesions and may also avoid inappropriate treatment of tumor patients that may cause allergic reactions or hematogenous intoxication with impairment of the general state of already debilitated patients

Conclusion

In conclusion, MRS is an important method useful in the distinction of inflammatory brain lesions and high-degree tumors when the Cho/Cr ratio is greater than 1.97 and the NAA/Cr ratio is less than 1.12. And so this method is important in the

planning of treatment and monitoring of the therapeutic efficiency.

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