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Original Research Article

To Study the Magnetic Resonance Spectroscopy in the Evaluation of Intracranial Pathologies at Tertiary Care Centre, Gujarat

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Conflict of interest: Nil

Abstract

Background: Magnetic Resonance Spectroscopy (MRS) is a method for detecting and quantifying metabolites. The MRS method contrasts with conventional magnetic resonance imaging (MRI). Because MRS provides physiological and chemical information, not just anatomy.

Objectives: To study the magnetic resonance spectroscopy in evaluation of intracranial pathologies.

Materials and Methods: This cross-sectional study conducted among 50 patients who were undergone for MRI brain and subsequent MRS of region of interest. The metabolites were observed in the spectrum and any alteration in form of increase or decrease in above mentioned metabolites was noted. In case of tumors final diagnosis was obtained by histopathology where possible while in non-neoplastic cases final diagnosis was obtained by clinical course and follow up.

Results: In our study 23 of 27 tumors (85%) showed contrast enhancement. Among non-neoplastic lesions, tuberculous lesions are the most common (48%), followed by demyelination (17%), encephalitis (13%), and toxoplasmosis (8%). Choline is elevated in 90% of tumors, NAA is decreased in 93% of neoplastic pathologies, and lipids are elevated in 56% of tumors. In tumor diagnosis, the sensitivity, specificity, PPV, and NPV MRI + MRS were all 96%.

Conclusion: MRS is an important diagnostic and research tool in clinical neuroscience. MRS is a very useful tool when combined with conventional MRI for glioma grading. It also plays an important role in narrowing the differential diagnosis of metabolic brain diseases. MRS is also important in diagnosing stroke and demyelination of the brain.

Keywords: Choline, Lipid, MRI, MR Spectrometry, N-Acetyl Alanine, Tumor.

Introduction

In clinical practice, radiologists often use magnetic resonance spectroscopy (MRS) as an interactive method when other radiological modalities do not provide sufficient information for diagnosis. In this setting, MRS findings are much more difficult to interpret than other diagnostic methods. MRS is used in selected cases with a limited number of alternative diagnoses to find an accurate diagnosis [1].

Magnetic resonance spectroscopy (MRS) is used to detect and metabolite abundance. The MRS method contrasts with conventional magnetic resonance imaging (MRI). This is because MRS provides physiological and chemical information, not just anatomy [2].

Single-voxel (SV) techniques that measure spectra from one brain zone at a time (a commonly used method is include "PRESS" [3] and "STEAM" [4] or multi-voxel techniques ("MR Spectroscopic Imaging" (MRSI)), also known as "Chemical Shift Imaging" (CSI) [5] which capture spectra from multiple regions. Simultaneously measure and map the spatial distribution of metabolites in the brain. MRSI is usually performed in two or three dimensions, but usually does not cover the entire brain. Although SV-MRS and MRSI each have their own strengths and weaknesses (spectral quality, scan time, spatial resolution, spatial coverage, ease of use/interpretation, etc.), important considerations in brain tumors are their Metabolic heterogeneity [6].

MR spectrum can measure specific metabolites in human body by supporting multiple nuclei such as 1H, 31P, 19F, 13C, 23Na. All of these can convey valuable metabolic and physiological information [7]. Field strengths used clinically in conventional MRI range from 0.2 to 3 T. Since the main purpose of MRS is to detect weak signals from metabolites, MRS requires higher magnetic field strengths (1.5 T or higher). High-field-strength devices have the advantages of high signal-to-noise ratio (SNR), high resolution, and short acquisition times [8]. So the present study was conducted with the objective to study the magnetic resonance spectroscopy in evaluation of intracranial pathologies.

Materials and Methods

Present cross-sectional study conducted among 50 patients who were undergone for MRI brain and subsequent MR spectroscopy of region of interest at radiology department of C. U. Shah Medical College, Surendranagar, Gujarat during July 2016 to July 2017 after ethical permission of IEC of institute. Inclusion criteria were all ages and genders, patients with suspected/known intracranial pathology, patients with positive/indeterminate MRI results, and patients presenting for follow-up evaluation of intracranial pathology.

MRI was performed with a 1.5 Tesla MRI scanner (Siemens 1.5 T Magnetom Essenza MRI) using a special head coil. Sedation was administered as needed. Conventional MRI has been done by the use of Axial T2 Weighted, axial and Sagittal T1 Weighted FLAIR images in the coronal plane.

Gadolinium-enhanced MRI (0.1 mmol/kg dose) was performed in axial, coronal and sagittal planes in cases selected based on clinical suspicion and patient availability.

MR spectroscopy was done by Point Resolved Spectroscopy. After determining the region of interest, the voxels were retained and subjected to 2D Multivoxel Proton Spectroscopy (TR 1000 ms, TE 144 ms, voxel size 20x20 mm) or Single Voxel Proton Spectroscopy (TR 1500 ms, TE 35 ms), voxel size) 20x20 mm)) and get the spectrum.

MRS observed the following metabolite & gave a spectrum:

1. N-Acetylaspartate at 2.0 ppm

2. Creatine-Phosphocreatine ratio at 3.0 ppm
3. Choline Compounds (Cho) at 3.2 ppm
4. Myoinositol (mI) at 3.56 ppm
5. Lactate acid doublets at 1.35 and 4.1 ppm
6. free lipids broad resonance, doublet at 1.3 and 0.9 ppm

Metabolites were observed in the spectrum at 1.3 and 0.9 ppm, and changes in the shape of increase or decrease of the above metabolites were noted. In the case of tumors, a definitive diagnosis was made by histopathological examination as much as possible, and in the case of non-neoplastic lesions, a definitive diagnosis was made by clinical course and follow-up. Data were recorded in an Excel sheet, descriptive analysis was performed, and the data are presented in a table.

Results

Table 1: Socio-clinical parameters of study participants [N=50]

Parameter	Group A: Neoplastic (n=27)		Group B: Non-neoplastic (n=23)	
	Number	%	Number	%
Age (in year)				
0-20	4	14.8	7	30.4
21-40	6	22.2	9	39.1
41-60	12	44.4	6	26.1
>60	5	18.5	1	4.4
Mean Age ± SD	43.5 ± 7.8		31.4 ± 6.4	
Gender				
Male	20	74.1	14	60.9
Female	7	25.9	9	39.1
Contrast Enhancement				
Present	23	85.2	16	69.6
Absent	4	14.8	7	30.4
Choline Level				
Normal	3	11.1	10	43.5
Increased	24	88.9	13	56.5
Lipid Level				
Absent	12	44	6	26
Increased	15	56	17	74
N-acetyl Alanine				
Normal	6	22.3	1	4.3
Increased	1	3.7	0	0.0
Decreased	20	74	22	95.7

Table 1 shows that 14.8%, 22.2%, 44.4%, 18.5% participants of group A and 30.4%, 39.1%, 26.1%, 4.4% of group B were belonged to age group 0-20, 21-40, 41-60, >60 years respectively. Mean age was 43.5 years with 7.8 SD and 31.4 years with 6.4 SD of the participants of group A and group B respectively. Almost 74.1% & 25.9% participants of group A and 60.9% & 39.1% of group B were male and female respectively. Contrast enhancement was seen in 85.2% neoplastic cases and 69.6% of non-neoplastic cases. Choline level was increased in 88.9% neoplastic cases and 56.5% non-neoplastic cases. Lipid level was increased in 56% neoplastic cases and 74% non-

neoplastic cases. N-acetyl alanine level was decreased in 74% neoplastic cases and 95.7% non-neoplastic cases.

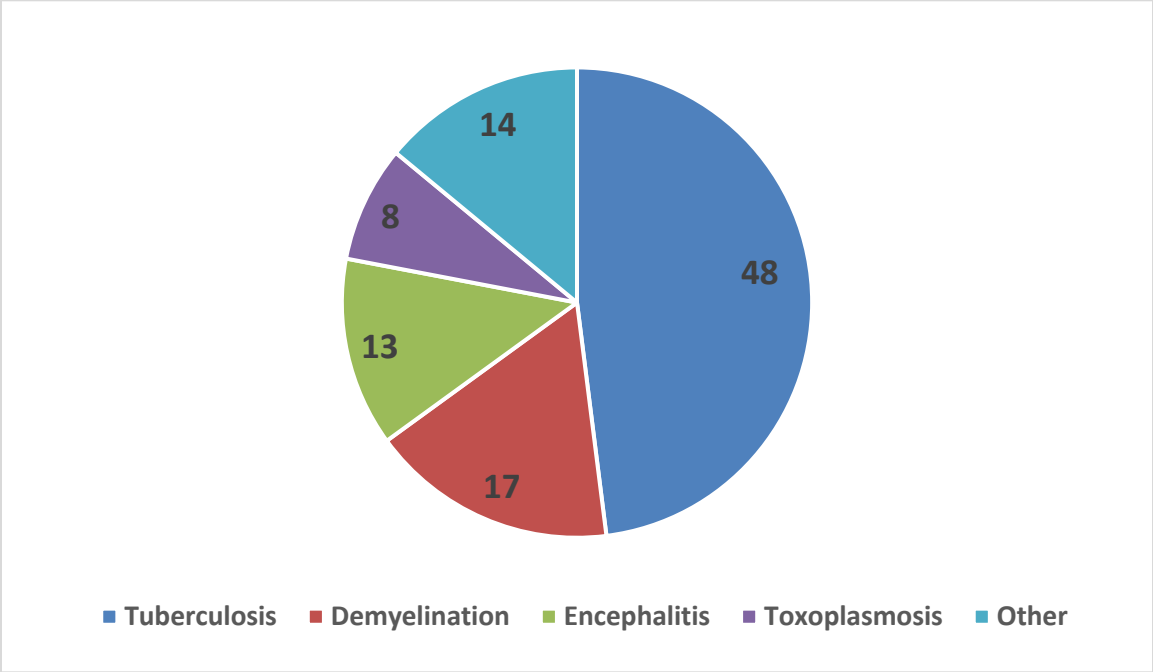

Figure 1: Distribution of non-neoplastic lesion among study participants

Figure 1 shows that among non-neoplastic cases, 48%, 17%, 13%, 8%, 14% cases were diagnosed as TB, demyelination, encephalitis, toxoplasmosis and others.

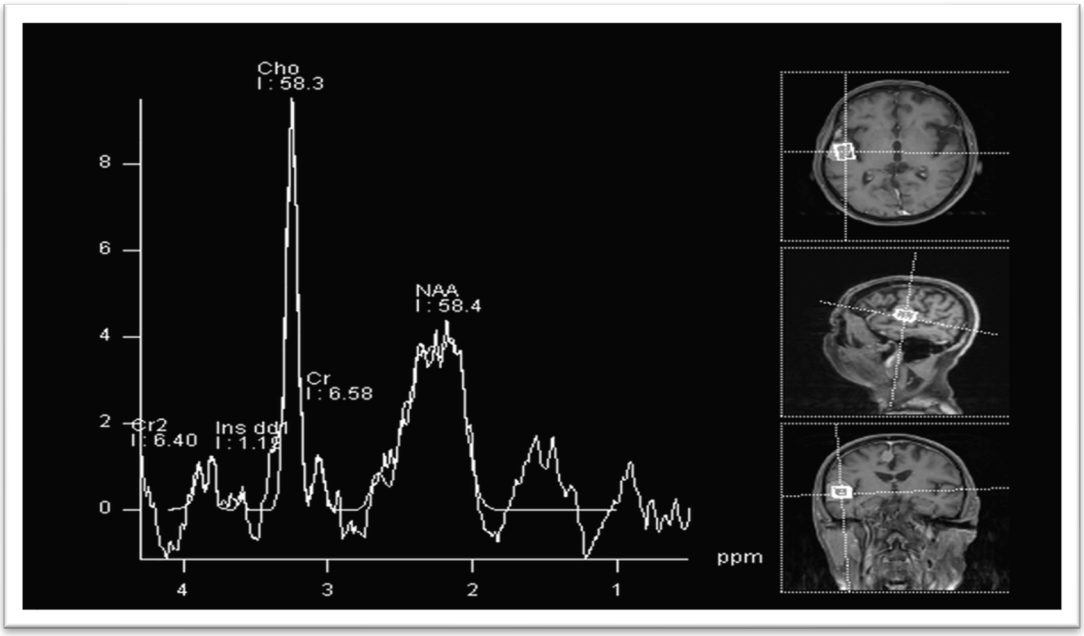

Figure 2: Increased NAA and Choline peak on spectroscopic study. Above MR+MRS finding are suggestive of meningioma.

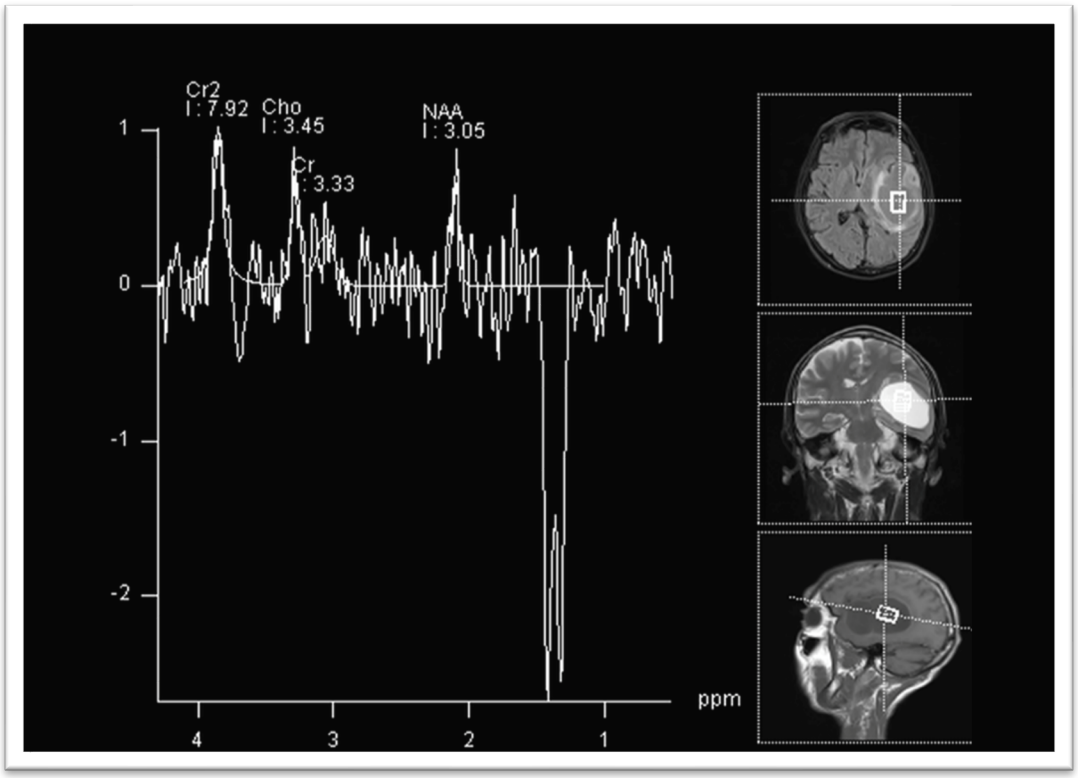

Figure 3: Increased Choline and NAA peak on spectroscopic study. Above MR+ MRS findings are suggestive of pilocysticxanthoastrocytoma

Table 2: Comparison of Sensitivity, Specificity, PPV, NPV of 'MRI only' and 'MRI + MR spectrometry' in diagnosis of different intracranial pathology

Pathology	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Tumor				
MRI	85	87	88	83
MRI + MR Spectrometry	96	96	96	96
Tuberculosis				
MRI	81	100	100	95
MRI + MR Spectrometry	90	100	100	97
Encephalitis				
MRI	100	100	100	100
MRI + MR Spectrometry	100	100	100	100
Demyelination				
MRI	75	100	100	98
MRI + MR Spectrometry	100	100	100	100
Toxoplasmosis				
MRI	100	100	100	100
MRI + MR Spectrometry	100	100	100	100
Residual Tumor				
MRI	60	100	100	96
MRI + MR Spectrometry	100	100	100	100

Table 2 shows that the sensitivity and specificity of MRI in tumor diagnosis were 85% and 87%, respectively. The positive and negative predictive values are 88% and 83%, respectively. The sensitivity and specificity of MRI for tuberculosis diagnosis are 81% and 100%, respectively. The positive and negative predictive values are 100% and 95%, respectively. For the diagnosis of encephalitis, the sensitivity and specificity of MRI are 100% and 100%, respectively. The positive and negative predictive values are 100% and 100%, respectively. The sensitivity and specificity of MRI for the diagnosis of demyelination are 75% and 100%, respectively. The positive and negative predictive values are 100% and 98%, respectively. The sensitivity and specificity of MRI for the diagnosis of toxoplasmosis are 50% and 100%, respectively. The positive and negative predictive values are 100% and 98%, respectively. The sensitivity and specificity of MRI in the diagnosis of recurrent/residual tumors are 60% and 100%, respectively. The positive and negative predictive values are 100% and 96%, respectively.

The sensitivity and specificity of MRI + MRS in the diagnosis of tumors are 96% and 96%, respectively. The positive and negative predictive values are 96% and 96%, respectively. In the diagnosis of tuberculosis, the sensitivity and specificity of MRI + MRS are 90% and 100%, respectively. The positive and negative predictive values are 100% and 97%, respectively. In the diagnosis of encephalitis, the sensitivity and specificity of MRI+MRS are 100% and 100%, respectively. The positive and negative predictive values are 100% and 100%, respectively.

In the diagnosis of demyelination, the sensitivity and specificity of MRI+MRS are 100% and 100%, respectively. The positive and negative predictive values are 100% and 100%, respectively. The sensitivity and specificity of MRI + MRS in the diagnosis of toxoplasmosis are 100% and 100%, respectively. The positive and negative predictive values are 100% and 100%, respectively. The sensitivity and specificity of MRI + MRS in the diagnosis of recurrent/residual tumors are 100% and 100%, respectively. The positive and negative predictive values are 100% and 100%, respectively.

Discussion

In present study, the age distribution of ICL ranged from 1 to 80 years. Intracranial neoplasia and other intracranial lesions were observed to be more common in the age group 31-50 years, with 22 (44%) cases. In present study, the mean age of participants in the neoplastic group was 43.5 years and the mean age of participants in the non-neoplastic group was 31.4 years.

The current study found a male to female ratio of 2.1:1 for all participants. There were 20 males and 7 females with an M:F ratio of 3:1 for intracranial tumors and 14 males and 9 females with a ratio of 1.5:1 for non-neoplastic lesions.

In present study, 23 out of 27 tumors (85%) showed contrast enhancement.

Among the non-neoplastic lesions in present study, tuberculous cases were the very common, accounting for approximately (48%) of cases, followed by demyelination (17%), encephalitis (13%), and Toxoplasma gondii. disease (8%).

For tuberculosis, MRS detected a lipid lactate peak at 1.3 ppm. No amino acid peak was observed in tuberculous abscesses, which helps distinguish them from pyogenic abscesses [9] In Pyogenic abscess, MRS detected an amino acid peak at 0.9 ppm helps distinguish suppurative abscesses from tumors. Abscesses from anaerobes additionally show acetate and succinate peaks at 1.9 and 2.4 ppm, respectively [10] In fungal abscesses, MRS detected several peaks between 3.6 and 4.0 ppm for amino

acids and lactate. These peaks are attributed to trehalose sugars present in the fungal wall [11].

In present study, the choline is higher in 90% of tumors, NAA is lower in 93% of neoplastic pathologies and lipid is higher in 56% cases of tumors.

The association between decreased NAA concentrations and increased glioma grade allows the use of NAA as an important marker [9]. A high level of NAA is associated with a favorable prognosis [12]. NAA also helps distinguish primary brain tumors from metastatic and non-neurological tumors in which metabolites are absent in the spectrum [13].The choline peak is at 3.2 ppm and is the most important metabolic peak for glioma diagnosis. Increased choline reflects increased cell membrane synthesis and degradation. Thus, all processes resulting in increased membrane turnover like primary brain neoplasm and myelin breakdown like demyelinating lesions lead to increased choline concentration [14]. When ischemia of tumorous tissue progresses further, the peaks of Lip increase, suggesting the existence of necrosis and the elimination of myelin sheaths. Thus, the level of Lip detected by MRS appears to reflect the severity of tissue damage [15].

Present study noted that false negative (FN) cases were indicating that MRI with MRS can be used to remove the possibility of a tumor in all doubtful cases with very high confidence.

MR spectroscopy, when used as an adjunct to conventional MRI, is a useful tool for diagnosing metabolic disorders in the brain. In most inherited metabolic disorders, MRS findings are atypical but not specific to a single metabolic disorder or syndrome. Some metabolic disorders have specific MRS findings, such as an abnormal increase or decrease in a single normal peak, or evidence of abnormal metabolic peaks. A specific MRS pattern is seen primarily in Canavan disease, with a significant increase in NAA peak and a characteristic decrease in creatine peak in creatine deficiency. In non-ketotic hyperglycemia, the glycine peak occurs at 3.55 ppm [8-16].

Hamsini BC *et al* [8] observed higher sensitivity, specificity, PPV and NPV of proton MR spectroscopy in differentiating glioma grades compared to conventional methods. MRI shows that proton MRS spectroscopy is a useful tool for differentiating glioma grades.

In other studies conducted by Law M *et al* [17] Zou QG *et al* [18] and Ellika SK *et al* [19] sensitivities of 72% to 86% and specificities of 60% to 67%. Other studies in the literature have shown sensitivities in the range of 55-83% [20,21].

Conclusion

MRS is an important diagnostic and research tool in clinical neuroscience. MRS is a very useful tool when combined with conventional MRI for glioma grading. In addition to grading tumors, MRS is useful in diagnosing many brain infections by displaying specific metabolite peaks. It also aids in post-radiotherapy patient diagnosis when distinguishing between recurrent brain tumors and radiation changes/damage. It also plays an important role in narrowing the differential diagnosis of metabolic brain diseases. MRS is also important in diagnosing stroke and demyelination of the brain.

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