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Role of Magnetic Resonance Spectroscopy in Evaluation of the Ring Enhancing Lesions of Brain

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ABSTRACT

A wide range of diseases manifest as ring enhancing lesions on neuroimaging. Magnetic Resonance Spectroscopy (MRS) helps in characterizing these lesions and help in differentiating these disease conditions, which have considerable overlapping conventional MR imaging findings. MR spectroscopy works on the principle of identification of metabolites present in the brain tissues, such as Choline, NAA, creatine, lipid, lactate and myoinositol. The aim of this study is to describe the diagnostic significance of the Magnetic Resonance Spectroscopy in characterization of the ring enhancing lesions of brain, when combined with routine MR imaging protocol. This retrospective study was conducted in Sri Manakula Vinayagar Medical College and hospital, Puducherry, which is a multidisciplinary, 900 bedded hospitals with fully equipped Radiology department. The study was conducted during the period of March 2019 to February 2020. The study was done using 1.5 Tesla PHILIPS INTERA whole body MR systems with standard head coil. Magnetic resonance spectroscopy images was performed through single voxel technique. The study population comprised of forty patients. In this study the youngest patient was 8 years old and oldest being 71 years. The highest incidence of ring enhancing brain lesions was found in the sixth decade, accounting for 25% of cases and the least incidence in the eighth decade, accounting for 2.5% of cases. Among various metabolites in MRS of the study population, elevated Choline peak was the most frequent and reduced NAA peak was the least frequent. In this study, all cases of neurocysticercosis were intraparenchymal form. Neurocysticercosis does not have an elevated lipid peak on MR spectroscopy and patients with tuberculoma typically had an elevated lipid peak. Choline/creatine ratio less than 1, differentiates tuberculoma, from the glioma and metastasis. Patients with tubercular abscesses lacks amino acid peaks, a feature that differentiates from pyogenic abscesses. Patients with glioma and metastasis had an elevated Cho/Cr ratio. Presence of increased choline peaks in the region of surrounding edema is seen in the high-grade glioma, which is absent in metastasis. Inclusion of the MR spectroscopy to routine MRI protocol helps to diagnose the disease conditions of the brain with confidence.

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Key Words
MRI, MR spectroscopy, MRS, ring enhancing lesions

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INTRODUCTION

A wide range of diseases manifest as ring enhancing lesions on neuroimaging. Diseases causing multiple ring-enhancing lesions of the brain can be infective, neoplastic, vascular, or inflammatory in aetiology[1]. Many brain neoplasms, such as gliomas and brain metastases can also present as multiple ring-enhancing lesions[1]. Infective diseases such as neurocysticercosis, tuberculosis, pyogenic abscesses, toxoplasmosis and fungal infections, and certain demyelinating disorders can mimic brain tumours on imaging. In tropical countries, neurocysticercosis granuloma frequently needs to be differentiated from intracranial tuberculoma[1].

Ring enhancing lesions are typically seen in grey white matter junction which is the common location. Among cross sectional imaging, Magnetic resonance (MR) imaging has a leading edge over computed tomography because of its superior tissue contrast properties[2]. Conventional MR imaging sequences provide the precise anatomical localization and relation to the adjacent structures[2]. MR spectroscopy (MRS) is a non-invasive technique which generates the biochemical information in form of metabolites in the selected region of the neuroparenchyma[2].

MR spectroscopy performed using 1H metabolite shows a better spectrum, compared to those methods using sodium (23Na) and phosphorous (31P)[3]. MRS can be done within short time which can be supplemented with conventional MRI study[4]. H1 MRS gives information about the concentration of metabolites such as N-acetyl aspartate (NAA), choline (Cho), creatine (Cr) and lactate in the brain tissue[5]. Widespread usage of faster MRS applications with higher signal-to-noise ratio (SNR) and spatial resolution, allow us to detect metabolic changes in abnormal brain parenchyma Further this helps in understanding the exact nature of the lesion with respect to the normal brain parenchyma[5].

MATERIALS AND METHODS

The main aim of this study is to describe the diagnostic significance of the Magnetic Resonance Spectroscopy in the ring enhancing lesions of brain, when combined with routine MR imaging protocol. This retrospective study was conducted at Sri Manakula Vinayagar Medical College and hospital, Puducherry, which is a multidisciplinary, 900 bedded hospitals with fully equipped Radiology department. The study was conducted during the period of March 2019 to February2020. This study included 40 patients, with ring enhancing lesions on Magnetic resonance imaging.

The study was done in 1.5 Tesla PHILIPS whole body MR systems with standard head coil. The studies present in the PACS with T1WI, T2WI, T2 FLAIR, T2 FFE, DWI, T1FS, T1 contrast (using Intravenous administration of Gadolinium) sequences were included in this study. Incomplete dataset and MRI/MR Spectroscopy images with artifacts were excluded from this study. In this study, Magnetic resonance spectroscopy with single voxel and short TE technique were included with representation of the metabolites including NAA, choline, creatine, lipid, lactate, myoinositol and amino acids.

Ethical consideration: Clearance from the ethics committee of Sri Manakula Vinayagar Medical College and Hospital, Puducherry was obtained prior to the initiation of the study on 05/11/2019. The IEC approval no. is SMVMCH/DR/AL-SRC/80/2019.

RESULTS AND STATISTICAL ANALYSIS

Data was entered into Microsoft excel data sheet and data analyses was carried out using SPSS statistical package IBM version 26.0 software. Categorical data was represented in the form of frequencies and proportions. Continuous data was represented as mean and standard deviation.MS Excel and MS word were used for graphical representation of data in form of Tables.

DISCUSSIONS

The main aim of this study is to describe the diagnostic significance of the Magnetic Resonance Spectroscopy in characterization of the ring enhancing lesions of brain, when combined with routine MR imaging. This retrospective study was done in the Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry.

In this study, forty patients were included, of which 26 (35%) were male and 14 (65%) were female. The study population included the patients of age from 8-71 years. The highest incidence of ring enhancing lesions were found in patients of the age 51-60 years, accounting for 25% of cases and the least incidence in patients of age 71-80 years comprising 2.5% of cases. Frequency of the various metabolites found in the MR spectra of these patients was tabulated. Choline peak was observed in 17 cases, lipid peak in 13 cases, lactate peak in 10 cases, myoinositol peak in 1 case and the reduced NAA in 24 patients. Elevated Choline peak was the most frequent finding and reduced NAA was the least frequent.

Neurocysticercosis (NCC): Out of 40 patients evaluated, 17 (42.5%) had Neurocysticercosis and these were intraparenchymal forms. Scolex was identifiable only in 12 cases. On conventional MR Imaging, patients with NCC had multiple and smaller lesions. These MRI features of parenchymal forms of NCC in this study, are similar to the study conducted by

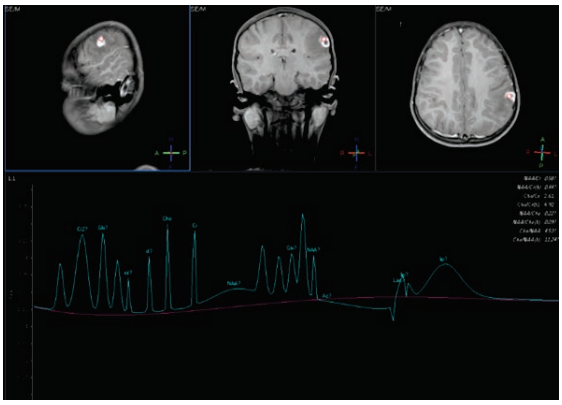

Fig. 1: MR Spectroscopy findings in a case of Neurocysticercosis: Normal choline/ creatine ratio, reduced NAA, absent lipid peak and presence of succinate and acetate

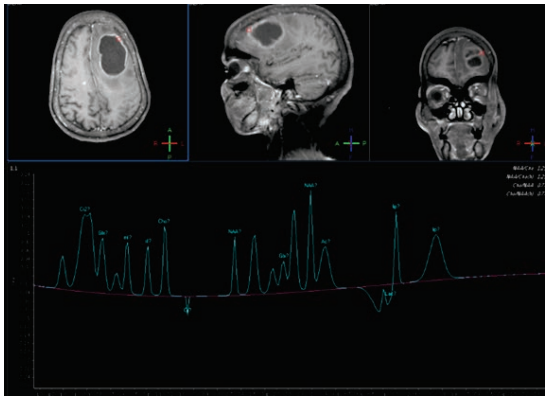

Fig. 2: MR Spectroscopy findings in a case of metastasis- Elevated choline, reduced NAA, increased lactate and lipid peak, absent myo-inositol peak. Raised choline/creatine ratio; Choline/NAA ratio greater than 1

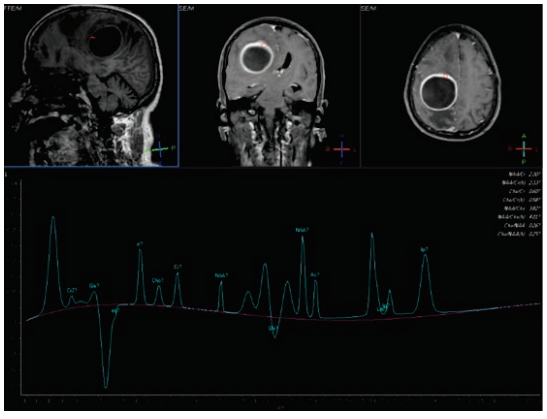

Fig. 3: MR Spectroscopy findings in a case of tubercular abscess- presence of lipid lactate peaks, raised choline/creatine ratio with reduced NAA peak

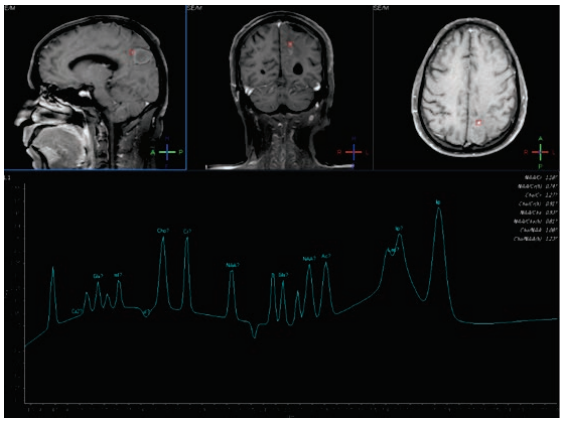

Fig. 4: MR Spectroscopy findings in a case of Tuberculoma- presence of lipid peak at 1.3 ppm; choline/creatine more than 1, Reduction in NAA

Table 1: Gender distribution of cases

Sex	No. of cases	Percentage
Male	26	65
Female	14	35

Table 2: Gender wise distribution of ring enhancing lesions

Lesions	Male	Female	Total
Neurocysticercosis	11	6	17
TB abscess	4	2	6
Tuberculoma	3	2	5
High grade glioma	6	2	8
Metastasis	2	2	4

Table 3: Frequency of ring enhancing lesions

Lesions	No of cases	Percentage
Neurocysticercosis	17	42.5
TB abscess	6	15
Tuberculoma	5	12.5
High grade glioma	8	20
Metastasis	4	10

Table 4: Frequency of metabolic peaks in MR Spectroscopy of the ring enhancing lesions

Metabolic peaks	No. of cases	Percentage
Choline	17	42.5
Lipid	13	32.5
Lactate	10	25
Reduced NAA	24	60
Myoinositol	1	2

Amaral *et al.*[6] On conventional MR Imaging, NCC lesions are usually multiple and smaller, whereas tuberculoma is usually single and larger in size[6].

Majority of the patients showed normal choline peak and reduced NAA on MRS. However, out of 17 patients, 5 patients had elevated choline peak, which can be due to destruction of the cell membranes. MRS showed amino acid peaks of acetate and succinate. These metabolites are not found in the MRS of the patients with tuberculomas. Further there was no elevation of the lipid peak, which differentiates from the tuberculoma. Cho/Cr ratio was comparatively less in NCC patients in the study population. These results are similar to the results of the study done by Kumar *et al.*[7]

Metastasis: In the study population, 4 patients (10%) had metastasis. On conventional MRI, the lesions appeared hypointense on T1WI, heterogeneously hyperintense on T2WI with significant perilesional edema. Primary tumors were identified as breast and lung carcinoma. MRS in these patients showed choline peak, lipid, lactate peak with reduced NAA. In all these patients, increased Cho/Cr ratio and decreased NAA/Cho ratio were seen. These findings were similar to the study done by Fink *et al.*[8] Both metastasis and high-grade gliomas demonstrated elevated Lipid and lactate in the areas of necrosis. The enhancing components in these lesions showed increased choline/creatine peak ratios, when compared to normal brain parenchyma.

Both these conditions have surrounding vasogenic edema. High grade gliomas have infiltration of the neoplastic cells along with vasogenic edema, which does not occur in the metastasis. MR spectroscopy findings in the region of surrounding edema, show increased choline peaks in case of high-grade glioma, a finding not seen in the metastasis.[9-10] In a study conducted by Law *et al.*[11] a choline/NAA ratio of greater than 1 had an accuracy of 100%.

Tuberculoma: In the study population, tuberculomas were seen in 5 cases (12.5%). On conventional MR imaging, they were heterogenous, predominantly hypointense on T1WI and hyperintense on T2WI. Significant perilesional edema and midline shift were present, which differentiates from the neurocysticercosis. Prominent lipid peak was the MR Spectroscopy finding in these patients. This finding is suggestive of tuberculomas than other infective granulomas. Reduction in NAA and creatine were found in these cases. Choline/creatine ratio was less than 1, which differentiates from the neoplastic lesions. These findings were similar to the results of the study conducted by Mukherjee *et al.*[3] which demonstrated a very high lipid peak, reduction in NAA and creatine with a choline/creatine ratio of less than 1. Among ring enhancing lesions, Lipid peak in MRS is specific for tuberculoma and it is typically absent in the NCC. These results are in concordance with studies done by Sethi *et al.*[12] and Verma *et al.*[13]

Tubercular abscess: Out of 40 patients evaluated, tubercular abscesses were found in 6 patients (15%). These lesions were heterogenous on T1WI and T2WI with a T2 hypointense rim, with post contrast ring enhancement. MR Spectroscopy findings were lipid lactate peak in all the cases, a finding typically seen in the tubercular abscesses. No elevation of choline was seen. Further no amino acid peaks such as leucine, isoleucine and valine were found. Amino acid peaks are not seen in case of tuberculous abscesses, which differentiates from pyogenic abscesses. MR spectroscopy helps to recognize the underlying causative organism in these instances. Elevated acetate and succinate peaks suggest the infection due to anaerobic bacteria, whereas absence of these metabolites is more likely due to obligate aerobes or facultative anaerobes[14,15]. The MR spectroscopy findings of the present study were similar to the study conducted byLuthra *et al.*[16]

Gliomas: In the present study, 8 patients had high grade glioma. These lesions were hypointense on T1WI and heterogeneous, predominantly hyperintense on T2WI and necrotic components were seen on contrast T1WI. In this study, all these lesions had elevated choline peak with reduction in NAA and Creatine, which is a typical MRS finding in high grade tumors. Lipid and lactate peaks were seen in the necrotic areas of the tumor. These findings were in concordance with the study conducted by Kumar *et al.*[7] which also showed significant increase in Cho/Cr ratio in these neoplastic lesions. Elevation of Cho/Cr ratio correlates with increasing grades of the glioma, i.e. tumor malignancy. Reduction of NAA indicates loss of neuronal elements. Myo-inositol peak was found in a case of the high-grade glioma and a feature which is not found in the metastasis. Both Glioma as well as metastasis show decreased N acetyl aspartate.

Limitations of the study: Lack of follow-up imaging.

CONCLUSION

Magnetic resonance imaging has the inherent ability to delineate normal and abnormal neuroparenchyma, due to excellent soft-tissue contrast properties and provides the precise anatomical information. Magnetic resonance spectroscopy is a non-invasive tool that generates the metabolic information of the diseased tissue, and further it improves the lesion characterization when included to routine MRI protocol.

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