

ROLE OF MAGNETIC RESONANCE SPECTROSCOPY IN THE EVALUATION OF RING ENHANCING LESIONS OF BRAIN

Narendra Kumar¹, R. K. Jain², Ganesh Kumar³, Kaleem Ahmad⁴, Ved Prakash Shukla⁵, Ajay Kumar⁶, Amit Goel⁷

Received : 30/04/2023
Received in revised form : 27/05/2023
Accepted : 09/06/2023

Keywords:

MRI, ring enhancing lesions.

Corresponding Author:

Dr. Narendra Kumar,

Email: drndkgmu2008@gmail.com

DOI: 10.47009/jamp.2023.5.3.410

Source of Support: Nil,

Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (3); 2081-2087



¹PG Resident, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

²Professor & head, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

³Dean & Principal, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

⁴Associate Professor, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

⁵Assistant Professor, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

⁶Professor, Department of General Medicine, BRD Medical College, Gorakhpur, India.

⁷Senior Resident, Department of Radiodiagnosis, BRD Medical College, Gorakhpur, India.

Abstract

Background: Aim: The aim of the present study was to assess the role of magnetic resonance spectroscopy in the evaluation of ring enhancing lesions of brain. **Materials and Methods:** This cross-sectional study was conducted at a Tertiary Care Hospital (BRD MEDICAL COLLEGE, GORAKHPUR) after acquiring the approval from the Institutional Ethics Committee. The study was conducted for 12 Months from November 2021 to November 2022. The Cases referred to department of Radiodiagnosis in the one year from OPD and IPD. This study included patients, aged between 2 to 80 years, who presented with symptoms of seizures, headache, fever & vomiting and were incidentally diagnosed with ring enhancing lesions of brain based on MRI studies. 84 patients were included in the study. **Results:** Mean age was 31.78±21.48 years. Median age was 26 (15-50.75) years. Range was 2-80 years. The total 14.3% of the participants had Age 1-10 Years, 25% of the participants had Age 11-20 Years, 20.2% of the participants had Age 21-30 Years. Male: female distribution was almost equal with male: female ratio of 1:1.1. Seizure (81; 96.4%) and headache (46; 54.8%) were two most common clinical pictures while fever was present in 43 (51.2%) subjects and vomiting was reported by 24 (28.6%) cases. Brain abscess was most commonly seen in pediatric age group (30% cases). No age group demarcation seen in Neurocysticercosis cases. Neoplastic lesions (Primary brain tumors & Metastases) were seen in elderly age group. Out of the 84 patients who were evaluated with ring enhancing lesions in the brain, Neurocysticercosis (n=29, 34.5%) was the most common pathology followed by tuberculomas 25 patients (29.8%). **Conclusion:** In our study, the most prevalent was tuberculomas (29.8%). Almost all cases of tuberculomas showed lipid lactate peak on MRS except one. Tuberculomas can be differentiated from NCC by high Cho: Cr ratio >1.1 in tuberculomas. Lactate/acetate peaks was seen in all cases of brain abscess and NAA peak also seen in 6 cases.

INTRODUCTION

A ring-enhancing lesion in brain imaging is a common feature on the Indian subcontinent. The two most common etiologies of inflammatory granulomas encountered in pediatric clinical practice include neurocysticercosis (NCC) and tuberculomas.^[1] The size, shape, wall thickness of ring-enhancing lesions, the extent of surrounding edema, and, more importantly, clinical history and age of the patient should be taken into consideration to help distinguish the condition.^[2] Multiple ring-enhancing lesions are one of the most commonly

encountered neuroimaging abnormalities. Widely available imaging Techniques, computed tomography (CT) and magnetic resonance imaging (MRI) are used to detect these lesions. A wide range of etiologies may present as cerebral multiple ring-enhancing lesions.^[3]

On neuroimaging, these lesions appear as Hypodense or isodense mass lesions on noncontrast CT studies. After contrast administration, there is a ring or a homogeneous disc-like enhancement within the region of hypodensity. The enhancing lesions are often of variable sizes and are usually surrounded by varying amounts of vasogenic edema. Typically, the

ring-enhancing lesions are located at the junction of the gray and white matter, but they could be located in the sub-cortical area, deep in the brain parenchyma or may even be superficial.^[3] The most common neuroimaging finding in children with partial epilepsy from India is single enhancing lesions (SEL) with perifocal density suggestive of edema.^[2] Wadia et al reported that 26.1% of Indian patients with focal seizures had enhancing ring or disc lesions visible in CT scans.^[4]

Magnetic resonance spectroscopy (MRS) provides information about the possible extent and nature of changes on a routine MRI scan by analyzing the presence and / or ratio of tissue metabolites such as NAA, creatine, choline, and lactate etc.^[5] Widespread usage of faster MRS applications with a higher signal-to-noise ratio (SNR) and spatial resolution, allows us to detect functional metabolic changes, which provides more data to understand the exact nature of the tumor and the morphological and physiological changes occurring in surrounding brain parenchyma.^[6] Longitudinal studies have demonstrated that HMRS is useful in monitoring disease progression and treatment effects. MR spectroscopy also has a prognostic implication.

MRS could clearly differentiate tuberculoma over other lesions, based on the metabolite level. Tuberculoma and neurocysticercosis lesions resembled in many aspects based on CT and MRI scans but could be differentiated on the basis of location, number of lesions, enhancement pattern and constitutional symptoms, however, MRS could differentiate between these lesions based on their metabolite levels. The aim of the present study was to assess the role of magnetic resonance spectroscopy in the evaluation of ring enhancing lesions of brain.

MATERIALS AND METHODS

This cross-sectional study was conducted at a Tertiary Care Hospital (BRD MEDICAL COLLEGE, GORAKHPUR) after acquiring the approval from the Institutional Ethics Committee. The study was conducted for 12 Months from November 2021 to November 2022. The Cases referred to department of Radiodiagnosis in the one year from OPD and IPD. This study included patients, aged between 2 to 80 years, who experienced seizures, headache, fever & vomiting and were incidentally diagnosed with ring enhancing lesions of brain based on MR studies. 84 patients were included in the study.

Inclusion Criteria

All Patients with suspicious intracranial ring enhancing lesions which were detected on contrast MR studies and were taken up prospectively.

- All Patients of all age groups irrespective of sex.

- Informed consent from the patients involved in the study was obtained. The sample size was taken 84 for this study.

Exclusion Criteria

- Patients with claustrophobia.
- Patient with prior history of any metallic implant or contrast allergy.
- Parents refused to consent for the study.

Study Protocol

- All patients referred to the department of Radiodiagnosis, Baba Raghav Das Medical College, Gorakhpur.
- Those patients meeting the study inclusion criteria were eligible for study.
- Each eligible patient informed by the primary investigator of this study and was explained the reason and purpose of the study.
- The demographic information was completed for each patient such as age, sex including symptomatology.

Methodology

The following patients, referred to the Department of Radiodiagnosis, BRD Medical College, Gorakhpur, from different departments were included as the subjects in the study: -

MRI scan was performed using Siemens magnetom aera machine, possessing an ultra-compact, superconducting, active shielded superconducting magnet with a magnetic field strength of 1.5 Tesla (T). Conventional spin echo sequences, axial T1, T2 and Fluid Attenuated Inversion Recovery (FLAIR): Coronal T2; Sagittal T1; Post-contrast axial, coronal and sagittal; Diffusion Weighted Imaging (DWI); T2 Gradient Echo Sequences (GRE), was performed at echo time (TE). The same instrument was used to perform MRS. With the application of single voxel MRS, the voxel was placed on the lesion such that the maximum area of the lesion, its margin and the normal brain tissue were covered in a single voxel. Spectroscopy was avoided in small lesions close to the bone. Various metabolites peaks were used in diagnosing ring enhancing lesions of brain: choline peak at 3.2 ppm, lipid peak at 1.3 ppm, lactate peak at 1.3 ppm and reduced NAA peak at 2.0 ppm while creatine peak obtained at 3.0 ppm. Special peaks (alanine at 1.48 ppm, acetate at 1.92 ppm, succinate at 2.4 ppm, aspartate at 2.6 ppm, AA at 0.9 ppm) were noted.

The quantitative data was analyzed using Microsoft excel software. The categorical data was represented as frequency (%). The graph was plotted by the MRI machine software, and the peak amplitude of choline, lipid, lactate, reduced NAA and amino acids in the ring enhancing lesions were recorded. The choline/creatine ratio was calculated and associated with the type of lesion the patient exhibited.

RESULTS

Table 1: Demographic data

Variables	No.	%
Age group		
1-10 years	12	14.3
11-20 years	21	25.0
21-30 years	17	20.2
31-40 years	7	8.3
41-50 years	6	7.1
51-60 years	9	10.7
>60 years	12	14.3
Gender		
Male	40	47.6
Female	44	52.4
Presenting symptoms		
Seizure	81	96.4
Headache	46	54.8
Vomiting	24	28.6
Fever	43	51.2

Mean age was 31.78±21.48 years. Median age was 26 (15-50.75) years. Range was 2-80 years. The total 14.3% of the participants had age 1-10 Years, 25% of the participants had age 11-20 Years, 20.2% of the participants had age 21-30 Years, 8.3% of the participants had age: 31-40 Years, 7.1% of the participants had age: 41-50 Years, 10.7% of participants had age 51-60 years and 14.3% of the participants had age >60 Years. Male: female distribution was almost equal with male: female ratio of 1:1.1. Seizure (81; 96.4%) and headache (46; 54.8%) were two most common clinical pictures while fever was present in 43 (51.2%) subjects and vomiting was reported by 24 (28.6%) cases.

Table 2: Age wise distribution of different ring enhancing lesions

	Age group (In Years)							Total
	1-10	11-20	21-30	31-40	41-50	51-60	>60	
BRAIN ABSCESS	3	0	1	1	2	1	2	10
CALCIFIED GRANULOMA	1	3	2	0	0	1	1	8
GLIOBLASTOMA MULTIFORME	0	0	0	0	0	1	0	1
GLIOMA	0	0	1	0	1	0	1	3
METASTASES	0	0	0	0	1	0	3	4
MULTIPLE SCLEROSIS	0	0	2	0	0	0	0	2
NEUROCYSTICERCOSIS	5	9	5	2	2	3	3	29
TOXOPLASMOSIS	0	0	1	1	0	0	0	2
TUBERCULOMA	3	9	5	3	0	3	2	25
Total	12	21	17	7	6	9	12	84

From the above findings, it can be estimated that, brain abscess was most commonly seen in pediatric age group (30% cases). No age group demarcation seen in Neurocysticercosis cases. Neoplastic lesions (Primary brain tumors & Metastases) were seen in elderly age group.

Table 3: Gender wise distribution of Type of Ring enhancing lesions of brain in study subjects

Lesion	Male	Female	Total
Neoplastic (n=8)			
Glioma	2	1	3 (3.6%)
Metastases	1	3	4 (4.8%)
Glioblastoma Multiforme	1	0	1 (1.2%)
Non-neoplastic (n=76)			
Brain abscess	7	3	10 (11.9%)
Calcified granuloma	4	4	8 (9.5%)
Multiple sclerosis	2	0	2 (2.4%)
Neurocysticercosis	15	14	29 (34.5%)
Toxoplasmosis	1	1	2 (2.4%)
Tuberculoma	11	14	25 (29.8%)

Out of the 84 patients who were evaluated with ring enhancing lesions in the brain, Neurocysticercosis (n=29, 34.5%) was the most common pathology followed by tuberculomas 25 patients (29.8%), brain abscess in 10 (11.9%) patients, Calcified granuloma in 8 (9.5%) patients, multiple sclerosis in 2 (2.4%) patients and toxoplasmosis in 2 (2.4%) patients. Neoplastic pathology was seen in total 8 patients in which glioma was seen in 3 patients and metastases were reported in 4 (4.8%) patients, 1 patient had Glioblastoma Multiforme.

Table 4: Finding on T1 and T2 on MRI in various ring enhancing lesions brain

	T1 MRI finding			Total
	Hyper T1 MRI finding	Hypo T1 MRI finding	Iso T1 MRI finding	
Brain abscess	0	0	10	10
Calcified granuloma	0	8	0	8
Glioblastoma Multiforme	0	1	0	1
Glioma	0	3	0	3
Metastases	0	4	0	4
Multiple sclerosis	0	2	0	2
Neurocysticercosis	17	12	0	29
Toxoplasmosis	0	0	2	2
Tuberculoma	1	0	24	25
Total	18	30	36	84

	T2 MRI finding		
	Concentric target	Hyper	Hypo
Brain abscess	0	10	0
Calcified granuloma	0	1	7
Glioblastoma Multiforme	0	1	0
Glioma	0	3	0
Metastases	0	4	0
Multiple sclerosis	0	2	0
Neurocysticercosis	0	29	0
Toxoplasmosis	2	0	0
Tuberculoma	0	25	0
Total	2	75	7

Brain abscess, Toxoplasmosis, and most of the tuberculomas cases were isointense on T1 weighted MRI. 17 out of 29 cases of Neurocysticercosis and only 1 tuberculoma lesion was hyperintense. Rest all lesions were hypointense on T1 weighted MRI. 7 out of 8 lesion of Calcified granuloma were hypointense on T2 weighted MRI. Toxoplasmosis showed concentric target on T2 weighted MRI. All other lesions were hyperintense.

Table 5: T1 Contrast enhancement findings of different ring enhancing lesions

	Hetero	Homo	Incomplete	No	Ring
Brain abscess	0	0	0	0	10
Calcified granuloma	1	0	0	7	0
Glioblastoma multiforme	0	0	0	0	1
Glioma	0	0	0	0	3
Metastases	0	0	0	0	4
Multiple sclerosis	0	0	2	0	0
Neurocysticercosis	0	0	0	0	29
Toxoplasmosis	0	0	0	0	2
Tuberculoma	0	24	0	0	1
Total	1	24	2	7	50

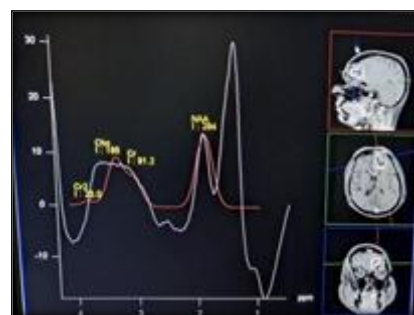
Out of the 84 patients who were evaluated with ring enhancing lesions in the brain, heterogeneous enhancement was seen in 1 case(1.19 %), homogenous enhancement was seen in 24 cases(28.5 %), incomplete enhancement was seen in 2 cases(2.38 %), ring enhancement was seen in 50 cases(59.5 %) and no any enhancement was seen in 7 cases(8.3 %). So in our study most common pattern of enhancement was ring enhancement.

Table 6: Metabolites on MR Spectroscopy in various Ring enhancing lesions of brain (n=84)

Lesion	Lipid MRS peak	Lactate MRS peak	Acetate MRS peak	Choline MRS peak	NAA peak	Succinate peak	Alanine peak
Neoplastic (n=8)							
Glioma (n=3)	0	0	0	3	0	0	0
Metastases (n=4)	0	0	0	4	0	0	0
Glioblastoma	0	0	0	1	0	0	0

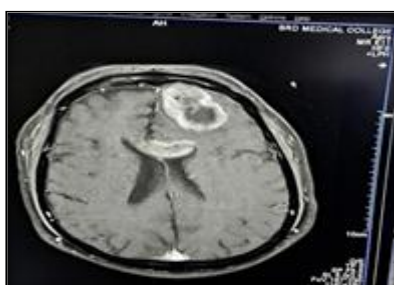
Multiforme (n=1)							
Non-neoplastic (n=76)							
Brain abscess (n=10)	0	10	10	0	6	0	0
Calcified granuloma (n=8)	0	2	0	2	0	0	0
Multiple sclerosis (n=2)	0	2	0	2	2	0	0
Neurocysticercosis (n=29)	0	13	0	3	0	19	8
Toxoplasmosis (n=2)	2	2	0	1	2	0	0
Tuberculoma (n=25)	24	25	0	0	0	0	0

It can be estimated that Lipid-peak was highly seen in 24 cases of tuberculoma and 2 cases of toxoplasmosis. Acetate peak was seen in all 10 cases of brain abscess. Lactate MRS peak was seen in all 10 cases of brain abscess, 2 cases of granuloma, 13 cases of Neurocysticercosis, 2 cases of toxoplasmosis and all 25 cases of tuberculoma. Choline MRS peak was seen in all 7 neoplastic lesion (glioma and metastases), 2 cases of granuloma, 1 case of Glioblastoma Multiforme, 2 case of multiple sclerosis, 3 cases of Neurocysticercosis and 1 case of toxoplasmosis. NAA peak was seen in all 4 cases of metastases, 6 cases of brain abscess, 2 case of multiple sclerosis and 2 case of toxoplasmosis. Special peaks like succinate and alanine peak were seen in 19 and 8 cases of Neurocysticercosis.

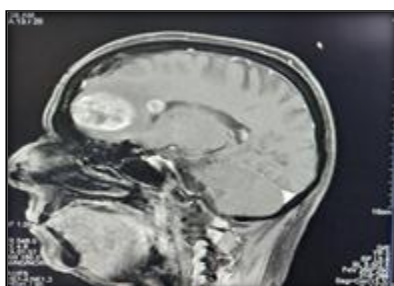


C

Figure 1: Primary Brain Neoplasm- A well-defined lobulated lesion (A & B) with marked perilesional edema and post-contrast heterogeneous enhancement with non-enhancing areas within s/o necrosis is seen in the subcortical white matter of left frontal lobe. On MR Spectroscopy (C), elevation of choline peak is seen. Features are suggestive of high-grade glioma.



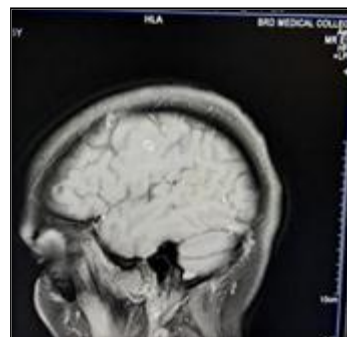
A



B



A



B

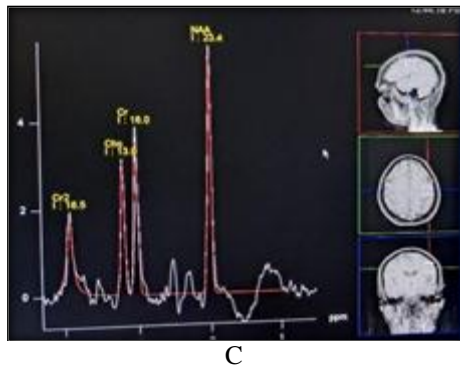
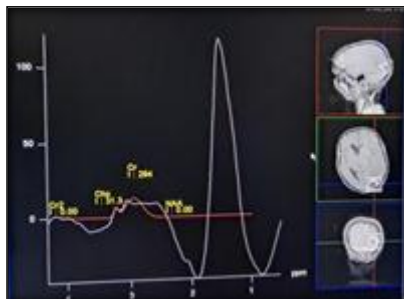


Figure 2: Neurocysticercosis- A well-defined thick-walled ring enhancing lesion (A &B) in the gray-white junction of left parietal lobe with perilesional edema. On MR Spectroscopy (C), low level of metabolites with poor signal to noise ratio with choline peak. Features suggestive of neurocysticercosis (colloidal vesicular stage).



A



B

Figure 3: Tuberculoma - Multiple well-defined ring enhancing lesions (A) are seen in bilateral cerebral hemisphere, largest conglomerate lesion in left occipital lobe. On MR Spectroscopy (B), low NAA levels with high lipid peak is seen. Features are suggestive of tuberculoma.

DISCUSSION

Magnetic resonance imaging is a highly accurate, noninvasive, multiplanar imaging with better inherent contrast for demonstrating any abnormal lesion accurately. MRI along with MRS provides an accurate and early assessment of brain changes in various ring enhancing lesions, thus leading to accurate diagnosis and introduction of early treatment.

According to Yashraj P Patil et al 2021.^[10], Out of 50 patients most common pathology among them was neurocysticercosis (NCC) that was seen in 19 patients (38%), followed by tuberculomas in 16 patients (32%), abscesses in 7 patients (14%), metastasis in 4 patients (8%), primary neoplasm in 3 patients (6%) and Tumefactive demyelination in 1 patient (2%). In our study, Out of the 84 patients who were evaluated with ring enhancing lesions in the brain, Neurocysticercosis (n=29, 34.5%) was the most common pathology followed by tuberculomas 25 patients (29.8%), brain abscess in 10 (11.9%) patients, calcified granuloma in 8 (9.5%) patients, multiple sclerosis in 2 (2.4%) patients and toxoplasmosis in 2 (2.4%) patients. According to Dr. Jernail Singh Bava et al 2016.^[11], Out of the 50 patients that we evaluated, tuberculoma (36%) was the most common pathology followed by NCC (34%), Brain abscesses (12%), primary brain tumour (10%) metastasis (6%), and toxoplasma infection (2%). In current study, out of the 84 patients who were evaluated with ring enhancing lesions in the brain, majority of cases showed statistically near similar results for Neurocysticercosis (n=29, 34.5%), tuberculomas 25 patients (29.8%), brain abscess in 10 (11.9%) patients and toxoplasmosis in 2 (2.4%) patients & metastases were reported in 4 (4.8%) patients.

Study conducted by Sheeba Khan et al 2018.^[12], out of the 42 patients who were evaluated with ring enhancing lesions in the brain, tuberculomas 16 patients (38%) was the most common pathology followed by metastasis 14 (34%) patients, Neurocysticercosis 7 (16%) patients and brain abscess 5 (12%) patients. In current study, out of the 84 patients who were evaluated with ring enhancing lesions in the brain, Neurocysticercosis (n=29, 34.5%) was the most common pathology followed by tuberculomas 25 patients (29.8%), brain abscess in 10 (11.9%) patients, cal granuloma in 8 (9.5%) patients, multiple sclerosis in 2 (2.4%) patients and toxoplasmosis in 2 (2.4%) patients. Neoplastic pathology was seen in total 8 patients in which glioma was seen in 3 patients and metastases were reported in 4 (4.8%) patients, 1 patient had GBM. Further according to Sachin L et al 2018.^[13], Out of the 50 patients who were evaluated, tuberculomas (44%) is the most common pathology followed by NCC (32%), Abscesses (10%), metastases (10%), primary brain tumour (2%) and tumefactive demyelination (2%).

In Tuberculoma cases of our study in out of 25 tuberculoma cases, MRS showed lactate peak in 25 & Lipid peak in 24 cases. In one case of tuberculoma lipid peak was not seen. Chol: Cr ratio was between 1-2 in 23 cases of tuberculoma. Likewise in the study of metabolite peak of Yashraj P Patil et al 2021.^[10] all tuberculoma cases showed lipid peak except one case in which lipid peak was not seen. As per study conducted by Sheeba Khan et al 2018.^[12], for Brain abscess, MRS showed lipid and lactate peak in all five cases suggesting anaerobic glycolysis. It also

showed special peaks like amino acids, aspartate and acetate in all five patients. In current study, lactate & acetate peaks were seen in all 10 cases of brain abscess. So in our study results for brain abscess were 100% similar in MRS peak. Sachin L et al 2018 also performed a relevant study & concluded that most common symptom was seizures in 84% of cases. Headache (22%), fever (18%), vomiting (6%), ataxia (8%) and motor weakness (6%) were the other presenting complaints. In the current study most common symptom was seizure (96.4%) followed by headache. Statistically, so no significant difference was seen.^[13]

Statistically non-significant difference was observed in the age wise distribution observed in study conducted by R. Archana et al 2018.^[14] In our research enrolled patients (n=84, male=44, female=40) range from 2 to 80 yrs showed ring enhancing lesions. The majority of cases were in younger age group, 25% (11-20 yrs), followed by young adult age group, 20.2% (21-30 yrs). So, gender specific prevalence was identical to the study conducted by Sheeba Khan et al 2018.^[12] However significance difference was observed in age specific prevalence of ring enhancing lesions of brain. It may be due to sample size difference.

CONCLUSION

In our study, the most prevalent pathology was tuberculoma (29.8%). Almost all cases of tuberculoma showed lipid lactate peak on MRS except one which showed no Lipid peak. Tuberculoma can be differentiated from NCC by high Cho: Cr ratio >1.1 in tuberculoma. Lactate/acetate peaks was seen in all cases of brain abscess and NAA peak also seen in 6 cases. High choline peak in the contrast enhanced portion was seen in all neoplastic lesions. Cho: Cr ratio was high in all primary brain tumors. MRI along with MRS has emerged as the

most sensitive modality in the characterization of ring enhancing lesions of brain.

REFERENCES

1. Seth R, Kalra V, Sharma U, Jagannathan N. Magnetic resonance spectroscopy in ring enhancing lesions. *Indian pediatrics*. 2010;47(9):803-4.
2. Shetty G, Avabratha KS, Rai BS. Ring-enhancing lesions in the brain: a diagnostic dilemma. *Iran J Child Neurol*. 2014 Summer;8(3):61-4. PMID: 25143776; PMCID: PMC4135283.
3. Garg R K, Sinha M K. Multiple ring-enhancing lesions of the brain. *J Postgrad Med* 2010;56:307-16
4. Sethi PP, Wadia RS, Kiyawat DP, Ichaporia NR, Kothari SS, Sangle SA, Wadhwa P. Ring or disc enhancing lesions in epilepsy in India. *J Trop Med Hyg*. 1994 Dec;97(6):347-53. PMID: 7966536.
5. Dr. B Venkateswarlu, Dr. G. Ramu, Characterisation of ring enhancing lesions in brain with MRI and MR spectroscopy, A series of 62 cases, *INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH: Volume-7 | Issue-2 | February-2018*.
6. Bulakbasi, Nail. 'Clinical Applications of Proton MR Spectroscopy in the Diagnosis of Brain Tumours'. 1 Jan. 2004 : 143 – 153. Print
7. Singhi P RM. Focal seizure with single small ring enhancing lesion Seminars in Pediatric Neurology. 1999;6(3):196-201.
8. John R. HAAGA, Daniel T. Boll. CT and MRI of the whole body Edited by Haaga, Daniel T Boll. Sixth edition, Elsevier, 2017. Page 274-301.
9. Anne G. Osborn, Gary I. Hedlund, Karen L. Salzman. Osborn Brain imaging, pathology, and anatomy. Edited by Anne G. Osborn. Second edition, Elsevier Friesens, Altona, Manitoba, Canada, 2018. page 456
10. Patil YP, Patel CR, Kuber RS, Sekhon RK. Characteristics of Ring enhancing lesions in brain in correlation with MRI and MR spectroscopy.
11. Bava JS, Sankhe A, Patil S. Role of MR Spectroscopy in Evaluation of Various Ring Enhancing Lesions in Brain. *Amino Acids*. 2016;3:6.
12. Khan S, Banode P, Phatak S, Sabir H, Gupta N, Lohchab P. Role Of Magnetic Resonance Spectroscopy (MRS) In Various Ring Enhancing Lesions In Brain.
13. Sachin L et al.2018, Role of Mri In Evaluation of Ring Enhancing Lesions In Brain In Correlation With Mr Spectroscopy. *Int J Recent Sci Res*. 9(5), pp. 26840-26845.
14. Archana R, Kumar PS, Kishore A. Role of MRI in evaluation of ring enhancing lesions of brain in correlation with MR spectroscopy. *Amino Acids*. 2018;3:7-5.