# ROLE OF MAGNETIC RESONANCE SPECTROSCOPY IN INTRACRANIAL LESIONS- A STUDY OF 75 CASES

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**ABSTRACT**

**BACKGROUND**

Our study have shown the role of MR spectroscopy in lesions whenever results are equivocal or non-conclusive even on MRI. MR spectroscopy can differentiate the lesions, particularly intracranial lesions on the basis of various metabolites.

The aims of this study is to diagnose the intracranial lesions and to show the advantage of MR spectroscopy over the conventional MRI, to differentiate the neoplastic from non-neoplastic lesion, to prove the reliability of MR spectroscopy in identifying the different grades of glioma with histopathological correlation as well as to differentiate recurrent tumour from post-operative changes or radiation necrosis.

**MATERIALS AND METHODS**

During the period of August 2009 to July 2011, a prospective study of 75 patients was carried out at Department of Radiodiagnosis, Civil Hospital and BJ Medical College, Ahmedabad, Gujarat. MRI was performed on 1.5 Tesla MR scanner (GE HDXT) using dedicated head coil. Conventional MR imaging was performed followed by MR spectroscopy using point resolved spectroscopy. After deciding the region of interest voxel was kept and 2D multivoxel proton spectroscopy (TR- 1000 msec, TE- 144 msec, voxel size 20 x 20 mm) or single voxel proton spectroscopy (TR- 1500 msec, TE- 35 msec, voxel size 20 x 20 mm) was performed and spectra obtained.

**RESULTS**

In the present study of 75 patients, the maximum number of patients were between 31 to 50 years of age. The approximate ratio of male: female was 2: 1. In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI are 89%, 87%, 87% and 89% respectively and of MRI + MRS are 100%, 97%, 97% and 100% respectively in tumours.

**CONCLUSION**

MRS (Magnetic Resonance Spectroscopy) is a non-invasive imaging technique that studies the chemical activity in the brain and detects the presence of certain chemical substances. Through this imaging technique, images and graphs of the brain can be obtained.

**KEYWORDS**

MRI (Magnetic Resonance Imaging), MRS (Magnetic Resonance Spectroscopy), Metabolites, Intracranial Lesions.

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## BACKGROUND

MRS scans are more precise techniques that help to determine the presence of certain molecules belonging to certain substances present in the body. A resonance frequency of the atoms is produced, which can vary depending on the specific chemical substance and can be determined with the help of MRS.[1] Since in many pathologic processes, metabolic changes precede anatomic changes during disease progression and treatment, MRS offers a method of early detection of new disease and can influence therapeutic success or failure. The nuclei with an odd number of protons and neutrons such as hydrogen-1, phosphorous-31, carbon-13 and fluorine-19 have a magnetic moment and interact with the external magnetic field and are commonly observed in MR spectroscopic studies.[2] MRS can be utilised to detect and study disorders that are inflammatory, ischaemic, neoplastic or metabolism-associated in nature. It can be used to examine several structures present in the body such as the brain, liver, kidney, prostate and the limbs. However, in human beings, MRS is frequently utilised to study disorders affecting the brain, as other techniques such as biopsy and microscopic studies cannot be performed. Frequently, MRS and MRI scans are performed together, so that the results are very specific and accurate.

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**Aims and Objectives**

1. Diagnosis of intracranial lesions.
2. To find out advantages of MR spectroscopy over routine MRI.
3. To differentiate neoplastic process from non-neoplastic process.
4. To assess the use of MR spectroscopy for characterisation of intracranial mass lesions and to ascertain its reliability in grading of glioma and histopathology correlation.
5. To differentiate recurrent tumour from post-operative changes or radiation necrosis.

**MATERIALS AND METHODS**

During the period of August 2009 to July 2011, a prospective study of 75 patients was carried out at Department of Radiodiagnosis, Civil Hospital and BJ Medical College, Ahmedabad, Gujarat.

All patients were seen by appointment, except for the emergency cases with following Inclusion criteria-

- Patients presented with suspected/ known intracranial pathology.
- Patients with positive/ indeterminate MR findings.
- Patients coming for followup evaluation of intracranial pathology.

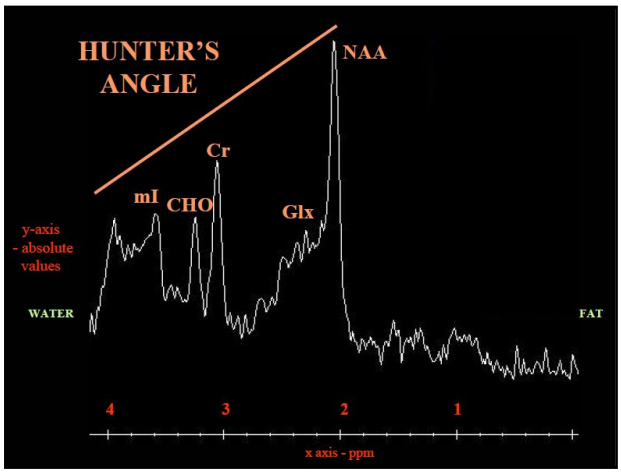
All patients were analysed by MRI brain and subsequent MR spectroscopy of region of interest. Relevant present and past history was taken.

MRI was performed on 1.5 Tesla MR scanner (GE HDXT) using dedicated head coil. Sedation was given whenever necessary. Conventional MR imaging was performed by taking axial T2-weighted, axial and sagittal T1-weighted, fast fluid attenuated inversion recovery (FLAIR) images in coronal plane. Post gadolinium (dose 0.1 mmol/kg) enhanced MRI was performed in axial, coronal and sagittal planes in selected cases depending on clinical suspicion and patient's affordability.

MR spectroscopy was performed by using point resolved spectroscopy. After deciding the region of interest, voxel was kept and 2D multivoxel proton spectroscopy (TR- 1000 msec, TE- 144 msec, voxel size 20 x 20 mm) or single voxel proton spectroscopy (TR- 1500 msec, TE- 35 msec, voxel size 20 x 20 mm) was performed and spectra obtained.

On MR spectroscopy following metabolites were observed and spectrum was obtained:

- N-acetyl-aspartate (NAA) at 2.0 ppm.
- Creatine/phosphocreatine (Cr) at 3.0 ppm.
- Choline compounds (Cho) at 3.2 ppm.
- Myo-inositol (mI) at 3.56 ppm.
- Lactate (Lac): doublet at 1.35 and 4.1 ppm.
- Free lipids (Lip): wide resonance, doublet at 1.3 and 0.9 ppm.




***Graph 1. Hunter's Angle***

**RESULTS**

In the present study of 75 patients presented with suspected intracranial pathology or having intracranial lesion, an attempt was made to evaluate correlation between MRI + MRS in evaluation of various intracranial lesions that included tumours and non-neoplastic lesions.

The maximum number of patients were between 31 to 50 years of age. The approximate ratio of male: female was 2:1. The lesions were divided into neoplastic and non-neoplastic lesions. The later included tuberculoma (47.3%), demyelination (18.4%), encephalitis (10.5%), toxoplasmosis (5.2%) and others (18.4%) like postictal oedema, cavernous angioma and tuberous sclerosis.

84% of total tumours showed contrast enhancement, while 68% of non-neoplastic lesions showed contrast enhancement.

Increase in choline was seen in 90% cases of tumours, 55% cases of non-neoplastic lesions. Decrease in NAA was seen in 92% cases of tumours, in 66% of non-neoplastic lesions and increase in single case of Canavan's disease. Increase in lipid was seen in 95% cases of tuberculoma and 57% of tumours.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI are 89%, 87%, 87% and 89% respectively and of MRI + MRS are 100%, 97%, 97% and 100% respectively in tumours.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI and of MRI + MRS are 94%, 100%, 100% and 98% respectively in tuberculous lesions.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI and of MRI + MRS is 100% respectively in encephalitis.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI are 86%, 100%, 100% and 98% respectively and of MRI + MRS is 100% in demyelination.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI are 50%, 100%, 100% and 98% respectively and of MRI + MRS is 100% in toxoplasmosis.

In our study sensitivity, specificity, positive predictive value, negative predictive value of MRI are 57%, 100%, 100% and 95% respectively and of MRI + MRS is 100% in recurrent/ residual changes.

In our study sensitivity, specificity, positive predictive value and negative predictive value of choline/creatinine ratio for grading of glioma is 100%.

In our study sensitivity, specificity, positive predictive value, negative predictive value of choline/ NAA ratio in grading of glioma are 75%, 90%, 75% and 90% respectively.

In our study, MRI + MRS is more accurate in diagnosis of intracranial pathologies.

| Age (Yrs.) | Number of Patients | | Total |
|---|---|---|---|
| | Neoplastic | Non-Neoplastic | |
| 0-10 | 2 (2.66) | 4 (5.33) | 6 (8) |
| 11-20 | 6 (8) | 6 (8) | 12 (16) |
| 21-30 | 4 (5.33) | 6 (8) | 10 (13.33) |
| 31-40 | 8 (10.66) | 10 (13.33) | 18 (24) |
| 41-50 | 10 (13.33) | 7 (9.33) | 17 (22.66) |
| 51-60 | 5 (6.66) | 1 (1.33) | 6 (8) |
| 61-70 | 2 (2.66) | 1 (1.33) | 3 (4) |
| 71-80 | 0 (0) | 2 (2.66) | 2 (2.66) |
| 81-90 | 0 (0) | 1 (1.33) | 1 (1.33) |

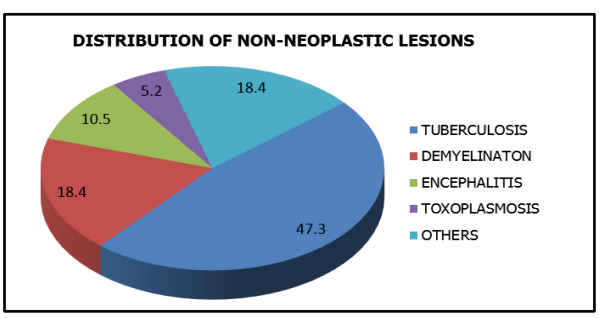
***Table 1. Age Distribution***

| Sex | Neoplastic | Non-Neoplastic | Total |
|---|---|---|---|
| Male | 24 (32) | 27 (36) | 51 (68) |
| Female | 13 (17.33) | 11 (14.66) | 24 (32) |

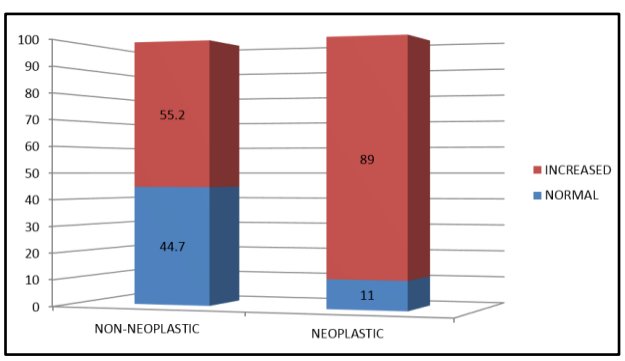
***Table 2. Sex Distribution***

| Contrast Enhancement | Present (%) | Absent (%) |
|---|---|---|
| Tumours | 31 (41.33) | 6 (8) |
| Non-Neoplastic Lesions | 26 (34.66) | 12 (16) |

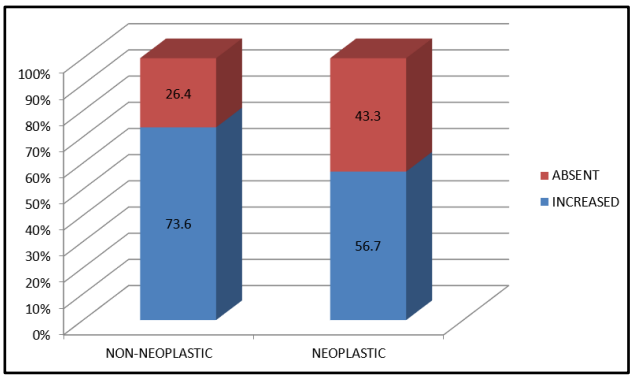
***Table 3. Contrast Enhancement***




***Graph 2. Distribution of Non-Neoplastic Lesions***




***Graph 3. Comparison of Choline Level between Non-Neoplastic and Neoplastic Lesions***




***Graph 4. Comparison of Lipid Level between Non-Neoplastic and Neoplastic Lesions***

**MRI and Histopathology/Followup Correlation**

| Diagnosis with MRI | Histopatho/Followup Diagnosis | | |
|---|---|---|---|
| | Tumours | Other Pathologies | Total |
| Tumours | 33 | 5 | 38 |
| Other Pathologies | 4 | 33 | 37 |
| **Total** | **37** | **38** | **75** |

***Table 4. Intracranial Tumours***

The above table shows correlation of MRI and histopathology/ followup study in tumours. It shows that the sensitivity and specificity of MRI in tumours are 89% and 87% respectively. The positive predictive value and negative predictive value are 87% and 89% respectively.

| Diagnosis with MRI | Histopathology/Followup Diagnosis | | |
|---|---|---|---|
| | Tuberculoma | Other Pathologies | Total |
| Tuberculoma | 17 | 0 | 17 |
| Other Pathologies | 1 | 57 | 58 |
| **Total** | **18** | **57** | **75** |

***Table 5. Tuberculosis***

The above table shows correlation of MRI and histopathology/ followup study in tuberculosis. It shows that the sensitivity and specificity of MRI in tuberculosis are 94% and 100% respectively. The positive predictive value and negative predictive value are 100% and 98% respectively.

| Diagnosis with MRI | Histopathology/Followup Diagnosis | | |
|---|---|---|---|
| | Encephalitis | Other Pathologies | Total |
| Encephalitis | 4 | 0 | 4 |
| Other Pathologies | 0 | 71 | 71 |
| **Total** | **4** | **71** | **75** |

***Table 6. Encephalitis***

The above table shows correlation of MRI and histopathology/ followup study in encephalitis. It shows that the sensitivity and specificity of MRI in encephalitis are 100% and 100%, respectively. The positive predictive value and negative predictive value are 100% and 100% respectively.

| Diagnosis with MRI | Histopathology/Followup Diagnosis | | |
|---|---|---|---|
| | Demyelination | Other Pathologies | Total |
| Demyelination | 6 | 0 | 6 |
| Other Pathologies | 1 | 68 | 69 |
| **Total** | **7** | **68** | **75** |

***Table 7. Demyelination***

The above table shows correlation of MRI and histopathology/ followup study in demyelination. It shows that the sensitivity and specificity of MRI in demyelination are 86% and 100% respectively. The positive predictive value and negative predictive value are 100% and 98% respectively.

| Diagnosis with MRI | Histopathology/Followup Diagnosis | | |
|---|---|---|---|
| | Toxoplasmosis | Other Pathologies | Total |
| Toxoplasmosis | 1 | 0 | 1 |
| Other Pathologies | 1 | 73 | 74 |
| **Total** | **2** | **73** | **75** |

***Table 8. Toxoplasmosis***

The above table shows correlation of MRI and histopathology/ followup study in toxoplasmosis. It shows that the sensitivity and specificity of MRI in toxoplasmosis are 50% and 100% respectively. The positive predictive value and negative predictive value are 100% and 98% respectively.

| Diagnosis with MRI | Histopathology/ Followup Diagnosis | | |
|---|---|---|---|
| | Recurrent/ Residual Tumour | Other Pathologies | Total |
| Recurrent/ Residual Tumour | 4 | 0 | 4 |
| Other Pathologies | 3 | 68 | 71 |
| **Total** | **7** | **68** | **75** |

***Table 9. Recurrent/ Residual Tumour***

The above table shows correlation of MRI and histopathology/ follow-up study in recurrent/ residual tumour. It shows that the sensitivity and specificity of MRI in recurrent/ residual tumour are 57% and 100% respectively. The positive predictive value and negative predictive value are 100% and 95%, respectively.

**MRI + MRS and Histopathology/Followup Correlation**

| Diagnosis with MRI + MRS | Histopatho/Followup Diagnosis | | |
|---|---|---|---|
| | Tumours | Other Pathologies | Total |
| Tumours | 37 | 1 | 38 |
| Other Pathologies | 0 | 37 | 37 |
| **Total** | **37** | **38** | **75** |

***Table 10. Intracranial Tumours***

The above table shows correlation of MRI + MRS and histopathology/ followup study in tumours. It shows that the sensitivity and specificity of MRI + MRS in tumours are 100% and 97% respectively. The positive predictive value and negative predictive value are 97% and 100% respectively.

| Diagnosis with MRI + MRS | Histopathology/ Followup Diagnosis | | |
|---|---|---|---|
| | Tuberculoma | Other Pathologies | Total |
| Tuberculoma | 17 | 0 | 17 |
| Other Pathologies | 1 | 57 | 58 |
| **Total** | **18** | **57** | **75** |

***Table 11. Tuberculoma***

The above table shows correlation of MRI + MRS and histopathology/ follow-up study in tuberculosis. It shows that the sensitivity and specificity of MRI + MRS in tuberculosis are 94% and 100% respectively. The positive predictive value and negative predictive value are 100% and 98% respectively.

| Diagnosis with MRI + MRS | Histopathology/ Followup Diagnosis | | |
|---|---|---|---|
| | Encephalitis | Other Pathologies | Total |
| Encephalitis | 4 | 0 | 4 |
| Other Pathologies | 0 | 71 | 71 |
| **Total** | **4** | **71** | **75** |

***Table 12. Encephalitis***

The above table shows correlation of MRI + MRS and histopathology/ followup study in encephalitis. It shows that the sensitivity and specificity of MRI + MRS in encephalitis are 100% and 100% respectively. The positive predictive value and negative predictive value are 100% and 100% respectively.

| Diagnosis with MRI + MRS | Histopathology/Followup Diagnosis | | |
|---|---|---|---|
| | Demyelination | Other Pathologies | Total |
| Demyelination | 7 | 0 | 7 |
| Other Pathologies | 0 | 68 | 68 |
| **Total** | **7** | **68** | **75** |

***Table 13. Demyelination***

The above table shows correlation of MRI + MRS and histopathology/ followup study in demyelination. It shows that the sensitivity and specificity of MRI + MRS in demyelination are 100% and 100% respectively. The positive predictive value and negative predictive value are 100% and 100% respectively.

| Diagnosis with MRI + MRS | Histopathology/ Followup Diagnosis | | |
|---|---|---|---|
| | Toxoplasmosis | Other Pathologies | Total |
| Toxoplasmosis | 2 | 0 | 2 |
| Other Pathologies | 0 | 73 | 73 |
| **Total** | **2** | **73** | **75** |

***Table 14. Toxoplasmosis***

The above table shows correlation of MRI + MRS and histopathology/ followup study in toxoplasmosis. It shows that the sensitivity and specificity of MRI + MRS in toxoplasmosis are 100% and 100% respectively. The positive predictive value and negative predictive value are 100% and 100% respectively.

| Diagnosis with MRI + MRS | Histopathology/ Followup Diagnosis | | |
|---|---|---|---|
| | Recurrent/ Residual Tumour | Other Pathologies | Total |
| Recurrent/ residual tumour | 7 | 0 | 7 |
| Other Pathologies | 0 | 68 | 68 |
| **Total** | **7** | **68** | **75** |

***Table 15. Recurrent/ Residual Tumour***

The above table shows correlation of MRI + MRS and histopathology/ followup study in recurrent/ residual tumour. It shows that the sensitivity and specificity of MRI + MRS in recurrent/ residual tumour are 100% and 100% respectively. The positive predictive value and negative predictive value are 100% and 100% respectively.

**Grading of Glioma using CHO/CR and CHO/NAA Ratios**

| Choline/Creatinine Ratio on MRS | Histopathology Diagnosis | | |
|---|---|---|---|
| | Low Grade Glioma | High Grade Glioma | Total |
| <2.2 | 5 | 0 | 5 |
| >2.2 | 0 | 10 | 10 |
| **Total** | **5** | **15** | **15** |

***Table 16. Correlation of Choline/ Creatinine Ratios on MRS and Histopathology Study in Grading of Low and High Grade Gliomas***

The above table shows correlation of choline/ creatinine ratios on MRS and histopathology study in grading of low and high grade gliomas. It shows that the sensitivity and specificity of choline/ creatinine ratios on MRS in grading of low and high grade gliomas are 100% and 100% respectively. The positive predictive value and negative predictive value are 100% and 100% respectively if a cut-off value of > 2.2 is used.

| Choline/ NAA Ratio on MRS | Histopathology Diagnosis | | |
|---|---|---|---|
| | Low Grade Glioma | High Grade Glioma | Total |
| <2.2 | 3 | 1 | 4 |
| >2.2 | 1 | 10 | 11 |
| **Total** | **4** | **11** | **15** |

***Table 17. Correlation of Choline/ NAA Ratios on MRS and Histopathology Study in Grading of Low and High Grade Gliomas***

The above table shows correlation of choline/ NAA ratios on MRS and histopathology study in grading of low and high grade gliomas. It shows that the sensitivity and specificity of choline/ NAA ratios on MRS in grading of low and high grade gliomas are 75% and 90% respectively. The positive predictive value and negative predictive value are 75% and 90% respectively, if a cut-off value of > 2.2 is used.

| Pathologies | Sensitivity | | Specificity | | PPV | | NPV | |
|---|---|---|---|---|---|---|---|---|
| | MRI | MRI + MRS | MRI | MRI + MRS | MRI | MRI + MRS | MRI | MRI + MRS |
| Tumours | 89 | 100 | 87 | 97 | 87 | 97 | 89 | 100 |
| Tuberculosis | 94 | 94 | 100 | 100 | 100 | 100 | 98 | 98 |
| Encephalitis | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Demyelination | 86 | 100 | 100 | 100 | 100 | 100 | 98 | 100 |
| Toxoplasmosis | 50 | 100 | 100 | 100 | 100 | 100 | 98 | 100 |

***Table 18. Comparison between MRI and MRI + MRS***

The above table shows comparison between MRI and MRI + MRS; MRI + MRS is more sensitive and specific than MRI for diagnosis of tumours. MRI + MRS is more sensitive, but equally specific as compared to MRI for diagnosis of demyelination and toxoplasmosis. However, MRI + MRS is equally sensitive and specific for diagnosis of tuberculosis and encephalitis.

**Case 1. Primary CNS Lymphoma**

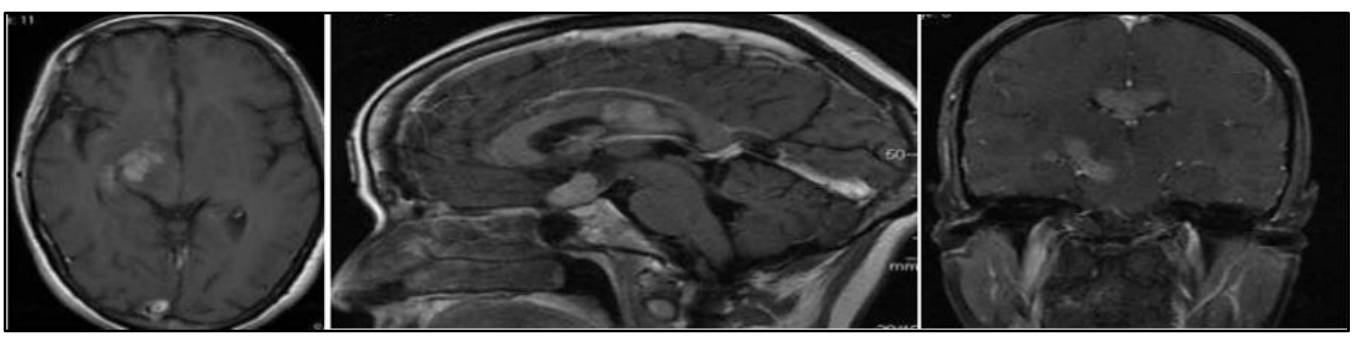


***Figure 1. T1W Axial, Sagittal and Coronal MR Images shows Enhancing Nodular Lesion in Right Thalamus and in Posterior Body of Corpus Callosum***

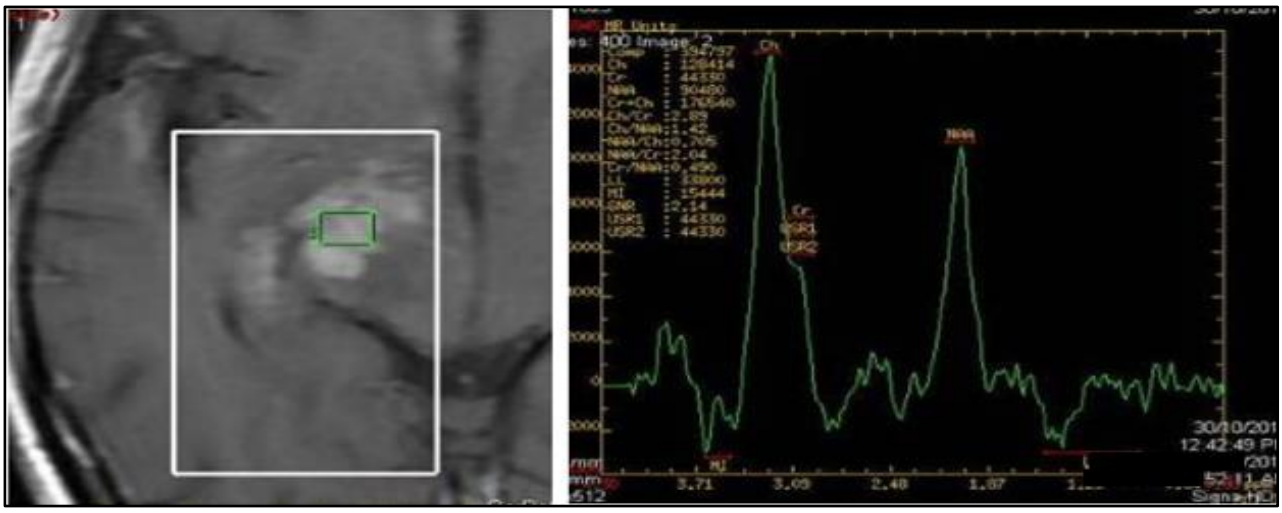


***Figure 2. MR Spectroscopy shows Large Choline Peak and markedly Decreased NAA, Case of HIV Reactive with Headache Primary CNS Lymphoma***

**Case 2. Metastatic Lesions**

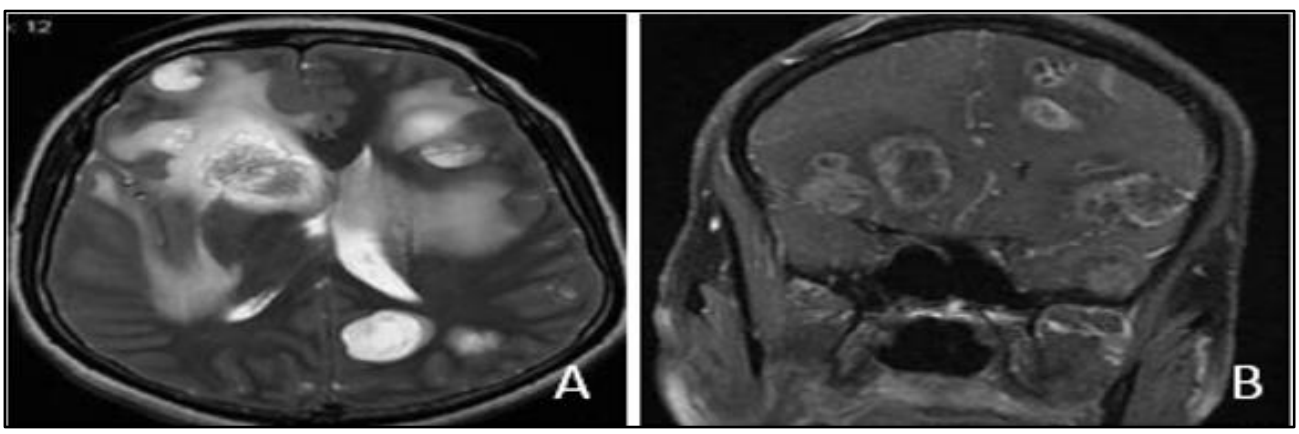



***Figure 3. Axial T2 WI (A) and Coronal Past Contrast T1 WI (B) suggest Multiple Nodular Lesions showing Ring Enhancement on Post Contrast Study***

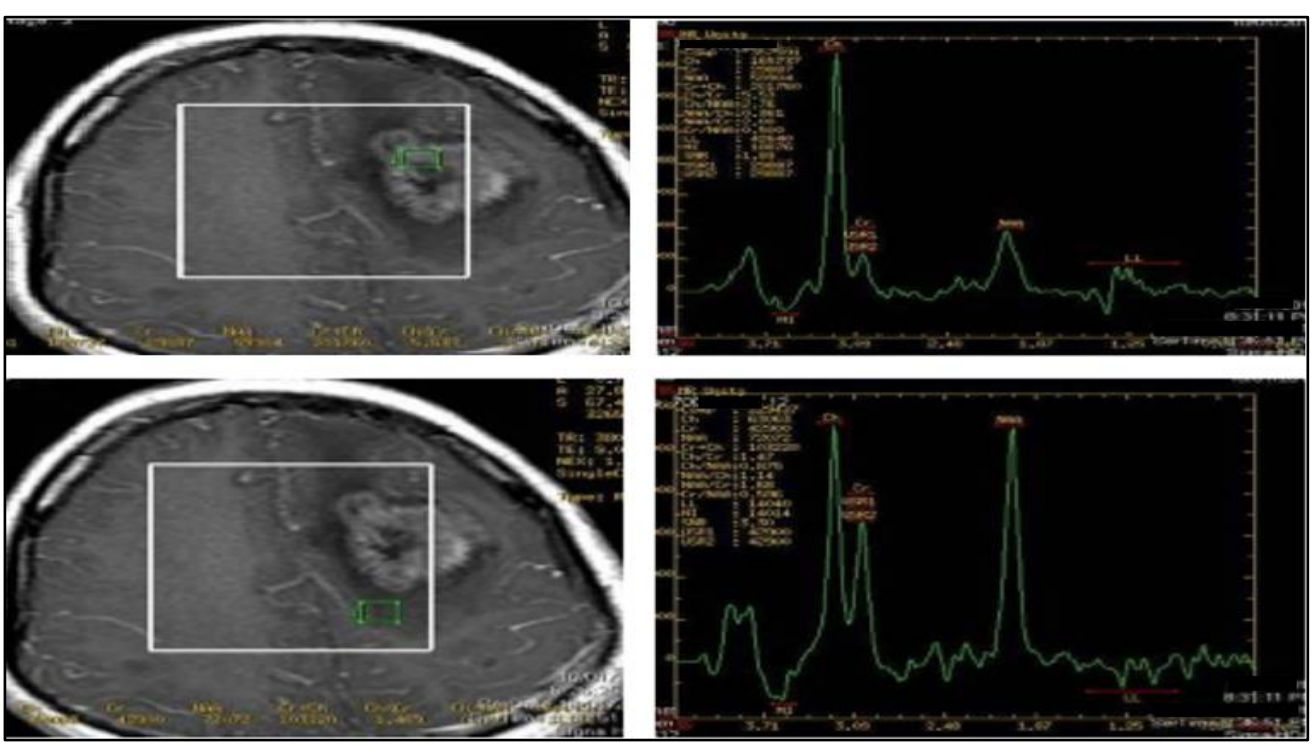


***Figure 4. MR Spectroscopy showing Elevated Choline Level in Lesion, but not in Perilesional Region suggest Metastatic Lesion***

**Case 3. High Grade Glioma- Glioblastoma Multiforme**

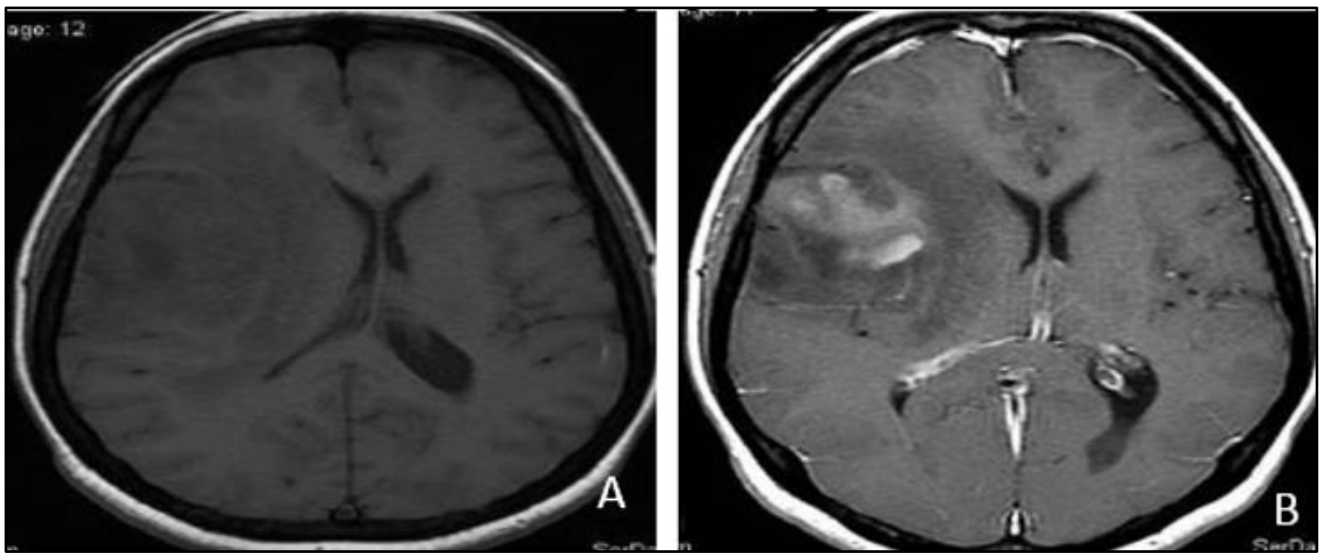



***Figure 5. Axial T1 WI (A) and Axial Post Contrast T1 WI (B) showing Nodular Enhancing Lesion in Right Parietal Lobe with surrounding Oedema and Mass Effect***

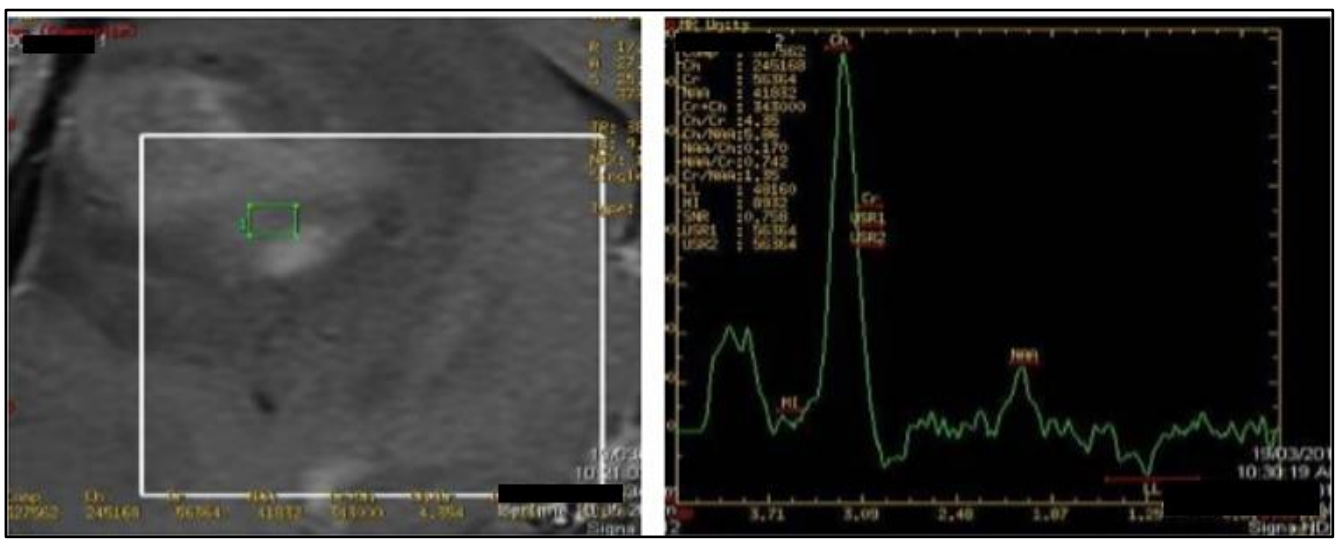


***Figure 6. MR Spectroscopy showing Elevated Choline Level and Significant Decreased NAA suggest High Grade Glioma- Glioblastoma Multiforme***

**Case 4. PNET**

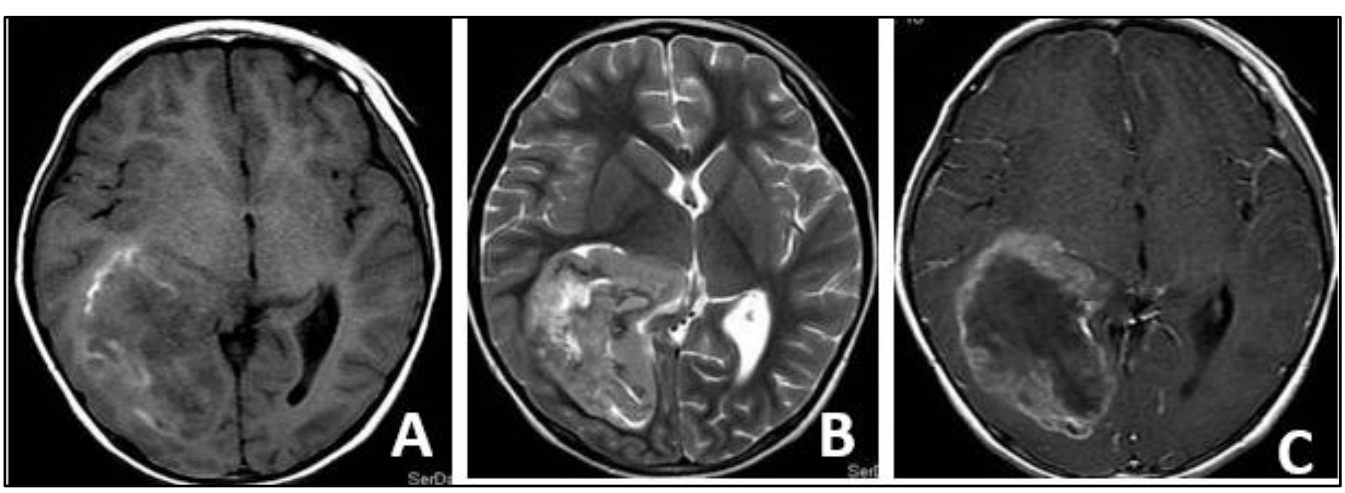



***Figure 7. Axial T1 WI (A), Axial T2 WI (B) and Axial Contrast Enhanced T1 WI (C) showing Heterogeneously Enhancing Mass Lesion in Peritrigonal Region Invading the Occipital Horn of Right Lateral Ventricle***

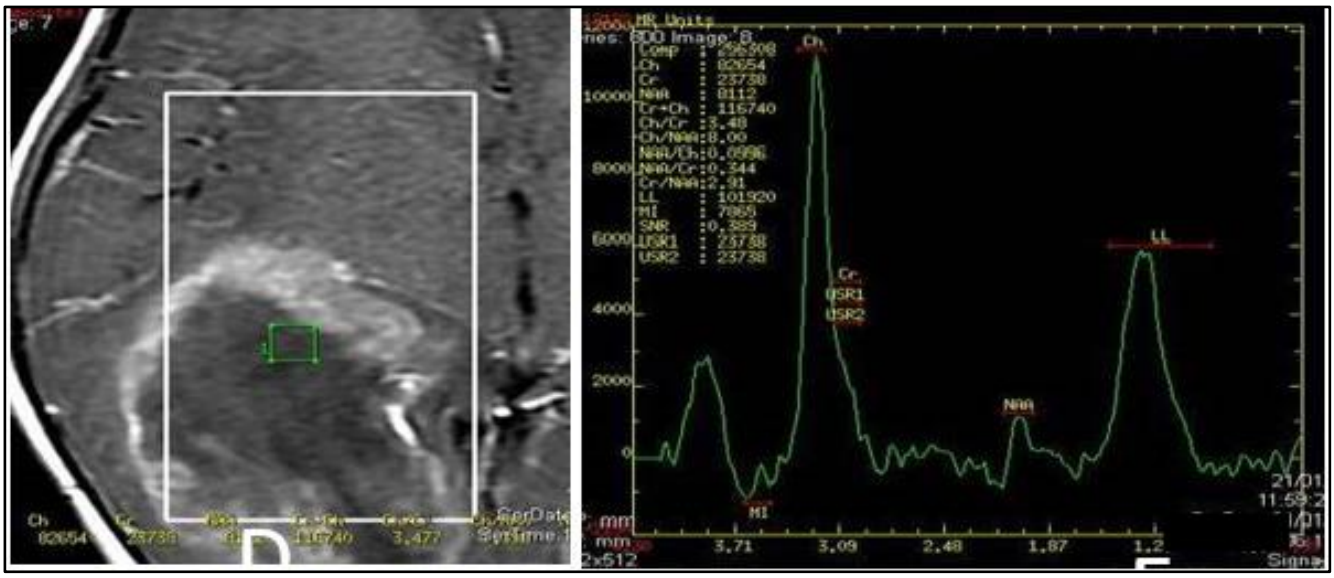



***Figure 8. MR Spectroscopy shows Elevated Choline, Decreased N-acetyl Aspartate, and a Small Taurine Peak in Case of PNET***

**Case 5. Meningioma**

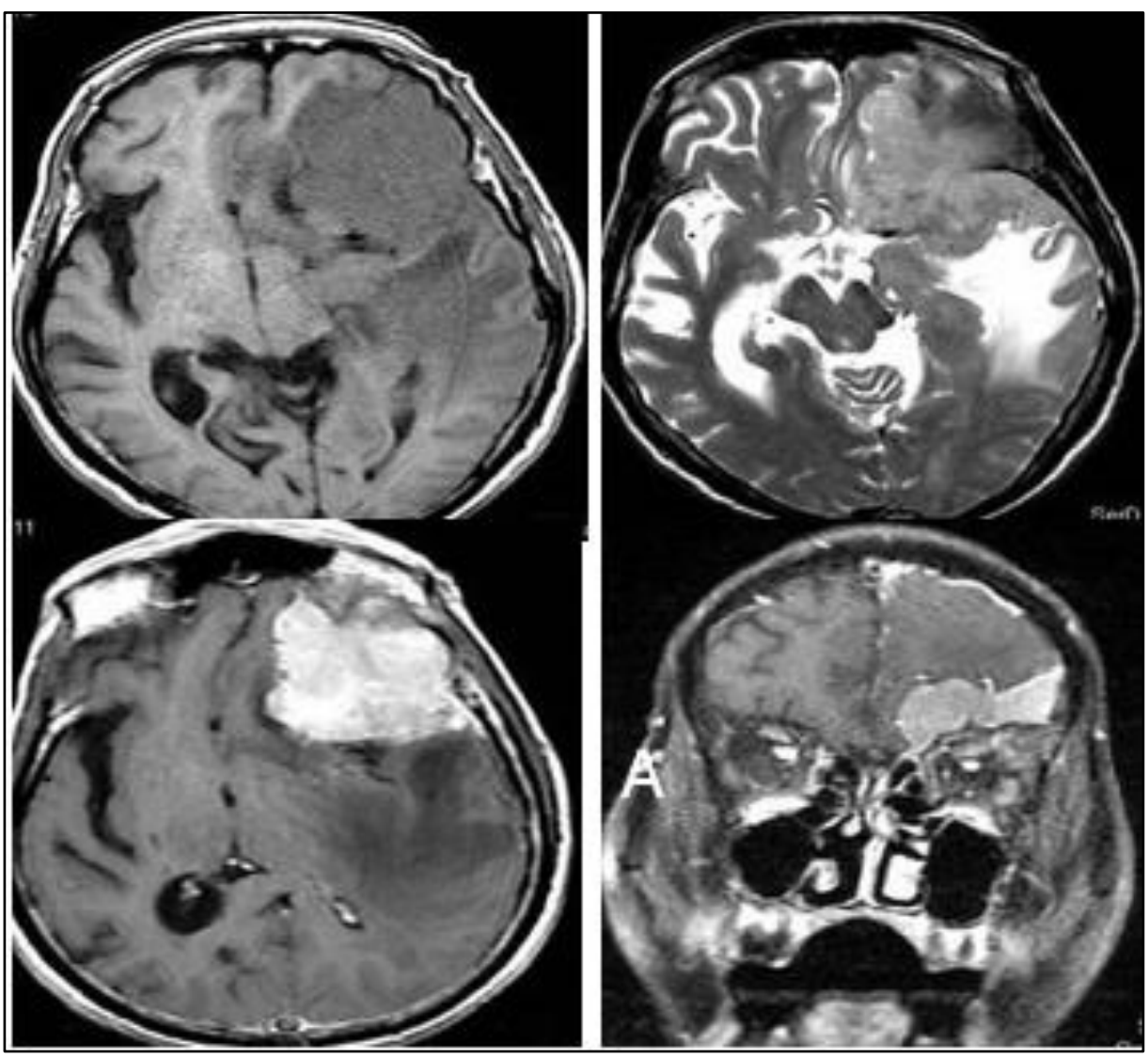


***Figure 9. Axial T1 WI (A), Axial T2 WI (B), Axial T1 WI Contrast Image (C) and Coronal T1 WI Contrast Image (D) showing Lobulated Heterogeneously Enhancing Extra-Axial Soft Tissue Mass Lesion causing Buckling of Gray White Matter and CSF Cleft Sign suggestive of Meningioma***

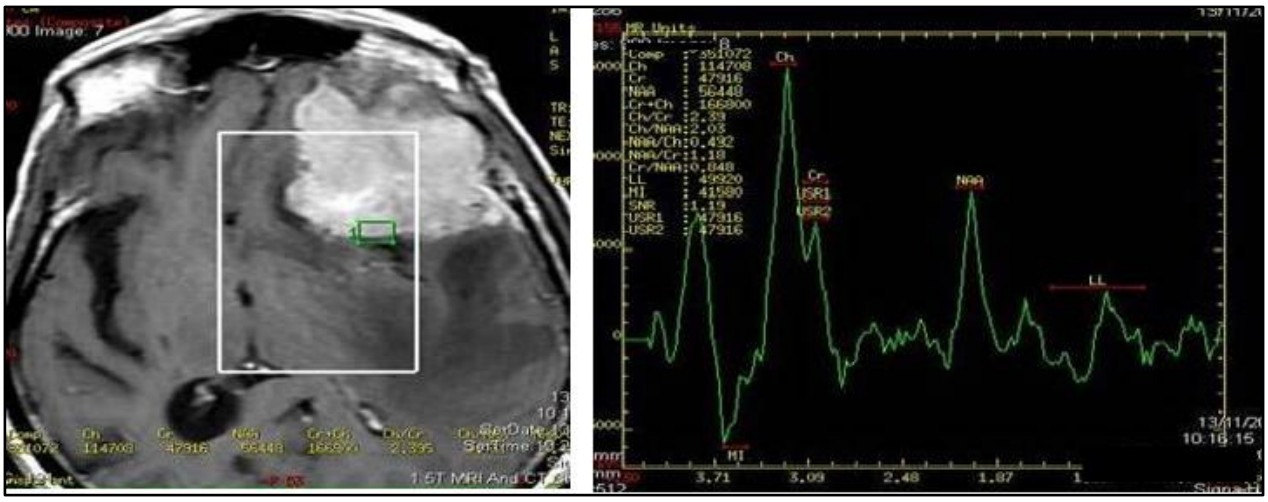



***Figure 10. MR Spectroscopy Images showing Increased Alanine (1.3 - 1.5 ppm), Increased Glutamine/ Glutamate, Increased Choline, Significantly Reduced N-Acetylaspartate (NAA) and Significantly Reduced Creatine (CR)***

**Case 6. Tuberculoma**

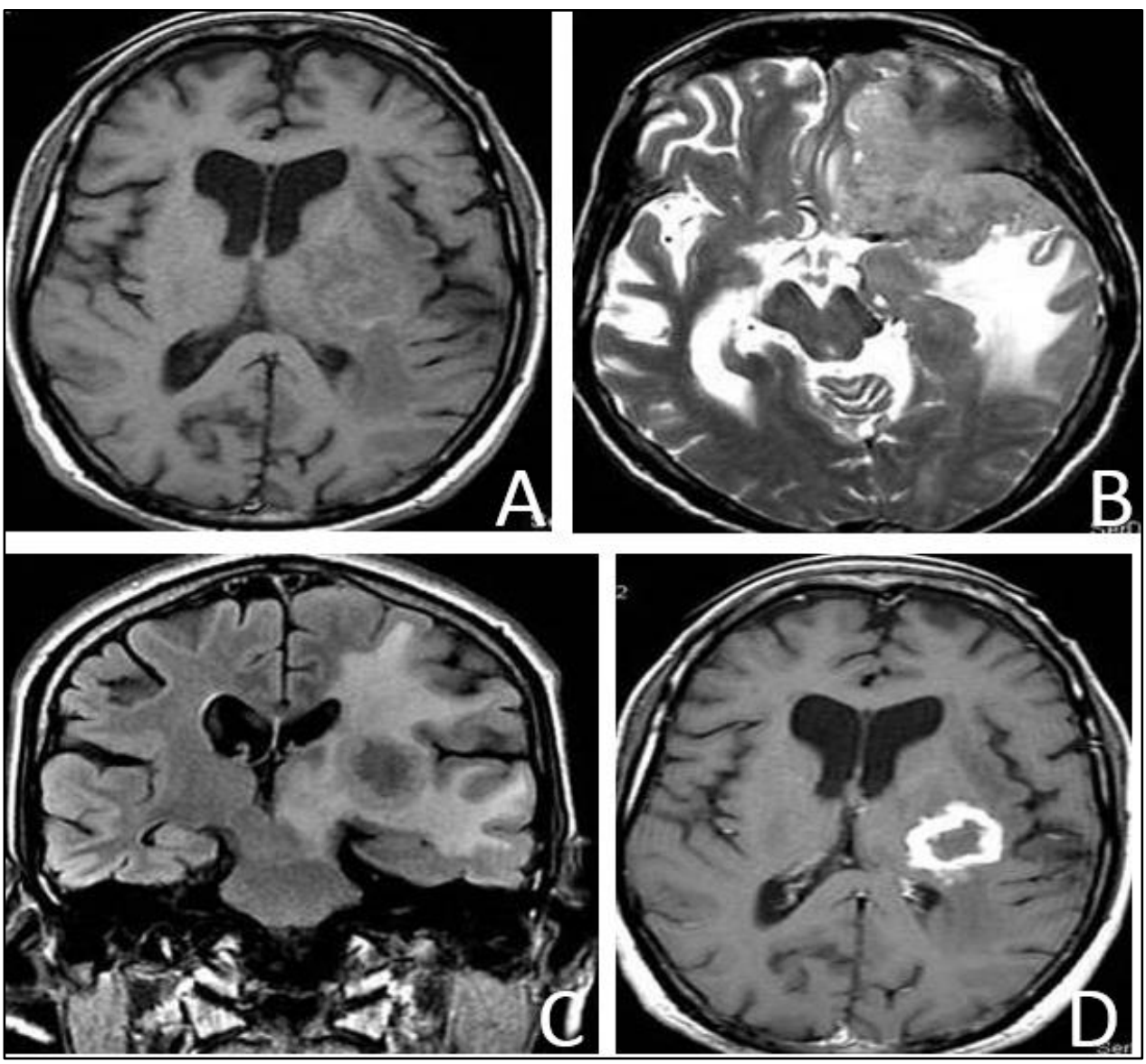



***Figure 11. Axial T1 WI (A), Axial T2 WI (B), Coronal FLAIR Image (C) and Axial Contrast Enhanced T1 WI (D) Image showing Irregularly Enhancing Ring Lesion in Left Basal Ganglia and Thalamocapsular Region suggest Tuberculoma***

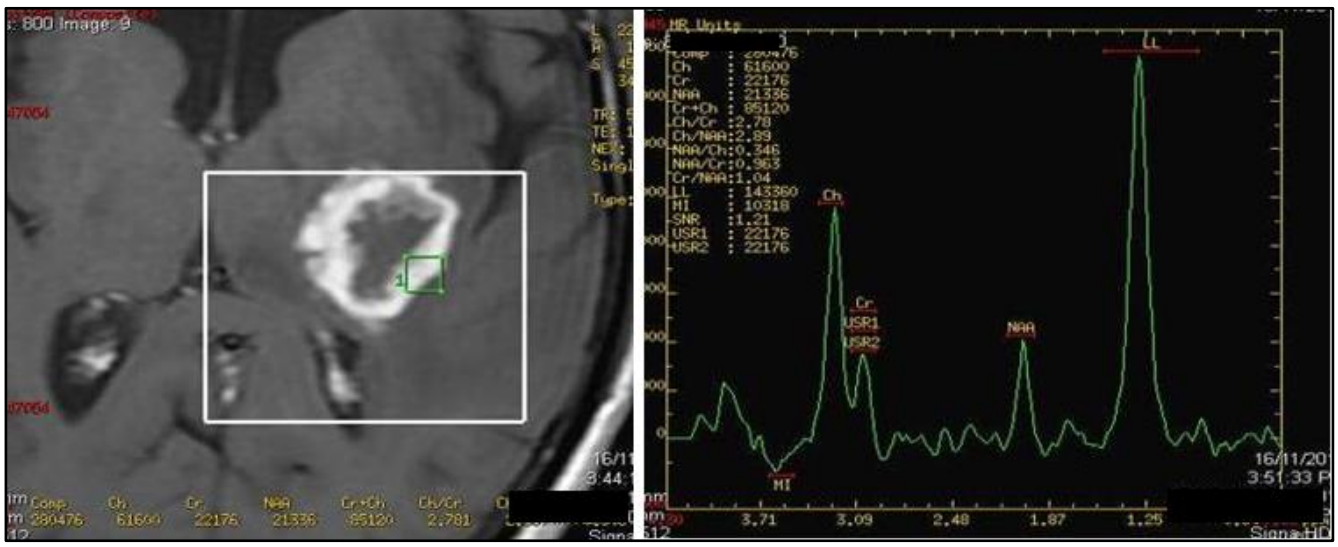



***Figure 12. MR Spectroscopy at the Site of Lesion shows Increased Lipid Peak and Decreased N-Acetylaspartate Peak with Increased CH/CR Ratio***

**DISCUSSION**

The results of the present study are discussed as follows-

**Age Distribution-** In our study, the age distribution in intracranial lesions is from 0.5 to 84 years. It is observed that the intracranial tumours and other intracranial lesions are more prevalent in 31 - 50 years' age group with the number of cases being 18 (24%) and 17 (22.6%) respectively. In our study, the mean age for intracranial lesions is 36 years. The mean age for tumours is 36.2 years, while the same for non-neoplastic lesions is 35.4 years.

**Sex Distribution-** The observation in our study regarding sex distribution in intracranial lesions is 51 males (68%) and 24 females (32%) with the ratio of M: F being 2.1: 1. In intracranial tumours, there is 24 males and 13 females with the ratio of M: F being 2: 1. In case of non-neoplastic lesions, there is 27 males and 11 females with the ratio being 2.5:1.

**Contrast Enhancement-** In our study, 31 of 37 tumours (84%) showed contrast enhancement. According to Zohu ZR et al[3] 98 to 104 cases showed contrast enhancement. This difference could be due to significant difference in the size of sample in both studies.

**Distribution of Non-Neoplastic Lesions**- In our study among non-neoplastic lesions, tuberculous lesions are most common constituting about 47% of cases followed by demyelination (18.4%) cases followed by encephalitis (10%) and toxoplasmosis (5.2%).

**Increases in Choline-** In our study, the choline is increased in 90% of tumours. In the study by Poptani H et al,[4] the choline is increased in all 100% of tumours. This variation could be due to decrease in choline in cases of glioblastoma multiforme as a result of necrosis.[5] Increase in choline is also not seen in case of pineal germinoma, which is consistent with the findings of Panigraphy et al.[6] In our study, the choline is increased in 55% of non-neoplastic lesions.

**Decrease in N-Acetyl Alanine-** In our study, NAA is decreased in 92% of neoplastic pathologies. All neoplastic conditions other than DNET shows reduced NAA. According to Ott D et al NAA is decreased in cases of Glioma, meningioma and metastasis. According to Saindane AM et al,[7] NAA is decreased in all Neoplasms that cause the neurons to be displaced or replaced with malignant cells. In the study done by Poptani H et al,[4] there is decrease or absence of NAA in all cases (100%) of glioma, lymphoma and metastasis. They stated that NAA is a neuronal marker and decreases in all tumours, because of the invasiveness of tumour cells within the normal tissue.

In our study, NAA is decreased in 66% cases of non-neoplastic lesions and is increased in single case of Canavan's disease.

**Increase in Lipid-** In our study, lipid is increased in 57% cases of tumours. In the study done by Krouwer HG et al,[8] lipid peak was elevated in 83% of cases. In the study done by Poptani H et al[4] there is elevation of lipid in all cases of metastasis and most cases of high grade glioma, while it is absent in all cases of low grade glioma. The variation in the findings in our study and above mentioned studies could be due to variation in the proportion of cases of high and low grade glioma included in the study. In our study, lipid is increased in 17 of 18 cases (95%) of tuberculoma. In the study done by Poptani H et al,[4] lipid is increased in all cases (100%) of tuberculoma. This correlates with our study.

**Grading of Glioma-** In our study, we have used choline/creatinine ratio of 2:2 as a cut-off for grading gliomas in low and high grade and it is 100% sensitive and specific respectively, while choline/NAA ratio of 2:2 as a cut-off is 75% sensitive and 90% specific. In a study by Zeng Q of 39 patients suspected of having gliomas, the Cho/ Cr and

Cho/ NAA ratios were significantly higher in high grade than in low-grade glioma (P < .001), whereas the NAA/ Cr ratios were significantly lower in high grade than in low-grade glioma (P < .001). A threshold value of 2.04 for Cho/ Cr ratio to provide sensitivity, specificity, PPV and NPV of 84.00%, 83.33%, 91.30% and 71.43% respectively. Threshold value of 2.20 for Cho/ NAA ratio resulted in sensitivity, specificity, PPV and NPV of 88.00%, 66.67%, 84.62% and 72.73% respectively.

**Intracranial Tumours- MRI and Histopathology/Followup Correlation in 75 Cases**

In our study, in detection of intracranial tumours with the help of MRI the true positive results were obtained in 33 (87%) and false positive results were obtained in 5 (13%) cases. In our study, the sensitivity and specificity of MRI in tumour are 89% and 87% respectively. The positive predictive value and negative predictive value are 87% and 89% respectively.

| MRI in Diagnosis of Tumours | Sensitivity Percentage | Specificity Percentage | Positive Predictive Value Percentage | Negative Predictive Value Percentage |
|---|---|---|---|---|
| Our study | 89 | 87 | 87 | 89 |
| Al-Okaili RN et al[9] | 95 | 67 | 91 | 86 |

***Table 19. Comparison of Our Study Data with Other***

The above table shows comparison of our study data with other. The results are almost similar except specificity which is higher in our study.

**Intracranial Tumours- MRI + MRS and Histopathology/ Followup Correlation in 75 Cases**

In our study in detection of intracranial tumours with the help of MRI and MRS, the true positive results were obtained in 37 (97%) and false positive results in 1 (3%) of cases. False negative cases were 0 suggesting that MRI with MRS can be used to exclude the possibility of a tumour in all doubtful cases with very high confidence.

In our study, the sensitivity and specificity or MRI + MRS in tumour are 100% and 97% respectively. The positive predictive value and negative predictive value are 97% and 100% respectively.

| MRI in Diagnosis of Tumours | Sensitivity Percentage | Specificity Percentage | Positive Predictive Value Percentage | Negative Predictive Value Percentage |
|---|---|---|---|---|
| Our Study | 100 | 97 | 97 | 100 |
| Rand SD et al[2] | 85 | 74 | 92 | 61 |

***Table 20. Intracranial Tumours- MRI + MRS and Histopathology/ Followup Correlation in 75 Cases***

The above table shows comparison of our study data with others. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy are more in our study as compared to others. This could be due to use of multivoxel spectroscopy technique. This can also be due to small sample size in our study. In addition, we have taken both MRI and MRS for the diagnostic consideration that enhances the accuracy of diagnosis as compared to MRS alone.

**Comparison of MRI and MRI + MRS (Without Considering Histopathology)**

Comparison of MRI and MRI + MRS was done for various intracranial pathologies (tumours and non-neoplastic lesions) and chi-square and p-value were obtained for all. Yates correlation was applied as at least one value in each table was < 5. The values were calculated using Epi Info software (version 3.5.1).

| | | Diagnosis of Tumour on MRI + MRS | | Total |
|---|---|---|---|---|
| | | Present | Absent | |
| Diagnosis of Tumour on MRI | Present | 32 | 5 | 37 |
| | Absent | 5 | 33 | 38 |
| **Total** | | **37** | **38** | **75** |

***Table 21. Comparison of MRI and MRI + MRS (Without Considering Histopathology)***

Chi-square value for the above table is 40.32 and p-value is < 0.01 (highly significant).

**Tumours-** Ott D et al,[10] March 1993, studied 122 in vivo proton spectra of brain tumours in 82 patients to better understand variations in spectra of brain tumours. They found that in several spectra, especially those of low-grade astrocytomas and glioblastomas (in 30%) and other tumours, a signal at 1.3 ppm was detected which possibly corresponded to lactate. They concluded that the clinical usefulness of in vivo H-I MR spectroscopy does not lie in differential diagnosis of brain tumours. The imaging modalities themselves enable a better distinction in most cases.

Hollingsworth W et al,[11] August 2006, in their review of 26 studies evaluated that MR spectroscopy may play a beneficial role in the management of suspected brain tumours.

Qing-Shi Zeng et al,[12] November 2006, studied 28 patients who had new contrast-enhancing lesions in the vicinity of the previously resected and irradiated high grade glioma, 3D[1] H-MRS examinations were performed on a 3.0T

MR scanner. The Cho/ NAA and Cho/ Cr ratios were significantly higher in recurrent tumour than in radiation injury ($P < 0.01$), whereas the NAA/ Cr ratios were lower in recurrent tumour than in radiation injury ($P= 0.02$).

Law M et al,[13] March 2002, studied 51 patients with a solitary brain tumour (33 gliomas and 18 metastases) to determine whether proton spectroscopic MR can be used to differentiate high grade primary gliomas and solitary metastases on the basis of differences in metabolite levels in the peritumoural region. Spectroscopic imaging demonstrated elevated choline levels in the peritumoural region of gliomas, but not in metastases.

Peng Juan et al to explore the value of multivoxel 2D proton magnetic resonance spectroscopy (H-MRS) in differentiating diagnosis of intra-axial tuberculoma from high grade glioma and metastatic brain tumour a study performed in 52 cases before treatment or operation. There was significant difference in the ratio of Cho/ Cr in the mass of intra-axial tuberculoma, high grade glioma and metastatic brain tumour [(1.90 ± 0.85), (3.84 ± 2.23) and (3.78 ± 2.38), respectively, $P < 0.05$].

**Infective-** Kim SH et al,[14] July 1997 performed MR spectroscopy prospectively in 7 patients with Pyogenic brain abscess and 7 patients with necrotic or cystic or necrotic brain tumour with hydrogen-1 MR spectroscopy and found that in six of seven patients with abscess there were various resonances attributed to lactate, valine alanine, leucine acetate, succinate and unidentified metabolites.

Luthra G et al,[15] August 2007 retrospectively performed analysis of 110 patients with surgically proved brain abscesses and concluded that based on the morphologic, ADC and metabolite information, it may be possible to differentiate among the pyogenic, tubercular and fungal brain abscesses.

**Demyelinating/ White Matter Disease-** Saindane AM et al[7] September 2002, retrospectively reviewed conventional MR images, proton MR spectra and medical records in six patients with Tumefactive demyelinating lesions (TDLs) diagnosed by means of biopsy or by documented clinical improvement with or without supporting laboratory testing and followup imaging. They concluded that the NAA/ Cr ratio in the central region of TDLs and high grade gliomas differed significantly.

Grossman RL et al,[16] 1992 studied 16 patients having clinically definite multiple sclerosis. They concluded that 1H spectroscopy has the ability to further categorise MR-demonstrated enhancing and unenhancing lesions in patients with multiple sclerosis and that it may be more sensitive than contrast enhancement in revealing the true time course of demyelisation.

**Vascular-** Gillard JH et al,[17] May 1996, studied 12 patients who had a stroke of the middle cerebral artery with proton MR spectroscopy, MR imaging and MR angiography within 24 hours of stroke onset. In the early stages of stroke tissue containing elevating lactate, but no other spectroscopic or MR imaging abnormality can be identified. Such regions may represent an ischaemic zone at risk of infarction.

**Epilepsy-** Castillo M et al,[18] January 2001, studied 17 patients with temporal lobe epilepsy to determine whether increased levels of lipids/ lactate are found in patients with acute seizures of hippocampus origin. They concluded that lipids/ lactate were present in the hippocampus of patients with acute seizures and decreased when the patients were seizure free.

Brandao LA et al,[5] 2002 described commonly observed metabolic changes in various intracranial pathologies.

| Metabolites and Their Peaks | Significance | Increase | Decrease |
|---|---|---|---|
| NAA-N-acetylaspartate peaks- 2.02, 2.5 and 2.6 ppm | Highest peak in the spectrum, marker of neuronal and axonal viability and density | Canavan's disease axonal recovery | Nearly any brain insult |
| Cr-creatine peaks - 3.02 and 3.94 ppm | Most stable cerebral metabolite | Trauma | Tumours, infections, necrosis |
| Cho-choline peak - 3.22 ppm | Reflects cellular proliferation | Tumours demyelination infarction encephalitis | Necrosis, abscesses |
| ml-myo-inositol peaks - 3.56 and 4.06 ppm | P product of myelin degradation | Multiple sclerosis Alzheimer's disease | Tumours, infarction |
| Lac-lactate peak doublet centered at 1.33 ppm, 2nd peak at 4.1 ppm | Indicates anaerobic glycolysis | Necrosis cystic lesions tumours acute/ sub-acute infarction | |
| Lipids multiple peaks within 0.8 to 1.3 ppm | Indicates necrosis | Tumours, necrosis, infarction | |
| Alanine peak 1.48 ppm | | Meningiomas, abscesses | |

***Table 22. Comparison of MRI and MRI + MRS (Without considering Histopathology)***

**CONCLUSION**

MR spectroscopy is accurate techniques that plays a role in equivocal findings on MRI, in challenging patients as well as to keep close followup and watch over the post-operative intracranial tumours. As MRI works on anatomical visualisation of the brain parenchyma structures, while MRS works on metabolic information and pick up the lesion in early stage even when MRI may be normal in certain condition.

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