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Original Article

Magnetic Resonance Spectroscopy: Role in clinical decision making and accurate diagnosis of the brain lesions.

Aurangzeb Kalhoro, Abdul Basit Sattar, Abdul Sattar M Hashim & Sanam B. Rajper

Neurospinal and Cancer Care Institute, Karachi-Pakistan.

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Corresponding Author Email: draurangzebkalhoro@gmail.com

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Abstract

Background: Magnetic Resonance Spectroscopy (MRS) combined Magnetic Resonance Spectroscopic Imaging (MRSI) can diagnose brain lesions and help manage several diseases. It has the advantage of differentiating neoplastic brain lesions from non-neoplastic brain lesions based on metabolic changes of the brain. The present study focuses on Magnetic Resonance Spectroscopy (MRS) assessment accuracy in the diagnosis of brain lesions.

Methodology: A prospective, non-probability, consecutive sampling study was conducted at the Neurospinal & Cancer care institute, Karachi-Pakistan, from June 2017 to September 2020. A total of 161 patients with brain space-occupying lesions shown on MRI brain contrast and associated with clinical symptoms of headache, fits, or limb weakness was included in the study. The single voxel method was used for MRS; after contrast. MRI was used to localize the pathology in the brain, and the voxel was used in the area of heed interest.

Results Spectroscopy interpretation showed that 114(70.8%) patients were diagnosed with a brain tumour, 41 (25.46%) had a non-neoplastic entity, and 6 (3.72%) were reported as non-specified. MR Spectroscopy reported non-neoplastic entities in 41 (25.46%) patients by spectroscopy. among them, 39(95.12%) patients had decreased choline, N-acetyl aspartate (NAA) and creatinine peaks, raised lactate peak 16(39.02%), lipid peaks 20(48.78%), while in 4 (9.75%) patients the peaks were absent.

Conclusion: This study recommends that MR spectroscopy has a high accuracy for the diagnostic purpose of neoplastic and non-neoplastic, which is 91.33% which can affect the course of the treatment plan and it can help to avoid unnecessary delay in management.

Keywords

Magnetic Resonance Spectroscopy (MRS), Brain Lesions, Histopathology, Brain Tumour.

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Introduction

The brain tumour is a common pathology that represents abnormally developed mass lesions in the brain. However, to differentiate neoplastic from the non-neoplastic lesions requires advancement in technology and MRS-based metabolic properties for diagnosis and better management of a patient[1]. MRS is non-invasive and shows the metabolic characterization of tissues[2] but MRS combined MRSI of the brain has an advanced mode that shows changes at the metabolic level associated with different neurological and psychiatric diseases[3].

Different patterns of tissue injury cause metabolic changes at the neuron level, which may be due to brain compression in line for space-occupying lesions, including brain tumors, abscess, and edema[4,5]. Such brain injuries cause the diverse patterns of metabolic variations in the brain measured by MRS and can be used to assess possible cause of disease, differentiating relative non-neoplastic and neoplastic brain lesions, as well as for the assessment of the prognostic factor for metastatic disease[6,7]. MRS in neoplastic brain lesion is helpful in showing a peak level of choline metabolite and a low level of N-Acetyl-aspartate (NAA); in contrast to brain inflammation, along with changes in alanine levels lactate, lipids and amino acids. Neoplastic lesions always present with raised choline and decreased NAA ratio levels while reduced choline levels, creatinine and NAA peaks typically represent the non-neoplastic pathology or infection. Lactate and lipid peaks represent either infectious pathology or high-grade tumor. MRS is an imaging technique used for brain lesions, so the relevant literature is not available for tumors pathologies. Though the diagnostic value of the MR sensitivity is said to be around 80% - 98% and specificity from 70%-78%, and in recent advances[1], Proton Magnetic Resonance Spectroscopy (H-MRS) help to differentiate pseudotumoral lesions and brain tumour as both presents as a solid mass in the brain MRI[8-10].

This study focuses on the assessment accuracy of MRS in the diagnosis of brain lesions and to differentiate neoplastic brain lesions from non-neoplastic lesions on MRS.

Methodology

A prospective study was conducted at the Neurospinal & Cancer Care Institute in Karachi-Pakistan, from June 2017 to September 2020. Independent ethics committee approved the study protocol and written consent was obtained from the patients before inclusion. A total of 161 patients with brain space-occupying lesions shown on MRI brain contrast and associated with clinical symptoms of headache, fits, or limb weakness were recruited through non-probability, consecutive sampling. Moreover, MRS patients were later operated on for excisional/ debulking surgery or biopsy to confirm the diagnosis.

The single voxel method was used for MRS; after contrast, an MRI was used to localize the pathology in the brain, and the voxel was used in the area of heed interest. A senior radiologist interpreted the images with experience in MRS for possible diagnosis of disease. The result was compared with the histopathological finding. Data was collected using a structured proforma concerning clinical, MRS, and histopathological findings. The collected data was analyzed using SPSS version 23.0, results were presented as mean±SD, frequencies and percentages.

Results

Of the total, there were 92(57.14%) males, and 69(42.85%) females. The mean age of the patients was 42.4 ± 13.2 years. Patient-reported clinical complaints are displayed in table 1.

Table 1: Clinical presentation of the patient.

Characteristics	n(%)
Headache	96(56.9)
Seizures	68(42.2)
Weakness of Limbs	49(30.43)
Visual Disturbance	38(23.60)
Difficulty of Walking	29(18)

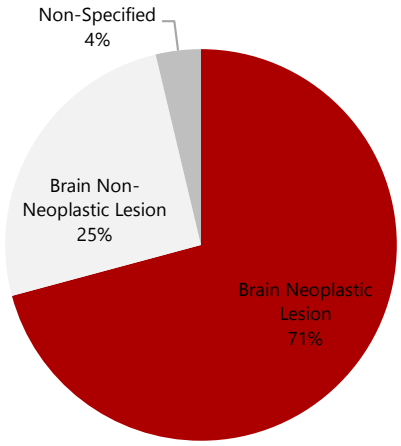

Figure 1: Based on MR spectroscopy.

Spectroscopy interpretation showed that 114 (70.8%) patients were diagnosed with a brain tumour, 41 (25.46%) had a non-neoplastic entity, and 6 (3.72%) were reported as non-specified. The patients who had a neoplastic lesion showed a high level of choline/ creatine ratio (5.78 ± 2.17), it was present in 59 (50%), especially in high-grade glioma, choline/ NAA (11.51 ± 4.32) was seen in 21(13%), were lactate and aspartate was high in 58 (36%) patients, and aspartate was high in non-neoplastic 19 (11%) patients. MRS reported non-neoplastic entities in 41 (25.46%) patients by spectroscopy. among them, 39 (95.12%) patients had decreased choline, NAA and creatinine peaks, raised lactate peak 16 (39.02%), lipid peaks 20 (48.78%), while in 4 (9.75%) patients the peaks were absent.

Table 2: Level of chemicals at their percentage.

Characteristic		n(%)
MR Spectroscopy Reported Neoplastic Entities	High Choline/ Creatine Ratio	59(51.75)
	High Choline/ NAA	21(18.42)
	High Lactate & Aspartate	35(29.8)
MR Spectroscopy Reported Non-Neoplastic Entities	Decreased Choline	39(95.12)
	NAA & Creatinine Peaks Raised Lactate Peak	16(39.02)
	Lipid Peaks	20(48.78)
	Peaks Were Absent	4 (9.75)

Table 3: Histopathological diagnosis after MR spectroscopy.

Histopathology	n(%)
Glioma	29(18.01)
Glioblastoma	18(11.18)
Metastasis	12(7.4)
Meningioma	09(5.5)
Lymphoma	10(6.21)
Hemangioblastoma	08(4.9)
Oligodendroglioma	05(3.1)
Medulloblastoma	08(4.9)
Craniopharyngioma	06(3.7)
Peripheral primitive neuroectodermal tumours	07(4.3)
Radiation Necrosis	11(6.8)
Gliosis	7(4.3)

As per the non-neoplastic infectious pathology histopathology findings, tuberculosis was observed in 9.9% of the patients. Furthermore, a patient MRS record shows high choline peak, while all other values remained low (Figure 1).

Table 5: Non-neoplastic infectious pathology based on histopathology

Histopathology	n(%)
Tuberculosis	16 (9.9)
Fungal	08(4.9)
Abscess	07(4.3)

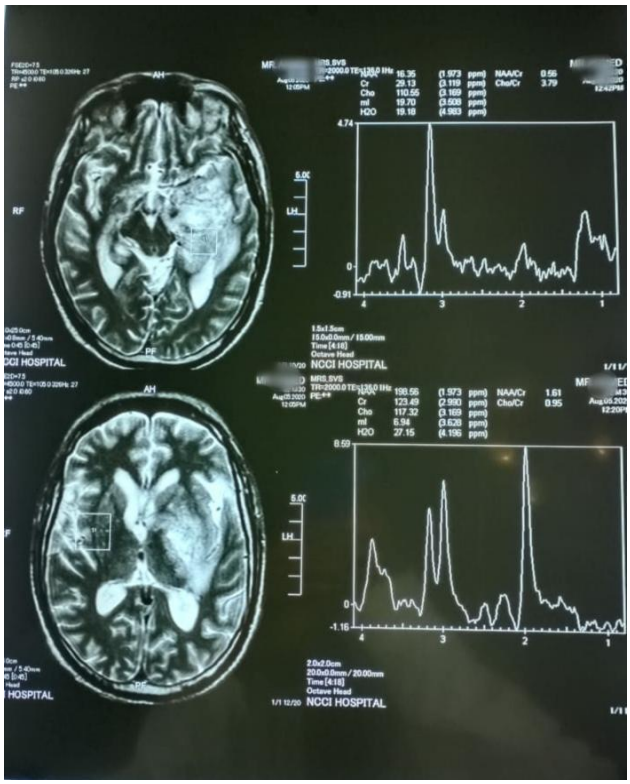

Figure 1: Image showing different components of chemical analysis of the specific case included in the study.

Discussion

It is evident that MRS provides information necessary for differentiating, tuberculosis, low-grade and high-grade gliomas, brain abscess and many more. Several previous studies have been carried out to investigate the sensitivities and specificities of various metabolite ratios for diagnosing and differentiating various brain lesions[11,12]. Onyambu et al. studied the use of MR spectroscopy and its assistance to the radiologist in diverse clinical presentations[13].

One of the studies reported that MRS, along with MRI, helps in diagnostic evaluation of several common neurologic diseases, including demyelinating disorders, brain tumours, infective lesions and inherited metabolic disorders, so the dimensions of neurological disorders. Furthermore, the use of MR spectroscopy is indeed expanding potentially in neurodegenerative diseases and epilepsy[14]. In the present study, we have also observed the assessment accuracy of MRS and its categorization abilities for various brain lesions. A total of 114 (70.8%) patients were diagnosed with a brain tumour, while 41 (25.46%) had a non-neoplastic entity based on chemical composition that is indicative of the accuracy of this technique.

A study was conducted with comparative use of perfusion, diffusion, and MR spectroscopy for differentiating pilocytic astrocytomas to high-grade glioma[15,16]. They showed that the ratio of the lipid lactate in tumour/ to creatine in tumour ratios was minimized significantly. Further, it was also reported that benign astrocytoma could be diagnosed based on the high value of apparent diffusion coefficient (ADC) and low relative cerebral blood volume curve in contrast to malignant astrocytoma, which has high lipid-lactate in tumour/creatine ratio in brain lesion added by central necrosis curves, so the raised choline/NAA and choline/creatine ratios indicator for recurrence[15,16]. Similarly, in our study the analysis was based on choline, NAA and creatinine as well as lipid and lactate in some cases. NAA presents neuronal integrity, choline was used as the cellular turnover indicator and creatinine indicates the metabolism of the cell.

A study relayed that NAA signals were low in almost all cases with brain tumours and showed raised choline levels that elevated the choline / NAA ratios. Furthermore, the peaks of MM12-fucose observed in several studies, indicate the molecular level of brain metastasis and can be further elaborated to specify metabolic phenotypes[13,17,18]. In the current study, choline was found raised in malignant tumours compared with non-neoplastic lesions. Also, the choline showed an elevated level in brain tumours due to the proliferating in tumour cells, with choline-containing compounds including products of degradation and membrane precursors. In contrast, the levels of NAA were low as they were part of the normal brain residual tissue infiltrated between tumours. Multiple studies have shown lipid and macromolecular signals differentiating glioblastoma from metastasis based on MR spectroscopy.

Another advanced study of interest reported glioma margin delineation using 3D proton-MRS (Proton-based MR spectroscopy) helped in the resection of glioma[19]. The results after one-year follow-up showed that the glioma resection based on 3D proton-MRS had a better prognosis, especially in identifying tumour boundaries that can help reduce potential neurological deficits. It was shown that the combination of function MRI, Proton–MRS and Diffuse Tensor Image resulted in the maximal safe resection for gliomas in 15 patients having gliomas. Further, no progression of the tumour was observed at the one-year follow-up[19]. In contrast, we did not have an extended follow-up, the MR spectroscopy was done preoperatively, and we observed 11 patients with radiation necrosis.

Advancements such as MRS help determine the demyelinating lesions from primary CNS lymphomas. It gives added information to conventional MR imaging[20]. We observed 10 (6.21%) cases with lymphomas through MRS, which helped manage the outcomes in this regard.

Studies have shown that post-radiation therapy for brain gliomas or the regrowth of tumours alone or

in combination with necrosis due to radiation, does not necessarily make a marked difference. It may be due to overlapping between recurrent tumours and radiation necrosis[21]. While in our study, radiation necrosis was observed in 11(6.8%) and 7(4.3%) had gliosis as per the histological reports.

Malpani et al. in their study concluded that MRS was reliable in making distinguishable points between neoplastic and non-neoplastic lesions[22]. Another study by Prajapat et al. also suggests that MRS combined with MRI, Diffusion-weighted can be used as an advanced MR technique that can provide metabolic and physiological knowledge that can be helpful in differentiating cerebral abscesses and necrotic/cystic brain lesions[23]. In our study, MRI 1.5 Tesla was used in all the tumours, it was also helpful in grading the lesions but we made the final definitive diagnosis on the basis of histopathology. Ahmed and Mokhtar in their study used multivoxel, and the diffuse weighted image in combination with MRS in 100 focal lesions of 64 patients with an accuracy of 96%[24]. In comparison, we had an accuracy of 91.33%.

The limitations include the single study site and limited patient count. It needs to be extended with increased number of patients and multiple centres may show combinations based on different points of view. Furthermore, we used only a single-voxel MRS.

Conclusion

The MRS has a high accuracy for the diagnostic purpose of neoplastic brain lesions, with a high diagnostic value as shown by the study outcomes. This can be helpful for the treatment of new and recurrent brain lesions.

Conflicts of Interest

The authors have declared that no competing interests exist.

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