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Diagnostic Accuracy of Magnetic Resonance Spectroscopy and Diffusion-Weighted Mri in Differentiating Between Pyogenic Brain Abscesses and Necrotic Brain Tumors

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ABSTRACT

Objective: To determine the diagnostic accuracy of magnetic resonance spectroscopy plus diffusion-weighted Magnetic Resonance Imaging in differentiating pyogenic brain abscess and necrotic brain tumors, taking histopathology as the gold standard.

Study Design: Validation study.

Place and Duration of Study: Department of Radiology, District Headquarters Hospital, Sargodha Pakistan, Jun 2019 to May 2022.

Methodology: A total of 160 patients presenting with symptoms suggestive of brain abscess or tumor, ranging from 20 to 70 years of age, irrespective of gender, were included. All patients were subjected to Magnetic Resonance Imaging including magnetic resonance spectroscopy and diffusion-weighted image. Patients were referred for biopsy to the department of neurosurgery of tertiary care hospitals. Histopathological diagnosis was taken as the gold standard for the determination of diagnostic accuracy.

Results: The values for magnetic resonance spectroscopy plus diffusion-weighted Magnetic Resonance Imaging differentiating pyogenic brain abscess and necrotic brain tumor, taking histopathology as the gold standard were as follows: sensitivity 93(75%); specificity (95.31%); positive predictive value 96(77%); negative predictive value 91(04%); and diagnostic accuracy 94(38%).

Conclusion: Diffusion-weighted images plus MRS are non–invasive tools with high-level diagnostic value. The combination of these modalities should be employed for accurate diagnosis, precise management, and prompt follow-up of the patients under suspicion of tumor or brain abscess.

Keywords: Abscess, Brain, Diffusion-weighted Image, Magnetic resonance imaging, Magnetic resonance spectroscopy, Tumor.

How to Cite This Article: *Ashraf H, X Ahsan K, Noor S, Kamran A , Ibrahim A, Arif A. Diagnostic Accuracy of Magnetic Resonance Spectroscopy and Diffusion-Weighted Mri In Differentiating Between Pyogenic Brain Abscesses and Necrotic Brain Tumors. Pak Armed Forces Med J 2024; 74(5): 1341-1345. DOI: https://doi.org/10.51253/pafmj.v74i5.10177*

INTRODUCTION

Pyogenic brain abscesses and necrotic brain tumours present as intracranial cystic lesions and are a major issue in neurosurgery. Differentiating these cystic lesions using computed tomography (CT) and conventional Magnetic Resonance Imaging (MRI) is often problematic due to non-specific clinical findings and a similar appearance on imaging.[1] Necrotic/cystic neoplastic brain lesions and brain abscesses share similar radiological features on conventional imaging.[2,3] but require exact identification as it is of paramount importance on account of markedly different management.[4,5]

Conventional MRI is still used with certain protocols for diagnosis of such ring-enhancing lesions.[6] but it has a limited role in discriminating these lesions and may require follow-up investigations or biopsy.[7,8] In contrast to conventional MRI and CT which provide structural data, Magnetic Resonance Spectroscopy (MRS) offers new data pertaining to neuronal integrity, cell degradation or proliferation, metabolism, energy, and necrotic transformation of tumor or brain tissues. Proton MRI thus provides data about the nature of the lesion, thus ultimately enhancing the specificity of conventional magnetic resonance imaging.[9,10] Diffusion-weighted imaging (DWI) evaluates the diffusion properties of water molecules in tissue.[6] Despite the development of these non-invasive techniques, histopathology has remained the gold standard, but cannot be used in routine on account of being a difficult procedure. This study was conducted to determine the diagnostic accuracy of magnetic resonance spectroscopy (MRS) plus diffusion-weighted MRI in differentiating pyogenic

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Received: 03 Apr 2023; revision received: 08 Mar 2024; accepted: 11 Mar 2000

brain abscess and necrotic brain tumors, taking histopathology as the gold standard.

METHODOLOGY

The validation study was carried out at the Radiology Department of District Head Quarter Hospital Sargodha, Pakistan from June 2019 to May 2022. Permission of Ethical Review Committee was taken (no. 015 ICMCTH/DHQ dated 06-01-2023) prior to commencement of the study. The sample size was calculated with prevalence of pyogenic brain abscess as 8% in developing countries, using WHO sample size calculator.[11]

Inclusion Criteria: Patients of either gender, aged between 20 and 70 years presenting with the suspicion of brain abscess or tumor and were having prolonged symptoms (more than one month) of fever, headache, blurred vision, dizziness, convulsions, or hemiparesis and with cystic lesion of brain were included in the study. Only those cases were included in the study who had tissue biopsies at the neurosurgery department of specialized care hospitals, after referral.

Exclusion Criteria: Any patients having hemorrhage and lesions in close approximation to the skull (as per medical record), already diagnosed cases and those patients who were not subjected to biopsy or for whom a histopathology report was not available were excluded.

The sample size of present study was 160. Cases were recruited through non-probability consecutive sampling, and Informed written consent was obtained. All patients were subjected to MRS and diffusion-weighted MRI. Both modalities were reported by two consultant radiologists, independently. In case of any disparity in radiological diagnosis, the case was excluded from the study. Sensitivity, specificity, negative predictive value, positive predictive value, and diagnostic accuracy of magnetic resonance spectroscopy (MRS) plus diffusion-weighted MRI in differentiating pyogenic brain abscess and necrotic brain tumor, taking into account histopathology as the gold standard, were calculated. Satistical Package for Social Sciences version 26.0 was used for data analysis. Frequencies, percentages and Mean+SD were calculated for quantitative variables. Two-by-two (2x2) contingency tables were used to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of magnetic resonance spectroscopy (MRS) plus diffusion weighted MRI in differentiating pyogenic brain abscess and necrotic brain tumor, taking histopathology as gold standard.

RESULTS

In the present study,160 patients were selected based on inclusion and exclusion criteria. Out of these patients (n=160), there were 103(64.38%) males and 57(35.62%) females with a male:female ratio of 1.8:1. Included patients had a mean age of 43.48±11.26 years. More than two thirds of patients had been having symptoms for less than three months while less than one third of the patients took more than three months to report after the onset of symptoms (Table-I). The mean duration of symptoms was 2.69±1.29 months

Table-I: Distribution of Patients According To Duration of Symptoms on Presentation (n=160)

Duration	n(%)
<3 months	113(70.63%)
>3 months	47(29.38%)

The patients were subjected to DWI and MRS of the brain and a diagnosis of a necrotic brain tumor or brain abscess was established. Figure-1 shows an altered signal intensity ring enhancing cystic lesion in the left parietal lobe, which appears hypo-intense on the T1-weighted image and hyper-intense on the FLAIR image and T2 weighted images. There is partially restricted diffusion on DWI along with ring enhanced post contrast images. Magnetic Resonance Spectroscopy shows choline and lipid lactate peaks, suggesting a cystic brain tumor. Figure-2 shows an altered signal intensity ring enhancing lesion in the right parietal lobe, which appears hypo intense on the T1-weighted image and hyper intense on FLAIR image and T2 weighted images. Diffusion Weighted Image shows restricted diffusion. The lesion has mild vasogenic surrounding edema, appearing hyper intense on FLAIR image and T2 images. Magnetic Resonance Spectroscopy reveals a lipid lactate peak without elevation of choline favouring brain abscess.

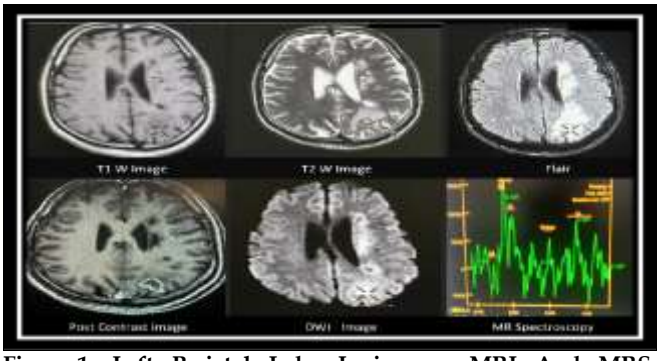

Figure-1: Left Parietal Lobe Lesion on MRI And MRS Favoring Cystic Brain Tumor

Histopathological findings confirmed necrotic brain tumor in 60.0% (n=96) cases and brain abscess in 40% (n=64) cases. Ninety cases were True Positive, while only three were False Positive in MRS + DWI positive patients. Six cases were False Negative, while 61 were True Negative (Table-II), out of 67 MRS + DWI negative patients. The diagnostic values have been illustrated in Table-II. The sensitivity of MRS with DWI was found to be 93.75%, while specificity, positive predictive value, negative predictive value, and diagnostic accuracy were found to be 95.31%, 96.77%, 91.04% and 94.38% respectively.

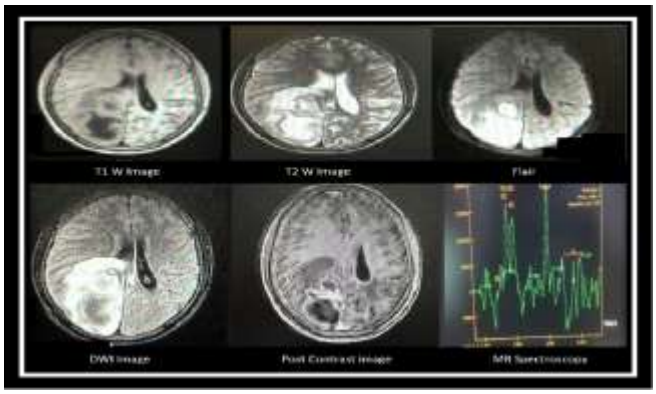

Figure-2: Right Parietal Lobe Lesion on MRI And MRS Favoring Brain Abscess

Table-II: Diagnostic Accuracy of Magnetic Resonance Spectroscopy (MRS) Plus Diffusion-Weighted MRI In Differentiating Pyogenic Brain Abscess And Necrotic Brain Tumor, Taking Histopathological Evaluation As Gold Standard

	Histopathological Evaluation (Positive result)	Histopathological evaluation (Negative result)
Positive on 1H-MRS + DWI	90(TP)*	03(FN)**
Negative on 1H-MRS + DWI	06(FP)***	61(TN)****

*(*TP=True positive, **FN=False negative, ***FP=False positive, ****TN=True negative)*

DISCUSSION

Diffusion-weighted images and MRS with other non-invasive radiological techniques have revolutionized the management of brain lesions and avoided invasive diagnostic biopsy.[12,13] These newer MRI modalities not only have a significant role in the revealing underlying pathology of these lesions, but also in preoperative mapping, diagnosis, and follow-up.[14] Present study aimed to determine magnetic resonance spectroscopy (MRS) plus diffusion-weighted MRI's diagnostic accuracy in differentiating necrotic brain tumor and pyogenic brain abscess, taking histopathology as the gold standard.[15]

In 2018 Elsadway *et al*. conducted a study for a variety of ring-enhancing lesions of the brain, where abscesses showed high levels of different amino acids (lactate, acetate, alanine) and the lack of Cr, NAA, and Cho on MRS. In case of gliomas there was high choline and high choline/NAA ratio in the surrounding oedema.[5] Similar results were seen in the present study. The same study also found that the Cho/Cr ratio was markedly reduced in the case of brain abscess than high grade gliomas, which was also confirmed by the present study.[5] They also employed diffusion tractography imaging (DTI) in addition to MRS and DWI in their study which gave them an edge over the present study in pinpointing the actual lesion.[5] A study in 2020 evaluated 64 patients using MRS and DWI and assessed the diagnostic value of MRS against histopathology and DWI results, while follow-up was considered as the gold standard.[15] They demonstrated that conventional MRI and DWI alone have a limited value when compared with MRS and combined (MRS+DWI). The diagnostic accuracy, sensitivity, and specificity of MRS+DWI increased to 96%, 95%, and 97%, respectively. The results were comparable with the present study where diagnostic accuracy, sensitivity, and specificity of MRS+DWI were comparable but slightly lower i.e 94.38%, 93.5%, and 95.75%, respectively. Perhaps the likely reason could be a better sample size of 160 patients rather than the small sample size of 64 patients taken by Ahmed *et al*.[15] and more stringent inclusion and exclusion criteria like already diagnosed patients and patients with multiple lesions were not included in the study.

Magnetic Resonance Spectroscopy provides information necessary for differentiating, tuberculosis, low and high-grade gliomas, brain abscesses, 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.[16] Onyambu *et al*. evaluated intracranial mass lesions using MRI and MRS considering histopathology as the gold standard. The study demonstrated three-fold improvement in the image-based diagnosis with MRS (74.6%) when compared with MRI alone (23.8%).[17] However, better results were seen in the present study where DWI was combined with MRS and the

diagnostic accuracy was much superior (96%) in the present study when compared with the results of the study by Onyambu *et al*.[17]

Alshammari QT *et al*., evaluated 30 cases and determined the diagnostic accuracy of MRS in differentiating neoplastic and non-neoplastic brain lesions and found that the diagnostic accuracy of MRS was 100%, which was higher compared to the present study.[18] Similarly, in another study by Kalhoro A *et al*. The diagnostic accuracy was found to be 91.33% in differentiating neoplastic and non-neoplastic lesions.[19] However, Alshammari *et al*. found that specificity was 85.71%, sensitivity was 82.60%, NPV was 60%, and PPV was 95% while in the present study, these values were much higher although combined with DWI i.e. diagnostic accuracy of MRS was 94.38%, with 93.75% sensitivity, 95.31% specificity, 96.77% PPV, and 94.38% NPV.18 Perhaps the difference is because of the small sample size in the study by Alshammari *et al*. and lesions were evaluated by only MRS rather than the two modalities that were used in the present study.

LIMITATION OF STUDY

The limitation of the present study is the handicaps associated with the technique itself, which hinders full imaging of the brain lesions.

CONCLUSION

Diffusion-Weighted Images plus MRS are non–invasive tools with high-level diagnostic value. The combination of these modalities should be employed for accurate diagnosis, precise management, and prompt follow-up of the patients under suspicion of tumor or brain abscess.

Conflict of Interest: None.

Authors Contribution

The following authors have made substantial contributions to the manuscript as under:

HA & KA,: Conception, Data acquisition, drafting of the manuscript, and approval of final version to be published.

SN & AK: Data acquisition, data analysis and Interpretation, and approval of final version to be published.

AI & AA:Study design, and data analysis, critical review, drafting the manuscript, and approval of final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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