ORIGINAL ARTICLE

DIAGNOSTIC ACCURACY OF DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING IN THE DIAGNOSIS OF BRAIN ABSCESS

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ABSTRACT

INTRODUCTION: Brain abscess is a serious life threatening infection of brain parenchyma. There is a high mortality rate of approximate 10% and may reach up to 80%. Due to its high morbidity and mortality, there is a need of early diagnosis and prompt treatment. MRI plays an important role to differentiate various brain lesions due to its multiplaner capability and high resolution. Diffusion-weighted MRI (DWI) has been reported to be very sensitive and efficient tool than conventional MRI in diagnosing brain abscess by virtue of restricted diffusion. To our knowledge, no local data is focused on Diffusion-weighted MRI sensitivity in the diagnosis of brain abscess. Early diagnosis through Diffusion-weighted MRI would eliminate the need for invasive diagnostic and surgical procedures. For this purpose the study was conducted to determine the diagnostic accuracy of Diffusion-Weighted MRI in the diagnosis of brain abscesses taking histopathological findings as gold standard. Study was conducted in department of Radiology and Imaging, Ziauddin University Hospital, Karachi. This was a descriptive study done from May 2013 to October 2013. About 136 patients were included in study. **RESULT:** Among a group of 136 patients, 90 patients were males and 46 patients were females with clinical suspicious of brain abscess. Out of 136 patients, 86 patients diagnosed as brain abscess on histopathology. Out of 86 patients, 85 were positive on Diffusion weighted images. Therefore, Diffusion Weighted MRI had 98.83% sensitivity, 94.0% specificity and 97.05% diagnostic accuracy for the diagnosis of brain abscess. **CONCLUSION:** The overall diagnostic accuracy of diffusion weighted MRI in the diagnosis of brain abscess in patients with clinical signs and symptoms are very close to histopathological findings.Diffusion weighted MRI should be recommended as a routine method in patients with clinical suspicion of brain abscess..

Key words: Magnetic resonance imaging, Diffusion weighted sequence, abscess and histopathology.

Introduction

Brain abscess is a serious life threatening infection of brain parenchyma.[1] The incidence of brain abscess varies from 8 - 10 % of all intracranial space occupying lesion in the developing countries with a morality rate of approximate 10% and may reach 80% if the abscess ruptures into ventricular system.[2,3] Its prevalence is estimated to be 2-14%.[4] It is common in 3rd to 5th decade of life and males are more commonly affected than females.[3]

The potential of brain abscess to cause permanent neurological damage and high mortality requires prompt diagnosis and timely initiation of treatment. Diagnosis depends upon clinical presentations and characteristic radiological findings. Difficulties in the diagnosis are mainly due to combination of non specific clinical findings and possible similarities in the radiological appearance of brain abscess and brain tumors.[5] Various imaging modalities likes com-

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puted tomography (CT) and magnetic resonance imaging (MRI) have been used for early detection of brain abscess.

The ability to detect and differentiate intracranial lesions has markedly improved with introduction of MRI. There is no harmful ionizing radiation involved in MRI scanning, moreover lack of bone artifact and multiplaner capability of MRI has led to this preeminence.[6] Using Conventional MR imaging to discriminate different intracranial lesion is often a very challenging task, and usually follow up studies and biopsy procedures are required.[7] Conventional contrast-enhanced MRI reveals ring enhancement of a brain abscess that is similar to the ring enhancement of necrotic brain tumors. The management of these two disease entities is different and can potentially affect the clinical outcome.[5]

Diffusion-weighted MRI (DWI) has been reported to be very sensitive and efficient tool than conventional CT and MRI in diagnosing brain abscess by virtue of restricted diffusion.[8,9] Brain abscess appears hyperintense whereas other intracranial mass lesions appear hypointense on Diffusion-weighted MRI. [8,10] Lai PH et al shows the sensitivity and specificity of DWI for detecting brain abscess are 95.2% and 95.7% respectively.[10]

To our knowledge, no study has found emphasizing the role of diffusion weighted imaging in brain abscess in local population but a local study was conducted in 2012 regarding role of Diffusion Weighted MR Imaging for ring enhancing brain lesions.[32] This study will help in determining the role of Diffusion-weighted MRI in making an earlier diagnosis of brain abscess and confirming its accuracy with histopatho-logical findings which will be taken as gold standard. Early diagnosis through Diffusion-weighted MRI could eliminate the need for invasive diagnostic and surgical procedures and lead to early initiation of treatment and hence will substantially reduce the morbidity of this condition.

Materials and Methods

A prospective descriptive study conducted in Radiology department of Ziauddin university hospital from May 2013 to October 2013 on 136 patients through non probability purposive sampling. Patients of all age groups and of either gender with suspected brain abscess were included in study. Exclusion criteria were include, already diagnosed or treated case of brain abscess, absences of well formed ring enhancing brain lesion on contrast-enhanced MRI, patient with post radiation and post chemotherapy history, patient having known allergy to contrast media. Informed consent was taken from all patients and MRI brain was performed with 1.5 Tesla Avanto (SIEMENS). Typical brain protocol including sagittal and axial T1–weighted spin echo, axial T2–weighted spin echo, axial contrast enhanced T1-weighted images, coronal FLAIR images were obtained. DW imaging was performed in all patients using a single-shot echo-planar (EPI) pulse sequence (TR/TE= 3000/90 ms), with matrices of 128×128 and a section-thickness of 5 mm with a 1-mm intersection gap. The diffusion-sensitizing gradient was applied along the three main axes (x, y, and z). The Image interpretation was done by senior radiologist with minimum 5 years of experience. Histopathological findings of all patients who undergone surgery was collected and compared with Diffusion-Weighted MRI findings. Data was analyzed on SPSS version 16 and mean ± SD for age was computed. A 2 x 2 table has been constructed and sensitivity, specificity, positive predictive value, negative predictive value and accuracy of Diffusion-weighted MRI for the diagnosis of brain abscess were estimated by taking histopathological findings as gold standard. Stratification has been done with regards to age and gender to see the effect of these factors on outcome. Frequency and percentages were calculated for gender.

Results

Out of 136 patients, 90 patients (66.2%) were male and 46 patients (33.8%) were female. Mean age of the patient in our study was 45.43 years with the standard deviation of 19.04 years. Age of most of the patients were in between 26 to 50 years (n=60), followed by 51 to 75 years (n=45). The lowest number

of patients were in the group of 76 years and above (n=8).

Out of 136 patients, 86 patients (63.23%) had histopathologically confirmed diagnosis of brain abscess and remaining 50 patients (36.77%) were found out to be disease negative. 85 patients were true positive i.e., diagnosed correctly by Diffusion Weighted MRI while 47 patients were true negative i.e labelled as disease negative by Diffusion Weighted MRI.

Out of 86 patients, 80 cases (93.1%) had bacterial abscess, 4 cases (4.6%) had fungal and 2 cases (2.3%) showed protozoa as an etiological agent (Fig.1).

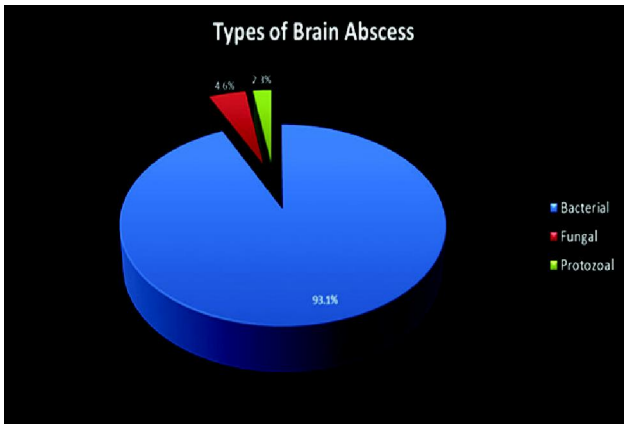

Figure 1: Types of brain abscess (Etiologic Distribution)

The sensitivity of Diffusion Weighted MRI was found out to be 98.83% and specificity of 94% in diagnosing brain abscess with a gold standard of histopathology. The positive predictive value was 96.59% and negative predictive value was 97.91%. The diagnostic accuracy of Diffusion Weighted MRI in diagnosing brain abscess was found out to be 97.05% with a gold standard of histopathology. (Tab. 1).

	Histopathology Results		
Diffusion-Weighted MRI **RESULTS**	Positive (+ve)	Negative (-ve)	**Total**
Positive (+ve)	85	3	88
Negative (-ve)	1	47	48
	86	50	136

Sensitivity	98.8%
Specificity	94.00%
Positive predictive value	96.59%
Negative predictive value	97.91%
Diagnostic accuracy	97.05%

Table 1: Diffusion-Weighted MRI Results

Concerning etiology, no specific findings were registered to differentiate between bacterial, fungal and protozoal abscess.

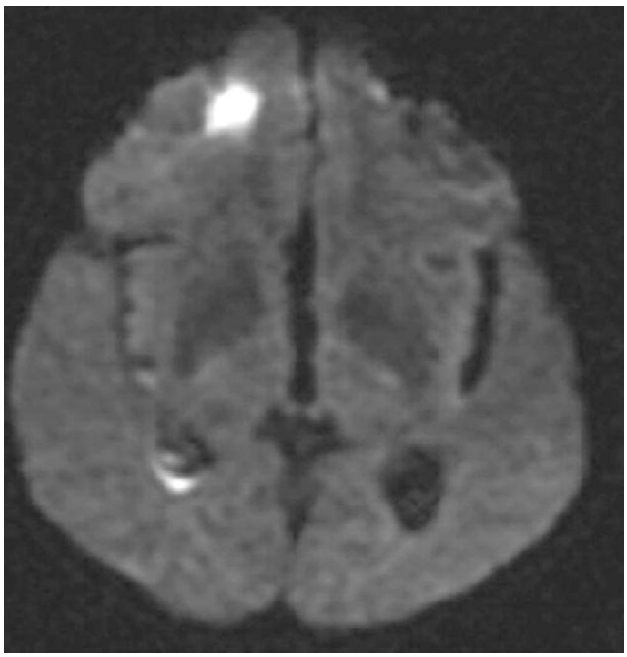

Figure 2: 26 years old young patient with fever and frontal headache. Diffusion weighted MR image shows hyperintence abscess cavity in right frontal lobe.

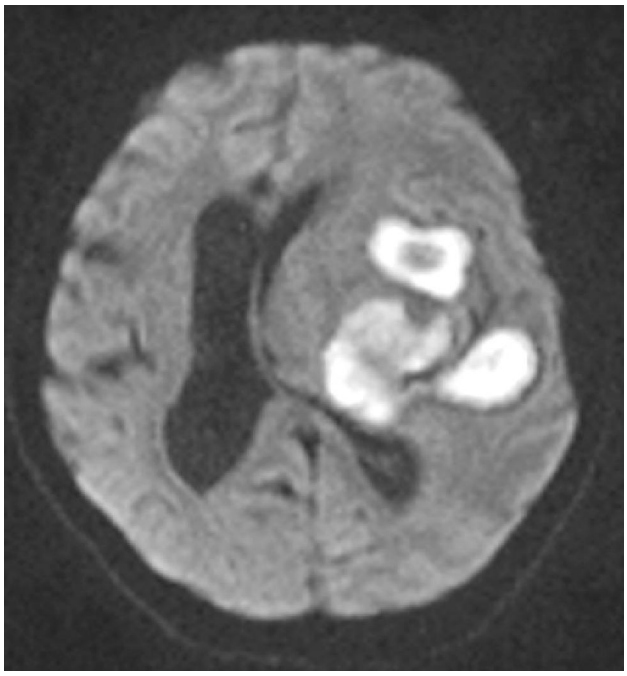

Figure 3: 76 years old male with fever, headache and right sided weakness. Diffusion weighted image reveals multiple hyperintence lesions involving left basal ganglia and frontal lobe with mass effect and moderate midline shift turned out to be abscess on histopathology.

Discussion

Brain abscess is a serious life threatening infection of brain parenchyma.[1] It accounts for 8-10% of all intracranial mass lesions in the developing countries with a high mortality rate of approximately 80% if the abscess ruptures into ventricular system.[2,3] its prevalence is estimated to be 2-14%.[4]

In our study, around 66% of the study population was male (n=90), while rest of the patients were female. Higher proportion of males i.e., 67.4% were diagnosed as having brain abscess (n=58), while around 32.6% were females that were diagnosed brain abscess (n=28). Similar findings were seen in various studies.[11,14] where the proportion of males was found out to be higher than females in brain abscess.

Similarly, most of the patients in our study that were diagnosed brain abscess were in the age group 25-50 years. These findings were similar in other studies which also quoted that proportion of brain abscess was higher in 3rd and 5th decade of life.[15,17]

In our study, the most common microbe isolated from the pus of brain abscess was of Bacterial origin (93%). It was followed by fungal type (5%). This finding was similar to the study conducted in South India, which also reported bacterial microbes to be the most common pathogen found in brain abscess.[18] Two more studies showed similar findings that bacterial species was the most common pathogen causing brain abscess.[19,20]

Using Conventional MR imaging to discriminate different intracranial lesion is often a very challenging task, and usually follow up studies and biopsy procedures are required. Diffusion weighted MRI has shown increased sensitivity in the diagnosis of intracranial infections.[7]

Our study found out that the sensitivity and specificity of diffusion weighted MRI to be 98.83% and 94.0% respectively in diagnosing brain abscess taking histopathology as gold standard. The positive and negative predictive values were found out to be 96.59% and 97.91% respectively, while the diagnostic accuracy was calculated as 97.05% (Tab. 1). The results of our study were compared with the studies done on the related topic i.e., Lai PH[31] et al that showed the sensitivity and specificity of diffusion weighted MRI in diagnosing brain abscess were 95.2% and 95.7% respectively, whereas the positive and negative predictive values were 95.7% and 95.2% respectively. The diagnostic accuracy of Lai PH et al study was found out to be 95.5%. Our study has given better diagnostic accuracy of diffusion weighted MRI in diagnosing brain abscess.

Application of DWI in distinguishing between brain abscesses and cystic or necrotic brain tumors has been reported to be useful in several publications.[21,23] Kim JY et al showed hypenintense signals within the abscess cavity while hypointense signals were noted in necrotic brain tumors, which in result helped to differentiate between brain abscess and necrotic brain tumour.[24]

Reddy JS et al showed high sensitivity of diffusion weighted MRI for the differentiation of brain abscess from non-brain abscess. The sensitivity and specificity of diffusion weighted MRI was found out to be 96% and 96% respectively whereas the positive and negative predictive value was calculated as 98% and 92% respectively in the above study.[8]

The probable factors for restriction in brain abscesses that resulted in hyperintense signal in diffusion weighted MRI are microscopic organization of the tissues, high viscosity of pus resulting from high protein, and different types of viable or dead cells along with necrotic tissue and bacteria, which collectively impede the microscopic motion of water molecules.[25,26] Ebisu et al suggested that high cellularity and viscosity in the abscess cavity are the likely reason for the impaired diffusion of water molecule in abscess.[27]

Other studies showed that restricted diffusion in a ring-enhancing lesion might be characteristic but not pathognomonic of brain abscess. Hartmann et al[28] found restricted diffusion in one metastatic adenocarcinoma and unrestricted diffusion in one postoperative abscess cavity. The reasons for restricted diffusion in this particular metastasis remain unclear. Possible explanations for high signal intensity on DW images of processes other than pyogenic brain abscess include high cellularity and reduced extracellular space, as seen in lymphomas and medulloblastomas. In two cases of lymphoma, restricted diffusion was demonstrated as high signal intensity on DW images. Tung et al[29] reported restricted diffusion in two cases

of metastases and in one case of radiation necrosis. Fewer studies compared conventional MRI with diffusion weighted MRI for differentiating abscess from necrotic brain tumor. Chang SC et al[30] showed high sensitivity of DWI as compared to conventional MRI, having sensitivity (93.3%), specificity (90.9%), positive predictive value (93.3%) and negative predictive value of (90.9%).

Few other studies have also compared diffusion weighted MRI with MR spectroscopy. Lai PH et al[10] compared diffusion weighted MRI and MR spectroscopy and found that DW MRI is more effective and accurate as it acquires less timing in differentiating brain abscess from necrotic brain tumor. They also suggested that combined use of DW MRI and MR spectroscopy may improve results as compare to only single technique to differentiate between brain abscess and necrotic brain tumors.

There were few limitations of our study. It was a single centre study, which can result in selection bias. Diffusion weighted images were read in conjunction with routine MRI sequences which can also lead to bias in making final diagnosis.

Finally the result of our study encouraged the use of diffusion weighted MRI to rule out the diagnosis of brain abscess showing its high sensitivity and specificity, but brain abscess like lesions can also be seen in cystic or necrotic brain tumors, epidermoid and infarction.

Conclusion

Diffusion weighted sequence in MRI examination has an important role in the diagnosis of brain abscess. The overall diagnostic accuracy of diffusion weighted MRI in the diagnosis of brain abscess in patients with clinical signs and symptoms are very close to histopathological findings.

Diffusion weighted MRI performed in patients with suspected brain abscess improves patient care both by eliminating the need for invasive diagnostic and surgical procedures and by averting delays before medical treatment, which consequently reduces hospital expenditure.

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