ORIGINAL ARTICLE

Diagnostic Accuracy of Diffusion Weighted Magnetic Resonance Imaging for Differentiation of Brain Abscesses from Brain Lesions taking Surgical Findings as Gold Standard

MARIA BABAR[1], USMAN ZAFAR[2], IRUM SHAHZAD[3], *ARSALAN JAMIL RAJA[4], MUTAHIRA MANNAN[5], HANNAN ZAFAR[6]*
[1]Consultant Radiologist at Lahore General Hospital, Lahore
[2]Senior Registrar, Interventional Radiology, PKLI &RC, Lahore
[3]Assistant Professor Radiology, LMDC Lahore
[4]Assistant Professor Gastroenterology, Quaid Azam Medical College, Bahawalpur
[5]PGR Histopathology, Fatima Memorial Hospital, Lahore
[6]PGR Gastroenterology, Lahore General Hospital, Lahore
Correspondence to: Dr. Maria Babar, Email: drmariaab@gmail.com Ph. 0300-8718778.

ABSTRACT

Aim: To determine the diagnostic accuracy of diffusion weighted magnetic resonance imaging for differentiation of Brain abscesses from brain lesions taking surgical findings as gold standard.
Methods: This cross sectional study was done at department of Radiology, Lahore General Hospital, Lahore. The study was completed in Six Months (October 1, 2014 till March 31, 2105). After taking informed consent, demographic information (name, age, gender and contact) was obtained. Then patients underwent through Diffusion weighted imaging (DWI). Diffusion-sensitizing gradients were applied with a diffusion sensitivity of b = 0, 500 and 1000s/mm^2. Apparent diffusion coefficient (ADC) values were also calculated on computer software. ADC values were taken from the center and wall of the lesion as well as from the surrounding oedema. DWI were analyzed on the basis of signal intensity on diffusion images and corresponding ADC maps. Then patients were underwent biopsy for histopathology. All biopsy samples were sent to the histopathology laboratory of hospital and results were compared with results of DWI.
Results: The mean age of the patients was 43.74±14.64 years with minimum and maximum ages of 20 & 70 years respectively. Out of 145(65.91%) patients were male and 75(34.09%) patients were females. The male to female ratio was 1.933:1. The sensitivity of DWI in our study was 91.67%, specificity was 93.18%, positive predictive value was 95.28%, negative predictive value was 88.17% and the diagnostic accuracy was 92.27% taking histopathology as gold standard.
Conclusion: Diffusion weighted imaging is an effective method with high sensitivity and specificity which can help in differentiation of Brain abscesses from brain lesions.
Keywords: Diffusion weighted imaging, DWI, Histopathology, Brain Lesions, Restriction, Abscess

INTRODUCTION

A brain abscess is a focal infection of the brain that begins as a localized area of cerebritis. In immunocompetent patients, bacteria are responsible for >95% of brain abscesses, and enter the brain either through contiguous spread following otitis, sinusitis, neurosurgery, or cranial trauma, or through haematogenous dissemination.[1]They can strike at any age and can often have devastating consequences.[2] Intracranial abscesses are uncommon, serious, life-threatening infections. They include brain abscess and subdural or extradural empyema and are classified according to the anatomical location or the etiologic agent[3].

One study found the brain abscess (infective brain lesion) as 25.2%[4]. Brain abscess is caused by intracranial inflammation with subsequent abscess formation.[5] The most frequent intracranial locations (in descending order of frequency) are frontal-temporal, frontal-parietal, partial, cerebellar, and occipital lobes. In at least 15% of cases, the source of the infection is unknown (cryptogenic)[5].

Brain tumors are common, requiring general medical providers to have a basic understanding of their diagnosis and management.[6]Differentiation between tumors and tumor-like lesions of the central nervous system is essential for planning adequate treatment and for estimating outcome and future prognosis.[7] The radiologist should be aware of all non-neoplastic pathologies and diseases that may mimic tumors. High-end anatomic and functional neuroimaging tools integrating multiple modalities and clinical correlation is mandatory.[7] A study conducted by DWI had a sensitivity of 94.73%, specificity of 94.44%, positive predictive value of 94.73%, and negative predictivevalue of 94.44% and diagnostic accuracy of 94.5% in differentiating brain abscess from neoplastic brain lesions[8].

The current study was designed to determine the diagnostic accuracy of diffusion weighted magnetic resonance imaging for differentiation of Brain abscesses from brain lesions taking surgical findings as gold standard. Literature has reported that DWI is highly sensitive and specific in differentiation distinguishing the brain abscess from neoplastic lesions or other brain lesions / tumors. But few literatures is present in literature. There was only one local study which was conducted in Aga Khan University, but in that study, sample size was very small (37 cases only). We took large sample size to attain more precise and accurate results as compared to previously reported in literature cited above.

Received on 11-12-2019
Accepted on 23-07-2020

MATERIALS AND METHODS

This cross sectional study was conducted in the Department of Radiology, Lahore General Hospital, Lahore for a period of six months i.e. from October 1, 2014 to March 31, 2105. Sample size of 220 cases is calculated with 95% Confidence level, 9% margin of error and taking expected percentage of brain abscess i.e., 20.52% and sensitivity and specificity of DWI were 94.73% and 94.44% respectively taking histopathology as gold standard. Sampling technique used was non probability, purposive sampling. All cases with age 20-70 years of either gender with brain lesions (on clinical and X-ray evidence) already planned to undergo histopathology for assessment of type of lesion were included. Patients having contraindications for surgery e.g.: hemodynamically unstable, BP>140/90mmHg, having co-morbid conditions as DM (BSR>186mg/dl), cerebrovascular accident (clinical examination), deranged LFT (AST>40IU, ALT>40IU), deranged RFT (serum creatinine >1.5mg/dl), Cardiac failure (on medical record), having deranged clotting profile, INR>2 and patients already diagnosed to have brain abscess or cystic tumor were excluded form study.

Data Collection Procedure: After taking informed subjects, 100 patients fulfilling the selection criteria was recruited for the study from Department of Radiology, Lahore General Hospital, and Lahore. After taking informed consent, demographic information (name, age, gender and contact) was obtained. Then patients underwent through DWI. All scans were done on Siemens 1.5 Tesla MR Scanner. Axial T1, T2, Sagittal T2, coronal FLAIR and post contrast axial, coronal and sagittal images were retrieved. Diffusion-sensitizing gradients were applied with a diffusion sensitivity of b = 0, 500 and 1000s/mm^2. ADC values were also calculated on computer software. ADC values were taken from the center and wall of the lesion as well as from the surrounding oedema. DW images were analyzed on the basis of signal intensity on diffusion images and corresponding ADC maps. Diffusion restriction was defined as hyperintense signals on diffusion imaging with corresponding hypointense signals on ADC maps were taken as diffusion restriction. Abscess was defined as ring enhancing lesions which showed diffusion restriction and cases were labeled as positive. Neoplastic lesion was a ring enhancing lesions which does not show diffusion restriction and cases were labeled as negative. All DWIs were performed by researcher himself under supervision of supervisor. Patients were labeled as positive or negative on the basis of DWI findings. Then patients were undergo biopsy for histopathology. All biopsy samples were sent to the histopathology laboratory of hospital and results were compared with results of DWI. The data was entered and analyzed in SPSS version 17.0. Quantitative variables like age was measured in the form of mean ± SD. Qualitative variables like gender were measured in the form of frequency and percentage. 2x2 tables was generated to calculate sensitivity, specificity, and positive and negative predictive values for the diagnosis of neoplastic brain lesion on DWI taking histopathology as gold standard.

RESULTS

Total 220 cases appeared in the department of radiology, Lahore General Hospital, Lahore. The mean age of the patients was 43.74±14.64 years with minimum and maximum ages of 20 & 70 years respectively. In our study out of 145(65.91%) patients were male and 75(34.09%) patients were females. The male to female ratio was 1.933:1. The study results showed that the DWI was observed positive in 127(57.7%) patients while it was observed negative in 93(42.3%) patients. In this study the histopathology was found positive in 132(60%) patients while it was found negative in 88(40%) patients. The study results showed that DWI was found positive in 127 cases in which 121 cases were also found positive by histopathology. The sensitivity of DWI in our study was 91.67%, specificity was 93.18%, positive predictive value was 95.28%, negative predictive value was 88.17% and the diagnostic accuracy was 92.27% taking histopathology as gold standard.(Table 2 & 3)

Table1: Descriptive statistics of age (years)

No. of cases	220
Mean	43.74
Std. Deviation	14.64
Range	50
Minimum	20
Maximum	70

Table 2: Frequency distribution of gender, DWI findings and histopathology findings

		Frequency	%age
Gender	Male	145	65.91
	Female	75	34.09
DWI	Positive	127	57.7
	Negative	93	42.3
Histo-pathology	Positive	132	60
	Negative	88	40

Table 3: Comparison of DWI findings and findings of histopathology

DWI	Histopathology		Total
	Positive	Negative	
Positive	121	6	127
Negative	11	82	93
Total	132	88	220

Table 4: End results of sensitivity and specificity

Sensitivity	91.67%
Specificity	93.18%
Positive Predictive Value	95.28%
Negative Predictive Value	88.17%
Diagnostic Accuracy	92.27%

DISCUSSION

Brain abscess is a serious and life-threatening clinical entity. In some instances, an etiology cannot be identified. Diagnosis can be challenging, as abscess presentation is highly variable and routine studies frequently lack specificity. High clinical suspicion is necessary for early recognition and initiation of appropriate treatment[9]. Brain abscess is still a common clinical entity in both developed and developing countries. Despite the development of antibiotics with good blood-brain barrier penetrance, the morbidity, and the mortality cause by brain abscess is significant, moreover, almost 25% of the patients are children[10].The early diagnosis and immediate institution of a holistic treatment plan is the key of success in management of brain abscess. However, this is always a challenge to the young surgeons as there are a wide variety of causes of brain abscess. The causes of brain abscess are divided into three categories, which are contiguous suppurative focus (45-50% of cases), hematogenous spread from distant focus (25% of cases) and trauma (10% of cases). First category includes otologic, rhinologic or odontogenic infections[11]. Second category includes cardiac diseases, chronic lung infections skin infections, abdominal and pelvic infections, transplantation, esophageal dilatation, injection drug use, and human immunodeficiency virus infection[12].

Diffusion-weighted magnetic resonance (MR) imaging provides image contrast that is different from that provided by conventional MR techniques. As stroke is common and in the differential diagnosis of most acute neurologic events, diffusion-weighted MR imaging should be considered an essential sequence, and its use in most brain MR studies is recommended [13].Abscess cavities and empyemas are homogeneously hyperintense on DWMR images, with signal intensity ratios of abscess cavity to normal brain tissue that range from 2.5 to 6.9 and with ADC ratios that range from 0.36 to 0.46[14].

In one study, the ADC of the abscess cavity in vivo was similar to that of pus aspirated from the cavity in vitro [15]. In another study, the ADC ratio of empyema compared with CSF was 0.13 in one patient[16]. The relatively restricted diffusion most likely results from the high viscosity and cellularity of pus. Although intracranial abscesses and intracranial neoplasms may appear similar on images obtained with conventional MR sequences, the signal intensity of the abscess cavity is markedly higher and the ADC ratios are lower than those of necrotic tumors on DW MR images[14].

In recent years, the emerging new imaging techniques not only show the detailed and complete aspects of brain neoplasm, but also promote clinical doctors using new techniques, such as CT three-dimensional reconstruction, magnetic resonance spectroscopy (MRS), diffusion weighted imaging (DWI), diffusion tensor imaging (DTI) to research the mechanism of those diseases in the aim of better treatment.Diffusion weighted imaging is more practical in clinical use. It is a fast echo planar imaging technique and requires less imaging time[13,17].

CT and MR imaging has high sensitivity for diagnosing ring enhancing brain lesions but most of the time, it is difficult to differentiate between neoplastic mass lesion and brain abscess.The sensitivity of DWI in our study was 91.67%, specificity was 93.18%, positive predictive value was 95.28%, negative predictive value was 88.17% and the diagnostic accuracy was 92.27% taking histopathology as gold standard. Some of the studies are discussed below to support the findings of our study. Muhammad Shahbaz Alam et al[18] showed in their study that DWI had a sensitivity of 94.73%, specificity of 94.44%, positive predictive value of 94.73%, and negative predictive value of 94.44% and diagnostic accuracy of 94.5% in differentiating brain abscess from neoplastic brain lesions (Table 4).

Our study showed high sensitivity, specificity, positive, negative predictive value and accuracy. Lai and Reddy et al. described similar results which are in close agreement with this study[19,20]. A study conducted by DWI had a sensitivity of 94.73%, specificity of 94.44%, positive predictive value of 94.73%, and negative predictive value of 94.44% and diagnostic accuracy of 94.5% in differentiating brain abscess from neoplastic brain lesions[8].

GS Young et al[21] described in their study that DWI has a sensitivity and specificity of over 90% for distinguishing epidermoid (low ADC) from arachnoid cyst (high ADC) and distinguishing abscess (low ADC) from necrotic tumor (high ADC).Sun et al[22] evaluated 39 spine tumors with DWI and PWI and found that the accuracy of MR-PWI (89.7%) was greater than MR-DWI (79.5%), noting that benign vascular tumors were falsely positive on PWI. They concluded that combined PWI/DWI would lead to greater diagnostic specificity.AM Mishra et al [23] suggested in their study that The sensitivity of DWI and PMRS for differentiation of brain abscess from nonbrain abscess was 72% and 96%, respectively, whereas the specificity was 1 for both techniques.Ping H. Lai et al [19] concluded in their study that diffusion-weighted imaging are useful for differentiating brain abscess from brain tumor, but the latter requires less time and is more accurate than is 1H-MRS. 1H-MRS is probably more limited in cases of smaller peripheral lesions, skull base lesions, and treated abscesses.

Pamela W. Schaefer, et al [13] demonstrated that Diffusion-weighted MR imaging also provides adjunctive information for other cerebral diseases including neoplasms, intracranial infections, traumatic brain injury, and demyelinating processes. Because stroke is common and in the differential diagnosis of most acute neurologic events, diffusion-weighted MR imaging should be considered an essential sequence, and its use in most brain MR studies is recommended.

CONCLUSION

Diffusion weighted imaging is an effective method with high sensitivity and specificity which can help in differentiation of Brain abscesses from brain lesions. Hence using DWI these can be diagnosed early as early diagnosis and differentiations plays an important role in improving treatment possibilities and increases the survival rate of the patients.

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