ORIGINAL ARTICLE

Diffusion Weighted MR Imaging of Ring Enhancing Brain Lesions

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ABSTRACT

Objective: To evaluate the role of diffusion weighted imaging in differentiating the cause of ring enhancing brain lesions.
Study Design: Analytical, descriptive study.
Place and Duration of Study: Department of Radiology, The Aga Khan University Hospital, Karachi, from March 2007 to July 2011.
Methodology: Diffusion weighted imaging (DWI) was performed on 37 patients having ring enhancing lesions on their post-contrast brain MRI scans. These lesions were characterized into neoplastic and abscess cavity on the basis of diffusion restriction. Correlation of all these findings was done with histopathology obtained in all these patients. Sensitivity, specificity, positive and negative predictive values and diagnostic accuracy of DWI were calculated. Comparisons of mean ADC values of abscess and neoplastic lesions were also done using t-test.
Results: 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. Mean ADC value in central cavity and wall of neoplastic lesions and brain abscesses were calculated with significant p-value of 0.001 and 0.025 respectively.
Conclusion: Diffusion weighted imaging is non-invasive method with high sensitivity and specificity which can help in differentiation of ring enhancing neoplastic lesions and brain abscesses. This modality should be read in conjunction with conventional imaging.

Key words: *Ring enhancing lesion. Diffusion weighted imaging (DWI). Brain. MRI. Abscess. Neoplasm.*

INTRODUCTION

Brain infections with secondary complications like abscess, usually appear as ring enhancing cerebral lesions on routine contrast enhanced MRI. Neoplastic lesions are the top differential diagnosis. Cystic/necrotic neoplastic brain lesions are difficult to differentiate from brain abscess as their imaging features are almost similar and differentiation is of paramount importance because of difference in the subsequent management.[1] Brain abscess can be medically managed by antibiotics or CT/MRI-guided drainage while neoplastic lesions usually require biopsy, surgical resection and metastatic workup. Conventional CT and MR imaging cannot reliably differentiate between these two entities most of the time and thus lead to diagnostic dilemma.[2]

Diffusion weighted imaging (DWI) was introduced in clinical practice in 1990's; initially much of its role was described in acute ischaemic stroke.[3] It provides information about physiologic state of the brain and is particularly sensitive for ischaemic infarctions. Presently, its role is not limited to identify acute brain infarction but also in various neoplastic and non-neoplastic pathologies not only in the brain but also in various bony and soft tissue pathologies as well. Besides infarctions, it has been used to evaluate various neoplastic lesions, infections and demyelinating disorders.

There are conflicting reports regarding use of DWI in differentiating brain abscess from cystic/necrotic neoplastic brain lesions.[3-6] To authors' knowledge, no local data has been published until recently from this part of the world. Therefore, the purpose of this study was to see the usefulness of DWI in differentiating these two entities using histopathology as gold standard in our population.

METHODOLOGY

This study was conducted in the Department of Radiology, The Aga Khan University Hospital, Karachi. A computer assisted search of MR reports from March 2007 to July 2011 showed 52 ring enhancing lesions in which diffusion weighted imaging was performed and images were available on PACS for review. Based on these criteria, 15 patients from the study were excluded due to non-availability of histopathology results or who were lost to follow-up.

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 1000 s/mm^2.

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Received January 27, 2012; accepted May 05, 2012.

ADC values were also calculated on computer software. ADC values were taken from the centre and wall of the lesion as well as from the surrounding oedema. All the images were interpreted by two consultant radiologists having experience in MRI reporting including DWI. Reporting was done on console as well as hard copies. Final diagnosis was made on histopathology results.

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 were defined as ring enhancing lesions which showed diffusion restriction (Figure 1). Neoplastic lesion was a ring enhancing lesions which did not show diffusion restriction (Figure 2). ADC value was calculated on Leonardo software with mean area of less than 5 mm.

Study was approved by the institutional ethical review committee and exemption of ethical approval was granted.

Data was entered using Statistical Package for Social Sciences (SPSS) program version 19.0. Mean and standard deviation were calculated for quantitative data and frequencies were performed for categorical data. Sensitivity, specificity, positive, negative predictive value and accuracy of DWI was calculated. Comparisons of mean ADC values of brain abscess and cystic/necrotic neoplastic lesions were done by using simple t-test. $P < 0.05$ was considered significant.

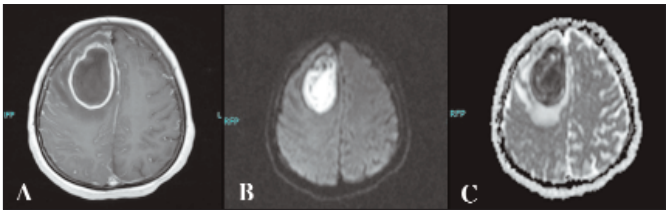

Figure 1: (**A.** Axial contrast T1; **B.** Diffusion image; **C.** ADC image): Ring enhancing lesion in right frontal lobe showing diffusion restriction-infective abscess on aspiration.

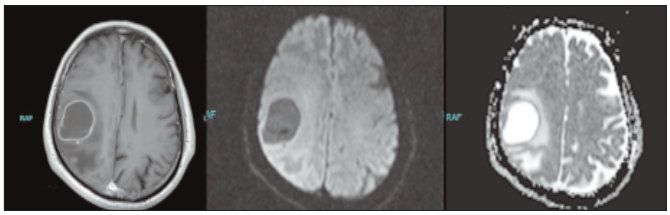

Figure 2: (**A.** Axial Contrast T1; **B.** Diffusion Image; **C.** ADC image): Ring enhancing lesion in right parietal lobe without diffusion restriction turned out to be astrocytoma on biopsy.

RESULTS

Most common clinical presentations were headache (28%) followed by fever (24%) and with signs and symptoms related to site of lesion. Twenty three were male patients (62.2%) while 14 were females (37.8%). Overall mean age was 35 ± 18 years with age ranging from 1 to 64 years. Mean size of neoplastic lesions and abscess cavity were 4.95 ± 1.16 and 3.93 ± 1.12 cm respectively.

Out of the 37 cases, 19 (51.4%) lesions showed high signals on diffusion with corresponding low signals on ADC images thus depicting diffusion restriction while 18 (48.6%) lesions did not show diffusion restriction. On histopathological examination, 18 (48.6%) of the total 37 cases have been diagnosed as neoplastic lesion while 19 (51.4%) were brain abscesses of various aetiology. The neoplastic lesions include various grades of astrocytoma (n = 14), metastasis (n = 2), neuro-ectodermal tumours (n = 1) and Haemangioblastoma (n = 1). Regarding abscesses, 4 were tuberculous on pus culture, 3 came out to be fungal and 12 were pyogenic gram positive and negative organisms including *Streptococcus, Staphylococcus, Klebsiella, Bacteroides* and *Enterobacter* species as well. Eighteen out of 19 brain abscesses (94.7%) demonstrated diffusion restriction while only one out of 18 neoplastic lesions (5.3%) show diffusion restriction. There were 18 true positive, 1 false positive, 17 true negative and 1 false negative results reported on diffusion based assessment (Table I).

Table I: Accuracy of diffusion weighted imaging.

True positive	n = 18
True negative	n = 17
False positive	n = 01
False negative	n = 01
Sensitivity	94.73%
Specificity	94.44%
Positive predictive value	94.73%
Negative predictive value	94.44%

n = Number of cases.

Based on these findings, 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 I).

Mean ADC value in central cavity of neoplastic lesions and brain abscesses are $2.58 \pm 1.2 \times 10^{-3}$ mm^2/second and $0.61 \pm 0.4 \times 10^{-3}$ mm^2/second respectively with significant p-value of 0.0001. Mean ADC value from the wall of the lesions in neoplastic lesion is $1.17 \pm 0.10 \times 10^{-3}$ mm^2/second compared to $0.882 \pm 0.11 \times 10^{-3}$ mm^2/second in abscess group with significant p-value of 0.025. Surrounding oedema in neoplastic lesions and abscesses have ADC value of $1.49 \pm 1.1 \times 10^{-3}$ mm^2/second and $1.66 \pm 0.5 \times 10^{-3}$ mm^2/second respectively with insignificant p-value of 0.061.

DISCUSSION

Diffusion weighted imaging is more practical in clinical use. It is a fast echo planar imaging technique and requires less imaging time.[3,7] 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. MR spectroscopy and diffusion weighted imaging are two additional sequences used to further classify these lesions. MR spectroscopy is more time-consuming and far less specific compared to DWI specially lesions near the bone or base of skull due to susceptibility effect. DWI shows much promise in differentiating differentials of ring enhancing lesions.[8-10]

Previous studies described high accuracy of DWI in differentiating brain abscess from cystic/necrotic tumours. Differentials of ring enhancing lesions include high grade gliomas, metastasis, abscess, demyelinating disease and resolving haematomas. There are reports that diffusion restriction can be seen in neoplastic cystic lesions. Similarly, increase diffusion and ADC value has been described thus raising the question mark over the accuracy of this technique.[11-16]

This 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.[4,5]

Mean ADC values were taken from the central cavity, enhancing wall as well as from the surrounding oedema. Mean ADC value from the centre of the lesion in abscess group was $0.61 \pm 0.4 \times 10^{-3}$ compared to neoplastic lesion of $2.58 \pm 1.2 \times 10^{-3}$ mm^2/second. Similarly, mean ADC value in the enhancing wall of the lesion in brain abscess and neoplastic lesions were $0.882 \pm 0.11 \times 10^{-3}$ mm^2/second and $1.17 \pm 0.10 \times 10^{-3}$ mm^2/second respectively. Surrounding oedema had mean ADC values of $1.66 \pm 0.5 \times 10^{-3}$ mm^2/second and $1.49 \pm 1.1 \times 10^{-3}$ mm^2/second. Reddy *et al*. described the mean ADC value in abscess group of $0.87 \pm 0.05 \times 10^{-3}$ mm^2/second compared with $2.59 \pm 0.05 \times 10^{-3}$ mm^2/second in non-abscess group.[5] Luthra *et al*. similarly, reported low ADC value ($0.72 \pm 0.17 \times 10^{-3}$ mm^2/second) in the cavity of pyogenic abscess.[17]

Although this study showed high sensitivity and specificity, there was one case of abscess which did not show diffusion restriction having high ADC value. Previous literature described only few cases of increased diffusion within an abscess.[15-18] Possible explanation for non-restricted brain abscess could be due to variable viscosity of abscess which could be due to variable concentration of purulent material in the cavity.[19] Other possibility would be the age of abscess or partially treated cavity. Diffusion imaging can be used for follow-up as completely treated abscess does not show diffusion restriction.[20,21]

There was one more case of neoplastic lesion which showed diffusion restriction. There is a lot of debate regarding this and lot of conflicting reports regarding possible explanation. Usually cystic neoplastic lesion cavity contains less viscous and cellular material with possible haemorrhagic content resulting in non-restriction on diffusion imaging. Previous studies tried to describe the probable aetiology for this but matter largely remained unclear. Again, change in the cellular content of the necrotic or cystic material of the lesion due to variable protein content can be a possibility.[16,18,19] Some lesions do have intratumoural haemorrhage which can also lead to diffusion restriction as well.

There were certain limitations of this study. It was a single centre study which can result in selection bias. Sample size was relatively small. Diffusion images were read in conjunction with routine MRI sequences which can lead to bias in making final diagnosis.

CONCLUSION

Brain abscess and necrotic tumours are most of the time difficult to differentiate on routine conventional imaging and prompt diagnosis is important as untreated brain abscess could be lethal. Diffusion imaging can aid in the diagnosis and further management plan so to help in improved patient care. Although this sequence has high sensitivity and specificity, it should be used as addition to conventional imaging and not as replacement for histopathology.

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