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Role of DWI in Ring Enhancing Lesions of Brain

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Abstract

The aim of this study was to access the role of diffusion-weighted imaging (DWI) in evaluation and differentiation of ring enhancing brain lesions in patients whose MRI examination revealed abnormal imaging features. The usefulness of the apparent diffusion coefficient (ADC) map in lesion characterization was also evaluated.

We compared the findings of conventional and contrast enhanced MR images with those of DWI: all 24 patients with cystic ring enhancing masses were examined with routine MR imaging and echo- planar DWI. The routine MR imaging included at least the axial T2- and T1-weighted sequences, and post-contrast T1 axial sequences.

In our study six patients suffered from abscesses with a total of 7 cysts, 10 from intra axial tumors with 12 cysts, and 4 from metastases with 4 cysts(epdermoid and arachnoid). All abscess cavities showed hyperintense DWI signal intensity compared to normal appearing white matter (NAWM), low ADC. 10 out of 12 glioblastoma cysts and all 4 metastatic cysts revealed hypointensity on DWI, high ADC compared to abscess . DWI findings of 2/12 glioblastoma cysts overlapped with those of abscesses showing hyperintensity on DWI, low ADC hence mimicked abscesses. Out of 4 patients of tuberculoma cyst showed ring type of restricted diffusion were as 2 showed no specific pattern.

It was concluded in our study that although some glioblastoma lesions may appear hyperintense on DWI thus imitating an abscess, evaluation of the lesions with both DWI and conventional MRI may have an important contribution to the differentiation of tumours from abscesses.

Keywords: MRI, DWI, ADC, Ring Enhancing Lesions, Glioblastoma, Abscess

Introduction

Intracranial cystic mass lesions represent a significant neurosurgical dilemma. Depending upon non-specific clinical findings and tumor appearances on imaging modalities including CT scan and conventional MRI, differentiation of various intracranial cystic lesions may be challenging[1].

The differential diagnosis of intracranial mass lesions can be difficult, even with sophisticated morphological techniques. This is especially true in cases of suspected brain abscess, for which an immediate correct diagnosis is necessary for prompt, adequate treatment of this life-threatening but treatable condition[2].

The medical management strategies for abscess and neoplasms are different, correct diagnosis must be obtained before the treatment of cystic brain lesions[3,4].

Diffusion-weighted imaging provides a way to assess the diffusion properties of the water molecules in tissue and has been used in clinical applications such as ischemia, tumors, epilepsy and white matter disorders[5].

Our purpose was to evaluate the usefulness of the DWI in the differential diagnosis of cystic brain lesions.

Methods

This prospective study was performed within the span of one year ,24 patients (15 males, 9 females) with pyogenic brain abscesses, metastasis,cystic and necrotic brain tumors were included in the present study, age range between 10 and 70 years, mean 43 years, all patients referred from the neuro- surgery department of our institution, these patients had ring-enhanced brain lesions on post contrast T1 images.

Imaging procedures

All patients showing evidence of ring enhancing brain lesion in post contrast T1WI of conventional MRI were examined using a 1.5T MR scanner .Conventional MR and DWI were carried out at the same time. Conventional MR images were obtained with axial T2-weighted, axial T1-weighted, coronal FLAIR (and axial contrast-enhanced (0.1 mmol/kg of contrast agent) T1-weighted images. Contrast-enhanced images were obtained. DWIs were obtained in the axial plane using echo-planar spin-echo pulse sequence (with three b values (0, 500, 1000 s/mm^2).

Post-processing of ADC map

It was done using the standard software supplied on the machine console to obtain the ADC value and map, the ADC values were measured in the regions of interest in the center of the lesion (cavity of the abscess and necrotic portion of the tumor) and in comparable normal contralateral regions in the white and gray matter of the brain.

The ADC values of the gray and white matter were $0.85 \pm 0.13 \cdot 10^{-3}$ and $0.8 \pm 0.13 \cdot 10^{-3}$ mm^2/s, respectively.

Restricted diffusion (hyper intense) and low ADC value was seen in ring enhancing brain abscess than that of normal-appearing brain, while necrotic tumor was defined as ring enhancing lesion with free diffusion (hypointense) and had high ADC value than that of normal- appearing brain. In tuberculomas the ADC value was not very specific.

Results

The final diagnosis was pyogenic abscess for 6 lesions, cystic lesions 4, metastatic brain tumour for 4 lesions, and primary brain tumour for 10 lesions (anaplastic astrocytoma: 2; cystic astrocytoma: 4; medulloblastoma: 1; glioblastoma multiforme: 3) (Table 1).

Imaging findings of metastatic disease include-characteristics of patients based on the conventional MR and DWI All the lesions in the study group appeared hypointense on T1-weighted images and hyperintense on T2-weighted images and showed peripheral contrast enhancement with no significant restricted diffusion .All the lesions except arachnoid and epidermoid cysts showed contrast enhancement. Only arachnoid cysts were hypointense with 100% on FLAIR sequences; lesions other than arachnoid cysts were either hypo-, hyper- or isointense. Of the 7 abscesses, 6 were hypointense (92%) on ADC whereas the remaining 1 lesion was isointense (5%). None of abscess showed hyperintensity on ADC. All 7 abscesses were hyperintense on DWI , 7 of primary tumours were hyperintense on ADC maps; and 3 were isointense on ADC maps. No primary tumours showed hypointensity on ADC mapping. The cystic or necrotic areas of all primary tumours were hypo or isointense on DWI. All arachnoid cysts showed hyperintensity on ADC and hypointensity on DWI ie no restricted diffusion. 2 epidermoid cysts showed bright signals on DWI and corresponding dark signals on ADC suggesting restricted diffusion in these cysts.

Table 1:

Lesions	Number of patients
pyogenic abscess	6
Cysts(epidermoid and aracnoid)	4
metastatic brain tumour	4
anaplastic astrocytoma	2
cystic astrocytoma	4
medulloblastoma	1
glioblastoma multiforme	3

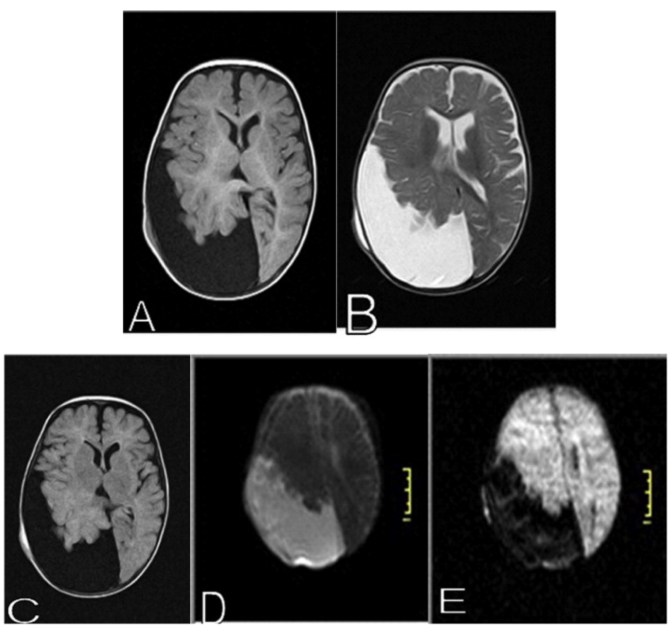

Fig.1: Arachnoid Cyst. (a) T1-weighted axial image showing well-defined hypointense cystic lesion in right parieto-occipital region. (b) T2-weighted axial image demonstrates the lesion to be brightly hyperintense. (c) Post-gadolinium axial image showing no enhancement of the lesion. (d) ADC map showing high signal (e) DWI image showing no evidence of diffusion restriction.

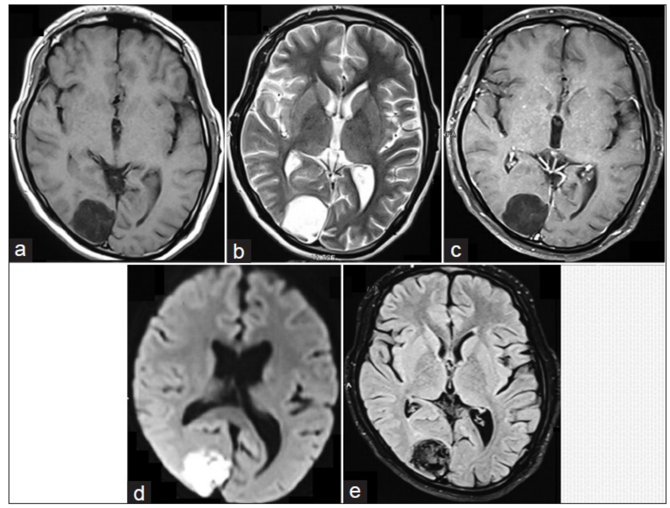

Fig. 2: Epidermoid cyst. (a) T1-weighted axial image showing well-defined hypointense cystic lesion of the occipital lobe. (b) T2-weighted axial image demonstrates the lesion to be brightly hyperintense. (c) Post-gadolinium axial image showing no enhancement of the lesion. (d) Diffusion-weighted axial image showing the lesion to be brightly hyperintense. (e) Fluid attenuated inversion recovery axial image showing internal heterogeneity giving dirty mop-like appearance.

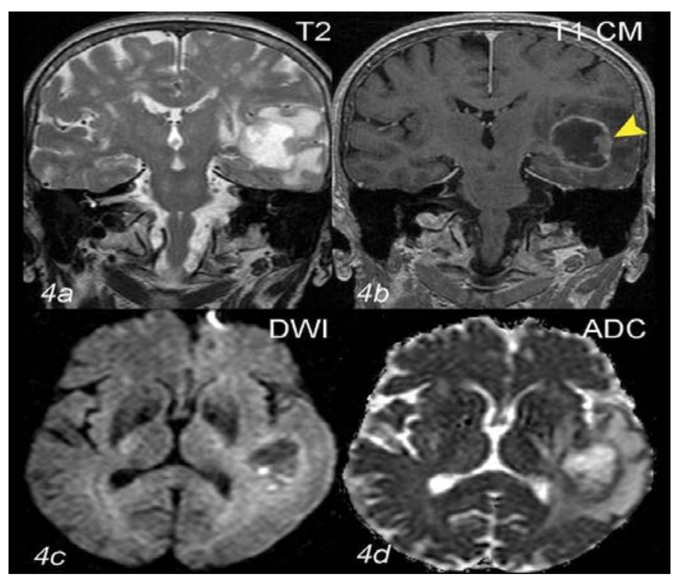

Fig. 3: Gliobalstoma Multiforme. Coronal T2-WI shows a necrotic mass with adjacent edema (a). Post-contrast T1-WI shows an irregularly thickened

enhancing rim (arrow) (b). Axial DWI shows markedly low signal intensity in the necrotic part of the tumour with high ADC values (c,d).

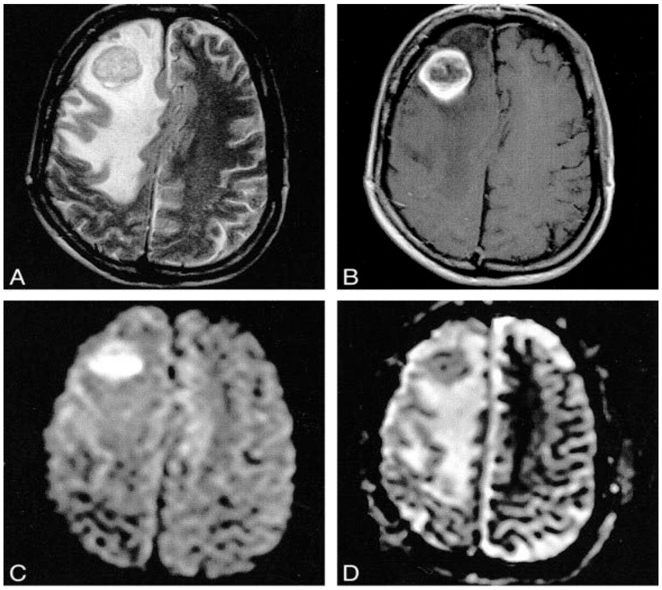

Fig. 4: Metastasis The T2-weighted image (A) shows a hypointense mass lesion surrounded by massive edema. On the contrast-enhanced T1-weighted image (B), there is ring enhancement presumably due to central necrosis. With diffusion weighting (C), the central part of the tumor becomes markedly hyperintense, while the ADC map (D) reveals low values, indicating restricted diffusion.

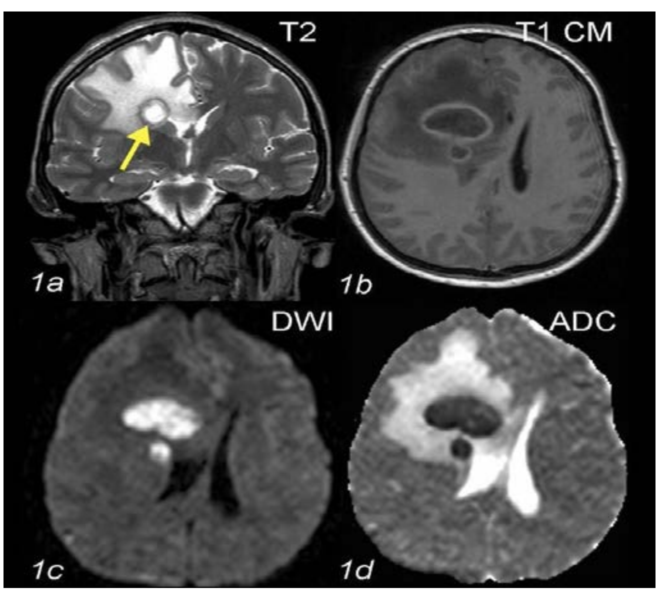

Fig. 5: Pyogenic Brain Abscess On T2-WI, high signal in the abscess cavity can be observed (a). Note low signal intensity of the capsule surrounding the cavity (arrow). On post-contrast T1-WI, the abscess in the right frontal lobe shows low signal intensity within its cavity and an enhancing capsule (b). On DWI, there is marked high signal in the abscess that corresponds to restricted diffusion (c). The dark signal on the ADC map in the abscess cavity confirms restricted diffusion (d).

Discussion

It is difficult to differentiate necrotic glioblastomas, cystic metastases, and abscesses with conventional MR imaging. All can appear as expansile rim-enhancing masses with prom- inent perifocal edema[6]. In some instances, cMRI is not effective for the differentiation of tumor type or for detection of tumor grade[7].

Currently the sensitivity and specificity of DWI in the diagnosis of cerebral infarct are widely accepted, and DWI is the definitive method for the differential diagnosis of epidermoid cyst from arachnoid cyst[8].

Intracranial epidermoid and arachnoid cysts give equal signal intensity with CSF on conventional MRI sequences. For this reason, their differentiation or detection may be difficult on some occasions. Epidermoid cysts should appear hyperintense because of the diffusional restriction due to their contents, whereas arachnoid cysts that have similar properties to CSF should be hypointense. In our study, all arachnoid cysts showed hypointensity on DWI and all of the epidermoid cysts showed hyperintensity. It has recently been reported that DWI can be used in the differential diagnosis of abscesses from tumours[4]

In our cases the necrotic part of the abscess was hyperintense on DWI images and hypointense on ADC images[9]. The cause of the hyperintense appearance of necrotic material in DWI may be the restriction of microscopic movement of water molecules by the bacteria, inflammatory cells, cellular debris and protein complex in the highly viscous pus. In addition, the water molecules in the abscess connect to the carboxy-, hydroxy- and amino-groups on the macromolecules. This limits their random movements. These factors probably explain the appearance of the abscess cavity as hyperintense on DWI and hypointense on ADC mapping, as occurs with other conditions that limit water diffusion[10].

Calculated ADC values were significant and useful in the grading of gliomas[11].In our study,ADC values calculated from tumoral area were higher in low-grade astrocytoma than in higher-grade ones; the lower ADCs suggested high-grade astrocytomas including GBM, whereas higher ADCs suggested low-grade ones, including diffuse GII pontine glioma in children. This agreed with the results of Dragana Ristic *et al.*[12], who showed a significant difference in mean ADCs between grade II glial tumors and grade III and IV glial tumors. These findings can be because high-grade tumors are characterized by increased cellularity, microvascular proliferation, and/or necrosis, and they concluded that diffusivity of glial tumors is inversely related to the cellularity and that ADC is inversely proportional to cellular density[13]

Sometimes CT and conventional MRI cannot easily differentiate cystic and necrotic brain tumours from abscesses. Ebisu et al. were the first to describe the role of DWI here. The authors reported that abscesses appeared hyperintense on DWI and hypointense on ADC mapping, whereas tumours appeared hypointense on DWI and hyper- intense on ADC mapping[14].

The differential diagnosis of peripherally enhanced cerebral lesions is difficult and occasion- ally impossible. However, recent reports indicated that cerebral abscesses might be differentiated from cystic-necrotic brain tumours[14,15]

Rana et al. showed that DWI can provide valuable information demonstrating ependymal invasion of abscesses[10]

Although it is rare, a metastatic adenocarcinoma can mimic an abscess but, according to the literature, an abscess never mimics a tumour. In none of our cases did a tumour mimic an abscess by appearing hypointense on DWI, but 1 case with metastasis mimicked an abscess by appearing hyperintense on DWI. This case was quite easily diagnosed as metastasis using routine and contrast- enhanced MRI

Hartmann et al. attributed the restricted diffusion in patients with adenocar- cinomatous metastasis to the viscous mucin content of the lesion[16]. The metastatic lesion they reported appeared hyperintense on DWI and hypointense on T2-weighted MRI, conflicting with the conventional MRI appearance of an abscess.

In our study 3 out 4 cases of metastasis- showed no restricted diffusion , only one showed high signal on DWI which was similar to the finding of Park et al. who reported 2 cases of necrotic brain metastasis with markedly high signal intensity on DWI, after surgery it was found that the cyst had a thick and creamy necrotic con- tent similar to pus, these metastasis were from colonic adenocarcinoma[17].

DWI is a more practical and reliable method and because its duration is very short (approximately 32 s) it is more practical in emergencies.

Conclusion

Even with the advent of MR imaging, the difficulties in differentiating between cystic tumours and abscesses have not disappeared and the differential diagnosis of ring-enhancing cerebral lesions continues to be a challenge. Such lesions include glioblastoma, metastasis, pyogenic abscess, subacute ischaemic infarction, resorbing haematoma and demyelinating disease. Nevertheless, these studies strongly suggest that the diagnosis of a brain abscess can be made if there is restricted diffusion within a cystic ring-enhancing cerebral lesion with low ADC values. When DWI is evaluated with contrast-enhanced MRI a sufficient number of parameters appear to help the radiologist in the differentiation of cystic lesions, and there is the further advantage of a short processing time.

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