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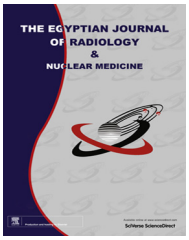

ORIGINAL ARTICLE

Magnetic resonance spectroscopy and diffusion imaging in the evaluation of neoplastic brain lesions

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KEYWORDS

Magnetic resonance spectroscopy;
Diffusion imaging;
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Abstract MR spectroscopy and apparent diffusion coefficient (ADC) calculation have been used frequently for tumour grading and differentiation during the last decade. The aim of this study is to evaluate whether the combination of these two techniques can improve the diagnostic effectiveness in patients with brain tumour.

Patients and methods: Thirty-six patients with histologically proven brain tumours (7 low, 13 high grade astrocytomas, 11 metastases, and 5 meningiomas) were evaluated with cMRI, MRS and DWI before surgery.

Results: MR spectroscopy could differentiate benign from malignant tumours but was not useful in tumour grading. In the differentiation of malignant from benign tumours, N-acetylaspartate (NAA), Choline (Cho), Creatine, lactate/lipid, and alanin ratios were significant. Increase in lipid and alanin could distinguish metastases and meningiomas from other tumours. Increase in the lactate level correlated with the degree of malignancy. ADCs were effective for grading malignant tumours but not for distinguishing tumour types with the same grade. High grade malignant tumours had lower ADC values ($0.428 + 0.006 \times 10^{-3}$ mm^2/s) than did low grade malignant ($1.6 + 0.325 \times 10^{-3}$ mm^2/s), and benign ($1.200 + 0.707 \times 10^{-3}$ mm^2/s) tumours.

Conclusion: The combination of MRS with cMRI and calculated ADC values added more and more information to MR imaging in the differentiation and grading of brain tumours and were more useful when done together than each alone.

1. Introduction

Accurate diagnosis is essential for optimum clinical management in patients with intracranial tumours (1). When accessible, most tumours are surgically resected, however there is a balance between removing as much tumour tissue as possible while maintaining vital brain functions, and radiotherapy is

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often used to treat any remaining cancerous tissue (2). Currently there is widespread use of MRI to determine tumour extent for surgical and radiotherapy planning, as well as for post-therapy monitoring of tumour recurrence or progression to higher grade. MRI provides an initial diagnosis of an intracranial mass lesion with a success rate of 30–90% depending on tumour types (3,4). However biopsy is still generally considered the gold standard for determining the cancer type and degree of malignancy (5).

The advantage of MRS has added to the diagnostic capabilities enabling tissue characterization based on their molecular composition. It provides information about cell proliferation, degradation, neuronal vitality and energy metabolism. Based on these characteristics, MRS attempts to differentiate between benign and malignant brain lesions (6,7).

Diffusion-weighted imaging (DWI) is based on the random or Brownian motion of water molecules in relation to their thermal energy. DWI has been used to assess brain tumours and while it has had limited success as a definitive prognostic tool, its proponents suggest that in certain settings it can increase both the sensitivity and specificity of MR imaging (8).

Calculated apparent diffusion coefficient (ADC) values from tumoural core and specific relative metabolite ratios acquired by MR spectroscopy added more and more information to MR imaging in the differentiation and grading of brain tumours (9).

1.1. Aim of the work

The aim of this study is to evaluate the role of magnetic resonance spectroscopy and diffusion weighted imaging in the differentiation and grading of brain tumours.

1.2. Patients and methods

This study included 36 patients (17 males and 19 females) and their ages ranged from 17 years to 76 years. All the Patients were referred to diagnostic radiology and medical imaging department at the Tanta University Hospital with symptoms of neoplastic brain lesions.

Informed consent was obtained from all patients after full explanation of the benefits and risks of the procedure. All patients were subjected to full clinical evaluation and specific laboratory investigations. All patients underwent MRI study of the brain.

2. MRI examination of brain

All the cases were evaluated by conventional MRI technique using a 1.5 Tesla superconducting MR scanner. All cases were examined in a supine position with a standard circularly polarized head coil.

Axial T1 WI [400/14 ms (TR/TE)] spin echo, T2 WI (4000/127 ms) turbo spin-echo and fast fluid attenuation inversion recovery (FLAIR) [9000/127/2800 ms (TR/TE/TI)] were obtained by using 5 mm section thickness.

After intravenous administration of gadolinium-DTPA (0.2 mg/kg) contrast enhanced T1 Weighted spin echo sequence was obtained in axial, coronal and sagittal planes. In all cases, normal, tumoural and peritumoural regions were defined on the bases of the following imaging features: Normal tissue, an area containing no enhancement and normal signal intensity on T2 WIs and (FLAIR); tumoural area, a region containing a well-defined solid portion, contrast enhancement and abnormal signal intensity on T2 WIs and (FLAIR); peritumoural area, a region containing no enhancement and shows high signal intensity on T2 WIs and (FLAIR).

We evaluated the cMRI commenting on the lesion signal characteristics, and the presence of haemorrhage, necrosis, peritumoural oedema, mass effect and contrast enhancement.

3. MR spectroscopy of brain lesions

Some cases were evaluated by single voxel spectroscopic technique (SVS), and the other cases were evaluated by multivoxel spectroscopic technique (MRS).

3.1. Voxel positioning

In SVS, the voxel was positioned in solid suspicious lesions seen in post contrast T1 WIs avoiding areas that show haemorrhage or necrosis, also avoiding contamination from nearby bone or CSF spaces, the voxel size of $2 \times 2 \times 2\ cm^3$ was employed , another similar voxel was positioned on the contra lateral normal brain white matter to obtain a reference spectrum.

In MVS we added multiple voxels of the same forementioned size in the peritumoural oedema.

3.2. Pulse sequence

We used point resolved spectroscopy (PRESS) with parameters TR/TE 1000/144 and 1500/35.

Both intermediate and short TE (144 & 35 ms) respectively were used, intermediate TE was used to clearly visualize peak intensity of CHO, Cr, and NAA, to obtain CHO/Cr ratio, and to determine the presence of Lac, while short TE was mainly used to illustrate Lip peak.

3.3. Spectroscopic data analysis

The time domain signal intensity was processed to remove the residual water signal. Post processing of the spectroscopic data consisted of frequency shift, phase and linear baseline corrections after Fourier transformation.

Frequency domain curve was fitted to Gaussian line shape by using the software provided by the manufacturer to define NAA at 2.02 ppm, CHO at 3.22 ppm, Cr at 3.01 ppm, Lip at 0.9 and 1.33 ppm, and Lac at 1.33 ppm metabolic values were calculated anatomically from the area under each metabolic peak using the standard commercial software programme provided by the manufacturer and expressed as percentage of the corresponding metabolites of the reference spectrum and from these metabolic values the CHO/Cr ratio was obtained. Lip and Lac which are not detectable in the normal brain were normalized using Cr of the contra lateral reference spectrum as an internal standard and those values were referred to as Lip level and Lac level.

4. Diffusion imaging with apparent diffusion coefficient calculation of brain lesions

DW images were obtained by using an axial echo – planar SE sequence (6000/92 ms) [TR/TE], one average, 5-mm section