Evaluation of Brain Lesions Using Magnetic Resonance Spectroscopy

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Authors’ contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Aims: This study designed to describe the spectrum of Magnetic Resonance in brain lesions and to show its diagnostic importance in differentiating neoplastic, non-neoplastic and other lesions. Also to show the importance of MRS in differentiating of other brain lesions and correlate MRS findings with histopathological findings.

Study Design: This is a prospective study included 30 patients with intracranial tumors underwent MR imaging, proton MR spectroscopy, and stereotactic biopsy.

Place and Duration: The study was carried out in the Department of Diagnostic Radiology, Royal Care International Hospital, Sudan. June 2015 to June 2016.

Methodology: MRS studies were performed with 1.5 Tesla Toshiba whole body MR systems using standard imaging head coil. All spectroscopy images were performed through single voxel technique. MR spectroscopic findings were evaluated for the distribution pattern of pathologic spectra (N-acetylaspartate (NAA)/ choline [1] ratio > 1) across the lesion and neighboring tissue.

Results: The result of this study revealed that the characteristic features in malignancy were increased Cho/creatinine (Cr) peaks with NAA remains unchanged, the increased Cho/Cr and
Cho/NAA ratio also noted with glioma. Furthermore grading of glioma as high or low can be obtained on the basis of Cho/Cr and the presence of lipid/lactate peak. In this study, there was total agreement between MRS, and histopathologically results. In addition, the study showed that the specific MR spectroscopic findings for meningioma were the absence or very small peak of neuronal markers NAA and Cr, and markedly elevated Cho.

**Conclusion:** Diagnosis of primary and secondary brain tumors and differentiating them from other focal intra-cranial lesions based on imaging procedures alone is still a challenging problem, combination of proton MRS and conventional MRI protocol can provide additive valuable information helping in tissue characterization of intra-cranial tumors leading to improved diagnosis and thus reducing biopsies.

**Keywords:** Brain tumors; MRS; Cho/Cr; NAA.

1. **INTRODUCTION**

Proton MR Spectroscopy (MRS) is a noninvasive imaging technique that may contribute in the preoperative diagnosis of patients with MR ring enhancing lesion [1]. MRS depends on a change in the resonance frequency of the nuclei within the molecules, regarding their chemical bonds, which is based on the chemical shift theory [2]. The resonance frequency difference (chemical shift) is expressed as parts per million or ppm, a value that is independent of the amplitude of the external magnetic field. The value of the chemical shift provides information about the molecular group carrying the hydrogen nuclei, and thus it provides differentiation among several metabolites [3].

Diagnosis of primary and secondary brain tumors and other focal intracranial lesions based on imaging procedures alone is still a challenging problem in Sudan. Magnetic resonant spectroscopy may give completely different information related to brain lesions and save time risk and cost.

Accurate diagnosis is essential for optimum clinical management in patients with intracranial tumors [4]. When accessible, most tumors are surgically resected, however there is a balance between removing as much tumor tissue as possible while maintaining vital brain functions, and radiotherapy is often used to treat any remaining cancerous tissue [5]. Currently there is widespread use of MRI to determine tumor extent for surgical and radiotherapy planning, as well as for post-therapy monitoring of tumor recurrence or progression to higher grade.

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.

The information content of a proton brain spectrum depends on quite a few factors, such as the field strength used, echo time, and type of pulse sequence. Signals from choline [1], creatine (Cr) and N-acetylaspartate (NAA) are observed in normal brain, while compounds such as lactate, alanine or others may be detectable if their concentration is elevated above normal levels due to pathological processes [6].

MR spectroscopy could differentiate benign from malignant tumors but was not useful in tumor grading. In the differentiation of malignant from benign tumors, NAA / choline, NAA/ Cho + creatine (Cr), lactate/Cr, and Alanine/Cr ratios were statistically more significant than NAA/Cr and lactate/lipid ratios. Grading of the tumors could be obtained from diffusion weighted imaging and apparent diffusion coefficients (ADC) [7]. Increase in lipid and Alanine could distinguish metastases and meningiomas from other tumors. Increase in the lactate level correlated with the degree of malignancy [8]. Lactate also can be measured as a marker of mitochondrial dysfunction in children with Autism Spectrum Disorders [9].

This study designed to describe the spectrum of Magnetic Resonance Spectroscopy in brain lesions and to show its diagnostic importance in differentiating neoplastic and non-neoplastic lesions, also to show diagnostic importance of MRS in differentiating of other brain lesions and correlate MRS findings with histopathological findings.

2. **MATERIALS AND METHODS**

2.1 **Subjects**

The study was carried out in the Department of Diagnostic Radiology, Royal Care International
Hospital, Sudan. It was a cross sectional comparative study. 30 patients with intracranial tumors confirmed with MR imaging were enrolled in the study, proton MR spectroscopy was performed, and then stereotactic biopsy was taken. MR spectroscopic findings were evaluated for the distribution pattern of pathologic spectra (NAA/Cho ratio > 1) across the lesion and neighboring tissue, for signal ratios in different tumor types, and for their potential to improve preoperative diagnostic accuracy.

2.2 Technique Used

MRS studies were performed on 1.5 Tesla Toshiba whole body MR systems using standard imaging head coil. All spectroscopy images were performed through single voxel technique. Initially, post contrast imaging was done to localize the lesion and then voxel was placed on volume of interest. After water suppression, appoint-resolved spectroscopy (RESS) technique was used for localization and the studies were obtained with parameters including echo time (TE) and repetition time (TR).

3. RESULTS AND DISCUSSION

Conventional magnetic resonance imaging (cMRI) is the gold standard in the initial evaluation of brain tumors. However, in some cases, cMRI is not effective for the differentiation of the tumor type or detection of the tumor grade. MRS limits the use of established invasive diagnostic approaches such as brain biopsy, which is the gold standard for evaluating brain tumor, as brain biopsy is a heavily invasive technique [7].

The aim of this study was to assess brain lesion using MR Spectroscopy in order to characterize the metabolic nature of these lesions. 30 patients were enrolled in the study with known brain masses diagnosed by conventional MRI. The most common site of these lesions was parietal lobe as shown in (Table 3).

Cases of various types of brain tumor were included in this study and most of them were malignant which showed increased Cho/Cr peaks with NAA remains unchanged, the increased Cho/Cr and Cho/NAA ratio also noted with glioma. This result was in line with previous studies [10].

Cases of glioma were included in the study, grading of glioma can be obtained on the basis of CHO/Cr and the presence of lipid/lactate peak; both grades of glioma showed High Cho/Cr ratio, but in high grade glioma the presence of lactate peak was noted. Chen et al. found that the increase in CHO/Cr ratios in high grade glioma that were higher than those found in low grade glioma was significantly correlated with the expression of proliferating cell nuclear antigen that was determined immune histologically, which reflect the proliferative potential of gliomas and hence their prognosis [11].

In this study, there was total agreement between MRS and histopathologically results; 86% of cases were agreed. The study showed that the specific MR spectroscopic finding for meningioma reported was the absence or very small peak of neuronal markers NAA and Cr, and markedly elevated CHO. These results were similar to many previous studies [10].

In this study a single voxel technique was used alone, further studies should be conducted with both single voxel and multi-voxel techniques using short repetition time (TE) and field strength of 3 Tesla for the evaluation of various types of brain lesions.

| Table 1. Descriptive statistics |
|-----------------------------|
| **N** | Minimum | Maximum | Mean  | Std. deviation |
|---|---|---|---|---|
| Age | 30 | 4 | 74 | 44.27 | 18.311 |

| Table 2. Gender distribution |
|-----------------------------|
| **Percent** |
| Male | 43.3 |
| Female | 56.7 |
| Total | 100.0 |

| Table 3. Regions of brain lesion |
|-----------------------------|
| **Percent** |
| Parietal | 30.0 |
| Brain stem | 16.7 |
| Temporal | 13.3 |
| Temporal-parietal | 6.7 |
| Frontal-parietal | 10.0 |
| Occipital | 6.7 |
| Frontal | 13.3 |
| Front-temporal | 3.3 |
| Total | 100.0 |
## Table 4. Spectral analysis * MRS findings crosstabulation

| Spectral analysis                                      | Astrocytoma | Malignancy | High grade glioma | Unremarkable | Meningioma | Glioma | Abscess | Total |
|--------------------------------------------------------|-------------|------------|-------------------|--------------|------------|--------|---------|--------|
| High Cho/Cr, High Cho/NAA                              | 1           | 4          | 0                 | 0            | 0          | 3      | 0       | 8      |
| Increase Cho/Cr peaks with NAA                         | 0           | 12         | 0                 | 0            | 0          | 0      | 0       | 12     |
| Increase Cho with reduction of NAA and Cr with increase Lactate | 0           | 0          | 1                 | 0            | 0          | 0      | 0       | 1      |
| Normal Curves                                          | 0           | 0          | 0                 | 4            | 0          | 0      | 0       | 4      |
| Raised Cho, Low Cr and NAA                             | 0           | 0          | 0                 | 0            | 2          | 0      | 0       | 2      |
| Significant elevation of both Lipid and Lactate peaks, moderately reduced NAA peak | 0           | 1          | 0                 | 1            | 0          | 0      | 0       | 2      |
| No evidence of neoplastic process                      | 0           | 0          | 0                 | 0            | 0          | 1      | 1       | 1      |
| Total                                                  | 1           | 17         | 1                 | 4            | 3          | 3      | 1       | 30     |
4. CONCLUSION

Diagnosis of primary and secondary brain tumors and differentiating them from other focal intracranial lesions based on imaging procedures alone is still a challenging problem, it was found that combination of proton MRS as a non-invasive procedures and conventional MRI protocol can provide additive valuable information helping in tissue characterization of intra-cranial tumors leading to improved diagnosis and thus reducing biopsies.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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