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The role of magnetic resonance spectroscopy in differentiation between neoplastic and non-neoplastic focal brain lesions

Sirous Nekooei (MD), Bahareh Haratizadeh (MD)*

Department of Radiology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

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ABSTRACT

The ability to differentiate between neoplastic and non-neoplastic focal brain lesions is critical for appropriate management of patient. Due to low specificity of magnetic resonance imaging (MRI) adequate data for differentiating would not be provided.

Magnetic resonance spectroscopy (MRS) is one of the newly supplementary methods for determining molecular structures and better differentiation among brain lesions. The applicability of MRI plus MRS in changing the histopathology is undetermined.

In order to evaluate the benefits of magnetic resonance spectroscopy combined with the conventional magnetic resonance imaging, we reviewed related literature till 2013.

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Introduction

Differentiation between tumoral and non-tumoral brain lesions is often a dilemma for physician and neurosurgeon. Primary imaging modalities cannot always provide details information about the lesion; therefore because pathology is the gold standard method for determining the nature of lesion, many patients undergone invasive procedures (1,2).

Almost 88% of central nervous system tumors are composed of brain tumors (3). On basis of annual report of cancer state in 2011, the incidence of malignant and non-malignant individuals from 2004 to 2007 in US were 31% and 62% in adults among 213525 cases with brain tumors, which

***Corresponding author:** Bahareh Haratizadeh. Department of Radiology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*
***E-mail:** bhma_haratizadeh@yahoo.com*
***Tel:**0511-8012616*

were 5% and 2% in pediatrics respectively (4).

This is true that the most sensitive method for finding brain lesions is magnetic resonance imaging (MRI), but due to the low specificity various features of different tumors might not be differentiated using this method. Differencing between high grade and low grade brain tumors and also between neoplastic and non-neoplastic ones are two major issues in imaging diagnosis method. Misdiagnoses may eventually lead to unnecessary surgery and chemoradiotherapy (5,6).

Technique and spectrum

MRI and MRS techniques are on the basis of the same physical principles of magnetism. The only difference is in processing and presenting of the obtained data. In the MRI, the data collected are analyzed in the time to obtain relaxation time data of the nuclei. Then these data are used to produce an anatomic image. In MRS, using Fourier transformation of the free induction decay time domain signal, the time domain information is converted to frequency domain information. This information is used to form a distribution of chemical substances intensities, instead of producing an anatomic image (7).

MRS is one of the methods for determining the molecular structures which provides metabolic information from viable brain tissues. Metabolites which were detected in brain tissue include choline (Cho), creatine (Cr), N-acetylaspartate (NAA), lactate, mioinositol (MI), glutamine/glutamate, lipids and amino acids. Brain lesions contain abnormal quantities of these metabolites compared with normal brain tissue (1).

MRS is applied in wide range of conditions such as evaluation of brain development, brain tumors, response rate to therapy, non-neoplastic brain lesions, epilepsy, Alzheimer's disease, degenerative and metabolic disorders, stroke, hypoxic-ischemic injury, acquired immune deficiency syndrome (AIDS), infections, multiple sclerosis and psychological disorders such as schizophrenia (7).

Researchers have found that metabolic ratios obtained by MRS are useful in predicting malignancy and histological grade of brain tumor (8).

The purpose of this article is reviewing literature till 2013, on evaluating MRS capabilities in differentiation among different focal brain lesions.

In a research done by Alam SM. et al. MRS was performed on 53 patients. They found this non-invasive modality sensitive and relatively nonspecific in differentiating between neoplastic and non-neoplastic brain lesions which can be an alternate to histopathologic evaluations.

MRS has sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of 93.02%, 70%, 93.02%, 70%, 88.67 %, respectively, in differentiation between neoplastic and non-neoplastic brain lesions. A considerable correlation was shown by Kappa statistics between MRS and histopathological evaluation (k=0.630) (1).

The successfulness of MRS in differentiating between malignant brain tumors and normal brain tissue has been proven in adults and children (9). The basic metabolite changes that are common to brain tumors include increasing of Cho, lactate, and lipid amount; and decreasing of NAA and Cr. Increasing of Cho is a result of rising in turnover and proliferation of cell membrane (10- 13). In MRS, cell membrane synthesis, destruction, or both may cause an elevation in Cho concentration (14).

In a study published in 2011, higher ratios of Cho/NAA and Cho/MI accompanied by lower ratio of NAA/Cr were associated

with the most probability for malignancy. Lactate and lipid peaks have been also observed in malignant tumors (15). Inflammation is shown in a case with focal cortical involvement of Behcet's syndrome by using MRS technique (16).

In 3D MRS with Cho, Cr and NAA peaks, the Cho/Cr and Cho/NAA ratios were significantly higher in high-grade than in low-grade glioma, whereas the NAA/Cr ratios were significantly lower in high-grade than in low-grade glioma. Statistic analysis demonstrated a threshold value of 2.04 for Cho/Cr ratio. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) with this threshold value were 84.00%, 83.33%, 91.30% and 71.43%, respectively. Threshold value of 2.20 for Cho/NAA ratio resulted in sensitivity of 88%, specificity of 66.67%, PPV of 84.62%, and NPV of 72.73%. There was no significant statistical difference in overall diagnostic accuracy between Cho/Cr and Cho/NAA ratios (17).

A review article on differentiating local tumor recurrence and radiation-induced changes showed that developing MRI modalities like MRS have technical limitations such as small size or irregular shape. Artifacts resulting from air or bone closed to the lesion may affect the results. So in this article, stereotactic biopsy has been introduced as a reliable modality (18).

Conclusion

The application of both conventional and advanced MRI provides additional information about focal brain lesions which in future may completely alternate histopathological evaluations. There is a strong necessity for further studies on MRS capabilities.

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Conflict of Interest

The authors declare no conflict of interest.

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