Original Article

A study of space occupying lesions of brain with magnetic resonance spectroscopy

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Abstract

Introduction: Magnetic resonance imaging (MRI) is an excellent method for anatomical and structural diagnosis of the brain, but it does not provide functional or metabolic information. Magnetic resonance spectroscopy (MRS) is used to detect the metabolic and biochemical profile of brain areas. MRS is an analytical method used in chemistry that enables the identification and quantification of metabolites in samples. It differs from conventional MRI in that spectra provide physiological and chemical information instead of anatomy. **Aims and Objectives:** To Study Space Occupying Lesions (SOL) of Brain with Magnetic Resonance Spectroscopy with Choline and Creatine as Metabolite. **Materials and Methods:** Prior to the commencement of the study, the ethical clearance was obtained from the Ethics Committee, MGM Medical College and Hospital, Aurangabad. Study was conducted in the Department of Radiology, MGM Medical College and Hospital, Aurangabad, Cross sectional study. The study was done in a period of 1 year from January 2013 to December 2013.A total of 45 Patients were included in the study. Biochemical metabolites and their ratios are evaluated on single or multi-voxel spectroscopy. **Result:** Majority of the SOL patients were from <10 yrs. age group i.e. 22.3% followedby 40-50 (20.0%); 30-40 (17.8%); 10-20 (15.5%); 20-30 (13.3%);>50 (11.1%) respectively. Majority of the patents were Male i.e. 65.5% followed by 35.5% Females. Maximum number of patients of infective granulomas/abscess (58.33%) had a choline a ratio between 0.9-1.2.Maximum number of patientswith brain tumors(25.81 %) had a Cho/Cr ratio between 2.1-2.5 followed by 19.35 % of patients with ratio >5. **Conclusion:** Using a choline to creatine ratio of 2.0 as the cut off, the sensitivity, specificity, positive predictive valve, negative predictive valve and accuracy of spectroscopy in differentiating neoplasms from non-neoplastic etiologies was 93.47%, 91.17%, 93.47%, 91.17% and 92.5% respectively, So these methods can be applied to Diagnose SOL much accurately.

Key Words: SOL (Space Occupying Lesions) of Brain,choline to creatine ratio, Magnetic Resonance Spectroscopy.

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Received Date: 02/09/2015 Revised Date: 26/09/2015 Accepted Date: 22/10/2015

Access this article online

Quick Response Code:

Website: www.medpulse.in

DOI: 10 November 2015

INTRODUCTION

Magnetic resonance imaging (MRI) is an excellent method for anatomical and structural diagnosis of the brain, but it does not provide functional or metabolic information.[1] Magnetic resonance spectroscopy (MRS) is used to detect the metabolic and biochemical profile of brain areas. MRS is an analytical method used in chemistry that enables the identification and quantification of metabolites in samples. It differs from conventional MRI in that spectra provide physiological and chemical information instead of anatomy.[2] At the beginning of the 1990s, one of the options for assessing the metabolic and functional activity of the brain was positron emission tomography or functional magnetic resonance (diffusion, perfusion and spectroscopy) [3, 4] which was used mainly in research institutes. In the mid-1990s, however, the development of computer software for spectroscopy coupled to the previously existing magnetic resonance equipment contributed towards reducing prices. For this reason, the clinical use of spectroscopy using *in vivo* magnetic resonance has become routine in many hospitals.[5] Several chemical elements can be used to obtain magnetic resonance spectroscopy such as phosphorus[6-8], carbon[9,10] and hydrogen.[11] Proton (^{1}H) resonance is nowadays the method most frequently used in neurospectroscopy, because hydrogen is the most abundant atom in the human body and its nucleus emits the most intense

How to site this article: Vikas Singh, P S Mishrikotkar, Gaurav Sharma, Neha Singhal, Pushan Sharma. A study of space occupying lesions of brain with magnetic resonance spectroscopy. *MedPulse – International Medical Journal* November 2015; 2(11): 771-774. http://www.medpulse.in (accessed 12 November 2015).

radiofrequency signal, when in an external magnetic field, in relation to other nuclei.[11] Proton spectroscopy has been recognized as a noninvasive method, approved since 1996 by the Food and Drug Administration (FDA). Coupled with magnetic resonance imaging techniques, it allows for the correlation of anatomical and physiological changes in themetabolic and biochemical processes occurring within previously-determined volumes in the brain.[12]

Creatine (Cr): The peak of Cr spectrum is assigned at 3.02 ppm. This peak represents a combination of molecules containing creatine and phosphocreatine. Cr is a marker of energetic systems and intracellular metabolism. Concentration of Cr is relatively constant and it is considered a most stable cerebral metabolite. Therefore it is used as an internal reference for calculating metabolite. ratios. However, there are regional and individual variability in Cr concentrations.In brain tumors, there is a reduced Cr signal. On the other hand, gliosis may cause minimally increased Cr due to increased density of glial cells. Creatine and phosphocreatine are metabolized to creatinine then the creatinine is excreted via kidneys.[13] Systemic disease (e.g. renal disease) may also affect Cr levels in the brain. [14]Choline -Creatine ratio is an important in differentiating neoplastic and non-neoplastic disorders.

Choline (Cho): It is heterogeneous peak assigned at 3.22 ppm and represents the sum of choline and choline-containing compounds (e.g. phosphocholine). Cho is a marker of cellular membrane turnover (phospholipids synthesis and degradation) reflecting cellular proliferation. In tumors, Cho levels correlate with degree of malignancy reflecting of cellularity. Increase Cho may be seen in infarction (from gliosis or ischemic damage to myelin) or inflammation (glial proliferation) hence elevated Cho is nonspecific.

Brain Abscesses v/s Necrotic Gliomas: The enhancing rim of GBMs represents infiltrating tumor cells, and an increased Cho/Cr ratio is observed. Pathologically, the enhancing rim of a abscess represents an inflammatory infiltrate composed of neutrophils and later, macrophages and lymphocytes. Significant differences were found in the maximum Cho/Cr ratios between abscesses and GBMs. Metabolite ratios i.e. Cho/Cr and Cho/NAA ratios of the contrast enhancing rim are significantly different and useful in differentiating abscesses from GBMs. Metabolite levels of choline (Cho) are lower in the ring-enhancing portion of abscesses compared with GBMs. The sensitivity of MR Spectroscopy for the differentiation of brain abscesses and non-brain abscesses ranges from 86% to 96%. MR spectroscopy is useful as an additional diagnostic technique to distinguish pyogenic brain abscesses from necrotic GBM.[15] In brain Tumors There is increase in the levels of choline containing compounds (Cho) and a reduction in the signal intensity of the NAA and creatine (Cr) in all neoplastic lesions. The Creatine peak is the signal from both Creatine and phosphocreatine. Creatine plays a role in tissue energy metabolism. The Choline peak is composed of choline, phosphocholine, and glycerophosphocholine. The elevated choline peak is a marker of increased cell membrane turnover caused by tumor growth or normal cell destruction. The increased anabolism of malignant cells in neoplastic lesions leads to a rapid cell membrane proliferation and thus to a real increase in the Choline concentration. On the other hand, the membrane breakdown of cells of the brain parenchyma (catabolism) is associated with an increased mobility of the Choline from the breakdown products.In proton MR spectroscopy, an elevation in Choline may be due to cell membrane synthesis, destruction, or both. Measurable levels of Cho vary considerably, depending on the cellular attenuation, tumor grade, and presence or absence of necrosis. Choline resonance is most prominent in regions with high neoplastic cellular attenuation and is progressively lower in moderate- and low-grade tumors.[16] Cho peak is usually higher in the center of a solid neoplastic mass and decreases peripherally. Cho signal is consistently low in necrotic areas.

AIMS AND OBJECTIVES

To Study Space Occupying Lesions (SOL) of Brain with Magnetic Resonance Spectroscopy with Choline and Creatine as Metabolite.

MATERIALS AND METHODS

Prior to the commencement of the study, the ethical clearance was obtained from the Ethics Committee, MGM Medical College and Hospital, Aurangabad. Study was conducted in the Department of Radiology, MGM Medical College and Hospital, Aurangabad, Cross sectional study. The study was done in a period of 1 year from January 2013 to December 2013.A total of 45 Patients were included in the study. All the patients fulfilling the selection criteria were explained about the purpose of study and a written informed consent was obtained to participate in the study before enrolment. All age groups were included,Both males and females, All subjects with space occupying lesions (SOL) of brain. Brain aneurysm clip, Implanted neural stimulator**,** Implanted cardiac pacemaker**,** Cochlear implant**,** Ocular foreign body**,** Metal shrapnel**,** Other implanted medical devices**,** Patients with surgery of uncertain type where the presence of metal clips or wires cannot be excluded were excluded from the study. All the patients underwent MRI and MRS scanning at our department on Philips Multiva

1.5 Tesla, Patient was placed supine on the table and the area from the vertex to the skull base was included, MRI Brain was performed with T1, T2, FLAIR, T2* and Diffusion sequences. Single and Multi-voxel Spectroscopy was performed in addition to MRI Brain study of those patients who present with various intracranial lesions and as per requirement data analysis was done. Biochemical metabolites and their ratios are evaluated on single or multi-voxel spectroscopy

RESULT

Table 1: Age wise distribution of Patients with brain SOL

Age	Frequency	Percent
<10	10	22.3
10-20	7	15.5
20-30	6	13.3
30-40	8	17.8
40-50	9	20.0
>50	5	11.1
Total	45	100.0

Majority of the SOL patients were from <10 yrs. age group i.e. 22.3% followed by 40-50 (20.0%); 30-40 (17.8%);10-20 (15.5%); 20-30 (13.3%);>50 (11.1%) respectively.

Table 2: Sex wise distribution of Patients with brain SOL

Sex	Frequency	Percent
F	16	35.5
M	29	65.5
Total	45	100.0

Majority of the patents were Male i.e.65.5% followed by 35.5% Females.

Table 3: Patients of infective granulomas/abscess according to Cho/Cr ratio

Choline/ Creatine ratio	No of patients
0.6 -0.9	2
0.9-1.2	7
1.2-1.5	2
>1.5	1

The above table shows the distribution of patients with infective granulomas according to the maximum Choline/ Creatine ratio. Maximum number of patients (58.33%) had a choline a ratio between 0.9-1.2.

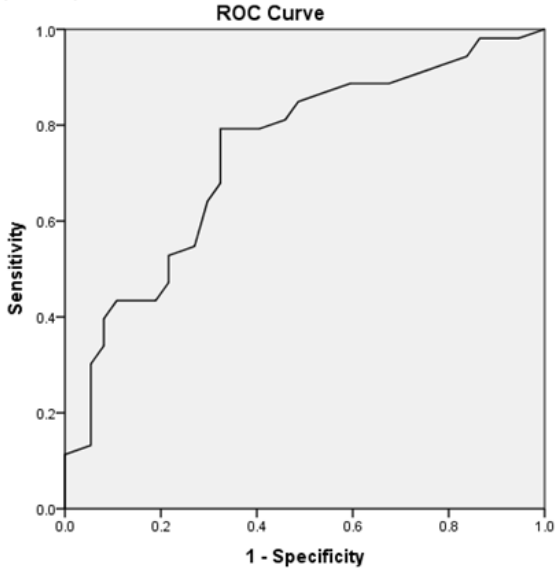
Table 4: Distribution of patients with brain tumors with Cho/Cr ratio

Choline/ Creatine ratio	No of patients
0 – 1	3
1-1.5	1
1.6-2.0	3
2.1-2.5	8
2.6-3.0	3
3.1-3.5	0
3.6-4.0	3
4.1-4.5	1
4.5-5.0	3
>5	6

The above table and chart shows the distribution of patients with neoplasms according to the maximum Choline/Creatine ratio. Maximum number of patients 25.81 % had a Cho/Cr ratio between 2.1-2.5 followed by 19.35 % of patients with ratio >5.

DISCUSSION

12 Cases of Tuberculous brain abscesses were studied with proton MR spectroscopy at TE 135.Elevated choline levels were consistently found in maximum number (9) of the patients. The raised levels are due to increased membrane breakdown in the abscess. Increased Cho/Cr ratio was also found in the lesions however the rise was modest. The ratio was between 1.0 and 1.6 in 7 cases. Fayed *et al*[17] demonstrated that a Cho/Cr ratio greater than 1.56 has a discriminatory power to differentiate between high- and low-gradeglial tumors. Cho/Cr ratio equal or higher than 1.56 and lactate peak predict malignancy at 88.9% sensitivity and 91.7% specificity. Meng Law *et al*[18] demonstrated that a threshold value of 1.56 of Cho/Cr ratio with minimum C1 value error and 75.8%, 47.5%, 81.2%, and 39.6% for the sensitivity, specificity, PPV, and NPV for determination of a high-grade glioma.



Diagonal segments are produced by ties.

Using ROC analysis, a Choline to Creatine ratio of 2.0 as the cut off the sensitivity, specificity, positive predictive valve, negative predictive valve and accuracy of MR spectroscopy in differentiating low grade neoplasms from high grade neoplasm was 99.21%, 92.14%, 96.29%, 90.12% and 97.64% respectively.

CONCLUSION

Using a choline to creatine ratio of 2.0 as the cut off, the sensitivity, specificity, positive predictive valve, negative

predictive valve and accuracy of spectroscopy in differentiating neoplasms from non-neoplastic etiologies was 93.47%, 91.17%, 93.47%, 91.17% and 92.5% respectively, So these methods can be applied to Diagnose more accurately the SOL

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Source of Support: None Declared
Conflict of Interest: None Declared