ISSN No. 2394-3971

Original Research Article

QUANTITATIVE DIAGNOSIS OF BRAIN TUMORS USING MAGNETIC RESONANCE SPECTROSCOPY RELATIVE TO ANALOGUE IMAGES

Ali Bashir Ali Elhaj[2] and Mohammed Ahmed Ali Omer[1, 2,*]

1. College of Applied Medical Science-Department of Radiologic Technology- Qassim University, Buraidah, KSA
2. Department of Radiotherapy & Nuclear Medicine, College of Medical Radiologic Science, Sudan University of Science and Technology, Khartoum, Sudan

Submitted on: September 2017
Accepted on: September 2017
For Correspondence
Email ID:
alkajam@gmail.com

Abstract:
The aim of this work was to determine the diagnostic variations between magnetic resonance spectroscope MRS and the conventional magnetic resonance imaging (MRI) analog image i.e. the accuracy and sensitivity of MRS, MRI and CT relative to histological section. The adapted method was a retrospective study for collecting data of brain tumor patients (350) which were being analyzed using Excel software. The results showed that: brain tumors represent an incident of 54% in Sudan during 2014 – 2017 with an increasing factor of 7.2/year. MRS showed excellent diagnostic achievement relative to standard (histology) with accuracy, sensitivity, and specificity as 93%, 90% and 85% respectively, the Diagnosis of analogue MRI by different radiologist showed 91%, 83% and 76% for accuracy, sensitivity, and specificity respectively; while CT showed 80%, 75% and 15% for accuracy, sensitivity and specificity respectively. MRS usually surpass MRI compared with the standard (histology) and the T-test showed a significant point of 0.5, depending on the level of Choline (Cho), N-Acetyl-Aspartate (NAA), Creatine/ Phosphocreatine (Cr) and Lactate (Lac).

Keywords: Brain Tumors, Spectroscopy, MRI, Accuracy, Sensitivity

1. Introduction

The incidence of brain tumors (BTs) increases annually as stated by De et al, [1]; There are approximately 2,500 new diagnosed cases per year in the USA and the incidence of brain tumors has increased slightly over the recent decades which is possibly ascribed to improved diagnostic imaging technologies [2]. Despite the fact that the actual incidence and prevalence worldwide still remain in accurately measured or detected, with 80% of patients with malignant brain tumors die from the disease. Moreover, it has been noticed that only half of these patients survive longer than one year [3]. Based on World Health Organization (WHO), most of the brain tumors in adults are in grade II with locytic astrocytomas, ependymomas, and others [2].

The common presentations of BTs imply nausea, seizure, or focal neurologic impairments and personality changes [4]. And BTs types include gliomas, meningiomas, and pituitary tumors, among others. Gliomas can be further divided into

astrocytic tumors, oligodendroglial tumors, ependymal tumors, and mixed gliomas [4, 5]

With referring to study of Salih, [6]; meningioma was the commonest brain tumor followed by astrocytoma, pituitary adenoma, and craniopharyngioma. Brain tumors are classified using different methods based on the origin or the histology of the cells [7]; based on that, primary tumors are originated from the brain and secondary tumors metastatic from the else anatomical cancerous tissue.

For revealing and diagnosis of these tumors; many diagnostic technologies have been introduced and still some in continuing development and invention. In this realm; Magnetic Resonance Imaging (MRI) has been utilized as a valuable tool in capturing and classifying brain tumors [8]. However, using MRI alone is not possible to detect brain tumor grade; which is considered an important step in disease management in terms of early detection and intervention for the sake of good outcome. Computerized Tomography (CT), Nuclear Medicine Imaging (NMI), Ultrasound (US) and the confirmation tool; the Histological Diagnostic Section (HDS) all have been utilized to diagnose BTs with considerable limitations and shortages as: seeking for more invasive method, dependent on eye resolution of the radiologists (analogue image) and availability of the equipment and it is facilities.

The predominant factors that influence the amount of signal and the extent of contrast received from a sample include spin-lattice/longitudinal relaxation time (T_1), transverse relaxation time (T_2) and spin density (r) [9], which differ from one tissue to another and are responsible for the contrast between different tissues. Therefore, several non-invasive neuroimaging methods have been used to determine the brain tumor grade including Proton Magnetic Resonance Spectroscope imaging (^{1}H-MRS), diffusion-weighted MRI, and perfusion MRI.

Despite that the accuracy of noninvasive advanced neuroimaging methods is controversial; however, numerous studies have shown that ^{1}H-MRS improves preoperative diagnosis of brain tumors [10]. Finally, as it becomes more widely available for clinical applications, Magnetic resonance spectroscopy MRS (*single or multi-voxel technique) is noninvasive diagnostic procedure for brain metabolite that could register the pattern of tissue with chemical compounds (Choline compounds (Cho), Creatine and Phosphocreatine (Cr), N-Acetyl-Aspartate (NAA), and Lactate (Lac)) and map out the spatial distribution of metabolites within the brain*) has been trusted in providing information about the metabolic properties of regions of normal and abnormal tissue morphology. Thus, (MRS) does not only provide a noninvasive insight into the biochemistry of the brain tumors, but it can also offer additional diagnostic information that improves the management and outcome of a patient with brain tumors [11]. Accordingly; the trend of this work is to determine the diagnostic variations between MRS and the conventional MRI i.e. the accuracy and sensitivity of MRS relative to histological section.

2. Methodology

The study was performed in Royal Care hospital in Khartoum State for 350 patients (*57.1% males, 42.9% females; age range, 4–80 years*) examined using MRI scanner (1.5 tesla-Toshiba Advantage-Japan 2009), CT and histopathology.

MRI protocol: All the cases were examined in the supine position with standard circularly polarized head coil using the following sequences:

Axial and Sagittal T1WI (550/8.7 ms) TR/TE spin echo. Coronal T2WI (5000/96 ms) TR/TE spin echo. Axial FALIR (9000/92/ms) TR/TE spin echo, 5 mm section thickness, 230-230 Field of view (FOV) and 256-256 matrix size.

And an intravenous administration of Gadolinium- DTPA, contrast enhanced

T1WI in axial, sagittal and coronal planes was performed.

MRS protocol: Two localization methods have been performed, each has a different TE. Data were acquired using Point Resolved Spectroscopy (PRESS) pulse sequence and spectroscopic localization has been performed on post contrast T1WI with automatic shimming. All MRS performed using single voxel technique initially post contrast imaging was done to localize the tumors and then voxel was placed on volume of interest.

Measurement parameters used were 2D-MRSI, TR/TE as 1500/135 ms, FOV as 120×120 mm, section thickness as 10 mm and total scan time was 7 min. The Region of interest (ROI) was carefully placed to avoid strong interference from subcutaneous fat and lipids of the skull, and outer volume suppression (OVS) slabs outside the ROI was used to further reduce the potential for the artifact. Measurement parameters used in SVS scans were 1500/35 ms (TR/TE) and voxel size was about 1.5 cm^3. The total scan time was 3.14 min.

Analysis of the spectroscopic data: The main metabolites identified by MRS with relative levels are (NAA) at 2.02 ppm, (Cr) at 3.0 ppm and (Cho) at 3.2 ppm. Concerning lipids and lactate (LL) were qualitatively defined and estimated their sum between 0.9 and 1.3 parts per mil (ppm). The following metabolite ratio was calculated using the standard commercial software. A spectrum was excluded for analysis if integration of any peak could not be accomplished using the automated analysis software (36700- 70300 + 8400). And based on the hypothetical prediction calculation tests (*accuracy, sensitivity, and specificity*) introduced by Šimundić, [12] and Alireza et al, [13] the calculation of these tests have been determined according to the following equations:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad (2)$$

$$\text{Specificity} = \frac{TN}{TN+FP} \quad (3)$$

Where: True positive (TP) = the number of cases correctly identified as a patient. False positive (FP) = the number of cases incorrectly identified as a patient. True negative (TN) = the number of cases correctly identified as healthy. False negative (FN) = the number of cases incorrectly identified as healthy

3. Results:

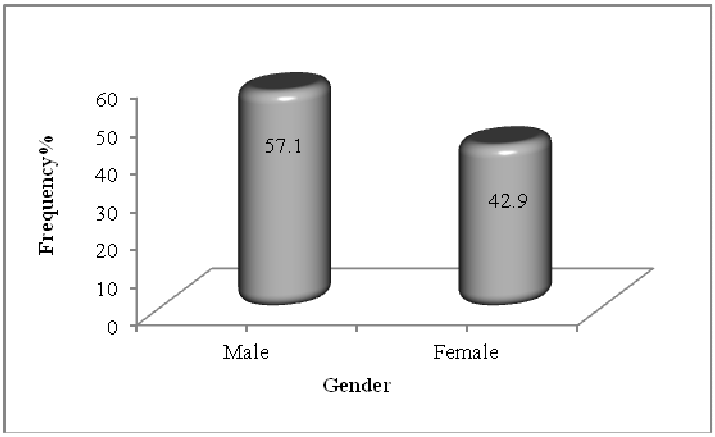

Figure 1: Shows the brain tumors incidence % in Sudanese population during 2014-2017

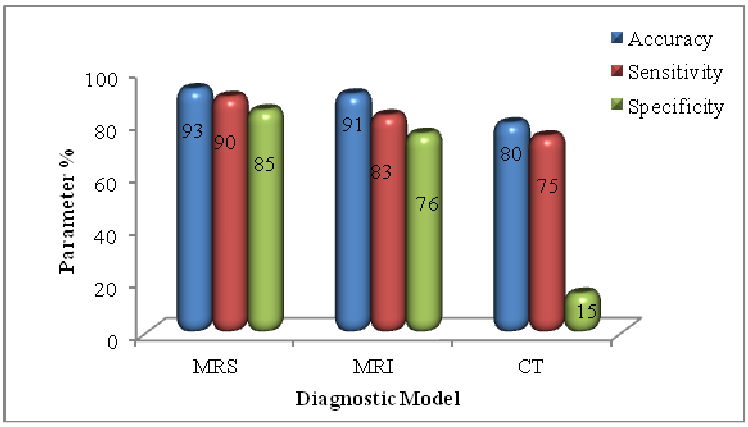

Figure 2: shows the accuracy & sensitivity of MRS and conventional MRI relative to histopathology

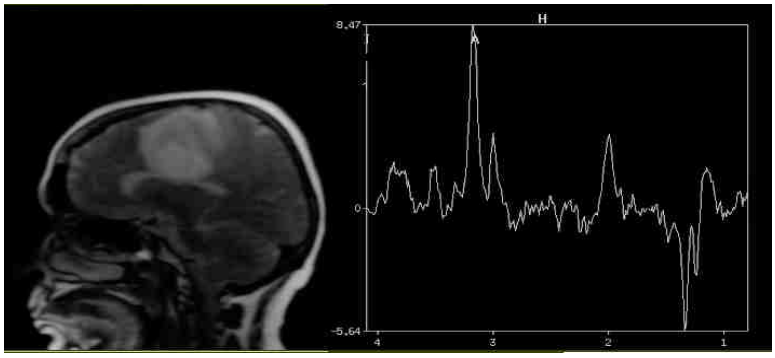

Figure 3: shows the MRS of BTs with NAA, Cr, Cho and MI with their relative level; indicating the malignancy of tumor

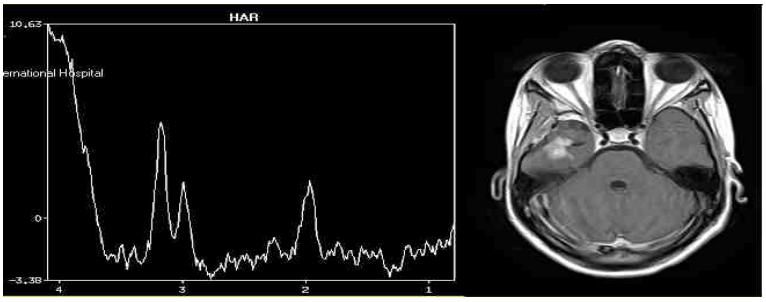

Figure 4: shows a patient with 17 years BT-male, Gadolinium MRI, TR = 778, TE = 10 and MRS with NAA, Cr, Cho and MI with their relative level; indicating the malignancy of the tumor.

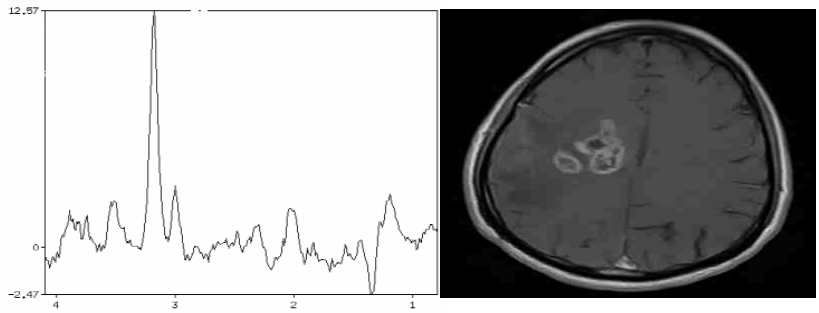

Figure 5: shows the MRS of BTs with NAA, Cr, Cho and MI with their relative level; indicating the malignancy of tumor

4. Discussion & analysis:

350 BT patients who referred for magnetic spectroscopy MRS at Radiology department at Royal Care hospital (RCH), Radiation and Isotopes Center of Khartoum (RICK) and Alshaab Hospitals in Sudan during 2014-2017. The collected variables from the total sample size were the incidence% based on gender, accuracy, sensitivity, specificity (*for MRS, CT and MRI*), histopathology findings, and metabolites level of AAN, Cr, Cho and MI as determined by MRS.

Figure 1: shows the incidence% of Brain tumors during the period 2014 – 2017, which represented the total tumors (*benign & malignant*) incidence (54%) from the total sample pathologies among 350 patients. It reveals clearly there was an increasing incidence annually by a factor of 7.2. Such results are quite agreed with Greig et al, [14] who reported that: the annual percentage increment of primary brain tumors among age groups (75-79, 80-84, and 85) were +7.0%, +20.4%, and +23.4% respectively.

The diagnostic study of BTs in Sudan using CT and MRS showed significant variation in view of accuracy, sensitivity, and specificity relative to histological findings (Gold standard); as in Fig. (2); in which MRS showed excellent diagnostic achievement relative to standard (histology) with accuracy, sensitivity and specificity as 93%, 90% and 85% respectively, the Diagnosis of analogue MRI by different radiologist showed 91%, 83% and 76% for accuracy, sensitivity and specificity respectively; while CT showed 80%, 75% and 15% for accuracy, sensitivity, and specificity respectively. Such variation could be ascribed to naked eye resolution in case of analog image and to visualization of all anatomical zone components in spectrum view in case of MRS; while CT is due to absorption coefficient by semi similar tissues. These results are agreed with the study done by Wang et al, [15] and Taghipour et al, [16]. However the comparative diagnoses of MRS and MRRI (Figs. 3-5) which were carried out by radiologists revealed that: MRS usually surpass MRI compared with the standard (histology) and the T-test showed a significant point of 0.5, depending on the level of Choline (Cho), N-Acetyl-Aspartate (NAA), Creatine and Phosphocreatine Cr, and Lactate (Lac).

5. Conclusion:

Magnetic resonance spectroscopy showed a significant and accurate diagnosis of BTs relative to analog magnetic resonance image which is diagnosed by necked eye and depending on the image contrast or gray scale level.

6. References:

[1] De Moor, J. S., Mariotto, A. B., Parry, C., Alfano, C. M., Padgett, L., Kent, E. E. and Rowland, J. H. Cancer survivors in the United States: prevalence across the survivorship trajectory and implications for care. Cancer Epidemiology and Prevention Biomarkers, 22(4), 2013, 561-570.

[2] Gill, Simrandip. K., Panigrahy, A., Arvanitis, T. N., & Peet, A. C. Magnetic resonance spectroscopy of pediatric brain tumors. In MR Spectroscopy of Pediatric Brain Disorders (pp. 45-60). Springer New York, 2013.

[3] Pantel, K., Alix-Panabières, C., & Riethdorf, S. Cancer micrometastases. Nature reviews Clinical Oncology, 6(6), 2009, 339-351.

[4] Benard F, Romsa J, Hustinx R. Imaging gliomas with positron emission tomography and single-photon emission computed tomography. Semin Nucl Med, 33, 2003, 148-162.

[5] Huile Gao, Xinguo Jiang. Progress in the diagnosis and evaluation of brain tumors. Cancer Imaging 13(4), 2013, 466-481. DOI: 10.1102/1470-7330.2013.0039.

[6] Salih, F. Brain Tumors among Sudanese Patients: A histopathological

Study (Doctoral dissertation), UOFK, 2015.
[7] Landis, S. H., Murray, T., Bolden, S., & Wingo, P. A. Cancer statistics. CA: A Cancer Journal for Clinicians, 49(1), 1999, 8-31.
[8] El-Dahshan, E. S. A., Hosny, T., & Salem, A. B. M. Hybrid intelligent techniques for MRI brain images classification. Digital Signal Processing, 20(2), 2010, 433 - 441.
[9] Sharma P, Brown S, Walter G, Santra S, Moudgil B. Nanoparticles for bioimaging. Adv Colloid Interface Sci. 2006; 123-126: 471- 485.
[10] McKnight, T. R. (2004). Proton magnetic resonance spectroscopic evaluation of brain tumor metabolism. Seminars in oncology. 31(5), pp. 605-617.
[11] Nelson, Sarah J. "Multivoxel magnetic resonance spectroscopy of brain Tumors1." Molecular Cancer Therapeutics 2(5), 2003, 497-507.
[12] Šimundić, Ana-Maria. "Measures of diagnostic accuracy: basic definitions." Medical and biological sciences 22(4), 2008, 61-65.
[13] Alireza Baratloo, Mostafa Hosseini, Ahmed Negida, Gehad El Ashal. Part 1: Simple Definition and Calculation of Accuracy, Sensitivity and Specificity. Emergency; 3 (2), 2015, 48-49.
[14] Greig NH, Ries LG, Yancik R, Rapoport S. I. Increasing annual incidence of primary malignant brain tumors in the elderly. J. Natl. Cancer Inst. 82(20), 1990: 1621-4. PMID: 2213902.
[15] Wang W, Hu Y, Lu P, Li Y, Chen Y, et al. Evaluation of the Diagnostic Performance of Magnetic Resonance Spectroscopy in Brain Tumors: A Systematic Review and Meta-Analysis. PLoS ONE 9(11), 2014, e112577. DOI:10.1371/journal.pone.0112577.
[16] Taghipour Zahir SH, Rezaei sadrabadi M, Dehghani F. Evaluation of Diagnostic Value of CT Scan and MRI in Brain Tumors and Comparison with Biopsy. Iranian Journal of Pediatric Hematology Oncology, 1(4), 2011, 121-125.