ejpmr, 2015,2(6), 159-163

SJIF Impact Factor 2.026

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 3294-3211

EJPMR

ROLE OF MR DIFFUSION WEIGHTED IMAGING IN THE EVALUATION OF ADULT INTRACRANIAL NEOPLASMS

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Article Received on 21/08/2015 **Article Revised on 13/09/2015** **Article Accepted on 05/10/2015**

ABSTRACT

Aim: The aim of the study was to compare the efficacy of Diffusion weighted imaging in predicting the histology of intracranial neoplasms and to correlate with WHO grading. **Methods and Materials**: This prospective study was performed in 41 patients with intracranial tumours.Diffusion gradients and ADC maps were calculated within the tumor, the peritumoral region, and the contralateral normal appearing white matter .The ratios were calculated by dividing the maximum value in the tumor and in the peritumoral region by the value in the contralateral normal-appearing white matter. For statistical analysis Student independent t-test and ROC curve analysis was performed. **Results:** The difference in the mean ADCt ratios of high and low grade gliomas were statistically significant. To identify high-grade gliomas, a cut off of < 1.217 for ADCt yielded 70 % sensitivity and 20 % specificity. ADCt and ADCp ratios showed no significant difference to differentiate between high grade glioma and metastasis. **Conclusion:** Diffusion weighted images showed very good diagnostic accuracy in grading glial tumors, however had limitation in differentiate between high grade glioma and metastasis.

KEYWORDS: Glioma, Magnetic resonance imaging, Diffusion, Tumour.

INTRODUCTION

MRI is the major technique for the detection of the presence of brain tumors in patients, not only for the anatomic information that can be obtained through its high soft-tissue contrast and resolution but increasingly also for functional information. Anatomic MRI relies on classic techniques such as T1- and T2-weighted imaging, fluid-attenuated inversion recovery sequences, and contrast-enhanced T1-weighted imaging. Differential diagnosis relies on the location, size, and disruption of the BBB of a lesion, medical history, and age of the patient.[6] Classic anatomic imaging is still the basis for diagnosis and grading but does not meet the requirements for individual cancer assessment before treatment or during follow-up (with the advent of modern cytostatic cancer therapies) or the trend toward individualized treatmen. In general, the role of MR imaging in the workup of intraaxial tumors can be broadly divided into tumour diagnosis and classification, treatment planning and post treatment surveillance. Advanced magnetic resonance imaging (MRI) techniques, such as MR spectroscopy, diffusion and perfusion MR imaging techniques can give important in vivo physiologic and metabolic information, complementing morphologic findings from conventional MRI in the clinical setting. The commonly used advanced MR imaging techniques include diffusion-weighted imaging, perfusion weighted imaging and MR spectroscopy. Molecular imaging is largely experimental at this stage. Discrimination of extra-axial and intra-axial brain tumors is relatively easy with only anatomic imaging; however, the major diagnostic challenge is to reliably, noninvasively, and promptly differentiate various histological tumour types to avoid biopsy and follow- up imaging studies. Integration of diagnostic information from advanced MR imaging techniques can further improve the classification accuracy of conventional anatomic imaging.[1] Diffusion imaging examines the motion of water molecules, which is normally random or Brownian in the unimpeded, isotropic state. Routine DWI can be used to calculate the ADC, which is a measure of the magnitude of water diffusion. ADC is considered a non-invasive indicator of cellularity or cell density. This study focuses on the role of the most commonly used advanced MR imaging technique-diffusion -weighted imaging for the diagnosis and classification of the adult intracranial tumours.

AIMS AND OBJECTIVES

1. Comparing the efficacy of diffusion weighted imaging technique with routine MR imaging technique in predicting the histology of intracranial neoplasms.
2. Determine the various indices obtained following post processing of MR data (ADCt and ADCp ratios) and correlate with WHO grading.

MATERIALS AND METHODS

This is a hospital based time bound prospective study, conducted between Oct 2012 to Aug 2014 over a period of 23 months in the Department of Radiodiagnosis and Imaging, Kasturba Medical College, Manipal. All the patients in whom intracranial neoplasms was suspected and who were conforming to the inclusion criteria were selected for the study. In each patient,MR diffusion parameters were calculated and relationship of these parameters with the final diagnosis was correlated.

Inclusion criteria

The study includes those adult patients whose final diagnosis is confirmed by histopathology in case of a tumor / known primary in case of metastasis. Patients must be previously untreated.

Exclusion criteria

Contraindication to perform MRI.
Histopathology proven non neoplastic lesions.

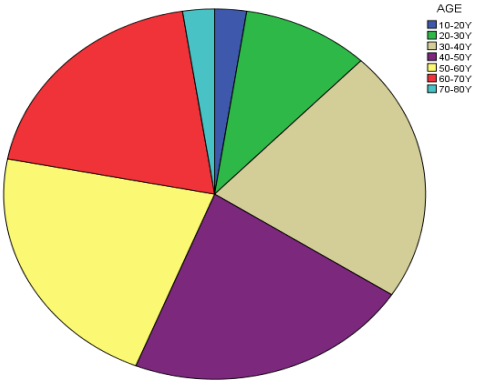
Statistical analysis

Statistical analysis was performed using SPSS 20 software to obtain the means of the diffusion parameters of various lesions. The means derived were further compared using student independent t-test to check the statistical significance in their difference. Receiver operating characteristic (ROC) curves were generated for the diffusion parameters which showed statistically significant difference to identify the cut off points that maximized the sensitivity and specificity for identifying each condition

OBSERVATIONS AND RESULTS

The present study sample included 41 patients who suffered from intracranial neoplasms. 27 patients were males and 14 were females.

1. Demographic details

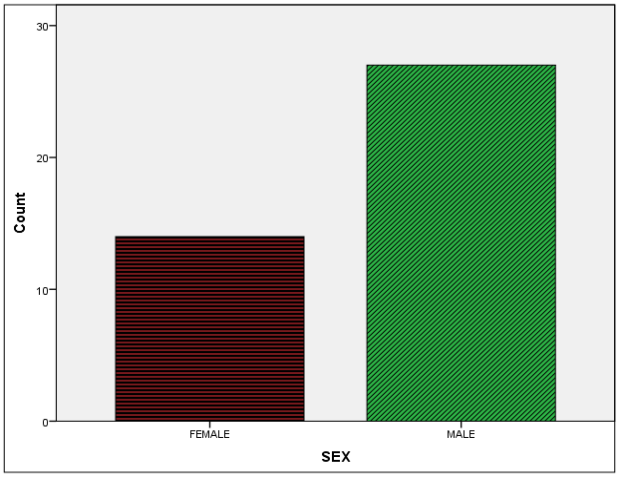


a) Age

Majority of the patients in the study were in the age group between 30 and 60 yrs age group. Minimum age was 19 yrs, Maximum age was 72 yrs. Mean age was 47.5 yrs.

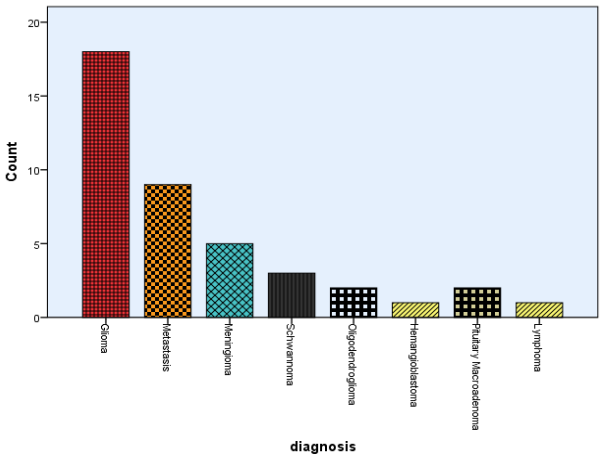
b) Sex

Male patients exceeded the female patients forming 65.9 % of the total population.



2. Frequencies of the lesions.

Gliomas constituted the most common intracranial space occupying lesions accounting for 43.9 % of the cases. Out of 18 cases of glioma, 8 had high grade glioma out of which 7 were glioblastoma multiforme (grade IV) and 1 was anaplastic astrocytoma (grade III) and 10 had low grade glioma (WHO grade I &II) which showed minimal to no enhancement after contrast administration.



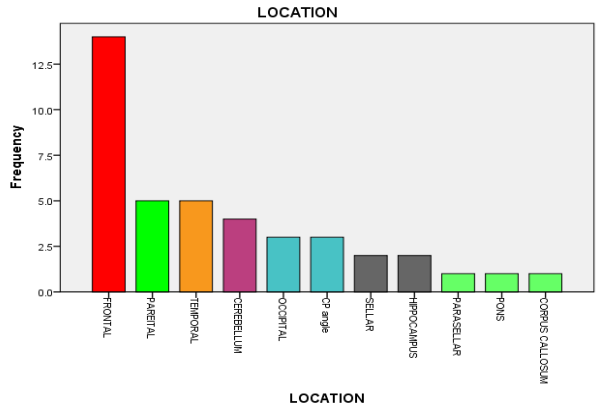
Metastasis was the second most common lesions accounting for a total of 9 cases out of which 4 were secondaries from bronchogenic carcinoma, 3 had breast carcinoma and 2 from the gastrointestinal tract.

Meningiomas were the third most common lesions accounting for a total of 5 cases in which 4 were histopathologically typical meningiomas and 1 was atypical meningiomas.

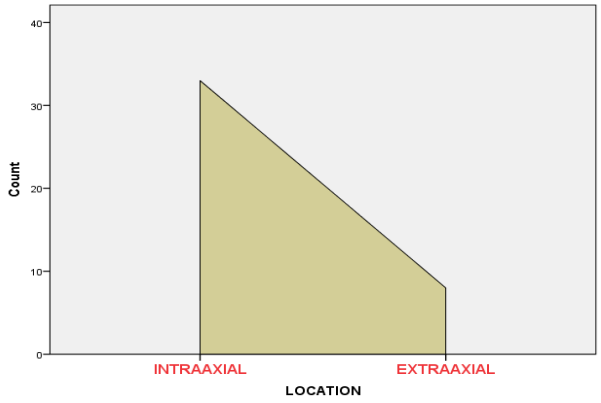
DIAGNOSIS	FREQUENCY
Low grade glioma	10
High grade glioma	08
Metastasis	09
Meningioma	05
Schwannoma	03
Oligodendroglioma	02
Pituitary macroadenoma	02
Lymphoma	01
Hemangioblastoma	01

3. MORPHOLOGICAL CHARACTERISTICS

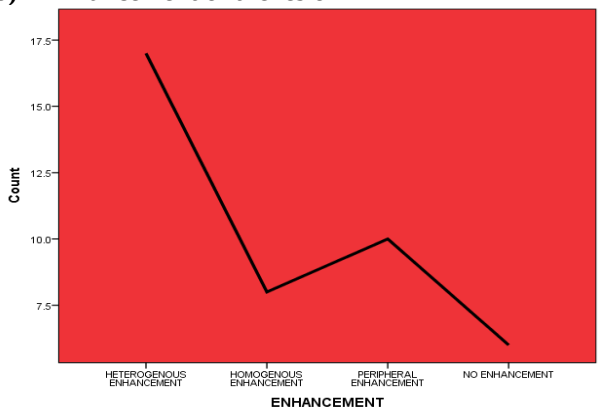
a) Location



34.1% of the lesions were in the frontal lobe followed by 12.2% in parietal and temporal lobe, 7.3% in occipital region and the rest (22.1%) in the locations as shown in the bar chart. Intra-axial lesions constituted the majority accounting to 80.5% of the lesions.



b) Enhancement of the lesion

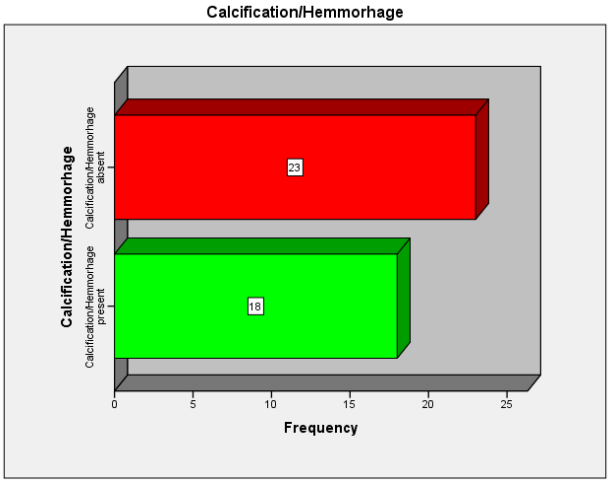


18 out of 41 lesions (41.5 %) showed heterogenous enhancement with majority in this group comprising of gliomas (7 lesions) followed by metastasis (4 lesions).

Peripheral enhancement was seen in 24.4% of the cases (10 out of 41 lesions) with the majority in this group constituted by gliomas (5 lesions), followed by metastasis (3 cases).

Homogenous enhancement was seen in 19.5% of the cases (08 out of 41 lesions) with majority being meningiomas (03lesions) and schwannomas (02 lesions). 06 lesions (14.6 %) were non-enhancing and mostly included low grade gliomas (05 lesions) and oligodendroglioma (01 lesion)

c) Presence of haemorrhage/calcifications



Calcifications/Hemorrhage was seen in 18 cases (43.9 %) (6 cases of glioma, 4 cases of metastasis, 3 cases each of meningiomas and schwannoma and 1 case each of pituitary macroadenoma and oligodendroglioma). Rest of the lesions 23 cases (56.1 %) showed no calcifications/hemorrhage.

4. Statistical Analysis

Descriptive statistics of the mean, total number of cases (N), standard deviation, minimum and maximum values of ADCt and ADCp for various lesions were calculated.

Using student independent t-test, a statistical analysis for comparing and characterizing the lesions with respect to the diffusion parameters was performed. The following set of lesions could be compared:

1. High grade and Low grade gliomas
2. High grade gliomas and Metastasis
3. High grade gliomas and Meningiomas
4. High grade gliomas and oligodendroglioma

Receiver operating characteristic (ROC) curves were generated to obtain the sensitivity and specificity for the diffusion parameters showing statistically significant difference in their means.

Statistical comparison of High grade and Low grade gliomas

The difference in the mean ADCt ratios of high grade and low grade gliomas were statistically significant ($P < 0.05$). No statistically significant difference found between the two with respect to mean ADCp ratios

MR DIFFUSION

To identify high-grade gliomas, a cut off of < 1.217 for ADCt yielded 70 % sensitivity and 20 % specificity.

Statistical comparison of High grade gliomas and Metastasis

MR DIFFUSION

ADCt and ADCp ratios showed no significant difference to differentiate between high grade glioma and metastasis

Statistical comparison of High grade glioma and Oligodendroglioma

No significant difference in the perfusion parameters was obtained in our study. Major limitation was the small sample size for oligodendroglioma

DISCUSSION

Advanced magnetic resonance imaging (MRI) techniques, such as MR spectroscopy, diffusion and perfusion MR imaging techniques can give important in vivo physiologic and metabolic information, complementing morphologic findings from conventional MRI in the clinical setting.

Diffusion imaging examines the motion of water molecules, which is normally random or Brownian in the unimpeded, isotropic state.[1,2,3]

Routine DWI can be used to calculate the ADC, which is a measure of the magnitude of water diffusion.[1] Transient association of water with large slow-moving macromolecules as well as impediment by membranes and other structures effectively reduce water mobility to an ADC lower than free water diffusion. In terms of tumors, ADC maps generated from DWI or DTI data have proved helpful in defining solid enhancing tumor, non-contrast enhancing lesion, peritumoral edema, and necrotic or cystic regions from normal surrounding brain tissue.[3] Necrotic regions havethe highest ADC values[4] , whereas contrast enhancing parts of the tumor have lower ADC values, presumably due to the presence of tumor cell elements impending mobility.[5] Several studies have shown that low-grade astrocytoma has high ADC values, whereas high grade malignant glioma has low ADC values, findings reflected more restricted diffusion with increasing tumor cellularity.[6,7]

The study comprised of 41 cases of intracranial neoplasms of which glioma (43.85%) constituted the most common lesion, followed by metastasis (21.9%) and meningiomas (12.1%). 27 patients were male and 14 were females. Most of the patients were between the age group of 30-60 yrs. Minimum age was 19 yrs, Maximum age was 72 yrs. Mean age was 47.5 yrs. A low ADC in an intra-axial neoplasm should raise suspicion of lymphoma or metastasis, because the higher cellularity of these tumors generally produces an ADC that is significant lower than that of glioma[8,9], however, although most gliomas have a much higher ADC, a number of case reports and several large series have demonstrated a low ADC in a small number of GBM. The resulting overlap among ADC values in the three tumor types reinforces the need to integrate DWI with other advanced and conventional neuroimaging data for accurate clinical interpretation.[10,11]

Prior studies have reported mixed results as to the utility of ADC maps in establishing the grade of glioma, with some authors finding a correlation between glioma grade and ADC and others not finding ADC maps useful. In the current study, the ADCt values and ratios were significantly different between patients with LGGs and HGGs in agreement with Server etal[12] and Sugahara et al.[13] By taking a cut off value of 1.217 we obtained a sensitivity of 75 % and specificity of 20 % however the lower specificity is due to areas of necrosis within high grade gliomas which was overlapping the area of interest. Other studies like Server etal[12] and Paulozonari etal[14] obtained a lower specificity. Peritumoral ADC ratios showed no significant difference between high grade and low grade gliomas in agreement with server etal[12] and with other authors.[6,8] ADCt and ADCp ratios showed no significant difference to differentiate between high grade glioma and metastasis in our study. Server etal[12] showed similar results to our study and ADCp ratios showed no significant difference between high grade glioma and metastasis. This is in agreement with Van Westen et al.[15], and Wang et al[16] and they reported that the ADC values of the peritumoral region of metastatic brain tumors did not differ compared to those of GBM. However Server etal[12] found a significant difference in ADCt ratios between high grade glioma and metastasis. One of the reasons for ADCt ratios to show falsely high values is because of necrosis within the high grade gliomas. In our study the ADC values and the ADC ratios for peritumoral edema did not differ significantly between HGGs and meningiomas. Server etal[12] and Provenzale et al.[17] showed similar results to our study showing ADC values and ratios showed no significant difference between high grade glioma and meningioma.Lui et al[18] found a difference in peritumoral ADC when comparing 12 HGGs and 12 meningiomas.

No significant difference in the values of ADCratios between high grade glioma and oligodendroglioma in our study. Khalid etal[19] found a significant difference in the value of ADC between grade III and grade II oligodendrogliomas. Once again small sample size was a major limitation. Oligodendroglioma is ambiguous on histopathology and also on diffusion weighted imaging..

The Bland Altmann test was performed to determine the agreement between the two observers. There was significant agreement between the observers and also within the observer, concluding that there was no significant variation between the values of the diffusion parameters obtained and the values are repeatable and consistent.

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