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Original Article

Assessment of Diagnostic Accuracy of MRI in Diagnosing and Characterizing Intra-axial Brain Gliomas

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Abstract

Background: Magnetic Resonance Imaging (MRI) has emerged as most prevailing noninvasive radiological modality for the diagnosis of brain tumor, its prognosis, therapeutic assessment, observation of progression or regression of disease and planning of neurosurgical approaches.
Objective: To assess the diagnostic accuracy of MRI in diagnosing and characterizing intra-axial brain gliomas taking histopathology as a gold standard.
Study type, settings & duration: This prospective research was conducted in the Department of Radiology at Jinnah Hospital, Lahore from March 2016 to August 2016.
Methodology: Two hundred patients with space occupying lesions diagnosed on CT scan of age 3 months to 65 years of either gender were included. Pregnant women and contraindication to MRI were omitted. The MRI of all other patients using 1.5 Tesla MR System with a gradient strength of 33 mT/m was performed. MRI study was interpreted by assessing the features favouring malignancy or benignity of gliomas. MRI findings were compared with the histopathology reports.
Results: Mean age was 44.41±7.52 years. Among these 200 patients, 113 (56.50%) were male patients and 87 (43.50%) were female patients making male to female ratio of 1.2:1. In MRI positive patients, 89 were found to be true positive patients while 23 were found to be false positive patients. Among 88 MRI negative patients, 74 were true negative (p =0.367) whereas 14 came out to be False Negative. Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of MRI in diagnosing malignant cerebral glioma were 86.41%, 76.29%, 79.46%, 84.09% and 81.50% respectively.
Conclusion: This study demonstrated that MRI is the non-invasive imaging modality of choice with high diagnostic accuracy in diagnosing malignant cerebral gliomas, and has not only radically improved our ability of distinguishing benign and malignant brain tumor pre-operatively but also aids the surgeons for appropriate decision-making.
Key words: Gliomas, malignant, magnetic resonance imaging, sensitivity.

Introduction

Brain tumor refers to disorder in which normal brain cells are replaced by abnormal cells which multiply abnormally and replace normal neural tissue of host, considerably affecting the normal functioning of brain. Vital brain functions including motor and sensory control, perception, neuroendocrine regulation, emotions can be compromised owing to tumoral mass effect by malignant cells.[1] Most of the brain tumors may remain asymptomatic initially becoming clinically symptomatic at a later stage. Brain tumors have been classified relating to the cells of origin which could be the oligodendrocytes, neurons, astrocytes, ependymal cells. Gliomas refer to brain tumors originating from glial cells i.e supportive tissue of brain and represent about 30 percent of all brain tumors. According to GLOBOCAN 2020, central nervous system tumors have 5 years prevalence of 52% in Asia.[2]

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Authors Contribution

SA conceptualized the project along with drafting and revision.. MM did the data collection. MK & RR performed the statistical analysis. & IM performed the literature search. SH also did the statistical analysis.SI also did the drafting, revision and writing of manuscript.

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Glial tumors (Astrocytoma, oligodendroglioma or oligoastrocytoma), lymphoma, medulloblastoma and hemangioblastoma are amongst the common brain tumors occurring with different prevalence in different age groups.[3] Astrocytoma is a heterogeneous group of brain tumors, having variable histological pattern comprising nuclear and cellular atypia, mitotic activity, necrosis and neovascularization.[4] Therapeutic management plan of astrocytomas require precise grading of astrocytomas.

Though hereditary disorders for instance tuberous sclerosis and neurofibromatoses (type 1 and type 2) have been identified as predisposing factors in the development of gliomas.[5] Association with cytomegalovirus infection has also been described, which hasten the tumor development. However the exact etiology and pathogenesis of gliomas is still unknown.

MRI approaches have proved to be the most powerful and multipurpose non-invasive imaging modality for diagnosis of brain tumor, predicting their prognosis, observing disease progression, guiding the therapeutic techniques and planning of neurosurgical intervention. Conventional paramagnetic or super-paramagnetic contrast media usually applied in MRI permit the assessment of integrity of blood-brain barrier. In addition, spectroscopy approach allows the interpretation of events associated with the tumor morphology, growth pattern and invasiveness.[6] Initial cellular and functional changes associated with tumor growth like neo-angiogenesis, metabolic and hemodynamic instability are being made detectable by functional MRI approaches.[7] Statistical analysis done by Server A published in 2011 demonstrated sensitivity, specificity, positive predictive value and negative predictive value of MRI in determining malignant brain gliomas as 79.7%, 60.0%, 88.7%, and 42.9% respectively.[8]

We conducted this study in Radiology department Jinnah Hospital, Lahore to know about the specificity and sensitivity of MRI in diagnosing malignant and benign brain gliomas in our setup. This study may provide the foundation for using MRI as an alternative to extensive biopsies of brain tumors before starting chemotherapy because the histopathology of brain tumors is most of the times not very convincing regarding the benignity or malignancy of the tumor.

Methodology

Non probability sampling technique was used. The 200 patients aged between 3 months and 65 years with intracerebral space occupying lesion diagnosed on CT scans were included complying with the inclusion criteria i.e patients having space occupying lesions on CT brain and clinical symptoms favoring malignancy. MRI brain was done using 1.5 T MR system in all the patients after taking informed consent and excluding the contraindications (metallic implants, chronic kidney disease with deranged renal function). MRI examinations were analyzed and evaluated for having different patterns favoring benign and malignant features.

Socio demographic information of patients was recorded on Proforma. Contact information was used to trace the patient for histopathology reports. MRI findings were also recorded to correlate.

Data was statistically analyzed by computer software; SPSS 20.0. Data comprising values of quantitative and qualitative variables was added. Quantitative variables were age and frequency. Mean and standard deviation were calculated for quantitative variables. Qualitative variables such as gender, duration of clinical symptoms (headache, seizures, behavioral changes, altered sensorium, neurological deficits), features of benign or malignant glioma on MRI and histopathology were measured. Frequency and percentage were calculated for qualitative variables. 2x2 contigency table was used to calculate sensitivity, specificity, negative predictive value, positive predictive value and accuracy of MRI brain in brain tumors keeping histopathology as gold standard.

The Ethical approval was obtained from Institutional ethical review board of Allama Iqbal Medical College/ Jinnah Hospital, Lahore.

Results

During the study period, 200 patients having space occupying lesions on CT brain were included in research. Mean age of patients was 44.41 +- 7.52 years. Majority of the patients, 65 out of 200, (32.50%) were between the ages of 3 months to 20 years as depicted in Table-1. Out of these 200 patients, 113 (56.5%) were males and 87 (43.5%) were females with male to female ratio of 1.2:1 (Figure-1).

MRI brain was conducted on all these patients. MRI reinforced the diagnosis of malignant brain glioma in 112 (56.0%) patients. Histopathology findings established malignant brain glioma in 103 (51.5%) cases. In those patients having positive MRI findings, 89 were true positive and 23 were false positive. Out of 88 MRI negative patients, 74 were true negative (p =0.367) whereas 14 were false negative as shown in Table-2.

Table-1: Patient stratification according to age.

Age in Years	*No. of Patients*	*Percentage*
3 months – 20 years	65	32.50
21-35 years	49	24.50
36-50 years	40	20.0

Mean±SD = 44.41±7.52 years

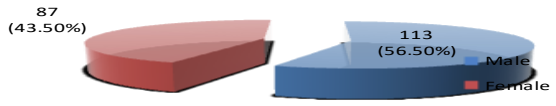


Figure 1: Stratification of patients in terms of gender (n=200).

Overall sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of MRI in diagnosing malignant cerebral glioma was 86.41%, 76.29%, 79.46%, 84.09% and 81.50% respectively (Figure-2).

Table 2: Histopathology findings.

	Positive on MRI	*Negative on MRI*
Positive on histopathology	89 (TP) 44.5%	14(FN) 0.07 %
Negative on histopathology	23 (FP)11.5 %	74 (TN) 37.0%

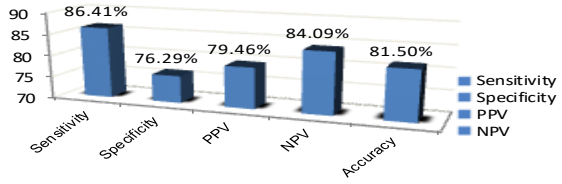


Figure 2: Diagnostic accuracy of MRI in diagnosing brain gliomas, keeping histopathology as gold standard.

DISCUSSION

Brain neoplasm is a lethal disorder in which malfunctioning malignant cells occupy the normal neural tissue of brain, hindering vital brain functioning such as motor stimulation and sensation, perception, memory and neuroendocrine activity. The neoplasm disturbs functioning of significant part of brain with resultant compression and serious neurological damages and deadly cerebrovascular complications. Therapy is assisted many times by timely detection of the tumor, hence making the neuroimaging strategies specifically inevitable in the management of these lesions.[9,10]

MRI has been a vital component in the radiological diagnostic field. Research has presented that MRI is superior to CT for intracranial tumor, whose correctness reaches up to 98% in making diagnosis and 70% to 85% in qualitative diagnosis. MRI offers several benefits like superior tissue contrast resolution, Multiplanar imaging for accurate orientation and localization of lesions; visualization of intracranial vasculature without need for contrast medium; No hazard of ionizing radiations. In current years, novel MRI techniques like functional MRI, diffusion weighted imaging, diffusion tensor imaging and Magnetic Resonance Spectroscopy are developing swiftly. In addition to achieving better understanding of anatomical variations, newer techniques offer the information regarding physiological function, pathology, and biochemistry of the neoplasm. Keeping in view this information, more targeted and accurate surgical approaches have been utilized decreasing the iatrogenic damage to brain tissue. The advanced MRI techniques have been applied extensively.[11] Not only pre-operative characterization of glioma but MRI is efficient in distinguishing radiation necrosis from residual or recurrent gliomas after radiotherapy or chemotherapy being helpful in assessment of treatment success.[12]

In our study, MRI reinforced the diagnosis of malignant brain glioma in 112 (56.0%) patients. Histopathology findings confirmed malignant brain glioma in 103 (51.50%) cases. In patients with positive MRI findings, 89 were true positive and 23 were false positive. Out of 88 MRI negative patients, 74 were True Negative (p =0.367) whereas 14 were false negative. Overall, sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of MRI in diagnosing malignant cerebral glioma was 86.41%, 76.29%, 79.46%, 84.09% and 81.50% respectively. The causes/factors for false positive and false negatives were considered as malignant gliomas being complex and adherent are difficult to excise completely by surgery thus leading to spurious biopsy reports. False positive cases goes for same disease process at histological level. Statistical analysis done by Server A published in 2011 demonstrated sensitivity, specificity, positive predictive value and negative predictive value of MR imaging in determining malignant brain gliomas as 79.7%, 60.0%, 88.7%, and 42.9% respectively.[8] Lesser values (sensitivity of 42.1-93.3% and a specificity of 60%-75.0%) were obtained using conventional MRI criteria in another study , perhaps as a result of using different MRI selection criteria for high-grade tumor.[13] For example, heterogeneity of MRI signals of the lesion could be regarded as

different intratumoral entities such as necrosis or blood or blood products. Mass effect is a vague variable as depicter of histological grade of tumor.[14]

A research comprised of 53 patients with ages between 22 months to 60 years (mean age= 32.7 years). Preoperative diagnosis made by MRI diagnosis was accurate in 50 patients with correctness of 94%. No noteworthy difference was found between preoperative MRI grading and postoperative histopathological grade of intra-axial tumor (*p*-value >0.05). [5]

Law et al. [16] presented that a combination of the approximation of rCBV, Cho/Cr and Cho/NAA ratios in 160 gliomas resulted in a specificity, sensitivity, PPV and NPV of 60.0%, 93.3%, 87.5% and 75.0% respectively, in grading these tumors, compared with a specificity, sensitivity, PPV and NPV of 65.0%, 72.5%, 86.1% and 44.1% respectively, in grading when only conventional MRI images were assessed. In some tumors, e.g. lymphomas and some types of metastases, this judgment might help in tumor therapy planning, without the need for biopsy. Solid tumors, such as lymphomas with great cellularity as the principal feature, usually display low rCBV, and PWI can help to distinguish these tumors from solid malignant tumors, such as glioma and metastases.[17]

In a research involving 111 patients, 44 patients with high-grade and 14 with low-grade primary neoplasms, 24 with abscesses, 12 with lymphoma, 11 with TDLs, 5 with metastases, and 1 with encephalitis who had undertaken conventional and advanced MRI, the accuracy, sensitivity, and specificity of the strategy were 90%, 97%, and 67% respectively for discrimination of neoplastic from non-neoplastic diseases, 90%, 88%, and 100% for differentiation of high-grade from low-grade neoplasms.[18]

On the whole, it is established that MRI is the non-invasive modality of choice with high diagnostic correctness in diagnosing malignant cerebral gliomas, and has not only intensely improved our capability of distinguishing benign and malignant brain tumor pre-operatively but also helps the surgeons for appropriate decision-making.

This study concluded that MRI is the potential non-invasive modality of choice with high diagnostic accuracy in diagnosing malignant cerebral gliomas, and has not only intensely improved our capability of discriminating benign and malignant brain tumor pre-operatively but also helps the surgeons for appropriate decision-making. So, we endorse that MRI should be performed regularly in all cases of cerebral gliomas for precise assessment pre-operatively and choosing appropriate surgical strategy and reducing invasive diagnostic biopsies in cerebral gliomas which ultimately decrease the mortality and morbidity of these patients however further large scale studies are required to define guidelines.

Conflict of interest: None declared.

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