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Diagnostic Accuracy of Magnetic Resonance Imaging in the Diagnosis of Astrocytoma

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Abstract

Background: Accurate detection of astrocytomas is very difficult. **Objective:** The purpose of the present study was to evaluate the usefulness of MRI in detection of intracranial astrocytoma. **Methodology:** This cross-sectional study was carried out in the Department of Radiology and Imaging with the collaboration of Department of Neurosurgery and Department of Pathology at Sir Salimullah Medical College (SSMC & MH), Dhaka from January 2013 to December 2013 for a period of one (1) year. Prior to the commencement of this study, the research protocol was approved by the ethical committee (Local Ethical committee) of SSMC. All the patients presented with clinically diagnosed cases of intracranial astrocytoma who were attended in the OPD and IPD were included as study population. The sampling technique was purposive, non-random sampling method. MRI was performed in all cases. The postoperative resected tissues were examined histopathological in the respective department. Then the collected reports were compared with findings of MRI. **Results:** The sample size of the present study was 48 astrocytoma patients. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI for the diagnosis of astrocytoma are 92.0%, 80.0%, 96.0%, 67.0% and 90.3% respectively. **Conclusion:** In conclusion MRI has a high diagnostic validity for the detection of astrocytoma. *[Journal of National Institute of Neurosciences Bangladesh, January 2025;11(1):63-67]*

Keywords: Magnetic Resonance Imaging; astrocytoma; validity test

Introduction

Astrocytomas are central nervous system (CNS) neoplasm derived from an immortalized astrocyte[1]. Usually astrocytic tumours are narrow zones of infiltration and diffuse zones of infiltration[2]. The incidence rate of all primary malignant and non-malignant CNS tumours is 20.6 cases per 100,000 which are 7.3 per 100,000 for malignant tumours and 13.3 per 100,000 for non–malignant tumours; furthermore, the rate is higher in females than males[3]. Almost half of all primary brain tumours are gliomas; in addition to that, three quarters of all gliomas are astrocytoma[4].

Astrocytomas are histologically heterogeneous. They also differ in their growth pattern, location, morphology, imaging features, also in disease progression and clinical course[5]. For detection of intracranial tumour MRI is very useful diagnostic tools. In addition to that MRI scan has made a significant impact on the differential diagnosis of intracranial tumours[6]. Compared with CT, MRI offers greater contrast resolution, including greater sensitivity for the detection of subacute and chronic haemorrhage in association with tumours and other lesions of brain[7]. MRI has the capacity to localize the tumour more accurately. MRI provides important information regarding contrast material enhancement, peritumoural oedema, distant tumour foci, haemorrhage, necrosis, mass effect and so on, which are all helpful in characterizing tumour aggressiveness and hence tumour grade[7]. MRI scan localizes and characterizes the vast

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majority of intracranial astrocytoma and the same is true of high-resolution CT scan[8]. Therefore, it has been recommended the use of MRI as a prime modality of investigation in detecting intracranial astrocytoma as it is highly sensitive, available and there is no ionizing radiation hazard. The purpose of the present study was to evaluate the usefulness of MRI in detection of different grades of intracranial astrocytoma.

Methodology

Study Settings and Population: This study was designed as observational type of cross-sectional study and was carried out in the Department of Radiology and Imaging with the collaboration of Department of Neurosurgery and the Department of Pathology at Sir Salimullah Medical College (SSMC & MH), Dhaka, Bangladesh from January 2013 to December 2013 for a period of one (1) year. Patients who were clinically suspected and CT scan diagnosed cases of intracranial astrocytomas referred to Radiology and Imaging department of Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh either from OPD or from indoor of DMCH for MRI of brain were included in this study.

Study Procedure: The sampling technique was purposive non-random sampling method. All cases having no contraindication for MRI underwent MR examination. Patients were asked for or checked for any metallic or harmful. MR imaging was obtained with 0.3 Tesla machine (HITACHI). T1W image in axial, sagittal and coronal plane were obtained using short TR (500-800ms) and short TE (14-20ms). T2W image in axial and coronal plane were obtained using long TR (3500-4500ms) and long TE (80ms). FLAIR images were also taken. Contrast MRI studies using intravenous Gd-DTPA (Magnevist, 0.1 mmol/Kg) with axial, coronal and sagittal T1W scan were performed in all cases. The average time of examination was 45 minutes but ranges from 30-90 minutes. Slice thickness was 5-6 mm with a field of view 230x230 mm and pictures matrix was 256x256 or 192x256. The postoperative resected tissues were examined histopathological in the respective department. MRI scan findings were compared with histopathological reports. Then the collected reports were compared with findings of MRI. Data were collected using a preformed data collection sheet. Base line information was collected from the patient after exploration of different complaints and sign and symptoms. All information regarding clinical features and histopathological results were recorded in a data collection sheet.

Statistical Analysis: Statistical analysis was performed using Windows-based software named Statistical Package for the Social Sciences (SPSS), version 22.0 (IBM SPSS Statistics for Windows, Version 22.0; Armonk, NY: IBM Corp.). Continuous data were expressed as mean, standard deviation, minimum and maximum. Categorical data were summarized in terms of frequency counts and percentages. Chi-square test was used for comparison of categorical variables and Student t test was applied for continuous variables. Every efforts were made to obtain missing data. A two-sided P value of less than 0.05 was considered to indicate statistical significance.

Ethical Consideration: All procedures of the present study were carried out in accordance with the principles for human investigations (i.e., Helsinki Declaration 2013) and also with the ethical guidelines of the Institutional research ethics. Formal ethics approval was granted by the local ethics committee. Participants in the study were informed about the procedure and purpose of the study and confidentiality of information provided. All participants consented willingly to be a part of the study during the data collection periods. All data were collected anonymously and were analyzed using the coding system.

Results

A total number of 69 patients were recruited in this study of which 1 patient refused to undergo surgery, 2 patients were unfit for the same and in 4 cases, histopathological reports were not available. Ultimately 62 patients were evaluated finally.

Both histopathological and MRI positive astrocytoma case is found in 48 cases which indicate true positive. Again, both histopathological and MRI negative

Table 1: Comparison of MRI Findings with Histopathological Findings during Diagnosis of Astrocytoma (n=62)

MRI Diagnosis	Histopathological Diagnosis		Total	p-value
	Test Positive	Test Negative		
Test Positive	48(92.3%)	2(20.0%)	50(80.6%)	
Test Negative	4(7.7%)	8(80.0%)	12(19.4%)	0.0001
Total	**52(100.0%)**	**10(100.0%)**	**62(100.0%)**	

astrocytoma case is found in 8 cases which indicate true negative. Histopathological positive but MRI negative case is found in 4 cases which is known as false negative. Histopathological negative but MRI positive case is found in 2 cases which is known as false positive (Table 1).

Table 2: Validity of MRI Test during diagnosis of Astrocytoma

Validity	Value	95% CI
Sensitivity	92.0%	85.2-98.7%
Specificity	80.0%	70.0-89.9%
Positive Predictive Value	96.0%	91.1-100.9%
Negative Predictive value	67.0%	55.3-78.7%
Accuracy	90.3%	82.9-97.7%

The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI for the diagnosis of astrocytoma are 92.0% (95% CI 85.2-98.7%), 80.0% (95% CI 70.0-89.9%), 96.0% (95% CI 91.1-100.9%), 67.0% (95% CI 55.3-78.7%) and 90.3% (95% CI 82.9-97.7%) respectively (Table 2).

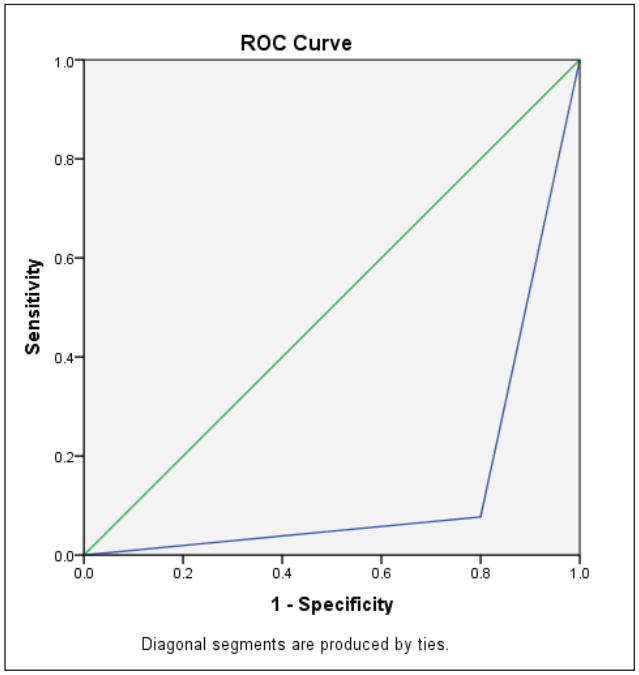

Figure I: ROC curve of MRI for the Detection of Astrocytoma of Brain

The test result variable(s): MRI has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. a. Under the nonparametric assumption; b. Null hypothesis: true area = 0.5.

Table 3: Area Under the Curve (AUC) of MRI for Detection of Astrocytoma

Area	P value	95% Confidence Interval	
		Lower Bound	Upper Bound
0.138	0.0001	0.000	0.290

Discussion

Brain tumors account for 85.0% to 90.0% of all primary CNS tumors[9]. The worldwide incidence rate of primary malignant brain and CNS in 2008 was 3.8 per 100,000 in males and 3.1 per 100,000 in females[10]. The incidence rates were higher in more developed countries (males: 5.8 per 100,000; females: 4.4 per 100,000) than in less developed countries (males: 3.2 per 100,000; females: 2.8 per 100,000)[11]. Two thirds of all brain tumours are primary neoplasms. Almost half of all primary brain tumours are gliomas; in addition to that, three quarters of all gliomas are astrocytoma[4]. Astrocytomas are histologically heterogeneous. They also differ in their growth pattern, location, morphology, imaging features, as well as in disease progression and clinical course[5].

In the past plain X-ray was used previously to detect intracranial tumour. In addition to that cerebral angiography and pneumocephalography were also done; however, none of which was conclusive[12]. With the advent of CT and MRI there is a revolutionary change in the detection of intracranial tumour. The comparison of MRI findings with histopathological findings during diagnosis of astrocytoma is recorded. Both histopathological and MRI positive astrocytoma case is found in 48 cases which indicate true positive.

Again, both histopathological and MRI negative astrocytoma case is found in 8 cases which indicate true negative. Histopathological positive but MRI negative case is found in 4 cases which is known as false negative. Histopathological negative but MRI positive case is found in 2 cases which are known as false positive. The validity of MRI during diagnosis of astrocytoma is recorded. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI for the diagnosis of astrocytoma are 92.0% (95% CI 85.2-98.7%), 80.0% (95% CI 70.0-89.9%), 96.0% (95% CI 91.1-100.9%), 67.0% (95% CI 55.3-78.7%) and 90.3% (95% CI 82.9-97.7%) respectively. From this result it is very clear that both the sensitivity and specificity of MRI for the detection of astrocytoma are above 80.0%. Therefore, the detection capacity of MRI of positive astrocytoma is very high among the patients. Similar to the present

study result Geets et al6 have reported that MRI scan has made a significant impact on the differential diagnosis of intracranial tumours. Boss et al[7] have added that MRI gives better contrast resolution than CT scan with a greater sensitivity for the detection of subacute and chronic haemorrhage in association with tumours and other lesions of brain which is consistent with the present study result.

MRI of brain allows accurate localization as to the likely histological type[10]. It has been explained that accuracy of lesion localization on MRI is enhanced by its direct multiplanar capability. Furthermore, MRI lacks ionizing radiation. Delineation of posterior cranial fossa soft tissue anatomy is better visualized with MRI than CT as because MRI lacks beam-hardening artefact[6]. In this study astrocytoma detection rate is very high by MRI which supports this issue. Nevertheless, MRI provides important information regarding contrast material enhancement, peritumoural oedema, distant tumour foci, haemorrhage, necrosis, mass effect and so on, which are all helpful in characterizing tumour aggressiveness and hence tumour grade[6]. All these capacities enhance the astrocytoma detection by MRI. MRI scan localizes and characterizes the vast majority of intracranial astrocytoma and the same is true of high-resolution CT scan[8]. Therefore, it has been recommended the use of MRI as a prime modality of investigation in detecting intracranial astrocytoma as it is highly sensitive, available and there is no ionizing radiation hazard.

Conclusion

In this study, MRI demonstrated high diagnostic performance for the detection of astrocytoma when compared with histopathological findings, the gold standard. MRI has showed a high sensitivity and specificity with a very high positive predictive value and overall diagnostic accuracy is also very high. These findings indicate that MRI is a highly reliable tool for identifying true cases of astrocytoma, with excellent ability to rule in the disease when positive. However, the relatively lower negative predictive value suggests that a negative MRI result does not fully exclude astrocytoma, and histopathological confirmation remains essential. The ROC analysis further supports the diagnostic utility of MRI, although the low AUC value observed may reflect limitations related to small sample size and potential statistical bias. Overall, MRI can be considered a valuable, non-invasive, and highly sensitive modality in the initial evaluation of suspected astrocytoma, but histopathology remains indispensable for definitive diagnosis.

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Data Availability
Any inquiries regarding supporting data availability of this study should be directed to the corresponding author and are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate
Ethical approval for the study was obtained from the Institutional Review Board. As this was a prospective study the written informed consent was obtained from all study participants. All methods were performed in accordance with the relevant guidelines and regulations.

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