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Original article:

Role of magnetic resonance imaging (MRI) in evaluation of pediatric brain tumors

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Abstract:

Background: Central nervous system (CNS) tumors are the most common type of solid tumors in the pediatric population and are the major cause of death from cancer in children.1,2 Every year, approximately 2500 new cases of CNS tumors are diagnosed, with an overall incidence of 3.5 cases per 100,000 children younger than 15 years old.3 Conventional CT and MRI are paramount in the workup of these tumors by depicting their imaging characteristics and location. Advanced neuro imaging provides additional information by determining the metabolism and physiology of these lesions that helps in the diagnosis and follow-up of brain neoplasms.

Methods: Hospital based Cross sectional study, Study setting: Radiology Department of tertiary care centre. All patients with clinically suspected brain tumor referred to the radiology department of medical college where the study was conducted.

Results: In this study Most of the patients in 0-2 age group had predominantly supratentorial (12) situation while most of the cases in 8 to 12 years had predominantly infratentorial situation (13),Majority of cases found in the age group of 8 to 12 years e.g 21 (42%), Mean age of cases was 7.48 years while mean ADC was1.05* 10-3 mm2/s, Most of the patients were male (60%) followed by female (40%), Pilocytic astrocytoma was seen in 20% and medulloblastoma was also seen in 20% cases followed by brain stem glioma (16%). Diffusion was free in most of the cases (56%) followed by restricted (44%).

Conclusions: A thorough knowledge and application of relevant advanced MRI imaging sequences can allow appropriate use of time and technology to solve diagnostic dilemma in difficult cases.

Keywords: Diffusion-weighted imaging (DWI), Diffusion tensor imaging (DTI), Functional MRI

INTRODUCTION:

Central nervous system (CNS) tumors are the most common type of solid tumors in the pediatric population and are the major cause of death from cancer in children.[1,2] Every year, approximately 2500 new cases of CNS tumors are diagnosed, with an overall incidence of 3.5 cases per 100,000 children younger than 15 years old.[3] Unlike brain tumors in the adult population, brain tumors in the pediatric population are mostly primary in origin. The age of the patient and the imaging characteristics and location of the tumor are key for establishing the diagnosis. Supratentorial tumors are more common in neonates and infants up to 2 years old, whereas infratentorial tumors are more common in children older than 2 years.[4-6]

As conventional anatomic brain MRI is often limitedin achieving these goals, advanced MRI techniques, such as diffusion-weighted imaging (DWI), diffusion tensor imaging (DTI), functional MRI, perfusion imaging, MR spectroscopy (MRS), and susceptibility-weighted imaging (SWI), are commonly included in the MRI protocol.[6] The recently introduced chemical exchange saturation transfer (CEST) imaging is at the early stage of clinical investigations.[7] However, no single advanced technique is perfect but different techniques typically complement one another. Besides the initial diagnosis, other goals of brain MRI for paediatric brain tumor should include differentiation of specific tumour types, grading tumors, distinguishing viable tumor from necrotic tissue, guiding stereotactic biopsy and determining treatment responses. As conventional anatomic brain MRI is often limited in achieving these goals, advanced MRI

Methodology

Study design: Hospital based Cross sectional study

Study setting: Radiology department of tertiary care centre

Study duration: 2 years (from October 2018 to December 2020)

All patients with clinically suspected brain tumor referred to the radiology department of medical college where the study was conducted.

A total of 50 patients diagnosed with brain tumor attending the department of radiology of medical college where study is being conducted.

Sample size: 50 patients

Inclusion criteria:

1) All patients with suspected brain tumors

2) Patients less than 12 years of age

Exclusion criteria:

1) Patients with suspected brain tumors but having contraindication for contrast such as contrast hypersensitivity / renal failure.

2) Patients more than 12 years of age

3) Highly irritable patient.

STUDY PROCEDURE:

All eligible patients were properly counseled and informed consent of parents / guardian was taken before entry into the study. Detailed medical histories of each patient were taken and general, physical, ophthalmic and systemic examination was done. All patients referred to hospital with H/O seizures, developmental delay, stroke, aphasia, para/ hemiplegia, nystagmus, strabismus- either or all or other symptoms fitting in the spectrum of CNS involvement in a period of 2 years were subjects for the study. Relevant investigations were done according to clinical findings.

Informed Consent has been taken after detail explanation to patient (age > 7 years) and patient's parent / guardian .

STATISTICAL ANALYSIS

Quantitative data is presented with the help of Mean and Standard deviation. Comparison among the study groups is done with the help of unpaired t test as per results of normality test. Qualitative data is presented with the help of frequency and percentage table. Association among the study groups is assessed with the help of Fisher test, student 't' test and Chi-Square test. 'p' value less than 0.05 is taken as significant.

This study was conducted after proper permission of ethical committee.

OBSERVATIONS and RESULTS

Table 1 – Location Predilection according to Age

Age	Total cases	Predominantly Supratentorial	Predominantly Infratentorial
0-2 years	16	12	4
2-8 years	15	8	7
8- 12 years	19	6	13

Table 1 shows Most of the patients in 0-2 age group had predominantly supratentorial (12) situation while most of the cases in 8 to 12 years had predominantly infratentorial situation (13)

Most of the patients were from 8 to 12 years of age group (42%)

Table 2- Distribution according to mean age and mean ADC

Descriptive Statistics	Minimum	Maximum	Mean	Std. Deviation
Age	2	12	7.48	3.228
ADC (10^{-3} mm^2/s) value	0.1	2	1.05	0.61

Mean age of cases was 7.48 years while mean ADC was1.05* 10^{-3} mm^2/s

Most of the patients were male (60%) followed by female (40%)

Table 3- Distribution according to diagnosis

Diagnosis	Number	Percent
Brain stem glioma	8	16.00%
Ependymoma	7	14.00%
Ganglioglioma	6	12.00%
Low grade glioma	9	18.00%
Medulloblastoma	10	20.00%
Pilocytic astrocytoma	10	20.00%

Pilocytic astrocytoma was seen in 20% and medulloblastoma was also seen in 20% cases followed by brain stem glioma (16%).

Table 4- Distribution according to grade on MRI and diffusion

Disease diagnosis by pathology	Number	Percent
High grade	20	40.00%
Low grade	30	60.00%
Diffusion	Number	Percent
Free	28	56.00%
Restricted	22	44.00%

Diffusion was free in most of the cases (56%) followed by restricted (44%). Low grade pathology was seen in most of the cases (60%).

Table 5- Association of diagnosis with grade of disease on MRI

Diagnosis	High grade (N)	High grade (%)	Low grade (N)	Low grade (%)
Brain stem glioma	6	30.00%	2	6.70%
Ependydmoma	2	10.00%	5	16.70%
Ganglioglioma	0	0.00%	6	20.00%
Low grade glioma	5	25.00%	4	13.30%
Medulloblastoma	4	20.00%	6	20.00%
Pilocytic astrocytoma	3	15.00%	7	23.30%
Chi-square	9.788	P value	0.0081 S	

Significant association was found between grade of disease with diagnosis. Ependymoma, ganglioglioma, medulloblastoma and pilocytic astrocytoma had low grade disease on MRI.

Table 6- Association of diffusion with grade of disease on MRI

Diffusion	High grade (N)	High grade (%)	Low grade (N)	Low grade (%)
Free	8	40.00%	20	66.70%
Restricted	12	60.00%	10	33.30%
Chi-square	3.463	P value	0.0063 S	

Free diffusion was mostly low grade on MRI. Significant association was seen between diffusion and grade on MRI

Table 7 - Sensitivity according to MRI

	Positive by diagnosis	Negative by diagnosis	Total
Positive by MRI	**24**	**4**	**28**
Negative by MRI	**16**	**6**	**22**
Total	**40**	**10**	**50**

According to MRI sensitivity was 60% while specificity was also 60%. Therefore diagnostic accuracy was 60% according to MRI

Table 8- Sensitivity according to Contrast Enhanced MRI

	Positive by diagnosis	Negative by diagnosis	Total
Positive by MRI	**39**	**2**	**41**
Negative by MRI	**1**	**8**	**9**
Total	**40**	**10**	**50**

According to contrast enhanced MRI sensitivity was 97.5% while specificity was also 80%. Therefore diagnostic accuracy was 94% according to contrast enhanced MRI

DISCUSSION:

The present study was done at our tertiary care centre on 50 patients to diagnose various brain tumors and assess MR imaging features of paediatric brain tumors. MRI remains the most common imaging modality used to evaluate CNS tumors. Having a basic understanding of both the principles of tumor genomics and the recent updates in tumor genomics is crucial to radiologists who interpret neuro-oncology imaging studies. Buzzwords such as radiogenomics and radiomics have been introduced into the radiology lexicon recently, necessitating that radiologists become familiar with these entities and their implications.

In the present study, most of the patients in 0-2 age group had predominantly supratentorial (12) situation while most of the cases in 8 to 12 years had predominantly infratentorial situation (13)**.** Most of the patients were from 8 to 12 years of age group (42%). This is well illustrated in the table number 1 and similar to the studies of Babita SS et al[8] and Bouzidi Y et al[9]. Babita SS et al[8] study assessing the correlation of pediatric brain tumors by CT scan and MRI imaging found out of the 50 cases, maximum number of patients belongs to the age group of 5.1 to 10 years (46%) and minimum of 4% belongs to 0 to 2 years. Only 2 cases were reported between 0-2 years. 7 (14%) cases belong to 2.1-5 age groups and 18 (36%) cases belongs to 10-15 age group. Out of total number cases suspected of brain tumors 58% were male and 42% were female.

Bouzidi Y et al[9] retrospective study found two groups were not significantly different except for age at time of diagnosis. The cancer recurrence population consisted of 14 (61%) boys and nine (39%) girls, and the mean age at diagnosis was 41 months (3 years and 4 months).

In our study, mean age of cases was 7.48 years while mean ADC was1.05* 10^{-3} mm^2/s, as illustrated in table no 2. This is comparable to the studies of Bull JG et al[10] and Bai Y et al[11]. Bull JG et al[10] and Bai Y et al[11] study reported that ADC ratios, histogram analysis, and diffusion kurtosis based on non-Gaussian water diffusion might better characterize high-grade brain tumors. Furthermore, a diffusion heterogeneity index calculated from a stretched exponential model or a fractional order calculus model with multi-b-value DWI recently demonstrates improved tumor grading in adult gliomas (16). It was observed in the present study that most of the patients were male (60%) followed by female (40%) These are well depicted in graph no 2. Pilocytic astrocytoma was seen in 20% and medullobastoma was also seen in 20% cases followed by brain stem glioma (16%). These are well depicted in table no 3. This is concordant to the study of Bouzidi Y et al[9].

Bouzidi Y et al[9] retrospective study found seventy-nine percent of the cases involved posterior fossa tumors. Three of the 29 cases of recurrence (9%) involved patients who had secondary lesions from the onset of diagnosis. The average follow-up time for these patients, from the initial diagnosis, was 49.5 months, (median: 34 months, extremities: 3 months, 202 months). Nineteen of the 29 cases of recurrence were anatomopathologically confirmed and 10 confirmed by clinicoradiological evolution, eight of which were by death. In this study Significant association was found between grade of disease with diagnosis. Ependydmoma, ganglioglioma, medulloblastoma and pilocytic astrocytoma had low grade disease on MRI. This is well depicted in the table 5. This is consistent with the studies of Babita SS et al[8] and Bouzidi Y et al[9]. Babita SS et al[8] study observed malignant Glioma accounted 4% according to CT but by MRI it was 2%, Brain stem glioma 8%, Gangliglioma 2%, Medulloblastoma 8%, Ependymoma 2%, Suprasellar tumor 6%, Craniopharyngioma 6%, Germ cell tumor 2% was diagnosed same by CT and MRI. 8% were diagnosed as infarct by MRI.

It was observed in the present study that free diffusion was mostly low grade on MRI. Significant association was seen between diffusion and grade on MRI, as shown in table 6. This is in concordance to the study of Sui Y et al[14]. Sui Y et al[14] reported pediatric brain tumors in 67 pediatric patients with brain tumors, fractional order calculus model parameters, such as diffusion coefficient, fractional order parameter, and a microstructural quantity, are used to improve differentiation between low- and high-grade pediatric brain tumor groups with a high predictive power (area under curve, 0.962) and accuracy (92.5%) at the expense of longer acquisition time.

In the present study, sensitivity according to MRI and Contrast Enhanced MRI are as follows:

Sensitivity according to MRI

Sensitivity= 60% ,Specificity= 60% ,Diagnostic accuracy= 60%

According to MRI sensitivity was 60% while specificity was also 60%. Therefore diagnostic accuracy was 60% according to MRI**,** as shown in table no 7

Sensitivity according to Contrast Enhanced MRI

Sensitivity= 97.5% ,Specificity= 80% ,Diagnostic accuracy= 94%

According to contrast enhanced MRI sensitivity was 97.5% while specificity was also 80%. Therefore diagnostic accuracy was 94% according to contrast enhanced MRI, as shown in table 8.

Different observations were noted in the study of Bouzidi Y et al[99], that demonstrated no significantly increased sensitivity of contrast enhanced MRI from the usual MRI.

Bouzidi Y et al[99] single-center retrospective study evaluating the sensitivity of unenhanced brain MRI (U-MRI) in detection of tumor recurrence in children reported U-MRI had a sensitivity of 81%, and a negative predictive value (NPV) of 82%. The U-MRI sensitivity, regardless of the observer, was not significantly different from the contrast-enhanced MRI sensitivity (86%). No significant difference in sensitivity within the subgroups was found. The interobserver agreement of seniors was good ($\kappa = 0.68$).

CONCLUSION

MRI diagnosis of pediatric brain tumors in clinical practice is usually based on diagnostic clues including tumor location, patient age, clinical history, tumor incidence, and MRI findings. In the current scenario, with increased availability of MRI scanners in remote areas of our country, there is a need to explore the imaging characters of various brain tumors on conventional MRI sequences (T1, T2, FLAIR) and make judicious use of post contrast sequences when required , for early diagnosis with reliable certainty so that prompt treatment options can be availed. Thus, if the radiological diagnosis of malignancy with a fairly confident level of certainity in the early phase of patient presentation made, making use of conventional and advanced imaging sequences and liberally employing contrast media , the road to treatment can be fast tracked with a resultant better patient prognosis.

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