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Role of Magnetic Resonance Imaging in Differentiating Intraaxial Brain Tumors at Tertiary Care Center

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Abstract: ***The brain is the most complex part of the human body. Brain tumors are defined as a collection or mass of abnormal cells in the brain. Brain tumour can be malignant or benign, localization of intraaxial / extra - axial brain tumour and tumour like conditions depends primarily upon careful study of patient's symptoms with accurate and detailed neurological examination. MRI has been the most spectacular advances in Radiology & has practically revolutionized the diagnosis of brain tumors and tumour like conditions. MRI can give a multiplanar image of a body. The complete imaging evaluation of the patients with CNS neoplasms includes detection, characterization and determination of tumour extent or metastatic spread and secondary effect can be done. Advances in MRI like diffusion, functional perfusion, and spectroscopic imaging techniques further enhance diagnostic accuracy by characterizing tumor cellularity, vascularity, metabolic profile, and microhemorrhages. These features aid in distinguishing high - grade from low - grade gliomas, metastases from primary brain tumors, and demyelinating lesions from neoplasms. MRI is currently being applied to grade gliomas, guide stereotactic biopsies, differentiate between glial, nonglial and extra - axial tumors and between primary and metastatic tumors, monitor treatment response and distinguish between recurrent tumors and treatment necrosis, and eliminate neoplastic - mimicking lesions, such as stroke and tumefactive demyelinating lesions. This article highlights the diagnostic utility of conventional and advanced MRI sequences in the differential diagnosis of intraaxial brain tumors, emphasizing its role in improving patient outcomes through accurate and early diagnosis.***

Keywords: MRI, intra axial brain tumors, DWI, advanced sequences, low grade and high grade tumors.

1. Introduction

Incidence of Intra - Axial Brain Tumors [(2)]:
Roughly one - third of CNS tumors are metastatic lesions, one third are gliomas and one - third is of non - glial origin. Glioblastoma multiforme is the most common type (50% of all diffuse gliomas). The non - glial cell tumors are a large heterogenous group of tumors of which oligodendroglioma is the most common.

Brain Tumor Incidence by Age Group [(2)]:
Pilocytic astrocytoma and embryonal neoplasms are the most common types in children. Compared with adults, malignant gliomas are rare, and metastases are insignificant.

Most of the tumors in children are located infratentorially. Astrocytomas are the most common supratentorial and juvenile pilocytic astrocytoma is the most common infratentorial tumor in children.

Metastases are by far the most common supra and infratentorial tumor in adults followed by gliomas. Hemangioblastoma is an uncommon tumor, but it is the most common primary intra - axial tumor in infratentorial region in the adult.

Road Map in Evaluation of Intraaxial Brain Tumors with Different Sequences Of MRI [(7)]

When we analyze a potential brain tumor, the following aspects should be analyzed.

- Age of the patient.
- Location of lesion - intra - or extra - axial, crossing midline and which lobe.
- Number of lesions.
- Tissue characteristics like calcifications, fat, cystic components, contrast enhancement and signal intensity on TlWI, T2WI and DWI.
- Secondary changes like perilesional edema, mass effect and midline shift are to be assessed

Intra Vs Extra - Axial Differentiating Features:
Intra - axial tumors are derived from the brain tissue while extra - axial tumors are derived from tissues outside of the brain, including the meninges (Meningioma), cranial nerves (Schwannoma) etc.

Typical signs of extra - axial tumors include:

- Presence of a CSF cleft.
- Subarachnoid vessels that run on the surface of the brain are displaced by the lesion.
- Presence of gray matter between the lesion and the white matter.
- Broad dural base or a dural tail of enhancement may be seen, as is typically seen in meningiomas.
- Bony changes
- homogenous enhancement
- Hypointense on T2 due to a fibro - collagenous matrix

Who Classification of CNS Tumors 5th Edition (2021) [8]

1) Adult - type diffuse gliomas
   - Astrocytoma (IDH - mutant)
   - Oligodendroglioma (IDH - mutant, and 1p/19q - codeleted)
   - Glioblastoma (IDH - wildtype)
2) Paediatric - type diffuse low - grade gliomas
3) Paediatric - type diffuse high - grade gliomas
4) Circumscribed astrocytic gliomas (eg: Pilocytic astrocytoma, Pleomorphic xanthoastrocytoma)
5) Glioneuronal and neuronal tumors (eg: GangliogliomaDysembryoplastic neuroepithelial tumor)
6) Ependymal tumors
7) Choroid plexus tumors
8) Embryonal tumors
9) Medulloblastoma
10) Other CNS embryonal tumors.
11) Pineal tumors.
12) Mesenchymal, non - meningothelial tumors.

2. Materials & Method

- Sample Size: 100 Patients (n=100)
- Study Design: Observational Study
- Type Of Study: Prospective study
- Duration Of Study: 1.5 Years
- Place Of Study: P. D. U. Medical College and Civil Hospital, Rajkot
- Instruments Used: Siemens Magnetom Sempra 1.5T/MRI 1.5T GE (2156158 - 143)
- Consent For Participation In Study: Yes

Inclusion criteria:

All the patients with clinical symptoms and signs of intraaxial brain tumors - referred to department of Radiodiagnosis.

Justification for study:

- MRI is non - invasive and radiation free modality.
- MRI being the most sensitive imaging helps in early detection, staging, and narrowing differentials and follow up after treatments.
- Detection of small sized tumors, type of tumor, grading of tumor and effective management can be done.

Exclusion criteria:

- Other than brain tumours & tumour like conditions i. e.: Infective conditions identified on contrast
- study, post operative or radiation induced gliosis, infarction, benign hemorrhage of brain - these
- cases are not to be included in the study.

3. Results and Discussion

Classification of Lesions:

Table 1: Different intra - axial brain tumors

Radiological diagnosis (family)	Radiological diagnosis (type)	Percentage
Metastasis		28
Adult type diffuse gliomas	1) Astrocytoma	7
	2) Oligodendroglioma	6
	3) Glioblastoma	16
Paediatric type high grade diffuse glioma		5
Paediatric type low grade diffuse glioma		4
Circumscribed astrocytic glioma	1) Pilocytic astrocytoma	5
	2) Pleomorphic xanthoastrocytoma	2
	3) Subependymal giant cell astrocytoma	3
Glioneuronal and neuronal tumors	1) Ganglioglioma	3
	2) Dysembryoplastic neuroepithelial tumors	2
Ependymal tumors	1) Ependymoma	1
	2) Subependymoma	1
Choroid plexus tumours	Choroid plexus papilloma	2
Embryonal tumors	Medulloblastoma	3
Pineal tumors	1) Pineocytoma	1
	2) Pineoblastoma	1
Mesenchymal, non meningothelial tumors	Hemangioblastoma	1
Germ cell tumor	1) Dermoid	2
Neoplastic SOL (cannot be differentiated)		5
Hematolymphoid tumours	Lymphoma	2

According to Osborn in adults, most common intraaxial neoplasm was metastasis. Most common malignant primary intraaxial neoplasm is diffuse gliomas of which glioblastoma type is more common (46%). It is followed by all other astrocytomas (17%) and oligodendroglioma (7%).

The present study shows Metastasis to be the most common intra - axial tumor to occur, with it comprising 28% of the

total number of cases and 41.1% of adults, considered in this study. Present study shows gliomas to be the most common primary intra - axial brain tumors at 51%, out of which the most common sub - type is Glioblastoma (n = 16), accounting for 31.3% of Gliomas. This corresponds to the 2005–2009 Central Brain Tumor Registry in the United States (CBTRUS) [13] statistical report, as explained by Dolecek et al., 2012, who found glial tumors constitute approximately 29% of all intracranial tumors (Dolecek et al., 2012).

Age Wise Distribution:

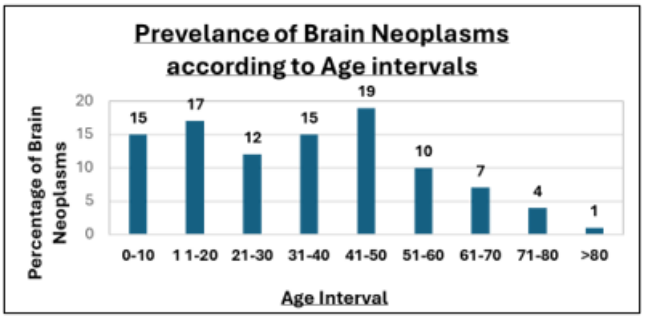

Figure 1: Bar - diagram of age wise distribution of intraaxial brain tumors.

According to Osborn and our study, the most common age group for adult brain tumour is in the 5th decade. According to Osborn, 15 to 20% of intra axial brain neoplasms are seen in children. And of the 100 individuals studied, 32 were found to be in the paediatric age group (considered at or below 20 yrs of age), making them 32% of the total population studied. In Meel et al., 2021 [16], a study of the Indian population, the frequency of brain tumours was highest in the 5th decade which corresponds to the present study.

Sex Distribution:

In Present study males are more in number at 58% of the study group and females make up 42%. Which corresponds to Osborn, and Meel et al., 2021, where there were 1, 982 (56.2%) male patients and 1, 544 (43.8%) female patients. In Panda et al., 2017 [17], majority of the study individuals were Males at 66% of the group, while females made up 33.9%.

According to Location:

According to Osborn and other literature, extra axial & supratentorial locations were more common. In adults supratentorial lesions were far more common. In the present study most of the tumors are supratentorial at 75% corresponding to Jay Thakkar et al., 2015 (71%), Bzuneck et al., 2021 (97.4%), Paul et al., 2023 (91%), Panda et al., 2017 (50.9%). In the present study, majority of the lesions (75%) were found to be in supratentorial fossa.

According to Lobe:

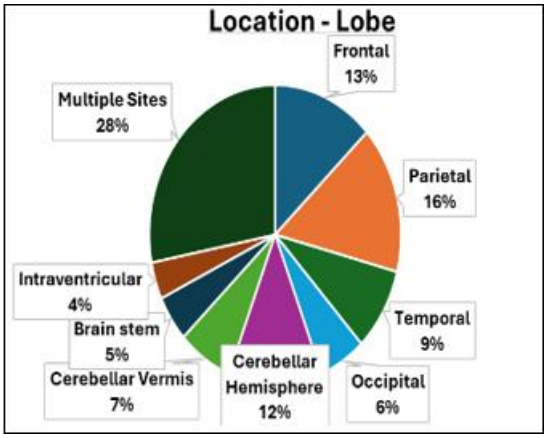

Figure 2: Pie chart of location of intraaxial brain tumors.

In the present study the most common location of tumor is parietal lobe with 16% of the tumors occurring there. Which corresponds to Jay Thakkar et al., 2015., with 15% of the tumors in Parietal lobe

According to Pattern of Enhancement:

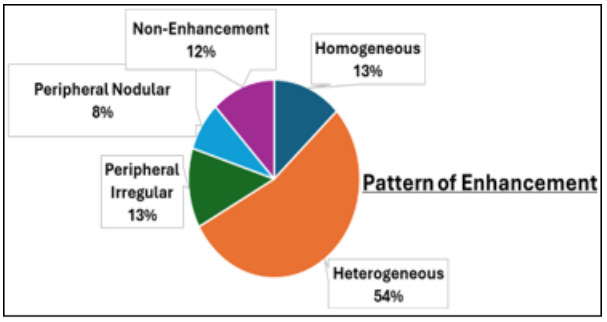

Figure 3: Pie chart of pattern of enhancement of intraaxial brain tumors.

Approximately 40% of lesions show heterogeneous enhancement due to mixed internal solid & cystic contents as well as internal hemorrhagic content & calcification. Homogenous contrast enhancement was seen in cases of complete disruption of blood brain barrier or internal solid content. Peripheral enhancement was seen in 12% cases. Most common cause of peripheral enhancement was cystic metastasis. Low grade neoplasms also did not show enhancement & the most common cause of non - enhancement was low grade glioma. Pallu et al., 2009 conducted a study on contrast enhancement which showed 68.8% oligodendrogliomas showed patchy & faint enhancement, while 30% of mixed Gliomas showed nodular enhancement & 24.6% of astrocytomas showed absent enhancement.

According to Content:

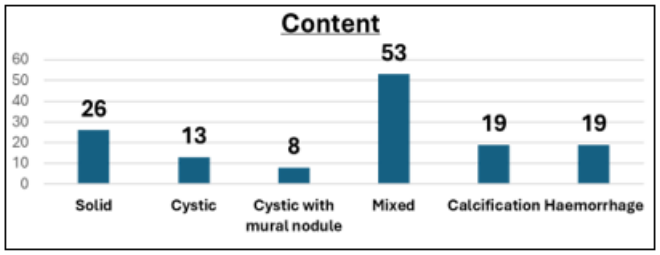

Figure 4: Bar - diagram of content of intraaxial brain tumors.

Lesions with internal mixed content - solid and cystic were seen in 53% cases. Most common cause for internal mixed content was metastasis, glioblastoma multiforme and pediatric high - grade glioma.26% of our present study showed solid content within. Most common lesions with internal solid content were astrocytoma followed by metastatic lesions, low grade gliomas, glioblastoma, medulloblastoma and lymphoma.13% of our present study showed cystic content within. Most common cause was cystic metastasis. Internal hemorrhagic was noted in 19% cases. Most common cause of hemorrhagic brain tumour were pediatric high - grade glioma, glioblastoma and metastatic lesions. Internal calcification was seen in also 19% cases (Ependymomas, medulloblastomas, Pinealocytomas, Dermoid, Oligodendrogliomas, Gangliogliomas).

According to Complications:

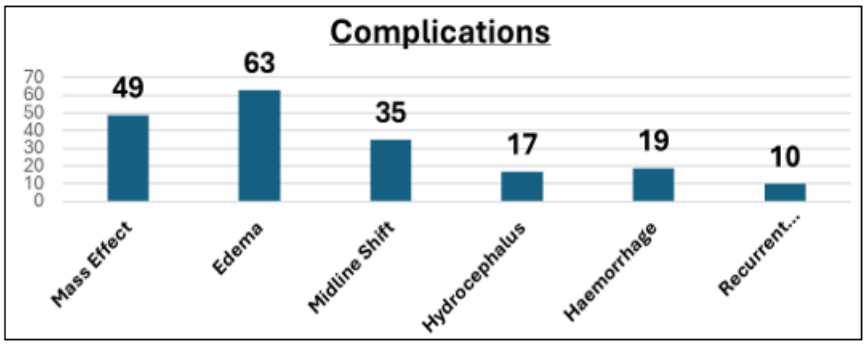

Figure 5: Bar - diagram of complications of intraaxial brain tumors.

Mass effect and edema were the most common complications noted in our study. Significant mass effects were seen in Glioblastoma multiforme and Metastatic lesions. Mild changes were seen with Astrocytoma and Oligodendroglioma. Hydrocephalus was seen most in Ependymoma, medulloblastoma, pinealoblastoma, Hemangioblastoma.

4. Summary

- Glioma is the most common primary intra - axial CNS neoplasm, seen in 51% cases.
- Most common malignant neoplasm is metastasis, seen in 28% cases.
- Most common primary malignant CNS tumour is Glioblastoma type of family adult diffuse gliomas, seen in 16% cases.
- Most common affected age group is 5th decade (41 - 50), 19% cases were reported from 5th decade of age group.
- Males are affected more frequently than females.58% cases were reported from males.
- Parietal lobe involvement is most commonly seen in brain tumour for single lesion in 16% cases, otherwise multiple lesions are more common, seen in 28% cases.
- Primary brain neoplasm is more common than secondary.67% cases were reported to be primary brain neoplasm.
- In 88% cases post contrast enhancement was noted among which, heterogeneous pattern (54%) was most common.
- Glioblastoma is the most common variant of glioma, reported in 16% cases.
- Most common complication of brain tumors & tumour like condition is surrounding edema was seen in 63% cases.

5. Conclusion

Imaging plays a vital role in characterizing and differentiating different intraaxial brain tumors. Addition of advanced MRI sequences, including Diffusion Weighted Imaging (DWI), Perfusion MRI (pMRI) and MR spectroscopy (MRS) along with post contrast sequences to the routine conventional MRI sequences (T1, T2 and FLAIR) have substantially enhanced the diagnostic accuracy for various intra - axial tumors. The integration of these advanced MRI sequences has significantly improved the differentiation of tumor grades and types, facilitating personalized treatment planning. In conclusion, MRI serves as an indispensable tool in the radiological assessment of intra - axial brain tumors. The application of advanced MRI techniques enhances diagnostic precision, informs therapeutic decisions, and improves patient outcomes. Continued research and technological advancements in MRI are essential to further refine tumor characterization and treatment strategies in the field of radiology.

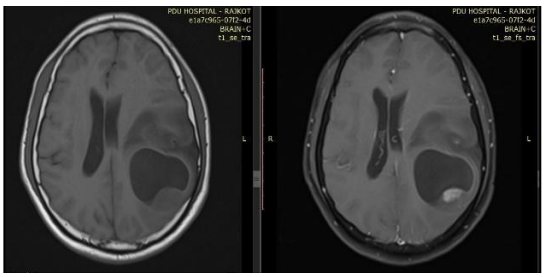

Image 1: Ganglioglioma

Heterogeneous predominantly cystic lesion with enhancing mural nodule noted in left parieto - occipital region.

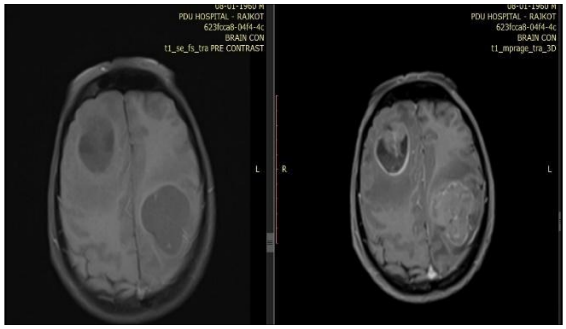

Image 2: Cerebral Metastatic Lesions in a Known Case of Breast Carcinoma

Multiple lesions: Hypointense on T1W images with heterogeneous peripheral rim like irregular enhancement on post contrast images with marked perilesional edema in a known case of breast carcinoma.

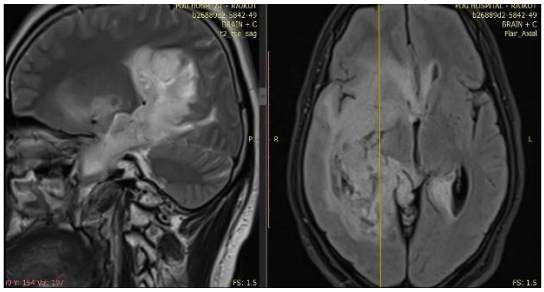

Image 3: Gliomatosis Cerebri Pattern – Diffuse Adult Astrocytoma

Intraaxial irregular diffusely infiltrative lesion noted along subependymal region of body, occipital horn and temporal horn of right lateral ventricle and periventricular right temporo - parietal lobe, right posterior peri insular region, right lateral basal ganglia and involve right peri - mesencephalic cistern.

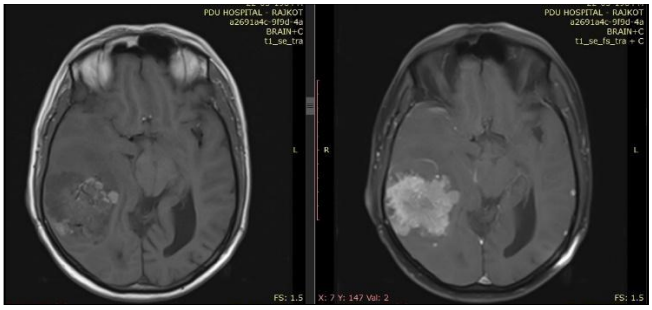

Image 4: Choroid Plexus Carcinoma

Medium sized lesion is noted in occipital horn of right lateral ventricle - isointense with few hemorrhagic areas within with marked enhancement.

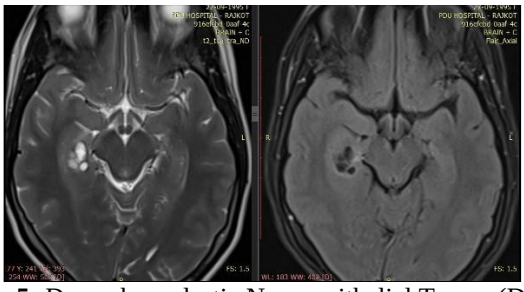

Image 5: Dysembryoplastic Neuroepithelial Tumor (DNET)

Multi - cystic lesion giving bubbly appearance is noted in medial aspect of right temporal lobe involving right para hippocampal gyrus with bright rim sign in FLAIR.

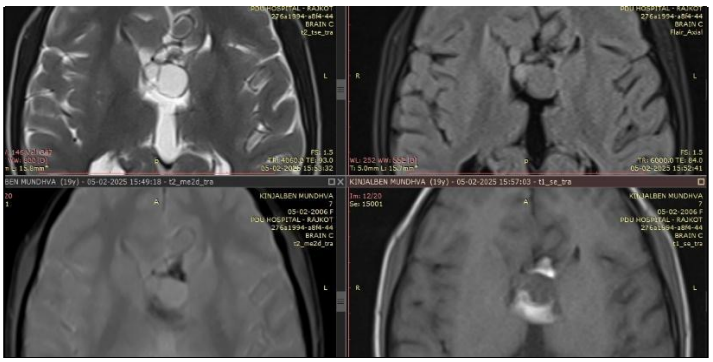

Image 6: Intracranial Dermoid Cyst

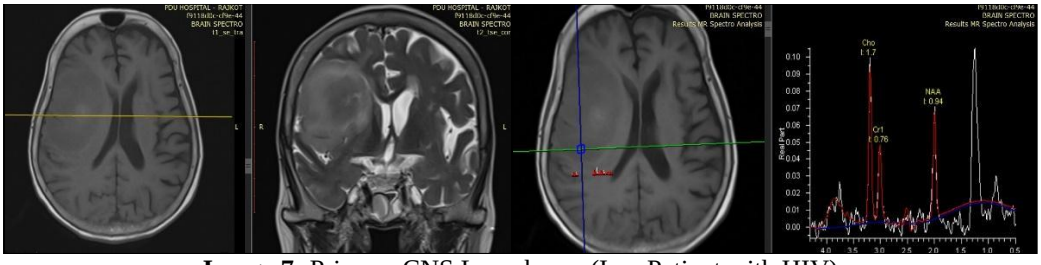

Image 7: Primary CNS Lymphoma (In a Patient with HIV)

Intra axial lesion in right frontal lobe and right basal ganglia region appears homogenous hypointense to isointense on T1W images and heterogeneously hyperintense on T2W images. Peak of choline is noted with reversal of Choline/NAA ratio and lactate peak.

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