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ROLE OF PERFUSION OF MRI AND MR SPECTROSCOPY IN EVALUATION AND MANAGEMENT OF INTRA CRANIAL SPACE OCCUPYING LESIONS.

Radiodiagnosis

Dr Shilpa Chudasama — Associate Professor, Department of Radiodiagnosis, Shri M.P. Shah Government Medical College and Shri Gurugobind Singh Government Hospital, Jamnagar.

Dr Divyesh Sarvaiya* — Second year resident, Department of Radiodiagnosis, Shri M.P. Shah Government Medical College and Shri Gurugobind Singh Government Hospital, Jamnagar. *Corresponding Author

Dr Daxa Khunt — Third year resident, Department of Radiodiagnosis, Shri M.P. Shah Government Medical College and Shri Gurugobind Singh Government Hospital, Jamnagar.

Dr Manukumar B. — Second year resident, Department of Radiodiagnosis, Shri M.P. Shah Government Medical College and Shri Gurugobind Singh Government Hospital, Jamnagar.

ABSTRACT

Objectives:-The objective of this study was to evaluate importance of MR spectroscopy and Perfusion MRI (pMRI) as complimentary advance MRI modalities in addition to conventional MRI sequences in diagnosis of intracranial space occupying lesions and its role in differentiate between recurrence/residual tumour from radiation necrosis.

Materials and methods: - The present prospective study is carried out at department of radiology, Guru Gobind Singh Hospital and M P Shah Medical College, Jamnagar. Patients, duly fulfilling inclusion criteria were included. The study group includes 35 consecutive patients refer to the radiological Department, GGH with intra-or extra-axial brain tumours. Patients ranged in age from 5 to 65 years of age. All patients were evaluated prior to any medical or surgical treatment.

Results*:* - In our study of 35 patients, 57 % were male and 43 % were female. Majority of the patients were adults which belongs to age group of above 40 years. In our study, we found that glioblastoma multiforme are the most common malignant brain tumours with occurrence in 10 patients. (28.75%) meningiomas are the most common non-malignant brain tumours which involve 6 patients of the study, (17.14%). Metastases are being second most common malignant brain lesion after glioblastoma multiforme. Most common sites for intracranial lesions are frontal, parietal and temporal lobes in our study (61.57%). Isolated involvement of occipital lobes was not found in our study. Above mentioned lesions involve both tumours arising from meninges and neuro-epithelial cells.

In our study using perfusion MRI, it was found that high grade tumours shows high rCBV (Relative cerebral blood volume) and low grade tumor shows low rCBV with rCBV of 1.16 for low grade tumours, 5.78 for high grade tumours and 2.66 for metastases.

In our study using MR spectroscopy, it was found that High choline peak and increased choline to creatinine ratio in peri tumoral areas are important parameters to differentiate between primary brain tumours from metastases.

Conclusions: -Dynamic contrast-enhanced perfusion weighted imaging provides important physiological information that cannot be obtained by conventional MRI. rCBV remains most important perfusion weighted MRI findings for grading of intra-or extra-axial intracranial neoplastic lesions that can help deciding further management strategy.

MR spectroscopy showed that high choline peak and increased choline to creatinine ratio in peri tumoral areas are important parameters to differentiate between primary brain tumours from metastases.

KEYWORDS

Intracranial space occupying lesions, MR spectroscopy, Perfusion MRI (pmri) and rCBV

INTRODUCTION

The annual incidence of primary intracranial brain tumours is 7 to 19 cases per 1,00,000 people. The incidence is peak of 18 to 19 per 1,00,000 between 65 to 79 years. Tumours of neuroepithelial origin are the most common, followed by tumours of meningeal, hematopoietic and nerve sheath origin. In adults, most neuroepithelial tumours are gliomas which constitute over 90% of primary brain tumours in person older than 20 years.

Conventional magnetic resonance imaging (MRI) is widely used in the diagnosis and follow-up of brain tumor patients, owing to its high sensitivity and exquisite delineation of anatomic relationships. Nonetheless, conventional MR techniques are often nonspecific and provide limited information on tumor physiology. perfusion MR techniques providing a better delineation of tumor margins than conventional techniques, helps to provide information on tumor physiology, assist in surgical and radiation planning, allowing differentiation between radiation effects and recurrent tumor. Other radiological techniques to evaluate tumor physiology, such as MR spectroscopy and ^{18}F-flurodeoxyglucose positron-emission tomography (FDG-PET), deserve mention here. MR spectroscopy (MRS) relies on detection of metabolites within tumor tissue.

MATERIALS AND METHODS

The present study of 35 patients between time period of February 2020 to October 2020 was carried out at department of radiology, Guru Gobind Singh Hospital and M P Shah Medical College, Jamnagar.

Inclusion criteria:

- Patients with diagnosed or high clinical suspicion of intracranial malignancy having age more than/equal to 2 years.

Exclusion criteria:

- Patients with age less than 2 years of age.
- Patients with chronic, severe kidney disease (< 30 ml/min/1.73 m2)
- Acute Kidney disease.
- Patient having high risk of developing Nephrogenic systemic fibrosis e.g. > 60 years, uncontrolled hypertension and diabetes.
- Patient opting out or not willing to take part in study.

Imaging technique:

Patient Position and MRI techniques

Before examination 18-or 20-gauge intravenous catheter was inserted in each patient for administration of contrast. Imaging was performed on a 1.5 Tesla MR scanner (Magnetom Essenza; Siemens Medical Systems, Erlangen, Germany). After conventional MRI (consisting of axial T1 weighted, T2 weighted, FLAIR, GRE-based axial and T2 weighted sagittal and FLAIR coronal), orthogonal diffusion weighted MRI sequences with ADC mapping and proton weighted magnetic resonance spectroscopy was done.

Perfusion Imaging after conventional MRI

Then obtained dynamic contrast enhanced T2* weighted gradient-echo (GRE) echo-planner imaging (EPI) axial images during the first-pass metabolism of bolus of Gadopentetate dimeglumine (Multihance, BRACCO, USA). Finally, post contrast axial coronal and sagittal T1 weighted fat suppressed images were obtained. Perfusion weighted

imaging was performed by using of fat suppressed T2*W EPI with following parameters: repetition time(TR), 1430 milliseconds; echo time (TE), 46 ms; field of view (FOV), 230 x 230 millimetres; section thickness, 5 mm; section gap, 10 mm; matrix, 128 x 256.

OBSERVATIONS AND RESULTS

Table 1: Tumour Pathology

Tumour	No. of Patients (n=35)	Percentage of Patients
Glioblastoma multiforme	10	28.75
Astrocytoma	5	14.26
Metastases	9	25.71
Meningioma	6	17.14
Ganglioganglioma	1	2.88
Oligodendroglioma	1	2.88
Tuberculoma	3	8.57

Table 2: Spectroscopy of the lesion

Spectroscopy findings	No. of Patients (n=35)	Percentage of Patients
High choline only	23	65.71
High choline with lactate in necrotic portions	3	8.58
Lipid-lactate levels	3	8.58
Lactate only	2	5.71
No choline or lipid-lactate levels	2	5.71
Equivocal or indeterminate	2	5.71

Table 3: Relative cerebral blood volume

Tumour	Relative cerebral blood volumes (rCBV) ratios			
	No. of Patients	Range	Mean	SD
Low grade tumours (Glioblastoma multiforme + Astrocytoma)	6	0.15 - 3.38	1.16	1.34
High grade tumours (Glioblastoma multiforme + Astrocytoma + oligodendroglioma)	10	2.83 - 10.11	5.78	5.32
Metastases	9	0.98 - 5.69	2.66	1.92
Meningiomas	6	1.76 - 8.35	5.35	1.92

DISCUSSION

Dynamic contrast-enhanced perfusion weighted imaging provides important physiological information that cannot be obtained by conventional MRI. CBV remains most important perfusion weighted MRI findings for grading of intra-or extra-axial intracranial neoplastic lesions, that can help deciding further management strategy. It remains most important perfusion parameter for grading gliomas and differentiating tumour recurrence from radiation necrosis. It also help differentiate between infiltrating oedema around a primary glioma and vasogenic oedema around metastasis and other non-infiltrating tumours. Other perfusion parameters, besides CBV, can also help increase specificity, such as finding increase mean transit time (MTT) within a region of ischemia in tumour and finding increased vascular permeability in a typical meningiomas. When compared with other imaging techniques such as positron emitting tomography (PET) and single photon emission computed tomography (SPECT), dynamic contrast-enhanced perfusion weighted imaging is a rapid and less expensive high-resolution imaging modality with greater availability. It may become the preferred modality in preoperative diagnosis and grading of brain tumours, as well as in the follow-up after treatment. Our study provides additional data on the usefulness of DSC-MRI in correctly differentiating between tuberculoma and neoplastic brain lesions and as a complementary tool to routine structural MRI.

There is a strong pathophysiologic and neurochemical basis for using perfusion MRI and MR spectroscopy in the evaluation of brain tumours. Increases in the vessel diameter, vessel wall thickness and vessel numbers (micro-vascular density) should lead to increased blood volume measurements made with dynamic Susceptibility Contrast-Enhanced Perfusion MRI (DSC MRI). The diameter of normal cerebral capillaries has a limited range of between 3 and 5 micrometres, whereas gliomas and other intracranial neoplasms contain tortuous hyperplastic vessels ranging between 3 and 40 micrometres in diameter[11]. Furthermore, the endothelial thickness in glial vessels is 0.5 microns versus 0.26 microns in normal cerebral vessels. One may expect as a result, reduced relative cerebral blood volume (rCBV). However, gradient-echo sequences exploit the local paramagnetic susceptibility within the vessel lumen, the vessel wall and surrounding tissues resulting in intra- and extra-vascular spins undergoing reduction of T2* signal[12]. Thus rCBV measurements have been shown to correlate reliably with tumor grade and histologic findings and histologic findings of increased tumor vascularity[13]. Tumor destructed hyper-permeable blood-brain barrier associated with or without immature vessels allows for contrast agent enhancement, extravasation and, hence, measurement of vascular permeability. Perfusion MRI can now measure parameters such as CBV and vascular permeability, which can be directly correlated with histopathologic changes[14-16]. Measurement of cerebral blood flow (CBF) requires determination of the arterial input function, which can be difficult with DSC MRI techniques which correlate with tumor grade[17]. Combination of clinical findings, conventional MRI, MR spectroscopy and DSC perfusion MRI can increase our diagnostic accuracy and confidence.

WHO classification of intracranial Tumours Neuroepithelial Tumors of the CNS

1. **Astrocytic tumors [glial tumors--categories I-V, below--may also be subclassified as invasive or non-invasive, although this is not formally part of the WHO system, the non-invasive tumor types are indicated below. Categories in italics are also not recognized by the new WHO classification system, but are in common use.]**
1. **Astrocytoma (WHO grade II)**
1. **variants: protoplasmic, gemistocytic, fibrillary, mixed**
2. **Anaplastic (malignant) astrocytoma (WHO grade III)**
1. hemispheric
2. diencephalic
3. optic
4. brain stem
5. cerebellar
3. **Glioblastoma multiforme (WHO grade IV)**
1. **variants: giant cell glioblastoma, gliosarcoma**
4. **Pilocytic astrocytoma [non-invasive, WHO grade I]**
1. hemispheric
2. diencephalic
3. optic
4. brain stem
5. cerebellar
5. **Subependymal giant cell astrocytoma [non-invasive, WHO grade I]**
6. **Pleomorphic xanthoastrocytoma [non-invasive, WHO grade I]**
2. **Oligodendroglial tumors**
1. **Oligodendroglioma (WHO grade II)**
2. **Anaplastic (malignant) oligodendroglioma (WHO grade III)**
3. **Ependymal cell tumors**
1. **Ependymoma (WHO grade II)**
1. **variants: cellular, papillary, epithelial, clear cell, mixed**
2. **Anaplastic ependymoma (WHO grade III)**
3. **Myxopapillary ependymoma**
4. **Subependymoma (WHO grade I)**
4. **Mixed gliomas**
1. **Mixed oligoastrocytoma (WHO grade II)**
2. **Anaplastic (malignant) oligoastrocytoma (WHO grade III)**
3. **Others (*e.g.* ependymo-astrocytomas)**
5. **Neuroepithelial tumors of uncertain origin**
1. **Polar spongioblastoma (WHO grade IV)**
2. **Astroblastoma (WHO grade IV)**
3. **Gliomatosis cerebri (WHO grade IV)**
6. **Tumors of the choroid plexus**
1. **Choroid plexus papilloma**
2. **Choroid plexus carcinoma (anaplastic choroid plexus papilloma)**
7. **Neuronal and mixed neuronal-glial tumors**
1. **Gangliocytoma**
2. **Dysplastic gangliocytoma of cerebellum (Lhermitte-Duclos)**
3. **Ganglioglioma**
4. **Anaplastic (malignant) ganglioglioma**
5. **Desmoplastic infantile ganglioglioma**
1. desmoplastic infantile astrocytoma
6. **Central neurocytoma**
7. **Dysembryoplastic neuroepithelial tumor**
8. **Olfactory neuroblastoma (esthesioneuroblastoma)**

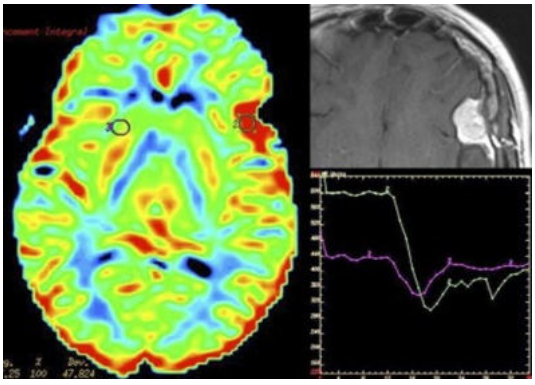
1. variant: olfactory neuroepithelioma
8. Pineal Parenchyma Tumors
1. Pineocytoma
2. Pineoblastoma
3. Mixed pineocytoma/pineoblastoma
9. Tumors with neuroblastic or glioblastic elements (embryonal tumors)
1. Medulloepithelioma
2. Primitive neuroectodermal tumors with multipotent differentiation
1. medulloblastoma
1. variants: medullomyoblastoma, melanocytic medulloblastoma, desmoplastic medulloblastoma
2. cerebral primitive neuroectodermal tumor
3. Neuroblastoma
1. variant: ganglioneuroblastoma
4. Retinoblastoma
5. Ependymoblastoma

Other CNS Neoplasms

1. Tumors of the Sellar Region
1. Pituitary adenoma
2. Pituitary carcinoma
3. Craniopharyngioma
2. Hematopoietic tumors
1. Primary malignant lymphomas
2. Plasmacytoma
3. Granulocytic sarcoma
4. Others
3. Germ Cell Tumors
1. Germinoma
2. Embryonal carcinoma
3. Yolk sac tumor (endodermal sinus tumor)
4. Choriocarcinoma
5. Teratoma
6. Mixed germ cell tumors
4. Tumors of the Meninges
1. Meningioma
1. variants: meningothelial, fibrous (fibroblastic), transitional (mixed), psammomatous, angiomatous, microcystic, secretory, clear cell, chordoid, lymphoplasmacyte-rich, and metaplastic subtypes
2. Atypical meningioma
3. Anaplastic (malignant) meningioma
5. Non-menigothelial tumors of the meninges
1. Benign Mesenchymal
1. osteocartilaginous tumors
2. lipoma
3. fibrous histiocytoma
4. others
2. Malignant Mesenchymal
1. chondrosarcoma
2. hemangiopericytoma
3. rhabdomyosarcoma
4. meningeal sarcomatosis
5. others
3. Primary Melanocytic Lesions
1. diffuse melanosis
2. melanocytoma
3. maliganant melanoma
1. variant meningeal melanomatosis
4. Hemopoietic Neoplasms
1. malignant lymphoma
2. plasmactoma
3. granulocytic sarcoma
5. Tumors of Uncertain Histogenesis
1. hemangioblastoma (capillary hemangioblastoma)
6. Tumors of Cranial and Spinal Nerves
1. Schwannoma (neurinoma, neurilemoma)
1. cellular, plexiform, and melanotic subtypes
2. Neurofibroma
1. circumscribed (solitary) neurofibroma
2. plexiform neurofibroma
3. Malignant peripheral nerve sheath tumor (Malignant schwannoma)
1. epithelioid
2. divergent mesenchymal or epithelial differentiation
3. melanotic
7. Local Extensions from Regional Tumors
1. Paraganglioma (chemodectoma)
2. Chordoma
3. Chodroma
4. Chondrosarcoma
5. Carcinoma
8. Metastatic tumours
9. Unclassified Tumors
10. Cysts and Tumor-like Lesions
1. Rathke cleft cyst
2. Epidermoid
3. Dermoid
4. Colloid cyst of the third ventricle
5. Enterogenous cyst
6. Neuroglial cyst
7. Granular cell tumor (choristoma, pituicytoma)
8. hypothalamic neuronal hamartoma
9. nasal glial herterotopia
10. plasma cell granuloma

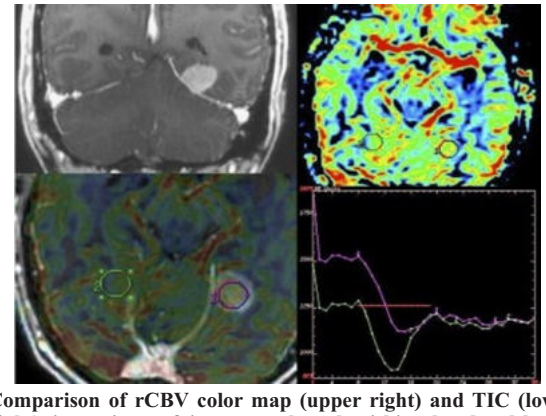
CASES:

Case 1:



PMR TIC (lower right) and rCBV map (left) demonstrate very high microvascular blood volume. The low return to baseline of the lesion TIC (green curve) compared with normal brain(purple curve) is characteristic of high first-pass leak in an extra-axial lesion without a BBB. In this case, the high permeability also produces prominent enhancement on the delayed post-Gd T1-weighted image (upper right) in a pattern strongly suggestive of high grade meningioma.

Case 2:



Comparison of rCBV color map (upper right) and TIC (lower right) in regions of interest selected within the dural-based enhancing lesion (lower left, purple) and an appropriate region of interest in the contralateral white matter (lower left, green) demonstrate the characteristic high first-pass leak of a nonglial tumor (TIC) and blood volume only minimally higher than white matter (TIC and rCBV color map). In combination with the appearance on coronal post-Gd T1-weighted image (upper left), the perfusion imaging strongly suggests dural metastasis, confirmed at biopsy to be from non–small cell lung carcinoma.

CONCLUSION:

Dynamic contrast-enhanced perfusion weighted imaging provides important physiological information that cannot be obtained by conventional MRI. rCBV remains most important perfusion weighted

MRI findings for grading of intra-or extra-axial intracranial neoplastic lesions that can help deciding further management strategy.

MR spectroscopy showed that high choline peak and increased choline to creatinine ratio in peri tumoral areas are important parameters to differentiate between primary brain tumours from metastases.

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