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The Significance of Contrast-Enhanced FLAIR Sequences in MRI for Intracranial Pathology Evaluation

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Abstract

Background and Aim: Magnetic resolution imaging (MRI) has superior soft tissue contrast for characterization and diagnosing various intracranial lesions. Various MRI techniques are used for characterizing intracranial lesions. Post contrast T1 imaging is the traditional technique used for assessing lesion contrast enhancement. The aim of this study was to identify and describe intracranial neoplasms through the use of CT and MRI imaging. It also sought to compare the benefits and drawbacks of each imaging technique, emphasising how they work together in the diagnostic evaluation of intracranial neoplasms.

Material and Methods: The research involved a cohort of fifty patients who received a diagnosis of intra neoplasms from their healthcare providers. By utilising a structured proforma, essential information including age, gender, radiological findings, and clinical indications was collected. By utilising a structured proforma, essential information including age, gender, radiological findings, and clinical indications was collected. Prior to and following the administration of contrast material, most preoperative CT scans were conducted o before the scheduled operations.

Results: There were fifteen patients who did not exhibit any symptoms, and the examination revealed that the findings were coincidental. The participants were analyzed by esions on both post contrast sequences, comparison of degree of contrast enhancement of all intracranial lesions on both post contrast sequences, comparison between various intra-axial & extra-axial intracranial lesions on both post contrast sequences, comparison between various intracranial lesions based on their etiology on both post contrast sequences and comparison of each intracranial lesion on both post contrast sequences.

Conclusion: The study suggests that the overall degree of contrast enhancement is superior for contrast enhanced T1 sequences for the majority of the lesions, however complete lesion pathology cannot be assessed on this sequence alone. Although post contrast FLAIR sequence has shown greater degree of contrast enhancement in infectious. Further studies with more sample size should be assessed to establish the significance. Therefore, contrast enhanced FLAIR sequence is an important adjunct for imaging of the various intracranial pathologies and should be incorporated for evaluating various intracranial pathologies..

Introduction

Intracranial neoplasms, which involve abnormal cell growth within the cranial vault, pose significant challenges in both diagnosis and management. Brain tumours are categorised according to their growth rate and the likelihood of recurrence following treatment. These can be primarily classified into two main categories: malignant and benign. Benign tumours are non-

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cancerous growths that typically develop at a slower pace and have a lower likelihood of recurrence following treatment. Malignant tumours consist primarily of cancer cells, which possess the capability to invade surrounding tissues. Additionally, they can disseminate to various regions of the body through a process known as metastasis.[1,2]

The advancements in medical imaging have greatly enhanced our capacity to comprehend and tackle these challenges. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are essential imaging techniques, each providing distinct advantages in the assessment of these neoplasms. This study explores the thorough assessment of intracranial tumours by combining MR and CT imaging techniques.[3,4]

The MRI, known for its exceptional soft tissue contrast and ability to produce images in multiple planes, offers detailed insights that are crucial for accurately defining tumour boundaries and evaluating adjacent anatomical features. CT demonstrates exceptional spatial resolution, allowing for the clear visualisation of haemorrhage, calcifications, and bone details. This capability is crucial for comprehending bony involvement and the vascular structures within the cranial vault.[5,6]

This research undertakes a retrospective analysis of confirmed intracranial neoplasm cases, with the goal of highlighting the complementary strengths of MRI and CT imaging techniques. This study examines the fundamental morphological features while also utilising advanced imaging techniques, including diffusion-weighted imaging and spectroscopy, to gain a more comprehensive understanding of the functional and metabolic properties of these neoplasms.[7,8]

The results of this study hold the potential to enhance diagnostic accuracy, improve treatment monitoring and strategies, and foster a deeper understanding of the intricate nature of intracranial neoplasms. The aim of this study was to identify and describe intracranial neoplasms through the

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use of CT and MRI imaging. It also sought to compare the benefits and drawbacks of each imaging technique, emphasising how they work together in the diagnostic evaluation of intracranial neoplasms.

Materials & Methods

The department of radio diagnosis at C. U. Shah Medical College in Surendranagar undertook the task of conducting this thorough retrospective analysis. Before the study commenced, a clearance certificate was obtained, and the ethical committees were given detailed information about the research experiment. The research involved a cohort of fifty patients who received a diagnosis of intra neoplasms from their healthcare providers. Before the patients engaged in the study, they received a thorough explanation of the procedure that would be implemented, and they took the necessary step of signing an informed consent form. The following criteria were established to identify participants for inclusion in the study:

Patients diagnosed with intracranial space-occupying lesions, regardless of whether these were developmental, inflammatory, or neoplastic at the time of diagnosis, were eligible to participate in the study.

It was found that individuals with a prior medical condition and those over the age of 80 were not eligible to take part in the study.

To carry out retrospective research, we gathered demographic information along with brain radiological reports. These reports included imaging findings and clinical indications for patients who were referred to this study centre over the past two years, all sourced from the archives. By utilising a structured proforma, essential information including age, gender, radiological findings, and clinical indications was collected. Prior to and following the administration of contrast material, most preoperative CT scans were conducted before the scheduled operations.

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Each patient in the radiodiagnosis department underwent imaging using a 1.5-Tesla magnetic resonance imaging (MRI) unit. We utilised T1 weighted images (T1 WI) characterized by short repetition times (TR) between 400 to 500 milliseconds and short echo times (TE) ranging from 15 to 25 milliseconds. T2 weighted spin echo images (T2 WI) are obtained with long TR lengths between 3500 and 5000 milliseconds and long TE lengths from 80 to 100 milliseconds, in addition to Fluid Attenuation Inversion Recovery (FLAIR) images. T1 images enhanced with gadolinium, featuring TE values between 15 and 25 milliseconds.

A total of thirty males and twenty females participated in the research study. The study included patients whose ages varied from 10 to 80 years. The study involved a retrospective analysis, during which the hospital records were carefully evaluated. Participation in the study was limited to patients who fulfilled the necessary criteria. A thorough examination of the demographics of the included patients was conducted. CT and MRI imaging was advised for all patients included in the study.

The statistical analysis of the data was conducted using the statistical package for social science (SPSS) version 16. The analysis indicated that a P value of 60.05 was considered significant for interpreting the results.

Results

As a whole, there were fifty patients who participated in the research. Out of the total population, there were thirty males and twenty females, ranging in age from ten to eighty years old. There were fifteen patients who did not exhibit any symptoms, and the examination revealed that the findings were coincidental. The majority of the remaining 35 patients exhibited symptoms such as the presence of headaches and altered sensorium, while only a small number of patients complained of experiencing dizziness. A small number of patients were the only ones who

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experienced major symptoms such as seizures, loss of control over voluntary activities, and unconsciousness.

The appearances of intracranial neoplasms varied between CT and MRI.

The low grade glioma

Appearance of CT :- Hypodense to adjacent parenchyma.

Appearance on MRI:-

T1:- Hypointense

T1 + C:- Non enhancing to minimal peripheral enhancement can be seen.

T2 and FAST FLAIR:- Hyperintense

DWI:- No restriction

Oligodendroglioma:

Appearance of CT :-

It shows heterogenous (Iso- to hypodense) appearance with internal/peripheral hyperdensities signifying calcifications more than hemorrhages.

On post-contrast images it shows variable enhancements.

Appearance on MRI:-

T1:- Hypointense

T1 + C:- Variable enhancement can be seen.

T2 and FAST FLAIR:- Hyperintense

DWI:- No restriction

GRE/SWI:- Calcific and haemorrhagic areas show blooming

GLIOBLASTOMA

Appearance of CT :-

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Iso- to hyperdense thick irregular margins with central hypodense core.

Heterogenous, mostly peripheral enhancement is seen on post-contrast studies.

Appearance on MRI:-

T1:- Hypo- to isointense with central heterogenous core.

T1 + C:- Variable peripheral and irregular enhancement with nodular components.

T2 and FAST FLAIR:- Hyperintense with surrounding vasogenic edema.

Occasionally flow voids are seen.

DWI:- Hyperintensity involving the solid component of the tumour is seen.

GRE/SWI:- Hypointense irregular and incomplete rim within the peripheral enhancing part of the tumour suggestive of blood products is seen.

CAVERNOMA

Appearance of CT:-

Well defined and round in shape. Appear hyperdense due to blood products.

Appearance on MRI:-

Popcorn or berry appearance with peripheral hypointense rim due to hemosiderin deposits.

T1:- Varied signal depending on the age of blood products with fluid-fluid levels.

T1 + C:- No enhancement is seen.

T2 and FAST FLAIR:- Varied signal depending on the age of blood products with fluid-fluid levels and flow voids.

GRE/SWI:- Prominent blooming is seen. These sequences are useful in detecting smaller lesions which can be missed otherwise in conventional sequences.

DWI:- No diffusion restriction is seen.

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MENINGIOMA

Appearance of CT :-

They are well defined, extra-axial lesions appearing iso- to hyperdense with some of them showing edema in adjacent brain parenchyma. It may show focal calcifications while some of them are completely calcified (Burnt out meningiomas). On contrast administration, they show strong homogenous enhancement. Malignant or cystic variants may show heterogenous pattern of enhancement.

Appearance on MRI:-

Well defined extra-axial masses with broad dural base.

T1:- Isointense to grey matter.

T1 + C:- Intense homogenous enhancement of the tumour is seen with visualisation of dural tail (70% cases) and sun-burst/spoke wheel pattern of vessels within the tumor.

T2 and FAST FLAIR:- Usually isointense to grey matter.

If hypointense, it represents the hard and fibrous structure of the tumour.

If hyperintense, it represents microcystic, secretory, cartilaginous, chordoid and angiomatous variants.

GRE/SWI:- Calcified components show blooming.

DWI:- No diffusion restriction is seen in grade I tumours, however grade II and III tumours may show variable degree of diffusion restriction.

ARACHNOID CYST

Appearance of CT :-

Well defined extra-axial hypodense (CSF density HU=0-15) lesion in subarachnoid space.

Appearance on MRI:-

T1:- Hypointense.

T2 :- Hyperintense.

FAST FLAIR:- Hypointense due to fluid suppression.

DWI:- No diffusion restriction is seen.

CEREBRAL ABSCESS

Appearance of CT :-

Double rim sign: - Outer hypodense rim (Vasogenic oedema) with inner hyper dense rim is seen.

Intense peripheral ring enhancement is seen on post contrast studies.

Appearance on MRI:-

Well defined extra-axial masses with broad dural base.

T1:- Central hypointensity (Relatively hyperintense to CSF)

T1 + C:- Ring enhancement.

T2 and FAST FLAIR:- Central hyperintensity (Hypointense to CSF) which does not supress. Peripheral vasogenic oedema is seen. Abscess capsule may be iso to hypointense.

GRE/SWI:- Peripheral hypointense rim which overlaps the contrast enhancing rim.

DWI:- Trye restricted diffusion is seen in central part.

EPIDERMOID CYST

Appearance of CT:- The combination of cellular debris along with a high cholesterol content lower the density of epidermoids to approximately 0 HU, and can thus be identical in density to CSF, and look the same as an arachnoid cyst.

Appearance on MRI:-

T1:- usually isointense to CSF. Rare intralesional haemorrhage can also result in intrinsic high signal.

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T1 + C:-. thin enhancement around the periphery may sometimes be seen.

T2 and FAST FLAIR:- usually isointense to CSF (65%). slightly hyperintense (35%) to grey matter

DWI:- very bright on DWI. similar ADC values compared to adjacent brain parenchyma.

MALIGNANT MELANOMA

Appearance of CT :-

Typically, intracranial melanoma metastases consist of single or multiple nodules with increased attenuation on CT. Out of a series of 101 patients with cerebral melanoma metastases, 62% were found to have multiple lesions (53% localised bilaterally), and 72% of these lesions had increased attenuation.

NECT: single to multiple nodules of increased attenuation localised to the gray/white matter junction; variable oedema and frequent intratumoural haemorrhage present

CECT: nodules typically enhance; dural-based, well-enhanced lesions are impossible to differentiate from meningiomas

Appearance on MRI:-

The blood products alter the signal on MRI resulting in hyperintensity on T1 and hypointensity on T2 images.

T1:- typically hyperintense secondary to haemorrhage or melanin

T1 + C:-. typically enhances in a peripheral rim pattern or a diffusely heterogeneous pattern

T2 and FAST FLAIR:- typically hypointense

SWI/T2: susceptibility artifacts are commonly encountered secondary to haemorrhage.

PITUITARY MACROADENOMA

Appearance of CT :-

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Non-contrast attenuation can vary depending on haemorrhagic, cystic, and necrotic components. Solid adenomas without haemorrhage, typically have attenuation similar to the brain (30-40 HU) and demonstrate moderate contrast enhancement.

Appearance on MRI:-

MRI is the preferred imaging modality. It is able to delineate the mass exquisitely as well as clearly visualise the optic chiasm, anterior cerebral vessels, and cavernous sinuses.

T1:- typically isointense to grey matter. larger lesions are often heterogeneous and vary in signal due to areas of cystic change/necrosis/haemorrhage

T1 + C:- solid components demonstrate moderate to bright enhancement

T2 and FAST FLAIR:- typically isointense to grey matter

GRE/SWI : most sensitive for detecting any haemorrhagic components, which appear as areas of signal loss. Calcification is rare but should be excluded by reviewing CT scans.

BRAIN METASTASIS

Appearance of CT :-

Often the first line of imaging, contrast-enhanced CT was previously thought to be equivalent to MRI for the detection of metastases. However, MRI technology has been shown to be more sensitive than CT and is the preferred imaging of choice.

Appearance on MRI:-

T1:- typically iso- to hypointense. If haemorrhagic may have intrinsic high signal.

T1 + C:- nhancement pattern can be uniform, punctate, or ring-enhancing.

T2 and FAST FLAIR:- typically hyperintense

DWI/ADC : oedema is out of proportion with tumour size and appears dark on DWI. ADC demonstrates facilitated diffusion in oedema.

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TUBERCULOMA

Appearance of CT :- On CT, tuberculomas may appear as a round or lobulated nodule with moderate to marked oedema. Either solid or ring enhancement is typical post-contrast. A central focus of calcification with a ring of peripheral enhancement (the "target sign") is described but is not specific to tuberculosis. When calcification is present it tends to be larger than that calcification seen in neurocysticercosis.

Appearance on MRI:-

T1:- iso- to- hypointense

T1 + C:- homogeneous enhancement

T2 : hyperintense

FAST FLAIR:- no suppression

DWI : no restricted diffusion

NEUROCYSTICERCOSIS

CT: hyperattenuating to CSF

MRI T1: hyperintense to CSF

Discussion

Physiologic imaging, along with high-resolution structural imaging, plays a crucial role in the imaging and clinical management of patients diagnosed with brain tumours. This progression has unfolded over time and remains an ongoing process. Imaging remains a valuable noninvasive tool that can significantly enhance the management of patients with brain tumours. To effectively plan the required intervention, it is crucial to achieve an early diagnosis of intracranial neoplastic lesions due to the significant morbidity and mortality rates linked to these conditions.[9,10]

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The advancement of imaging techniques, particularly computed tomography (CT) and magnetic resonance imaging (MRI), has significantly enhanced our ability to visualise intracranial neoplastic space-occupying lesions. This advancement allows for exceptional anatomical detail to be achieved in the axial, sagittal, and coronal planes, enabling a thorough characterisation of the tumoral tissue. An MRI offers several benefits compared to a CT scan. It can accurately assess the specific characteristics of a lesion, identifying whether it is diffuse or focal, and can also help determine the presence of a residual tumour or a recurrence.[11,12]

The diagnosis of brain tumours involves three key processes: detecting the tumour, segmenting it, and classifying it. The identification of MRI images of tumours from a database represents a prevalent application of brain tumour detection techniques. This process is essential and should be clearly understood by everyone. Techniques for brain tumour segmentation are employed to effectively localise and isolate different tumour tissues within magnetic resonance imaging (MRI) images. Additionally, methods for classifying brain tumours are employed to distinguish abnormal images as either malignant or benign tumours.

Most cases typically presented with a complaint of headache. In fifty percent of the cases, this was observed, which aligns with the findings reported by Goyani et al. (51.42%) and Snyder et al. (55.4%). Seizures represented the second most frequent presenting complaint, occurring in twenty percent of the cases. This finding aligns with the research conducted by Bhavesh Goyani et al., which reported a percentage of 30.85, and Snyder et al., who found a percentage of 23.76%. In our study, we observed that 13.3% of patients exhibited altered mental status. This finding aligns with the research conducted by Goyani et al. and Snyder et al., which reported that 50.49% of patients experienced this condition.

CONCLUSION:

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This study examined 50 cases of intracranial neoplasms, offering important insights into their demographic characteristics, clinical presentation, and treatment results. The patient population encompassed a diverse age range, with a minor predominance of males. Headaches and neurological deficits were the most frequently reported symptoms, with differing lengths of time before a diagnosis was made. The MRI stands out as a highly effective diagnostic tool, offering detailed imaging characteristics that are essential for accurate diagnosis and treatment planning.

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