Section: Radiodiagnosis

Original Research Article

ROLE OF COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING IN NONTRAUMATIC NEUROEMERGENCIES

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Received : *08/03/2025*
Received in revised form : *01/05/2025*
Accepted : *18/05/2025*

Keywords:
Non traumatic neuroemergencies, Acute infarct, computed tomography, Magnetic resonance imaging, hemorrhage, Intracranial infection, Endephalopathy.

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DOI: 10.47009/jamp.2025.7.3.100

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (3); 531-539

ABSTRACT

Background: Various clinical presentations require emergent neurological imaging to establish the cause of the neurological deficit and to institute appropriate therapy. Trauma being the most common neurological emergency requiring emergency medical attention. Non traumatic neurological emergencies constitute a set of medical conditions which require fast diagnosis and appropriate treatment. Time is crucial because neurons that are lost cannot be regenerated. Generally, the clinical symptoms are due to ischemia, compression, or destruction of neural elements. The two primary imaging modalities for the central nervous system (CNS) are computed tomography (CT) and magnetic resonance imaging (MRI). CT is fast and can promptly detect hemorrhage and thrombus. Multi planar reformations in CT scan can substantiate various findings. MRI provides better contrast resolution and has higher specificity for most CNS diseases. In this we are describing imaging findings of non- traumatic neuro-emergencies. Objective: To describe imaging spectrum of various non traumatic neuroemergencies in tertiary care hospital. **Materials and Methods:** A retrospective study was done on patients who were referred for CT or MRI brain to department of Radio-Diagnosis with acute neurological symptoms. This study was conducted between march 2024 to march 2025 at PESIMSR, kuppam, India using 32 detector MDCT and 1.5 T MRI. **Results:** A total 262 patients showed positive findings. Out of 262 cases , most common age group is around 60-80 yrs (53 %). Males (57 %) were affected more commonly than females (43%). Infarcts being the most common cause found in 141 cases (54.3 %) , acute intracranial non traumatic hemorrhages were seen in 50 patients (19%) , intracranial infections were found in 36 patients (14%), Cerebral venous thrombosis were seen in 13 patients (5%) , posterior reversible encephalopathy syndrome was seen in 9 patients (3.5%),and encephalopathy in 9 patients (3.5 %). **Conclusion:** Non-traumatic neurological emergencies require urgent diagnosis and treatment to minimize permanent damage to the nervous system. Imaging modalities like CT and MRI are vital tools that help clinicians identify the cause of neurological deficits quickly and accurately. MDCT offers fast results and is highly effective in detecting hemorrhages, while MRI provides greater detail and sensitivity, especially for ischemic changes, infections. Understanding the imaging findings specific to each condition ensures better management and improved patient outcomes.

INTRODUCTION

Various clinical presentations require emergent neurological imaging to establish the cause of the neurological deficit and to institute appropriate therapy. Trauma being the most common neurological emergency requiring emergency medical attention. Non traumatic neurological emergencies constitute a spectrum of medical conditions which necessitate timely diagnosis and appropriate treatment.[1]

Acute infarct, various causes of non traumatic intracranial hemorrhages, intracranial infections, cortical venous thrombosis, posterior reversible encephalopathy syndrome and other encephalopathies are some of the conditions which constitute non traumatic neurological emergencies and requiring timely diagnosis and treatment. Time is crucial because neurons that are lost cannot be regenerated. Generally, the clinical symptoms are due to ischemia, compression, or destruction of neural elements.[2]

The two primary imaging modalities for the central nervous system (CNS) are computed tomography (CT) and magnetic resonance imaging (MRI).

CT is fast and can promptly detect hemorrhage and thrombus. Multi planar reformations in CT scan can substantiate various findings. MRI provides better contrast resolution and has higher specificity for most CNS diseases.

In this we are describing imaging findings of non-traumatic neuro-emergencies. Non-traumatic neurological emergencies require urgent diagnosis and treatment to minimize permanent damage to the nervous system. Imaging modalities like CT and MRI are vital tools that help clinicians identify the cause of neurological deficits quickly and accurately. MDCT offers fast results and is highly effective in detecting hemorrhages, while MRI provides greater detail and sensitivity, especially for ischemic changes, infections. Understanding the imaging findings specific to each condition ensures better management and improved patient outcomes.

Objective

To describe imaging spectrum of various non traumatic neurological emergencies in tertiary care hospital.

MATERIALS AND METHODS

Study Design: This was a retrospective study conducted in the department of Radio Diagnosis at PES institute of medical sciences and Research, Kuppam, between march 2024 to march 2025.The study included a total of 262 patients who underwent CT / MRI with findings of acute non traumatic neurological emergencies.

Inclusion Criteria

- Patients who presented with acute neurological symptoms.

Exclusion Criteria

- Patients who underwent trauma.
- Pediatric age group.

CT and MRI Imaging protocols

CT scans were performed using GE Revolution Aspire 32- slice CT scanner with slice thickness of 5mm. MRI scans were performed using GE signa1 1.5 T MRI.

RESULTS

Acute Stroke

Stroke is a leading cause of mortality and morbidity in the developed world. The primary goals of an imaging evaluation for acute stroke are to establish a diagnosis as fast as possible and to attain precise information about the intracranial vasculature and brain perfusion for guidance in selecting the appropriate therapy.

A comprehensive evaluation may be performed with a combination of computed tomography (CT) or magnetic resonance (MR) imaging techniques.

Unenhanced CT can be performed quickly, can help identify early signs of stroke, and can help rule out hemorrhage. These examinations are easy to perform on most helical CT scanners with multiple reformations and are increasingly used in stroke imaging protocols to decide whether intervention is necessary. It also can help detect early-stage acute ischemia by depicting features such as the hyperdense vessel sign, the insular ribbon sign, and obscuration of the lentiform nucleus. The last two features are caused by a loss of contrast between gray matter and white matter on CT images.[5]

MRI as the initial imaging modality for the evaluation of acute ischemic stroke has gained traction as it offers superior assessment of parenchymal integrity, tissue viability, and the extent of ischemic injury.[6] The MR sequences typically used in the evaluation of acute stroke include T1W FSE, T2W FSE, DWI , FLAIR, T2*-W GRE, and gadolinium-enhanced T1-weighted spin-echo sequences.MR images including sequences like diffusion-weighted imaging combined with ADC mapping is more sensitive for detection of hyperacute ischemia. Typical MR imaging findings in patients with hyperacute cerebral ischemia include hyperintense signal on T2- weighted images and fluid-attenuated inversion recovery images, with a resultant loss of gray matter–white matter differentiation, sulcal effacement and mass effect. DWI–FLAIR mismatch is useful in detecting the salvageable tissue to perform reperfusion. Gradient-echo MR sequences can be helpful for detecting a hemorrhage. The status of neck and intracranial vessels can be evaluated with MR angiography. Time-of-flight MR angiography and contrast-enhanced MR angiography are commonly used to evaluate the intracranial and extra cranial circulation. Loss of the arterial flow voids seen on T2- weighted images and stasis of contrast material within vessels in the affected territories can be seen. The information obtained by combining various imaging techniques may help differentiate patients who do not need intravenous or intraarterial therapy from those who do, and may alter clinical outcomes.[5]

Demography

In our study,141 cases (54.3 %) of acute infarcts were found.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Age Range: 27-89 yrs.
Males were affected more commonly than females.

Table 1: Infarcts distribution according to vascular territory

Infarcts	Frequency	Percentage
MCA Territory	28	19.8 %
ACA Territory	5	3.5%
PCA Territory	2	1.4%
PICA Territory	1	0.7%
Capsulo-ganglionic region	33	23.4%
Others (Miscellaneous)	72	51%

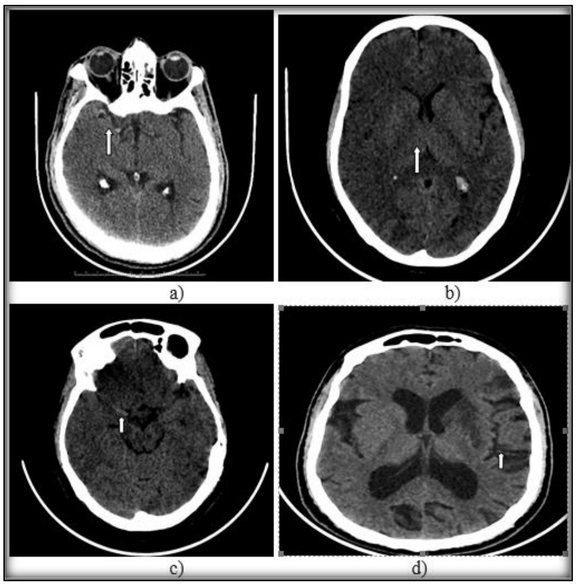
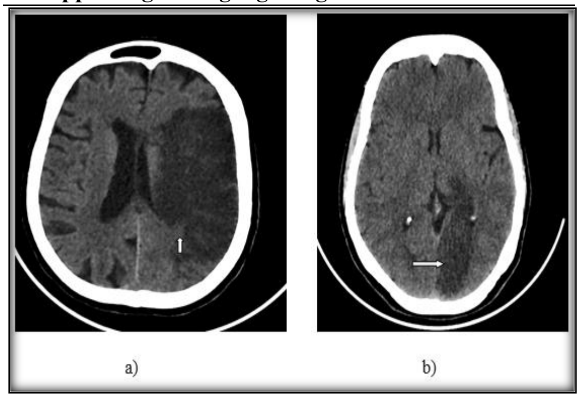
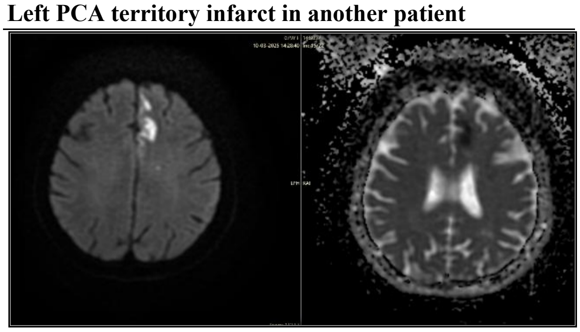


Fig 1: Axial CT images showing CT signs of early acute infarct A and C showing hyperdense MCA sign. Loss of insular ribbon sign on right side in image B. Dissappearing basal ganglia sign in D.



a) Axial CT image showing wedge shaped hypodensity in left MCA territory – Left MCA territory infarct. b) Left PCA territory infarct in another patient



c) Axial DWI with corresponding low ADC showing acute infarct in Left ACA territory

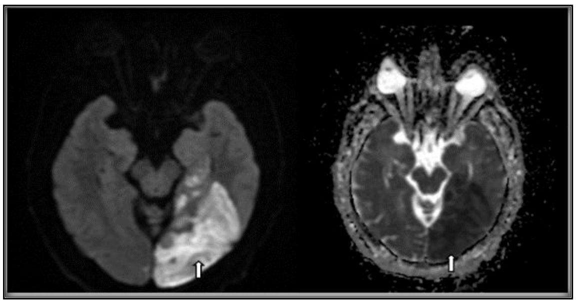


Fig d) DWI with ADC mapping with acute infarct in left PCA territory

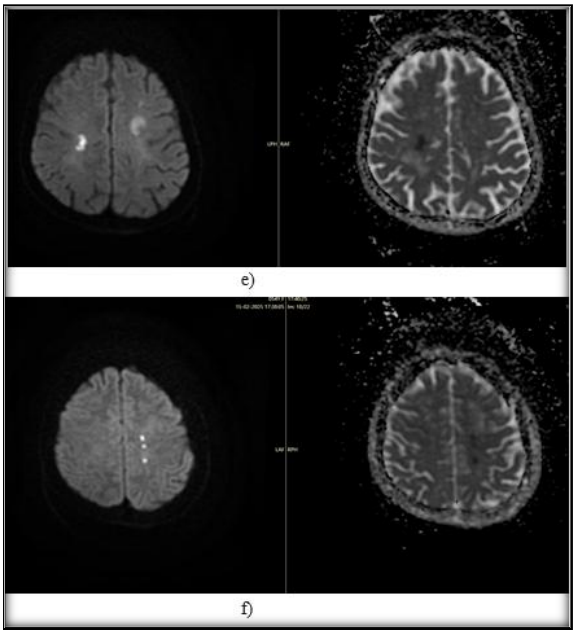


Fig2 E showing acute cortical watershed infarct between ACA and MCA territory. F showing acute deep watershed infarcts

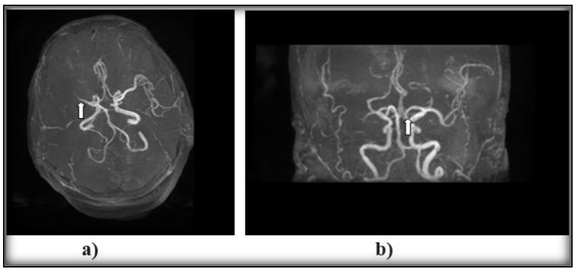


Fig 3: TOF MRA showing non visualization of right MCA in axial (a) and coronal (b) images in patient with MCA territory infarct.

Intracranial Hemorrhage

Intracranial hemorrhage is common and is caused by various pathologies. Hypertension being the most common after to trauma, cerebral amyloid angiopathy, hemorrhagic conversion of ischemic infarction, intracranial aneurysmal rupture, cerebral arteriovenous malformations, dural arteriovenous fistula, vasculitis, and venous sinus thrombosis, among other causes.

Neuroimaging is essential to identify the exact cause of hemorrhage and to understand the location and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

severity of hemorrhage, the risk of impending cerebral injury, and to guide often emergent patient treatment. CT is most sensitive in identifying hemorrhage.[7]

MRI pulse sequences of T1- and T2-weighted images are sensitive for the detection of subacute and chronic blood. Hyperacute parenchymal blood can be accurately detected using gradient recalled echo (GRE) pulse sequences that are sensitive to static magnetic field inhomogeneity (T2*sensitive). These sequences detect the paramagnetic effects of deoxyhemoglobin and methemoglobin.[8]

Our study included 50 patients with intracranial hemorrhage.

Age range of 20 – 75 yrs.

Males were affected more commonly than females.

Table 2: Hemorrhages according to various etiologies

Hemorrhage	Frequency	Percentage
Hypertensive	37	74
Amyloid angiopathy	2	4
Aneurysmal SAH	2	4
Hemorrhagic Metastasis	2	4
Cavernoma	2	4
CVT bleed	5	10

Fig 4: A: Axial CT image showing hypertensive bleed in left capsule-ganglionic region with intra ventricular extension of hemorrhage.

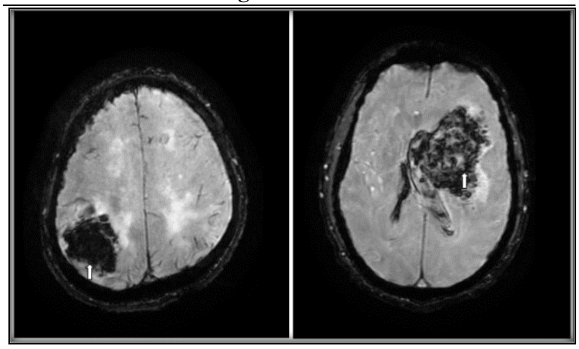


Fig 5: A) Axial GRE image showing peripheral lobar hemorrhage – Due to Amyloid angiopathy.
b) Axial GRE image showing central capsulo-ganglionic region hypertensive bleed.

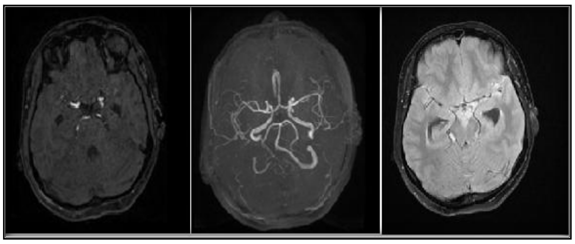


Fig 6: MR TOF images A and B showing Aneurysm in M1 segment of LEFT MCA, c) SAH in same patient

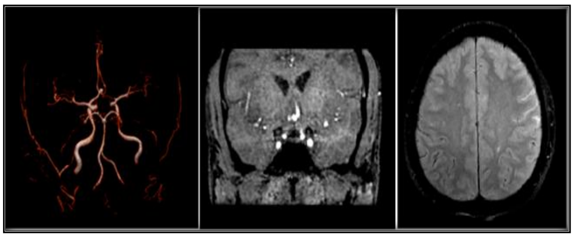


Fig 7: a, b, c : ACOM Aneurysm in Volume rendering and MIP coronal images , with acute subarachnoid hemorrhage in left frontal cortical sulci.

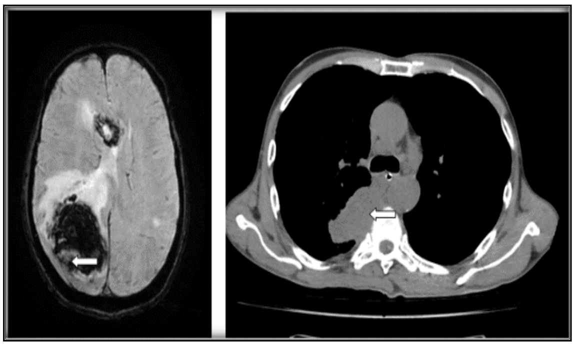


Fig 8: Axial GRE image showing hemorrhagic metastasis in right posterior parietal and occipital lobe , right medial frontal lobe , genu and anterior body of corpus callosum.
Axial CT image showing mass in right lung which is primary in same patient.

(CVT) is a rare but potentially life-threatening condition that presents with highly variable clinical symptoms, making imaging crucial for timely diagnosis. Both CT and MRI play important roles in identifying CVT, but MRI is generally superior, particularly for detecting isolated cortical or deep vein thromboses and associated parenchymal damage. On imaging, a direct sign of venous thrombosis is the identification of the thrombus itself. On non-contrast CT, an early thrombus may appear as a spontaneous hyperdensity in a tubular shape—referred to as the "cord sign." MRI offers greater sensitivity, especially with sequences like T2* and susceptibility-weighted imaging, which highlight blood degradation products. Venous occlusion can be confirmed through venography, which is performed using CT angiography or MR venography. CT angiography offers high-resolution, multiplanar imaging that can reveal the classic "empty delta sign" and is effective even in cortical veins. The parenchymal consequences of CVT can

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be severe, including vasogenic edema, cytotoxic edema, and hemorrhage, which occur in upto half of cases. MRI is the best modality to evaluate these changes, particularly with FLAIR, T2*, and diffusion-weighted imaging. Venous infarcts often lack a classic arterial pattern and may show hemorrhagic components, which are typically subcortical and nodular on imaging. Some cases can present as large lobar hematomas, which should prompt consideration of CVT in the differential diagnosis.[9]

In terms of associated causes, CVT can arise from a wide range of systemic or local factors including inherited thrombophilias, pregnancy, infections, trauma, neoplasms, and intracranial hypotension. Although visible focal causes on imaging are uncommon, radiologists should be aware of them to guide further management.10

Demographics

Age Range : 19- 68 yrs

Males were affected more common than females.

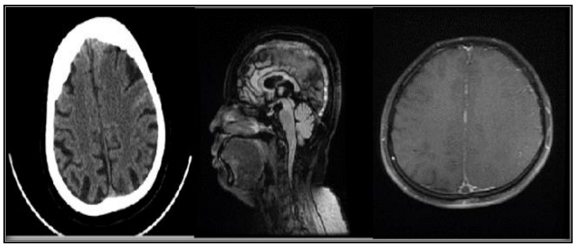

Fig 9: CT axial and T2 FLAIR MR image showing acute thrombus in Superior sagittal sinus. A) Delta sign, B) Cord sign. c) Contrast enhanced T1WI showing empty delta sign.

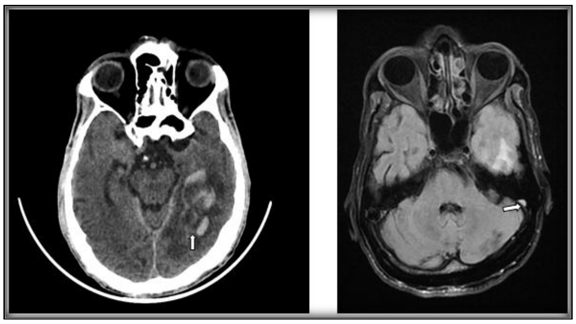

Fig 10: Axial CT image showing hemorrhagic venous infarct in left temporal lobe (non arterial in location), Axial T2 FLAIR showing hyper intensity in left sigmoid sinus.

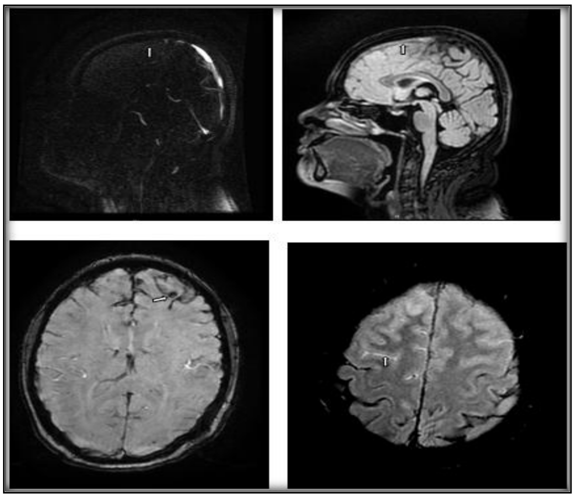

Fig 11: A) MR venogram showing no flow in anterior 2/3rds of Superior saggittal sinus. b) Acute thrombus in anterior 2/rd SSS appearing as T2 hyperintensity. c) Area of blooming in left frontal lobe corresponds to hemorrhagic venous infarct. d) Subarachnoid hemorrhage in bilateral frontal cortical sulci in same patient.

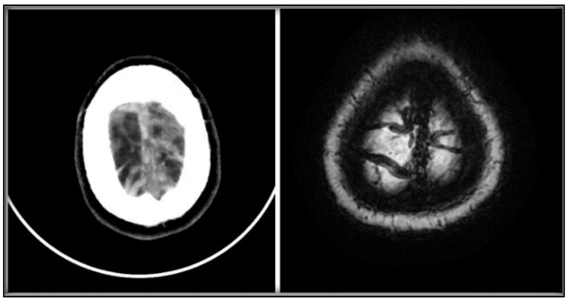

Fig 12: CT and MRI image showing thrombosis in cortical veins . Hyperdense cortical veins in Axial CT and GRE blooming in MRI.

Intracranial Infections

Intracranial infections such as meningitis, cerebritis, abscesses and tuberculomas, represent critical neurological emergencies that require prompt and accurate diagnosis. Neuroimaging plays a pivotal role in their assessment, guiding both diagnosis and treatment strategies. Computed Tomography (CT) is often the first imaging modality used due to its wide availability and speed, particularly in acute settings. It can identify complications such as hydrocephalus, mass effect, hemorrhage, but has limited sensitivity for early or subtle changes in infection, particularly in meningitis where findings may be minimal or nonspecific.[11]

Magnetic Resonance Imaging (MRI), with its superior soft tissue contrast, is more sensitive than CT in detecting the early and subtle features of intracranial infections. In meningitis, MRI demonstrates leptomeningeal enhancement on post-contrast T1-weighted images, and FLAIR sequences can highlight sulcal hyperintensities reflecting meningeal inflammation. In cases of cerebritis and brain abscesses, MRI not only detects the lesions earlier than CT but also characterizes them more accurately. Brain abscesses typically appear as ring-

ISSN (O): 2687-5365; ISSN (P): 2753-6556

enhancing lesions with central restricted diffusion on diffusion-weighted imaging (DWI), a hallmark feature that helps distinguish them from necrotic tumors or other mimics.[12]

Tuberculous infections of the central nervous system often present with basal cistern enhancement and tuberculomas, which appear as ring-enhancing lesions with T2 hypointense centers and minimal diffusion restriction. Magnetic Resonance Spectroscopy(MRS) can further aid in differentiating abscesses from neoplastic lesions by analyzing metabolic profiles.[13]

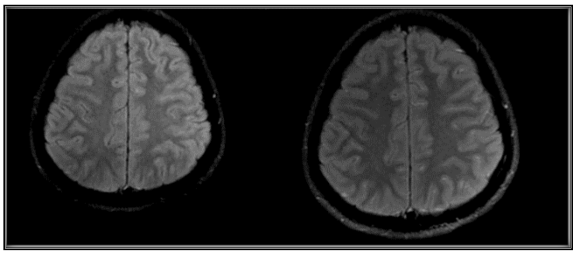

Fig 13: A case of pyogenic meningitis: Axial T2 FLAIR showing hyperintenities in bilateral fronto –parietal cortical sulci. Post contrast T2 FLAIR showing bilateral fronto parietal sulcal enhancement.

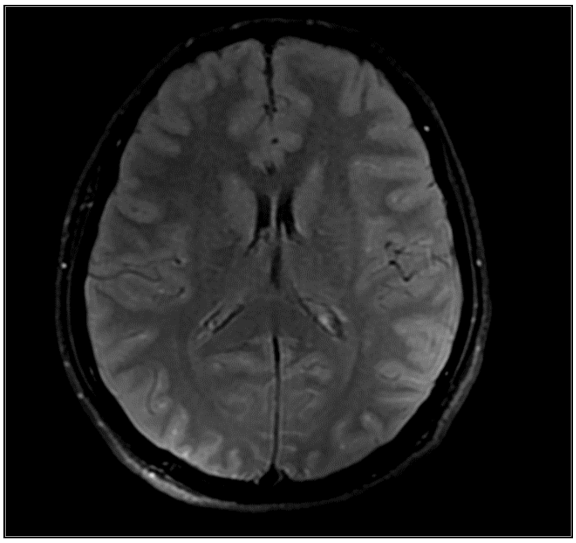

Fig 14: Axial T2 FLAIR image showing sulcal hyperintensities with swelling of grey white matter – Meningoencephalitis.

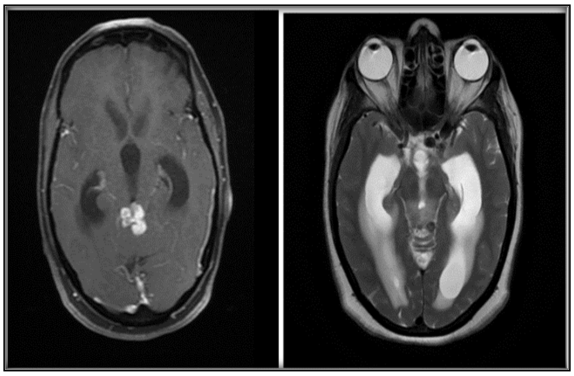

Fig 15: A) Ring enhancing tuberculomas at floor of 4th ventricle B) Showing T2 hypointensity and causing obstructive hydrocephalus.

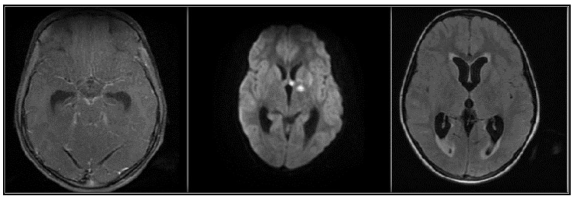

Fig 16: Above images showing tubercular meningitis with enhancing basal exudates. Tubercular endarteritis causing infarcts in basal ganglia region. Hydrocephalus in tubercular meningitis.

Encephalopathy

Encephalopathy refers to a broad clinical condition characterized by diffuse brain dysfunction, often resulting from systemic, metabolic, or toxic disturbances. Encephalopathy generally manifests as altered mental status, ranging from agitation to coma, frequently accompanied by seizures, focal deficits, brainstem signs, or movement disorders. In severe cases, it may lead to permanent neurological damage or death. Spectrum includes wernickes encephalopathy, hypoglycaemic encephalopathy, hypoxic ischaemic encephalopathy, non-ketotic hyperglycaemia, hepatic encephalopathy, uraemic encephalopathy,hyperammonaemic encephalopathy, and posterior reversible encephalopathy syndrome (PRES).Signal changes,diffusion restriction patterns on MRI, and MR spectroscopy findings can aid in diagnosis and management. Nonetheless, definitive diagnosis often requires a combination of imaging, clinical evaluation, and laboratory data. While MRI is the modality of choice, CT remains useful in acute settings due to its speed and accessibility.

Table 3: Distribution of various encephalopathies

Encephalopathy	Frequency
Wernickes encephalopathy	1
Non ketotic hyperglycemia	1
Hypoxic ischemic encephalopathy	2
Metabolic encephalopathy	2
Hyperparathyroidism	1

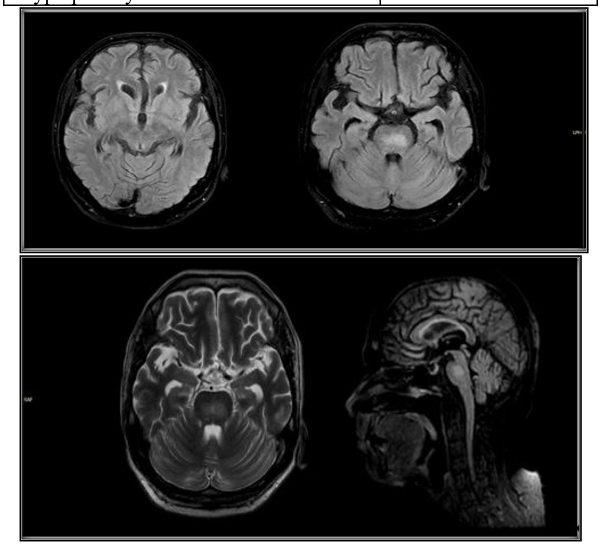

Fig 17: Wernickes encephalopathy: A 45 yr old male patient with altered sensorium and chronic alcoholic abuse : A) FLAIR hyperintensities noted in pons , peri aquductal grey white matter , around 3rd ventricle.

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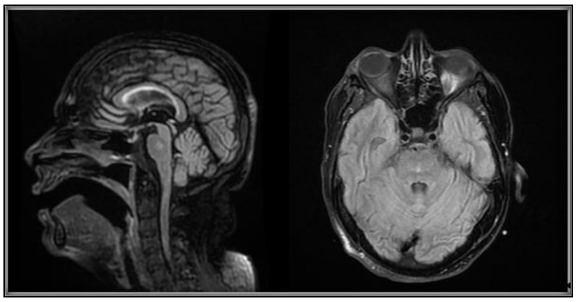


Post thiamine injection, There is significant reduction in hyperintesities in pons and peri aqueductal grey matter. A case of Wernickes encephalopathy

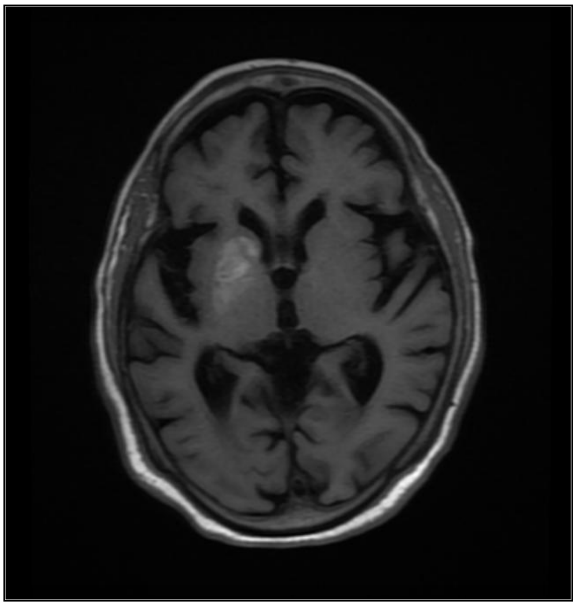
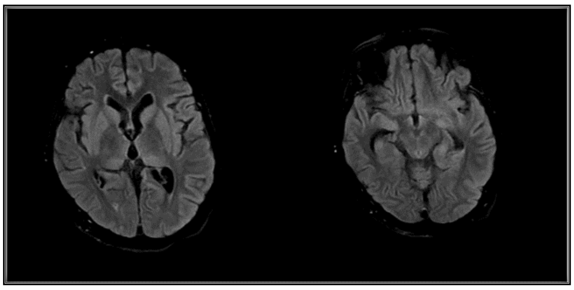


**Fig 18: 68 yr male patient with involvuntary movement of left upper limb and lower limb. On MRI , T1 hyperintensities in right basal ganglia.
A case of Non Ketotic hyperglycaemia.**

Fig 19; Case of uremic encephalopathy : Axial CT showing hypodensities in basal ganglia

Fig 20: A 19 yr old female with atonic PPH has MRI : FLAIR hyperintensities in bilateral thalami, basal ganglia , dorsal midbrain and pons – Hypoxic ischemic encepahloapthy.



On post treatment, there is significant reduction inT2 FLAIR hyperintesties.

PRES

Posterior Reversible Encephalopathy Syndrome (PRES), also known as Reversible Posterior Leukoencephalopathy Syndrome (RPLS) or hypertensive encephalopathy, is a neurological condition marked by non-specific symptoms such as headache, visual disturbances, seizures, and altered mental status. It is commonly associated with acute hypertension, preeclampsia, renal disease, autoimmune disorders, and the use of cytotoxic or immunosuppressive medications like cyclosporin A, tacrolimus, and cisplatin. Although the exact pathophysiology of PRES remains uncertain, it is believed to result from vasogenic edema caused by a disruption of the blood-brain barrier and loss of cerebral blood flow autoregulation, particularly in response to elevated intracranial pressure or hypertension.[2]

Imaging findings typically reveal hypodense areas in the posterior white matter on CT scans and hyperintense signals in the same regions on T2-weighted MRI. The posterior brain regions—especially the parieto-occipital lobes—are most commonly affected, as they have relatively reduced sympathetic innervation. Lesions may also extend to the frontal lobes (68%), temporal lobes (40%), and cerebellar hemispheres (30%). Cortical, subcortical, and deep white matter involvement is common, often appearing bilateral and symmetrical, although asymmetry is seen in about 28% of cases. Bartynski et al. described three main patterns of distribution: holohemispheric (23%), superior frontal sulcus (27%), and predominantly parieto-occipital involvement (22%). Importantly, PRES is considered a medical emergency due to its potential to progress to cerebral infarction or death if not promptly managed. However, with timely treatment—including blood pressure control and

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withdrawal of the causative agent—most patients experience a near-complete resolution of clinical and radiological abnormalities.[3]

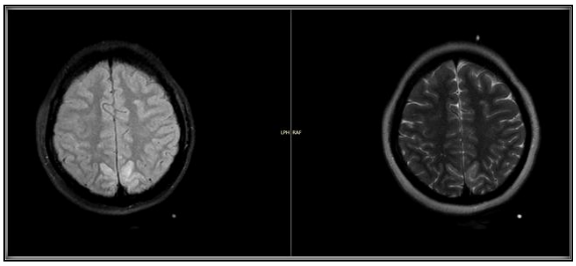

Fig 21 : T2 , FLAIR hyperintensities in bilateral posterior parietal cortical and sub cortical regions – Typical Posterior reversible encephalopathy syndrome.

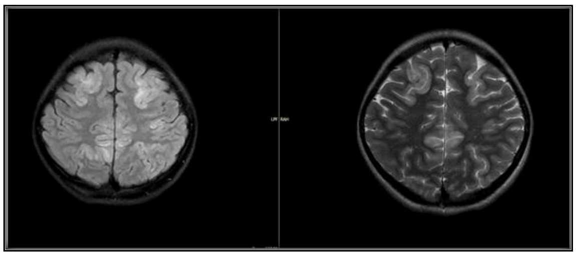

Fig22: Axial T2, FLAIR images showing hyperintensities in bilateral frontal, parieto-occipital regions – Atypical PRES.

DISCUSSION

This study emphasizes the pivotal role of neuroimaging, particularly CT and MRI, in the rapid diagnosis and management of non-traumatic neurological emergencies. The most common condition identified was acute infarction (54.3%), with imaging playing a crucial role in differentiating between ischemic and hemorrhagic strokes—critical for therapeutic decision-making. CT remains the first-line modality for its speed and sensitivity in detecting acute hemorrhage, while MRI, especially with diffusion-weighted imaging (DWI), provides superior sensitivity for early ischemic changes.

Intracranial hemorrhage accounted for 19% of cases, with hypertensive bleeds being the most prevalent. The use of GRE sequences in MRI allowed for better detection of microbleeds and chronic hemorrhages. Rare causes like amyloid angiopathy, aneurysms, and cavernomas were also effectively evaluated through advanced imaging techniques such as TOF MRA and volume rendering.

Cerebral venous thrombosis (CVT), though less common (5%), highlighted the utility of MR venography in identifying venous occlusions and associated parenchymal changes, which are often missed on non-contrast CT.

Intracranial infections (14%) like meningitis, cerebritis, and tuberculomas demonstrated characteristic findings on MRI, such as leptomeningeal enhancement and ring-enhancing lesions with restricted diffusion, aiding in distinguishing infections from neoplastic or other inflammatory causes.

Cases of encephalopathy and PRES (each 3.5%) reinforced MRI's role in diagnosing metabolic and reversible toxic encephalopathies through signal alterations in characteristic brain regions, particularly on FLAIR and T2-weighted sequences.

CONCLUSION

Non-traumatic neurological emergencies encompass a wide range of conditions, including acute infarcts, intracranial hemorrhages, infections, cortical venous thrombosis, and encephalopathies, all of which require prompt recognition and management to prevent irreversible neurological damage. Timely imaging is pivotal in these scenarios, as early diagnosis directly influences treatment decisions and patient outcomes. While CT offers rapid assessment and is particularly effective in identifying hemorrhages, MRI provides superior detail and specificity, especially in detecting ischemic and infectious pathologies. A thorough understanding of the imaging characteristics of various non-traumatic neuro-emergencies is essential for clinicians and radiologists to ensure accurate diagnosis and timely intervention.

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