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Original Article

MRI Features of Neurological Complications During the Postpartum Period: Think beyond CVT and PRES

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Abstract

Background: The assessment of the individual magnetic resonance imaging (MRI) features provides vital clues about the diagnosis of neurological complications during the postpartum period assists in the determination of the common neurological complications, differentiates these neurological disorders on basis of the MRI features, and helps with the early treatment planning. This study aimed to describe various complications that occur during the postpartum period to describe the MRI features of these neurological complications and the differentiating features from each other.

Materials and Methods: The study was a retrospective hospital-based analysis study conducted in the Department of Radiodiagnosis and modern imaging, Maharana Bhopal government hospital and RNT Medical College Udaipur, Rajasthan, India, from October 2017 to September 2018 (All the patients presented during this time frame were included in the study). A total of 58 postpartum cases of neurological disorders who were referred to the department for radiological evaluation and who had positive MRI imaging findings were included in the study.

Results: Most common neurological symptoms were seizures followed by headache and focal neurological deficit (FND). Moreover, the most typical neurological complication was cerebral vein thrombosis, followed by posterior reversible encephalopathy syndrome (PRES). Other common complications were intracranial hemorrhage, ischemic infarcts, infections, acute hypoxic-ischemic encephalopathy, and metabolic encephalopathy. Rare but important findings included postpartum hypernatremic encephalopathy with extra pontine myelinolysis and rhabdomyolysis and postpartum reversible cerebral vasoconstriction syndrome (PRCVS).

Conclusion: MRI, along with angiography and venography, is the modality of choice to evaluate postpartum neurological symptoms and plays a crucial role in the early diagnosis of neurological complications. Furthermore, MRI helps establish this diagnosis early to avoid further complications.

Keywords: MRI, Extra pontine myelinolysis, Postpartum reversible cerebral vasoconstriction, Pontine hemorrhage

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Introduction

The evaluation of postpartum neurological illness is an extremely challenging task. There are varied clinical features and many under-recognized diseases that are overlooked in postpartum patients. The disease is presented in a postpartum state such as posterior reversible encephalopathy, cerebral cortical venous thrombosis, ischemic stroke, intracerebral hemorrhage, postpartum cerebral angiopathy, infectious causes, and the like (1). The presentations of these diseases are nonspecific and include headaches, seizures, altered mental state, focal neurological deficits (FNDs), and the like. The recognition of characteristic imaging findings in these patients contributes to the proper management. There is more occasionally a delay in the diagnosis of these uncommon but serious conditions in the peripartum period owing to all clinical features of eclampsia and hence the reluctance to perform imaging studies. Magnetic resonance imaging (MRI) is used as the first line of the modality of imaging for neurological disordered due to high soft tissue resolution and lack of radiation hazards. Accordingly, this study investigated the clinical and radiologic manifestations of the neurologic conditions observed during the postpartum period (2).

Materials and Methods

Setting and Design

This study is a retrospective hospital-based analysis conducted in the Department of Radiodiagnosis and

modern imaging, Maharana Bhopal government hospital and RNT Medical College Udaipur, Rajasthan, India, from October 2017 to September 2018 (All the patients presented during this time frame were included in the study). A total of 58 postpartum cases of neurological disorders who were referred to the department for radiological evaluation and who had positive MRI imaging results were included in the study.

MR Imaging Protocol

MRI was performed by a 1.5 Tesla 8-channel Philips Achieva MR system with a dedicated 8-channel head coil. MRI of the brain was performed according to the standard brain protocol, which included axial T1WI, T2WI, diffusion-weighted imaging (DWI), gradient-recalled echo, coronal, and axial fluid-attenuated inversion recovery (FLAIR) Sag T1WI. Then, additional MR 2D time-of-flight (TOF) Venography was performed using phase contrast magnetic resonance venography, and MR angiography for circle of Willis was performed using TOF.

Inclusion Criteria

All patients presented with neurological symptoms in the postpartum period were included in the study.

Exclusion Criteria

The patients who were unwilling for the study and those with contra-indications for MRI imaging were excluded from the study. Moreover, pregnant patients and patients with neurological disorders not directly related to pregnancy were excluded from the study.

Statistical Analysis

This study is a retrospective hospital-based analysis. The data were processed using SPSS software version 22. The categorical data were presented as frequencies and ratios. For qualitative data, a one-proportion Z-test was employed as a test of significance (A *P* value less than 0.05 indicates a significant difference). The descriptive analysis was carried out using frequencies and percentages of occurrences among the patient population.

Results

A total of 58 cases were taken after considering all-inclusive and exclusive criteria. The findings indicated that the main neurological complaints seen in the population are seizures, headache, FND, unconsciousness, altered sensorium, seizures with FND, fever, fever with altered sensorium, and seizures with headache. It was found that 22 patients (37.9%) experienced or complained of seizures followed by headaches in 8 patients (13.7%) and then other symptoms (Table 1). With regard to MRI, 12.06% (n = 7) of the total studied cases were found to be normal. Out of the 87.9% (n = 51) of abnormal cases, 21 patients showed cerebral venous sinus thrombosis (CVST) with brain parenchyma involvement. The frontal lobe was involved in most of the cases, and deep venous sinus involvement was observed in 2 patients, followed by posterior reversible encephalopathy syndrome (PRES) which involved 20.68% (n = 12) of the cases. Moreover, a few patients exhibited cerebral infections (8.62%), intracranial hemorrhage (5.17%), ischaemic infarcts (5.17%), and metabolic and hypnosis encephalopathy (3.4%) changes. The final result found in this study is presented in Table 2.

We have compared the current study with prior studies conducted by Mugadasweeran et al (1), Chandrashekaran et al (3), and Kavthale et al (4). We used the proportion Z-test to find out the significant difference (a *P* value of < 0.05 was considered significantly different), the result of which is summarized in Table 3. According to this table, it can be concluded that there is a significant difference in the number of cerebral venous thrombosis (CVT) patients compared to Mugadasweeran and colleagues' study (1); furthermore, significant differences were seen in the number of PRES patients compared to Chandrashekaran and colleagues' study (3).

Table 1. Neurological Symptoms Encountered during the Postpartum Period (N = 58)

Symptoms	No. (%)
Seizures	22 (37.93)
Headache	8 (13.79)
FND	7 (12.06)
Unconsciousness and altered sensorium	6 (10.34)
Seizures with FND	5 (8.62)
Fever	3 (5.17)
Fever with altered sensorium	3 (5.17)
Seizures with headache	2 (3.44)
Other	2 (3.44)

Note. FND: Focal neurological deficit.

Table 2. Neurological Complications Observed on MRI during the Postpartum Period (N = 58)

Complications	No. (%)
CVT	21 (36.20)
PRES	12 (20.68)
Normal	7 (12.06)
Infective	5 (8.62)
ICH	3 (5.17)
Ischemic infract	3 (5.17)
Metabolic	2 (3.4)
Acute HIE	2 (3.4)
RCVS	2 (3.4)

Note. CVT: Cerebral venous thrombosis; PRES: Posterior reversible encephalopathy; ICH: Intracranial hemorrhage syndrome; HIE: Hypoxic ischaemic encephalopathy; RCVS: Reversible cerebral vasoconstriction syndrome.

Table 3. Comparison Between the Present Study and the Literature

Imaging Findings	Present Study (N=58)	Mugadasweeran et al (N=150)	Chandrashekaran et al (N=120)	Kavthale et al (N=40)	Proportion with Mugadasweeran et al's Study	Proportion with Chandrashekaran et al's Study	Proportion with Kavthale et al's Study
CVT	36.20% (n=21)	15% (n=22)	29.1% (n=35)	25% (n=10)	*P* (two tailed)=0.00078	*P* (two tailed)=0.26053	*P* (two tailed)=0.07592
PRES	20.68% (n=12)	21% (n=46)	10% (n=12)	60% (n=24)	*P* (two tailed)=0.9520	*P* (two tailed)=0.04462	*P* (two tailed)=0.000
Ischemic infarcts	5.17% (n=3)	8% (n=12)	1.6% (n=19)	4% (n=16)	*P* (two tailed)=0.00078		
Metabolic encephalopathy	3.4% (n=2)	33.33% (n=21)	-	-			
ICH	5.17% (n=3)	-	-	-			
Infective	8.62% (n=5)	-	-	-			
Acute HIE	3.4% (n=2)	-	-	-			
RCVS	3.4% (n=2)	-	-	-			
Normal	12.06% (n=7)	-	-	-			

Note. CVT: Cerebral venous thrombosis; PRES: Posterior reversible encephalopathy; ICH: Intracranial hemorrhage syndrome; HIE: Hypoxic ischaemic encephalopathy; RCVS: Reversible cerebral vasoconstriction syndrome.

It should be noted that a few pathologies investigated in the present study were not included in other studies, including intracranial hemorrhage (ICH), infective pathologies, reversible cerebral vasoconstriction syndrome (RCVS), metabolic encephalopathy, and acute hypoxic-ischemic encephalopathy. Hence, the *P* value could not be achieved for these pathologies. Other pathologies were compared using descriptive analysis by frequencies and percentages of occurrences in the patient population.

Discussion

Previously, most of the studies were done during pregnancy and postpartum periods together, while very little research has been conducted on isolated postpartum neurological diseases. The current study has explored only the postpartum period and not pregnancy, concluding that seizures were the most prevalent neurological manifestations in the postpartum period, while headache was the most prevalent in combined studies of pregnancy and the postpartum period.

The most prevalent neurological complication observed in the current study was CVST, while previous studies reported PRES to be the most prevalent complication (4). The patients in our study were between 18-40 years old, and the majority of them (81%) were between 20-30 years old. In a study by Sarella and Rao (5), the age range of patients was 17-31 years.

The acute neurological disorders encountered in our study were divided into various categories, including CVST, PRES, ischemic and hemorrhagic strokes, infections, and so on.

Cerebral Venous Sinus Thrombosis

CVST may occur anytime during pregnancy and the puerperium, but the risk is highest during the first two weeks of the puerperium (6). In our study, the most common observed neurological complication was CVST, and the most common sinus involved was the superior sagittal sinus. Out of these, 21 patients diagnosed with CVST showed asymmetrical hyperintensities in the superior sagittal sinus, bilateral thalami, and basal ganglia on their brain MRI with the involvement of the right temporal lobe due to thrombosis of the right transverse sinus and several areas of diffusion restriction. Further, there was non-visualization of superior sagittal, bilateral transverse, and bilateral sigmoid sinuses on TOF 2D venography images, representing venous ischemia, as depicted in Figure 1.

Posterior Reversible Encephalopathy Syndrome

The underlying hypothesis of PRES is that endothelial dysfunction leads to increased permeability. Four major types of radiological presentation of PRES are holohemispheric watershed pattern, superior frontal sulcus involvement pattern, predominant parieto-occipital involvement, and asymmetric presentation of the primary pattern (7). Furthermore, the most important complications of PRES are cerebral ischemia, cerebral herniation, and cerebral hemorrhage. In our study, most of the patients presented a holohemispheric watershed pattern radiologically, and typical MRI findings displayed hyperintensities on FLAIR and T2W images in the subcortical and periventricular white matter of bilateral cerebral hemispheres (Figure 2).

Infection

Among our study population, five patients were reported as having central nervous system (CNS) infection during their postpartum period, and meningitis and meningoencephalitis were the most common entities observed in the peripartum period due to obstetric spinal

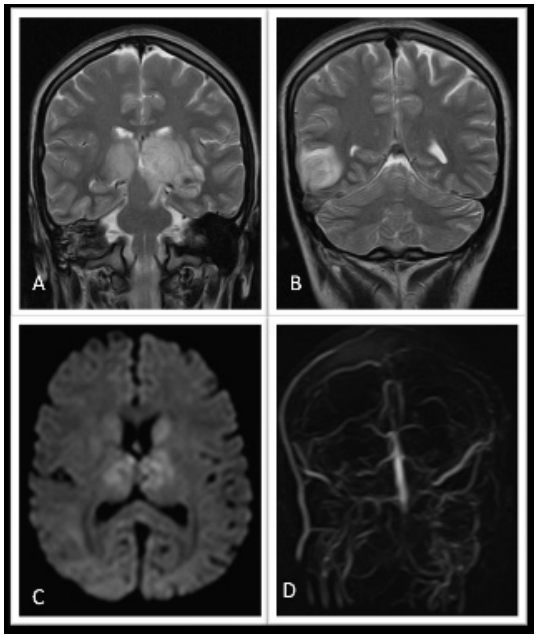

Figure 1. Cerebral Venous Thrombosis. A 28-year-old female was presented with severe headache and vomiting. On MRI brain, (A, B) T2W coronal plane image showed asymmetrical hyperintensities in the bilateral thalami and basal ganglia, representing venous ischemia. The right temporal lobe was also involved due to the thrombosis of the right transverse sinus. (C) The same areas described above indicated diffusion restriction. (D) TOF 2D venography image revealed non-visualization of superior sagittal, bilateral transverse, bilateral sigmoid sinuses, and internal cerebral veins. Bilateral straight sinuses were also partially visualized. *Note.* MRI: Magnetic resonance imaging; TOF: Time-of-flight

anesthesia. A study by Gupta et al (8) showed 12 patients with CNS infections in which seven cases (58.3%) had tubercular meningitis, four cases (33.3%) had acute pyogenic meningitis, and one case had viral encephalitis (8.3%), while one of the CNS tuberculosis cases had multiple thick nodular leptomeningeal enhancement (Figure 3).

Stroke

Embolic infarcts can occur due to difficult and prolonged labor, dilated peripartum cardiomyopathy, and cardiac valvular disease. Obstetric hemorrhage can also cause watershed infarcts. The most common part of the brain affected by these infarcts are the frontal and parietal lobes (9). The use of DWI-MRI improves the precision of the subtype diagnosis of stroke. Based on the DWI findings, three types of lesions can be identified: single subcortical lesion (diameter < 15 mm), large and scattered lesions in 1 vascular territory (≥ 15 mm, small scattered lesions < 15 mm, or confluent scattered lesions ≥ 15 mm), and multiple lesions in multiple vascular territories. Post-contrast MR images are also important to see the leptomeningeal enhancement. In the population of the present study, three patients were presented with stroke. One of the patients had wedge-shaped hyperintensity in the left frontal lobe and along the falx on the left side, and the MRI illustrated diffusion restriction in the same

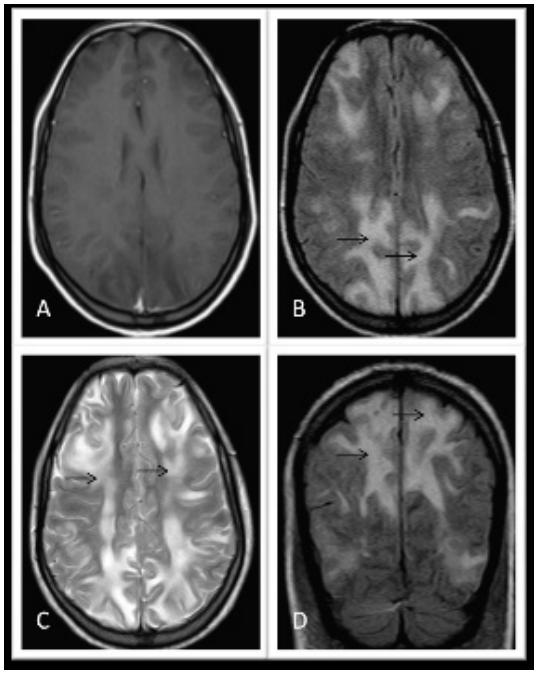

Figure 2. Posterior Reversible Encephalopathy Syndrome. A 26-year-old female with a history of hypertension during pregnancy came with seizures and blindness on her 7th day of postpartum. In MRI brain axial plane, (A) T1W image showed subtle hypointensities in the subcortical and periventricular white matter of bilateral cerebral hemispheres. (B) FLAIR. (C) T2W images manifested asymmetrical hyperintensities in the corresponding areas (black arrows). (D) Coronal FLAIR image illustrated hyperintensities in the same areas (black arrows). *Note.* MRI: Magnetic resonance imaging; PRES: Posterior reversible encephalopathy syndrome; T1W: T1-weighted; T2W: T2-weighted; FLAIR: Fluid-attenuated inversion recovery

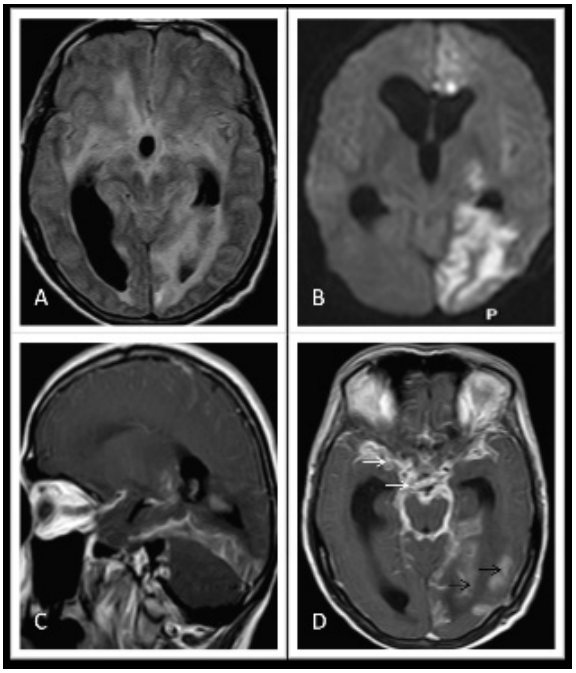

Figure 3. Tracheobronchomalacia. A 26-year-old female on her 9th day of postpartum was presented with fever, headache, and altered sensorium. MRI brain in axial plane (A) FLAIR image showed abnormal hyperintensity signal in bilateral periventricular regions and basifronto-temporal lobes and (B) showed restricted diffusion in left frontal, temporal, and occipital lobes. Post-contrast T1FS images in (C) Sagittal and (D) Axial planes exhibited thick nodular leptomeningeal enhancement (white arrows) in cisternal spaces and in the left occipital region (black arrows). *Note.* MRI: Magnetic resonance imaging; FLAIR: Fluid-attenuated inversion recovery; T1FS: T1-weighted fat-saturated

area with reversal on apparent diffusion coefficient (ADC), signifying an acute infarct (Figure 4), while on MR angiography, their artery was a narrow caliber of left internal carotid (ICA), as depicted in Figure 5). Another patient who was a 20-year-old female was presented with headache, vomiting, and lower cranial nerve palsies, and her MRI brain exhibited a large pontine haemorrhage that was compressing the 4th ventricle (Figure 6).

Metabolic and Toxic encephalopathy

It is characterized by a triad of acute confusion, ataxia, and ophthalmoplegia. Thiamine deficiency results from malnutrition or malabsorption, which can occur for several reasons, especially due to hyperemesis gravidarum and, they may lead to electrolyte imbalance (Seasonal postpartum hypernatremic encephalopathy with osmotic extrapontine myelinolysis and rhabdomyolysis). On MRI, it is generally seen as areas of symmetrical increased T2/FLAIR signal involving the mammillary bodies, tectal plate, dorsomedial thalami, periaqueductal area, or around the third ventricle. The treatment of these acute phase encephalopathies includes intravenous thiamine hydrochloride, along with other vitamins or minerals and electrolyte correction. If untreated, there is high mortality of up to 20% (10,11). In our study, two patients were found to have encephalopathic metabolic changes, one of which had symmetrical FLAIR hyperintensities in bilateral basal ganglia along with diffusion restriction (Figure 7). This patient already had similar episodes, and her laboratory value confirmed the diagnosis of seasonal postpartum hypernatremic encephalopathy with osmotic extrapontine myelinolysis and rhabdomyolysis. Finally, her brain abnormalities returned to normal in follow-up scans (Figure 8). Another 30-year female patient on her 5th postpartum day was referred to us in an unconscious state, and her blood glucose level was 48 mg/dL.

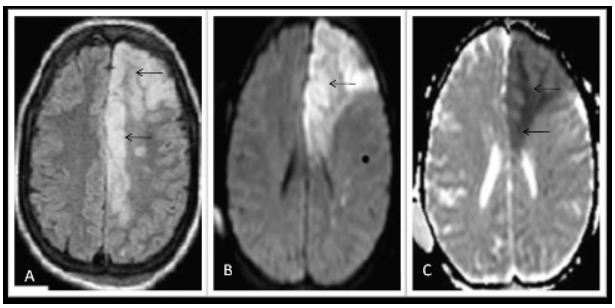

Figure 4. Left ICA Stenosis with Reversible Cerebral Vasoconstriction Syndrome. A patient came with the complaint of acute severe headache and FND (right-sided weakness). On MRI brain axial plane, (A) FLAIR image showed wedge-shaped hyperintensity in the left frontal lobe and along the falx on the left side. (B, C) Images illustrated diffusion restriction in the same area with reversal on ADC signifying an acute infarct. *Note*. FND: Focal neurological deficit; MRI: Magnetic resonance imaging; ICA: Internal carotid artery; FLAIR: Fluid-attenuated inversion recovery; ADC: Apparent diffusion coefficient

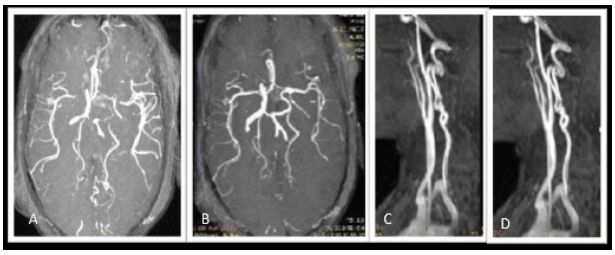

Figure 5. Left ICA Stenosis with Reversible Cerebral Vasoconstriction Syndrome. (A, B) MRA of the brain in the axial plane and (C, D) sagittal plane showed the narrow caliber of left ICA. *Note*. MRI: Magnetic resonance imaging; ICA: Internal carotid artery

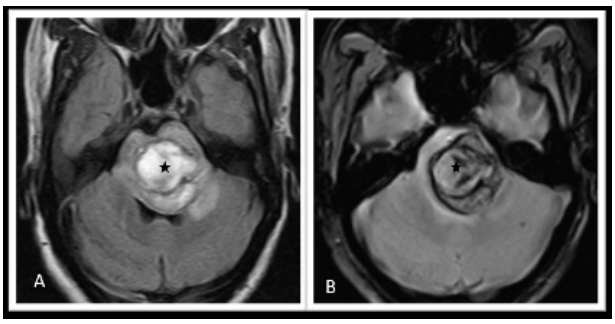

Figure 6. Pontine ICH. A 20-year-old female was presented in her postpartum period with headache, vomiting, and lower cranial nerve palsies. MRI brain FLAIR (A) and SWI (B) images showed a large pontine haemorrhage compressing the 4th ventricle (black star). *Note*. MRI: Magnetic resonance imaging; ICH: Intracranial hemorrhage syndrome; FLAIR: Fluid-attenuated inversion recovery; SWI: Susceptibility weighted imaging

Reversible Cerebral Vasoconstriction Syndrome

Patients are usually presented with diffuse, severe

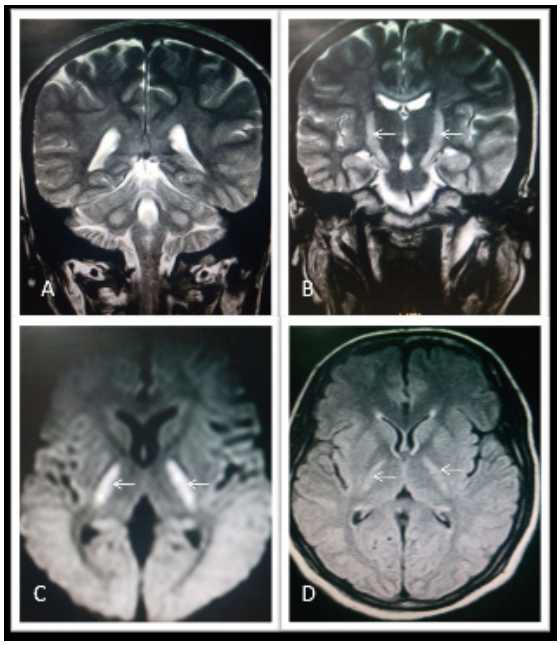

Figure 7. Metabolic-seasonal Postpartum Hypernatremic Encephalopathy with Osmotic Extrapontine Myelinolysis and Rhabdomyolysis. A 28-year-old female on her 6th postpartum day was presented with fever and quadriparesis. On MRI brain (A, B) T2 sequence coronal plane showed hyperintensity in bilateral thalami and bilateral dentate nucleus. (C) Axial plane illustrated diffusion restriction in bilateral thalami, and (D) Axial FLAIR image showed hyperintensity in the same area. *Note*. MRI: Magnetic resonance imaging; ICH: Intracranial hemorrhage syndrome; FLAIR: Fluid-attenuated inversion recovery

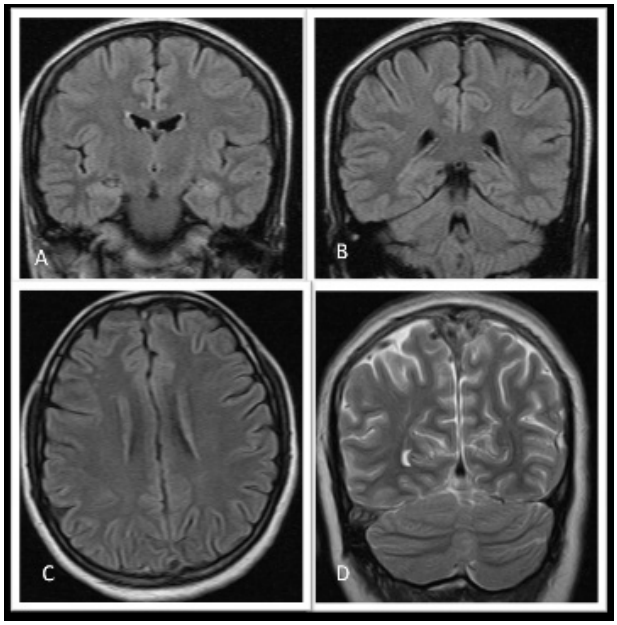

Figure 8. (Follow-up of Figure 7) Metabolic-seasonal postpartum hypernatremic encephalopathy with osmotic extrapontine myelinolysis and rhabdomyolysis- follow-up): Metabolic-seasonal postpartum hypernatremic encephalopathy with osmotic extrapontine myelinolysis and rhabdomyolysis

headaches (often "thunderclap" headaches) of abrupt or progressive onset, with or without FNDs and/or seizures. The exclusion of aneurysmal subarachnoid hemorrhage as an etiology for presentation is the main aim of imaging. There is normal or nearly normal cerebrospinal fluid. The diagnosis can be made through evidence of segmental vasoconstriction (a string of beads and sausage) in the cerebral arteries via catheter angiography, computed tomography angiography, or magnetic resonance angiography, with reversibility of the vascular lesions within three months demonstrated by repeat angiography (12). Among the population of this study, two patients had RCVS, one of which exhibited FLAIR hyperintensities in the cortical and subcortical white matter of bilateral occipital and parietal lobes with diffusion restriction in the same areas. The follow-up scans of the same patient indicated a decrease in hyperintensities in the respective areas. Moreover, the TOF angiography images showed transient vasoconstriction in bilateral occipital regions.

Hypoxic Ischemic Encephalopathy

The hypoxic-ischemic injuries can result from excessive postpartum hemorrhage, eclampsia, or status epilepticus. Excessive postpartum hemorrhage may lead to hypotension and global ischemic brain injury. Eclampsia is defined clinically as a seizure or coma associated with pregnancy-induced hypertension. Status epilepticus is a condition defined as one continuous unremitting seizure lasting longer than five minutes. These conditions may lead to vasoconstriction of the vessels resulting in hypoxic changes in the end organs. MRI is superior to computed tomography in imaging the patients with these encephalopathies. Lesions are characterized by low to iso signal intensity on T1W images and high signal intensity on T2W images in the cortex and subcortical white matter. In our study population, two patients were found to have these hypoxic changes in the brain. Of the two patients, a female on her 8th day of the postpartum period showed diffuse cortical hyperintensities and restricted diffusion with reversal on ADC. Knowledge of the neuroimaging feature of these entities helps to make an early diagnosis, differentiate them from each other, and appropriate the management of serious postpartum-related neurological complications. This study also concluded that infective etiology such as tubercular meningitis is not extremely uncommon in Indian patients, while complications related to the pituitary gland during a postpartum period are extremely uncommon (12).

Furthermore, the results indicated that the most common neurological symptom is seizures, followed by headache and FND. In addition, the most prevalent neurological complication was cerebral vein thrombosis, followed by PRES. Other common complications were intracranial hemorrhage, ischemic infarcts, infective, acute hypoxic-ischemic encephalopathy, and metabolic encephalopathy. The findings also reported postpartum hypernatremic encephalopathy with extrapontine myelinolysis and rhabdomyolysis, RCVS, and bilateral carotid arteries hypoplasia as other rare but important complications.

Conclusion

MRI, along with magnetic resonance venography, is the modality of choice to evaluate postpartum neurological symptoms and plays a very crucial role in the early diagnosis of neurological complications associated with the postpartum period. Furthermore, the most common neurological complications which cause increased maternal mortality were eclamptic encephalopathy and CVT. Hence, the knowledge of the neuroimaging feature of these complications helps make an early diagnosis, differentiate them from each other, and appropriate the management of serious postpartum-related neurological complications.

Authors' Contribution

Conceptualization: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal.
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Methodology: Rambir Singh, Tarun Kumar Ralot, Rajaram Sharma, Gaurav Goyal.
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Supervision: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal, Kritika.
Validation: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal.
Visualization: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal, Kritika.
Writing – original draft: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal.
Writing – review & editing: Rambir Singh, Tarun kumar Ralot, Rajaram Sharma, Gaurav Goyal, Kritika.

Competing Interests
There is no conflict of interests.

Data Availability Statement
All the data are available with the corresponding author.

Ethical Approval
This study was approved by Institutional Ethical Committee of RNT Medical College (Ethics No. RNT/2022/624).

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Informed Consent
Informed consent was taken from all the participants.

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