Factors Associated with Poor Outcome in Patients with Posterior Reversible Encephalopathy Syndrome Admitted to a Tertiary Hospital in Bangladesh

Suman Sen[1*] Laboni Dey[2] Shoyela Sahnaz[3] Kanon Sen[4] Panchanan Das[5] Shagor Deb Tapu[6] Pijush Majumder[7] Rushmila Ferdous[8] Md. Rubel[9] Md. Hasanuzzaman[10]

Abstract

Background: Posterior Reversible Encephalopathy Syndrome (PRES) is a clinical-radiological phenomenon linked to various clinical disorders. There needed to be more studies on the hospital outcome of PRES in Bangladesh. The objective was to investigate the outcome of PRES on different clinical, biochemical, and imaging findings at admission in patients with PRES admitted to a tertiary-level hospital in Bangladesh.

Materials and methods: This prospective observational study included 97 cases of PRES from the admitted patients in Chittagong Medical College Hospital. The poor outcome was defined as an mRS score ≥3 or partial symptomatic recovery. Univariate and multivariate analyses were performed to identify the association between different factors and outcomes.

Results: The mean age was 23.3±5.6 years (range 18-50 years), 95.9% were women, and most cases (91.8%) had eclampsia. Poor functional outcome was seen in the 4 (4.1%) patients, and incomplete resolution of symptoms was observed in 58.8% (37 out of 94 survived cases) patients at 30-day follow-up. In logistic regression analysis, other than age and severe PRES, extensive oedema was independently associated with the persistence of symptoms after 30 days (OR:10.45, 95% CI:1.29-84.31, p=0.028).

Conclusion: The finding of extensive oedema on initial imaging in PRES was associated with poor outcomes.

Key words: Extensive Oedema; Neurological impairment; Posterior Reversible Encephalopathy Syndrome (PRES).

1. Medical Officer
Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj.
2. Post Graduate Student of Obstetrics & Gynaecology
Chittagong Medical College, Chattogram.
3. Assistant Professor of Obstetrics & Gynaecology
Chittagong Medical College, Chattogram.
4. Post Graduate Student of Cardiology (Phase-B)
Chittagong Medical College, Chattogram.
5. Professor of Neurology
Chittagong Medical College, Chattogram.
6. Medical Officer
Khagrachari Modernized Sadar Hospital, Khagrachhari.
7. Registrar of Neurology
Chittagong Medical College Hospital, Chattogram.
8. Post Graduate Student of Neurology (Phase-B)
Chittagong Medical College, Chattogram.
9. Medical Officer
Adhunik Khagrachari Zilla Sadar Hospital, Khagrachori.
10. Professor of Neurology
Chittagong Medical College, Chattogram.

***Correspondence: Dr Suman Sen**
Cell : 01815 82 26 72
E-mail: sensuman1979@gmail

Submitted on : 23.07.2023
Accepted on : 14.11.2023

Introduction

PRES is a well-defined clinical and radiological condition. The condition was initially documented in 1996 among a cohort of fifteen individuals presenting with acute neurological manifestations, such as headache, seizures, visual impairments, and various focal neurological impairments.[1] In recent years, there has been a notable rise in the utilization of brain Magnetic Resonance Imaging (MRI) resulting in a heightened awareness of PRES. Consequently, medical practitioners across several disciplines increasingly see individuals presenting with PRES. Nevertheless, the underlying mechanisms of PRES still need to be fully comprehended and continue to be debated.[2,3] PRES is commonly linked to several clinical manifestations, such as headaches, focal neurological impairments, seizures, visual impairments and encephalopathy. There is considerable variation in the degree and sharpness of clinical symptoms.[4] The risk factors associated with the development of PRES encompass a range of conditions, including hypertension, pregnancy, puerperal disorders, organ transplantation, the use of immunosuppressive or cytotoxic medicines, acute or chronic kidney disease, autoimmune diseases, infections, and endocrine diseases, among others.[5] The condition known as PRES can be reversed if identified early and rapidly treated by eliminating the causative component. However, if left untreated, it can result in severe and sometimes fatal consequences such as cerebral haemorrhage, cerebellar herniation, and refractory status epilepticus.[6] A study has indicated that a significant proportion of patients, precisely 44%,

have reported experiencing functional impairments of different magnitudes.[7,8] Typically, PRES exhibits a favourable prognosis in most instances when promptly and appropriately managed, with clinical symptoms demonstrating reversibility within several hours to days.[9]

Nevertheless, it is essential to note that PRES reversibility does not always occur spontaneously. If there are delays in diagnosing and treating the condition, it can result in irreversible damage and neurological complications, ultimately leading to unfavourable outcomes[10,11] The user has provided a numerical reference.[12] Many studies investigated the impact of different factors, such as clinical symptoms, imaging findings and biochemical markers, on the prognosis of PRES.[14,13] The variables examined in this study included age, sex, interval between symptom onset and hospital admission, precipitating cause, presenting symptoms and signs, blood pressure and Glasgow Coma Scale (GCS) score at admission, modified Rankin Scale (mRS) score at admission, various biochemical parameters (Such as haemoglobin, total white blood cell count, random blood sugar, and serum creatinine), and radiological findings (Including the location, pattern, and severity of the lesion, presence of haemorrhage and its type, diffusion-weighted imaging restriction, contrast enhancement, presence of oedema and its extent, and evidence of mass effect).[13-15] Recent studies have identified several variables that are associated with poor outcomes. These variables include a history of diabetes mellitus, coma, a high Charlson Comorbidity index, post-transplantation status, presence of an autoimmune condition, absence of systolic or diastolic hypertension, elevated blood urea nitrogen levels, involvement of the corpus callosum, altered mental state, subarachnoid haemorrhage, elevated C-reactive protein levels, and altered coagulation. These factors have been reported to contribute to poor outcomes.[13-15]

Nevertheless, there needs to be a more comprehensive understanding of the factors that influence clinical outcomes of PRES.[16] This study aimed to examine the outcomes of PRES concerning various clinical, biochemical, and imaging findings upon admission to a tertiary-level hospital in Bangladesh.

Materials and methods

A prospective observational study was conducted at the Department of Neurology, Chittagong Medical College, Chattogram, Bangladesh, from July 2021 to June 2022. Purposively selected 97 patients were enrolled and analyzed in this study.

Inclusion criteria

- Patient with a variable combination of clinical manifestations suggestive of PRES:
  - seizure activity, consciousness impairment, headaches, visual abnormalities, nausea/ vomiting and focal neurological signs
- Age ≥18 years

Exclusion criteria

- Patients with cerebral oedema secondary to ischemia, haemorrhage or space-occupying lesions.
- Patients or attendants refuse to provide voluntary consent.

Patients were discharged according to hospital discharge criteria. The researcher assessed PRES's clinical outcome during discharge and at 30 days of follow-up.

After collection, data were fed into SPSS for processing analysis. Associations between the predictors and clinical outcomes were expressed using Odds Ratios (OR) and 95% Confidence Interval (CI) for OR. $p < 0.05$ was considered statistically significant.

Ethical approval for this study was received from the Institutional Review Committee of Chittagong Medical College and informed written consent was obtained from the caregivers of the patients.

Results

One hundred patients were initially included and followed up for 30 days to assess their outcomes. The mRS at 30 days could not be determined for three cases. So, the available 97 cases were included in the final analysis. Table I shows the study's demographic characteristics; the patients' mean age was 23.3±5.6 years (Range 18-50 years). Most patients (95.9%) were women (Table I). Out of 97 cases, 93 (95.9%) had a previous history of hypertension or were newly detected as hypertensive. The generalized seizure was the most frequent presenting symptom reported by 94 (96.9%) of the patients, followed by drowsiness (81.4%), headache (74.2%), nausea (63.9%), vomiting (61.9%)

and blurring of vision (56.7%). The median values of different clinical and laboratory parameters are shown in Table I. After 30 days, initial symptoms were resolved entirely in 57 (58.8%) cases (Table II). In univariate analysis, precipitating causes other than eclampsia and lower median GCS were significantly associated with poor outcomes, as determined by mRS at 30 days (Table III). Among the biochemical admission parameters, only serum creatinine was associated with a 30-day result in univariate analysis. Patients with poor results had significantly higher median serum creatinine levels at the diagnosis of PRES than the patients with good outcomes (Table IV). In univariate analysis regarding radiographic characteristics at the time of PRES diagnosis, none of the features was associated with a poor clinical outcome as determined by mRS at 30 days (Table V). A multivariate binary logistic regression analysis included variables with a $p \leq 0.20$ to determine the independent predictors for poor 30-day outcomes. However, none of the variables was revealed to have an independent association with the poor functional outcome at 30 days (Table VI).

Table I Clinical and biochemical characteristics of the patients (n=97)

Features	Frequency	Percentage
Hypertension	93	95.9
Headache	72	74.2
Nausea	62	63.9
Vomiting	60	61.9
Blurring of vision	55	56.7
Drowsiness	79	81.4
Generalized seizure	94	96.9
Status epilepticus	1	1
Focal neurological deficits	3	3.1
Pulse, /min		100 (97-107)
Systolic blood pressure, mmHg		160 (140-170)
Diastolic blood pressure, mmHg		100 (100-120)
Temperature, ^{0}F		99.0 (98.4-99.0)
Glasgow coma scale		13 (12-13)
Haemoglobin, mg/dl		10.9 (9.8-12.8)
Total WBC count, ×mm^3		14.9 (10.1-18.7)
Random blood sugar, mg/dl		5.2 (4.5-8.5)
Serum creatinine, mg/dl		0.9 (0.7-1.0)

Table II Outcome based on mRS Score and persistent symptoms at 30 days after PRES onset (n=97)

Outcome parameters	Frequency	Percentage
	mRS score at 30 days	
0 (No symptoms)	57	58.8
1 (No significant disability)	36	37.1
3 (Moderate disability)	1	1
6 (Death)	3	3.1
	Symptoms at 30 days	
Resolved completely	57	58.8
Resolved partially	37	38.1

Table III Association between admission clinical factors and 30-day outcome in 97 cases of PRES

Variables	Good outcome (n=93)	Poor outcome (n=4)	p-value
Age, years	23.5±5.8	19.8±1.7	0.201†
Female	90 (96.8)	3 (75.0)	0.157*
	Precipitating cause		
Eclampsia	88 (94.6)	1 (25.0)	0.001*
Others	5 (5.4)	3 (75.0)	
Onset to hospitalization$^{¥}$	4.0 (2.5-7.0)	3.5 (1.3-5.0)	0.364‡
Hypertension	89 (95.7)	4 (1000)	1.0*
Headache	69 (74.2)	3 (75.0)	1.0*
Nausea	59 (63.4)	3 (75.0)	1.0*
Vomiting	57 (61.3)	3 (75.0)	1.0*
Blurring of vision	52 (55.9)	3 (75.0)	0.631*
Drowsiness	77 (82.8)	3 (75.0)	0.544*
Generalized seizure	90 (6.8)	4 (100.0)	1.0*
Status epilepticus	1 (1.1)	0 (0)	1.0*
Pulse, /min	100 (95-102)	111 (101-112)	0.102‡
Temperature, ^{0}F	99.0 (98.4-99.0)	99.0 (98.5-99.8)	0.355‡
Systolic blood pressure, mmHg	160 (140-170)	150 (132-167)	0.414‡
Diastolic blood pressure, mmHg	100 (100-120)	110 (85-120)	0.841‡
Glasgow coma scale	13 (12-13)	11 (10-13)	0.040‡
Focal neurological deficits	3 (3.2)	0 (0)	1.0*

Table IV Association between admission imaging characteristics and 30-day outcome in 97 cases of PRES

Variables	Good outcome (n=93)	Poor outcome (n=4)	p-value
	Pattern		
Typical	29 (31.2)	2 (50.0)	0.591*
	Atypical	64 (68.8)	2 (50.0)
Location			
Frontal	53 (57.0)	2 (50.0.0)	1.0*
Parietal	86 (92.5)	4 (100.0)	1.0*
Occipital	82 (88.2)	4 (100.0)	1.0*
Temporal	28 (30.1)	2 (50.0)	0.585*
	Severity of PRES		
Mild	30 (32.3)	0 (0)	0.153*
Moderate	46 (49.5)	2 (50.0)	
Severer	17 (18.3)	2 (50.0)	
	Haemorrhage		
Absent	88 (94.6)	4 (100.0)	1.0**

Variables	Good outcome (n=93)	Poor outcome (n=4)	p-value
Parenchymal hematoma	2 (2.2)	0 (0)	
Subarachnoid blood	1 (1.1)	0 (0)	
Minute haemorrhages	2 (2.2)	0 (0)	
	Diffusion-weighted restriction		
Absent	84 (90.3)	2 (50.0)	0.062*
Present	9 (9.7)	2 (50.0)	
	Extensive oedema		
Absent	74 (79.6)	2 (50.0)	0.204*
Present	19 (20.4)	2 (50.0)	

Table V Multivariate Binary Logistic Regression analysis of clinical, laboratory and radiologic factors associated with 30-day poor outcome after PRES

Variables		95% CI for OR		p-value
	OR	Lower	Upper	
Female sex	0.262	0	1417.621	0.76
Eclampsia	0.033	0	83	0.393
Pulse	1.219	0.89	1.67	0.217
GCS	0.331	0.045	2.425	0.276
Creatinine	2.739	0.337	22.236	0.346
Severity of PRES	12.632	0.112	1421.719	0.293
DWRI	10.145	0.335	307.405	0.183

Discussion

Besides a few case reports, studies on the Bangladeshi PRES population were scarce.[17-21] The mean age of the present study was comparatively lower than the related previous studies, where the mean age ranged between 31 to 57 years.[22-26] The lower mean age of the present study is likely explainable in the aetiology of the PRES. Eclampsia or preeclampsia was the precipitating cause in most cases, and the mean age of presentation of such cases in the tertiary hospitals of Bangladesh agreed with the present age distribution.[27] However, the female preponderance of the present study was in concordance with the previous studies.[22-26] In the present study, most cases (91.8%) suffered from eclampsia; the rest of the 8.1% had other conditions, like glomerulonephritis, systemic lupus erythematosus, and cholelithiasis with cholecystitis with dyselctrolytemia.

Regarding the aetiology of PRES, studies vary considerably. In the study, the most frequent cause was active cancer, chronic kidney disease, history of bone marrow transplantation, solid organ transplantation, autoimmune disease, sepsis, and peripartum eclampsia.[25] The study of etiologies of PRES included hypertension, cytotoxic medications, sepsis, preeclampsia or eclampsia, multiple organ dysfunction, and autoimmune disease.[28] Previously reported published cases of PRES in Bangladesh were related to eclamptic encephalopathy.[17-21] The symptoms are highly non-specific, with encephalopathy and seizures being the most common, followed by visual disturbances, headache, and focal neurological deficits.[3,29] In this study, 100% of patients had brain parenchymal oedema. Extensive oedema was seen in 21.6% of cases. Eleven (11.3%) cases had restricted diffusion involving some portion of the T2 hyperintense parenchyma. Among 97 cases, only 5.2% had an ICH, and none had a haemorrhage with mass effect. The rate of diffusion restriction in the present study (11%) is consistent with the range reported in the literature, from 10 to 33%.[10,25,30-32] However, the rate of haemorrhage observed in the present study (5.2%) is lower than the rates of ICH reported in other studies, which range from 15 to 65%.[25,30-34] Diffusion restriction is seen in 11–26% of cases and has been associated with poor outcomes.[25] Previous studies have also demonstrated that PRES patients with preeclampsia-eclampsia have less severe imaging findings and clinical symptoms.[29] It is in line with the existing evidence where it was established that the aetiology of toxaemia in pregnancy had a more favourable and less severe course of the disease.[14,29] However, the present study, like the previous study, failed to observe any difference between PRES due to preeclampsia or Eclampsia and PRES due to other causes, probably due to the minimal number of cases due to different overall small sample sizes.[29] Although residual neurological deficit has been reported in 10%-37% of patients with PRES, 95.9% had no residual neurological deficit or significant disability (MRS, 0 and 1) 30 days after PRES in the present study.[29] All PRES patients with eclampsia had reversible PRES lesions in a study by Pande et al.[32] Another review showed that toxaemia of pregnancy (preeclampsia/eclampsia) might be associated with a reduced risk of adverse outcomes in patients with PRES.[14] The association between extensive oedema and poor clinical outcomes in the present study aligns with previous reports on the extent of oedema associated with stroke or death.[10,25]

Limitations

The study group did not have seriously ill patients with underlying sepsis, multi-organ dysfunction, and autoimmune disorders. Neuroimaging protocols and timing varied among patients. Radiological proof of reversibility was not obtained in the study due to a lack of follow-up MRI in patients after the resolution of neurological symptoms.

Conclusion

PRES was a favourable outcome disorder in this prospective observational study, which included 97 patients from a single public tertiary care hospital in Bangladesh. Poor functional outcome was seen in the 4 (4.1%) patients, and incomplete resolution of symptoms was observed in 58.8% (37 out of 94 survived cases) patients at 30-day follow-up. Increasing age, severe PRES, and presence of extensive oedema at diagnosis of PRES were independently associated with the persistence of symptoms after 30 days.

Recommendation

Further prospective studies on larger populations with diverse aetiology other than eclampsia of pregnancy from different centres are needed to establish independent predictors of unfavourable outcomes in PRES.

Acknowledgement

The authors expressed their gratitude to all the study population and staffs of Neurology Department.

Contribution of authors

SS-Conception, acquisition of data data analysis, manuscript writing, final approval.
LD-Acquisition of data, manuscript writing &final approval.
SS-Data analysis, interpretation of data, final approval.
KS-Acquisition of data, data analysis, critical revision of version, final approval.
PD-Acquisition of data, data analysis, critical revision of version, final approval.
SD-Data analysis, critical revision of version, final approval .
PM-Interpretation of data, critical revision of version, final approval.
RF-Design, data analysis, manuscript writing, final approval.
MR-Conception, Design, critical revision of version & final approval.
MH-Conception, Design, critical revision of version & final approval.

Disclosure

All the authors declared no conflicts of interest.

References

1. Hinchey J, Chaves C, Appignani B, Breen J, Pao L, Wang A, et al. A reversible posterior leukoencephalopathy syndrome. New England Journal of Medicine. 1996;334(8):494-500.

2. Fugate JE, Rabinstein AA. Posterior reversible encephalopathy syndrome: Clinical and radiological manifestations, pathophysiology, and outstanding questions. The Lancet Neurology. 2015;14(9):914-925.

3. Hinduja A. Posterior reversible encephalopathy syndrome: Clinical features and outcome. Frontiers in neurology. 2020;11:71.

4. Gewirtz AN, Gao V, Parauda SC, Robbins MS. Posterior reversible encephalopathy syndrome. Current pain and headache reports. 2021;25:1-9.

5. Tetsuka S, Ogawa T. Posterior reversible encephalopathy syndrome: A review with emphasis on neuroimaging characteristics. Journal of the neurological sciences. 2019;404:72-79.

6. Cordelli DM, Masetti R, Ricci E, Toni F, Zama D, Maffei M, et al. Life-threatening complications of posterior reversible encephalopathy syndrome in children. European Journal of Paediatric Neurology. 2014;18(5):632-640.

7. Alhilali LM, Reynolds AR, Fakhran S. A multidisciplinary model of risk factors for fatal outcome in posterior reversible encephalopathy syndrome. Journal of the neurological sciences. 2014;347(1-2):59-65.

8. Legriel S, Schraub O, Azoulay E, Hantson P, Magalhaes E, Coquet I, et al. Determinants of recovery from severe posterior reversible encephalopathy syndrome.PLoS One. 2012; 7(9): e44534

9. Roth C, Ferbert A. Posterior reversible encephalopathy syndrome: Long-term follow-up. Journal of Neurology, Neurosurgery & Psychiatry. 2010;81(7):773-777.

10. Covarrubias DJ, Luetmer PH, Campeau NG. Posterior reversible encephalopathy syndrome: prognostic utility of quantitative diffusion-weighted MR images. American Journal of Neuroradiology. 2002;23(6):1038-1048.

11. Antunes NL, Small TN, George D, Boulad F, Lis E. Posterior leukoencephalopathy syndrome may not be reversible. Pediatric neurology. 1999;20(3):241-243.

12. Wilson JL, Hareendran A, Hendry A, Potter J, Bone I, Muir KW. Reliability of the modified Rankin Scale across multiple raters: benefits of a structured interview. Stroke. 2005;36(4):777-781.

13. Hinduja A, Habetz K, Raina S, Ramakrishnaiah R, Fitzgerald RT. Predictors of poor outcome in patients with posterior reversible encephalopathy syndrome. International Journal of Neuroscience. 2017;127(2):135-144.

14. Chen Z, Zhang G, Lerner A, Wang AH, Gao B, Liu J. Risk factors for poor outcome in posterior reversible encephalopathy syndrome: Systematic review and meta-analysis. Quantitative Imaging in Medicine and Surgery. 2018;8(4):421.

15. Siebert E, Bohner G, Liebig T, Endres M, Liman TG. Factors associated with fatal outcome in posterior reversible encephalopathy syndrome: A retrospective analysis of the Berlin PRES study. Journal of neurology. 2017;264:237-242.

16. Gao B, Lerner A, Law M. The clinical outcome of Posterior reversible Encephalopathy syndrome. American Journal of Neuroradiology. 2016;37(9):E55-56.

17. Begum A, Khanam K. Posterior Reversible Encephalopathy Syndrome (PRES). Journal of Bangladesh College of Physicians and Surgeons. 2017;35(1):43-45.

18. Biswas R, Nessa SS, Gupta PS, Biswas S. Posterior Reversible Encephalopathy

Syndrome (PRES): A case series in postpartum patients. Bangladesh Critical Care Journal. 2013;1(2):104-106.

19. Islam AT, Uddin MK, Ali MA, Kundu PK, Alahi MM, Amin MP, Sarkar MK. Posterior reversible encephalopathy syndrome: A rare case with delayed reverse. BIRDEM Medical Journal. 2019;9(3):248-250.

20. Mahmood S, Talha KA, Mahmood W. Clinical Features and Location of Intracranial Edema in Posterior Reversible Encephalopathy Syndrome (PRES) Patients. Mymensingh Medical Journal: MMJ. 2020;29(3):633-637.

21. Rashid F, Sattar MA. Postpartum Posterior Reversible Encephalopathy Syndrome A Case that can Press Hard an Obstetrician. Bangladesh Journal of Obstetrics & Gynaecology. 2016;31(1):46-49.

22. Algahtani H, Algahtani A, Aldarmahi A, Hmoud M, Marzuk Y, Shirah B. Posterior reversible encephalopathy syndrome: local experience from Saudi Arabia. The Neurohospitalist. 2017;7(1):24-29.

23. Alshami A, Al-Bayati A, Douedi S, Hossain MA, Patel S, Asif A. Clinical characteristics and outcomes of patients admitted to hospitals for posterior reversible encephalopathy syndrome: A retrospective cohort study. BMC neurology. 2021;21(1):1-7.

24. Kalaiselvan MS, Renuka MK, Arunkumar AS. Clinical features and outcomes of patients with posterior reversible encephalopathy syndrome. Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine. 2017;21(7):453.

25. Schweitzer AD, Parikh NS, Askin G, Nemade A, Lyo J, Karimi S, Knobel A, Navi BB, Young RJ, Gupta A. Imaging characteristics associated with clinical outcomes in posterior reversible encephalopathy syndrome. Neuroradiology. 2017;59:379-386.

26. Yadav PK, Sen D. Clinicoradiological profile and outcome of patients with posterior reversible encephalopathy syndrome. The Journal of the Association of Physicians of India. 2019;67(1):13-16.

27. Yeasmin S, Uddin MJ. Determination of Risk Factors for Pre–Eclampsia in aTertiary Hospital of Bangladesh. Chattagram Maa-O-Shishu Hospital Medical College Journal. 2017;16(1):29-32.

28. Fugate JE, Claassen DO, Cloft HJ, Kallmes DF, Kozak OS, Rabinstein AA. Posterior reversible encephalopathy syndrome: Associated clinical and radiologic findings. InMayo Clinic Proceedings. 2010;85(5):427-432.

29. Liman TG, Bohner G, Heuschmann PU, Scheel M, Endres M, Siebert E. Clinical and radiological differences in posterior reversible encephalopathy syndrome between patients with preeclampsia-eclampsia and other predisposing diseases. European journal of neurology. 2012;19(7):935-943.

30. Junewar V, Verma R, Sankhwar PL, Garg RK, Singh MK, Malhotra HS, et al. Neuroimaging features and predictors of outcome in eclamptic encephalopathy: A prospective observational study. American Journal of Neuroradiology. 2014;35(9):1728-1734.

31. McKinney AM, Short J, Truwit CL, McKinney ZJ, Kozak OS, SantaCruz KS, et al. Posterior reversible encephalopathy syndrome: Incidence of atypical regions of involvement and imaging findings. American Journal of Roentgenology. 2007;189(4):904-912.

32. Pande AR, Ando K, Ishikura R, Nagami Y, Takada Y, Wada A, et al. Clinicoradiological factors influencing the reversibility of posterior reversible encephalopathy syndrome: A multicenter study. Radiation medicine. 2006;24:659-668.

33. Hefzy HM, Bartynski WS, Boardman JF, Lacomis D. Hemorrhage in posterior reversible encephalopathy syndrome: imaging and clinical features. American Journal of Neuroradiology. 2009;30(7):1371-1379.

34. Sharma A, Whitesell RT, Moran KJ. Imaging pattern of intracranial hemorrhage in the setting of posterior reversible encephalopathy syndrome. Neuroradiology. 2010;52:855-863.