

## SPECT in periodic lateralized epileptiform discharges (PLEDs): A case report on PLEDs

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Periodic lateralized epileptiform discharges (PLEDs), which are known as unusual electroencephalogram (EEG) patterns, are described in a patient who had stroke and seizures. This patient underwent Tc-99m HMPAO (hexamethyl propylene amine oxime) brain single photon emission computed tomography (SPECT) imaging both during PLEDs on EEG and after the cessation of PLEDs. The initial SPECT study revealed increased CBF in the left frontal and parietal cortex extending through the left temporal region and in the left basal ganglion. After the PLEDs disappeared, the second SPECT study showed decreased perfusion on the left frontal and parietal region in the brain. Brain SPECT findings supported the contention that PLEDs may be an ictal phenomenon. Here we also present a review on PLEDs and contributions of brain SPECT as a functional imaging modality to investigate the underlying mechanism of this interesting EEG pattern.

**Key words:** PLEDs, Tc-99m HMPAO, SPECT, seizure, EEG

### INTRODUCTION

PERIODIC LATERALIZED EPILEPTIFORM DISCHARGES (PLEDs), first reported by Chatrian,<sup>1</sup> are unusual electroencephalogram (EEG) patterns which are defined as repetitive, periodic, focal or hemispheric epileptiform discharges (spikes, spike and waves, polyspikes, sharp waves) usually recurring every 1 to 2 seconds.<sup>2</sup> PLEDs may occur during interictal, ictal or postictal period and it is not clear whether PLEDs represent an ongoing electrical seizure or a nonepileptiform but synchronized bursting phenomenon of damaged brain area especially when they are seen immediately after the seizure.<sup>3,4</sup>

Various types of high-resolution tomographic neuroimaging in the past 15 years have had a significant impact on the diagnosis and management of seizures. Since epilepsy is primarily a functional disturbance of the brain, functional neuroimaging modalities, such as single photon emission computed tomography (SPECT), and

positron emission tomography (PET), are sensitive in detecting generalized and focal abnormalities in epilepsy.<sup>5</sup> The expected findings in SPECT studies of the epileptic patients are hypoperfusion in the epileptogenic area during the interictal period and hyperperfusion during the ictal period. Especially, when magnetic resonance imaging (MRI) findings are ambiguous or normal, or discordant with those of scalp EEG, localizing information from functional neuroimaging is used for localization of the epileptogenic cortex or to guide the placement of intracranial electrodes.

In this report, we present a patient with PLEDs on EEG immediately after the clinical seizure in which SPECT findings indicating the hyperperfused area concordant with the EEG confirmed that PLEDs can be a feature of an ongoing electrical seizure without any overt clinical seizure. We also give a review of this interesting EEG pattern.

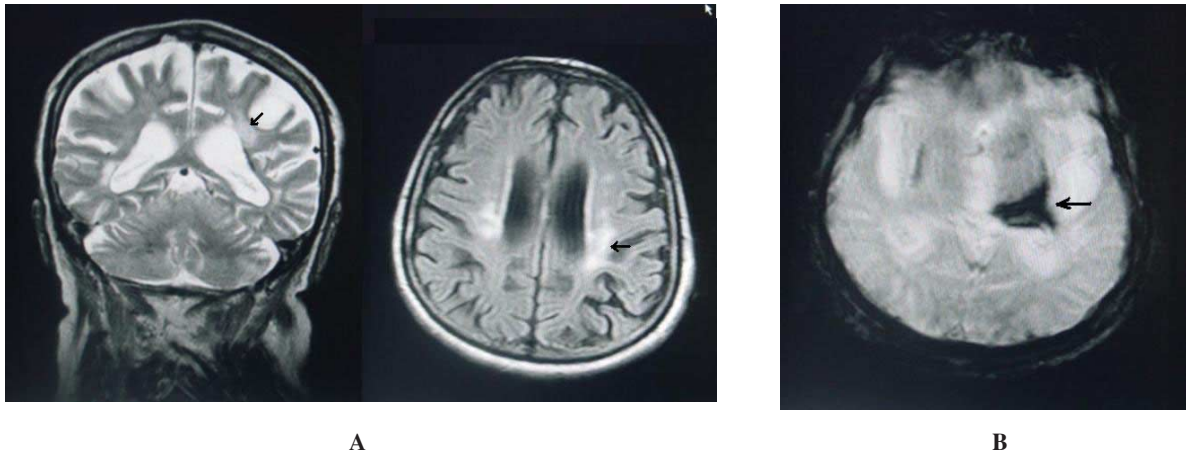
### CASE REPORT

A 70-year-old male patient was admitted to our hospital because of the acute onset of right sided focal motor seizures that lasted for 5 minutes. His consciousness was impaired. He was stuporous and unresponsive. He had mild right hemiparesis. His CBC and blood chemistry

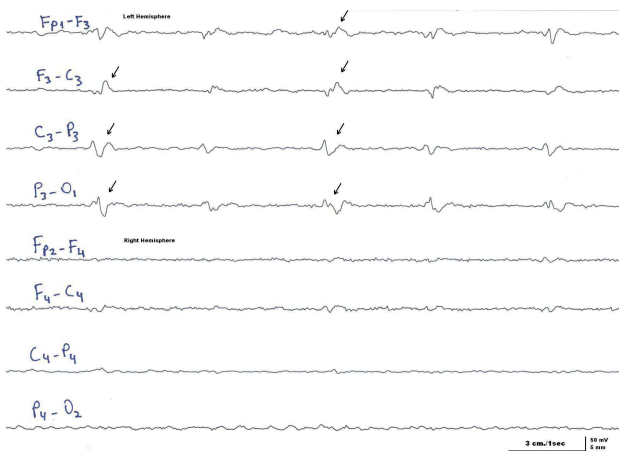
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**Fig. 1** A: Coronal and transverse MRI slices (ADC diffusion map) show multiple infarctions in white matter prominently in the left parietal lobe (arrow). B: Left thalamic hematoma is seen in brain MRI (arrow).



**Fig. 2** EEG shows periodic lateralized epileptiform discharges on the left hemisphere (arrows). EEG scale is displayed at the right bottom (paper speed: 3 cm/sec; amplitude of the brain electrical activity: 5 mm represents 50 microvolts).

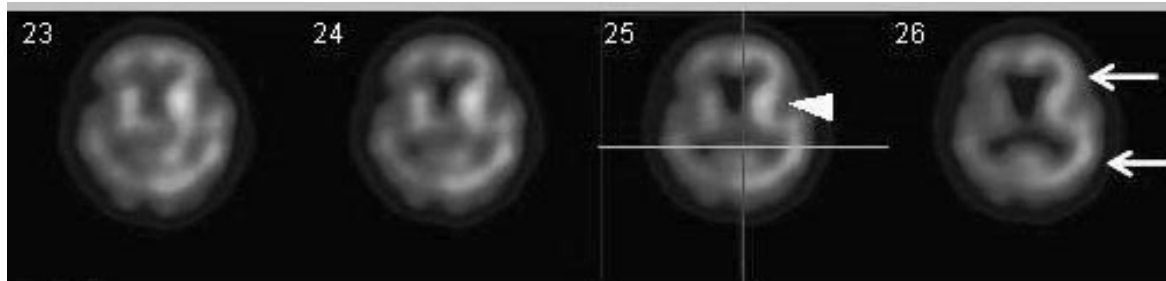
were normal except for mild hyponatremia and hypokalemia. MRI showed infarct area in the left parietal lobe and hematoma in the left thalamic region (Fig. 1). The patient was diagnosed with stroke. His EEG showed PLEDs on the left hemispheric region of the brain (Fig. 2). Regional cerebral blood flow (RCBF) was assessed with Tc-99m HMPAO (hexamethyl propylene amine oxime) brain SPECT while the patient was having PLEDs. The HMPAO kit (Ceretek, Amersham) was labeled according to the instructions of the kit. 740 MBq (20 mCi) Tc-99m HMPAO was injected via the intravenous route while the patient was in a room with dim lighting. Fifteen minutes after radiopharmaceutical administration, SPECT imaging was performed with a dual-headed rotating gamma camera (Siemens, E-CAM, Germany) equipped with a high resolution, parallel hole collimator. During a 360° rotation in 128 × 128 matrix, 128 × 40 second frames were obtained.

Reconstruction was performed parallel to the orbito-meatal line. SPECT displayed increased CBF in the left frontal and parietal cortex extending through the left temporal region and in the left basal ganglia (Fig. 3). Phenytoin was loaded at the dosages of 18 mg/kg and continued at 300 mg/day. In his daily EEGs, PLEDs persisted for the first 3 days despite the fact that the patient became responsive and cooperative. On the 10th day of admission, EEG was normal except for rare slow waves on the left side. A second SPECT study was also performed on the 10th day of admission and revealed minimally decreased perfusion on the left frontal and parietal region in the brain (Fig. 4). CBF in the bilateral basal ganglia was normal in the control SPECT.

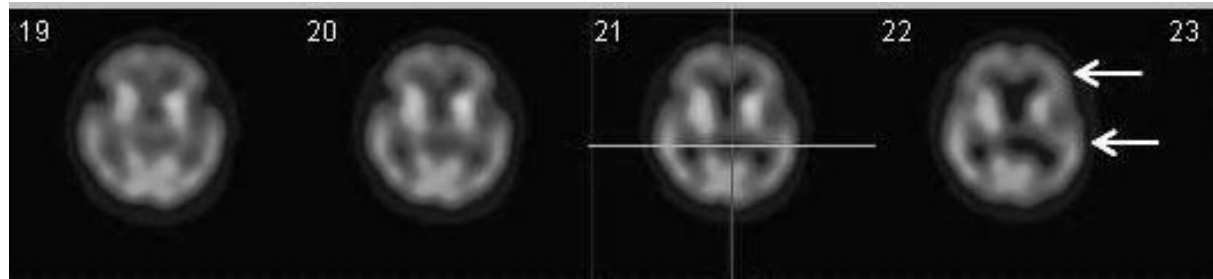
A semiquantitative study was also performed both on the SPECT study during PLEDs and the SPECT images after the cessation of PLEDs. Regions of interest (ROIs) were drawn on selected cortical areas. Left and right frontal and parietal regions were drawn on the compressed form of three consecutive slices according to Talairach coordinates.<sup>6</sup> Mean counts (total counts/pixel size) for each ROI were calculated for each region. Left to right ratios were calculated in each SPECT study. Left/right ratio significantly decreased in the second SPECT study after the cessation of PLEDs when compared to SPECT during PLEDs (Table 1). This confirmed the visual evaluation of SPECT studies.

## DISCUSSION

Although PLEDs have been recognized for 41 years, their pathophysiological mechanism remains questionable. PLEDs have been reported to be usually associated with an acute process and occur early during the course of illness with stroke being the main etiology<sup>2</sup> as we have also observed in our case. Other processes observed in PLED patients are brain infections like herpes encephali-



**Fig. 3** Transverse images of the SPECT study during PLEDs show significant hyperperfusion in the left frontal and parietal cortex extending through the left temporal region (*white arrows*). Increased Tc-99m HMPAO uptake is seen in the left basal ganglium (*arrowhead*).



**Fig. 4** Images of the second SPECT study after the cessation of PLEDs indicate relative hypoperfusion in the left frontal and parietal region of brain (*white arrows*). Bilateral basal ganglia perfusion is normal and symmetric.

**Table 1** Semiquantitative analysis of brain perfusion SPECT studies

Brain lobes		Right (counts)	Left (counts)	L/R
After the cessation of PLEDs	Frontal lobe	1152	1215	1.05
	Parietal lobe	1133	1067	0.94
	Occipital lobe	1173	1128	0.96
	B Ganglia	1405	1435	1.02
During PLEDs	Frontal lobe	710	787	1.1
	Parietal lobe	779	865	1.11
	Occipital lobe	812	898	1.1
	B Ganglia	821	995	1.21

tis, cryptococcosis in AIDS, intracranial abscess, tumors, hematomas, and other entities such as anoxic encephalopathy, subarachnoid hemorrhage, craniocerebral trauma, Creutzfeldt-Jacob disease, migraine, multiple sclerosis, aminophylline intoxication, solitary cysticercus granuloma, and neurocysticercosis.<sup>7-12</sup>

A role of the associated basal ganglia circuit in the generation of this periodic phenomenon has also been proposed.<sup>13</sup> In our case, increased Tc-99m HMPAO uptake was noted in the left basal ganglium during PLEDs. However, the second SPECT study revealed normal perfusion in the subcortical regions bilaterally. Increased perfusion in the basal ganglium may show that subcortical nuclei have a role in the generation of this periodic EEG pattern.

Neufeld et al. reported that patients with PLEDs had more metabolic disarrangements as compared to patients with no PLEDs.<sup>14</sup> They showed that PLEDs were significantly associated with hyperglycemia and fever. They proposed that acute stroke as a structural lesion predisposed to PLEDs but the latter might be triggered by metabolic disturbances, mainly hyperglycemia and fever. Itoh et al. have considered that PLEDs had occurred transiently in relation to hemispheric ischemic disturbance induced by hyponatremia.<sup>15</sup> Mild hyponatremia and hypochalemia in our patient might have played a role in the generation of the PLEDs.

PLEDs may also be bilateral, and bilateral PLEDs (BIPLEDs) are known to be associated with poor prognosis. However, Fushimi and co-workers reported a patient

with recurrent benign BIPLEDs.<sup>16</sup> PLEDs occurring independently on 3 different areas can be called TRI-PLEDs.<sup>17</sup>

In brain studies, SPECT has been used primarily to provide an index of cerebral blood flow (CBF). During seizures, there are large increases in the blood flow to and demand for metabolic substrates in the involved cortical area.<sup>5</sup> Therefore ictal SPECT studies show increased CBF in the affected region of the brain. The sensitivity of ictal SPECT is 90–95% in localization of the epileptic region.<sup>18</sup> The expected finding in interictal SPECT studies is decreased CBF in the epileptic region. It might reflect an obvious structural abnormality, such as a vascular malformation or hamartoma with decreased number of neurons and other metabolically active cells. However, approximately 50% of patients with proven epilepsy demonstrate interictal hypoperfusion in the corresponding epileptogenic region.

PLEDs are very rarely seen in routine EEGs as an interictal, ictal or postictal finding. It is not clear whether PLEDs are an ictal pattern or not although they persist despite the fact that convulsive seizure is over. In literature, there are a few reported cases who had SPECT studies during PLEDs.<sup>8,19–22</sup> In these reported cases, SPECT showed hyperperfusion that resolved with further aggressive antiepileptic drug therapy. In our case, the initial SPECT, which was performed during PLEDs on EEG, showed increased CBF in the left frontal and parietal cortex extending through the left temporal region. The second SPECT study after the cessation of PLEDs displayed minimally decreased perfusion on the left frontal and parietal region in the brain. SPECT findings in the patient support the concept that PLEDs may be an ictal phenomenon. This is a very important finding for the diagnosis of the patient as nonconvulsive status epilepticus and selection of appropriate treatment. The initial SPECT study performed in the presence of PLEDs can be considered as ictal and the second one obtained in the absence of PLEDs can be thought of as interictal brain perfusion studies.

PLEDs might be symptomatic or asymptomatic.<sup>23</sup> Our patient was accepted to be in status epilepticus during PLEDs. This condition might represent a nonconvulsive status epilepticus in the elderly.

PLEDs of our patient resolved after phenytoin administration. Response to the medication is also confirmed with the second SPECT study. Several authors used felbamate,<sup>24</sup> diazepam and carbamazepine.<sup>25</sup> for PLEDs. Disappearance of PLEDs after acyclovir treatment has also been reported in a patient with herpes simplex encephalitis.<sup>26</sup>

Stroke seems to be the dominant etiology for PLEDs.<sup>2</sup> Our patient had a stroke event also. PLEDs might be a key pattern for focal hyperexcitability in the penumbra zone of the stroke patient and increased CBF in the region of increased neuronal excitability is an expected finding as

we observed in the first SPECT study of our patient.

In conclusion, PLEDs seen immediately after the seizure may be the representation of ongoing seizure especially in the patient with impaired consciousness or confusion. We recommend the use of functional neuroimaging studies such as SPECT in these patients. SPECT findings may support the contention that PLEDs may be an ictal phenomenon and treatment of nonconvulsive status epilepticus can be planned appropriately. SPECT is an important functional imaging tool which can help us to understand the underlying mechanism in some conditions of functional disturbances in brain such as PLEDs.

## REFERENCES

1. Chatrian GE, Shaw CM, Leffmanan H. The significance of periodic lateralized epileptiform discharges in EEG: An electrographic, clinical and pathological study. *Electroencephalogr Clin Neurophysiol* 1964; 17: 177–193.
2. Garcia-Morales I, Garcia MT, Galan-Davila L, et al. Periodic lateralized epileptiform discharges: etiology, clinical aspects, seizures, and evolution in 130 patients. *J Clin Neurophysiol* 2002; 19: 172–177.
3. Singh G, Wright MA, Sander JW, et al. Periodic lateralized epileptiform discharges (PLEDs) as the sole electrographic correlate of a complex partial seizure. *Epileptic Disord* 2005; 7: 37–41.
4. Baykan B, Kinay D, Gokyigit A, et al. Periodic lateralized epileptiform discharges: association with seizures. *Seizure* 2000; 9: 402–406.
5. Robinson RO, Ferrie CD, Capra M, et al. Positron emission tomography and the central nervous system. *Arch Dis Child* 1999; 81: 263–270.
6. Talairach and P. Tournoux Atlas of Stereotaxic Anatomical Correlations of Gray and White Matter, Thieme, New York, 1993.
7. Kumar S, Kesavalu N, Chandy E. Periodic lateralized epileptiform discharges (PLEDs) in a child with solitary cysticercus granuloma. *Neurol India* 2004; 52: 523–524.
8. Gurer G, Yemisci M, Saygi S, et al. Structural lesions in periodic lateralized epileptiform discharge (PLEDs). *Clin EEG Neurosci* 2004; 35: 88–93.
9. Cury RF, Wichert-Ana L, Sakamoto AC, et al. Focal nonconvulsive status epilepticus associated to PLEDs and intense focal hyperemia in an AIDS patient. *Seizure* 2004; 13: 358–361.
10. Fushimi M, Sato K, Shimizu T, et al. PLEDs in Creutzfeldt-Jakob disease following a cadaveric dural graft. *Clin Neurophysiol* 2002; 113: 1030–1035.
11. Gross DW, Wiebe S, Blume WT. The periodicity of lateralized epileptiform discharges. *Clin Neurophysiol* 1999; 110: 1516–1520.
12. De Carvalho-Filho P, Arruda OM, De Melo-Souza SE. Periodic lateralized epileptiform discharges in neurocysticercosis. *Arq Neuropsiquiatr* 1989; 47: 94–99.
13. Gross DW, Quesney LF, Sadikot AF. Chronic periodic lateralized epileptiform discharges during sleep in a patient with caudate nucleus atrophy: insights into the anatomical circuitry of PLEDs. *Electroencephalogr Clin Neurophysiol* 1998; 107: 434–438.

14. Neufeld MY, Vishnevskaya S, Treves TA, et al. Periodic lateralized epileptiform discharges (PLEDs) following stroke are associated with metabolic abnormalities. *Electroencephalogr Clin Neurophysiol* 1997; 102: 295–298.
15. Itoh N, Matsui N, Matsui S. Periodic lateralized epileptiform discharges in EEG during recovery from hyponatremia: a case report. *Clin Electroencephalogr* 1994; 25 (4): 164–169.
16. Fushimi M, Matsubuchi N, Sekine A, et al. Benign bilateral independent periodic lateralized epileptiform discharges. *Acta Neurol Scand* 2003; 108: 55–59.
17. Hughes JR, Taber J, Uppal H. TRI-PLEDs: a case report. *Clin Electroencephalogr* 1998; 29: 106–108.
18. Mountz JM, Deutsch G, Kuzniecky R, Rosenfeld SS. Brain SPECT: 1994 Update. In: *Nuclear Medicine Annual 1994*, Freeman LM (ed), New York; Raven Press, 1994: 1–54.
19. Lee BI, Schauwecker DS. Regional cerebral perfusion in PLEDs: a case report. *Epilepsia* 1988; 29 (5): 607–611.
20. Ali II, Pirezada NA, Vaughn BV. Periodic lateralized epileptiform discharges after complex partial status epilepticus associated with increased focal cerebral blood flow. *J Clin Neurophysiol* 2001; 18 (6): 565–569.
21. Assal F, Papazyan JP, Slosman DO, Jallon P, Goerres GW. SPECT in periodic lateralized epileptiform discharges (PLEDs): a form of partial status epilepticus? *Seizure* 2001; 10 (4): 260–265.
22. Bozkurt MF, Saygi S, Erbas B. SPECT in a patient with postictal PLEDs: is hyperperfusion evidence of electrical seizure? *Clin Electroencephalogr* 2002; 33 (4): 171–173.
23. Westmoreland BF, Frere RC, Klass DW. Periodic epileptiform discharges in the midline. *J Clin Neurophysiol* 1997; 14: 495–498.
24. Hughes JR, Fuller T. The use of felbamate in patients with periodic lateralized epileptiform discharges (PLEDs). *Clin Electroencephalogr* 1995; 26: 180–183.
25. Terzano MG, Parrino L, Mazzucchi A, et al. Confusional states with periodic lateralized epileptiform discharges (PLEDs): a peculiar epileptic syndrome in the elderly. *Epilepsia* 1986; 27: 446–457.
26. Shimada K, Koh CS, Hashimoto T, et al. A case of aseptic meningoencephalitis with recurrent abnormal behavior, status epilepticus and aphthous stomatitis, improved by acyclovir. *Rinsho Shinkeigaku* 1989; 29: 367–370.