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Interictal crossed cerebellar hyperperfusion on Tc-99m ECD SPECT

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Crossed cerebellar hyperperfusion (CCH) in epilepsy is a rare condition that is observed on ictal cerebral perfusion SPECT. The mechanism of CCH assumes that hyperperfusion in the epileptic foci of the unilateral supratentorium causes hyperperfusion secondary to the corticopontocerebellar pathway (CPCP)-mediated remote effect in the contralateral cerebellar hemisphere. This phenomenon is similar to that of crossed cerebellar diaschisis (CCD). In this report we demonstrated interictal CCH in a patient with epilepsy in technetium-99m-ethyl cysteinate dimer (Tc-99m ECD) SPECT of the brain. To the best of our knowledge, interictal CCH has not been reported in the literature. This is the first report to describe the phenomenon with interictal Tc-99m ECD SPECT.

Key words: crossed cerebellar hyperperfusion, crossed cerebellar diaschisis, epilepsy, single photon emission computed tomography, technetium-99m-ethyl cysteinate dimer

INTRODUCTION

A UNILATERAL CEREBRAL HEMISPHERIC LESION such as cerebral infarction sometimes causes a reduction in cerebral circulation and metabolism secondary to the corticopontocerebellar pathway (CPCP)-mediated remote effect in the contralateral cerebellar hemisphere. This phenomenon is known as crossed cerebellar diaschisis (CCD)[1] on single photon emission computed tomography (SPECT) or positron emission tomography (PET) studies of the brain. In recent years a reversed phenomenon of CCD has been reported in the literature.[2–6] These reversible phenomena of CCD have been called "reversible CCD[2]", "reverse CCD[3]" and "crossed cerebellar hyperperfusion (CCH)[4,5]" by investigators. These phenomena are rare conditions. In this report, we describe a case of "crossed cerebellar hyperperfusion," in a patient with epileptic seizure visualized with interictal technetium-99m ethyl cysteinate dimer (Tc-99m ECD) SPECT of the brain.

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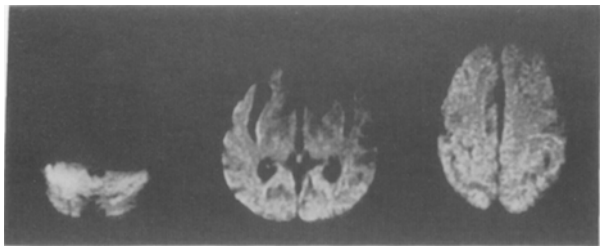
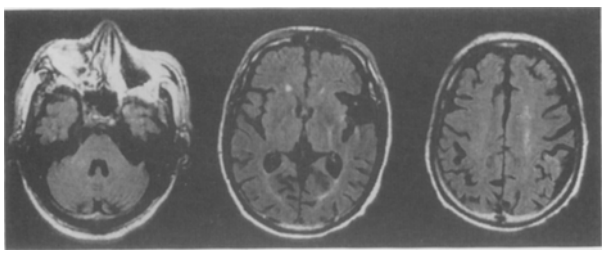
CASE REPORT

This patient was a 79-year-old man with hypertension. In the night of November 7, 2000, he was alert and well oriented, but he noticed transient repeated aphasic episodes intermittently. Because this condition continued for 1 day, he was brought to a local physician at 18 : 30 on November 8, 2000. During emergency computerized tomography (CT) of the brain, he suddenly had a tonic convulsion with conjugate eye divisions to the right side at 19 : 45. Diazepam was administered intravenously to control his seizure. To clarify the cause of the seizure, he was immediately transported to our hospital at 21 : 30. Neurological examinations on admission revealed mild disorientation and conjugate eye divisions to the left side. His verbal response was normal. His cranial nerves, motor and sensory showed no abnormalities. Emergency CT of the brain was obtained immediately after admission. CT showed multiple low density lesions related to old multiple cerebral infarctions. After admission, he had an anticonvulsant therapy. His consciousness became clear by the morning of November 9, 2000. Magnetic resonance (MR) imaging of the brain was obtained 14 hours after the seizure. Diffusion-weighted MR images (b-value = 1000) showed no signal abnormalities (Fig. 1a). Fluid-attenuated inversion recovery (FLAIR) images



a



b

Fig. 1 Magnetic resonance (MR) imaging 14 hours after the seizure. (a) Diffusion-weighted magnetic resonance (MR) imaging (b-value = 1000). Diffusion-weighted MR images show no increased signal intensity related to acute cerebral infarction in both cerebral and cerebellar hemispheres. (b) Fluid-attenuated inversion recovery (FLAIR) imaging. FLAIR images show brain atrophy and multiple high intensity lesions related to old multiple cerebral infarctions in the white matter around the bilateral ventricles and centrum semiovales. High intensity in the left thalamus is an artifact.

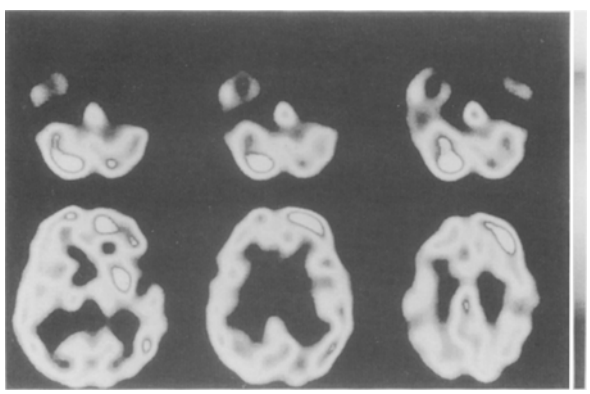


Fig. 2 Interictal Tc-99m ECD SPECT 15 hours after the seizure. Tc-99m ECD SPECT shows interictal hyperperfusion in the left frontal cortex, the left basal ganglia and the right cerebellar hemisphere, indicating the existence of interictal crossed cerebellar hyperperfusion (CCH).

showed brain atrophy and old multiple cerebral infarctions in the white matter around the bilateral ventricles and in the centrum semiovales (Fig. 1b). MR imagings showed no evidence of acute cerebral infarction. Immediately after MR imagings, interictal cerebral perfusion SPECT with Tc-99m ECD (740 MBq) was obtained 15 hours after

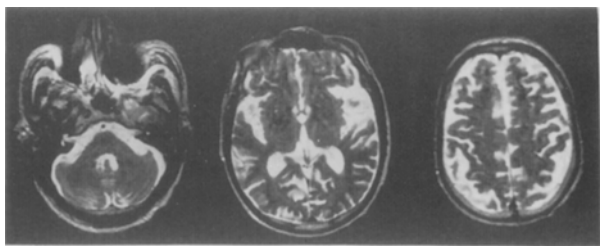


Fig. 3 Magnetic resonance (MR) imaging on the second study 6 days after the seizure. T2-weighted MR images show no new intracranial lesion such as acute cerebral infarction.

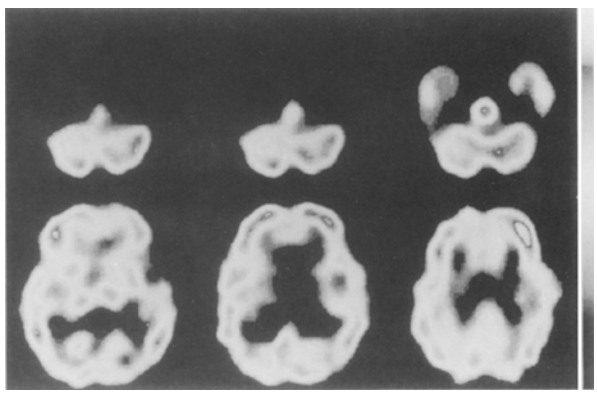


Fig. 4 Interictal I-123 IMP SPECT 22 days after the seizure. I-123 IMP SPECT shows slightly interictal hyperperfusion still persisting in the left frontal cortex and hypoperfusion in the right cerebellar hemisphere.

the seizure. Interictal Tc-99m ECD SPECT showed significant diffuse hyperperfusion in the left frontal cortex, the left basal ganglia and the right cerebellar hemisphere, indicating the existence of CCH (Fig. 2). Electroencephalography 17 hours after the seizure showed no seizure discharges or waves. Thereafter, he had no epileptic episode. MR imaging on the second study obtained again 6 days after the seizure. Diffusion-weighted MR, T2-weighted MR (Fig. 3) and FLAIR images showed no new intracranial lesion such as acute cerebral infarction. In the second SPECT study, cerebral perfusion SPECT with I-123-*N*-isopropyl-*p*-iodoamphetamine (I-123 IMP) of 167 MBq was obtained 22 days after the seizure. Interictal I-123 IMP SPECT showed normal cerebral perfusion in most of the left frontal cortex and left basal ganglia, but showed slightly hyperperfusion still persisting in a part of left frontal cortex and hypoperfusion in the right cerebellar hemisphere (Fig. 4). On the basis of these repeated SPECT and MR findings and his clinical course, it was suggested that his episode was epileptic seizure, and interictal hyperperfusion in the left frontal lobe on Tc-99m ECD SPECT were the epileptic foci.

DISCUSSION

Excitatory afferent impulses from the unilateral cerebral cortex via the CPCP pass through the internal capsule to reach the pontine nuclei. From the pontine nuclei, the pathway runs through the middle cerebellar peduncle and then terminates in the contralateral cerebellar cortex. CCD may be caused by functional disconnection between the unilateral cerebral hemisphere and the contralateral cerebellar hemisphere via the CPCP. It is assumed that CCH is also correlated with CPCP. A reversed phenomenon of CCD called CCH is a rare condition. Since the first described by Duncan et al.[2] in 1987, CCH has been reported in 14 patients with the seizure in the ictal state.[2–6] Won et al.,[4] however, reported that CCH was observed in 75% (8 of the 12 patients) on the ictal SPECT and was a frequent phenomenon in the ictal state. These ictal SPECT findings in the literature showed hyperperfusion in the unilateral cerebral hemisphere identifying on the epileptic foci and the contralateral cerebellar hemisphere. The epileptic focus in CCH involves the frontal lobe,[2,4–6] the temporal lobe[3,4] and the occipital lobe.[4] Ictal hyperperfusion of the unilateral cerebral hemisphere and contralateral cerebellar hemisphere have returned to the baseline[4] or hypoperfusion[4–6] in the postictal or interictal state. Concerning the mechanism of CCH, it is suggested that in the ictal state the neuronal overaction of the epileptic foci in the unilateral cerebral hemisphere spreads through the CPCP to the contralateral cerebellar hemisphere, and this neuronal overaction may lead to ictal hyperperfusion in both areas. In the present case, 15 hours after the seizure, interictal Tc-99m ECD SPECT showed CCH in the left frontal cortex, left basal ganglia and the right cerebellar hemisphere. Twenty-two days after the seizure, interictal I-123 IMP SPECT showed hypoperfusion due to the excitotoxic neuronal damage caused by seizure activity[7] in the right cerebellar hemisphere, and moreover, slightly interictal hyperperfusion in the frontal cortex was observed. In a similar case, Lang et al.[6] reported that interictal hyperperfusion had been prolonged for 14 days after the seizure. In general, ictal SPECT shows hyperperfusion caused by seizure activity, and interictal SPECT shows the baseline or hypoperfusion in the epileptic focus.[8,9] Cerebral perfusion SPECT, therefore, has been used to confirm the localization of epileptic focus and the evaluation of seizure activity.[8,9] Newton et al.[10] reported that the postictal blood flow changes gradually returned to normal within 10–30 minutes. As far as we know, interictal CCH has not been reported in the literature. This is the first report to describe this phenomenon with interictal cerebral perfusion SPECT. Interictal hyperperfusion on SPECT[6,11] or PET,[12] and postictal and interictal hypermetabolism on PET[13] in the epileptic focus have been observed by investigators. Although these significant mechanisms are not clear, it is suggested that postictal and interictal hyperperfusion may be related to seizure activity prolonged by additional factors, such as glucose metabolisum[14] or increased lactate[12] produced by anaerobic metabolism[13] in the epileptic focus during the ictal state. We suggested that interictal CCH was caused by seizure activity prolonged from the ictal state to the interictal state. The interictal hyperperfusion in the right cerebellar hemisphere had become hypoperfusion 22 days later, but the patients had no neurological symptoms involving the right cerebellum and no morphologic changes in the right cerebellar hemisphere. In epilepsy, it is known that patients with long-standing intractable or chronic epilepsy have cerebellar atrophy.[7,15] The cerebellar atrophy may be consequent on chronic and the repeated excitotoxic neuronal damage mediated through the CPCP caused by seizure activity in the unilateral cerebral cortex.[5] The existence of CCH may predict cerebellar atrophy. In epilepsy, the seizure activity in the epileptic focus spreads to the remote area associated with the epileptic focus via the neural tract. The secondary to the neural tract-mediated remote effects such as CCH and CCD, may therefore be important phenomena in predicting the hypofunction of cerebral perfusion and metabolism in the remote area. To clarify the remote effect and remote area caused by seizure activity, it is necessary to evaluate the CCH with the quantitative flow-mapping and the statistical images such as statistical parametric mapping (SPM) and three-dimensional stereotactic surface projections (3D-SSP).

REFERENCES

1. Baron JC, Bousser MG, Comar D, Castaigne P. "Crossed cerebellar diaschisis" in human supratentorial brain infarction. *Trans Am Neurol Assoc* 1980; 105: 459–461.
2. Duncan R, Patterson J, Bone I, Wyper DJ. Reversible cerebellar diaschisis in focal epilepsy. *Lancet* 1987; 2: 625–626.
3. Park CH, Kim SM, Streletz LJ, Zhang J, Intenzo C. Reverse crossed cerebellar diaschisis in partial complex seizure related to herpes simplex encephalitis. *Clin Nucl Med* 1992; 17: 732–735.
4. Won JH, Lee JD, Chung TS, Park CY, Lee BI. Increased contralateral cerebellar uptake of technetium-99m-HMPAO on ictal brain SPECT. *J Nucl Med* 1996; 37: 426–429.
5. Umemura A, Suzuka T. Crossed cerebellar hyperperfusion in symptomatic epilepsy. *Neurol Med Chir (Tokyo)* 2000; 40: 65–68.
6. Lang W, Podreka I, Suess E, Müller C, Zeitlhofer J, Deecke L. Single photon emission computerized tomography during and between seizures. *J Neurol* 1988; 235: 277–284.
7. Duncan R, Patterson J, Hadley DM, Bone I. Unilateral cerebellar damage in focal epilepsy. *J Neurol Neurosurg Psychiatry* 1990; 53: 436–437.
8. Runge U, Kirsch G, Petersen B, Kallwellis G, Gaab MR, Piek J, et al. Ictal and interictal ECD-SPECT for focus localization in epilepsy. *Acta Neurol Scand* 1997; 96: 271–276.
9. Zubal IG, Spencer SS, Imam K, Seibyl J, Smith EO, Wisniewski G, et al. Difference images calculated from

ictal and interictal technetium-99m-HMPAO SPECT scan of epilepsy. *J Nucl Med* 1995; 36: 684–689.
10. Newton RM, Berkovic SF, Austin MC, Rowe CC, McKay WJ, Bladin PF. Postictal switch in blood flow distribution and temporal lobe seizures. *J Neurol Neurosurg Psychiatry* 1992; 55: 891–894.
11. Devous Sr MD, Thisted RA, Morgan GF, Leroy RF, Rowe CC. SPECT brain imaging in epilepsy: a meta-analysis. *J Nucl Med* 1998; 39: 285–293.
12. Tatlidil R. Persistent postictal hyperperfusion demonstrated with PET. *Epilepsy Res* 2000; 42: 83–88.
13. Chugani HT, Shewman A, Khanna S, Phelps ME. Interictal and postictal hypermetabolism on positron emission tomography. *Pediatr Neurol* 1993; 9: 10–15.
14. Lewis DV, O'Conner MJ, Schuette WH. Oxidative metabolism during seizure in the penicillin-treated hippocampus. *Electroencephalogr Clin Neurophysiol* 1974; 36: 347–356.
15. Tien RD, Ashdown BC. Crossed cerebellar diaschisis and crossed cerebellar atrophy: Correlation of MR findings, clinical symptoms, and supratentorial diseases in 26 patients. *AJR Am J Roentgenol* 1992; 158: 1155–1159.