10. Maloteaux JM. Drug and transmitter receptors in human brain. Characterization and localization of serotonin, dopamine and adrenergic receptors. *Acta Neurol Belg* 1986;86:61–129.
11. Flexner JB, Flexner LB, Church AC, Rainbow TC, Brunswick DJ. Blockade of beta-1 but not of beta-2 adrenergic receptors replicates propranolol's suppression of the cerebral spread of an engram in mice. *Proc Natl Acad Sci USA* 1985;82:7458–7461.
12. Stone EA, Platt JE. Brain adrenergic receptors and resistance to stress. *Brain Res* 1982;237:405–414.
13. De Paermentier F, Cheetham SC, Crompton MR, Katona CL, Horton RW. Brain beta-adrenoceptor binding sites in depressed suicide victims: effects of antidepressant treatment. *Psychopharmacology* 1991;105:283–288.
14. Garattini S, Samanin R. Drugs: guide and caveats to explanatory and descriptive approaches–I. A critical evaluation of the current status of antidepressant drugs. *J Psychiatr Res* 1984;18:373–390.
15. Okada F, Tokumitsu Y. Is the β-downregulation a prerequisite of the antidepressant activity? *J Psychopharmacol* 1994;8:62–63.
16. Jellingen KA. Pathology of Parkinson's disease: changes other than the nigrostriatal pathway. *Mol Chem Neuropathol* 1991;14:153–197.
17. Elsinga PH, Vos MG, Van Waarde A, et al. (*S,S*)- and (*S,R*)-1′-[^{18}F]flu-orocarazolol, ligands for the visualization of pulmonary β-adrenergic receptors with PET. *Nucl Med Biol* 1996;23:159–167.
18. Van Waarde A, Elsinga PH, Brodde OE, Visser GM, Vaalburg W. Myocardial and pulmonary uptake of (*S*)-1′-[^{18}F]fluorocarazolol in intact rats reflects radioligand binding to β-adrenoceptors. *Eur J Pharmacol* 1995;272:159–168.
19. Zheng LB, Berridge MS, Ernsberger P. Synthesis, binding properties, and ^{18}F labeling of fluorocarazolol, a high-affinity β-adrenergic receptor antagonist. *J Med Chem* 1994;37:3219–3230.
20. Visser TJ, Van Waarde A, van der Mark TW, et al. Characterization of thoracic β-adrenoceptors in healthy volunteers using fluorocarazolol-PET [Abstract]. *J Nucl Med* 1996;37(suppl):71P.
21. Brown L, Deighton NM, Bals S, Spare receptors for beta-adrenoceptor-mediated positive inotropic effects of catecholamines in the human heart. *J Cardiovasc Pharmacol* 1992;19:222–232.
22. Cheng YC, Prusoff WH. Relationship between the inhibition constant (K_i) and the concentration of inhibitor which causes 50 per cent inhibition (IC_{50}) of an enzymatic reaction. *Biochem Pharmacol* 1973;22:3099–3108.
23. Van Waarde A, Visser TJ, Posthumus H, et al. Quantification of the β-adrenoceptor ligand, (*S*)-1′-[^{18}F]-fluorocarazolol, in plasma of humans, rats and sheep. *J Chromatogr B* 1996;678:253–260.
24. Edwards E, Whitaker-Azmitia PM. Selective beta-antagonists are equally and highly potent at 5-HT sites in the rat hippocampus. *Neuropharmacology* 1987;26:93–96.
25. Nishio H, Nagakura Y, Segawa T. Interactions of carteolol and other beta-adrenoceptor blocking agents with serotonin receptor subtypes. *Arch Int Pharmacodyn Ther* 1989;302:96–106.
26. Morin D, Zini R, Urien S, Sapena R, Tillement JP. Labeling of rat brain beta-adrenoceptors: (^{3}H)CGP-12177 or (^{125}I)iodocyanopindolol? *J Recept Res* 1992;12: 369–387.
27. Oksenberg D, Peroutka SJ. Antagonism of 5-hydroxytryptamine$_{1A}$ (5-HT$_{1A}$) receptor-mediated modulation of adenylate cyclase activity by pindolol and propranolol isomers. *Biochem Pharmacol* 1988;37:3429–3433.
28. Van Waarde A, Meeder JG, Blanksma PK, et al. Suitability of CGP12177 and CGP26505 for quantitative imaging of β-adrenoceptors. *Nucl Med Biol* 1992;19:711–718.
29. Van Waarde A, Meeder JG, Blanksma PK, et al. Uptake of radioligands by rat heart and lung in vivo: CGP12177 does and CGP26505 does not reflect binding to β-adrenoceptors. *Eur J Pharmacol* 1992;222:107–112.
30. Van Waarde A, Elsinga PH, Anthonio RL, et al. Study of cardiac receptor ligands by positron emission tomography. In: Van der Wall EE, Blanksma PK, Niemeyer MG, et al, eds. *Cardiac positron emission tomography: viability, perfusion, receptors and cardiomyopathy.* Dordrecht, Germany: Kluwer Academic Publishers;1995:171–182.
31. De Pärmentier F, Cheetham SC, Crompton MR, Horton RW. Beta-adrenoceptors in human brain labeled with [^{3}H]dihydroalprenolol and [^{3}H]CGP 12177. *Eur J Pharmacol* 1989;167:397–405.
32. Pazos A, Probst A, Palacios JM. Beta-adrenoceptor subtypes in the human brain: autoradiographic localization. *Brain Res* 1985;358:324–328.
33. Reznikoff GA, Manaker S, Rhodes CH, Winokur A, Rainbow TC. Localization and quantification of beta-adrenergic receptors in human brain. *Neurology* 1986;36:1067–1073.
34. Arango V, Ernsberger P, Marzuk PM, et al. Autoradiographic demonstration of increased serotonin 5-HT$_2$ and beta-adrenergic receptor binding sites in the brain of suicide victims. *Arch Gen Psych* 1990;47:1038–1047.
35. Bjornerheim R, Golf S, Hansson V. Specific non-beta-adrenergic binding sites for [^{125}]I-iodocyanopindolol in myocardial membrane preparations: a comparative study between human, rat and porcine hearts. *Cardiovasc Res* 1991;25:764–773.

Cerebral Sparganosis: Increased Uptake of Technetium-99m-HMPAO

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Cerebral sparganosis is an extremely rare intracranial parasitic infectious disease. We report findings of ^{99m}Tc-HMPAO cerebral perfusion SPECT in a case with cerebral sparganosis. SPECT revealed an irregularly shaped area with markedly increased ^{99m}Tc-HMPAO uptake in the parasitic infectious region of the cerebrum. Both white and gray matter was involved, the white matter involved predominantly. Decreased perfusion to the right cerebellum, suggesting cross cerebellar diaschisis, was also demonstrated. This article illustrates that cerebral sparganosis is one of the causes of increased ^{99m}Tc-HMPAO uptake in the cerebrum and should be considered clinically if present.

Key Words: sparganosis; technetium-99m-HMPAO; cerebral perfusion SPECT

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Cerebral sparganosis is an extremely rare central nervous system (CNS) parasitic infectious disease caused by the plerocercoid larva, called sparganum, of Spirometra mansonoides (*1,2*). Most cases of cerebral sparganosis have been reported from Korea, Japan, China, Taiwan and Southeast Asia (*2–9*). This article demonstrates the findings of ^{99m}Tc-HMPAO cerebral perfusion SPECT in a case with cerebral sparganosis.

CASE REPORT

A 74-yr-old man patient presented to our hospital with seizure and progressive weakness of the right side of his body for 1 mo. The patient did not have a fever. Neurological examination revealed decreased sensation and muscle power of the right side of the body. The white blood cell count on admission was 5,900/mm^3, and the differentiation showed 70% granulocytes, 19% lymphocytes, 4% eosinophils and 7% monocytes. EEG revealed continuous, focal, slow waves over the left frontotemporoparietal area. Brain CT revealed a cystic, enhancing mass lesion at left temporal area (Fig. 1). Brain MRI also revealed a mass lesion with hypointensity on T1-weighted images and hyperintensity on T2-weighted images (Fig. 1) with heterogeneous enhancement at the left temporal area. Based on the clinical presentations, examinations, CT and MRI findings brain tumor was suspected.

Technetium-99m-HMPAO cerebral perfusion SPECT was arranged to evaluate the regional blood flow to the intracranial mass lesion. SPECT imaging was performed using a triple-head gamma camera equipped with fan-beam collimators. Acquisition was started 20 min after an intravenous injection of 925 MBq (25 mCi) ^{99m}Tc-HMPAO in 120 projections, 3° apart, in a 128 × 128 matrix.

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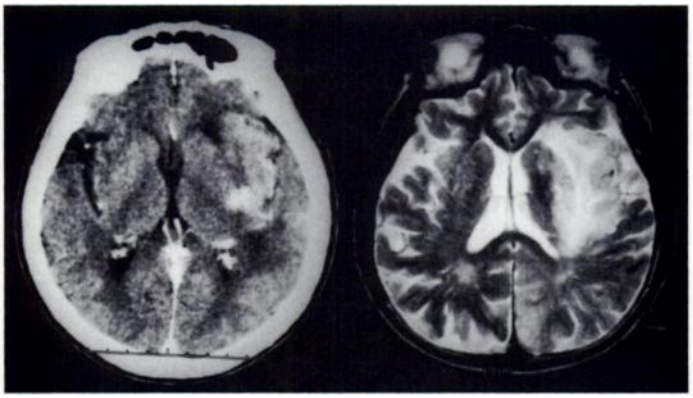

FIGURE 1. CT (left) shows a large, enhanced, irregularly shaped mass lesion at the left temporal lobe. T2-weighted MRI (right) shows a large high-signal lesion at the left temporal lobe. White matter was involved predominantly.

The raw data were reconstructed using the filtered backprojection method with a Butterworth filter.

SPECT images revealed a large irregularly shaped area of markedly increased ^{99m}Tc-HMPAO uptake at the left temporal area extending from the anterior lower portion to the medial and superior portions of the left temporal lobe (Fig. 2). Both white and gray matter of the left temporal lobe was involved, the white matter being involved predominantly. The left thalamus was displaced medially and posteriorly. There was also decreased ^{99m}Tc-HMPAO uptake at the right cerebellar cortical region (Fig. 2), suggesting cross cerebellar diaschisis (CCD).

For the purpose of final diagnosis, surgical biopsy using the stereotactic technique was performed. A 3 × 3 × 3 mm sample of tissue was removed from the left temporal lesion. The histopathological findings revealed many oval shaped foreign bodies and elongated integumentary structures surrounded by numerous granulomatous and astroglial cells (Fig. 3). The diagnosis of cerebral sparganosis was confirmed.

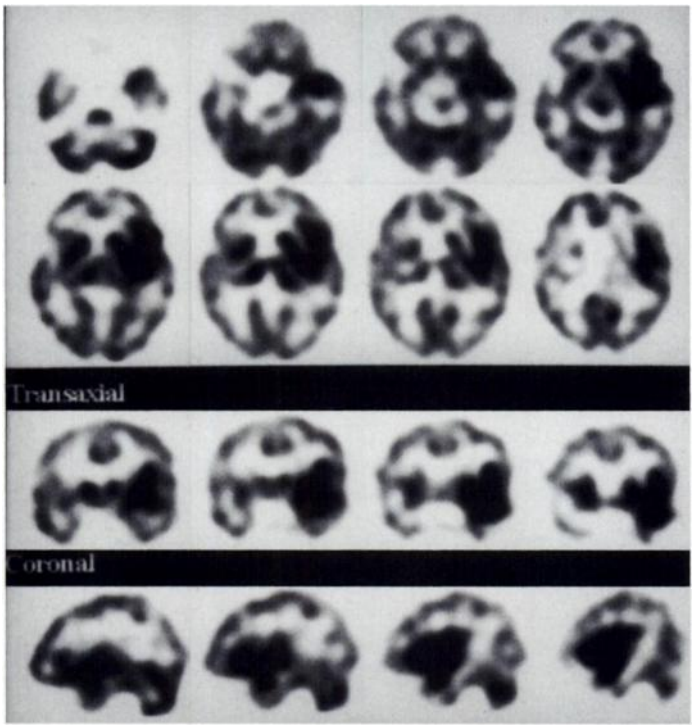

FIGURE 2. Transaxial, coronal and sagittal views of ^{99m}Tc-HMPAO cerebral perfusion SPECT. A markedly increased uptake lesion in the left temporal lobe extending from anterior lower part to superior part. White matter is predominantly involved. Decreased perfusion to right cerebellum is also noted.

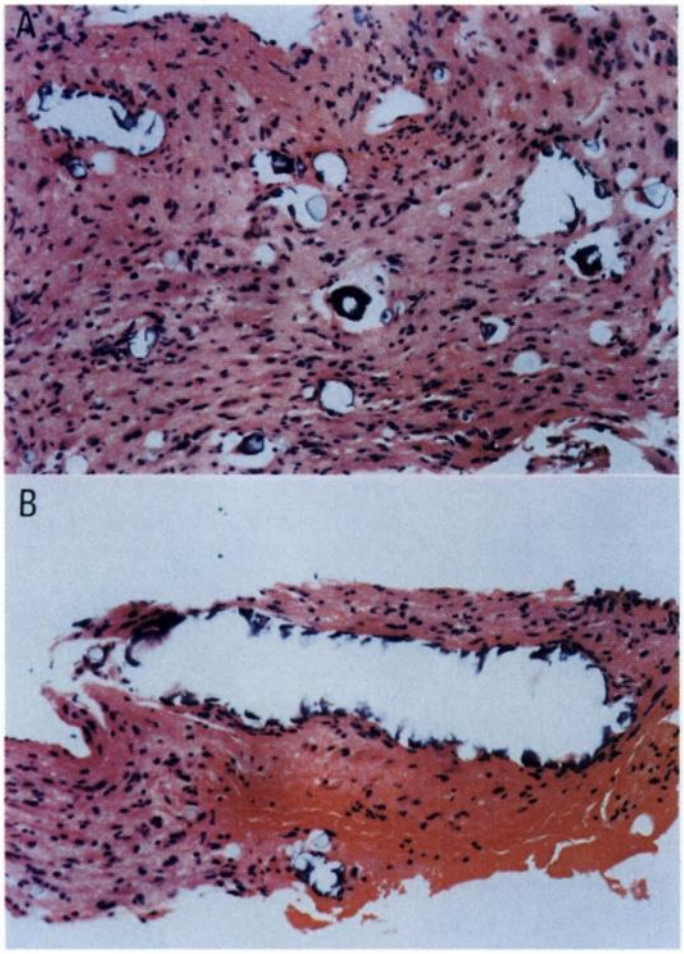

FIGURE 3. Histopathological findings. (A) Many oval shaped corpuscles and larval integumentary structures with astrogliosis are shown (100×). (B) An elongated integumentary structure surrounded by mononucleated cells and multinucleated giant cells can be seen (100×). Surrounding hemorrhage is also visible. All specimens were stained by hematoxylin and eosin.

DISCUSSION

Sparganosis is an incidental parasitic infectious disease which may occur after drinking untreated water contaminated with copepods, or after eating inadequately cooked flesh of fish, frog or snake contaminated with sparganum (*1,2*). We thought our patient had been infected through drinking inadequately treated water, which is the most common infected mode of sparganosis (*1,2*), although there was no obvious history of such infection.

Sparganosis usually involves the skin and skeletal muscle tissues (*1,2*). CNS involvement is extremely rare (*2–9*). The pathway of CNS involvement is not yet known, but the foramina of the skull base may be the route of entry (*2*). If the CNS is involved, the frontal, parietal and temporal lobes of the brain are most commonly infected, with the white matter of the cerebrum being involved predominantly (*2,10*). The parasite in the cerebrum may initiate an intense inflammatory reaction, causing accumulation of eosinophils, lymphocytes, plasma, giant, granulomatous and astroglial cells surrounding the parasite (*2,7,11*).

The clinical presentations of cerebral sparganosis vary depending on the site of infection (*2,10*). The most common presentation is seizure followed by slowly progressive hemiparesis, which was the chief complaint from our patient. However, the clinical presentations of cerebral sparganosis are like some other slow progressive CNS diseases, such as brain tumors, and

are not specific to cerebral sparganosis. Although both CT and MRI provide sensitive modalities for the detection of cerebral sparganosis, their findings, mimicking brain tumors, are not specific to the diagnosis of cerebral sparganosis (*6,10,12*). Because cerebral sparganosis often mimicks brain tumors in clinical presentations as well as in CT and MRI findings, it is difficult to diagnose and differentiate from a brain tumor before pathological proof of parasite from surgical specimen (*2,8*).

Increased ^{99m}Tc-HMPAO uptake lesions in the cerebrum have been reported in cases of brain tumor, acute encephalitis, ictal epileptic focus, luxury perfusion, auditory or photic stimulation, schizophrenia and others (*13–20*). The mechanisms of increased ^{99m}Tc-HMPAO uptake in cerebral sparganosis are not known. It may be closely related to the increased blood flow, intense inflammatory reaction, surrounding hyperemia, change of tissue pH or damage of blood brain barrier (*14,15*). However, the increased blood flow, inflammatory reaction and surrounding hyperemia may play the most important roles.

There are some characteristics of intracranial increased ^{99m}Tc-HMPAO uptake lesion in this case. The first characteristic is that both white and gray matter were involved, with the white matter being involved predominantly. This characteristic matches the intracranial lesion found in cerebral sparganosis, which usually affects white matter predominantly (*10*). The second characteristic is the markedly increased uptake of ^{99m}Tc-HMPAO, which may reflect the intense inflammatory reaction usually present in cerebral sparganosis (*2,7,11*). The third characteristic is the irregular shape of the lesion. An irregularly shaped lesion may favor an infectious lesion rather than a tumor lesion that is usually round or oval in shape. If these three characteristics are present in the case with slow progressive neurological manifestations, then the possibility of a parasitic infection such as cerebral sparganosis should be considered.

Based on the previous cases reported, brain tumor is a resonable consideration in the case of an intracranial increased ^{99m}Tc-HMPAO uptake lesion with slow progressive neurological manifestations. However, brain tumor usually shows decreased or normal ^{99m}Tc-HMPAO uptake (*16,17,21*). In the reviews of focal intracranial increased ^{99m}Tc-HMPAO uptake lesions, Meyer et al. (*14*) and Broich et al. (*15*) indicated that an inflammatory lesion should be considered more readily than a tumor in the case of an intracranial increased ^{99m}Tc-HMPAO uptake lesion. Cerebral sparganosis is a chronic infectious disease and is one of the possibilities causing increased ^{99m}Tc-HMPAO uptake lesion, especially when the above mentioned characteristics exhibiting.

Because the lesion was located at the left middle cerebrum, CCD was present in our case. It reflects deactivation of right cerebellum secondary to the impaired cross corticopontocerebellar pathway damaged by the intracranial parasitic lesion.

CONCLUSION

This article illustrates that cerebral sparganosis may cause a characteristically increased ^{99m}Tc-HMPAO uptake lesion in the cerebrum, and this should be considered in an intracranial increased ^{99m}Tc-HMPAO uptake lesion in patients with slow progressive neurological manifestations, especially in those patients who live in Asia or have immigrated from Asia.

REFERENCES

1. Neva FA, Brown HW. Extraintestinal larval tapeworms of human beings. In: Neva FA, Brown HW, eds. *Basic clinical parasitology*, 6th ed. Norwalk, CT: Appleton and Lange; 1994:213–214.
2. Holodniy M, Almenoff J, Loutit J, Steinberg GK. Cerebral sparganosis: case report and review. *Rev Infect Dis* 1991;13:155–159.
3. Mineura K, Mori T. Sparganosis of the brain: case report. *J Neurosurg* 1980;52:588–590.
4. Anders K, Foley K, Stern WE, et al. Intracranial sparganosis: an uncommon infection. Case report. *J Neurosurg* 1984;60:1282–1286.
5. Chan ST, Tse CH, Chan YS, et al. Sparganosis of the brain: report of two cases. *J Neurosurg* 1987;67:931–934.
6. Anegawa S, Hayashi T, Ozuru K, et al. Sparganosis of the brain: case report. *J Neurosurg* 1989;71:287–289.
7. Mitchell A, Scheithauer BW, Kelly PJ, Forbes GS, Rosenblatt JE. Cerebral sparganosis: case report. *J Neurosurg* 1990;73:147–150.
8. Tsai MD, Chang CN, Ho YS, Wang DJ. Cerebral sparganosis diagnosed and treated with stereotactic techniques: report of two cases. *J Neurosurg* 1993;78:129–132.
9. Wong ChW, Ho YS. Intraventricular hemorrhage and hydrocephalus caused by intraventricular parasitic granuloma suggesting cerebral sparganosis. *Acta Neurochir* 1994;129:205–208.
10. Chang KH, Chi JG, Cho SY, Han MH, Han DM, Han MC. Cerebral sparganosis: analysis of 34 cases with emphasis on CT features. *Neuroradiology* 1992;34:1–8.
11. Ho YS. Conditions simulating central nervous neoplasms. In: Ho YS, ed. *Pathology of brain tumor*, 1st ed. Taipei, Taiwan; Hwa-Shiang-Yuan Press; 1995:365–371.
12. Chang KH, Cho SY, Chi JG, et al. Cerebral sparganosis CT characteristics. *Radiology* 1987;165:505–510.
13. Launes J, Nikkinen P, Lindroth L, Brownell L, Liewendahl K, Iivavainen M. Diagnosis of acute herpers simplex encephalitis by brain perfusion single-photon emission computed tomography. *Lancet* 1988;28:1188–1191.
14. Meyer MA. Focal high uptake of HMPAO in brain perfusion studies: a clue in diagnosis of encephalitis. *J Nucl Med* 1990;31:1094–1098.
15. Broich K, Horwich D, Alavi A. HMPAO-SPECT and MRI in acute disseminated encephalomyelitis. *J Nucl Med* 1991;32:1897–1990.
16. Lindegaard MW, Skretiing A, Hager B, et al. Cerebral and cerebellar uptake of ^{99m}Tc-d,l-HMPAO in patients with brain tumor studied by single-photon emission computerized tomography. *Eur J Nucl Med* 1986;12:417–420.
17. Biersack HJ, Grunwald F, Kropp J. Single-photon emision computed tomography imaging of brain tumors. *Semin Nucl Med* 1991;XXI:2–10.
18. Ramsay SC, McLaughlin AF, Greenough R, et al. Comparison of independant aura, ictal and interictal cerebral perfusion. *J Nucl Med* 1992;33:438–440.
19. VanHeertum RL, O'Connell RA. Functional brain imaging in evaluation of psychiatric illness. *Semin Nucl Med* 1991;21:24–34.
20. Woods SW, Hegeman IM, Zubal IG, et al. Visual stimulation increases ^{99m}Tc-HMPAO distribution in human visual cortex. *J Nucl Med* 1991;32:210–215.
21. Babich JW, Keeling F, Flower MA, et al. Initial experience with ^{99m}Tc-HMPAO in the study of brain tumor. *Eur J Nucl Med* 1988;14:39–44.