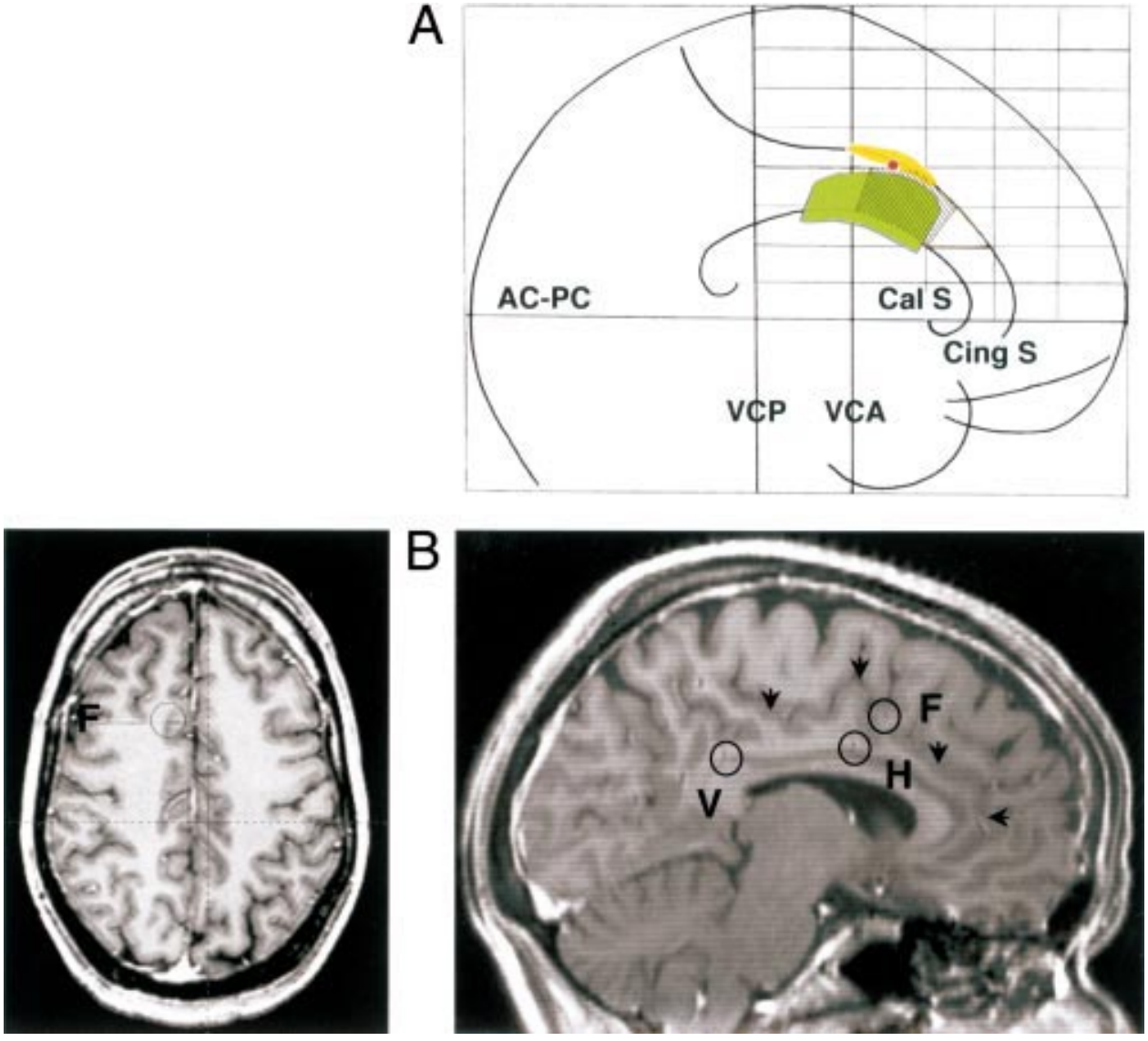
LETTERS TO THE EDITOR

The cingulate hidden hand

Studies on primates, and increasing evidences in humans, support the notion that the anterior cingulate cortex, which subserves various executive functions, is involved in the preparation and execution of motor operations.[1] Recently, the specific role of the caudal part of the anterior cingulate cortex in manual control has been demonstrated in a patient with a focal anterior cingulate cortex lesion,[2] thus providing additional arguments for the functional specialisation of cingulate motor areas in the human brain. Interestingly, the damaged area widely overlapped a more anterior part of Brodmann's area 24 from where complex coordinated movements adapted to environmental constraints have been electrically induced in epileptic patients (figure A).[3] Both areas encompass dorsally the ventral bank of the cingulate sulcus, at a level that seems to correspond to the simian rostral cingulate motor area (CMAr),[1] but whether this region is specifically involved in voluntary movements in humans is not known. We report a finding which shows for the first time that compulsive goal directed motor behaviour can be electrically induced in humans by stimulating the anterior cingulate sulcus.

The patient, a 30 year old right handed woman, had medically intractable epileptic seizures which proved to arise from the right parietal cortex. Before surgery, she underwent intracerebral EEG recordings and stimulation to locate the epileptogenic zone, using 13 stereotactically implanted multilead intracerebral electrodes, three of which investigated the right cingulate cortex. Electrical stimulation at low intensity of the anterior and posterior cingulate gyrus (figure B, electrodes H and V) did not result in any motor reaction. Conversely, using the same parameters, stimulation of the ventral bank of the anterior cingulate sulcus (figure A red dot, and B electrode F) incited the patient to act.



Anatomical representation of the electrical stimulation site. (A) Normalised proportional grid system of the atlas of Talairach and Tournoux, sagittal view. The anterior cingulate cortex lesion of the case of Turken and Swick[2] (in green) widely covers the cingulate area from where electrical stimulation can elicit complex coordinated movements (cross hatching).[3] The proposed location of the CMAr is represented in yellow,[1] and includes the stimulation site from where an "incitement to act" has been induced in the present case (red dot). AC/PC=anterior commissure/posterior commissure; VCA/VCP=coronal plane passing through the anterior/posterior commissure; Cal S/Cing S=callosal/cingulate sulcus. (B) MRI of the patient performed after removing the electrodes. Right side: right parasagittal view showing the three sites of stimulation in the cingulate cortex. Bipolar electrical stimulation (1 ms, 50 Hz, 5 s) was delivered from a conventional rectangular pulse generator and applied between 2 mesial contiguous contacts (0.8 mm diameter, 2 mm length, 1.5 mm apart) of the electrodes V, H, and F, which were respectively located in the posterior cingulate gyrus, in the anterior cingulate gyrus, and in the ventral bank of the anterior cingulate sulcus. Bipolar recordings between these contiguous contacts were previously shown to exhibit cortical electrical activity. Stimulation was performed at low intensity (V: 1.2 mA, H: 1.2 mA, F: 1.4 mA) under the threshold of afterdischarge. Incitement to act was elicited on F. Arrows=cingulate sulcus. Left side: horizontal view passing through the plane of electrode F, showing that the site of stimulation where an "incitement to act" was induced was clearly located in the ventral bank of the cingulate sulcus (empty circle). The stimulated contacts were located laterally at 9.5 mm and 13 mm from the medial line.

It consisted in an irresistible urge to grasp something, resulting in exploratory eye movements scanning both sides of the visual field, and accompanied by a wandering arm movement contralateral to the stimulation side. Then, after the patient had visually localised a potential target, her left hand moved towards the object to grasp it, as if mimicking a spontaneous movement. This irrepressible need started and ended with stimulation, and the patient was unable to control it. Yet, the patient was aware of both her inability to resist and of the movement she thus performed and could describe very precisely. Interestingly, the arm movement seemed visually guided, as when the patient was asked to keep her eyes closed while stimulated, her arm executed a wandering movement which did not result in grasping an object. This was not true if the object location had been memorised before closing her eyes; in that case, the arm moved blindly towards the place where the object was set.

Our finding demonstrates that a cingulate motor area buried in the ventral bank of the cingulate sulcus, just below the presupplementary motor area, is engaged in motor intention in humans, involving the contralateral upper limb. We can assume that the stimulated zone was restricted to the cingulate sulcus, as the stimulation was performed here with a highly localising technique using low intensity in bipolar mode through adjacent contacts distant only by 3.5 mm. This area could be homologous to the simian CMAr, which contains many neurons firing in relation to the intention to move,[4] and has essentially an arm representation. In addition, the CMAr lies within the cingulate sulcus anterior to the VCA plane, and then seems embedded in foci of activation seen in humans during relatively simple movements, as well as during more complex manual tasks. It remains that the behavioural response we found involved a high level of motor integration, as previously reported in epileptic patients when stimulating the anterior cingulate gyrus proper,[3] but it was preceded in the present case by an "urge to grasp", which gave rise to a compulsive and adapted manual reaction only when there was visual guidance. The anterior cingulate sulcus has been recently proved in humans to be responsive to visual stimuli,[5] and together with our finding, this may suggest that this area plays a part in integrating visual information in execution for movement.

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1 Roland PE, Zilles K. Functions and structures of the motor cortices in humans. *Cur Opin Neurobiol* 1996;**6**:773–81.
2 Turken AU, Swick D. Response selection in the human anterior cingulate cortex. *Nat Neurosci* 1999;**2**:920–4.
3 Bancaud J, Talairach J, Geier S, *et al*. Manifestations comportementales induites par la stimulation électrique du gyrus cingulaire antérieur chez l'homme. *Rev Neurol (Paris)* 1976;**132**: 705–24.
4 Shima K, Aya K, Mushiake H, *et al*. Two movement-related foci in the primate cingulate cortex observed in signal triggered and self-paced forelimb movements. *J Neurophysiol* 1991;**65**:188–202.
5 Bradzil M, Rektor I, Dufek M. The role of frontal and temporal lobes in visual discrimination task-depth ERP studies. *Neurophysiol Clin* 1999;**29**:339–50.

Localised myelitis caused by visceral larva migrans due to *Ascaris suum* masquerading as an isolated spinal cord tumour

Eosinophilic meningitis is caused by various parasites, a representive of which is *Angiostrongylus cantonensis*. The disease has also occasionally been reported in visceral larva migrans due to *Toxocara canis*, although the parenchymatous involvement of the CNS is extremely rare in *T canis* visceral larva migrans.[1] Recently an outbreak of visceral larva migrans due to *Ascaris suum* infection has been reported in Kyushu, Japan, where chemical fertiliser has been replaced in part with pig manure.[2] We report a case of myelopathy probably due to *A suum* infection.

A 22 year old man, living in the Tokyo metropolitan area, noticed that his right hand was swollen and warm in mid-August, 1999. The oedema subsided spontaneously within a week. In early October, he felt thermanaesthesia in his right leg while he was taking a shower. Because he had sometimes felt numbness in one or both axillas from the beginning of November, he was admitted to a hospital on 7 December 1999. Physical examination on admission showed hypalgesia and thermanaesthesia below the Th9 level on the right and a positive Lhermitte's sign. Peripheral blood eosinophil count was raised at 610/µl (10.5% leucocytes). Serum IgE concentration was 155 IU/ml (normal <240 IU/ml). Thoracic MRI disclosed an isolated high signal intensity lesion at the Th1 spine level on T2 weighted images. His symptoms improved gradually without any treatment. He was transferred to our hospital for diagnostic evaluation on 31 January 2000. He had a habit of eating raw beef liver and chicken liver. He had been to Fukuoka City, which is located at the northern part of Kyushu island, and ate raw beef liver in early August, 1999.

Physical examination on 31 January was normal except for the positive Lhermitte's sign. The peripheral blood eosinophil counts remained increased at 470/µl (7.0% leukocytes). Serum IgE, IgM, IgG, IgA, glutamic oxaloacetic transminase, and glutamic pyruvic transminase were normal. Antinuclear antibody, anti-ds-DNA antibody, c-ANCA, p-ANCA, and all other autoantibodies tested for were negative. Radioallergosorbent tests for *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* were positive. Chest radiography and CT of the liver were normal.

His CSF showed 10 cells/µl, 10% of which were eosinophils, a protein concentration of 65 mg/dl, normal glucose concentration, and a normal IgG index. Oligoclonal IgG bands were negative. Spinal cord MRI showed a high signal intensity lesion at the Th1 spine level on T2 weighted images, which was enhanced by gadolinium-DTPA (figure). Brain MRI, somatosensory evoked potentials, motor evoked potentials, visual evoked potentials, and peripheral nerve conduction studies were all normal. On multiple dot ELISA for 12 parasite antigens, *A suum, T canis, Dirofilaria immitis, Anisakis simplex, Gnathostoma doloresi, Strongyloides ratti, Paragonimus westermanii, Paragonimus miyazakii, Fasciola hepatica, Clonorchis sinensis, Spirometra erinacei* and *Cysticercus cellulosae*, both serum and CSF bound strongly to *A suum* and weakly to *T canis* but not to the others. On Ouchterlony's double diffusion test in agarose gel, the patient's serum but not CSF formed a sharp precipitin band against *A suum* antigen, but not against either *T canis* or *Angiostrongylus cantonensis* antigens. Parasite eggs were not found in repeated stool examinations.

The diagnosis of *A suum* infection was made, and albendazole (600 mg/day) was given for 2 weeks with a 1 week interval. Thereafter, Lhermitte's sign as well as the MRI lesion were almost resolved (figure). His CSF after therapy showed normal cell counts (0/µl) and a normal protein concentration (41 mg/dl).

This is the first case report of myelopathy caused by visceral larva migrans probably due to *A suum*. The presence of a specific antibody against *A suum* in CSF as well as in serum, together with the presence of eosinophils in CSF, suggest that the spinal cord lesion is attributable to the presence of parasite larvae in the lesion. The resolution of the lesion after albendazole treatment strongly supports this hypothesis.

Among *A suum* visceral larva migrans cases, only one probable case of encephalopathy in which multiple enhanced lesions on brain MRI were markedly attenuated by corticosteroids has been reported.[3] In that case, an immunoallergic mechanism was suggested for the CNS involvement. In our patient, albendazole, which efficiently passes through the blood-brain barrier, showed beneficial effects clinically as well as on MRI. Ascarid larvae have been reported to survive longer in the parenchymatous tissue and secrete antigens that cause allergic reactions in hosts.[4] Albendazole was therefore considered to have directly killed the larvae and effectively suppressed the host's immunoallergic reactions in the present patient.

Visceral larva migrans due to ascarid parasites is characterised by hepatopulmonary lesions associated with marked eosinophilia,[2] which was also true for the previously reported patient with encephalopathy due to *A suum* visceral larva migrans.[3] The present patient had neither pulmonary nor hepatic lesions, although he had had a transient hand oedema before the onset of neurological symptoms. Variations in clinical manifestations of visceral larva migrans may, at least in part, be attributed to the degree of infection. Even in a low grade infection without detectable hepatopulmonary lesions, ascarid larvae can migrate to an unexpected site to cause unusual clinical manifestations.

In areas where it is endemic, such as Kyushu, Japan, infection with *A suum* occurs primarily from ingesting vegetables contaminated with pig manure containing parasite eggs.[2 3] In addition, some patients were assumed to be infected by eating raw beef or chicken liver contaminated with *A suum* larvae (Nawa Y, unpublished data). Infection of cattle with *A suum* has been reported when they were kept in the same field.[5] Our patient developed myelopathy after ingesting raw beef liver, although he had never lived in the endemic areas. Because food borne parasitic zoonoses can be transported to areas distant from where they are endemic, neurologists should take a careful history of eating habits